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There are many different organizations and agencies which share responsibility for educating the public about responsible use of aquatic and marine resources. However, organizations specifically focused on particular dimensions of water use, such as Oregon State Marine Board (OSMB), often face challenges when attempting to recruit teachers to implement educational materials in their classrooms, because the curriculum design and limited content may not meet a teacher's needs. Teacher recruitment and retention in OSMB outreach efforts have been unsuccessful, largely because of a lack of understanding of educator needs and because many teachers view boating and water safety as marginalized topics not relatable to the subjects they teach. To address this, the author developed a new K-12 educational curriculum for OSMB entitled "Water Wits" which integrates boating and water safety concepts with STEM (science, technology, engineering, and math) and stewardship principles. Partnerships were forged with other water-related organizations in the Oregon community to provide feedback, promote the program, and share recruiting and training resources. Formative research was conducted with a pilot group of participating educators, who completed a survey measuring their motivations for selecting a curriculum to use with their students. This helped to clarify the target audience's wants and needs and informed the final design and content of the Water Wits curriculum. Summative research also provided insights into the outcomes, gaps, and successes of the pilot program. The results of this research may be used to determine future education efforts for OSMB, as well as potentially guide other organizations seeking to design or improve their own education programs.

Water Wits: The Development and Evaluation of a New Model for Integrated Marine Science, Safety, and Stewardship Education

by
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I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

Sara Shaw Roberts, Author

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CHAPTER 1: INTRODUCTION AND THEORETICAL FRAMEWORK

Background

Aquatic and marine education is an increasingly prevalent aspect of many agencies, non-profits, and organizations. Even in organizations whose primary focus is science, conservation, or policy, the imperative for outreach is often a strong presence in mission statements. The need to communicate with the public has even been recognized by the National Science Foundation, which now requires a "broader impacts" section for every research proposal, in which scientists describe methods for transmitting their research to the public arena (NSF, 2016). The approaches taken by aquatic and marine organizations to create outreach and education initiatives are very diverse. Many create original, hands-on lesson plans themed to their particular organization's goals. Some host on-site education programs led by instructors that can be attended by families or formal school classes. Others simply post their curricula on their website for free use by formal or informal educators. Another increasingly popular approach by many scientists and organizations is to write blogs or utilize social media, through which anybody can learn more about current research and news in their particular fields.

These efforts are valiant but not always successful. Poor translation of technical terms into more simple language, lack of marketing or name recognition, and insufficient engagement with the scientists behind the research being communicated may all contribute to this (Moore, 1991; Newton, 2001). A common mistake occurs when organizations fail to incorporate teachers into the development and evaluation of their education programs. Too often, the focus is on student learning outcomes, without the recognition that in order to get these materials to the students they must first be appealing to teachers. As teachers are often the main consumers of these programs, whether through field trips or the implementation of curricula in their classrooms, this can be a dooming oversight (Van Duzor, 2010). When education programs are not designed according to teachers' needs and trends in the education system, they are far less likely to be successful in recruiting and retaining teachers to use them (Carl, 2004). These trends include an emphasis on STEM (science, technology, engineering, and math), integrated interdisciplinary learning, and the incorporation of "21st-Century skills" such as collaboration, critical thinking, flexibility, and creativity (Lee et al, 2009). New national education standards such as Common Core and Next Generation Science both embrace many of these ideals.

While some organizations do bear these in mind when developing their education and outreach efforts, it is not always easy to decipher which of these many education imperatives are most important to their usual target audience: local teachers. This is often due to a lack of assessment of teacher wants and needs before developing a curriculum and a lack of evaluation of the success of the program after teachers have used it. While there has been some research done on teachers' motivations for implementing professional development concepts (Van Duzor, 2010; Schieb & Karabenick, 2011), and for participating in field trips (Kisiel, 2005; Anderson & Zhang, 2003), there is a gap in knowledge about which aspects of an education program are perceived as most valuable and necessary by teachers, and how this may play into their overall satisfaction with and perceptions of the program. Just as businesses conduct consumer opinion and satisfaction surveys when launching a new product, treating aquatic and marine education programs as products and teachers as customers (even if the programs are free) may lead to more effective education efforts.

The Oregon State Marine Board (OSMB) is an example of an agency which seeks to incorporate outreach into their business model, as evidenced by their mission statement: "Serving Oregon's recreational boating public through education, access, and environmental stewardship for a safe and enjoyable experience." Despite this, most of their education efforts have focused on adult education for those seeking boating licenses, youth-oriented games at public events such as fairs and expos, and occasional school visits by volunteer marine law enforcement officers to teach elementary students about basic water safety. The content of these efforts focused almost exclusively on boating and water safety. There was no formal curriculum, no consultation from teachers or education experts being pursued, and minimal efforts to engage school districts or others in the water resources community. Because of the poor attention that has been given to K-12 education, few teachers use OSMB learning materials and retention for outreach programs is poor.

Though the topics of boating and water safety are not generally appealing to most teachers, they are very important. U.S. Coast Guard statistics show that drowning was the reported cause of death in almost three-fourths of recreational boating fatalities in 2015, and that 84% of those who drowned were not wearing life jackets (OSMB, 2015). In Oregon, drowning is the second leading cause of death for children 14 and under (Oregon Center for Health Statistics, 2007). Over half of these deaths take place in natural water bodies including rivers, lakes, and the ocean: Oregon rivers and lakes are fed by snow-melt and are cold and swift long into the summer, while the ocean is cold enough to cause hypothermia year-round. Many of these drownings could have been prevented had the parents and children known to wear life jackets any time they are in, on, or around the water, and by understanding the dangers of cold water and hazards such as rip currents.

While OSMB outreach efforts have understandably focused on these issues alone, it was acknowledged that this myopic approach was not accessible to the majority of teachers. Because staff resources, time, and expertise in the area of curriculum development were so limited, the author was hired by OSMB as an independent contractor to develop a new K-12 education program to be distributed to classrooms across Oregon. The aim was to incorporate the traditional water safety messages with more school-friendly scientific concepts and environmental stewardship principles. Every effort was made to bear in mind teachers' needs and current education trends to make the curriculum as appealing and useful to educators as possible. The pilot program of this curriculum, which was titled "Water Wits", provides a case study of efforts to engage Pacific Northwest educators in integrated aquatic safety and environmental education.

Research surrounding the Water Wits program focused on three questions:

1. What motivates Pacific Northwest formal and informal educators to select a curriculum?
2. How well did the Water Wits pilot program fulfill these motivations and its goals?
3. How can pilot program outcomes inform future improvements to the Water Wits program?

Beyond informing specific modifications to the Water Wits program and attempting to validate the rationale of this program, this research may provide useful insights to all organizations that endeavor to develop or improve their own aquatic and marine education programs. A better understanding of how and why teachers choose to implement these programs allows agencies to create curricula which are not only more appealing, but also more effective. As this project has united several diverse groups under the umbrella of "water resources education", it may also help organizations of different aims to see themselves as working towards the same ultimate goal and encourage other collaborative projects.

Theoretical framework

Current education trends

A current trend in education is the push for integrated curricula, also referred to as interdisciplinary, thematic, or synergistic education. This is defined by Humphreys, Post, and Ellis (1981) as "one in which children broadly explore knowledge in various subjects related to certain aspects of their environment" (p. 11). Skills and knowledge are developed and applied across the humanities, sciences, and arts. Curricula are designed to include lessons, activities, and assessments which cut across several academic themes. Shoemaker (1989) provides a more detailed description of an integrated curriculum as "organized in such a way that it cuts across subject-matter lines, bringing together various aspects of the curriculum into meaningful association… It views learning and teaching in a holistic way and reflects the real world, which is interactive" (p. 5). This emphasis on real-world application is recognized as a valuable aspect of integrated education because it encourages life-long learning (Lake, 2003).

Many integrated education programs focus specifically on STEM subjects: Science, Technology, Engineering, and Mathematics. The push for increased STEM education is largely the result of concerns that the United States is falling behind in the global economy due to a lack of qualified workers graduating from STEM fields (US Dept. of Labor, 2007). As a result, billions of dollars have been devoted to student STEM programs in the education system (Kuenzi, 2008). Some attribute poor student success in STEM to a lack of qualified teachers, and as a result teacher professional development opportunities in these areas have also received a great deal of attention. Professional development (PD) may be defined as "systematic efforts to bring about change in the classroom practices of teachers, in their attitudes and beliefs, and in the learning outcomes of students" (Guskey, 2002). For STEM PD, this may involve intensive training on scientific principles, resources for extending learning such as ready-to-use curricula, or workshops demonstrating hands-on activities which may be used to illustrate STEM concepts. Recent major reviews agree that there is inadequate empirical evidence for what exactly makes such programs effective or not (Wilson, 2011; Cochran-Smith & Zeichner, 2005), and that what research has been done is largely descriptive, and "has not identified causal relationships between specific aspects of preparation programs and measures of prospective teachers' subsequent effectiveness" (NRC, 2010).

Largely in response to concerns about a lack of science-literate Americans, the national science education standards have recently undergone a major overhaul. The end result of this, dubbed the *Next Generation Science Standards* (NGSS), take a radical new approach to science education. Rather than focusing on discreet pieces of knowledge that require memorization such as facts, dates, and equations, NGSS emphasizes the practice of science and all its disciplines (Stage et al, 2013). Simply put, the standards themselves require the learning of both content knowledge and skills. Thus, a Disciplinary Core Idea in the standards may read "sound can make matter vibrate, and vibrating matter can make sound", while the Performance Expectation linked to that idea asks students to "plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate" (NGSS 1-PS4, p. 10, 2013). This emphasis on active student learning through experimentation, building models, and communicating information is vital to incorporate into informal curricula created by organizations and agencies, to meet the needs of teachers as they incorporate the NGSS into their classroom practices.

Environmental education has also been gaining more of an emphasis in the K-12 education system, especially in Oregon. This is exemplified by legislation passed by the State of Oregon (No Oregon Child Left Inside Act, 2009) creating the Oregon environmental literacy plan (OELP). This plan seeks to "ensure that Oregon students become lifelong stewards of their environment; are willing and able to exercise the rights and responsibilities of environmental citizenship; choose to interact frequently with the outdoor environment; have multifaceted knowledge of our relationship to the environment and its resources; and are prepared to address challenges and make sound decisions for our future" (ODE OELP, p. 3, 2013). Environmental literacy is vital as our population and the demand for limited resources continue to grow, yet many children today are severely disconnected from the natural world (Clemens, 2004). The Plan was created in acknowledgement of Oregon's role as a world leader in environmental practices, and of the need for citizens who lead healthy lifestyles and can make informed judgments about their environment, communities, and natural resources. The recommendations of the OELP include the alignment of OELP goals with existing state and national education standards, as well as Oregon's diploma requirements for graduation.

Constructivism is a pedagogic theory that has informed a wide variety of thought about student learning and teaching methods. This approach, influenced by early thinkers such as

Dewey and Vygotsky and later clarified by Piaget, is essentially a philosophy about how humans build knowledge (Popkewitz & Thomas, 1998). Constructivism, as the name implies, states that meaning is constructed from individual and social experiences, and from this learning happens over the course of one's lifetime. In other words, knowledge is not passively received but is actively built by the learner based on their experiences in the world, and the meanings they assign to those experiences. In this view, there is no such thing as knowledge that is independent of the learner, but only knowledge which we construct and create for ourselves as we learn (Hein, 1991). Constructivism has been both praised for its emphasis on learners' active participation and its recognition of the social nature of learning, and criticized for its tendency towards relativism – the doctrine that knowledge, truth, and morality exist only in relation to their cultural contexts and are not absolute (Phillips, 1995). Nevertheless, it remains a popular approach for education theory and is commonly taught as a core paradigm in teaching courses (DeVries, 2002).

Curriculum development

A curriculum can be described as a deliberate set of planned learning opportunities offered by an organization to learners as an interactive event (Print, 1993). The development of curricula is a complicated process in which the designer must take into account the needs of both the students and teachers, the target audience, the environment in which the curriculum will be implemented, state and national education standards, and a host of other considerations such as the resources and goals of the entity which is creating the curriculum, and potential barriers for implementation. Ornstein & Hunkins (2009) describe successful curriculum implementation more succinctly, as resulting from "careful planning which focuses on three factors: people, programs, and process" (p. 250). The use of purposefully-designed, deliberate curricula is crucial for the well-being and effectiveness of education (Barnett & Coate, 2005), yet it has been noted that some schools fail in implementing curricula because they neglect the people factor (Rusman, 2015). While there is no "one size fits all" method for good curriculum design, it should always be guided by the best available knowledge about learning and education (Barrow, 1984).

The most successful curricula involve teachers throughout the development process because they are directly involved in classroom practice, often unlike the education specialists at the agency or organization developing the curriculum (Carl, 2004). Teachers can provide valuable perspective about what may work and what may not, and insights about scaffolding the material for various student abilities. Involvement in the curriculum development process, in turn, empowers teachers to optimally develop student potential and encourage learners to be more involved in the learning process (Carl, 2004; Miller, 1994). Effective teacher involvement requires specific knowledge and skills, making professional development opportunities that build content knowledge related to the curriculum very important in the curriculum implementation process.

As no two students are the same, it is also important to incorporate curricular elements that address different learning styles. These are preferences or predispositions towards a certain type of learning setting or approach (Romanelli et al, 2009). While there may be over seventy different learning style schemes (Coffield, 2004), one of the most popular classifications of learning styles is described by the acronym VARK: visual, aural, read/write, and kinesthetic (Fleming, 2001). Visual learners absorb information best from visual sources such as charts, maps, and diagrams. Aural learners have a preference for things which are heard or spoken such as discussions, stories, and guest speakers. Read/Write learners enjoy learning from lists, notes, and text such as books and essays. Kinesthetic learners are most successful when engaged in activities which utilize concrete experiences – this includes demonstrations, simulations, and videos. Of course, most students will be able to utilize more than one learning style, but it is important to include all of these types of activities when designing an education program to reach all learning styles. Similarly, it is important that lessons and activities are able to be differentiated by the teacher. Tomlison defines differentiated instruction as “an instructional model which provides guidance for teachers in addressing student readiness, interest, and learning profile, with the goal of maximizing the capacity of each learner” (2013, p. 287). A differentiated curriculum then would have opportunities for students of varying interests and backgrounds to take different avenues for learning, and would provide clear guidance for the instructor for facilitating this.

Curriculum evaluation

Glatthorn et al. (2009) describes curriculum evaluation as “an attempt to toss light on two questions: do planned courses, programs, activities, and learning opportunities as developed and organized actually produce desired results? How can the curriculum offerings best be improved?” (p. 357) Research indicates that teachers should be directly involved not only in the development and implementation of a curriculum, but the evaluation of it as well. Two types of program evaluation have been identified: formative, which is intended to provide feedback as the program is being developed to inform necessary adjustments and improvements (Sadler, 1998) and summative, which may be viewed as “a judgment which encapsulates all the evidence up to a given point” (Taras, 2005), usually at the end of a program’s implementation. Formative assessments serve a myriad of feedback-related purposes such as diagnosis, prediction, and evaluation of teacher and student performance (Black & Wiliam, 1998). Summative assessments are designed to determine a program’s achievements, downfalls, and fulfillment of goals after the material has been finalized and distributed. While each of these types of evaluation is useful on its own, the most complete assessment of a program or curriculum should include both formative and summative aspects.

Daniel Stufflebeam first proposed the CIPP model for program evaluation in 1966, an acronym standing for Context, Input, Process, and Product. These four parts of an evaluation respectively ask what needs to be done, how should it be done, is it being done, and did it succeed? In the first phase, the context of the program to be developed is evaluated to identify the needs, assets, and resources of the provider (Mertens & Wilson, 2012). Program goals are assessed, and the general design of the program is discussed. Alongside this phase, input from the provider is gained to solidify the mission, goals, and plans of the program. Next, process evaluation investigates the program implementation by monitoring, documenting, and assessing activities. This phase provides initial feedback concerning how the program can be modified or improved. Finally, the product evaluation assesses the positive and negative effects the program had on its target audience and its outcomes, both intended and unintended. This model has been used for a number of applications within and outside education research, including rural education, achievement testing, welfare reform, community development, and nonprofit organization services (Stufflebeam, 2007).

Aquatic and marine education

While environmental education has been popular for several decades, much of this has focused on terrestrial systems. In 1978, Sea Grant released their “Statement on the Need for Marine and Aquatic Education to Inform Americans about the World of Water” (Goodwin & Shaadt, 1978). This seminal work spoke of the need for a higher presence of water within the realm of environmental education, because water is “the essential ingredient… Whether it is the water of the global sea or the fresh water of the land, our lives and fortunes depend upon it” (p.

9). Goodwin and Shaadt lay out several goals, including to develop a public with a basic understanding of the importance of water resources and a sense of responsibility for these resources, and to motivate people to take part in decisions affecting aquatic and marine environments (p. 11). This report also calls for the integration of marine and aquatic education into every school subject, and across subjects, not just science, using it to engage the interests of diverse teachers and students alike.

In 2001, the Recreational Boating and Fishing Foundation (RBFF) released a document containing 11 commissioned papers aiming to increase public awareness, appreciation, and stewardship of aquatic resources entitled “Defining Best Practices in Boating, Fishing, and Stewardship Education.” (Fedler, ed., 2001) This includes works framing recommendations for curriculum development, evaluation, reaching diverse audiences, and effective implementation. The need for carefully-designed curricula is a prevalent theme. The authors provide a number of guidelines, including the need to induce a sense of ownership and empowerment of stewardship issues in learners and in teachers through comprehensive training (Siemer, 2001); to make curricula accessible to minority groups which may not have a strong personal connection to aquatic resources (Floyd, 2001); and incorporating environmental education topics into current education practices in a way that meets teachers’ needs (Fortner, 2001).

The value and effectiveness of marine and aquatic education programs undertaken by agencies have been questioned, illustrating the need for program evaluation to go beyond merely demographic outputs. A wide gap in knowledge has been identified for aquatic education-related research, illustrated by the RBFF document authors’ inability to uncover more than a handful of articles investigating aquatic and marine education effectiveness (Fedler, 2001). There is a substantial amount of general environmental education literature available, however differences in materials, instructional methods, and learning environments make it difficult to extrapolate these findings for aquatic and marine education specifically. Of significance is the assertion that many successful aquatic and marine education programs are cooperative ventures which create partnerships among multiple organizations. A collaborative approach may be key in supporting better program development, implementation, and evaluation, though this does not appear to be supported by much existing empirical evidence.

Another important feature recommended by research but often overlooked in aquatic and marine education is the need to ground scientific concepts in the social context. The literature on morals, ethics, and values education clearly establishes the important influence of social context on the success of educational efforts (Leming, 1993; Matthews and Riley, 1995). According to Laska (1989), educational programs designed to change and encourage aquatic resource stewardship behavior should also consider the social aspects of relevant environmental issues. If not grounded within the community and cultural context, aquatic and marine education will remain abstract, outside the scope of experience of the teacher and the learner, and ultimately irrelevant and ineffective (Hauerwas, 1981; Sichel, 1988). These ideas are supported by a rigorous meta-analysis of environmental education literature conducted by Hines et al. (1987), which concluded that mere knowledge of ecological concepts was not enough to cause long-lasting behavior changes; rather a personal connection with the issues was critical.

Regional audience

Because the new OSMB curriculum was specifically aimed at Pacific Northwest educators, it was vital to understand the specific needs and perspectives of this particular market. In 2014, the Oregon Coast Regional STEM Hub conducted a Teacher Needs Assessment Survey which invited coastal teachers to provide feedback concerning their experience in teaching STEM, their needs and interests concerning professional development, and other needs for successfully implementing STEM classroom programming. A number of notable results emerged from this, including that the majority of STEM teachers do not hold degrees in a STEM field; that many do not consider themselves as having adequate access to professional development; that obtaining new ideas and/or resources for students was the top-ranked consideration for choosing professional development; and that overall, access to STEM lesson plans and programs for students was their most important need (Oregon Coast STEM Hub, 2014).

South Slough National Estuarine Research Reserve, located by Coos Bay, Oregon, conducted both a market analysis and a needs assessment survey in 2012. Administered by NOAA's National Estuarine Research Reserve System (NERRS), South Slough provides both public and K-12 education programs and includes an interpretive center, classroom, and numerous hiking trails. They conducted these analyses to better understand services provided by other Oregon coastal education providers, and curricular and professional development needs of coastal educators. The market analysis, which included focus groups and surveys distributed amongst key stakeholders such as watershed associations, school districts, and non-profits, resulted in several striking findings. Most significantly, the highest-ranked topics deemed to require more attention in education programs included estuarine biology and ecology, conservation/restoration, human interactions with nature, sustainable practices, and careers in science. Respondents expressed the need for extended curricular resources including kits and web resources. Top-ranked barriers for participation in education programs were transportation costs and lack of time.

The needs assessment survey, which focused on educators in six Oregon counties as a sample frame (Coos, Curry, Douglas, Lane, Jackson, and Josephine), revealed that the most frequently used web resources for teachers were NOAA's education portal, the Oregon Department of Education website, and Wikipedia, showing the need for promotion of more high-quality educational web resources. A high percentage identified intent to focus on scientific inquiry skills in the coming school year, which may reflect the trend in science education to emphasize process over content. Teachers also expressed a need for more training in the scientific method, biodiversity, adaptation, and sustainable practices. Notably, the lowest-ranked topics for this question included recreation topics (such as boating and fishing). This reflects the lack of curricula and literature available on this topic, and highlights the fact that while outdoor recreation is an enormous business in Oregon and a risk to many students, it is still deemed a low priority by educators.

Motivation theory

Simply put, motivation is the desire to do something, but it actually represents a complex theoretical construct that is used to explain human behavior. Motivation explains the reasons behind people's actions, desires, wants, and needs. As a person goes through life, certain higher-order natural motivations (such as hunger) will remain the same while other, more rational motivations are constantly changing, driven by the development of new meanings and self-identity (Reiss, 2002). Two incentive-based theories of motivation have been under study over the last several decades: intrinsic versus extrinsic motivation. Intrinsic desires are based in one's own interest or enjoyment in certain endeavors, causing someone to seek out new experiences to gain new knowledge (Ryan & Deci, 2000). As such, it is a critical element in both teacher professional development and student learning: those who are intrinsically motivated are far more likely to be self-directed in expanding their knowledge. In contrast, extrinsic motivation is reward-driven: activities or tasks are undertaken in order to achieve a particular desired outcome. These motivations commonly include monetary awards, achieving good grades, or the threat of punishment. While these drives may create motivation in the short-term, research has revealed that over time, extrinsic motivation may lead to a diminishment in performance and loss of intrinsic motivation (Cordova & Lepper, 1995). Therefore, in the pursuit of new education programs and curricula, it is important to foster intrinsic interest in the subject matter.

The Expectancy Value Theory of motivation proposes that motivations are shaped by the expectation that efforts to participate (such as time and money spent) will lead to behavior (i.e. engagement in programs or activities), which will result in desired experience outcomes and benefits (Palmgreen, 1984). Behavior, then, is a function of the expectancies one has and the perceived value of the goal toward which one is working – the behavior chosen will be the one with the largest combination of expected success and value. This builds on Fishbein's theory of reasoned action, which simply states that behavior can be predicted by both attitude and by norms – the expectations imposed by other people and society (Fishbein, 1968). Therefore, to persuade somebody to do something (such as participate in an education program), one must seek to strengthen the attitudes which support implementing said program.

CHAPTER 2: METHODS

Front-end analysis

Needs assessment

As a general guideline for the project, the CIPP model (Stufflebeam, 2007) described in the theoretical framework was employed to provide evaluative steps throughout the process. Before beginning development of the Water Wits program, as part of the Context and Input Evaluation phases, the author conducted a needs assessment. This included an evaluation of prior educational materials used by OSMB and identification of gaps in the content and procedures. Similar materials from other boating and water agencies were reviewed for strengths and weaknesses to help create the most effective possible program. This evaluation was based upon well-vetted guidelines for environmental education, including *Excellence in Environmental Education: Guidelines for Learning* (North American Association for Environmental Education, 2010) and *Education for Sustainability Standards* (The Cloud Institute, 2010). These resources set a high standard for quality environmental education and provided a solid framework for building a new OSMB curriculum. The Oregon Department of Education's "diploma requirements" – the skills that all graduating high school seniors should show proficiency in – were also consulted (ODE, 2016). While there is not a large amount of literature specifically focusing on water safety and stewardship education, available research concerning general environmental and science education, curriculum development, and teacher professional development was reviewed for best practices. Market and audience research conducted by Oregon informal education service providers was used to guide for the needs and perspectives of our target group, Oregon educators. OSMB education staff members were also consulted to determine key themes, content, and messages to communicate, as well as assets and limitations within OSMB resources.

It was found that educational materials previously provided by OSMB were not developed with any specific standards or educational frameworks in mind, making the curricula sometimes sporadic or unstructured in nature. The most recent effort to revamp the education program was undertaken in 2013 by a Marine Patrol Officer who does classroom visits. He created a PowerPoint-style presentation, which he then conducted at three schools with middle school Health classes, focusing on case studies of young local victims who had been injured or killed by not wearing life jackets while boating. However, due to difficulties encountered by the

Marine Patrol Officer surrounding the scheduling and organization of these presentations with school administration, by the time the author began working at OSMB in September 2014, this program had been abandoned. There was no information available about how these presentations were received by teachers or students.

The content of existing OSMB educational materials was also very limited, with a general overarching water safety theme and an emphasis on life jacket wear. There were no concepts of aquatic resources ecology, stewardship, or management to help fulfill the OSMB mission statement. Significantly, we could find no boating or waterway management agency in the United States which attempted to go beyond simple boating/water safety information in their education efforts. The best effort to create some integrated material comes from the California Department of Boating and Waterway's AquaSmart program, which the OSMB had used components of in the past. This program aligned lessons with education standards (mainly literacy-related standards such as reading and writing but also including some math and art standards), and each grade unit did have content about "keeping waterways clean", but the main focus was still limited to boating and water safety related topics.

It seems that in each state, the responsibility for educating students and the public is compartmentalized by topic: boating and fish and wildlife agencies teach about recreation and safe practices while using marine and aquatic resources, while environmental agencies and non-profits teach about the ecology and conservation issues surrounding those resources. Very few agencies seem to reach beyond these self-determined roles to integrate concepts across the one uniting factor: water. It was also found that staff and volunteer outreach resources at OSMB were quite limited, consisting of only one Boating Education Coordinator whose main task was overseeing the safety course for those seeking new boater licenses, and a handful of Marine Patrol Officers who occasionally volunteered to do classroom visits. However, an important asset, which OSMB did have, was extensive experience and knowledge about boating and water safety and an understanding of the most significant dangers to focus on.

General program design and goals

As a result of the needs assessment, it was determined that the new OSMB education program should be designed to be academically rigorous, integrated across subjects (science, math, social studies, health, and language arts), and aligned to state and national education standards including Next Generation Science and Common Core. An emphasis on science, technology, engineering, and math would be given to meet teachers' desire for STEM-related curricula. Each lesson plan would provide guidance for differentiation and for adapting the activity for younger and for more advanced students. Due to limited staff resources, the lessons would be easy to implement in the typical classroom, and require only simple and inexpensive materials – educators should be able to read and conduct each lesson with little or no support from the OSMB. An important part of this endeavor was the inclusion of printable resources to go along with each grade unit, including student worksheets, hand-outs, and take-home materials to share what they learned with their families.

While traditionally OSMB education efforts have been limited to boating and water safety, after discussions amongst colleagues and a review of the literature which revealed the value of interdisciplinary education, it was decided that the new program would be more successful and more attractive to educators if it also included other concepts which could be linked both to education standards and waterway use. The core themes were determined to be boating and water safety, science related to marine and aquatic environments, and stewardship of water resources, with an emphasis on both ecological and social dimensions of marine and aquatic resources use woven throughout. These main strands – science, safety, and stewardship – were dubbed the "Three S's" and guided the design and content of the entire curriculum. The water safety themes which OSMB deemed most important included life jacket use, cold water immersion, informed decision-making when in or around the water, and responsible boating and waterway use. Environmental stewardship themes included conservation of shared water resources, habitat management, keeping waterways clean, and invasive species awareness and prevention. All of these concepts were illustrated using one or more scientific disciplines: physics, ecology, engineering, the social sciences, resource management, etc.

Overall, the goals of the Water Wits program were to:

- Engage educators and students with hands-on, interactive activities.
- Reach learners of diverse interests and backgrounds.
- Be useful for both formal and informal educators.
- Empower teachers, through their instruction, to help save lives and conserve precious water resources.

The end product of the front-end analysis was a logic model which represents resources available (inputs), planned products and achievements (outputs), and desired outcomes both in the short-term period of the pilot program and in the long-term (Figure 1). Inputs relied mainly upon external knowledge about teacher wants and needs, curriculum development, and current education trends, and internal expertise about boating and water safety and environmental education. Outputs included a complete a thorough review and modification process of a new K-12 curriculum, the forging of community partnerships, and benefits for participants including a training workshop and activity kits. Expected goals and outcomes were the establishment of an education program which increased community and teacher awareness of aquatic safety and resource management issues in the short term, and which could support a broad network of educators committed to and capable of teaching about these issues in the long term.

Inputs	Outputs	Goals/Outcomes	
		Short-term (Pilot):	Long-term:
• Existing boating/water safety, environmental, and science curricula • Current research on teacher needs and motivations for education programs • Best practices for curriculum development and education methods • State and National education standards • OSMB staff expertise in boating and water safety content knowledge • OSMB mission statement and project goals • Formative feedback from colleagues • Author expertise in science and environmental content knowledge • Pilot program participant expertise in pedagogy, instructional methods, and content • Formative feedback data results	• An interdisciplinary, inquiry-based, standards-aligned curriculum which spans Grades K-12 • Pilot test of curriculum with select group of study subjects • Curriculum is reviewed and tested by a diverse pool representing various grades, subjects, and school districts • Study subject participation in an immersive all-day training workshop • Workshop attendees receive kits with activity materials which can be used with multiple classes • Author provides support, additional resources, and general assistance through the pilot program process • New partnerships are formed with other organizations in the marine and aquatic education community	• Increased OSMB reach to formal and informal educators and schools • Network of community partners that support integrated aquatic safety, science, and stewardship education • Increased teacher awareness of and caring for boating/water safety issues • Increased teacher pedagogical knowledge of STEM and environmental topics	• Summative feedback is gathered and analyzed to create a proven curriculum product • Teachers across Oregon are aware of and utilize OSMB educational materials • Teachers seek out lesson plans and activities related to marine/aquatic resources • Improved aquatic safety, science, and stewardship literacy amongst Oregon students • The Water Wits program provides a model which can be shared with other organizations and agencies across the country

Figure 1. Logic model for the Water Wits Education Program resulting from the Front-End Analysis.

Study population

Recruitment of teachers to pilot the Water Wits program and provide formative feedback (the Process Evaluation phase) during the 2015-2016 school year occurred through online and on-site advertising. Potential participants were recruited via the community partners described below, as well as OSMB contacts and promotion at conferences, and through various science, environmental, and marine education listservs. All participants were consenting adults over the age of 18 and of various ethnicity, race, and gender. Participants were restricted to formal and informal educators who voluntarily contacted the author, were provided the Water Wits curriculum, and who returned the formative assessment survey described below. As this was meant to be a small-scale pilot of the Water Wits program before mass implementation by the Oregon State Marine Board begins next year, the target sample size was 30 participants.

These recruitment efforts resulted in a group of 32 formal and informal educators who reviewed and/or tested the Water Wits curriculum with their students. These study subjects represent a broad range of educators from different school districts, sites, grade levels, and subject areas (Figures 2, 3, and 4). Elementary and middle school teachers and informal educators tended to teach multiple subjects, but high school teacher participants were exclusively science teachers. The vast majority were Oregon educators, though there were some respondents from other states (California and Arizona) and even from international schools (in Hong Kong and Dubai) who provided feedback. While most participants were concentrated in the Salem area (Marion County), likely due to OSMB office’s location and thus greater recognition amongst the public in Salem, there was representation from several regions in Oregon (Figure 5). Overall the sample satisfied the targeted audience for the Water Wits program, which was Pacific Northwest formal educators, though there were a significant number of informal educators who provided feedback.

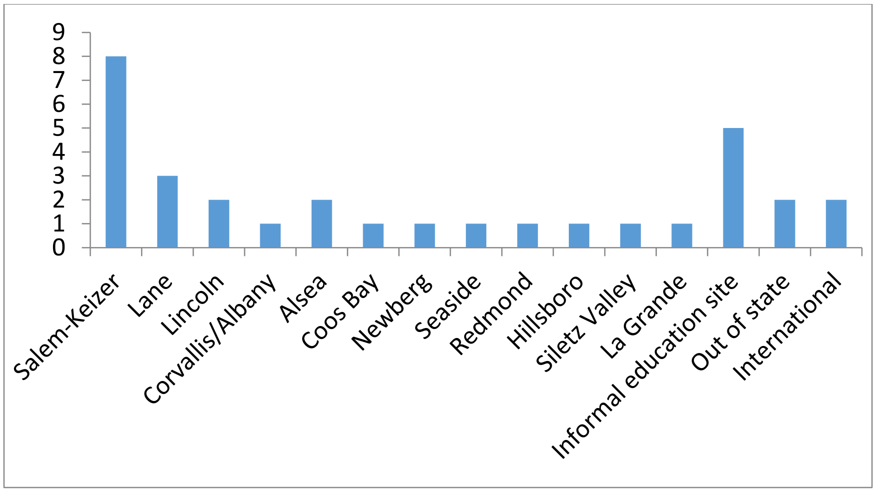


Figure 2. Participants by school district, informal education site, or other location.

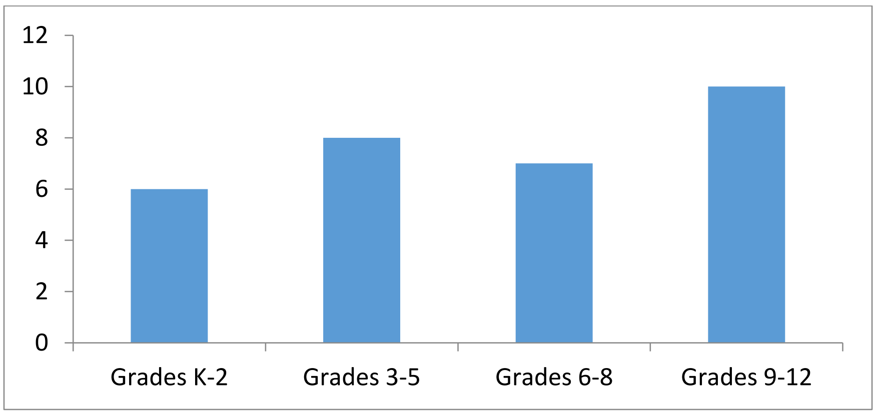


Figure 3. Participants by grade band. Note that *n* does not equal 32 due to the fact that some participants teach multiple grade bands.

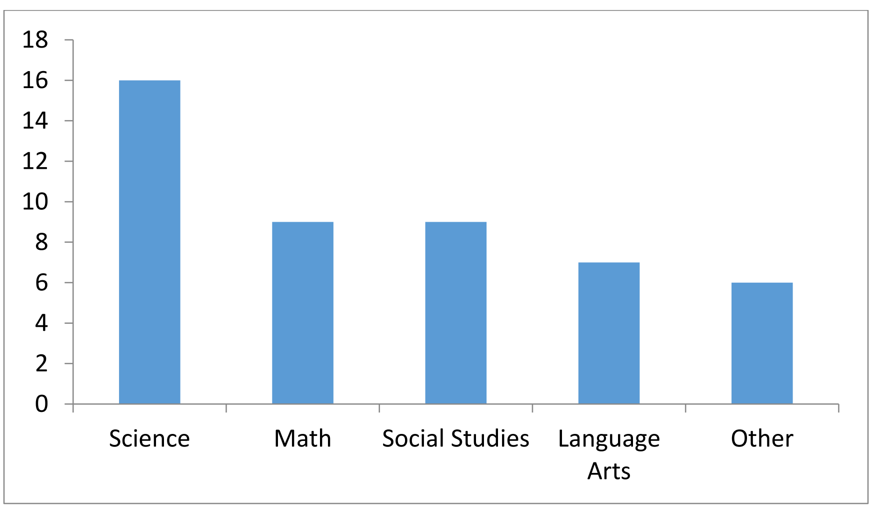


Figure 4. Participants by subject area. The "other" category included Art, ELL/Spanish, and specialty subjects such as chemistry and marine science.

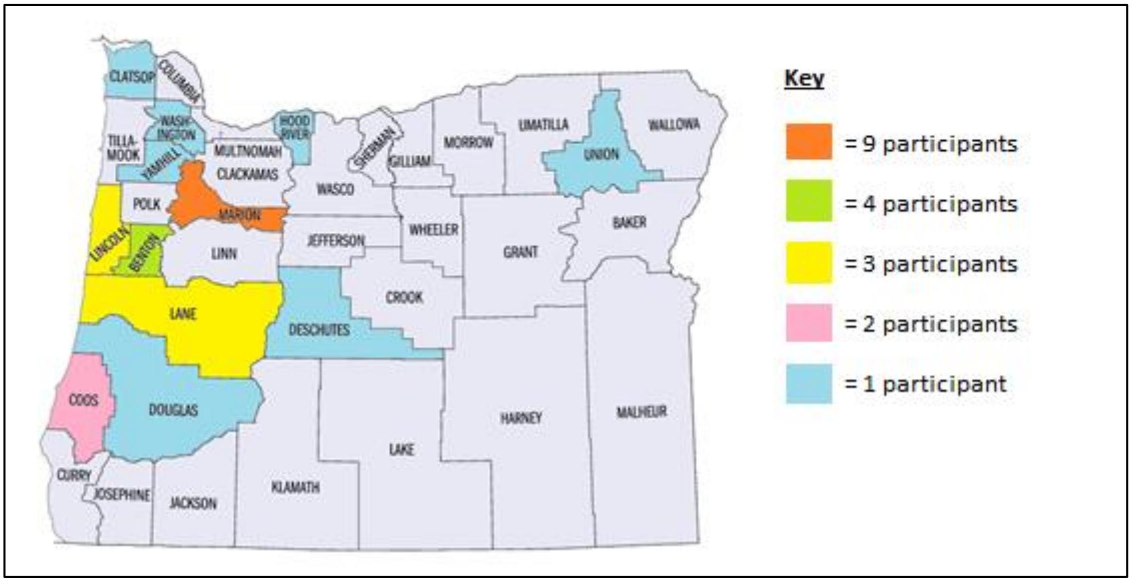


Figure 5. The geographic distribution of Oregon pilot program participants by county.

This group was targeted for several reasons. Many classroom teachers are eager to try new activities and build upon their teaching abilities and pedagogy, whether because they are new teachers seeking guidance, or experienced educators looking for new ideas. This idea is backed up by the research reports from various Oregon education organizations described in the theoretical framework, which showed that teachers felt a general lack of opportunities to expand their knowledge and the need for new curricula. Because they were professionals in education, they were able to provide much practical and useful feedback. They also have the ability to reach many students (and potentially their families) each and every day, thereby expanding the reach of programs such as Water Wits, which was one of the goals of the Oregon State Marine Board in developing this curriculum. This is also the a goal of many other aquatic/marine organizations, so focusing on a sample of local teachers may make this research more relevant for Community Partners and other organizations.

Community Partnerships

Several partnerships with marine and aquatic and environmental education organizations were forged to help expand the OSMB's reach and strengthen community relationships. A primary collaboration was initiated early with Oregon Sea Grant's Watershed and Invasive Species Education (WISE) program. This relationship developed with the recognition of both parties' shared focus on water-related issues and education. The WISE program includes a number of activities and resources to help students recognize the risks of aquatic invasive species and watershed pollutants, and ways to prevent these issues, such as not releasing classroom pets into the environment. Because both parties were undergoing a curriculum development process at the same time, the author collaborated with WISE staff to identify shared themes, develop aligned lesson plans, and provide language promoting each program within the other's materials. The goal for this partnership was to encourage teachers of each respective program to also incorporate the other program, to create a broader experience for their students.

A connection was also made with the Oregon Coast STEM Hub to include the Water Wits program in their pool of resources. The Coast STEM Hub promotes integrated science, technology, engineering and math education and serves coastal teachers, students and communities. It is one of several Regional STEM Hubs funded by the Oregon Department of Education and provides teachers with resources and professional development to further their STEM practices. It is centered at OSU's Hatfield Marine Science Center in Newport and serves the entire Oregon coast community, and engages multiple stakeholders and organizations as community partners. As one of these partners, the Water Wits program can leverage the assets of schools, nonprofits, businesses, civic leaders, and others to reach more audiences and help drive improvements in STEM learning along the Oregon coast.

Another significant relationship was established with Straub Environmental Center in Salem, Oregon. This organization strives to provide quality educational programs and information on a variety of environmental and sustainability topics to residents of all ages in the Mid-Willamette Valley. These programs include family retreats, day trips, presentations to local schools, and the annual Mid-Valley Green Awards, which honors local residents and businesses for following sustainable practices. The Center itself, completed in 2004, functions as a lab, classroom, community meeting space, and showcase of sustainable building and landscaping activities. Access to their facilities and network of teachers was utilized to solicit and train participants at a Water Wits workshop, an all-day event that engaged over a dozen teachers from several different regions across Oregon (see next chapter).

While each of these organizations has their own specific missions and aims, the goal is to take advantage of one ultimate shared mission: educating others about the world of water. This reflects one of the overall goals of the Water Wits program, which was to unite the seemingly disparate concepts of safety, science, and stewardship by treating aquatic and marine environments as resources used by people of different backgrounds and for different purposes.

Research design

Because there is little existing research about educator motivations or the evaluation of similar programs, a systematic grounded theory approach was used (Strauss & Corbin 1998). According to Creswell (2012), this is defined as a study in which "the investigator seeks to systematically develop a theory that explains process, action, or interaction on a topic" (p. 86). A mixed methods approach using both quantitative and qualitative data was employed to gain a broader understanding of these research areas. According to Johnson & Onwuegbuzie (2004), "A key feature of mixed methods research is its methodological pluralism or eclecticism, which frequently results in superior research (compared to monomethod research)." (p. 1) In other words, the use of multiple research approaches can provide multiple angles from which to tackle an issue and lead to a stronger overall project.

Formative evaluation

Survey instrument

While the Water Wits program was under development, teachers were asked to complete a survey which measured their motivations for selecting an education program to use in their classroom. This asked teachers to rate the importance of many different aspects of a curriculum. These items were organized into three conceptual motivation groups: ease of use, professional development opportunities, and curriculum content. Included items were determined based on similar surveys conducted by other Oregon education service providers, while also being personalized to Water Wits program goals and concepts. Items were rated on a Likert-type scale, and each category also included an open-ended response box for respondents to provide feedback in their own words. Demographic information, including school/site, district, subject(s) and grade(s) taught, was also collected. The survey was designed according to the general principles described by social science researcher Jerry Vaske (Vaske, 2008). Namely, this meant that survey questions used simple words, were brief and specific, were written at a level which could be easily understood but did not "talk down" to respondents, and avoided imposing any sort of bias upon the survey-taker. The survey underwent many iterations and was reviewed by

OSU faculty including Dr Mark Needham and Dr Allison Hurst – social scientists with expertise in survey design and social science research methods – to ensure the best possible instrument.

Data collection

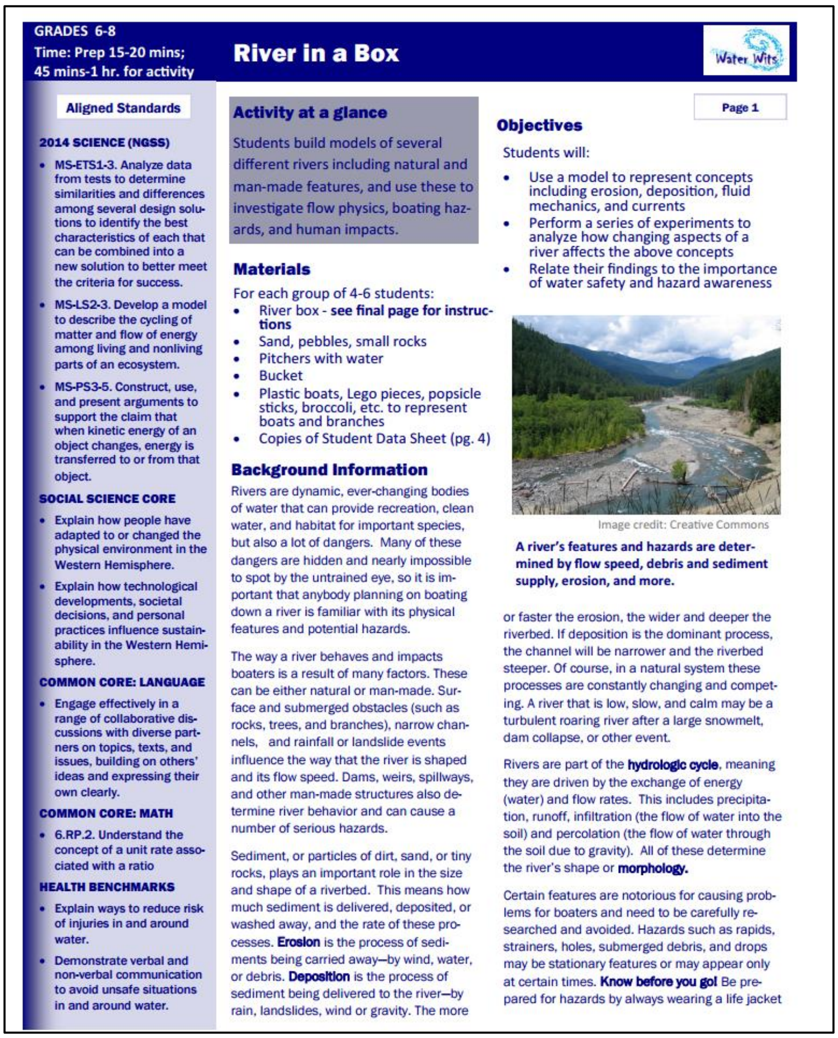
The survey was administered to study subjects upon first contact. For many of the participants, this took place with paper surveys at the conference at which they were recruited. These events included the Northwest Aquatic and Marine Educators annual conference in July 2015 and the Sharing the Coast Conference in March 2016. For those recruited via email, the link to the online survey was provided within the first response to an expression of interest. To achieve a complete response rate, those who did not take the online survey within two weeks were sent a general reminder; two weeks after that, those whose surveys were still missing were sent individual reminder emails, until 32 surveys were returned. Those who responded with interest to the original listserv or website posting but who did not return a survey after 4 weeks were dropped from the list of study subjects and were no longer contacted.

In November 2015, these pilot program participants were invited to a workshop hosted by Straub Environmental Center in Salem. There, the 15 attendees received intensive training about the rationale of the program and recommended implementation strategies. They also had the opportunity to try all of the activities themselves, and each received a “starter kit” containing the materials necessary for teaching the lessons. Participants’ reports of challenges and successes, as well as general comments, were recorded by the author. This workshop served as an informal focus group in which we were able to identify necessary or useful changes to the curriculum, and allowed participants to meet each other and share expert insights about how the curriculum could be adapted to various students, grades, and settings.

Curriculum development

Format and organization

Because early feedback showed that clear organization was important to educators in selecting curricula, all twelve lesson plans in the Water Wits program were written with the same features and using the same format (Figure 6). The title of the activity, grade level, and time required for teaching and preparation are clearly shown at the top of each lesson. Along the left margin, appropriate aligned education standards are listed by subject with their descriptions so teacher can clearly see how each is connected to the activity. Beneath the title, the “activity at-a-glance" box provides a succinct description of the lesson plan's main concepts and activities. Immediately to the right of this box, the Objectives section lists three to four measureable outcomes for students, which may include skills, knowledge, or experiences gained. The remainder of the front page consists of the Background Information, which aims to provide the content knowledge necessary for the educator to successfully teach the lesson plan, and contains bolded vocabulary. This section was written to give basic material which assumed that the educator may never have been exposed to this topic before, while also providing interesting and more complex details that could be of use to teachers with more experience in that subject area. Each front page also includes one representative image, either a picture or graphic, which encapsulates the activity and includes a brief caption meant to capture the interest of the reader.



GRADES 6-8
Time: Prep 15-20 mins; 45 mins-1 hr. for activity

River in a Box

Water Wits

Page 1

Aligned Standards

2014 SCIENCE (NGSS)

- MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
- MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
- MS-PS3-5. Construct, use, and present arguments to support the claim that when kinetic energy of an object changes, energy is transferred to or from that object.

SOCIAL SCIENCE CORE

- Explain how people have adapted to or changed the physical environment in the Western Hemisphere.
- Explain how technological developments, societal decisions, and personal practices influence sustainability in the Western Hemisphere.

COMMON CORE: LANGUAGE

- Engage effectively in a range of collaborative discussions with diverse partners on topics, texts, and issues, building on others' ideas and expressing their own clearly.

COMMON CORE: MATH

- 6.RP.2. Understand the concept of a unit rate associated with a ratio

HEALTH BENCHMARKS

- Explain ways to reduce risk of injuries in and around water.
- Demonstrate verbal and non-verbal communication to avoid unsafe situations in and around water.

Activity at a glance

Students build models of several different rivers including natural and man-made features, and use these to investigate flow physics, boating hazards, and human impacts.

Materials

For each group of 4-6 students:

- River box - **see final page for instructions**
- Sand, pebbles, small rocks
- Pitchers with water
- Bucket
- Plastic boats, Lego pieces, popsicle sticks, broccoli, etc. to represent boats and branches
- Copies of Student Data Sheet (pg. 4)

Background Information

Rivers are dynamic, ever-changing bodies of water that can provide recreation, clean water, and habitat for important species, but also a lot of dangers. Many of these dangers are hidden and nearly impossible to spot by the untrained eye, so it is important that anybody planning on boating down a river is familiar with its physical features and potential hazards.

The way a river behaves and impacts boaters is a result of many factors. These can be either natural or man-made. Surface and submerged obstacles (such as rocks, trees, and branches), narrow channels, and rainfall or landslide events influence the way that the river is shaped and its flow speed. Dams, weirs, spillways, and other man-made structures also determine river behavior and can cause a number of serious hazards.

Sediment, or particles of dirt, sand, or tiny rocks, plays an important role in the size and shape of a riverbed. This means how much sediment is delivered, deposited, or washed away, and the rate of these processes. **Erosion** is the process of sediments being carried away—by wind, water, or debris. **Deposition** is the process of sediment being delivered to the river—by rain, landslides, wind or gravity. The more

Objectives

Students will:

- Use a model to represent concepts including erosion, deposition, fluid mechanics, and currents
- Perform a series of experiments to analyze how changing aspects of a river affects the above concepts
- Relate their findings to the importance of water safety and hazard awareness

Image credit: Creative Commons

A river's features and hazards are determined by flow speed, debris and sediment supply, erosion, and more.

or faster the erosion, the wider and deeper the riverbed. If deposition is the dominant process, the channel will be narrower and the riverbed steeper. Of course, in a natural system these processes are constantly changing and competing. A river that is low, slow, and calm may be a turbulent roaring river after a large snowmelt, dam collapse, or other event.

Rivers are part of the **hydrologic cycle**, meaning they are driven by the exchange of energy (water) and flow rates. This includes precipitation, runoff, infiltration (the flow of water into the soil) and percolation (the flow of water through the soil due to gravity). All of these determine the river's shape or **morphology.**

Certain features are notorious for causing problems for boaters and need to be carefully researched and avoided. Hazards such as rapids, strainers, holes, submerged debris, and drops may be stationary features or may appear only at certain times. **Know before you go!** Be prepared for hazards by always wearing a life jacket

Figure 6. Sample of typical front page of a Water Wits lesson plan.

Content of lesson plans

Curriculum content was written to focus on the goals and themes decided upon during the front-end analysis and as a result of formative feedback. One of the primary considerations was the need for alignment to state and national education standards. Thus, the curriculum writing process began with a review of Oregon state standards in Social Studies, Health, and Math; Common Core standards for English Language Arts; and Next Generation Science Standards. Potentially relevant standards in each subject area were noted and condensed into a single document, organized by grade band. After the front-end analysis was completed, and the desired themes and content areas identified by OSMB staff, the most relevant standards were highlighted and formed the backbone of the curriculum. It was important that each lesson not only address standards, but meet standards across different subjects to provide an interdisciplinary perspective on issues. Figure 7 shows a cross-walk of several exemplary Water Wits lessons and their links to education standards in various subject areas.

Each subject area in the cross-walk provides four sample topics, or focus areas, which are part of the requirements mandated by the set of standards listed with each subject. It is important to note that in the state of Oregon, the type of education standards used varies by subject area. All Water Wits activities link to standards in at least two subject areas; the examples listed below link to three or even all four subject areas. In some cases, a lesson links to multiple focus areas within a subject. While the Water Wits program is grounded in education standards, it is important to note that some activities are more closely aligned to standards than others. For some lessons, only certain parts of some listed standards are addressed, but were included so that educators could see how using that activity could contribute to fulfilling the entire standard as part of a larger unit. In some cases, it was deemed that priority should be given to a particular topic in aquatic safety or stewardship, even if it did not perfectly match with the standards in that grade level, to fulfill the desired goals and outcomes of the education program.

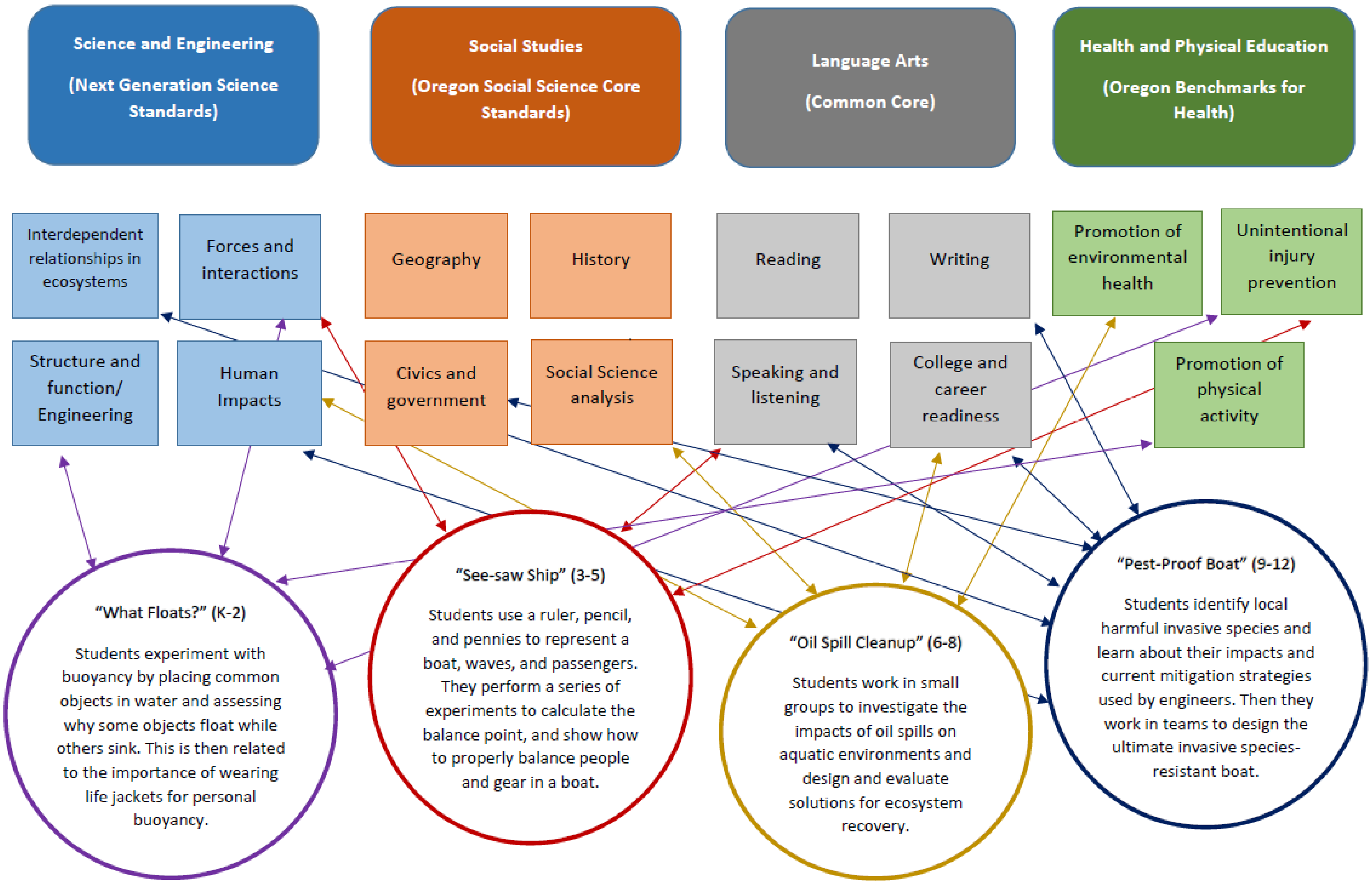


Figure 7. Examples of a lesson plan from each grade unit and their alignments to education standards across subjects and focus areas.

Another important consideration was that the curriculum should be developmentally appropriate for each grade level. The Water Wits program is divided into four grade units: Kindergarten-2nd Grade, Grades 3-5, Grades 6-8, and High School. For each unit, the design of lesson plans was based upon Piaget's Stages of Cognitive Development (Piaget, 1964). This theory states that from birth to early adolescence, a child goes through four distinct stages of development, each marked by specific skills and abilities. Chicago Brookfield Zoo's guide to age appropriate activities (Chicago Zoological Society, 2001) was also used as a resource for applying these developmental stages to informal environmental education efforts.

In early childhood, ages 2-7, children are in the "pre-operational" phase in which they engage in symbolic thinking and have a strong imagination and intuition, but complex and abstract thought is still difficult. Therefore the K-2 lessons include a song with lyrics about safe swimming, to both provide concrete information and take advantage of young children's strong affinity for music; a call-and-response game in which students reply to questions about water safety with the correct response and body movement to reinforce memory; and a story-telling activity in which students create their own story about what happens to a body of water under different weather conditions and because of human impacts, activating their imagination.

According to Piaget, from ages 7-11, children are "concrete operational": able to attach concepts to concrete situations. The child can now reason logically about events, classify objects, and understand space and quantity. More complex subjects can be discussed and reasoned, though children are still focused on the self and are just beginning to apply empathy and understanding to others and to global issues. With this in mind, the 3rd-5th Grade lesson plans include an activity in which students experiment with buoyancy by placing common objects in water and assessing why some objects float while others sink; another in which they use classroom materials to represent a boat, moving waves, and passengers, and perform a series of experiments to understand the physics of balance; and a cold-water immersion activity in which students feel the impact of icy water on their own hands both with and without the insulation of a model life jacket to reinforce the importance of life jacket wear. The use of models as concrete, representative objects was applied liberally to help these younger students attach meaning to real-life concepts and issues.

By age 11 and older, children can apply logical thinking to more abstract concepts – the "formal operations" stage. They have become more concerned with the future and can consider the hypothetical, and can grasp the concept of action and reaction to create and test hypotheses. The middle school (Grades 6th-8th) lesson plans thus put a greater emphasis on scientific processes, especially physics and engineering. Rather than merely using existing models, students begin to design and build their own. There is also a greater focus on environmental issues and, to avoid the "ecophobia" phenomenon in which young children become overwhelmed and paralyzed by all of the problems facing our environment (Sobel, 1996), this is coupled with a strong focus on solutions. In one activity, students build models of several different rivers including natural and man-made features, and use these to investigate flow physics, boating hazards, and human impacts. Using common household materials such as cotton balls, sponges, and dish soap, students also design and evaluate solutions for the impacts of oil spills in aquatic environments (represented by a pool of vegetable oil in a tub of water), and also investigate the societal dimensions of clean-up efforts. Finally, students build a simple engine and perform a series of experiments to demonstrate Newton's Laws of Motion. They then modify their designs to address common boating safety concerns.

The design of the High School lessons relied upon Piaget's work as well as other research in education and developmental psychology specific to this unique age group. According to Pennington (2009), high school learners need to understand the importance and relevance of what they are learning, are both internally and externally motivated, may have cognitive barriers due to past academic failures which must be overcome, and want to take control of their own learning and express themselves. Therefore, the High School activities include a lesson which focuses on the dangers of cold-water immersion using a video with testimonial from teens who have been or have known victims of boating-related accidents, and another in which students research current advances in boat engineering to explore methods for the prevention of aquatic invasive species. The final lesson plan is a town hall meeting style-activity, an instructional method with proven effectiveness with older learners (Hanson, 2003). Students play the role of various citizens in a town hall meeting to reach a resolution about whether or not debris in a local waterway should be removed. Competing interests, conflicting opinions, and issues of public safety and ecology must be reconciled. This immersive activity allows students both to put themselves in the shoes of professionals, helping them to see potential careers for their own future, and to explore the different perspectives and complexities involved with natural resource management.

Inclusion on the OSMB website

Towards the end of the process when the curriculum was close to being finalized, a dedicated page of the Marine Board website was added to house the curriculum and additional information (http://www.oregon.gov/OSMB/boater-info/Pages/K-12-Water-Wits-School-Education-Program.aspx). This was an essential aspect of the final product for two main reasons: one, the presence of full lesson plans available online with one click greatly increases the chance that teachers will actually use them, and two, a publicly-available website brings in traffic that may reach well beyond OSMB's usual audiences. This was crucial to address one of OSMB's main concerns at the beginning of this project, that they have a very limited reach as far as schools and educators go. The Water Wits webpage includes the full Teacher's Guide with the entire K-12 curriculum as well as links to download each grade unit separately. Additional information about the program design and contact information for the Education Coordinator are also included.

Summative evaluation

While the focus of this research was the production of a final complete curriculum based on formative evaluation, the author was able to collect a limited amount of summative data from study subjects who tested Water Wits Lessons with their students. To better understand the complex experiences and contexts involved with motivations and satisfaction, subjects were asked to participate in semi-structured interviews. These were guided by a series of open-ended questions inquiring about the subjects' overall experience with the Water Wits education program, initial expectations and goals in participating, reflection on how participating in this program may have impacted their own knowledge or attitudes and that of their students, and their perspectives on the program's successes and needs for improvement. This served as a minimal but useful Product Evaluation. Three teachers were interviewed, representing different grade levels, subjects, school districts, and Water Wits lessons tested. Interview discussions aimed to build upon formative data to provide a more solid framework for understanding outcomes based on both empirical and anecdotal evidence. Feedback from interviewees provided deeper insights about meaningful outcomes for educators and students, and helped clarify participant motivations and satisfaction. Since only three educators were interviewed, it is important to bear in mind that participant responses may not represent the entire study group's perceptions.

Data analysis

Quantitative data

Quantitative data resulting from surveys were analyzed with the appropriate statistical procedures using the Statistical Package for Sociological Studies (SPSS) software. Means were analyzed to investigate patterns and trends in the survey data and identify the most prominent motivation variables. Frequencies were further analyzed to compare results across various demographics, such as grades and subjects taught by respondents. Spearman's Rho Correlation tests were used to explore the relationships between the highest-ranked motivators and other various motivators of interest. These tests were used to identify the strength of association between variables and thus gain a more detailed view of which motivations may predict other motivations as being important in selecting a curriculum. This could be useful in working with educators on a case-by-case basis to help forecast what curriculum aspects may be important to them based on their expression of importance of a particular motivation. Correlation coefficients of statistically significant relationships, representing effect sizes, were used to visualize the strength of relationships between motivators. Reliability (Cronbach Alpha) tests were also performed to ensure that variables in each motivations category (Ease of Use, Professional Development Opportunities, and Curriculum Content) had been grouped properly. Due to the small sample size, non-parametric tests were used for all procedures.

Qualitative data

Qualitative data resulting from open-ended survey responses and interviews were transcribed and analyzed using NVivo 10 software to identify major concepts and themes. The semi-structured interviews followed the protocol outlined in Appendix A. An inductive approach was used to group the data, discern patterns, and infer theory for participants' experiences. Tools such as word frequency to identify commonly-used language and coding to reorganize data into themes helped to explore and clarify results. After Strauss & Corbin (1998), this analysis occurred in three phases. First, open coding was performed to identify general themes, followed by axial coding to dig deeper into causes and context. Finally, selective coding was employed to connect the categories and build theory. The final coding scheme may be seen in Appendix B. Based on the conceptual framework and on the survey items, theoretical categories included professional development gained, expansion of educators' own knowledge or abilities in particular content areas, and initial motivations. Substantive themes which emerged included perceptions of student experiences, challenges encountered, and ideas for curriculum adaptations. Conditions for how the curriculum was successful and unsuccessful, and for participants' level of overall satisfaction, were also guiding questions for analysis.

Concept mapping

To illustrate the most prominent motivators for educators in using a curriculum and the linkages between them, concept maps were developed. These were based on both quantitative and qualitative data obtained from the survey and interviews. Essentially, a concept map is a graphical representation of an individual or group's cognitive links to a central concept or theme (Novak 1990). Vilela et al (2004) notes the ability of such mapping to identify not only relationships between concepts, but also gaps in proposed curricula. Thus these visualizations hold the potential to produce central topics around the main Water Wits themes and create a useful process for not only establishing new curriculum content, but also in highlighting gaps in the existing content. For the purpose of this study, concept mapping was a formative evaluation tool which sought to document consensus amongst the pilot program study subjects concerning the most important aspects of an education program, and thus informed the continued development of the Water Wits curriculum.

Validity

To help ensure validity, members of the author's committee reviewed data and coding schemes. Member checking was also employed to ensure that the author's transcriptions and interpretations were correct. To minimize bias during interviews, the author emphasized that she was interested in both positive and negative feedback and in their full viewpoints as educators. The author attempted to be both reflective and reflexive during data collection, exercising self-awareness to mitigate any personal biases. This was achieved by taking extensive notes throughout, noting areas which need clarification or expansion during the interviews, and by being aware of how the author's own personal sensibilities could be affecting the way responses were interpreted. During data analysis, the author avoided imposing any sort of predetermined framework and instead used the progressive coding scheme described above to develop categories, themes, and eventually, theory directly from the data.

CHAPTER 3: RESULTS AND DISCUSSION

Survey Results and Discussion

The primary purpose of the survey was to identify the most and least important aspects of a curriculum for a Pacific Northwest educator, and to clarify how they make decisions about which education programs to integrate into their classrooms. For analysis, internal reliability tests were conducted to ensure the grouping of motivation concepts on the Survey into three major categories: Ease of Use, Professional Development Opportunities, and Curriculum Content. Reliability is the degree to which an assessment tool produces stable and consistent results across study respondents. All three groups were shown to have a satisfactory reliability rating exceeding α of .65 (Table 1). The "ease of use" group had an initial Cronbach's Alpha (α) of .77; however, the analysis showed that reliability increased to .81 if the item "clearly aligned to state/national education standards" was deleted, so that particular item was removed from this group. The "professional development opportunities" group had an α of .89, and the "curriculum content" group had an α of .91. Neither of these latter groups had items that would significantly improve α if removed and so were kept intact.

Table 1. Reliability analyses of motivation concepts

	Item total correlation	Alpha if item deleted	Cronbach Alpha
Ease of use			.77
Easy to adapt to varying student skill levels	.771	.679	
Requires only inexpensive and easy to find materials	.328	.775	
Can be related to students' personal lives and experiences	.645	.719	
Provides built-in resources to extend learning	.274	.778	
Instructions are easy to follow	.705	.696	
Appropriate for the skill levels of my students	.642	.706	
Clearly aligned to state/national education standards	.216	.809	
Professional development opportunities			.89
Helps me to meet state/national education standards	.383	.910	
Provides opportunities for collaboration with others	.578	.892	
Enhances my education practices/pedagogy	.764	.872	
Expands my teaching skills and abilities	.795	.869	
Increases my knowledge about aquatic/marine resources	.765	.873	
Increases my interest in aquatic/marine issues	.671	.881	
Increases my knowledge about STEM topics	.765	.873	
Increases my interest in STEM topics	.762	.875	

Table 1. Reliability analyses of motivation concepts (Continued)

Curriculum content			.91
Addresses major boating and water safety issues	.494	.922	
Instills an environmental stewardship ethic in my students	.768	.893	
Emphasizes STEM concepts	.734	.897	
Includes interdisciplinary (multiple-subject) topics	.573	.910	
Relevant to current local and/or global issues	.926	.878	
Prepares students to make responsible decisions	.776	.892	
Engaging for different learning styles	.671	.903	
Provides a broader understanding of resource management	.832	.888	

Of the 23 motivation items listed in the survey, there were several which were consistently ranked as highly important and likewise several which were not as highly valued by participants. Responses to each motivation were averaged on a five-point scale where 1 was "not important" and 5 was "critical". The following motivation items were ranked at or above 4.0, marking them as very important or critical to participants:

- Can be related to students' personal lives and experiences (4.29)
- Instills an environmental stewardship ethic in my students (4.10)
- Easy to adapt to varying student skill levels (4.03)
- Prepares students to make responsible decisions when using resources (4.03)
- Engaging for different learning styles (4.03)
- Relevant to current local and/or global issues (4.0)

No items earned an average below a 3.0, meaning that all survey items were generally deemed important by participants, though several items were consistently given a lower score by respondents. These included the following items:

- Clearly aligned to state/national education standards (3.52)
- Helps me to meet state/national education standards (3.34)
- Provides opportunities for collaboration with other educators (3.34)
- Addresses major boating and water safety issues (3.0)

Correlation tests were conducted to clarify significant relationships between motivation variables and thus create a concept map of priorities in developing curricula. Because testing all relationships between all 23 motivation variables would have been a monumental undertaking with hundreds of potential combinations, these analyses were focused on the six most highly-ranked motivations described above. For each of these, correlation was tested with all of the remaining motivation variables for significant positive or negative relationships at a significance threshold of *p*<.001 (Table 2). All statistically significant results were positive correlations.

Table 2. Results of binomial correlations tests for top six highly-rated motivation variables. Numbers shown are rho ρ. Significance for all numbers shown is p<.001.

	Predictor variables					
Outcome variables	Easy to adapt	Student lives	Env. ethic	Current issues	Prepares students	Learning styles
Easy to adapt						.717
Student lives					.646	
Instructions easy to follow		.618				
Appropriate for student skill levels	.785					
Enhances pedagogy	.615			.752		.627
Expands teaching skills	.636			.695		.629
Knowledge about aquatic/marine resources	.649	.689		.623	.649	
Knowledge about STEM	.691			.667		
Interest in STEM				.716		
Environmental ethic				.647		
Emphasizes STEM				.700		
Collaboration			.629			
Interdisciplinary				.705		.704
Prepares students		.646		.719		
Different learning styles	.717					
Broad understanding	.721	.691		.783	.716	
Current issues			.647		.719	

Overwhelmingly, the motivation variable with the most significant relationships was "relevant to current local and/or global issues". This variable had a positive correlation with ten other motivation variables, only two of which were among the top six overall most important motivations ("instills an environmental ethic in my students" and "prepares students to make responsible decisions when using aquatic and marine resources"). Although none of the STEM-related variables appeared as important motivators overall, all three were positively correlated with this variable ("increases my interest in STEM", "increases my knowledge about STEM", and "emphasizes STEM concepts"). This variable was also strongly correlated with professional development-related concepts ("enhances my education practices and pedagogy" and "expands my teaching skills and abilities"). "Provides a broader understanding of resource management issues" had the strongest correlation with this variable.

The motivation with the second highest number of correlations to other variables was "easy to adapt to varying student skill levels". This had relationships with seven other motivations, including professional development items, "increases my knowledge about marine and aquatic resources", and "provides a broader understanding of resource management issues". Surprisingly, the top-ranked overall motivation, "can be related to students' personal lives and experiences," was significantly related to only four others: "instructions are easy to follow", "increases my knowledge about aquatic/marine issues", "prepares students to make responsible decisions when using aquatic and marine resources", and "provides a broader understanding of resource management issues".

Interestingly, while "instills an environmental stewardship ethic in my students" was the second most important motivation overall, it was not highly related to many other motivations: the only correlations were to "relevant to current local/global issues" and, less strongly, "provides opportunities for collaboration with other educators". Although the value of environmental ethics for their students is clearly deemed important by educators, it does not seem related to or predictive of other curriculum aspects which may be considered important.

These results imply that relevance to current issues, amongst all the other motivators, was a unifying factor amongst this particular group of Pacific Northwest formal and informal educators in selecting a curriculum. This was somewhat surprising, as this motivation was ranked last amongst the top six most important factors (see Table 2). It seems these educators were interested in their students gaining real-world knowledge that they could directly apply to their future experiences, both in exploring aquatic and marine areas and in their exposure to current issues. This emphasis on timely, real-world content reflects a changing education climate as exemplified by the Next Generation Science Standards. No longer is it enough to teach students facts and figures: now, teachers must also relate information to what is happening in their community and in the world. Students are now asked to obtain and analyze information from local and global sources, as well as engage in argument from evidence found in many types of media, and teachers must be able to facilitate this process. Thus, although alignment to education standards was not overtly expressed as a highly important motivator, perhaps the need for this is embedded within this corollary variable; a curriculum which can provide built-in references to current local and global issues could be desirable to help ease the transition to NGSS.

The importance of relevance to current issues may also reflect another movement in education, which while not a mandated part of education standards has become a popular approach amongst education professionals. This is the idea that certain real-world practical skills, dubbed "21st Century Skills", need to be included as a part of classroom practices throughout a student's education career. Content knowledge and academic abilities should be enhanced by regular practice in skills such as critical thinking, communication, collaboration, and creativity. Mastery of these skills is thought to help students succeed at work, life, and citizenship (Trilling & Fadel, 2009). A framework for defining these skills was designed in 2007 by the Partnership for 21st Century Learning (P21). One of their recommendations was to use 21st century skills to address global issues and understand the local and global implications of civic decisions (P21, 2007). These concepts echo the desire for curriculum that is relevant to current issues which was expressed by survey respondents.

These results were applied to the Water Wits program through the deliberate inclusion of current issues, both local and global. Each grade unit contains at least one lesson which references a timely issue which students may encounter in the news or other media. While generally the focus of the Water Wits program is on issues relevant to a Pacific Northwest audience, many of these issues could also be applied to a broader nation-wide or global scale. Many of the extension activity ideas provided also encourage teachers to take advantage of resources in their local community, such as stewardship projects, field trips, or making connections with local scientists or conservation professionals. It is hoped that this "think global, start local" approach will better engage teacher and student interest, foster 21st century skills, and contribute toward improved student achievement in school and in life.

The ease of adaptability of curriculum to different types and levels of students was also clearly another important consideration for educators. This was unsurprising, as teachers are expected to communicate an immense amount of information to all of their students, regardless of the diversity of backgrounds and abilities in any given class. Each lesson must be customized and delivered in such a way that it can guide all learners towards a particular standard, understanding, or goal. A curriculum that makes it easy to scale the material up or down to fit each teacher's particular assemblage of students would thus be more attractive and convenient. This was anticipated during the development of the Water Wits program, which includes numerous suggestions for ways educators could adapt the material for different skills and abilities.

These results were synthesized into the concept map which follows (Figure 8). Some concepts were grouped for simplification: "enhances my education practices and pedagogy" and "expands my teaching skills and abilities" were combined into "teacher pedagogy and abilities", while "increases my knowledge/interest in STEM" and "emphasizes STEM topics" were simply combined into "STEM". Items which had only one corollary relationship were deemed to be only weak indicators of educator motivations and therefore are not shown. This concept map seeks to visualize the above findings and to serve as a tool for predicting additional educator wants and needs concerning a curriculum based upon their own expressed motivations. For example, based upon an expressed desire for an education program which builds the teacher's pedagogy and abilities, one could surmise that this person would also have a strong interest in relevance to current local and/or global issues and a weaker interest in both ease of adaptability to varying student skill levels and engagement for different learning styles. This map clearly demonstrates that relevance to current issues was a dominant theme for respondents and strongly predictive of many other motivations for selecting a curriculum. The desire for a curriculum which provides a broad understanding of resource management issues, while not one of the six most important overall motivators, was also strongly predictive of other factors which educators may be interested in.

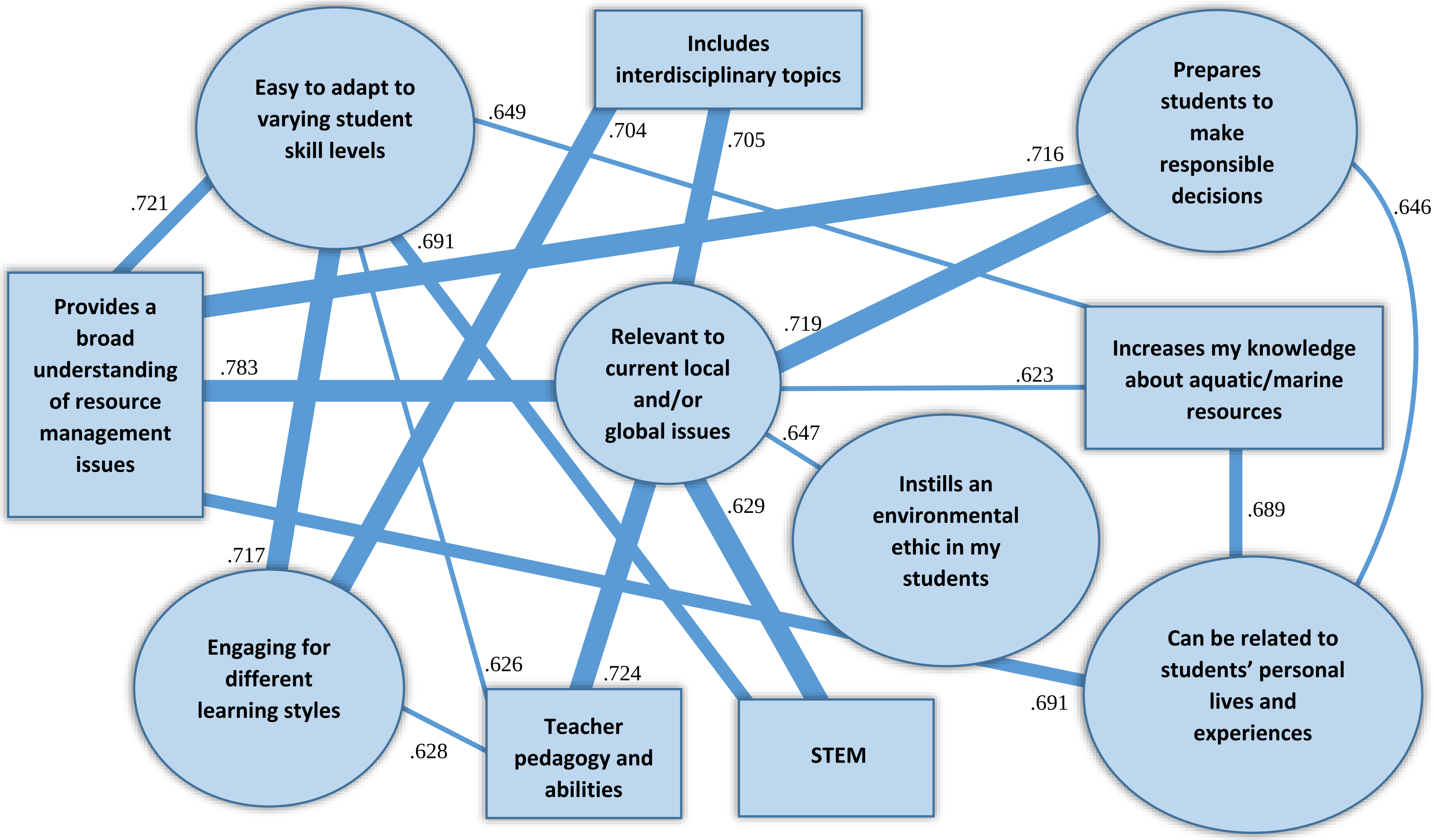


Figure 8. Concept map of statistically significant correlations between motivation variables. All shown correlations are positive. The strongest relationships are denoted by the thickest lines, while weaker relationships are shown by more narrow lines. Members of the six most important overall motivations are shown in ovals; the relative size of each oval indicates how highly that motivation was rated by the overall study sample. Motivations which were not a part of the six most important overall motivators, but had significant relationships to those motivations, are shown in rectangles. Numbers shown are rho ρ. Where items were combined, the numbers shown are averages.

To explore possible effects on motivations from different grade levels and subjects, further analysis of means was conducted (Figure 9). For K-2 teachers, the most important items were “easy to adapt to varying student skill levels” (4.29), “appropriate for the skill level of my students” (4.17), “can be related to students’ personal lives and experiences” (4.0), and “engaging for different learning styles” (4.17). For teachers of Grades 3-5, all of the above items were also the most highly rated at a mean of 4.0, with an additional item also averaging at 4.0: “requires only inexpensive materials”. For 6th-8th grade teachers, no motivations scored higher than a 4.0, but two items scored at 4.0: “instills an environmental stewardship ethic in my students” and “increases my interest in STEM”. For High School educators all items were generally lower. The highest scores were 3.8 for “provides built-in resources to extend learning” and 3.67 for both “increases my knowledge” and “increases my interest” in STEM topics.

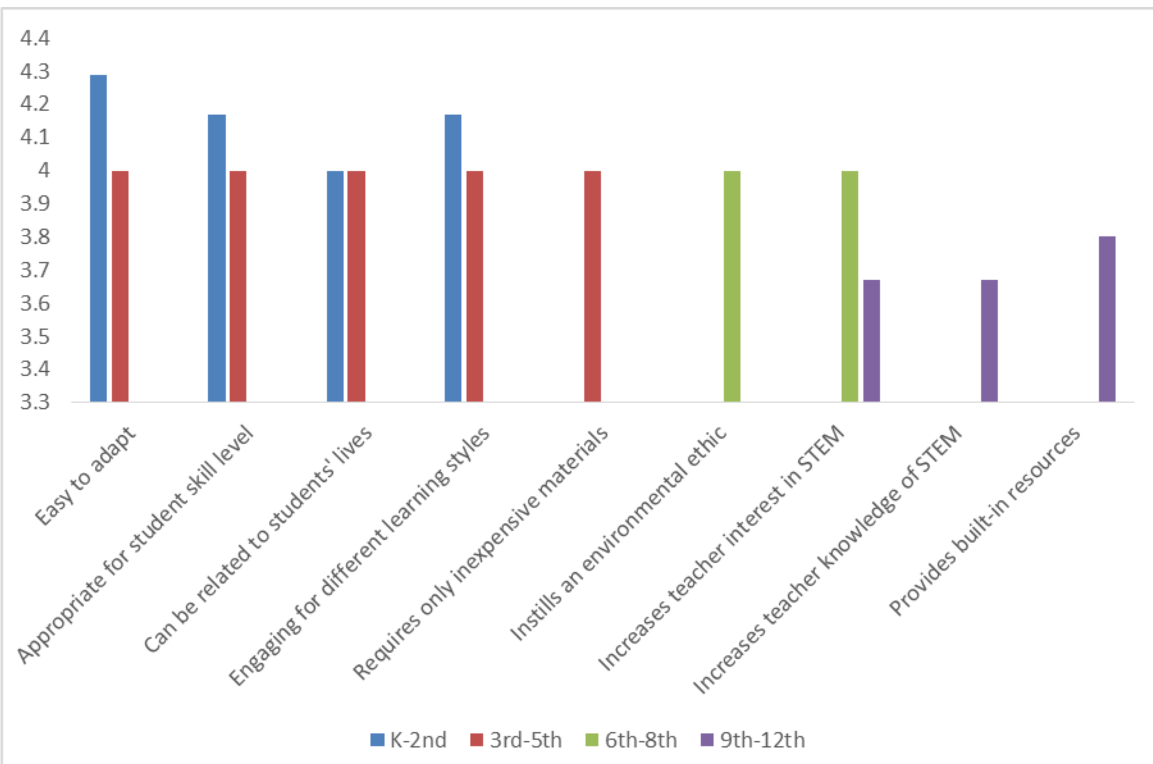


Figure 9. Graph showing motivations by grade level taught.

These results indicate that in general, elementary educators are more highly motivated by the provided motivation items in choosing a curriculum. Middle and high school teachers were more neutral in their rating of importance of curricular aspects. The types of aspects each of these groups valued varied as well. Elementary educators found items relating to their students, especially those relating to flexibility and adaptability, the most important. In contrast, middle and high school educators were specifically interested in building their experience with STEM topics, as well as their students' environmental content knowledge. High school teachers were most interested in built-in resources to extend student learning. These results may reflect the manageability of various age levels: teachers of very young students, who tend to be more difficult to organize and to focus, are more concerned with finding lesson plans which are easy to use and easy to adapt to different types and levels of learners. Results also likely reflect the fact that elementary educators are teaching multiple subjects, while middle and high school teachers are generally specialized to one subject. That, as well as the push for STEM in many middle and high schools, is likely why motivations for these educators relate more to specific content areas.

There was also variance amongst participants who taught different subjects (Figure 10). Participants included fourteen science teachers, nine math teachers, nine social studies teachers, seven language arts teachers, and eight teachers who selected "other" subjects such as art, Spanish, and science specialty areas including chemistry, AP environmental science, and marine biology. The majority of respondents who provided "subjects taught" data (n=16) taught multiple subjects (n=11). The low response rate for this was likely due to the number of informal educators who do not teach traditional school subjects. For science teachers the most important items were "can be related to students' personal lives", "appropriate for skill levels of my students", and "engaging for different learning styles" (all of which rated a 4.0). For math teachers most important items were "easy to adapt to varying skill levels" (4.0), "can be related to students' personal lives and experiences" (4.11), "appropriate for the skill levels of my students" (4.11), "includes interdisciplinary topics" (4.25), and "engaging for different learning styles" (4.13). For social studies teachers, the most important items were "easy to adapt" (4.11), "appropriate for skill levels of my students" (4.13), "includes interdisciplinary topics" (4.0), and "engaging for different learning styles" (4.25). For language arts teachers, many items scored at or above a 4.0. The most important items were "easy to adapt" (4.43), "appropriate for the skill levels of my students" (4.29), "engaging for different learning styles" (4.33), and "includes interdisciplinary topics" (4.17). For educators who taught "other" specialty subjects, most important items were "provides built-in resources to extend learning" (4.0), "instructions are easy to follow" (4.0), and "instills an environmental stewardship ethic in students" (4.0).

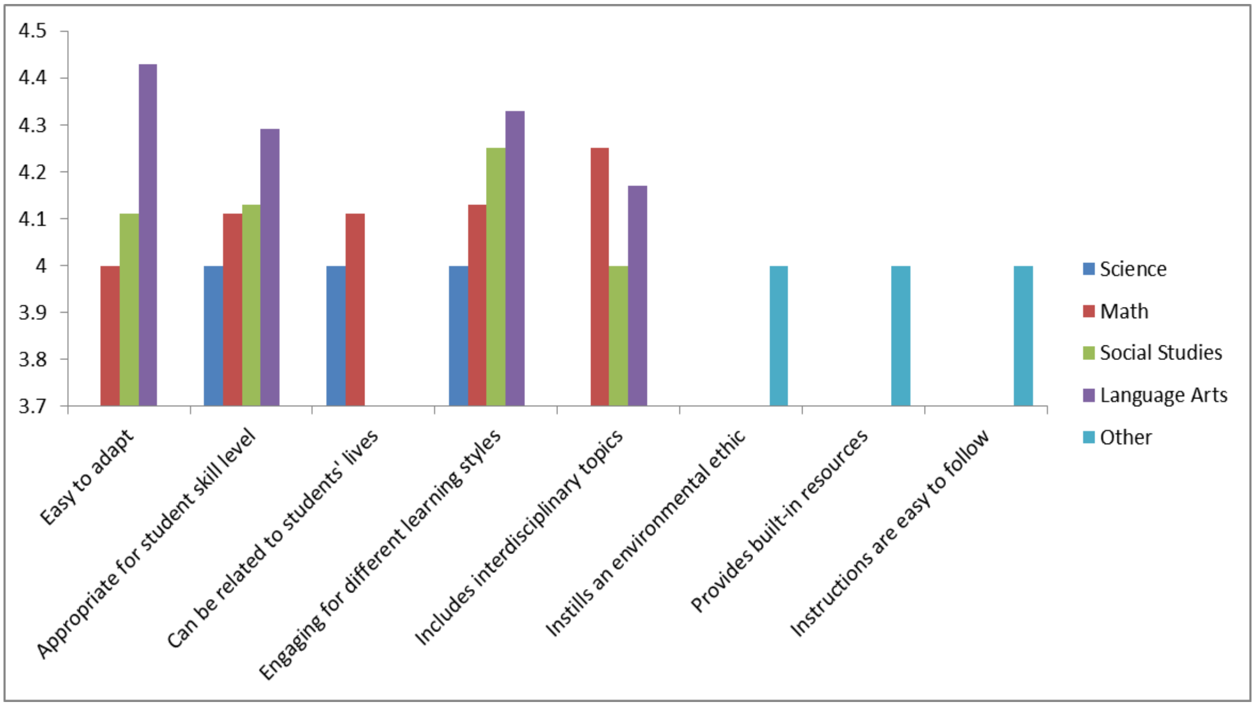


Figure 10. Graph showing motivations by subjects taught.

Here, Language Arts teachers are generally the most motivated, while Math and Social Studies teachers are slightly less so; science teachers and specialty teachers are the least motivated. Generally speaking, teachers in all subjects valued the same selection of features; these included those related to student skill levels and learning styles, and the inclusion of interdisciplinary topics. The exception was the "other" specialty subject teacher group, which most highly valued entirely different aspects: the instilling of environmental ethics in students, built-in extension resources, and easy-to-follow instructions. These results are more difficult to interpret, but may be related to the grade level results previously discussed: specialty teachers are likely to be in older grades and therefore less concerned with ease of use and adaptability. Results were also somewhat surprising, as we assumed this curriculum would particularly attract science teachers, yet these respondents were somewhat lukewarm. That, as well as the clear importance of interdisciplinary content, pointed to the need to target educators beyond science classrooms. While the Water Wits program was designed to focus heavily on science with other subject matter woven in, it was also designed to contain the features deemed important by teachers in non-science disciplines, and therefore could be useful and appealing to them as well.

Open-ended qualitative responses generally reflected the above results, while also helping to provide additional detail about the trends already described. In the Ease of Use category, subjects expressed a need for clear organization of materials, for flexibility and adaptability, and for an interdisciplinary nature: they wished to be able to integrate it with other subjects, especially math and English. One respondent notably stated, “I also must consider how the new materials can be supported by Spanish language resources that will enable me to teach Bilingually”. There were not a lot of open-ended responses to the Professional Development section, but a few respondents stated the desire for up-to-date resources and for weekend training workshops, since “taking time away from my classroom is almost impossible.” In the Content section, the word “engage” appeared frequently: respondents wanted a curriculum that kept students engaged, and was engaging for different learning styles. The need for an easy-to-use format, and for support for English Language Learners, was reiterated here as well. There was one final open-ended prompt at the end of the survey, which asked respondents to share any final comments. Respondents here expressed excitement to implement these lessons, and anticipated their students would have fun and learn something. References were also made to the fact that the water safety component of the curriculum was beyond their usual practices: one respondent stated that it was “very new to me, but something students should be aware of and learn.”

Formative feedback from other correspondence

Early in the curriculum development process, drafts of lesson plans were sent to a number of education specialists for review. One, a boating safety education coordinator at the equivalent agency to Oregon State Marine Board in Arizona, provided extensive feedback from the early stages of curriculum writing. As a career classroom teacher, he provided a number of suggestions which were beneficial: more math integration, the inclusion of leveled reading passages, and the need to list expected teaching and preparation time at the beginning of each lesson plan were among his suggestions which were implemented.

Staff members of the Sea Grant WISE program also provided helpful insights based on their experiences creating a successful program – WISE has about 100 teachers who have participated in the program, with about a 90% retention rate (Sam Chan, personal communication, 1 Jan. 2015). WISE holds multi-day trainings during the summer, with travel expenses covered by a stipend, which help to build teachers’ background knowledge and guide them in planning how they will use the WISE curriculum. This model was later used for the Water Wits training workshop, which included both content knowledge and a walk-through of program activities, though instead of a stipend free activity kits were provided as incentive. Further conversations identified overlapping themes and concepts for WISE and Water Wits, and to make links between specific lesson plans from both programs.

A representative from Straub Environmental Center who specializes in STEM education in Marion County was also consulted. He appreciated the interdisciplinary nature of the Water Wits curriculum, and shared that the educators he worked with were primarily interested in programs which are engaging and connected to sustainability and stewardship concepts, so the program seemed to be a good fit for his audience. He reinforced the need for incentives to attract teachers to attend workshops, such as travels stipends or mini-grants for implementing activities. He also suggested several avenues for recruiting participants, such as the Oregon Science Teachers Association and the Oregon Sustainable Schools Awards. These contacts were later pursued to gain more participants.

Responses of interest from potential pilot program participants were useful in identifying needs for the Water Wits program as well as in understanding our target audience. Several were teachers who used the WISE Program curriculum and felt it would be a nice addition to those units. Another shared that her school was in a water-focused year across the curriculum, "from political science to climate change, social studies, and early peoples". She felt the interdisciplinary nature of Water Wits would be a good fit. A few stated that they wanted to use the curriculum as a jumping-off point for field trips and other outdoor field studies with students. Some respondents identified areas where they could "plug in" Water Wits lessons to their existing curricula; for example, one teacher who always began her AP Environmental Science course with "The Tragedy of the Commons" said she would use the "Hazard or Habitat?" town-hall style activity to discuss those concepts in more depth. Two respondents planned to use the curriculum with boating and water safety related activities; one was a guide for a whitewater rafting company which also offers summer camps, while the other runs after-school canoeing programs. Several were concerned with timing issues: scheduled district trainings, planned timing for various themed units, limited available classroom time, etc., and wished to know whether the Water Wits program would be designed to be implemented at a certain time or in a certain order. (To maintain flexibility and ease of access for as many educators as possible, it was not. Any Water Wits lesson may be used on its own at any time, or may be combined with other lessons at the educator's discretion.) One education specialist at an informal education site stated, "We are always looking for new programming to support teachers' classroom work. Your program looks like a great way to do this."

Workshop Focus Group

The training workshop held at Straub Environmental Center in November 2015 provided valuable insights for improvements to the Water Wits program as well as the opportunity to share ideas about how teachers might adapt the curriculum to their own students. The 15 workshop attendees represented several different Oregon school districts including Salem-Keizer, Newberg, Seaside, Redmond, Lincoln, and Albany. There was also one Marine Patrol Officer in attendance who conducts educational classroom visits for the OSMB, which provided useful insights about the water safety components of the curriculum. All grades were represented, though the vast majority taught K-2nd Grade or Grades 3-5; there was only one middle school teacher and one high school teacher. We went through each activity in each grade band one at a time, using the actual materials that teachers would use in their classrooms and which were provided in the activity kits which were a free gift in exchange for attending the workshop. This allowed the educators to act as learners and thus understand how the activities would be experienced by their students.

This process revealed a number of necessary changes to the curriculum, though these were mainly in the technical details. For example, we discovered that the "Hero's Engine" in the middle school unit should be constructed differently than previously described, and that the "Seesaw Ship" activity in the Grades 3-5 unit worked better when conducted a bit differently from what was described in the lesson plan. For the most part, the content and themes of the program were supported by participants as developmentally appropriate, easy to integrate into their existing curricula and classroom practices, and adaptable across grade levels and abilities. The one gap in the program, which was also mentioned in survey responses, was that the student materials were available only in English, which would make it difficult to use with ELL (English Language Learners) students. Overall, workshop feedback showed that the Water Wits program had successfully met its original design goals.

Summative feedback

While the focus of this research was to conduct a formative evaluation of the Water Wits program, a limited amount of data provided summative feedback after the lessons had been tested with students. A number of participants contacted the author either while they were in the midst of piloting the activities with their students, or immediately after. This provided informal but useful feedback about the curriculum and about teachers' experiences using it with their students. One of these responses follows:

> *"I started with the first lesson in the K-2 curriculum ('The Story of Water'). The students were really responsive and very invested in their lake. The dice kept giving us drought and thirsty plants, so they were getting really worried, but then they rolled a flood, rainstorm, snow melt and so on. The lake ended up fuller than when we started and they ended the story with the people, animals and plants enjoying the lake even more. I also used the Robert Frost poem, 'Nothing Gold Can Stay', to lead into the lesson and connect them with the fact that things in nature and life are always changing. I was amazed at how intuitive the whole process was for the students. We are following up this next week with some water facts and looking at some books about water safety. Can't wait to do the next lesson."*

This comment was particularly gratifying, because it encapsulated several of our original hopes and goals in developing the Water Wits program. This teacher's students were invested and engaged in the experience, and found it easy to understand the activity and its concepts. The teacher herself was able to enrich the activity with a poem of her own choosing, helping to deepen the already interdisciplinary content, and was also inspired to extend the activity with an additional lesson focused on water safety – a subject she had initially expressed little interest in. Moreover, she seemed to enjoy the activity as much as her students and looked forward to the next one. For this teacher, the goals of engaging both educators and students with hands-on, interactive activities, and empowering teachers to help save lives and conserve aquatic resources, were well satisfied.

Another participant was so excited by the curriculum that she recruited two other teachers at her school to also test the lessons with students, as part of a greater water-related unit they were conducting together. She then went on to organize an aquatic/marine "job fair" for students in which they would go between different experts and learn more about boating, water safety, and general aquatic and marine science topics. Unfortunately, she had to cancel this event due to a lack of volunteers, but this showed that the Water Wits program has the potential to inspire enthusiasm in teachers and students which can lead to a wealth of related activities and opportunities.

Semi-structured interviews with teachers who had tested activities with students helped identify several emergent themes concerning impressions of the Water Wits program and their students' experiences. Broader theoretical categories included professional development gained, expansion of educators' own knowledge or abilities in particular content areas, and initial motivations, while substantive themes included perceptions of student experiences, challenges encountered, and ideas for curriculum adaptations. Interviewees represented various activities tested, school districts, and grades and subjects taught (Table 3).

Table 3. Descriptions of interview subjects.

Subject	School District	Grade(s) taught	Activities tested
A	Seaside	4th	What Floats?, Seesaw Ship; Chilly Fingers; Plenty of Fish?
B	Lincoln County	1st	Swimming Song; Captain Says; Boating Safety 101
C	Alsea	11th	Hazard or Habitat?

Several specific concepts recurred as common themes across interview subjects:

- *Flexibility.* None of the subjects used any of the activities exactly as written. Subject A used selected pieces of several lessons and combined them into one unit, and also related the "Plenty of Fish" activity to the topic of invasive species, though in the Water Wits curriculum this topic isn't introduced until High School. This subject stated, "The ability to adapt and combine activities into one period was great because that's all the time I had." Subject B used the complete lessons but adapted them to her students by having students read the song before singing it. This was ideal because she wished to work on reading skills with her students, and it was also helpful in meeting Common Core literacy standards. She added, "It was nice to say, 'read this', and then do something with it." Subject C at first found the activity difficult to implement with his small class size, but was able to make adjustments to better accommodate his classroom while still accomplishing his goal of having students "create and defend a well-reasoned and researched argument and debate it with other students." All of the interviewees expressed their appreciation for the flexibility of the lessons, which allowed them to adjust the activities to their students and their particular time and classroom resources.

- *Timing.* Two of the subjects (A and B) used the lessons at the very end of the school year. For both, this was a deliberate decision related to the content of the lessons they used, which were primarily focused on water safety: they wanted their students to get this knowledge before summer, when they are most likely to be engaged in aquatic activities such as swimming and boating. Subject B stated, "It's important to communicate this stuff before summer on the coast." And Subject A similarly said, "I think the safety aspect was a great thing to do right before summer – since we live by the coast." It was also clear that these subjects felt the lessons were ideal to easily add into their curriculum at the end of the school year. Subject A said, "It was nice having everything right there to grab and use at the end of the year when everything is crazy." And Subject B stated, "It was good at the end-of-year to plug in easily." She added that the hand-outs in particular were convenient to have already made and ready to print. Subject C devoted an entire week to the lesson early in the Spring, giving his students plenty of time to do background research before debating, but said that if he didn't have that much time next year he felt he could easily scale it down to two or three days. He was able to use this much time because he folded it into the policy unit he usually teaches at that point in the school year.
- *Student engagement.* All interviewees made multiple mentions of the interactive and engaging aspects of the Water Wits program. Subject A shared that she specifically looks for lessons which promote "active engagement and high interest, and get kids' attention – it seemed like Water Wits would accomplish that." She added, "With the hands-on aspects… they could really feel and see what they were learning." Subject B liked that the lessons illustrated not only the basics of water safety, but *why* it was important: "It was helpful because it gives them a purpose – an understanding of why we're talking about this." She believed this was crucial not only in giving her students awareness of the issues, but also in engaging them in the lesson. Subject C shared that his students really

enjoyed taking on the roles of other people and "getting the chance to be dramatic", which made the learning experience exciting as well as educational – something that is very important, he said, when working with teenagers.

- *Relatability.* Interview subjects enjoyed relating the Water Wits content to other concepts and to students' own lives, and felt it was easy to do so. For example, Subject B broached the topic of life jackets with a discussion of when and where students had worn them before, to relate it to their past experiences. She also planned to relate the lessons to the resources in their own community, namely the Siletz River, in the future. Subject A similarly expressed approval of the interdisciplinary learning aspect, and said that while she liked that Water Wits hit specific topics, she also liked that it was easy to extend the learning beyond those topics. Subject C was surprised by which aspects of the activity turned out to be relatable to his students. He expected that his students would tend to take the side of recreational boaters and fishermen, since "those are more directly relevant to their personal experience"; however he found that his students, after going through the entire activity, were able to understand that "preserving the ecology and environment directly impacts their future use of waterways." In this way he was able to help his students see new ideas as relatable to their own lives.

In many ways interview responses reflected survey responses, and helped to support the rationale of Water Wits development as well as the final product. Once again, the need for materials which can be related to students' personal lives and experiences was clear; relatability to other topics through interdisciplinary content was also important. As a whole, pilot program participants felt that the Water Wits program fulfilled this need. Student engagement was also a paramount concern, and was successfully achieved by interview respondents, who showed appreciation for the interactive and inquiry-driven approach of the program. Summative data showed that the Water Wits program was deemed easy to use and easy to adapt, a major goal when developing the curriculum. Finally, though respondents shared a few minor suggestions for tweaks and changes to the lesson plans, none of these were radical. In short, the approach, content, and design of the Water Wits curriculum were all upheld as satisfactory to educator needs and enjoyable for their students.

CHAPTER 4: CONCLUSIONS AND RECOMMENDATIONS

Overall the pilot test of the Water Wits curriculum was successful both in the outcomes it obtained, as well as the reception it received. Both formative and summative feedback supported the general rationale and final content of the program. However, a number of possibilities for future curriculum improvement efforts were revealed. A discussion of final thoughts as well as recommendations for future efforts follows, arranged by research question.

What motivates Pacific Northwest formal and informal educators to select a curriculum?

The motivations for selecting curricula and other educational materials for use in the classroom expressed by the pilot program sample generally reflected the literature on teacher wants and needs (Oregon Coast STEM Hub, 2014; Kisiel, 2005; Schieb & Karabenick, 2011), as well as the market research specific to the study region (NERRS 2012). Educators most valued activities which were relatable to students, infused with content from multiple subject areas, easy to implement, and easy to adapt to their needs. They wanted to be able to connect the lessons with real-world issues, both in their local community and around the globe. Alignment to state and national standards were not deemed unimportant, but they were also not mentioned as highly critical. Perhaps this is because educators are accustomed to tying diverse materials to the standards themselves, or because this was not something which is heavily stressed at their schools or informal education sites.

Another explanation could be that adherence to education standards is a very extrinsic motivation: it is something which is required of educators by external forces, not something which most teachers seem to personally value. Since the formative instruments asked educators which curricular aspects were most important *to them*, and since these are likely to be intrinsic motivations, perhaps this is why alignment to education standards was never very highly rated. It is possible that the rating could have been different if given by those with higher stakes in the assessment of standards, such as school administrators and superintendents. Future education efforts by OSMB and others may benefit from including these district- and state-level educators in the process as well: since these are the people that teachers must ultimately answer to, their opinions and motivations are also important. A curriculum which is also designed to administrator wants and needs may also be easier for teachers to implement, because it is more likely to be approved by their supervisors.

How well did the Water Wits pilot program fulfill these motivations and its goals?

Based on formative feedback, the Water Wits program was carefully designed to meet teacher and student needs as well as possible. Summative feedback, while limited, indicated that this was achieved. Pilot program participants stated that the aspects which they found most appealing about the program were clear once activities were tested with students: the lessons were found to be relatable to students and to other concepts, easy to follow and to implement in various types of classrooms, well-suited for adaptation to different student and teacher needs, and excellent at promoting student interest and engagement. Nobody expressed any major surprise or disappointment in using the curriculum, and felt that it met their initial hopes for participating. This is likely due in part to the fact that these educators were involved in the development of the curriculum from an early stage. They were invested in the process and thus felt like they had an impact on the final product. Given the success of this initial pilot program, it is recommended that any future major changes or updates to the Water Wits program also take care to include educators in the process from the beginning.

The initial goals of the Water Wits program were to engage educators and students with hands-on, interactive activities; reach learners of diverse interests and backgrounds; be useful for both formal and informal educators; and empower teachers, through their instruction, to help save lives and conserve precious water resources. The level of student engagement achieved by the curriculum, discussed in more detail above, was a commonly mentioned outcome and thus deemed to be satisfactorily met. While the exact interests and backgrounds of students who participated in activities were not quantified by this study, teachers' feedback indicated that the content was suitable for the majority of their diverse pools of students. Future research focusing on student outcomes, including affective and cognitive outcomes, would be ideal to better clarify the impact and effectiveness of the Water Wits curriculum. One gap which became clear but which could not be addressed during the scope of this study was the lack of support for English Language Learner teachers and students. This is important, because approximately 11% of Oregon K-12 students are English language learners – this is above the national average of 9.8% (Migration Policy Institute, 2015). In some school districts this number is even higher. It would help to reach many more students, especially at-risk and vulnerable student populations, if the Water Wits program could eventually be translated into Spanish and provide additional materials specific to ELL teachers and students.

While the target audience for this program was formal classroom teachers, it was hoped that informal education sites would also find some of the activities useful and applicable at their sites. While we were not able to collect summative data from any of these sites, a number of informal educators provided formative feedback, including staff from Bonneville Dam, South Slough Interpretive Center, and Cascadia Expeditions (a raft trip outfitter). These respondents indicated that with some adaptation, they could find activities from the curriculum which were relevant to what they hoped to teach at their respective sites. It would be helpful in the future to learn more about these participants' experiences utilizing Water Wits lessons, and to consider adding to the curriculum a sample of simple activities which could more easily be used by potential users of interest such as summer camps, boating clubs, or Marine Patrol Officers interested in volunteering to facilitate educational classroom visits.

Though it was not possible in this study to investigate how the curriculum may have impacted student behavior and decision-making when in or around waterways, it is clear that educators themselves gained valuable experiences which would help them communicate important issues to students. Educators who participated in this pilot program gained new knowledge, especially in the areas of boating and water safety. Perhaps more importantly, many gained an appreciation of the critical need to teach these concepts, even in classrooms beyond Health class. While this idea was a new and sometimes off-putting one for many pilot program participants, in the end they could see that it was possible to both meet education standards and address subject-area content while also touching on vital safety concepts.

How can pilot program outcomes inform future improvements to the Water Wits program?

In addition to the above-mentioned recommendations, this experience revealed areas for improvement both in the curriculum content itself and the recruitment of more participants. A potential effort would be to offer more professional development opportunities for educators – not only to promote the program and get teachers trained on implementing it, but also to build general content knowledge. For example, a training illustrating the basics of water safety could be made appealing to educators by also including concrete ways to integrate those concepts into classrooms (through Water Wits lessons or other resources). PD offerings would need to be incentivized, through grants or stipends, but should also make a concerted effort to inspire intrinsic motivation for attending. Educators need to be made to feel that the subject matter is important, not just as a tool for helping them to meet standards or hit certain topics, but because there is a reason to care about their students' understanding of aquatic safety, science, and stewardship principles. Retention rates could also be improved by the organization of regular meetings of Water Wits teachers, at which they could share their successes and challenges faced, give examples of student achievement, and support and encourage each other in implementing the curriculum.

One of the most exciting and unexpected outcomes of the Water Wits program is the enthusiasm with which it was received by other states' boating agencies. Specifically, the Arizona Department of Fish and Game, which is also the regulatory agency for boating and water use, has been an eager recipient of the curriculum. After reviewing the final product, the Boating Education section of the department requested use of the Water Wits curriculum in their own outreach efforts. While some of the content will need to be adapted to Arizona's particular environment, issues, and education climate, this is a promising indication that Water Wits has the potential to serve as a model for other states. At the very least, it shows that other agencies are beginning to see the need to move past their traditional self-determined roles and incorporate interdisciplinary material in order to reach a wider audience.

Future research

An additional tool which will provide valuable summative feedback is the website survey (see Appendix A). This survey replicates the initial motivations survey, by listing the same motivation items and asking respondents to rate how well they believe the Water Wits program fulfilled each motivation item. It was designed to be placed on the Water Wits page of the OSMB website, to provide long-term quantitative data in support of the qualitative data collected during the pilot. This will help the OSMB to keep track of user demographics and to identify gaps in participation, as well as gain better insights about educator perceptions of the curriculum. It is recommended that at a predetermined time in the future, perhaps five years from now, the OSMB conducts a thorough analysis of these survey results. The conclusions reached by this analysis can then be applied to an update or, if necessary, an overhaul of the Water Wits program. To fully determine whether the Water Wits programs has met its goals and the mission of OSMB, it will also be necessary in the future to assess student outcomes. This may include knowledge gained, attitude changes, and indicators of potential behavior changes. Assessment tools should include a mix of both quantitative and qualitative items, such as student quizzes, sample worksheets from the curriculum, interviews, or before-and-after artwork or writings.

Final conclusions

By venturing beyond their traditional realm of boating and water safety, the Oregon State Marine Board reached a wider and more diverse group of teachers than ever before. Educators who had never considered incorporating water safety into lessons about environmental science or stewardship are now planning to continue using Water Wits lessons in the years to come. New relationships were established with agencies and organizations who had never worked together before, creating a community of partners dedicated to integrated aquatic and marine education. The pilot program led to a finished product which can now be broadcast widely across Oregon and beyond with evidence-backed assurance of its success and positive reception by diverse audiences.

It is the author's hope that the Water Wits program will serve as a model for other agencies and organizations who seek to integrate boating and water safety into environmental education efforts. It is also hoped that this work will continue to help people to see boating and water safety as a benefit, rather than an unnecessary addition, to general aquatic and marine education. By addressing these issues together, educators can better meet one of their most highly-valued motivations for choosing a curriculum: relatability to students' personal lives and experiences. What better way is there to relate to students than by evoking memories of pleasant days spent boating, fishing, or at the shore with their friends and family? These cherished memories have the power to not only pique students' interest, but to also truly reach the affective domain and perhaps even change their behavior. Applying these experiences to current local and global issues also makes the lessons more relevant to the world beyond and helps to meet important education standards. Through engaging, integrated education programs such as Water Wits, agencies such as OSMB and beyond can help to build the next generation of responsible, caring, and well-informed aquatic and marine resource users.

Figure 11. Educators working together to test activities at the Water Wits training workshop.

CHAPTER 5: THE COMPLETE “WATER WITS” CURRICULUM

The following pages contain the complete Teacher’s Guide for the Water Wits program, Grades K-12. This includes the introductory pages, all lesson plans for each grade unit, additional materials such as printable hand-outs and student worksheets, and the Glossary. All materials are as they appear in the final published version of the curriculum and on the OSMB website. Study participants were provided this Teacher’s Guide in a professionally-bound booklet as part of the pilot program.

Water Wits

aquatic safety, science, and stewardship
education program

TEACHER'S MANUAL

OREGON STATE MARINE BOARD

Dear Educators,

June 30th, 2015

With thousands of people enjoying activities on Oregon's waterways each year and rising demand for clean water resources, there is a need to educate people early about responsible waterway use. Humans and wildlife both need resilient waterways for health, safety, and survival. That's why we have developed this new K-12 educational curriculum, *Water Wits*!

This program aims to encourage awareness and responsible use of aquatic and marine resources. It goes beyond traditional boating and water safety education to include stewardship messages and scientific principles. It is designed to be interdisciplinary, academically rigorous, interactive, and student-led. We hope that by taking an integrated approach to thinking about water, this curriculum will spark a renewed interest in responsible waterway enjoyment for both educators and students.

Water Wits addresses 3 pillars of aquatic literacy:

Safety: what are the best practices for smart decision-making in, on, and around the water?

Stewardship: how can we reduce our impacts and manage water resources for people and wildlife?

Science: how do physics, engineering, ecology, and the social sciences explain and inform both of these?

The curriculum includes 12 complete lesson plans, divided into grade units (Kindergarten-2nd Grade, 3rd-5th Grade, 6th-8th Grade, and 9th-12th Grade). All lessons are aligned to state and national education standards, including Next Generation Science and Common Core, across multiple subjects. Each unit contains 3-4 leveled lesson plans with suggestions for how to adapt the activity to best suit your audience. Lesson plans include a list of aligned standards, background information, detailed instructions, and additional resources including printable worksheets and hand-outs. Each is designed to be completed in one class period, but many offer rich opportunities for extension – suggestions for additional activities are also included.

The *Water Wits* program includes concepts from all subjects: Science, Math, Social Studies, Language Arts, and Physical Education. It also fosters 21st-century skills including collaboration, critical thinking, problem solving, global awareness, and civic and environmental literacy. We encourage you to work with other educators at your school or in the community to create a cross-cutting implementation plan. Doing so will provide you with exciting professional development opportunities and enable you to reach students with different learning styles and interests!

While much of the *Water Wits* curriculum is designed to be academic in nature, the interactive activities and low-cost materials make the lessons adaptable for almost any setting. Determine the age range of your audience and set up the hands-on portions of appropriate lessons at public events, workshops, classroom visits, or your camp site.

For more information and additional support, or if you are interested in adapting this curriculum for your own organization or agency, please contact MariAnn McKenzie, Boating Education Coordinator at Mariann.Mckenzie@state.or.us / 503-378-5158.

Thank you for choosing the *Water Wits* program. We hope that you and your students enjoy it!

Sara S Roberts

Randy Henry, Boating Safety Program Manager

Sara Shaw Roberts, Curriculum Writer

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Kindergarten – 2nd grade

3rd – 5th grade

Water Wits

aquatic safety, science, and stewardship education program

GRADES K-2

OREGON STATE MARINE BOARD

GRADES K-2
Time: 10-15 mins for prep; 45 mins-1 hr. for activity

The Story of Water

Aligned Standards

2014 ORSS (NGSS)

- K-ESS2-1. Use and share observations of local weather conditions to describe patterns over time
- K-ESS3-3. Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment.
- K-ESS2-2. Construct an argument supported by evidence for how plants and animals (including humans) can change the environment to meet their needs.
- 2-ESS2-2. Develop a model to represent the shapes and kinds of land and bodies of water in an area.
- 2-ESS2-3. Obtain information to identify where water is found on Earth and that it can be solid or liquid.

OR SOCIAL SCIENCE

- K.10. Explain how people can care for the environment.
- 1.12. Give examples of local natural resources and describe how people use them.

COMMON CORE MATH

- K.OA. Understand addition as putting together and adding to, and subtraction as taking apart and taking from.
- 2.OA. Represent and solve problems involving addition and subtraction.

COMMON CORE ELA

- 1.2. Ask and answer questions about key details in a text read aloud or information presented orally or through other media.
- 2.4. Tell a story or recount an experience with appropriate facts and relevant, descriptive details, speaking audibly in coherent sentences.

Activity at a glance

Students roll a special dice to create their own story about what happens to a body of water because of natural conditions such as drought and because of human water use.

Objectives

Students will:

- Demonstrate how natural and human-caused changes in the environment affect water availability
- Understand the impacts of water scarcity for people and wildlife, including the creation of boating hazards
- Discuss solutions for reducing their daily water use

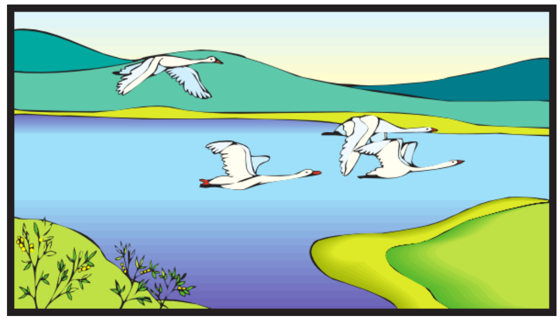


Image credit: Creative Commons

Everything on Earth needs plenty of clean, fresh water to survive—including us!

Materials

- Clear bowl or waterproof container, large enough to hold 2 liters of water
- Graduated cylinder or beaker
- Small pebbles
- Assembled jumbo dice (see dice template page)
- Books for reading (optional, see Additional Resources)

Background Information

Despite its name, the planet Earth is mostly water. Water makes up over 70% of Earth's surface and can be found in many different forms and **reservoirs** (see figure below). All life on Earth depends on water in some form for survival—for humans, we need the fresh water found in lakes, rivers, and under the ground. However, fresh water is not always readily available for people and wildlife. Weather factors like rainfall and **drought**, and human uses such as **irrigation** and industry can change regional water availability dramatically from year to year. This can cause problems for **aquatic** animals that rely on water for **habitats**, and for people too. Without a water supply farms can't produce the crops we need for food, and drinking water can become more expensive. Many industries such as mining, plastics manufacturing, and electricity production require water as well.

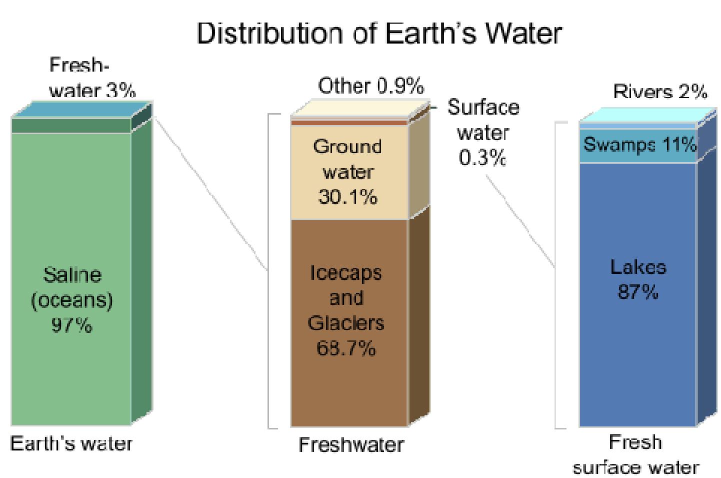


Image credit: Creative Commons

Water scarcity can affect boaters too. When water levels drop, features of the bottom such as rocks, roots, or sandbars are exposed, creating hazards. For all of these reasons it is in everybody's best interest to protect our waterways by reducing our water consumption and not polluting.

Procedures

1. Fill the bowl with 2 liters of water and place near the front or middle of the class where all students will have a good view. Place small pebbles in the bowl to represent the bottom of the lake. Have the pre-made jumbo dice (see pg. 3), the graduated cylinder and a sink or pitcher of water nearby.
2. Introduce the activity and engage the students by asking them what all plants and animals, including them, need to survive. Answers will include food, shelter, etc. but the answer you are looking for is *water!* Water is one of the most important resources on Earth for all living things. Ask students to BRIEFLY name a few places where water is found (ice, snow, oceans, groundwater, etc).
3. If time allows, read part or all of one of the books listed in the *Additional Resources* section. This may also be done at the end as a wrap-up activity.
4. Tell students that now, they are going to create their own story about water together! The story will depend on the roll of the dice, similar to a "choose your own adventure" book.
5. Explain that the large bowl of water in the middle of the room represents all of the water in a local lake (use the name of a local water body that students may be familiar with).
6. Students will take turns rolling the jumbo dice. Each side of the dice will have an action, and an accompanying question (see pg. 4). The action will decide whether they add or take water away from the lake. The question must be answered by the group before moving on to the next roll.
7. Like all good stories, ours starts with "*once upon a time…"* Read the brief passage to the right aloud, then start playing the game! Ensure that students are taking turns and treating the dice with care. Throughout the game, help guide students in adding and taking away the correct amounts of water, and in brainstorming answers.

NOTE: The game can be played indefinitely. You may play just until every side of the dice has been rolled, until you run out of water, or until students lose interest, then move on to the wrap-up questions on pg. 4.

8. After you have finished rolling the dice, ask students to re-tell the story of what happened to their lake by taking turns to share different parts.

Once upon a time, in a land not so far away….

There once was a lake named [local or imaginary water body name]. It was home to many animals who loved to play in the fresh clear water. Fish hid in the rocks while birds skimmed the surface with their wings. At night, foxes would slip quietly through the shadows to drink from the lake. Trees and plants grew tall and strong along the edges. People loved to play in the water too, and during the summer the happy sounds of children splashing and squealing in the lake would echo off the trees.

But nothing stays the same forever, and things at Lake [name] were about to change...

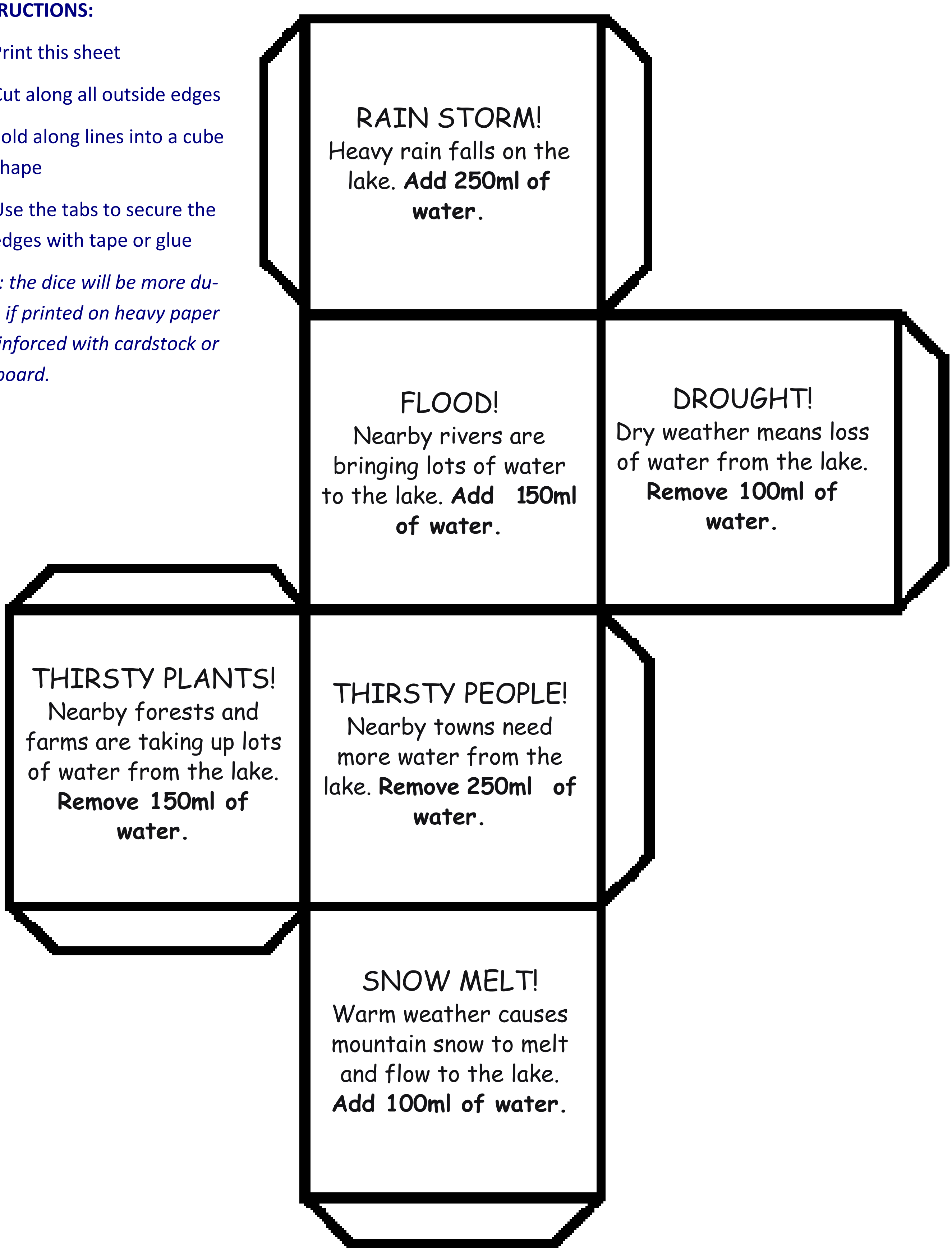
To adapt this activity for grades 3-5, break students up into small groups. Distribute to each group their own bowl, beaker, and dice, and have them play the game and do the water measurements themselves. You may also wish to have older students cut and assemble their own dice.

JUMBO DICE PRINTABLE TEMPLATE

INSTRUCTIONS:

1. Print this sheet
2. Cut along all outside edges
3. Fold along lines into a cube shape
4. Use the tabs to secure the edges with tape or glue

Note: the dice will be more durable if printed on heavy paper or reinforced with cardstock or cardboard.



Questions for dice game

Note: If you plan to play the game several times, ask for only one answer each time the dice lands.

FLOOD: Why do floods happen? (*possible answers: broken dams, heavy rainfall, rivers running too high)*

DROUGHT: What are some causes of drought? (*hot weather causing lots of evaporation, lack of rain, irrigation)*

RAINSTORM: Name something that needs fresh water to live. (*fish, people, plants, deer, birds, frogs, etc.)*

SNOW MELT: Is snow a solid or a liquid? (*snow is solid and rain is liquid. An example of water in gas form is fog.*)

THIRSTY PLANTS: What do plants need besides water to survive? (*sunlight, nutrients*)

THIRSTY PEOPLE: What are some ways people use water every day? (*bathing, brushing teeth, drinking, etc .)*

Wrap-up discussion questions

What happened to the lake bottom when the water got too low? (*It is exposed like an island*) Why can this be dangerous for boaters? (*boats can get caught on the rocks and be damaged*)

How can people reduce their water use? (*taking shorter showers, turning off the water when brushing their teeth, turning off lights because electricity uses water, etc.)*

Additional Resources

<u>One Well: The Story of Water on Earth</u> by Rochelle Strauss, illustrated by Rosemary Woods

<u>A Drop of Water Around the World</u> by Barbara Shaw McKinney, illustrated by Michael S. Maydak

Water in Oregon—Education handout: http://www.oregon.gov/owrd/pubs/docs/infosheet5.watered.pdf

Willamette Water 2100—Anticipating water scarcity and informing integrative water system response in the Pacific Northwest: http://water.oregonstate.edu/ww2100/

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GRADES K-2

Time: 30-45 mins.

"Captain Says" Game

Aligned Standards

COMMON CORE: READING

- 1.2. Retell stories, including key details, and demonstrate understanding of their central message or lesson.
- 2.3. Describe how characters in a story respond to major events and challenges.

OR SOCIAL SCIENCE

- Explain why rules are needed and how rules reduce conflict and promote fairness.

HEALTH BENCHMARKS

- Identify safety equipment needs and procedures for physical activity.
- Identify ways to reduce risk of injuries in and around water.
- Demonstrate water safety behavior.
- Set a goal for safety in and around water.
- Explain the importance of safety at play including wearing helmets, pads and other safety equipment.

Activity at a glance

Students participate in a call-back and movement game to learn safe practices for participation in water-related activities.

Materials

- White board and markers
- Open space for playing the game, inside or outside
- Copies of "Boating Safety 101" hand-outs

Background Information

In Oregon and nation-wide, drowning is the second-leading cause of death in children age 15 and under. Especially for very young children, many of these deaths would have been preventable with the proper knowledge and understanding of how to act safely in, on, or around the water.

This game will introduce students to several skills important to know when in or around the water, including the proper behaviors for swimming, floating in a river, helping somebody who has fallen in the water, and what to do if they've fallen in the water themselves.

Equipped with these skills, students will be more likely to take personal action to prevent accidents and feel more confident and secure when enjoying water activities with their friends and families.

Objectives

Students will:

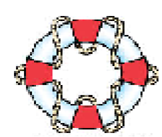
- Understand several important skills for safety in, on, and around the water
- Have fun playing a group game in their classroom
- Use a short story to reinforce concepts and identify right and wrong water safety practices

Image credit: Creative Commons

Understanding a few important skills will keep water-related activities both fun and SAFE!

Ask! 

 Look!

Throw! 

 Feet up!

Wear a life jacket! 

 Huddle!

Procedures

1. Introduce the activity by telling students they will be playing a game to learn about being safe in, on, and around the water. This game is just like Simon Says, but because it involves boats it is called—Captain Says!
2. List the responses which students must do on the board, and explain each one:
    - **Ask**: Before approaching or going into any water, students should always ask an adult if it’s okay! *Motion: Students hold their hands around their mouths and pretend to be calling to their parents*.
    - **Look**: Students pretend to scout out the surrounding area. This is something they should always do before going into any type of water, even a pool! If something doesn’t look safe, they should go and get an adult. *Motion: Students hold up their hand over their eyes, mime looking around or having binoculars, etc*.
    - **Throw**: If somebody falls into the water, students should NEVER go after them or try to pull the person out themselves! Instead they should throw something that floats, like a life jacket or even a cooler, towards that person for them to grab, and also yell for help. *Motion: Students can pretend to throw a life ring*.
    - **Feet up**: Lots of kids go floating or tubing on the river with their families. This can be fun but also dangerous, because the bottom of rivers often have branches and rocks that can catch your feet. To be safe, students should always float with their feet up at the surface, pointing down-river. *Motion: Students sit or lie on the floor and stick their feet up in the air*.
    - **Huddle**: What should you do if you fall into cold water? First of all, you should ALWAYS be wearing your life jacket so you can easily float. To keep your body warm, you should “huddle”, which means holding your knees against your body and crossing your arms while you float. *Motion: Students sit on the floor and huddle as tight as they can*.
    - **Life jacket:** The number one most important rule for any time you are in, on, or around the water! Students should always be wearing a life jacket, and encourage their families to do so as well. *Motion: Pretending to pull on and buckle up a life jacket (they can even make the “clicking” sounds*.
3. Play the game! For a more physically engaging game, be sure to alternate the sitting and standing motions. Encourage kids to be vocal with their responses, i.e., actually “asking” their parents aloud.
4. Wrap up the activity by reinforcing the meaning of each of the concepts learned and why they are important. Extend the activity with the “What would you do” story on the following page.

What would you do?

Read the following story aloud, then ask students what Louise did right and wrong. What would students do differently? Encourage use of the concepts learned in the "Captain Says" game. For an extra interactive element, select a student to play Louise and have her act out the scene in front of the class.

Louise was so excited to play in the river today! The sun was bright and the river looked so nice and cool. She had gotten ready by putting on her swimsuit and life jacket, and was waiting on the beach for her parents to go with her into the water. But they were taking a long time, and she was getting very hot, so she took off her life jacket. That felt better! The river looked calm so Louise stood with just her ankles in the water, feeling the cold water on her skin and the mud between her toes. A small fish suddenly appeared and started nibbling on her toes, startling Louise. She squealed, kicked, lost her balance, and fell into the water! It was deeper than she thought and really cold, taking her breath away. For a few seconds, she couldn't scream and started splashing around, trying to get back to shore, and choking on water. Luckily, Louise's dad saw the whole thing and came running to help. He pulled her out of the river and onto the beach. Louise was safe but very cold, wet, and scared. From now on, she decided, she would leave her life jacket on no matter what—just in case!

Additional Resources

US Army Corps of Engineers Kids' Water Safety—animated cartoons, games, and coloring: http://bobber.info/

Boating Safety Sidekicks—coloring pages, quizzes, and interactive activities: www.boatingsidekicks.com

Safe Kids Worldwide—Boating Safety Tips: www.safekids.org/boatingsafety

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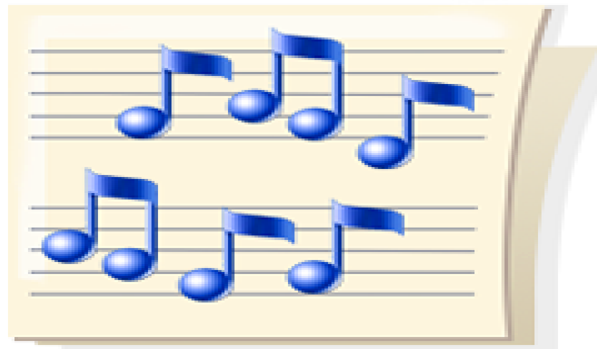
GRADES K-2

Time: 10-15 mins.

Swimming Song

Activity at a glance

Students sing a song to encourage confidence and knowledge about swimming, while performing motions to reinforce the concepts.



The Swimming Song!

(sung to the tune of the Hokey Pokey)

You put your right arm in,
You pull your right arm out,
You put your left arm in,
and you paddle all about!

You kick and kick your legs
And don't get water in your snout-
That's how you swim around!

You put your life vest on,
DON'T take your life vest off,
You put your life vest on,
And you buckle it all up!

You kick and kick your legs
And don't get water in your snout-
That's how you swim around!

You pick a safe place here,
You pick a safe place there,
You pick a safe place here,
And if it's cold then don't swim there!

You kick and kick your legs
And don't get water in your snout-
That's how you swim around!

What other good swimming practices can you think of?

Suggestions

- Use this song as an introduction or wrap-up for other activities in the K-2 unit.
- Engage students by asking them to invent motions to go along with the lyrics.
- Extend the activity by helping students write additional lyrics about the concepts they have learned during this unit.

Additional Resources

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Boating Safety 101

- Make sure all gear and people are balanced
- Don't make sudden movements that could tip the boat over
- Stay seated at all times when boat is in motion
- If your boat does capsize, STAY WITH IT! Most boats will float even when upside-down. And a boat is much easier to spot by rescuers than a person!
- For safety, everyone on board should wear a life jacket at all times — adults AND kids. Children 12 & under must wear one when the boat is in motion— it's the law!

DID YOU KNOW?
Life jackets are available to borrow at many Oregon Waterways! For a list of sites, visit:
www.oregon.gov/osmb

Draw a picture of your family having a fun day on the water here!

I PLEDGE TO USE THESE SAFE PRACTICES WHEN ON A BOAT.

SIGNED: ____________ ____________ ____________ ____________

Boating Safety 101

- Make sure all gear and people are balanced
- Don't make sudden movements that could tip the boat over
- Stay seated at all times when boat is in motion
- If your boat does capsize, STAY WITH IT! Most boats will float even when upside-down. And a boat is much easier to spot by rescuers than a person!
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Water Wits

aquatic safety, science, and stewardship education program

GRADES 3-5

OREGON STATE MARINE BOARD

GRADES K-2 OR 3-5

Time: 30 mins-1 hr.

What Floats?

Aligned Standards

2014 ORSS (NGSS)

- 2-PS1-2. Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.
- 5-PS1-3. Make observations and measurements to identify materials based on their properties

COMMON CORE: MATH

- K.G. Identify and describe shapes.
- K.G. Analyze, compare, create, and compose shapes.
- 1/2.G. Reason with shapes and their attributes.
- 1/2.MD. Represent and interpret data.
- 3.OA. Represent and solve problems involving multiplication and division
- 3.OA. Multiply and divide within 100
- 5.OA. Write and interpret numerical expressions

COMMON CORE: READING

- Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on grade-appropriate reading and content.

HEALTH BENCHMARKS , K-5

- Identify ways to reduce risk of injuries in or around water.
- Set a goal for safety in and around water.
- Identify safe behaviors in and around water.

Activity at a glance

Students experiment with buoyancy by placing common objects in water and assessing why some objects float while others sink. This is then related to the importance of wearing life jackets for personal buoyancy.

This lesson can be used with both K-2nd and 3rd-5th grades. For younger students, simply make observations together. Older students may record these observations on Student Sheet 1. More advanced students may calculate density on Student Sheet 2.

Materials

- Tub or container (clear is best to allow better observations)
- Water
- Orange(s)
- Common everyday objects such as: bath toys, buttons, beans, coins, sponges, etc. (NOTE: you may request that students bring in items from home to test)
- Copies of Student Sheets (pg. 3-4)
- Scale and graduated beakers (optional—see pg. 4)

Objectives

Students will:

- Investigate how the physical properties of objects affect the objects' buoyancy
- Explore the concept of density and how this determines buoyancy
- Understand the necessity of wearing personal floatation devices (i.e. life jackets) when in, on, or around water

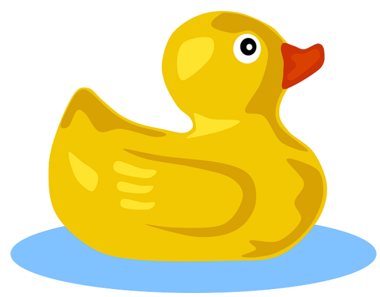


Image credit: Creative Commons

Background Information

Why do some objects float while others sink?

Some objects float while others sink. This is not always due to differences in weight, but also due to the object's **density**, which is calculated by dividing the object's **mass** by its **volume**. An object's shape and size also influence whether it can float or not.

The ability of an object to float on a fluid is called **buoyancy.** Technically, buoyance is the upward force exerted by the fluid that opposes the object's weight. An object's buoyancy can sometimes be difficult to predict. Sometimes, changing the property of an object will change its buoyancy.

A striking example of this phenomenon can be demonstrated with an orange. Drop an orange in the water and it will float, but remove the peel from that same orange and it will sink. Why is this? It would seem as if removing the peel would decrease the orange's mass and therefore make it even more buoyant. However, the physical properties of the peel actually make it more buoyant than the orange itself. The rind is very **porous**, meaning it is filled with tiny pockets that trap air. This makes the orange less dense overall than the water, causing it to float.

This same principle applies to all of us when swimming or boating in our local waterways. Without life jackets, it is much more difficult for people to float. The foam in the life jacket is porous and traps air, just like an orange peel, buoying us on the water. These same properties make life jackets life-saving in cold water, because it helps our bodies to stay warmer longer.

Procedures

1. Introduce this activity by asking students to name some things that float in the water.
2. Looking at the objects you have gathered for the activity, ask students if they think any of these will float? If so, why (or why not)?
3. Conduct the experiment! One at a time, place each object in the tub of water so the entire class can see. Get students to participate by allowing them to volunteer to drop objects in the water. *ALTERNATIVELY, if you have enough containers and objects, break students into smaller groups and have them work together.* Allow each object to sit in the water a few moments, then ask students what they are observing. Does the object sink, float, bob up and down, or something else?
4. For each object, engage students in a brief discussion about WHY the object reacts the way it does. Does it sink because it is heavy? Does it float because it is small? What is the object made of? Note factors such as size, shape, texture, etc. *Older students may record their observations on Student Sheet 1.*
5. Tell students that the last special object they are going to test is an orange. Do they think it will sink or float? Drop it in the water and watch it float. Then, remove the peel (or have a second orange with the rind already removed to save time). Drop it in the water again and watch it sink. (*NOTE: this may take a couple of minutes. Older students may do this themselves in small groups.*) Why do you think this happened?

The average density of an orange peel is about .41 g/cm^3.

6. After brainstorming answers with your students, reveal the real reason why oranges float only with the peel on: the rind has pockets of space in it which trap air. The air makes the orange float. Without the air-filled rind, the orange is too heavy (dense) and sinks. Tell students that the air pockets inside the peel are like tiny soap bubbles – and what is inside a bubble that makes it float in a bathtub? AIR!
7. *More advanced students may calculate each object's density and compare this to water density to show that an object's density determines buoyancy—see Student Sheet 2.*
8. Wrap up: Ask students if they have been swimming lately. Without wearing life jackets or other floatation, did they feel like they could float in the water? Chances are students will say no, they had to keep swimming to stay afloat. This is because they, like a peeled orange, are heavier than the water. But what can they wear to make themselves float? Hint: It is often also orange and full of air!

Children under 13 years of age *must* wear a life jacket when on board a moving vessel and *should* wear one when in, on, or around water!

The answer is: LIFE JACKETS! Like an orange peel, a life jacket can wrap you in a floating bubble that can save your life. In rough waters, or if you are too tired to swim yourself, a life jacket will keep you from sinking. Other floatation devices, such as swim floats, pool noodles, and boogie boards are also great things to have when in, on, or around the water.

Buoyancy Experiment Student Sheet 1

OBJECT	OBSERVATIONS (size, shape, material, etc.)	MY PREDICTION	RESULTS
EXAMPLE: *Rubber ducky*	*Small, round, made of rubber*	*It will float because it feels light*	*It floats!*
1.			
2.			
3.			
4.			
5.			
6.			

The orange floats when the peel is on because: ______________________________

____

Buoyancy Experiment Student Sheet 2

DENSITY is how much "stuff" is packed into the space within an object. The more tightly packed together the "stuff", or **molecules** are, the denser the object. Think of a dice versus a marshmallow: both are about the same size, but the dice is more dense because the marshmallow is mostly air inside. We can find out an object's density if we know the object's **mass** and **volume** by solving this equation:

mass / volume = density

Density is the reason an object floats or sinks. If an object is more dense than water, it will sink. If it less dense than water, it will float.

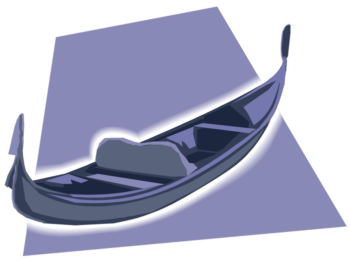
Now that you've observed your objects' buoyancy, you are going to calculate each object's density. Weigh each object on a scale and record its mass in **grams** below. Then determine its volume by placing it in a graduated beaker with water. Record how many **millimeters** the water in the cylinder rose when the object was placed inside: that is the volume. Finally, divide each object's mass by its volume to calculate its density.

OBJECT	MASS (g)	VOLUME (ml)	DENSITY (g/cm^3)
EXAMPLE: *Rubber ducky*	*65*	*150*	*65/150 = .43*
1.			
2.			
3.			
4.			
5.			
6.			

The density of tap water at room temperature is about 1 g/cm^3. Did the objects which have a density less than 1 g/cm^3 float? Did objects heavier than this sink?

Discussion Questions

- What did the floating objects have in common?
- What did the sinking objects have in common?
- Did any of the results surprise you? Why?
- Are people more or less dense than water? Can everyone float easily? What can we wear to make sure we are *always* buoyant in the water?
- Why can huge, heavy boats float? (Think about the shape of the bottom of the boat…)



A boat's bottom, or hull, is usually curved. This helps the boat to stay stable and upright even in waves. The shape also creates a pocket of air in the bottom of the boat, which keeps it floating even though it is heavy.

Additional Resources

Importance of life jackets for kids: http://www.uscgboating.org/safety/life_jacket_wear_wearing_your_life_jacket.aspx

NOVA Online Buoyancy Basics: http://www.pbs.org/wgbh/nova/lasalle/buoybasics.html

Book: Things that float and things that don't by David A. Adler, illustrated by Anna Raff.

Calculating density for kids video: https://www.youtube.com/watch?v=SimFy9wOMXY

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GRADES 3-5

Time: 45 mins-1 hr.

Seesaw Ship

Water Wits

Aligned Standards

2014 SCIENCE (NGSS)

- 3-PS2-1. Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on an object.
- 3-PS2-2. Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.

COMMON CORE: MATH

- 3.OA. Represent and solve problems involving multiplication and division
- 3.OA. Multiply and divide within 100
- 3.MD. Solve problems involving measurement and estimation of intervals
- 4.OA. Generate and analyze patterns
- 5.OA. Analyze patterns and relationships
- 5.OA. Write and interpret numerical expressions

COMMON CORE: LANGUAGE

- 4.6. Acquire and use accurately grade-appropriate general academic and domain-specific words

HEALTH BENCHMARKS

- Identify safe behaviors in and around water.
- Demonstrate communication skills encouraging water safety behavior.
- Encourage family and friends to practice water safety behavior.

Activity at a glance

Students use classroom materials to represent a boat, moving waves, gear, and passengers, and perform a series of experiments to understand the physics of balance and center of gravity.

Objectives

Students will:

- Investigate the effects of balanced and unbalanced forces
- Understand the physics of balance and center of gravity
- Use simple math to calculate and predict the amount of force necessary to achieve balance
- Apply knowledge to describe safe boating behavior

Materials

For each group of 4-6 students:

- 1 sturdy (not flexible) ruler: plastic or wooden
- 1 Pencil with flat sides (not rounded)
- 10-20 Pennies
- Seesaw or materials to make a simple seesaw (optional—see Extension Activities)

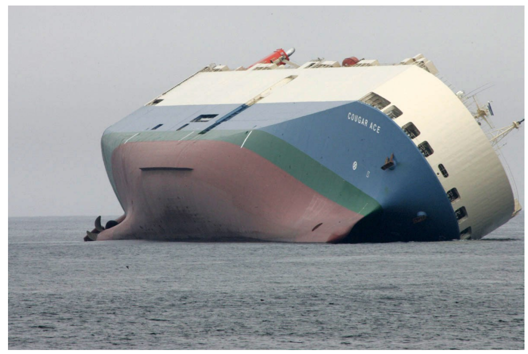


Image credit: Creative Commons

Physics determine how and why boats stay balanced—or not.

Background Information

As land animals, we are not used to having to constantly adjust ourselves to stand upright, but this is exactly what you must do when onboard a boat. If the people and gear on board are not arranged evenly, the boat will tilt towards one direction, or **list**, in the water. This makes it much more likely to **capsize** (overturn) in large waves or windy conditions. One person suddenly switching sides on a boat may be enough to cause it to flip, which could quickly become a dangerous situation in cold or rough waters.

Balanced and **unbalanced forces** impact the motion of an object such as a boat in different ways. When the forces (or mass) acting on all parts of the boat are equal, it is said to be balanced, or at **equilibrium.** The amount of force from gravity pulling downward is equal to the force of the boat's deck pushing all the gear upward. The boat will feel stable even when moving over waves. However, if the forces acting upon the boat are unbalanced—meaning the boat deck is not pushing upward equally across its entire surface—it will list. The friction caused by shifting gear increases this unbalanced effect. Given enough weight of gear and/or people and enough imbalance on one side of the boat, it can capsize completely.

In such situations, there is very little or no time to put on a life jacket before going into the water. Once in the water, with the shock of the cold and waves in your face, it is nearly impossible to fasten the buckles of a life jacket. This is why it is so important to always prepare by wearing a **PFD** at all times. **Remember—no accidents are planned!**

Procedures

1. Ask students if they have ever been on a boat. What did it feel like? Was it stable? Did they feel like they were going to fall in? If so, there's a reason for that—it's called *forces.* Forces can be something like your friend pushing you, but there are also invisible forces acting on your body every day. Can students name one of these? How about GRAVITY! Gravity pulls you down towards the Earth. Without it, we would all float away!

2. Tell students that they are going to do an experiment to see if they can balance the force of gravity with the force of objects arranged on a ruler. The ruler will represent a boat, and it will rest on a pencil that represents a moving ocean. Their first task is to set their ruler on their pencil so that it is centered and balanced. Split students into their small groups and wait until they have done this before moving on.

3. Now they must put their "gear" on their "boat" so that it doesn't tip to one side or the other. Allow students to experiment with the best process for this. Does it work better to place one penny at a time on each side of the ruler, or to place them simultaneously? Where on the ruler do the objects best balance? Encourage group discussion and cooperative problem-solving. The goal is to have the most pennies on their ruler while still keeping it balanced—in other words, neither side of the ruler should touch the table. Friendly competition between the groups will make it more fun!

4. Next, students will explore the physics of balance with some simple calculations. Remove all pennies and make sure the ruler is balanced on the pencil as before. First instruct students to place 4 pennies on one side of the ruler. Then place 4 on the other side so that the ruler balances. Are the pennies at about the same location on both sides of the ruler? To make it balance, they should be.

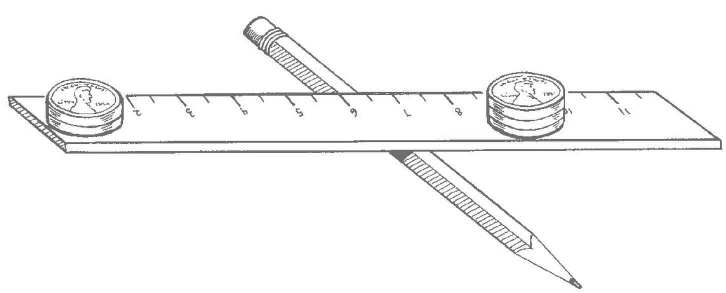
5. We are going to see how we can make our "boat" balanced even when there are unequal numbers of pennies on each side of the ruler. Place 6 pennies exactly 2 inches from the pencil on either side. Tell students they must find a way to make the boat balanced with only 3 pennies on the other side. After some trial and error, they should discover that this is possible!

6. When each group is successful, tell them to measure the distance from the pencil to the pile of 3 pennies. It should be about 4 inches. *Why is this?* The farther away from the **fulcrum**, or balance point (in this case the pencil), the more their gravity works to balance the ruler. We can see this using simple math:

   6 (pennies) x 2 (inches) = 12

   3 (pennies) x 4 (inches) = 12

7. Knowing this, what other combinations of pennies and distances can students come up with to make their ruler balanced? Record successful calculations on the board.



Extension Activities

1. Create a large-scale seesaw at school! Find an open area and create a simple seesaw using a sturdy plank of wood and a round log as the fulcrum. Have students experiment with how many of them should sit on each side to create balance. Try moving the fulcrum away from the center and see how that changes where and how many students should sit on each side to create balance.
   NOTE: Monitor this activity carefully and watch for safety issues!

2. Ask students to stand squarely on their two feet. It's pretty easy to balance when standing like this. Then have students stand on one foot and see how long they can balance. Finally, have students stand on their tippy-toes on only one foot—this makes it very hard to balance! Why is this? It's because the smaller the point of support, the more difficult it is to keep their center of gravity steady. Ask students to report ways that make it easier to balance, such as raising their arms at their sides. Just like the ruler and the seesaw, their arms act as levers which generate balanced forces, helping to prevent tipping over.

Additional Resources

The Physics Classroom—Balanced and Unbalanced Forces: http://www.physicsclassroom.com/class/newtlaws/Lesson-1/Balanced-and-Unbalanced-Forces

Center of Mass, Balance, Torque, and Acrobats: http://www.pbs.org/opb/circus/classroom/circus-physics/center-mass/

Online Physics Balance Game: http://www.physicsgames.net/game/Balance.html

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GRADES 3-5
Time: 15 mins for prep, 45 mins. for activity

Chilly Fingers

Aligned Standards

2014 ORSS (NGSS)

- 3-LS3-2. Use evidence to support the explanation that traits can be influenced by the environment.
- Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.

HEALTH BENCHMARKS

- Describe the correct use of safety equipment during physical activity
- Identify safe behaviors in and around water.
- Encourage family and friends to practice water safety behavior.

COMMON CORE: ELA

- Describe characters in a story and explain how their actions contribute to the sequence of events.
- Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on grade-appropriate reading and content.

Activity at a glance

Students experience the impacts of cold water immersion, discuss actions they can take to lessen these impacts, and learn about how marine mammals stay warm and buoyant in the ocean.

Objectives

Students will:

- Experience the impacts of cold water immersion in a safe environment
- Investigate what to do if they fall into cold water, and steps to take to prevent cold water injuries
- Relate the human invention of life jackets to marine mammal adaptations (i.e. blubber)

Materials

- Bucket of ice water
- Ziploc bags
- Crisco or other vegetable shortening
- Duct or other strong tape
- Life jacket for demonstration (if available)
- Images of marine mammals (optional)

Image credit: Creative Commons

Marine mammals such as this Minke whale use blubber to survive cold waters and stay afloat.

Background Information

Have you ever jumped into water that was so cold, you actually gasped? This **involuntary reaction** is only the first your body undergoes when immersed in very cold water. Drowning often begins in these very first moments, when the victim gasps water into his or her lungs and goes under. **Hyperventilation** can also occur, causing the victim to become unconscious and sink. After only a few minutes, the body begins to conserve its heat for the vital organs so the victim finds it very difficult to move his or her limbs to swim. **Hypothermia** is actually the final step in **cold water immersion**—many times, the victim is not in the water long enough to undergo hypothermia because they have already drowned or been rescued. "Cold water" does not mean only icy waters—especially in children, these reactions can occur in water 77°or less.

Drowning, especially due to cold water, is a serious concern for adults and children alike. It is the second-leading cause of death in children age 15 and under. Most of these deaths could have been prevented with adult supervision—because drowning most often occurs swiftly and silently—and the use of life jackets. *In 90% of drownings, the victims were not wearing life jackets*.

Not only do life jackets keep your head above water and prevent immediate water inhalation, they also insulate your body. It takes much longer to reach the hypothermia stage. They also make the victim much more visible. All of these factors add up to a simple fact: children and adults wearing life jackets are much more likely to be rescued and survive.

Marine mammals which inhabit cold waters have adapted over millennia to have their own "life jackets": blubber. **Blubber** is a thick layer of fat beneath the animal's skin, which both insulates and protects. In large whales, blubber can be up to 12 inches thick! Also like life jackets, blubber provides buoyancy, making it easier for marine mammals to surface for air.

Procedures

1. Make one or more Blubber Gloves (see box).
2. Fill one or more tubs with ice water.
3. Introduce the activity: Ask students what it feels like when they jump into cold water. What happens to their body? Encourage physiological descriptions such as shivering, gasping, skin becoming numb, etc. For extra fun students can even act out their reactions.
4. Tell students they are going to test their cold water survival skills using only their hands. Each student will take turns sticking their hand into the ice bucket and seeing how long they can stand it before pulling their hand out.

NOTE: It is very important NOT to introduce this activity as a challenge or competition. Otherwise, students may keep hands in the water longer than is safe and become injured. **If a student has pre-existing health conditions, such as circulatory or heart problems, they should not participate.**

5. Discuss students' reactions to the cold water. How did it feel? What would it feel like if their entire body was in that ice bucket? Would they be able to survive for long?
6. Next, remind students that many animals actually live in water that cold their whole lives. Ask students for some examples (whales, seals, dolphins…) - these are *marine mammals* and though they breath air like us (we are also mammals), they have special *adaptations* which allow them to live in water humans could never survive.
7. Ask if students can name some of these adaptations. Lead them to the answer "blubber" and briefly describe using the Background Information.
8. Tell students they are now going to experience the same icy cold water the way a whale would, with blubber. Have each student take a turn wearing the Blubber Glove and putting it into the water. They should barely be able to feel the cold this time (if they can, there might be a leak in the glove!)

MAKE A "BLUBBER GLOVE"!

- Fill about half of a gallon size Ziploc bag with Crisco or other vegetable shortening. Do not seal the bag.
- Place another open, gallon size Ziploc bag inside the first bag. Press down until it is surrounded by the Crisco but don't let any Crisco get into the inside bag. Do not seal this bag either.
- Fold the tops of both open bags down together on both sides, two or three times. Use the duct tape to secure the folded edges of the bags.
- The "blubber glove" should now be sealed with the Crisco trapped between the two bags.

9. Gather again as a group and ask how the water felt while wearing the Blubber Glove. Compare and contrast this experience with how it felt on their bare hands.
10. Of course, humans do not have blubber. But what is something that we can wear that acts like blubber, helping us float and protecting us from the cold? If nobody lands on "life jackets", lead students to this conclusion.
11. Wrap up the activity with a discussion of WHY life jackets are so important, based on the evidence they have gathered during this activity. Remind them how numb and stuff their hands were after being in the ice water—would they be able to put on and buckle up a life jacket once already in the cold water? This is why it is especially important to wear a life jacket at all times when on a boat or playing near water, just in case!

Extension Activities

- Ask students to bring in any life jackets they may have from home, and have them practice putting these on. Point out that some of these may not fit properly: they should be snug and not too big, and when pulled by the shoulder straps, shouldn't be able to be pulled past the ear lobes.
- If you have access to a large area outside, hold a Life Jacket Relay Race! Students form two teams and must *properly* put on a life jacket (fully buckled up and snug) before running to the other side.
- Print out copies of *Boating Safety 101* and have students sign the pledge. Encourage students to take these home and have their families do the same.
- Have students investigate other marine mammals which use blubber for protection and warmth.

Image credit: Creative Commons

In the 1800s, people used natural materials for buoyancy, such as this jacket made from cork!

Additional Resources

Facts about cold water immersion: www.oregon.gov/OSMB/pages/safety/coldwaterimmersion.aspx

Life jacket loaner program information: www.boatoregon.com/OSMB/BoatEd/index.shtml

Marine mammal adaptations: http://www.scientificamerican.com/article/marine-mammals-cold-avoid-freezing-death/

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GRADES 3-5

Time: 1-2 hrs.

Plenty of Fish in the Sea?

Aligned Standards

2014 SCIENCE (NGSS)

- 3-LS4-4. Make a claim about the merit of a solution to a problem caused when environmental changes and the types of plants and animals that live there may change.
- 5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and the environment.

OREGON SOCIAL SCIENCE

- Identify conflicts involving use of land, natural resources, economy, and competition for scarce resources.
- Identify and analyze Oregon's natural resources and describe how people in Oregon and other parts of the world use them.

COMMON CORE: MATH

- 3.OA. Represent and solve problems involving multiplication and division
- 3.OA. Multiply and divide within 100
- 3.NF. Develop understanding of fractions as numbers
- 4.OA. Generate and analyze patterns
- 5.OA. Analyze patterns and relationships
- 5.OA. Write and interpret numerical expressions
- 3/4/5MD. Represent and interpret data.

Activity at a glance

Students learn about fishing catch limits through an activity demonstrating the effects of overfishing, and calculate their own fishing regulations to maintain sustainable populations.

Objectives

Students will:

- Learn about local fish species and catch limits
- Calculate new regulations to best conserve the fish resources at their "lake"
- Discuss how people might react to these catch limits and ways students can explain why they are important
- Be reminded of important boating rules that must be followed when fishing

Materials

- Short wooden dowels
- String or twine
- Duct tape
- Magnetic tape
- Paperclips
- Fish coloring pages (pg. 4)
- Calculators
- Copies of student sheets
- Stopwatch/timer

Image credit: Creative Commons

For everyone to be able to fish long into the future, we must be aware of and follow regulations.

Background Information

Oregon's waterways offer a bounty of fish which people may harvest commercially or recreationally. Salmon, trout, catfish and bass inhabit rivers and lakes throughout the state. Off the coast, marine species such as rockfish, tuna, mackerel and halibut range from shallow to deeper waters. These provide people with money and food.

To maintain healthy populations of these species, scientists set fish **catch limits.** These restrictions are based on research studies determining how many fish of any particular species can be caught while still maintaining a **sustainable** population. This means a group of individuals that are abundant and healthy enough to ensure the existence of that species into the future. Both marine and freshwater species have limits on how many can be taken home by **anglers** (people who fish). Beyond that number, fish must be released. If too many fish are removed from the ecosystem and there are not enough left, it is called **overfishing.**

All anglers over the age of 14 must obtain a fishing license from the Oregon Department of Fish and Wildlife and follow catch limits, or they can be fined.

In Oregon, two thirds of boaters use their boats primarily for fishing. This means that not only must they obey catch restrictions, they must also help protect fish and other water users by using waterways responsibly, by never throwing trash into the water, and watching for oil leaks from their boats. They must also remember that although they are fishing, they still need to be aware of boating safety and regulations.

Procedures

DAY ONE

1. Introduce the activity briefly and show students the "local fish species" sheet. Have students color and cut out their fish. Attach a paper clip to each fish. (see pg. 3)

2. Students make their fishing rods with a small piece of magnetic tape on the end as "bait". They should design a rod that they think will catch the most fish (see pg. 3).

3. While students are working, the teacher may begin setting up the lake or ponds (see Note box) in the classroom and "stocking" them with the prepared paper fish.

DAY TWO

1. Engage students by asking whether any of them have gone fishing before. Did they catch anything? If so, did they release it or take it home and eat it? Were there plenty of fish? Did they follow any limits on how many they caught?

2. Explain that **one minute will represent one day**. Allow kids to catch whatever they want, however much they want for **up to 7 minutes (one "week"**). Time how long it takes for all the fish to be caught.

> **NOTE: If the class is small, all students may fish out of one large "lake" or "sea". For larger classes, divide students into groups of 4-6 and have each group fish out of their own smaller "pond".**

3. Calculate the rate of fish caught per minute (i.e. if 30 fish were caught in 5 minutes ("days"), then 6 fish per minute ("day") were caught). Write this simple equation on the board.

$$\frac{\text{30 fish total}}{\text{5 days}} = \frac{\text{6 fish}}{\text{1 day}}$$

TEACHER'S NOTE

This works best as a two-day activity: students can color their fish and make their fishing rods on Day 1, and complete the activity on Day 2. However if you are limited to one class period, you may wish to make the fishing rods and fish yourself ahead of time.

4. What happened when everyone was allowed to fish however much they wanted? Did they catch every fish? The number of fish decreased. Introduce the concept of catch limits and why scientists use these to help maintain a good fish population.

5. Have students estimate a better rate for capture (i.e., if 6 fish per minute ("day") were caught without regulations, then maybe we should only allow 4 fish per "day"). Write this new equation on the board and calculate how many fish that would be per week.

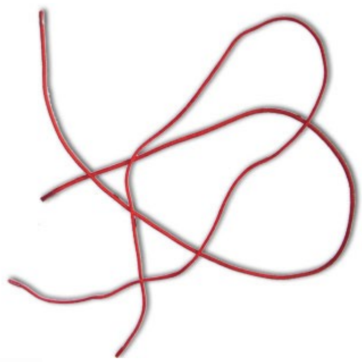
$$\frac{\text{4 fish}}{\text{1 day}} \times \text{7 days} = \frac{\text{28 fish}}{\text{week}}$$

6. Try the exercise again, enforcing the students' agreed-upon catch limit. Keep track of fish caught each minute on the board, and when the limit is reached for that minute, yell STOP! Until the next "day" (minute) begins, students may keep fishing but must release anything they catch. *It may be useful for students to call out "Fish on!" when they catch a fish to make it easier for you to keep track.*

7. Evaluate the success of their catch limit. Were there enough fish left this time for the population could continue? If it was unsuccessful, come up with a new number and try the exercise again (if time allows).

8. Discuss the experience. How might catch limits impact anglers? Would they be happy about not being able to take every fish home? How might students convince an angler to follow the catch limits? Help students cite the ecological and economic reasons for maintaining a sustainable population.

Assembling the fish and rods

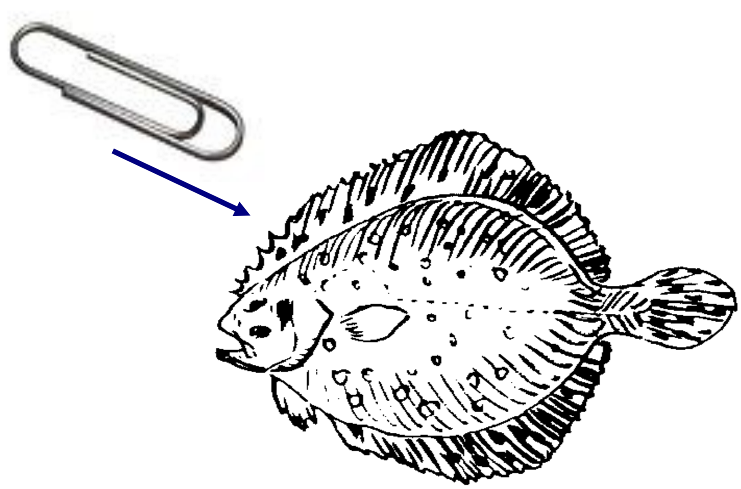


1. Get a short wooden dowel about 10-12 inches long. Alternatively, collect sticks outside to use as fishing rods.

2. Cut a piece of string about 20-24 inches long (long enough for the end to reach the floor when you're holding the rod at waist height). Tie it to the top of your fishing rod and use duct tape to secure it.

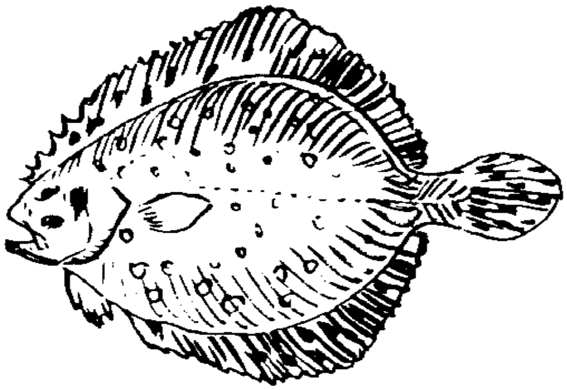
3. Cut two squares of magnetic tape, both the same size, about 1 square inch. Peel the backing off the sticky sides. Sandwich the end of the string between the sticky sides of the squares of magnetic tape (with both sticky sides facing each other). Press tightly together until it is secure.

To make the fish, just slide a paperclip onto each fish. If it seems the paperclip may slide off you can secure it with a piece of Scotch tape.

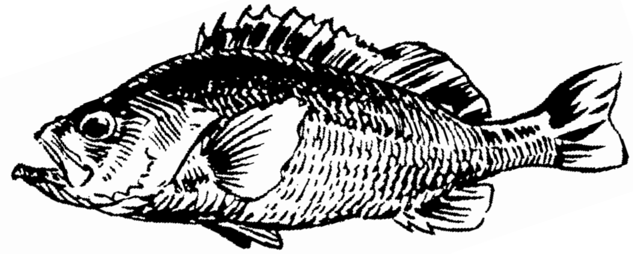


Oregon Fish Species

Color and cut out each fish.



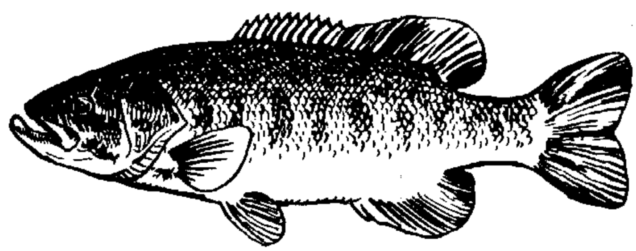
Halibut



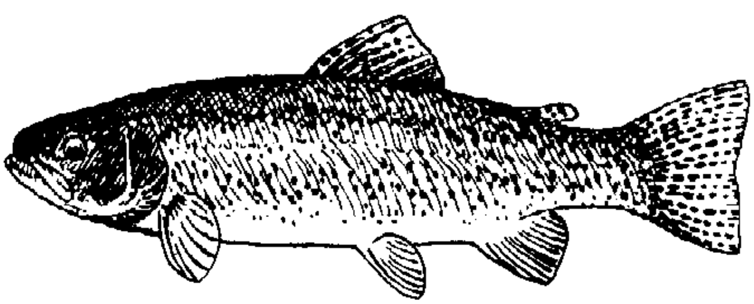
Rockfish

Mackerel

Salmon



Bass



Trout

Extension activities

Boating and fishing: Remember, even if you only use a boat to go fishing, you are still a boater! Remind students of the safe practices and rules for boating which must be followed at all times while fishing, including wearing life jackets and knowing what to do if a person falls overboard (**reach** toward them with a pole or branch, **throw** something to them that floats, or **row** to them without using the motor. Only strong swimmers should go after the victim and only as a last resort!). It is especially easy to fall overboard when reaching to net a fish out of the water, so remember to always keep the boat balanced with the same amount of gear and people on all sides.

Habitat adaptations: Study the body shapes and adaptations of each fish species. Note that they are all different, and ask students why this may be? Fish, like all organisms, are adapted to the habitat where they live. Some fish are flat and camouflaged to match the sand which they sit on. Others are sleek, silvery and striped to blend in with the open ocean, where they swim quickly to catch prey. Some are brownish or greenish to match the rocks they hide in. Have students draw a picture of one or more marine or aquatic habitats, and paste the cut-out fish in their correct habitat on the drawing.

Additional Resources

Oregon fishing regulations and catch limits: http://www.dfw.state.or.us/resources/fishing/

The importance of fishing laws: http://takemefishing.org/fishing/fishopedia/fishing-and-conservation/the-importance-of-fishing-laws/

Science of annual catch limits: http://www.fpir.noaa.gov/SFD/SFD_regs_acls.html

Oregon common fish species: http://www.dfw.state.or.us/fish/species/

Fish adaptations and habitats: http://earthguide.ucsd.edu/fishes/environment/environment.html

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Boating Safety 101

- Make sure all gear and people are balanced
- Don't make sudden movements that could tip the boat over
- Stay seated at all times when boat is in motion
- If your boat does capsize, STAY WITH IT! Most boats will float even when upside-down. And a boat is much easier to spot by rescuers than a person!
- For safety, everyone on board should wear a life jacket at all times — adults AND kids. Children 12 & under must wear one when the boat is in motion— it's the law!

DID YOU KNOW?
Life jackets are available to borrow at many Oregon Waterways! For a list of sites, visit:
www.oregon.gov/osmb

Draw a picture of your family having a fun day on the water here!

I PLEDGE TO USE THESE SAFE PRACTICES WHEN ON A BOAT.

SIGNED: ____________ ____________ ____________ ____________

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Water Wits

aquatic safety, science, and stewardship education program

GRADES 6-8

OREGON STATE MARINE BOARD

GRADES 6-8
Time: Prep 15-20 mins; 45 mins-1 hr. for activity

River in a Box

Aligned Standards

2014 SCIENCE (NGSS)

- MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
- MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
- MS-PS3-5. Construct, use, and present arguments to support the claim that when kinetic energy of an object changes, energy is transferred to or from that object.

SOCIAL SCIENCE CORE

- Explain how people have adapted to or changed the physical environment in the Western Hemisphere.
- Explain how technological developments, societal decisions, and personal practices influence sustainability in the Western Hemisphere.

COMMON CORE: LANGUAGE

- Engage effectively in a range of collaborative discussions with diverse partners on topics, texts, and issues, building on others' ideas and expressing their own clearly.

COMMON CORE: MATH

- 6.RP.2. Understand the concept of a unit rate associated with a ratio

HEALTH BENCHMARKS

- Explain ways to reduce risk of injuries in and around water.
- Demonstrate verbal and non-verbal communication to avoid unsafe situations in and around water.

Activity at a glance

Students build models of several different rivers including natural and man-made features, and use these to investigate flow physics, boating hazards, and human impacts.

Materials

For each group of 4-6 students:

- River box - **see final page for instructions**
- Sand, pebbles, small rocks
- Pitchers with water
- Bucket
- Plastic boats, Lego pieces, popsicle sticks, broccoli, etc. to represent boats and branches
- Copies of Student Data Sheet (pg. 4)

Background Information

Rivers are dynamic, ever-changing bodies of water that can provide recreation, clean water, and habitat for important species, but also a lot of dangers. Many of these dangers are hidden and nearly impossible to spot by the untrained eye, so it is important that anybody planning on boating down a river is familiar with its physical features and potential hazards.

The way a river behaves and impacts boaters is a result of many factors. These can be either natural or man-made. Surface and submerged obstacles (such as rocks, trees, and branches), narrow channels, and rainfall or landslide events influence the way that the river is shaped and its flow speed. Dams, weirs, spillways, and other man-made structures also determine river behavior and can cause a number of serious hazards.

Sediment, or particles of dirt, sand, or tiny rocks, plays an important role in the size and shape of a riverbed. This means how much sediment is delivered, deposited, or washed away, and the rate of these processes. **Erosion** is the process of sediments being carried away—by wind, water, or debris. **Deposition** is the process of sediment being delivered to the river—by rain, landslides, wind or gravity. The more or faster the erosion, the wider and deeper the riverbed. If deposition is the dominant process, the channel will be narrower and the riverbed steeper. Of course, in a natural system these processes are constantly changing and competing. A river that is low, slow, and calm may be a turbulent roaring river after a large snowmelt, dam collapse, or other event.

Rivers are part of the **hydrologic cycle**, meaning they are driven by the exchange of energy (water) and flow rates. This includes precipitation, runoff, infiltration (the flow of water into the soil) and percolation (the flow of water through the soil due to gravity). All of these determine the river's shape or **morphology.**

Certain features are notorious for causing problems for boaters and need to be carefully researched and avoided. Hazards such as rapids, strainers, holes, submerged debris, and drops may be stationary features or may appear only at certain times. **Know before you go!** Be prepared for hazards by always wearing a life jacket

Objectives

Students will:

- Use a model to represent concepts including erosion, deposition, fluid mechanics, and currents
- Perform a series of experiments to analyze how changing aspects of a river affects the above concepts
- Relate their findings to the importance of water safety and hazard awareness

Image credit: Creative Commons

A river's features and hazards are determined by flow speed, debris and sediment supply, erosion, and more.

Procedures

1. Introduce activity with information from the *Background Information* section. Write down key vocabulary on board.

2. Explain that each group is going to create their own mini-rivers and try to determine how both natural and human-made features impact water flow.

3. Distribute materials and allow student groups to build their model of a river however they want to start. There is no right or wrong way—the variety of their river models will help to illustrate concepts later. Throughout the activity students should record results and observations on the *Student Data Sheet*.

4. Once initial rivers are complete, have students pour a small amount of water starting at the furthest point "upstream" (opposite the hole in the box). What happens to the rocks or obstacles they put in their model? How does the water move around these objects? Encourage sharing aloud of observations.

5. Tell students their next challenge is to build a river that will flow *quickly*. The goal is to design a model that allows water to flow as fast as possible. Allow time for students to build, then again pour water down the river. Was the flow as fast as they expected? Why or why not?

CALCULATE RATE: Advanced students can count the number of seconds it takes water to travel down their river, then calculate the rate of flow in inches per second or other units.

6. Next, instruct students to build a river that flows very slowly. Repeat the experiment and discuss results.

7. After these experiments, help students identify patterns in their results. Note that straight, clean rivers will flow more quickly than meandering rivers with many turns or obstacles. *Why is this?* Have students brainstorm answers.

8. Which type of river will be more likely to experience flooding? (*Answer: meandering, winding rivers will likely accumulate and hold more water rather than quickly routing it downstream*.)

9. Now we will explore how humans have changed the way many rivers operate. Dams, rerouting water flows (known as channelizing), and the filling of wetlands for development are just a few examples. First, build a river with a few meanders, without too many sharp curves or straight paths—this is representative of most average rivers. Then, give students time to experiment with changing river behavior when they do the following:

- Build dams upstream, midstream, and downstream—what happens to the water speed and sediment transportation?
- Add additional streams to the river
- Make the river more narrow using the sand and/ or rocks

10. Lastly, identify hazards which may have formed in their model rivers. Did they notice any areas that collected dangerous debris, swift currents, miniature drops or areas of turbulent water around rocks, etc.? Use the pictures on Page 5 to relate these observations to hazards they could encounter on real rivers. Emphasize that these are often unexpected, so it is vital to be prepared.

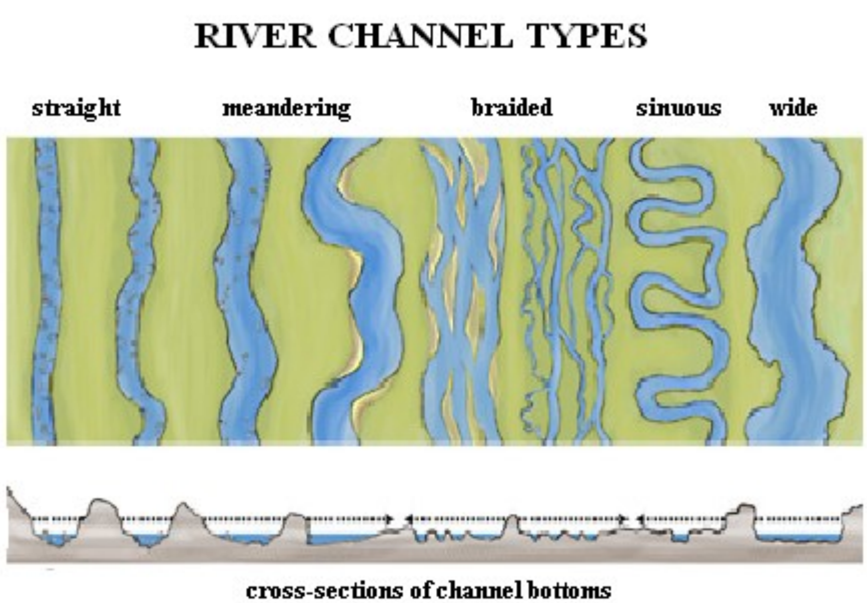
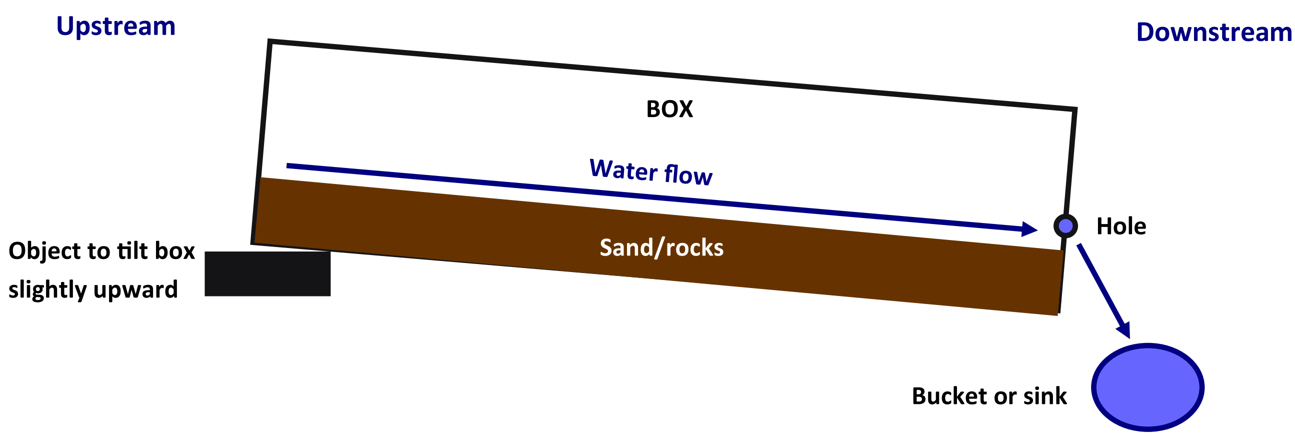


Image credit: Steven Adams/Creative Commons

How to build a River Box

1. Use a plastic, rectangular, waterproof box. It does not need to have a top. It should have enough depth to allow room for sand and rocks and for water flow.
2. Punch or cut a hole into one of the short sides of the box. This will be the “downstream” side of the river. The hole should be approximately 2 inches from the bottom of the box, or just above the desired level of sand. It should be about a quarter-inch in size.
3. Place the “downstream” side of the box over a sink, or on the edge of a table above a bucket. This is where the water will drain into, so if you are using a bucket make sure it is large enough. You may need to have students dump it out if it fills during the activity.
4. Fill the bottom of the box with approximately 1.5 inches of sand or small gravel, at least half an inch below the bottom edge of the hole. Be aware that some sand may wash out of the box. Add some larger pebbles to represent rocks or boulders.
5. Add rocks and pebbles. Add items such as plastic boats, game pieces, and small sticks if desired. These can represent logs, bridges, dams, etc. Add pieces of broccoli to represent fallen trees. Students can make small floating boats out of Legos.
6. Elevate the “upstream” side of the box (opposite the hole) slightly with a binder, piece of wood, or other flat stable object. A couple of inches of elevation should be enough for good water flow.



Additional suggestions

The larger your container, the better it will work as a river model.

Instead of making several small river boxes, you can make a large scale model using a rain gutter! Lay it across several tables, or place it on the ground outside. One end of the rain gutter will still need to be elevated to allow water flow. The entire class should be able to fit around the rain gutter. Each student can create their own section of the river or they may still work in small groups to design each section.

STUDENT DATA SHEET

Sketch each of your river models, including the shapes and major manmade and natural features, and record observations below. Discuss the results with your group. How might these different types of rivers and their features impact water currents, sediment transportation, boaters, and wildlife?

Upstream → Downstream

OBSERVATIONS: ____________________________________

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Upstream → Downstream

OBSERVATIONS: ____________________________________

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Upstream → Downstream

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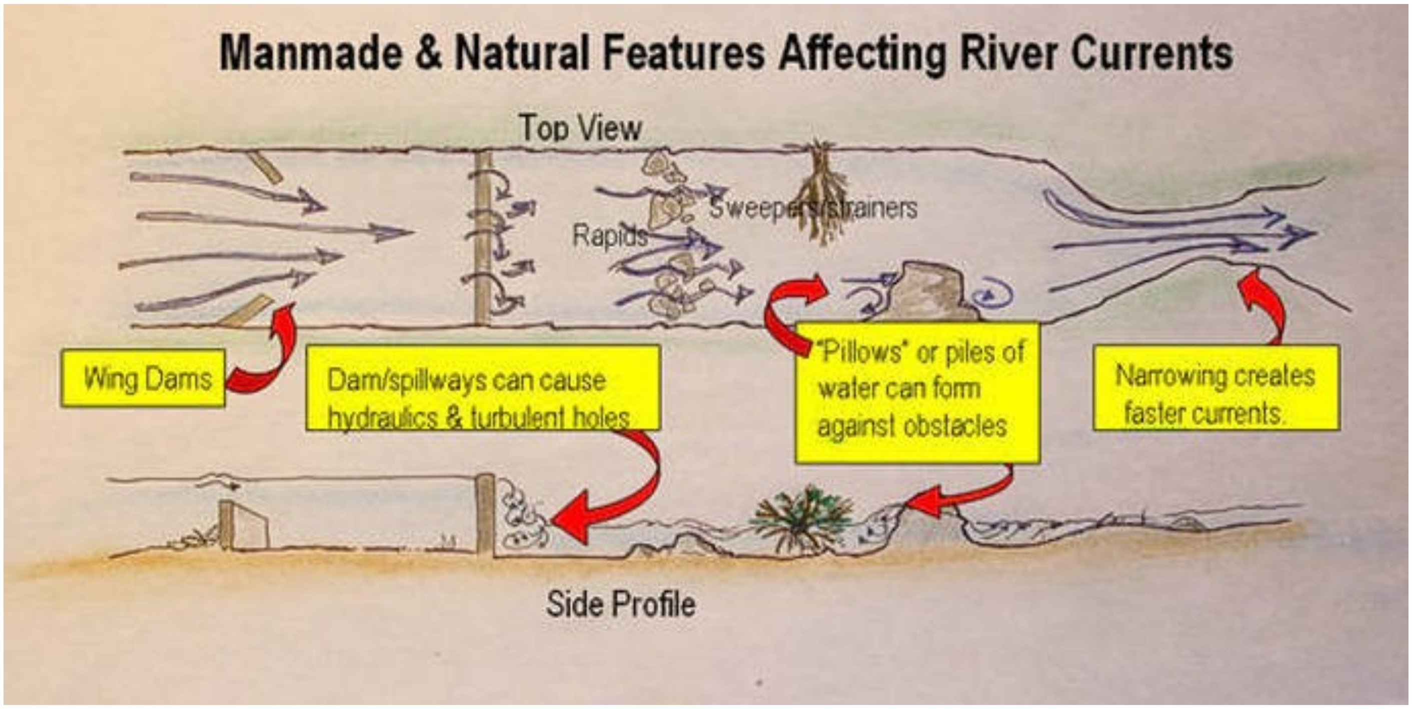

Image credit: www.paddling.net

Resources

Guide to river hazards and how to handle them: http://www.paddling.net/guidelines/showArticle.html?566

Navigation obstructions on Oregon rivers: http://www.oregon.gov/osmb/pages/safety/navigation_hazards.aspx

Video: Why Do Rivers Curve? (2.5 mins) http://mentalfloss.com/article/61170/why-do-rivers-curve

How A River Flows—information and visuals: http://chamisa.freeshell.org/flow.htm

All about Rivers: http://education.nationalgeographic.com/education/encyclopedia/river/?ar_a=1

Impacts of Dams: http://www.americanrivers.org/initiatives/dams/why-remove/

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GRADES 6-8
Time: 10 mins for prep;
1-2 hrs. for activity

Oil Spill Cleanup

Water Wits

Aligned Standards

2014 SCIENCE (NGSS)

- MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
- MS-PS1-3. Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.
- MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services.
- MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

OR SOCIAL SCIENCE

- Explain how technological developments, societal decisions, and personal practices influence sustainability in the Western hemisphere.
- Investigate a response or solution to an issue or problem and support or oppose, using research.

COMMON CORE: READING AND WRITING

- Integrate information presented in different media or formats as well as in words to develop a coherent understanding of an issue.
- Cite textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.
- Write arguments to support claims with clear reasons and relevant evidence.

Continued on following page...

Activity at a glance

Students design and evaluate solutions for the impacts of oil spills in aquatic environments, and investigate the societal dimensions of clean-up efforts.

Objectives

Students will:

- Identify the causes of oil spills
- Infer the impacts of oil spills on wildlife and important water resources
- Create and discuss solutions for a model oil spill in the classroom
- Consider the viewpoints of diverse people when dealing with oil spills in their own communities

Materials

For each group of 4-6 students:

- Water (access to a sink is ideal)
- 1 bowl
- 2-3 tablespoons vegetable oil
- Cotton balls, Q-tips, cotton pads, etc.
- Spoon
- Liquid soap, diluted in a spray bottle
- Small nets or pieces of mesh
- Sponges
- Copies of Student Worksheet (pg. 3)
- Copies of "Clean Boater" handout for students to take home (pg. 5-6)

Image credit: Creative Commons

Oil spills can impact oceans, streams, groundwater, and the people who use these resources.

Background Information

Aquatic wildlife is extremely vulnerable to water pollution, because they cannot survive out of the water and so cannot avoid pollution. A major concern for these organisms is oil spills. In lakes and rivers, oil can come from leaking motorboats or in runoff from nearby roads. In the ocean, huge spills from transport ships can have large-scale consequences. Oil and other pollution can be classified as either **point source**, meaning it comes from a specific place or event, or **non point source**, meaning from multiple or unknown sources. Point source pollution is more easily regulated, though non point source pollutants pose just as much of a major concern as they affect entire communities. For aquatic ecosystems, both of these types of pollution have negative impacts.

The physical properties of oil make it particularly difficult to contain and remove from water. Because oil is less dense than water, it forms thin layers or **slicks** on the water's surface. This means that the oils are exposed to the wind and easily spread—this can be especially damaging in the ocean, where oils can spread vast distances with nothing to stop them.

A number of solutions have been developed to attempt to mitigate the impacts of oil spills. **Chemical dispersants** similar to household detergents are sprayed from planes or helicopters and help to break up the oils—though sometimes these materials can be just as harmful to wildlife as the oil. **Oil skimmers** (essentially large specialized nets) can be dragged across the surface to separate the oils from the water. **Booms** are floating barriers which are placed around the spill to contain it, though in rough waters these are ineffective as waves simply wash the oil right over the booms. Fire is also sometimes used to burn off the oil, though of course this poses a serious potential danger for humans and wildlife.

Each of these **mitigation methods** has advantages and disadvantages for cost, effectiveness, human safety, and environmental impact. Scientists must carefully consider these factors and many others when designing clean-up techniques.

Aligned Standards

...continued

COMMON CORE: SPEAKING AND LISTENING

- 6-8.7. Conduct short research projects to answer a question, drawing on several sources and refocusing the inquiry when appropriate.
- 6-8.1. Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade-level topics, texts, and issues, building on others' ideas and expressing their own.

HEALTH BENCHMARKS

- Identify sources of air and water pollution and how pollution affects health.
- Identify ways that transportation affects environment and health.

Procedures

1. Ask students what impacts humans can have on the environment (directly or indirectly) when they are enjoying waterways. Answers may include pollution, damaging wildlife, etc. If nobody specifically mentions oil, dig deeper on the "pollution" answer: *What types of pollution can occur?* Trash is a common pollutant and a serious concern, but today we are going to focus on a different type of pollution: oil spills.
2. Ask: *What can cause oil spills? How can people help ecosystems recover from spills?* Expand on student answers with additional information from the **Background Information** section. Be sure to go over the bolded vocabulary words and mitigation techniques.

NOTE: For older students or a more challenging design process, refrain from sharing any information about modern mitigation techniques before the activity Instead, let students freely design their solutions. Share the modern techniques after, and relate these to student designs.

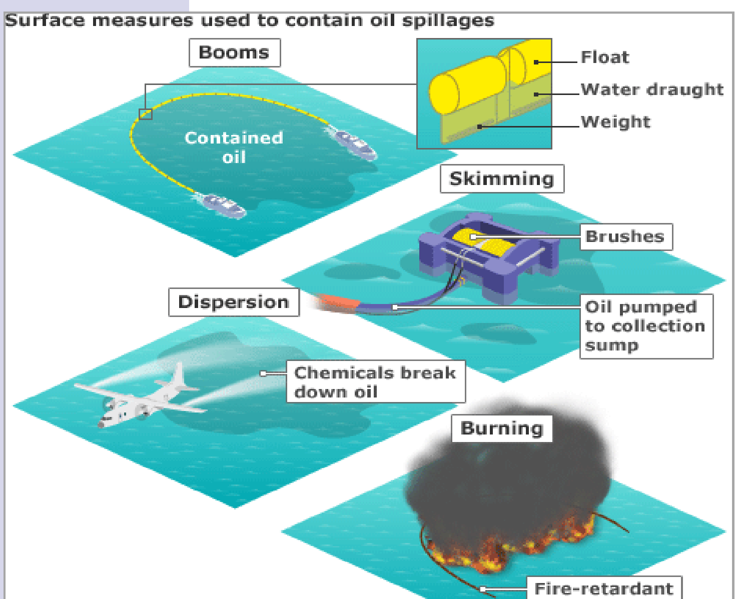

Image credit: BBC/Creative Commons

3. Explain that today, we are going to simulate an oil spill on a lake or ocean. A bowl of water will represent the body of water, while vegetable oil will represent the crude oils and petroleum found in oil spills. *Your task is to design a solution using these materials to mitigate the impacts of your oil spill.*
4. Divide class into groups of 4-6 and distribute the Materials.
5. Allow students to work together to devise and test a clean-up method using the provided materials. Monitor progress and group coherence. Provide guidance if necessary, but encourage independent thinking and group discussion. Give sufficient time to experiment—**the Hands-On portion should be the majority of your class period.**
6. If time allows, have each group present their design, explain their rationale and development process, and defend its success.
7. Discuss all student designs, comparing and contrasting methods used and final products. *Which designs worked the best, and why?*
8. Engage in discussion with students reviewing this activity. *What was the most challenging part?*
9. Wrap up the activity by relating their experiment to the real world. Would their design solutions work in a real body of water? Why or why not?
10. Use the *Community Connections* sheet to encourage students to think about different perspectives in environmental management.

Community Connections: The wreck of the New Carissa

Read the following story about a historical oil spill event off the coast of Oregon. Then use the information provided and your best judgment to explain how you might have reacted.

In 1999, a freighter named M/V New Carissa ran aground on a beach near Coos Bay, Oregon. It was 639 feet long and weighed over 36 tons. Conditions were stormy and the ship's anchor dragged, and by the time the crew noticed this it was too late to navigate away from shore. The ship was abandoned and nobody was injured, but the ship broke into pieces. The fuel tanks began to leak oil onto the beach and into the water, damaging coastal sands and wildlife. To try to mitigate these impacts, it was decided to set the fuel tanks on fire. Napalm, plastic explosives, and other devices were used to ignite the fuel on board. The ship burned for 33 hours, but still did not burn up all of the oil. The bow section was towed out to sea, shot with gunfire and a torpedo to puncture the hull, and sank, trapping the remaining oil within. Efforts to haul the stern section out to sea were not as successful—it remained on the beach for another nine years. Local residents debated whether the stern posed a hazard to human and animal health, and whether it could be more ecologically harmful to further damage the fuel tanks through removal efforts and cause more oil to leak. Some contended that the wreck could become an attraction and generate tourism money that could help the local economy. Eventually, the stern section was dismantled and the metal scrapped. The New Carissa ultimately leaked over 70,000 gallons of fuel oil and diesel on the beach and in the water, and is one of the worst oil spills in Oregon history. Over 3,000 birds were killed, including rare and threatened species. Seals, fish, and valuable oyster beds were also affected.

What would you do?

You are a member of the Coos Bay community and the New Carissa has just run aground on the beach. Everyone is arguing what to do: whether to remove wreckage, leave it on the beach, or find another way to clean up the oil. What do you think should be done, and why?

____

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Do you think you would have the same opinion if you were a:

Hotel owner? ____

Oyster grower? ____

City Health and Safety Official? ____

(HINT: Think about what each person is interested in, and how the wreckage could help or harm their personal wants and needs.)

Additional Resources

If time allows and you have access to a computer lab, students may use the following resources to research oil spills and the New Carissa wreck before completing the *Community Connections* activity.

General oil spill information:

Environmental Protection Agency—Oil Spill Response information and techniques: www.epa.gov/oilspill

NOAA Office of Response and Restoration—How Oil Harms Marine Environments: http://response.restoration.noaa.gov/oil-and-chemical-spills/oil-spills/how-oil-harms-animals-and-plants.html

Clean Boater Guide—preventing and dealing with oil spills: http://www.oregon.gov/OSMB/Clean/docs/clean_boater_booklet_final.pdf

The New Carissa:

Oregon Department of State Lands: The Wreck of the New Carissa—history and legal actions: http://www.oregon.gov/dsl/LW/Pages/ncar.aspx

Oregon Land Management: The Wreck of the New Carissa—timeline, removal processes, site maps, and photos: http://www.oregon.gov/DSL/LW/Pages/carissa.aspx

Article in The Columbian: “The New Carissa– 15 Years Later” (February 2014): http://www.columbian.com/news/2014/feb/08/the-new-carissa-15-years-later/

Oregon Fish & Wildlife: New Carissa Oil Spill—from response to restoration: http://www.fws.gov/oregonfwo/Contaminants/Spills/NewCarissa/

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OREGON CLEAN BOATER

Every boater loves being on the water. A clean marine environment is a vital aspect of enjoying the boating experience. With 180,000 boats registered in Oregon today, the cumulative actions of boaters can have a significant impact on the health of the marine environment. This guide provides some tips on how to become a cleaner boater and do your part to keep our waterways clean and healthy.

Use a fuel collar or fuel bib

BoatUS

BoatUS

Install a fuel/air separator

BoatUS

GAS AND OIL

Small drips and spills of gasoline, diesel, and other petroleum products add up and can have a serious effect on the marine environment, such as: death of fish, mammals, and birds; cancer, mutations, and/or birth defects; destruction of plant life; and reduction of food supply for marine organisms.

Fuel cautiously

- Fuel your boat slowly and carefully – attend the fuel nozzle at all times.
- Make sure the fuel nozzle connects to the fuel tank to prevent static discharge.
- Only fill the tank to 90% since fuel expands as it warms up.
- Use your hand to check for air escaping from the vent. When the tank is nearly full, you'll feel an increase in airflow. Also listen for a gurgling sound indicating the tank is nearly full.
- Fill portable gas tanks on shore – where spills are less likely to occur and easier to clean up.
- Outboards: close tank fuel vent when boat is not in use to save fuel from vapor loss.
- Built-in fuel tanks: install fuel/air separator in the air vent line from tank to prevent air vent spills.

Two-stroke engine exhaust

Inefficient two-stroke engines release up to 30 percent of their gas/oil mixture unburned directly into the water. For every 10 gallons of gas used, more than two gallons of gas and oil go into the water in the form of a rainbow sheen seen when the motor is idling.

Reduce two-stroke engine use

- Consider replacing a carbureted two-stroke outboard (no longer manufactured) with a quieter, cleaner, and more efficient direct-injection two-stroke engine or a four stroke engine.
- If you have a large outboard you don't plan to replace, consider purchasing a small four-stroke "kicker" to use when trolling or moving short distances. You'll save money on fuel, save wear-and-tear on your larger motor and enjoy a cleaner environment.

When detergents, soaps, and solvents are put on fuel spills, fuel that might otherwise evaporate from the surface is scattered down into the water. This "rainfall effect" causes pollution in all levels of the water, rather than just the surface, and is very difficult to cleanup. Additionally, detergents can contain chemicals that are harmful to marine life.

Handle spills appropriately

- If you have a spill wipe it up with a rag – don't hose it off into the water.
- If fuel is spilled into the water:
  - Call 1-800-OILS-911 and the Coast Guard at 1-800-424-8802 for any spill, large or small, that causes a sheen.
  - Don't use soap or dish detergent - they worsen the problem and their use on spills in the water is against federal law.
- If a spill occurs in a marina, notify the marina management immediately.

GRADES 6-8

Time: 45 mins-1 hr.

Boat Engine-eering

Aligned Standards

2014 SCIENCE (NGSS)

- MS-PS2-1. Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.
- MS-PS2-2. Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.
- MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

OR SOCIAL SCIENCE

- Investigate a response or solution to an issue or problem and support or oppose, using research.

COMMON CORE: LANGUAGE

- Integrate information presented in different media or formats as well as in words to develop a coherent understanding of a topic or issue.
- Cite textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.
- Write arguments to support claims with clear reasons and relevant evidence.
- Engage effectively in a range of collaborative discussions with diverse partners on grade-level topics, texts, and issues, building on others' ideas and expressing their own clearly.

Activity at a glance

Students build a simple engine and perform a series of experiments to demonstrate Newton's Laws of Motion. They then modify their engine design to address common boating safety concerns.

Objectives

Students will:

- Understand Newton's three laws of motion through experimentation
- Build an aeolipile ("Hero's Engine") to represent a boat engine
- Design solutions to improve engine performance
- Apply these experiences to understand safe boating practices

Materials

For each group of 4-6 students:

- 1 plastic cup
- 2 plastic bendable straws
- String (approx. 24 inches)
- Modeling clay
- A skewer or something sharp to poke holes in cup
- Pitcher with water
- Sink or bucket
- Copies of Student Sheets

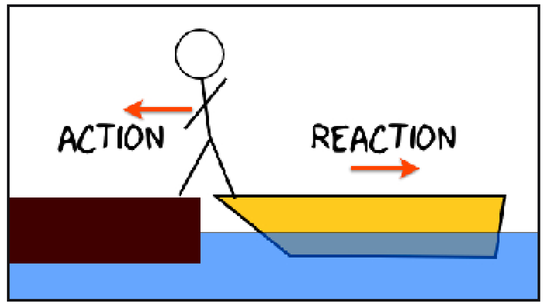


Image credit: wired.com

Newton's Three Laws of Motion explain how boats move and are controlled on the water.

Background Information

Have you ever stepped off a boat onto a dock and felt the boat get pushed away? If so you have experienced **Newton's Third Law** of Motion: for every **action**, there is an equal and opposite **reaction**. The stepping off of the boat is the action, and the boat responds by traveling some distance in the opposite direction. The amount that the boat travels depends both on the mass of the person and the boat, and the force and speed with which they step off. This is explained by **Newton's Second Law,** which states that the **force** on an object is equal to the **mass** of that object multiplied by **acceleration** (F=ma). **Newton's First Law** states that an object at rest stays at rest and an object in motion stays in motion with the same speed and in the same direction unless acted upon by an external force—in other words, an object tends to keep doing what it's doing. This tendency to resist changes in objects' state of motion is known as **inertia**. Of course, a ball rolling across a flat surface won't keep rolling forever because **friction** will eventually slow and stop the ball, which is considered an external force.

These laws of motion govern many things in the world around us every day. Every time you sit in a chair, knock something over, fly in an airplane or high-five a friend, Newton is at work. It is especially important to understand these concepts when boating. Beyond simply stepping off a boat onto the dock, Newton's Laws control the boat's movement, steering, and ability to avoid collisions. These laws help a boat's engine to operate, dictate how quickly the boat can swerve, and the reaction of the boat when it hits the waves. On a sailboat, the wind both pushes and pulls the sail to create movement.

The principles of action and reaction, force, and inertia were understood to some degree before described by Newton. In the first century AD, Hero of Alexandria invented the **aeolipile** (also called Hero's Engine) which was the first known steam engine. The same Laws of Motion which allowed Hero's invention to work are also the basis for today's engine designs.

Procedures

PART 1

1. Introduce the activity by asking if students have ever stepped off a boat onto a dock and felt the boat seem to fly away from their foot behind them. Ask students why that happened? Tell students that Newton's Laws of Motion were behind this event and are the reason for many things in our every-day lives.
2. Use the Background Information and the Resources provided to give a brief overview of Newton's Laws (if students have no previous knowledge of this topic). Use the board to note key terms and vocabulary.
3. Tell students that they will be using Newton's Laws of Motion to build their very own engine. Explain the history and function of a Hero's Engine using the Background Information (there is further information provided on Student Sheet #1).
4. Break students into groups of 4-6 and distribute the building materials. Students will follow the instructions on Student Sheet #1 to build their engines.

NOTE: If you are short on time, or feel that it would be unsafe to allow your students to handle sharp instruments, you may prepare the cups ahead of time by poking the holes yourself.

5. Monitor students carefully for safety concerns while they work, but encourage students to use the directions and diagrams and work as a team to construct their engines.
6. Provide sinks or large buckets for students to test their engines—watch out for water flying around! Students will have to carefully hold their engine above the sink or bucket to avoid spills.
7. Help to troubleshoot any engines that fail to spin. This will likely be due to leaks from the straw holes or not enough water poured into the cup to create the necessary pressure.

PART 2

1. Instruct students to follow the directions to complete Student Sheet #2. Help guide them using the answers provided in the Teacher's Key. You may need to provide additional materials for students to modify their engine designs.
2. Evaluate student understanding and discuss the experience with questions such as:
    - What were some challenges your group faced during the construction process?
    - How does the engine demonstrate Newton's Laws of Motion?
    - Is there anything you would do to change the design if you were to build another engine?
3. Relate the concepts learned to boating safety. Now that students have demonstrated how boat engines work, and learned why boats turn and stop so slowly, remind them that collisions on the water are much more difficult to avoid than in cars. This is why it's so important to operate a boat at a safe speed and stay alert for any obstacles such as other boats, rocks, and swimmers. It is also an important reminder that the best way to be prepared for any accident is to wear a life jacket AT ALL TIMES while the boat is moving, and to encourage friends and family members to do the same!

Sir Isaac Newton (born in England in 1642) was a physicist and mathematician and is regarded as one of the most important scientists of all time. His contributions to science include work in the fields of optics, mechanics, calculus, and astronomy.

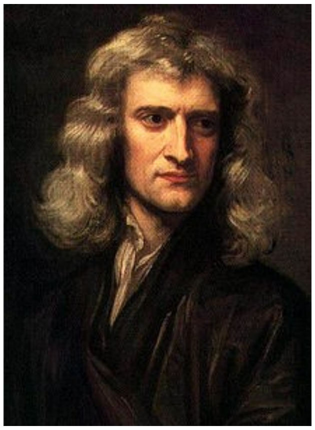


Image credit: Creative Commons

STUDENT SHEET #1

BUILD YOUR OWN "HERO'S ENGINE"!

Hero of Alexandria was the first known inventor of a steam-powered turbine, which he invented in the first century AD and named the "aeolipile". This device consists of a vessel, usually a sphere or cylinder, sitting on an axis and having oppositely bent nozzles projecting from it. When the vessel is pressurized with steam, the steam is pushed out through the nozzles, generating thrust. Because the nozzles point in opposite directions, force is produced along different paths; this combined with the thrust makes the vessel turn on its axis. This invention is the basis of many modern engines, including the ones used in cars and on motor boats.

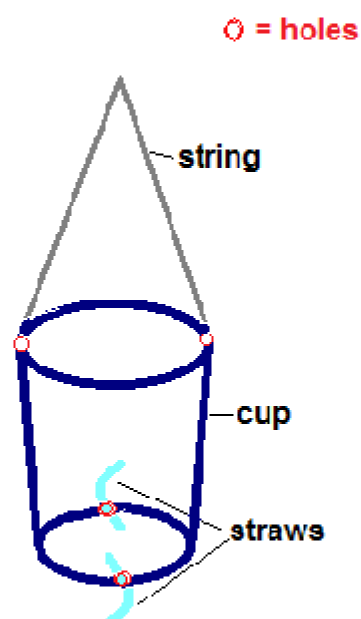
Using a few simple materials we can be "Heroes" and build our own aeolipoles! Instead of using steam to turn the engine, we will be using the power of water pressure.

Image credit: Creative Commons

A sketch of Hero's Engine, showing the vessel pressured with steam from water being heated by fire below.

DIRECTIONS

1. Gather your group's materials: 1 plastic cup, 1 length of string, 2 straws, and a small amount of modeling clay
2. Ask for your teacher's help to poke two small holes near the top of the cup, on opposite sides.
3. Thread the string through the holes and tie the ends of the string in a knot. This will allow you to hold the cup suspended by the string.
4. Ask your teacher to help poke two slightly larger holes, just large enough for the straws to fit through, near the bottom of the cup on opposite sides.
5. Cut each straw about 2 inches below the "bendy" part.
6. Push the end below the "bendy part" of each straw through one of the holes. Turn the straws so that they point towards opposite directions.
7. Divide your lump of modelling clay in half and use each half to firmly seal the spaces between the cup and the straws. Test for leaks by pouring in a small amount of water.
8. Hold your engine away from yourself, over a sink or a bucket. Use a pitcher to slowly pour in water, and watch it spin!



STUDENT SHEET #2

Answer the questions below.

1. Which of Newton's Laws of Motion are involved with making your engine spin, and how? HINT: There may be more than one correct answer.

2. In which direction does your engine spin, clockwise or counter-clockwise?

How would you make your engine spin the other way? Test your hypothesis by modifying your engine design, then record your methods and results:

3. Your engine works much like a boat engine, with the straws representing the propellers, though it is powered by water pressure instead of by fuel combustion. Because boat engines (unlike car engines) are moving through a fluid which is denser than air, they are much slower to react to changes in speed or direction.

How could you modify your design to make your engine spin faster, and thus better allow a boat to swerve more quickly to avoid a collision? Use the space below to describe your methods and sketch a new engine design.

STUDENT SHEET #2

TEACHER'S KEY

Results and Modifications

1. Which of Newton's Laws of Motion are involved with making your engine spin, and how? HINT: There may be more than one correct answer.

*All three of Newton's Laws can be considered to be at play in the engine. The First Law tells us that the engine will remain at rest until acted on by an external force (the water). The Second Law tells us that the stronger the force of the water, the faster the engine will spin (Force=mass * acceleration). The Third Law states that for every action there is an equal and opposite reaction, which is what makes the engine spin: the water being forced by gravity to leave the cup pushes back on the cup in the opposite direction, making it spin.*

2. In which direction does your engine spin, clockwise or counter-clockwise?

Answers will vary depending on which way their straws point.

How would you make your engine spin the other way? Test your hypothesis by modifying your engine design, then record your methods and results:

The straws simply need to be switched around to point in the other direction to make the cup spin the other way. For example, if the straws were initially pointed in a clockwise direction, they need to be turned to point counter-clockwise to make up the cup turn in that direction.

3. Your engine works much like a boat engine, with the straws representing the propellers, though it is powered by water pressure instead of by fuel combustion. Because boat engines (unlike car engines) are moving through a fluid which is denser than air, they are much slower to react to changes in speed or direction.

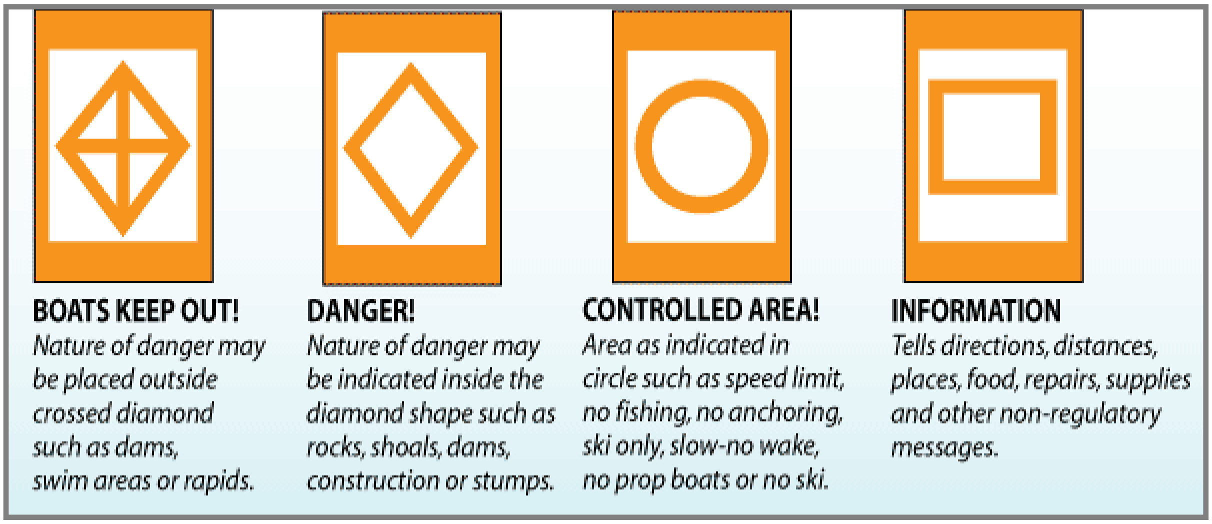
How could you modify your design to make your engine spin faster, and thus better allow a boat to swerve more quickly to avoid a collision? Use the space below to describe your methods and sketch a new engine design.

There are several possible options that could make their engines perform better, i.e. spin more quickly. They could increase the size of the cup to allow more water to be poured in, thereby increasing pressure. The pressure of the water flow could also be increased by making the straw diameters smaller. Making the straws longer or shorter might also change the speed of the engine.

NOTE: If you are able to extend this activity to an additional class period, students may use additional materials to build new engines or modify their existing designs to test the above hypotheses.

The Boating “Rules of the Road”

Navigational aids are similar to traffic signs. They’re placed at various points along our waterways to help boaters locate their position and to steer clear of danger. Because it is difficult to stop or turn a boat quickly, it is very important to understand what the signs mean so you can avoid accidents and collisions. **Draw these common sign shapes on the board and discuss their meanings.**



Additional Resources

The Physics Classroom—Newton’s Laws: http://www.physicsclassroom.com/Physics-Tutorial/Newton-s-Laws

Physics and History of Propellers: http://www.explainthatstuff.com/how-propellers-work.html

Safe Boating—Know Before You Go: http://www.oregon.gov/OSMB/Pages/safety/safety.aspx

Oregon State Marine Board
Education Program

PO Box 14145
Salem, OR 97309

Serving Oregon's recreational boating public through education, enforcement, access, and environmental stewardship for a safe and enjoyable experience.

For more information please contact Mariann McKenzie, Boater Education Coordinator:

Mariann.Mckenzie@state.or.us
503-378-5158

We’re on the Web!
www.boatoregon.com

Water Wits

aquatic safety, science, and stewardship
education program

GRADES 9-12

OREGON STATE MARINE BOARD

GRADES 9-12 OR 6-8

Time: 1-2 hrs.

Cold Water Physiology

Aligned Standards

2014 SCIENCE (NGSS)

- HS-LS1-3. Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

HEALTH BENCHMARKS

- HE.12.PE03.CC: Describe how physical environments affect health and well-being.
- HE.12.UI02.CC: Explain ways to reduce risk of injuries in and around water.
- HE.12.UI04.CC: Explain safe behaviors to reduce injuries during sports/recreational participation.
- HE.12.UI04.GS: Set a goal to wear appropriate safe equipment properly during sports and physical activity, even when peers may not.
- HE12.UI08.CC: Describe methods for avoiding, responding to and recovering from climate-related physical conditions.

COMMON CORE: WRITING, SPEAKING AND LISTENING

- Cite strong and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.
- Integrate information presented in different media or formats as well as in words to develop a coherent understanding of a topic or issue.
- Prepare for and participate effectively in a range of conversations and collaborations with diverse partners.

Activity at a glance

Students learn about the consequences of cold water immersion using videos, case studies, and survivor testimonials. A hands-on activity provides evidence for the impacts of cold water on the body. Strategies for surviving cold water immersion are also discussed.

Objectives

Students will:

- Investigate the physiology of cold water immersion
- Experience the impacts of cold water immersion on mobility and other body functions
- Relate the stories told by survivors to their own experiences and decision-making

Image credit: coldwaterbootcampusa.org

The first moments after a cold water immersion are critical. Without a life jacket most people will drown within minutes, even close to shore.

Materials

- Cold Water Bootcamp and Texas Parks and Wildlife videos (see Resources section for links)
- Projector linked to internet-capable computer to view videos
- Tubs of very cold water - about 10 inches deep and 10 inches wide
- Nuts and screws, assorted sizes
- Copies of Student Sheets (pgs. 3-4)

Background Information

Cold water immersion can happen without warning and immediately impact your body's ability to move, react, and function. There are three stages of cold water immersion: shock, incapacitation, and hypothermia. **Shock** happens the first few seconds your body becomes submerged in cold water (which is technically classified as under 70 degrees). Symptoms include gasping, unable to catch one's breath, and hyperventilation. If your head went under when you fell into the water, you run the risk of breathing in water, which can be very difficult to recover from in windy or wavy conditions. **Incapacitation** occurs after only about 10 minutes, and severely decreases your body's ability to move or do simple tasks such as grasping or holding onto things. At this stage, it becomes exponentially harder to swim, even short distances. The final and often fatal stage is **hypothermia**, in which movement is impossible and the brain begins to shut down. You lose consciousness and finally, your heart will stop.

Without a life jacket, your survival time in cold water is around 10 minutes.

With a life jacket, you can survive for over an hour until hypothermia sets in. Since you lose any meaningful ability to swim after 10 minutes, this extra time is vital, allowing help to arrive.

The **1-10-1 Principle** is an important mantra for cold water survival. This states that you have *one minute* to get your breathing until control and calm yourself, *ten minutes* of meaningful movement, and *one hour* before you lose consciousness due to hypothermia.

Wear a life jacket, don't panic, and remember these rules to give yourself the best chance of surviving accidental cold water immersion.

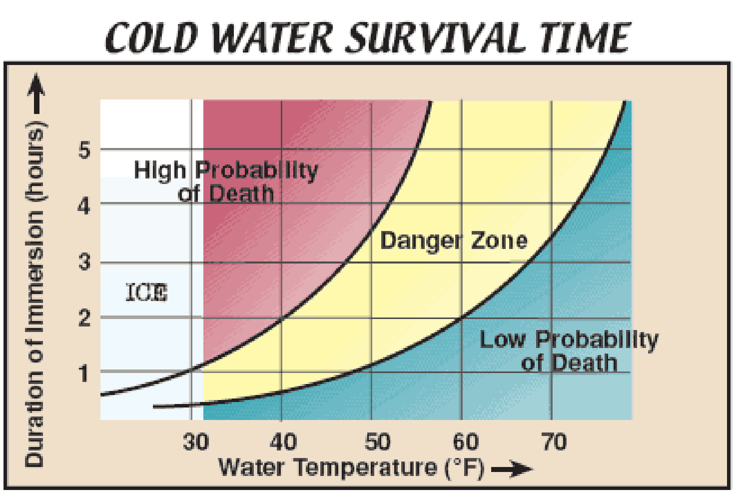
Procedures

1. PREPARE THE COLD WATER TUBS: Fill one or more clear containers halfway with water. Add about a cup of ice. Set aside or in a fridge to keep cold.

2. Introduce the lesson briefly by asking if students have ever become suddenly immersed in very cold water. How did it feel? What reactions did they notice in their bodies? Tell students that they are going to learn about the physiology of cold water and how to survive it by watching two videos and then doing an activity to simulate cold water immersion.

3. First, watch *Cold Water Bootcamp*. This video follows several volunteers as they struggle to swim in very cold water. Note throughout the reactions you can observe in the volunteers when they first hit the water, and what happens over time, with and without a life jacket. Note that these volunteers are all extremely strong, experienced swimmers.

4. Next, watch *Never Happens*. This is a video showing testimonials from young people who watched their friends drown. Note that this is an emotional video, and may be a sensitive subject for some students present, so be aware and cautious before showing this.



The Danger Zone indicates where safety precautions and appropriate behavior can increase your chances of survival when immersed in cold water.

Image credit: Creative Commons

FOR GRADES 6-8: Watch the shorter (10 min) version of *Cold Water Bootcamp*, and skip *Never Happens.* Instead of using nuts and screws, have students pick pennies only out of the tubs from an assortment of other coins.

5. Take some time after these videos for students to share their reactions before beginning the next activity.

6. Now students will simulate the impacts of cold water immersion on dexterity. They will reach into tubs of icy water and attempt to fit together matching nuts and screws. This replicates the feeling of being unable to grasp things, buckle a life jacket, or easily move in cold water. For large classes, use multiple tubs and give each student one minute to fit together as many nuts and screws as they can. *IMPORTANT NOTE: Some students are more sensitive to cold water than others. Monitor students carefully to ensure that nobody is reacting badly, and stop them if they begin to shiver or their skin becomes pale or blue.*

7. Discuss the experience. Were students surprised by the results? Was the exercise difficult for everybody or easier for some? How did their ability to perform the tasks change over time? It is especially important to emphasize their lack of dexterity and mobility. In a real-world situation, it is nearly impossible to hold onto anything or put on a life jacket after going into the water, which is why it’s so important to be prepared and wear a life jacket at all times.

8. Introduce the concept of *homeostasis* and how in cold water the body’s ability to maintain its temperature and function properly is compromised in a number of ways.

9. Distribute copies of Student Sheet #1. Have students read the excerpts and discuss the questions in groups.

10. Distribute copies of Student Sheet #2. If you have access to a computer lab, have students read the information at the *US Search and Rescue Task Force* website and conduct other research to complete the worksheet. If you don’t have access to computers this may also be assigned as homework.

Up close and personal with cold water

Journal excerpts from "Cold Water Bootcamp" volunteer Jonah Pike, US Coast Guard

Swim 1: "...I think I can make it, it's mind over matter. I can do this...I immediately regret my cannon ball. The water on my face is painful. I start to hyperventilate and struggle to stay afloat. My hands are completely numb, I start to get disoriented. I don't know how long it takes but my body starts to go numb, my senses are so confused right now. I know I am doggy paddling and I can't keep more than half my face out of the water. Every kick of my feet feels like getting my legs beat with a broom handle. I finally swim in to shore. All I can remember is the tightening of my whole body… before the interview was over I was uncontrollably shaking violently. Dr Geizbrecht explained I wasn't in hypothermia yet so my core temperature was still high enough to warm up normally. If I wasn't even hypothermic and I was THAT incapacitated I can't imagine really having my core temperature be in the low 90s."

Swim 2: "I'm swimming next to Tim and luckily I get chosen to wear the life jacket. I feel bad for Tim but I can't bring myself to volunteer to switch with him. During class I learn that a large amount of people who drown in cold water do so within a few meters of safety. If that fact alone doesn't scare people into wearing their life jacket, I really don't know what will. Today is so much colder than yesterday, and the wind is blowing. I figure out quickly that with the life jacket on I don't need to move my arms to stay afloat. I tuck my arms close to my side and quit moving them. I look at Tim swimming next to me and the pain on his face makes me feel guilty for effortlessly floating next to him. I know it has been five or ten minutes now and I feel fine. My body is numb, but I'm not in pain and I feel totally coherent. I look back at Tim again, now his face is going under the water every couple of strokes—he's done. I've been in the water fifteen minutes now and I start freestyle swimming towards the boat… When I get on the boat I am in total awe of how much different the swim was with a life jacket.

I learned so many things from this experience. Cold water is something to be feared because it doesn't look any different than warm water and yet it is a hundred times more dangerous. I learned how to swim when I was four and grew up in pools and lakes like many others, but when I jumped in the water without a life jacket it was a crippling feeling. I also feel like it was a very controlled environment I swam in, a harbor with no waves at all. When I was swimming with no life jacket at times my nose was barely out of the water. If I fell off my boat in the lake, it would not be as calm of an environment. I would fall in the water and while I struggled to control my breathing a wave would splash my face, I would suck in water, and it would all be over.

If you do wear a life jacket and make smart decisions when you end up in the water, you can greatly increase your chances for survival and/or rescue. Hypothermia can't kill you without a life jacket—you'll be dead before you get there."

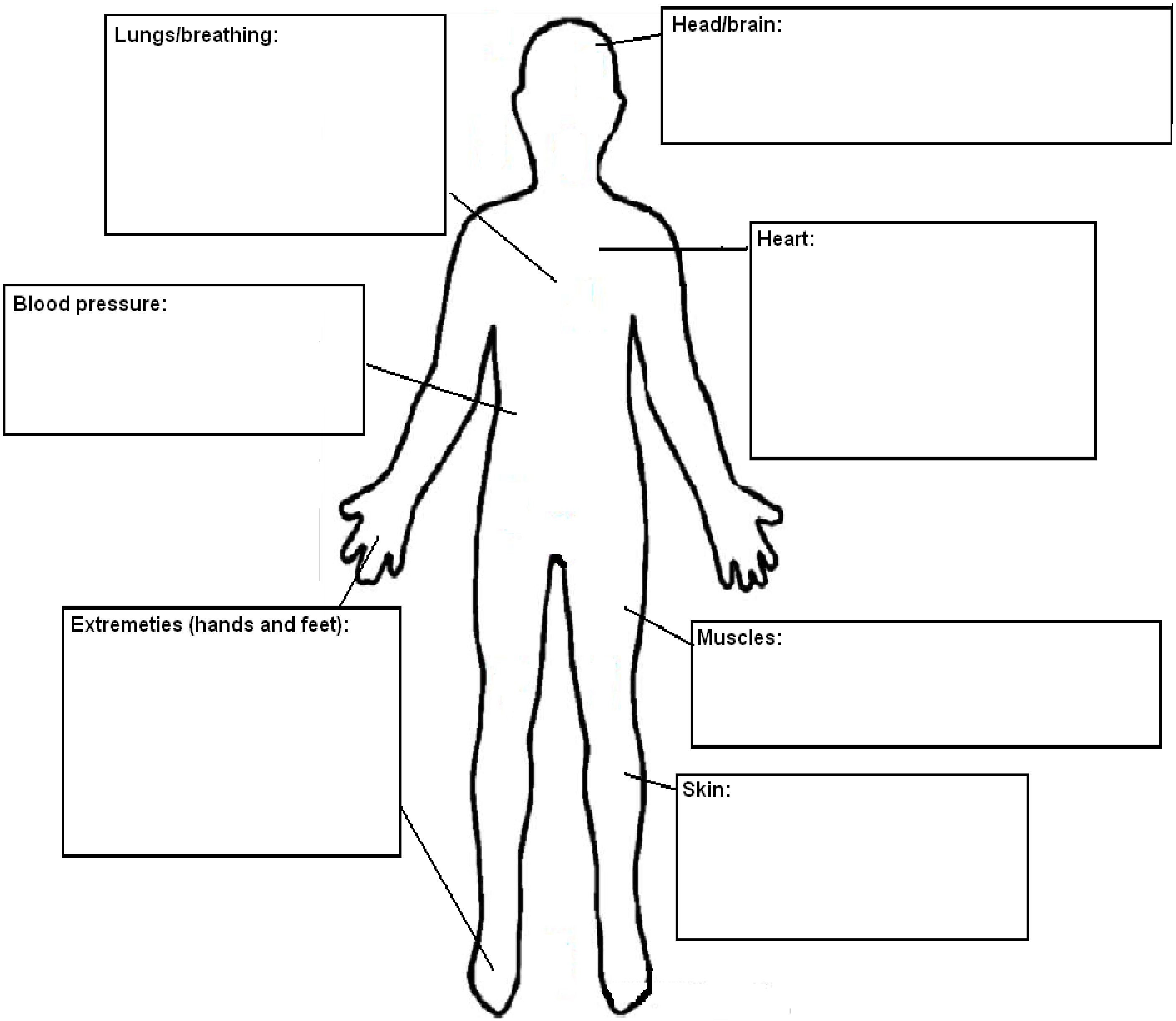
Round-table Discussion

After reading the above excerpts, discuss the following in small groups:

1. What words or phrases jumped out at you, from the journal excerpts or the videos?
2. Have you ever had a similar experience where you came close to a dangerous situation in cold water? How did you deal with it?
3. Will your decisions or actions when out boating or on cold water be different in the future? If so, how?

Physiology

Based on what you have learned, list all of the possible physiological responses to cold water immersion expected for each part of the body:

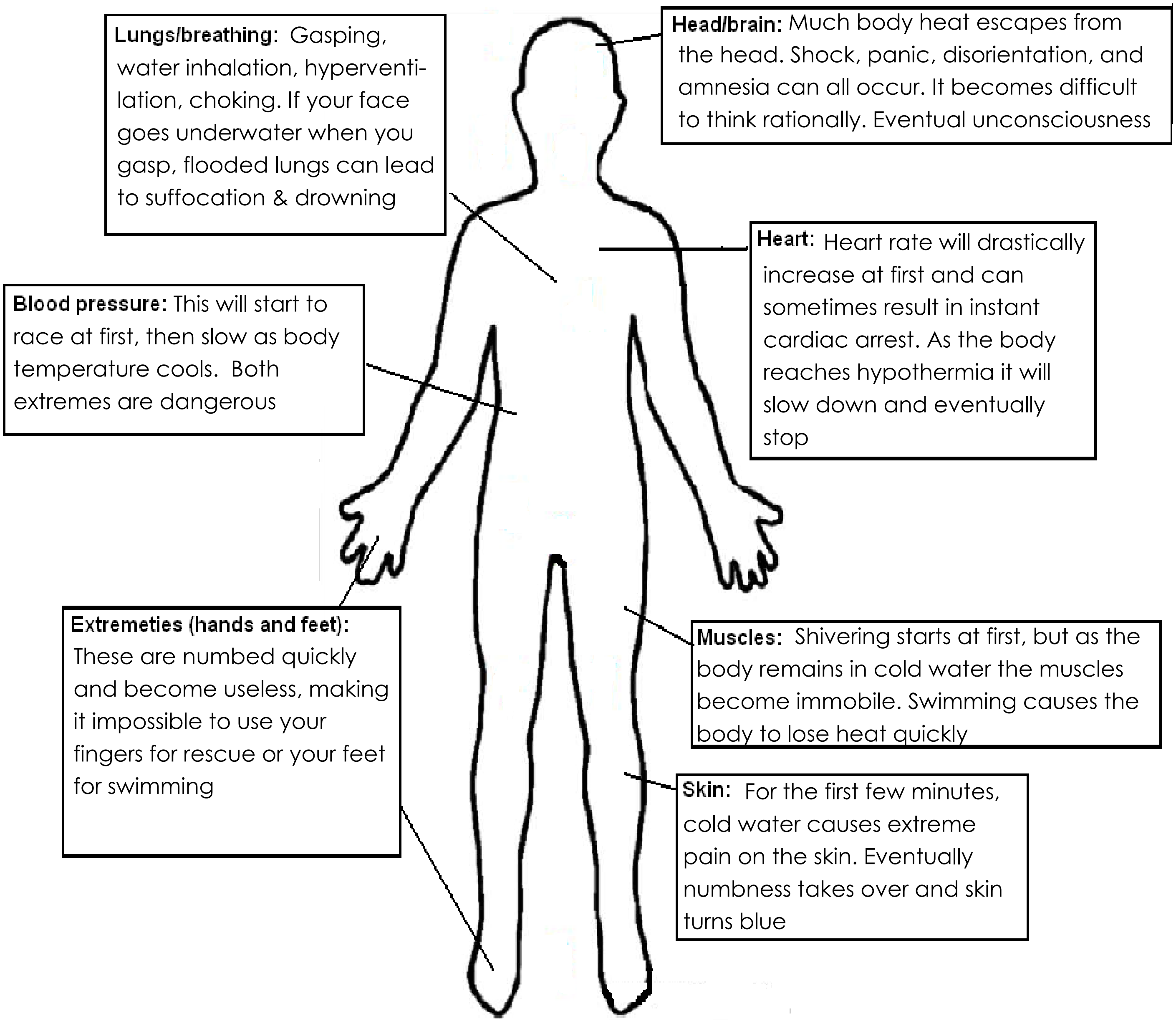


Answer the following:

1. What is your survival time in cold water with and without a life jacket?
2. What is the 1-10-1 Principle?
3. What is the first step all boaters should take to prevent drowning in the event of an accident?

Physiology

Based on what you have learned, list all of the possible physiological responses to cold water immersion expected for each part of the body:



Answer the following:

1. What is your survival time in cold water with and without a life jacket? One hour or more with a life jacket, 10 minutes without one
2. What is the 1-10-1 Principle? In cold water you have 1 minute to get your breathing under control, 10 minutes of swimming time before your muscles shut down, and an hour before you lose consciousness
3. What is the first step all boaters should take to prevent drowning in the event of an accident? Wear a life jacket every time!

Extension Activities

- Have students look for recent newspaper articles describing drowning accidents in their local area. Discuss why the situation may have occurred, what the victims did right and/or wrong, how the situation could have been avoided, etc.
- Start an informational campaign on campus or in the community. High school students can visit the classrooms of younger students to teach them about water safety. Put flyers up around the school encouraging students and faculty to always wear a life jacket and to always boat sober.
- Assign students the task of designing a five-minute "presentation" to teach their family members about cold water dangers, what to do if they go into the water, and accident prevention. Families can then come up with a boating/water safety plan of their own.

Qulin woman drowns in St. Francis river

By MICHELLE FRIEDRICH
Associate Editor

FISK — A Qulin woman drown Thursday afternoon while swimming in the St. Francis River near Fisk.

The victim, who is identified as 42-year-old Lisa Barnett, was pronounced dead at Poplar Bluff Regional Medical Center by Butler County Deputy Bruce Goin.

Authorities learned of the possible drowning at 3:51 p.m. when an 911 call came into the Butler County Sheriff's Department.

Deputies, as well as Missouri State Water Patrolman Jeff Johnson, responded to a location on the river, which reportedly was at the end of a field road off of County Road 628.

According to Chief Deputy Jim Bumpus, when the first deputy arrived he found David

See WOMAN/2A

Additional Resources

- Cold Water Bootcamp: videos and additional resources—coldwaterbootcampusa.org
- "Never Happens" video and additional resources—http://tpwd.texas.gov/fishboat/boat/safety/
- Cold water physical responses (for Student Sheet #2)—www.ussartf.org/cold_water_survival.htm
- Physiology of "Polar Plunges" article—http://www.ibtimes.com/polar-bear-plunge-physiology-what-cold-water-dip-new-years-day-does-your-body-1523686

Oregon State Marine Board Education Program

PO Box 14145
Salem, OR 97309

Serving Oregon's recreational boating public through education, enforcement, access, and environmental stewardship for a safe and enjoyable experience.

For more information please contact Mariann McKenzie, Boater Education Coordinator:

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503-378-5158

We're on the Web!
www.boatoregon.com

GRADES 9-12

Time: 1-1.5 hrs.

Pest-Proof Boat

Aligned Standards

2014 SCIENCE (NGSS)

- HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
- HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

SOCIAL SCIENCE CORE

- HS.61. Analyze an event, issue, problem, or phenomenon, identifying characteristics, influences, causes, and both short– and long-term effects.
- HS.62. Propose, compare, and judge multiple responses, alternatives, or solutions to issues or problems; then reach an informed, defensible, supported conclusion.

COMMON CORE: SPEAKING AND LISTENING

- Conduct short as well as more sustained research projects to answer a question or solve a problem, and synthesize multiple sources on the subject.
- Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric, identifying any fallacious reasoning or exaggerated or distorted evidence.

Activity at a glance

Students learn about the impacts of aquatic invasive species and prevention strategies used by boat manufacturers, then work in teams to design the ultimate invasive species-proof boat using the latest technology and creative solutions.

Objectives

Students will:

- Identify common invasive species which cause problems for boats and waterways
- Learn about current mitigation techniques used by boat engineers
- Work in groups to engineer their own solutions

Materials

- Copies of student worksheets (pgs. 3-4)
- Graph paper or blank paper for sketching designs
- Copies of "Stop The Spread" handout for students to take home (pg. 7)
- Projector, computers, internet access (optional)

Image credit: Creative Commons

How can marine engineers reconcile the need for safe, fast boats with the need to prevent aquatic invasive species?

Background Information

Pollution such as trash and oil spills is a well-known problem for organisms and ecosystems. But there is another threat which is just as dangerous though not as well understood: biological pollution, in the form of **invasive species.** These are plants and animals ranging from algae and seagrass to snails and fish which are not **native** to the region. Invasive species compete with native species for resources like food and space, and are often aggressive and fast-growing. Left unchecked, they can eventually completely replace native ecosystems and the species which live there.

There are a number of **vectors**, or pathways, which transport invasive species to new habitats. The release of pets from home aquariums or classrooms, illegal stocking of lakes or streams with sports fish, and accidental hitchhikers on tsunami debris or driftwood are all culprits. The biggest vector, however, is transport ships. Many aquatic species spend their larval stage as **plankton**, meaning they drift freely in the water. Eventually some of these species attach to a hard surface. At either stage they can be transported across oceans by ships, either in **ballast** (which is the water boats pump into their holding tanks as a counter-weight) or on the sides of the vessel itself. This growth is known as **biofouling** and can damage ships while also creating drag which slows boats down.

Scientists are still searching for solutions, and seeking to understand the many complex impacts of invasive species. An obvious solution, and one required by law, is that boaters must thoroughly clean their boats inside and out when leaving any water body AND before entering another. While not 100% effective, this can help prevent the spread of some species.

An emerging area of nautical engineering is designing boats which are less likely to transport invasive species. Advances in features such as ballast systems and anti-biotic paints could help prevent aquatic invasive species at the source. The challenge is that these boats must also be safe for both humans and the environment. For example, some copper-based paints which are used to prevent biological growth on the sides of boats can be toxic to other marine species. Future scientific research must find the solutions best for both people and the environment.

Procedures

1. Introduce the topic of invasive species, vectors, and threats they pose to habitats. If you have already discussed this topic before, this should be a brief review. If this is a new concept for students, be sure to define the vocabulary and fully discuss the *Background Information* on pg. 1.

2. If time allows watch the videos and/or review selected "Additional Resources" as a class to introduce the concepts.

3. Share the "Stop the spread of aquatic invaders" poster and the boat plumbing schematic. This will help set the stage for students to design their own boats.

4. Discuss current anti-fouling techniques currently used or being researched. If time and computers are available, students may research this independently.

5. Introduce the activity: students will become engineers seeking to create the best design for an anti-invasive species boat. They must work together and think both creatively and scientifically.

6. As a class, come up with a list of specifications that all boat designs must comply to. These don't need to be too detailed or constraining, but should include basics such as: the boat must float, it must carry evenly distributed weight, it must be safe for humans, and must not cause major damage to the environment. You may also designate size requirements.

7. Break students into small groups of "design teams" (4-6 students each). Before beginning their sketches, groups must answer the following questions together:

EXTENSION: Use activities from the *Watershed and Invasive Species Education (WISE) Program* as an introduction or accompaniment to this lesson—see pg. 5 for more information.

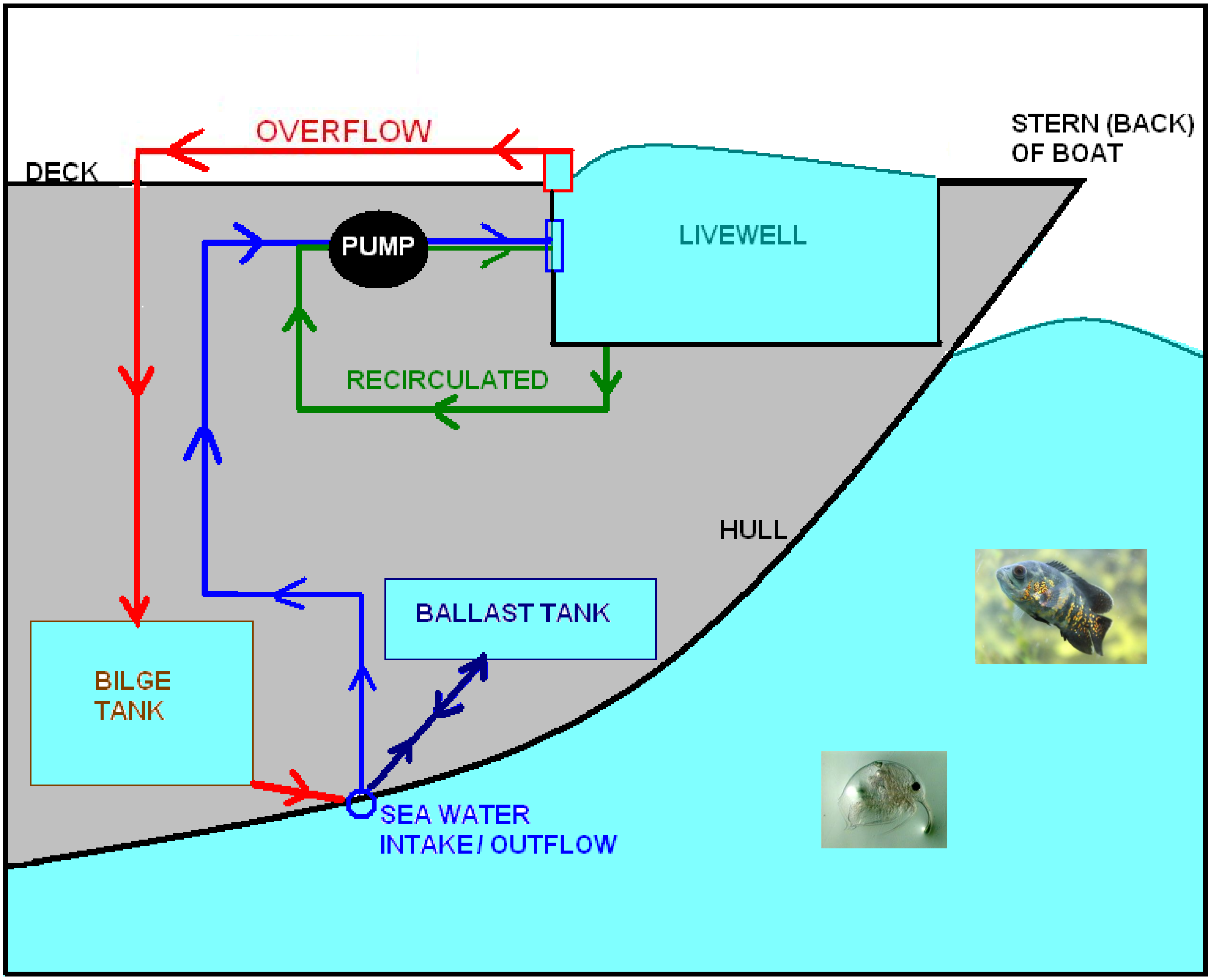
- What type of boat will we design? (sailboat, motorboat, barge, etc.)
- What is the boat used for? (recreation, commercial shipping, etc.)
- What features will we design to prevent the transport of invasive pests?
- How will we incorporate these features while still meeting the required specifications?

7. Start engineering! Give groups ample time to discuss, design, and ultimately draw their ideal "pest-proof" boat. Special features should be labeled. Encourage students to work together, providing guidance or assistance if necessary. Your role as the facilitator should be that of the "project manager", ensuring all teams are following the agreed-upon requirements.

8. At the end of the class period, have each group present their design. Students may vote on the best design, or you as the "project manager" may select the best design based on feasibility, creativity, and how well specifications were followed. Remind students that in the real world, this is often how the process goes: engineering firms compete for the job by pitching their designs to the manufacturers.

Additional option: Over the course of a few weeks, students can build models of their boat designs using household and/or classroom materials.

Simple Boat Plumbing Schematic

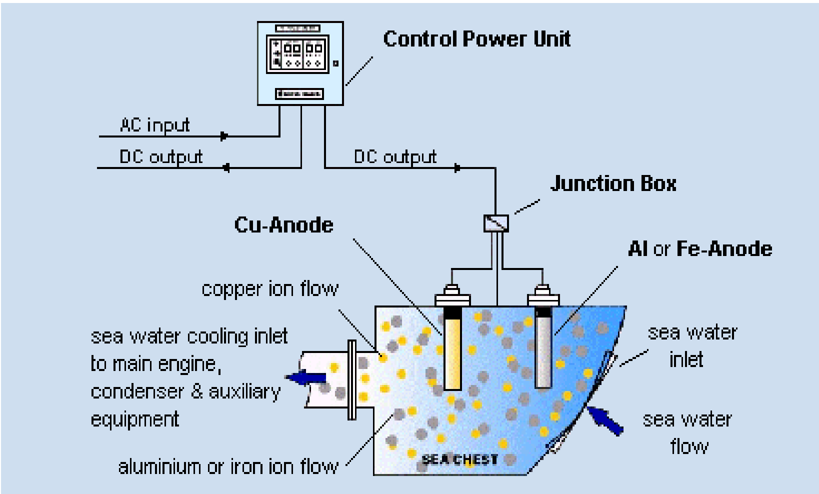


Note the directions that water flows in and out, remembering that sea water can contain planktonic invasive species.

Can you identify the areas most at risk for accumulating or storing aquatic invaders?

Use this schematic to help engineer your own boat, modifying it to reduce the risk of pest species while still performing the necessary plumbing.

Stopping the Invasion: Modern Anti-Fouling Techniques



Schematic Layout of Electrolytic Anti-Fouling System

Image credit: www.cathwell.com

Electrolytic antifouling systems is one of the most commonly used methods to fight biofouling. A pair of anodes (through which electricity flows, as in a battery), one made of copper and the other aluminum or iron. When sea water passes over the anodes, the electric charge produces copper ions which are then carried through the entire boat's plumbing system. This prevents organisms from settling in the pipes.

Electro-chlorination can also be used, in which the salt in sea water is converted to chlorides through electrolysis, but it is more complex and costly to operate.

Ultrasonic antifouling systems are environmentally friendly, and do not introduce chemicals or metals into the water. They work by producing bursts of sonic energy in multiple frequencies simultaneously. This creates an alternating pattern of positive and negative pressure. These in turn create and implode microscopic bubbles, creating tiny jets that scrub the boat's hull. In addition, these sonic bursts can destroy single-celled organisms such as algae, removing that first link in the food chain and thus reducing the ability of other organisms such as mussels to settle on the boat. These systems can also help improve fuel efficiency, but are very expensive .

Antifouling paints are designed to deter the attachment of organisms and/or slow their growth. They contain copper or other "biocides" which slow fouling, but can be highly toxic to other marine life. Some also contain silicone, which creates a smooth surface on which is difficult to attach. Other paints even contain tiny fibers which prevent plankton from adhering.

Oregon Sea Grant Watershed and Invasive Species Education (WISE) Program

The Oregon State Marine Board is proud to partner with the WISE program. This educational curriculum is designed to help teachers learn about emerging watershed issues, which can be used as tools to engage students in science learning and community action.

Now more than ever, watersheds are straining under the weight of emerging issues such as climate change, invasive species, and contaminants. The WISE program addresses this problem by 1) engaging teachers and classrooms in learning about the science of watersheds, and 2) supporting teachers and students to do community stewardship projects. Students have the opportunity to take action on a locally and globally important watershed need.

WISE offers teacher trainings, a STEM (Science, Technology, Engineering and Math) Based curriculum, and on-going teacher engagement in a community for learning and teaching about emerging watershed issues. Students and teachers have created a great variety of stewardship projects ranging from watershed restoration to awareness campaigns. Other classes create comic strips, games, poetry, skits, models, and more.

The WISE curriculum is available online and features several activities relating to this curriculum, including:

Mussel Quarantine Model - students learn the life cycle of the zebra and quagga mussels, their impact on natural systems, and the risk of transport through boaters' habits. Students will take the role of a boater to use a model for determining how long to quarantine their boats.

Design the Ultimate Invader - students will apply their knowledge of biology, ecology, and society to design the ultimate, invincible, invasive species. It also fosters creativity and teamwork to understand the mechanics and mechanisms that make species invasive.

For more information or to get involved in the WISE program, please visit their website at:

http://seagrant.oregonstate.edu/invasive-species/wise

Additional Resources

Invasive Species

Stop the Spread of AIS: http://seagrant.oregonstate.edu/sites/default/files/sgpubs/onlinepubs/g06003.pdf

Hood River News—Invasive mussels found on boat in Ontario: http://www.hoodrivernews.com/news/2015/apr/29/invasive-mussels-found-boat-ontario/

Teacher resources list: www.invasivespeciesinfo.gov/resources

Resources to teach students about aquatic invaders: http://www.sgnis.org/kids/index.html

Invasive Species Information Node: http://invasivespecies.nbii.gov

Habitattitude—preventing aquatic pet/plant introductions: http://www.habitattitude.net/

Oregon Invasive Species Council: http://www.oregon.gov/OISC/

Boat design and engineering

American Society for Mechanical Engineers—Boat design: https://www.asme.org/engineering-topics/articles/transportation/boat-design-an-open-sea-for-mechanical-engineers

VIDEO—Designing a faster boat hull: http://www.engineering.com/Videos/ProductDesignChannel/VideoId/2604/Designing-A-Faster-Boat-Hull.aspx

VIDEO—Boat Manufacturer Shares Design to Prevent Invasive Species Spread: http://kstp.com/article/stories/s3694432.shtml

Marine anti-fouling systems: http://www.cathwell.com/technical/details-on-electrolytic-antifouling/

Oregon State Marine Board Education Program

PO Box 14145
Salem, OR 97309

Serving Oregon's recreational boating public through education, enforcement, access, and environmental stewardship for a safe and enjoyable experience.

For more information please contact Mariann McKenzie, Boater Education Coordinator:

Mariann.Mckenzie@state.or.us
503-378-5158

We're on the Web!
www.boatoregon.com

STOP THE SPREAD OF AQUATIC INVADERS

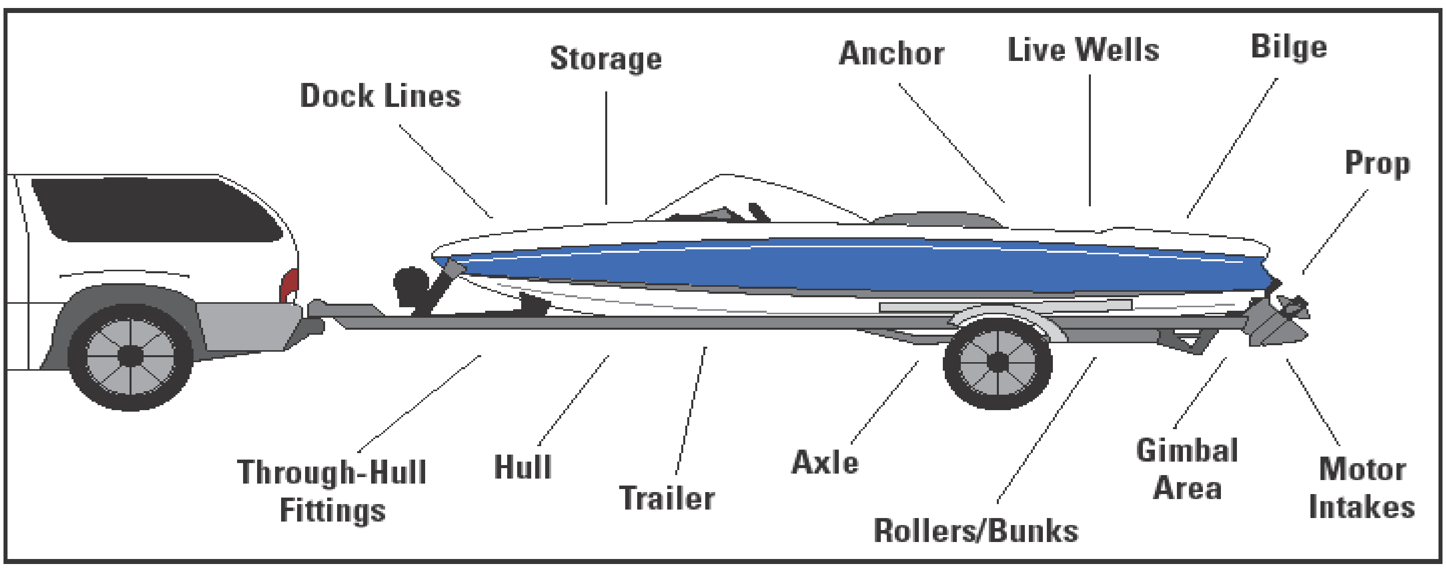
Motorboats, kayaks, canoes, drift boats and other watercraft can carry destructive quagga and zebra mussels, New Zealand mudsnails and aquatic plants—invasive species that cause serious economic and environmental damage to lakes, streams, irrigation and water delivery systems. To halt the spread of these destructive invaders, clean, drain and dry your boat.

Before launching and before leaving... INSPECT EVERYTHING!

CLEAN all aquatic plants, animals and mud from your vehicle, boat, motor or trailer and discard in the trash. Rinse, scrub or pressure wash, as appropriate away from storm drains, ditches or waterways.

DRAIN livewell, bilge and all internal compartments.

DRY your boat between uses if possible. Leave compartments open and sponge out standing water.



Oregon requires boaters to have an Aquatic Invasive Species Permit. Information:

www.dfw.state.or.us or www.boatoregon.com

Report invasive species, 1-866-INVADER

OREGON Fish & Wildlife

the OREGON CONSERVATION STRATEGY

OREGON STATE MARINE BOARD

GRADES 9-12

Time: 1-2 hrs. or up to 1 week

Hazard or Habitat?

Aligned Standards

2014 SCIENCE (NGSS)

- **HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constrains, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.**
- **HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.**

OR SOCIAL SCIENCE

- **Analyze the impact on physical and human systems of resource development, use, and management and evaluate the issues of sustainability.**
- **Analyze an event, issue, problem, or phenomenon from varied or opposing perspectives or points of view.**
- **Propose, compare, and judge multiple responses, alternatives, or solutions to issues or problems; then reach an informed, defensible, supported conclusion.**
- **Engage in informed and respectful deliberation and discussion of issues, events, and ideas.**

COMMON CORE: SPEAKING AND LISTENING

- **Initiate and participate effectively in a range of collaborative discussions with diverse partners, building on others' ideas and expressing their own clearly and persuasively.**

Continued on next page...

Activity at a glance

Students play the roles of various stakeholders in a "town hall meeting"-style debate. Competing interests and issues must be reconciled to reach a resolution about whether or not debris in the local river should be removed.

Objectives

Students will:

- Research viewpoints, opinions, and perspectives to put themselves in the shoes of a stakeholder
- Explore issues of ecology, human safety, economics, and recreation
- Use speaking and critical thinking skills to engage in debate with classmates
- Consider all viewpoints to compromise and devise an acceptable solution

Materials

- Copies of *Town Meeting Instructions*, 1 per student
- Copies of *Town Meeting Announcement*, 1 per student OR posted somewhere in classroom
- Copies of stakeholder role pages, enough for the number of students playing each role
- Access to computers and internet (optional)

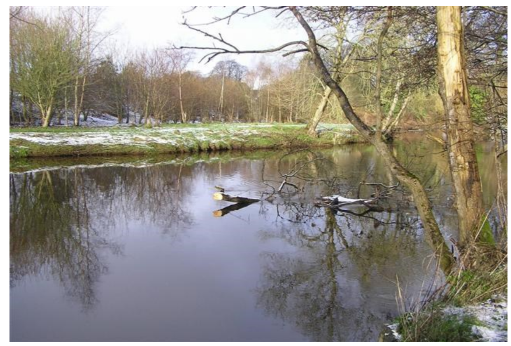


Image credit: Creative Commons

How do people balance ecological and human concerns when making decisions about resource management issues?

Background Information

Resource managers, the people responsible for making decisions about **natural resources** such as rivers, lakes, and beaches, face a number of challenges. Many different people like using these resources for different purposes and will fight for their right to use them. These places are often habitats for commercially important or endangered species. It can be very difficult to balance these competing needs, especially in situations where human safety is threatened.

A common example of such a situation in Oregon is when **woody debris**—fallen trees, branches, or logs—appears in rivers used by boaters. This can present a number of hazards for people, causing damage to boats, blocking passage and navigation, and forming dangerous underwater features called **strainers** which can entangle and capsize boats and their occupants.

However, woody debris also provides a number of benefits to river ecology. The pools created by fallen trees are critical habitat for fish, especially juvenile fish, and accumulate **organic materials** eaten by these fish. Each year millions of salmon make the arduous journey from the ocean up Oregon's rivers to lay their eggs, and woody debris provides vitally important resting places. Since salmon are a species of both ecological and economic importance, river debris is often left in place by resource managers. Woody debris can also help with flood management by absorbing and redirecting the force of the water flow, stabilizing stream banks and protecting them from erosion. This can help protect river-front properties.

The question of whether or not woody debris should be removed from a river is often a contentious one and requires careful consideration to balance the need for human safety and recreational access with potential ecological benefits. Resource managers use a number of tools to help them make these decisions. One of these is holding community **"Town Hall" meetings** inviting all people with an interest in the issue, or **stakeholders**, to discuss the problem. This allows everyone to be heard and to take part in devising a solution which is best for both people and wildlife.

...continued

COMMON CORE: SPEAKING AND LISTENING

- Conduct short as well as more sustained research projects to answer a question or solve a problem, narrow or broaden the inquiry when appropriate, synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
- Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric, identifying any fallacious reasoning or exaggerated or distorted evidence.

HEALTH BENCHMARKS

- Explain ways to reduce the risk of injuries in and around water.
- Advocate for safe alternatives to risky situations in and around water.

Don't forget—Oregon's State Animal the Beaver also needs woody debris to build its dams!

Procedures

1. Introduce with an announcement: our "town" (i.e., classroom), "Salmon River" will be holding a meeting to discuss a hazard recently discovered in our local river. Each student will take on the role of a particular stakeholder (define this term) and prepare some talking points and statements to share their opinion on the issue. Discuss some things they may want to consider when preparing:
    - What would their "character" think about the issue based on their background, wants, and needs?
    - How can a community of people reach a consensus on a controversial issue?
    - What are the best methods for framing a persuasive argument?
2. Distribute the *Town Meeting Announcement.* This will provide some information and details about the issue. Provide further information as needed from the Background Information.
3. Distribute the *Town Meeting Instructions* sheet. Tell students they must follow these rules when debating so we can remain civil and respectful.
4. Assign stakeholder roles and distribute *Role Information* sheets. If time allows, have students conduct research to better understand their assigned stakeholder (see "Options" box to right). Take care to balance the number of students assigned to each role: this could influence the outcome. Each student will decide for themselves, *based on their role sheet*, if they are for or against ("pro" or "con") the Resolution.
5. Allow time for students to prepare talking points, opening and closing statements, and rebuttals. Encourage use of the *Town Meeting Instructions* sheet to prepare. Guide preparations using further information provided in the Additional Resources.
6. The Moderator (played by the teacher and/or a student-see the Moderator role sheet) convenes the town meeting by reading the rules aloud.

OPTIONS FOR THIS EXERCISE

This activity was designed to be very flexible depending on the amount of time and resources available. If you are limited to one class period, give students a few minutes to brief themselves on their roles and prepare some talking points, then use the remaining time to hold the debate, making sure enough time is left at the end to conclude and discuss.

If you have more time and access to computers, students can spend a class period thoroughly researching their roles and preparing opening and closing statements. Alternately you can introduce the activity and assign roles the class period before holding the debate, and have students conduct background research as a homework assignment.

There are also opportunities to extend this activity for several weeks. Visit a local river to look for debris and analyze whether it might constitute a hazard or good habitat. Invite a fish biologist, ODFW agent, or Marine Patrol officer to speak with your students about their experiences with similar issues. Have students work in stakeholder groups to conduct background research, strategize, and prepare their statements. As a final wrap-up assignment, ask students to write papers detailing the viewpoints of all the stakeholders, the trade-offs (ecological, social, etc.) involved, and a defense of their personal opinions on the issue.

Procedures (continued)

7. The first statements will be made by the Marine Patrol Officer to offer details about the debris and potential safety concerns, reading the official report. NOTE: this role should only have one speaker, but you may assign more students to play this role—see Stakeholder sheets

8. The Moderator opens the floor to those wishing to oppose the resolution ("con" participants) who make their opening statements.

9. The Moderator asks for opening statements by those supporting the resolution ("pro" participants), who can also offer rebuttals to statements made by the "con" side. These initial arguments should succinctly state the advantages or disadvantages of the resolution.

10. The Moderator opens the floor up to everyone. He/she should closely monitor speaking times and enforce the two-minute limit for statements. The meeting continues with stakeholders from each side taking turns providing clear evidence to support their arguments. To encourage participation, each student should be required to make at least one statement; to accommodate this, you may need to modify the speaking time limits.

11. The Moderator calls for final closing statements. If time is running short you may limit these to 1 minute or less. At least a couple of representatives from each side should speak, concluding their main points and attempting to persuade those present.

12. Moderator asks for a vote on the resolution. This should be conducted anonymously by the Moderator. The Town Council Members may vote, but the Moderator may not.

13. The results of the vote are announced. A 70% majority is required to pass the resolution (this may be calculated by the Town Council). If this majority has not been achieved, the meeting goes into a Recess while the Town Council members *re-frame the resolution based on the comments made during the meeting*. This will likely involve finding a compromise or middle ground that more people will feel comfortable with.

14. The new resolution is read aloud, and the Moderator conducts another vote. As before, if there is no majority consensus, the resolution must be re-framed by the Town Council.

15. The Moderator announces, "Resolved!", followed by another reading of the agreed-upon resolution, and he/she officially closes the meeting.

16. Wrap up the activity with a discussion of the experience. Questions to ask the class may include:

- Were students pleased with the outcome? Why or why not?
- Do they think there were any groups/people that were not represented at the meeting that should have been?
- Do they feel that such public forums are a useful tool for communities to make decisions?
- Do they feel everyone's voice was heard and treated fairly?
- What would they change about the proceedings if they were in charge and why?
- What was the most challenging aspect of this activity?

NOTE: The following instructions and stakeholder roles were designed for a class of about 30 students. Adapt as needed.

TOWN HALL MEETING ANNOUNCEMENT

ATTENTION RESIDENTS!

We will be holding a public meeting to hear comments and vote to decide on the resolution:

THE WOODY DEBRIS CURRENTLY OBSTRUCTING SALMON RIVER WILL BE REMOVED.

A majority "yes" vote will mean that the debris will be removed immediately and entirely. A majority "no" vote means the debris will be left in the river as it is. If the town is unable to reach a majority vote, the resolution will be re-framed based on public comments.

BACKGROUND INFORMATION: A large pile of woody debris (fallen tree branches) has been reported in the Salmon River at a site popular with boaters and fishermen (see map below for exact location). It has not yet caused any major accidents, though the state has received several complaints from concerned boaters claiming it is a navigation hazard. However, this area is part of the annual salmon run and such debris provides vital habitat for salmon and other fish. Some people have expressed a desire to remove the debris to protect boater safety and access, while others have spoken out for leaving it to help the salmon population.

All public opinions and comments are welcome. Representatives from the Oregon Department of Fish and Wildlife (ODFW) and our local Marine Patrol Office will also be present to offer their professional opinions.

Image credit: Creative Commons

Image credit: Google Earth

Rules for participating in a Town Hall Meeting (to be read before each meeting is convened):

1. All attendees must remain respectful and courteous at all times
2. Anybody who wishes to speak must first raise their hand and be formally recognized by the Moderator before speaking
3. No interrupting or speaking out of turn
4. There is a **two-minute time limit** for each statement and/or rebuttal. This will be strictly enforced by the Moderator
5. The Moderator and Town Council Members retain the right to dismiss or ban from speaking any participant who does not follow the above rules

Tips and suggestions for speaking at a public forum

1. Know your material—research your speaking points thoroughly to avoid giving false information
2. Utilize evidence and scientifically-supported information to strengthen your arguments. Select key evidence which best supports your main points—avoid overwhelming the audience with facts
3. Speak clearly, loudly, and slowly so that everybody can hear and understand you
4. Prepare an opening statement, closing statement, and a list of main talking points
5. Focus on two or three clear, well-supported arguments rather than many weak ones
6. Avoid personal attacks on members or groups on the opposing side—this is grounds for dismissal
7. Anticipate potential rebuttals from the opposing side, and prepare responses for these
8. Understand that others will not share your opinion and be open-minded to diverse viewpoints

Typical structure of a Town Hall Meeting

-Moderator officially convenes the meeting and reads the rules above

-A representative will offer an official report relating the key points of the issue being resolved

-Those opposing the resolution (the “con” side) wishing to speak will offer opening statements

-Those supporting the resolution (“pro”) wishing to speak will offer opening statements and/or may rebut points offered by the “con” side

-The discussion continues with participants each taking turns to speak, guided by the Moderator

-Moderator calls for closing statements

-When the conversation has reached a natural stopping point OR 20 minutes are remaining, the Moderator calls for a vote

-If there is no majority consensus, the Town Council re-frames the resolution and offers it again for vote. This continues until a majority can be reached (may require additional Town Hall Meetings)

The Moderator

Image credit: www.freestockphotos.biz

This is arguably one of the most challenging and important roles of the entire meeting, because the Moderator is responsible for making sure the meeting runs smoothly and that participants remain civil. The Moderator enforces all rules, and has the power to dismiss or ban from speaking any participant who does not follow those rules. As such they need to be very familiar with all rules and proceedings. She or he officially opens and closes all meetings and calls for votes, and is the only person who may count the votes. She or he is also responsible for carefully timing all speakers and enforcing the two-minute-per-turn time limit. The Moderator coordinates with Town Council Members as needed, especially in the case of a re-framing of the resolution and a re-vote. The Moderator monitors the discussion, keeping speakers on-topic and directing the discussion as needed. In the case of a "lag" in the discussion, the Moderator may pose a question to help spark continued conversation. However, it is essential that the Moderator remains neutral throughout the meeting. (S)he should not offer any personal opinions or attempt to steer the discussion in any way.

The Moderator also needs to have a strong grasp on the subject matter, so as to be able to help guide the discussion and ask stimulating questions. She or he should be familiar with the history of the issue, steps taken to date, the pros and cons of each side, and potential trade-offs for different interests or stakeholders. The Moderator should have excellent communication skills, be highly organized, be able to command the room, and be able to make quick decisions and judgment calls when necessary.

This role may be played by the Teacher, shared by 1-2 students, or a combination of the Teacher and a student working together.

Resources for preparation and research

- Real Democracy: The New England Town Hall Meeting and How It Works by Frank M. Bryan
- An interview with Candy Crowley, moderator for the 2012 Presidential debate: http://www.cnn.com/2012/10/10/politics/crowley-debate/
- 20 Tips to Host an Effective Townhall: http://prtini.com/20-tips-to-host-an-effective-townhall-online-or-in-person/
- King County, WA Woody Debris page: http://www.kingcounty.gov/environment/watersheds/general-information/large-wood.aspx
- Management and use of large wood in rivers: http://evidence.environment-agency.gov.uk/FCERM/en/SC060065/MeasuresList/M5/M5T3.aspx

Town Council Members (3-4 people)

Image credit: Creative Commons

Council Members have been elected by their community to represent the interests of the community as a whole. While each Council Member likely has their own interests and agendas, their job is to advocate for the desires of their constituents while also seeking the best solution for the majority. They must weight the needs of any one person or group with the needs of the community as a whole. At the same time, they must represent the larger interests of the local and state government, including economic budgets, practical limitations, and under-represented groups such as children and minorities. They pay close attention to the legal aspects of any discussion, and must be able to identify the short-term as well as long-term impacts of decisions. Councilors may be career politicians but they are also often businesspeople, activists, lawyers, educators, or economists.

At a public forum such as a town hall meeting, the Council Members are responsible for upholding the democratic process. In other words, they make sure that everybody's voice is being heard and that as many interests as possible are being represented. They do this in cooperation with the Moderator by asking questions that help to facilitate the discussion, offering insights which the general public may not have, and voicing their own concerns about the issue. They act in support of the Moderator to help enforce meeting rules and civility, and if necessary may also exercise the power to dismiss an aggressive speaker. In the case of a vote which does not achieve a majority (70%) consensus, the Councilors are responsible for re-framing (re-writing) the resolution. For example, if the majority of voters don't agree with the resolution "All dogs must be kept on leashes in all public areas", the Councilors may need to re-frame this as something like, "Dogs displaying aggressive behaviors towards people or other dogs must be kept on a leash in public areas." The term *aggressive behaviors* would then need to be defined and agreed upon by the voters. Re-framing a resolution almost always involves finding a compromise between the two opposing sides, and often requires creativity and cooperation on the part of Council Members to get a majority consensus.

Resources for preparation and research

- Real Democracy: The New England Town Hall Meeting and How It Works by Frank M. Bryan
- 20 Tips to Host an Effective Townhall: http://prtini.com/20-tips-to-host-an-effective-townhall-online-or-in-person/
- King County, WA Woody Debris page: http://www.kingcounty.gov/environment/watersheds/general-information/large-wood.aspx
- Salem, OR City Council page: http://www.cityofsalem.net/CityCouncil/Pages/default.aspx
- How Local Government Works: http://www.thepeoplesbudget.org.uk/start/localgov/
- How City Councils Work: http://people.howstuffworks.com/government/local-politics/city-council.htm

Marine Patrol Officer (1 person or more)

Image credit: Creative Commons

A Marine Patrol Officer is essentially a police officer on the water. They ensure the safety of boaters and all others who use freshwater and saltwater areas, both recreationally and commercially. These may include swimmers, water-skiers, fishermen, shipping vessels, and non-motorized boaters such as kayakers and rafters. Marine Patrol Officers protect these users' safety by enforcing all the rules and laws on the water. These laws may pertain to safety but also include environmental regulations, such as pollution and fishing limits. Generally they patrol the waterways on their own boats labelled "Sherriff" or "Marine Law Enforcement". Officers may work for a separate state agency, a division of the state police, or a special unit within a local sheriff's office or police department. They work in cooperation with state agencies such as the Oregon Department of Fish and Wildlife (ODFW) and the Oregon State Marine Board (OSMB).

Regardless of who they work for, if it happens on the water, the marine patrol is generally responsible for it. They are responsible for investigating events such as boating accidents, drownings, and other fatalities which happen in, on, or near the water. Sometimes they are even called upon to remove dangerous aquatic wildlife, such as alligators, snakes, or sharks. Just like traffic officers, Marine Patrol officers stop any boaters they suspect of engaging in illegal activities while boating (such as alcohol or drug use) and issue tickets or arrests. A Marine Patrol officer needs to have excellent knowledge of marine law, good judgment, and strong "people skills" to interact with diverse members of the public. Above all, their main concern is for public safety and the safety of their own officers.

Part of the job of a Marine Patrol officer is to make public appearances, both to help raise awareness about safety issues and to provide testimony or details about a particular case or issue. For this Town Hall Meeting, the Marine Patrol Officer is responsible for reading the following official report on the Salmon River debris issue:

OFFICIAL REPORT: We first received calls about the Salmon River debris about two months before this meeting. Marine Patrol officers were dispatched to investigate, and determined that the debris present was small and did not constitute a safety concern. A few weeks after that, officers determined that the debris pile had grown significantly since it was first reported and could pose a threat to navigation and human safety. The debris is approximately in the middle of the channel, half a mile downstream of the bridge, in a location which already has limited navigation due to the presence of a wide sand bar on the eastern bank. The debris pile is in a round shape, about 10 feet in radius and is visible at both high and low tide. At this time it has not caused any major accidents but there have been a few instances of entanglement with fishing gear.

Resources for preparation and research

- Marine Patrol Officer Career Information: http://criminologycareers.about.com/od/Law-Enforcement-Careers/a/Career-Profile-Marine-Patrol-Officer.htm
- Oregon Boating Regulations: http://www.oregon.gov/OSMB/BoatLaws/pages/regulations.aspx
- Oregon Law Enforcement Program—What Marine Patrols do: http://www.oregon.gov/osmb/boatlaws/pages/leprogram.aspx

Fish & Wildlife Biologist (2-3 people)

Image credit: Creative Commons

The mission of the Oregon Department of Fish & Wildlife (ODFW) is "to protect and enhance Oregon's fish and wildlife and their habitats for use and enjoyment by present and future generations". Essentially, it is the agency responsible for managing all of the state's natural resources. Sometimes this means protection and conservation, while at other times it means removing harmful weeds or invasive species. Sometimes certain habitats are changed to improve habitats for ecologically important or socially desirable species. Other projects undertaken by ODFW include restoring native animal populations to their historic range, restoring wetlands, and tagging endangered or threatened species to track their movement and survival. Much of the agency's annual budget comes from the sale of fishing and hunting licenses, and hunting and catch limits are carefully monitored.

To work as a biologist for an agency such as ODFW, you must have at least a bachelor's degree in a natural science such as Fisheries and Wildlife Science, Ecology, or Biology as well as several years working in the field of conservation or resource management. Many scientists have advanced degrees and decades of experience. Biologists must be experts not only in local flora and fauna, but also in data collection and project management. They must be aware of current research in their field and be sensitive to local cultural issues, such as fishing as the main food or income source for local families. Biologists spend a lot of time outdoors doing habitat restoration, collecting samples, and monitoring ecosystem changes. They also have to spend a lot of time in front of a computer, recording and analyzing data and preparing reports to help other ODFW staff make decisions about wildlife management.

Habitat and wildlife management requires a lot of work, so ODFW biologists rely on volunteers to help with many of their projects. One such project is the Salmon and Trout Enhancement Program (STEP). Based on local needs, scientists and volunteers work together to assess stocks (populations) of these species, restore their habitats, and raise new stocks in hatcheries. These species are of high concern not only because they provide a lot of food and money for Oregonians; they are a vital link in marine and aquatic food chains. Due to climate change, dams, loss of habitat, and pollution, some species are declining. ODFW biologists are taking steps to change this. Salmon need the pools and shelter provided by woody debris such as fallen trees and large branches to survive their long journey up-river: without it, fish have nowhere to rest or find food. Many salmon conservation efforts focus on placing woody debris where these fish live. Doing so has been proven to help more fish survive and increase stocks.

Resources for preparation and research

ODFW main page: http://www.dfw.state.or.us/agency/

ODFW Biologist/Natural Resource Specialist job description: http://dfw.state.or.us/hr/docs/hrInsertBio.pdf

The Salmon and Trout Enhancement Program: http://www.dfw.state.or.us/fish/STEP/docs/SS11_SalmonTrout.pdf

Salmon Ecology 101: http://www.pebblescience.org/pdfs/salmon_ecology_fact_sheet.pdf

Woody Debris and Fish Conservation: http://anrcatalog.ucdavis.edu/pdf/8157.pdf

Recreational Boater (3-4 people)

Image credit: Creative Commons

Oregon's waterways offer many opportunities for recreation, one of the most popular of which is boating. From small streams and lakes to mighty whitewater rapids to the ocean, Oregon has some of the best opportunities for recreational boating in the U.S. A boat allows people to explore isolated waterways, go fishing or hunting, and enjoy scenery they would never have access to on foot. Motorboats, sailboats, rafts, kayaks, canoes, kite boards, and jetskis (also known as personal watercraft or PWC's) are all different types of boats which provide fun outdoor experiences. Boating also allows the opportunity for friends and families to spend time together away from screens and offices. Whether for adventure or relaxation, about 29% of US households has at least one member who boats, according to a 2011 USCG survey.

Recreational boaters come from all walks of life, but they are united by their love for our shared waterways and the desire to be able to enjoy them now and into the future. In order to do so, boaters require access to waterways and waterways which are safe, navigable, and unpolluted. If people are unable to get into the water, or navigate it safely, they may be less likely to go boating. Many people use boats for recreational hunting, fishing, birding, or wildlife viewing, so boaters also generally want waterways with healthy populations of fish and other wildlife. Sometimes, in order to protect the environment, boating is limited or temporarily banned. This is a trade-off that some, though not all boaters are willing to make. Boating can be a dangerous activity if not done safely, and just like when driving a car, boaters must follow certain "rules of the road" on the water including speed limits and passing other boats safely. Important laws governing boating safety include mandatory life jacket use for children 12 and under when the boat is in motion, and the use of alcohol or drugs—any person in control of the boat must be sober. If boaters break any of these rules they are subject to being pulled over by Marine Law Enforcement and may be given a ticket or even arrested.

Many boaters are actively involved with government and legislation surrounding boating issues. These issues range from the building of boating facilities, to conservation of waterways, to the regulation of fishing catch limits, and more. There are a number of local, state, and nationwide advocacy groups for boaters, not all of which take the same stances on certain issues (see Resources below). Ultimately it is the boater's personal interests, experiences, and knowledge which determines how they stand on the issues affecting them.

Resources for preparation and research

Recreational Boating and Fishing Foundation: http://takemefishing.org/boating/overview/

BoatUS Action Alerts: http://www.capwiz.com/boatus/home/

National Boating Foundation: http://www.n-b-f.org/issues.html

Public Use of Oregon's Rivers and Lakes: http://www.oregon.gov/OSMB/access/docs/navigabilitybrochure.pdf

Responsive Management Boating Demographics: http://www.responsivemanagement.com/boating.php

Commercial Fishers and Fishing Guides (3-4 people)

Image credit: pixabay.com

For many centuries, fish which populate rivers for at least part of their lives, such as salmon, have been an important source of food and income for the Pacific Northwest. Over time, changes in habitats and in fishing methods have majorly influenced the fishing industry.

Commercial fishing is the industry of harvesting large amounts of fish for profit and is done by a range of large– and small-scale operations, from corporations to family businesses. Targeted species range from fish to mussels, clams, shrimp, squids, lobsters, and more, but in general very few species support most of the commercial fishing industry. Millions of tons of these species are caught each year and sold in markets around the world, making it a very important part of the global economy. In the US, commercial fishing provides about two million jobs and 185 billion dollars each year. Many different methods are used to capture fish including nets, lines, traps, and trawling.

In Oregon, much commercial fishing takes place in large rivers such as the Rogue and the Columbia (which alone sees over one million salmon every year). Salmon populations vary from year to year, sometimes appearing in great abundance while at other times there are not enough for every boat to catch enough to make a profit. Each commercial fishing operation has a limit on how many fish they may catch in a day or a season, depending on that year's stock assessments, which are performed by biologists to determine the population of each species. In years when there are few fish, it is very difficult for commercial fishermen to make a living and they sometimes suffer huge economic losses. Because they depend on healthy fish populations for their livelihood, fishermen are often very interested in and supportive of fish conservation efforts. However, their operations also require safe and navigable waterways, free of large debris or other dangerous obstacles.

There are others in the fishing industry besides commercial fishers who are reliant on clean water and good fish populations for their livelihood. Fishing guides, for example, make their living by taking recreational fishers out on their boats. Fishing guides need to have access to good fishing spots to support their business. Rivers with good fish habitat which are also easy to navigate are the most popular with fishing guides and recreational fishers alike.

Resources for preparation and research

Pacific Fisheries Management Council: www.pconcil.org

Voices of the Fisheries—Interviews and videos: https://www.st.nmfs.noaa.gov/humandimensions/voices-from-the-fisheries/index

History of Commercial Fishers—Columbia River salmon: http://americanhistory.si.edu/onthewater/exhibition/3_6.html

A guide to Oregon's commercial fishing vessels: http://ir.library.oregonstate.edu/xmlui/bitstream/handle/1957/25066/SGNO681981.pdf?sequence=1

National Fisherman—news and blogs: http://www.nationalfisherman.com/

General Public (6-8 people or more)

As a member of the Salmon River community, you want to know how this issue affects you and want to make sure that the final decision serves your best interests. Choose one of the following roles, working together with others in this group to make sure that each person is representing a different role. **Use the following profiles and provided resources to formulate a clear viewpoint for your character (you may be pro, con, or undecided**).

Seafood restaurant owner: Your restaurant serves local seafood caught in the Salmon River, and you work with local fishermen to buy their catches fresh off the boat. How will the presence of woody debris help or harm the amount of local seafood you are able to buy? Will you be able to sustain your business?

Start here: http://www.nmfs.noaa.gov/stories/2012/03/05_localocean_laura_anderson.html

Environmentalist: You are concerned about habitat, biodiversity, and pristine waterways. You may not know much specifically about woody debris, but you do know that it can serve as an important habitat for many different species.

Start here: http://www.environmentoregon.org/

Reporter/Journalist: While you may have your own opinions about this issue, you are mostly concerned with getting a good story. Ask stimulating and potentially antagonistic questions to get the conversation flowing in an interesting, exciting way.

Start here: http://www.wikihow.com/Read-and-Speak-Like-a-TV-News-Reporter

Aspiring politician: Are you a Republican or Democrat? What issues do you care about? And what stance will help you, as a potential candidate, to get the most votes? As somebody looking to appeal to the masses, you may choose to go with the majority opinion, or opt to speak out for your own opinions.

Start here: http://goingpolitical.com/how-to-become-a-politician/

OSMB staff: As the first point of contact with waterway users, Marine Board staff must be able to balance individuals' concerns about boating and environmental issues with the best decisions for the waterway as a whole– people AND wildlife. They rely on good relationships with Marine Patrol Officers and ODFW scientists to make these decisions. At meetings they may represent the interests of both boaters and other waterway users.

Start here: http://www.oregon.gov/OSMB/

Birder/Wildlife viewer: As an avid wildlife enthusiast you are most concerned with how the presence of woody debris affects birds, especially endangered or migratory species. Do some research to find out if woody debris provides habitat or other resources for birds or other animals.

Start here: http://audubonportland.org/

Boat shop owner: Your business is boaters, and for years you've done very well selling supplies and equipment to Salmon River boaters and fishermen. With woody debris obstructing part of the river, how will this affect you? Will it decrease boating and make you lose business, or increase fishing and actually help your profit margin?

Start here: http://www.bloomberg.com/consumer-spending/2012-05-15/the-real-cost-of-owning-a-boat.html#slide2

You may also choose to invent your own character not on this list. If you do so, make sure that you do the necessary research to understand your character's perspectives, experiences, wants and needs.

Additional Resources

Woody Debris Fact Sheet: http://www.ct.gov/deep/lib/deep/fishing/restoration/largewoodydebrisfactsheet.pdf

Woody Debris Management 101: http://www.hrwc.org/wp-content/uploads/2013/03/Clean-and-Open-Method.pdf

King County, WA Woody Debris page—FAQs, procedures for considering public safety, “Living with Large Wood” poster: http://www.kingcounty.gov/environment/watersheds/general-information/large-wood.aspx

Root ball causes two drownings in the Willamette River: http://registerguard.com/rg/news/local/33213262-75/man-drowns-in-river-near-springfield.html.csp

What is “Natural Resource Management”?: http://www.landlearnnsw.org.au/production-chains/nrm

The Ecosystem Management Approach: http://www.snre.umich.edu/ecomgt/emapproach/whatisem.htm

Tips for Performing Well in a Debate: http:// www.wikihow.com/Perform-Well-in-a-Debate

Debating Matters Top Tips: http://www.debatingmatters.com/getinvolved/toptips/

Guide to a Public Forum Debate: http://debate.uvm.edu/dcpdf/PFNFL.pdf

Image credit: Creative Commons

Juvenile salmon rest in a calm pool before continuing their long journey to the sea.

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Glossary of key terms and vocabulary

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1-10-1 Principle—in cold water, you have *one minute* to get your breathing until control and calm yourself, *ten minutes* of meaningful movement, and *one hour* before you lose consciousness due to hypothermia.

Acceleration— in physics, is the rate of change of velocity of an object.

Action and Reaction—in every interaction, there is a pair of forces acting on interacting objects. Each reaction is in response to the initial action.

Aeolipile—also known as a "Hero's Engine", it is a simple bladeless steam turbine which spins when the central water container is heated. Torque is produced by steam jets exiting the turbine, much like a rocket engine.

Anglers—Men, women, or children who fish.

Aquatic—of or relating to water.

Balanced and unbalanced forces—If two individual forces are of equal magnitude and opposite direction, then the forces are said to be balanced. An object is said to be acted upon by an unbalanced force only when there is an individual force that is not being balanced by a force of equal magnitude and in the opposite direction.

Ballast—heavy material, such as gravel, iron, or water, placed low in a vessel to improve its stability.

Biofouling—the gradual accumulation of waterborne organisms on the surfaces of structures in water that contributes to corrosion of the structures and to a decrease in the efficiency of moving parts.

Blubber—The thick layer of fat between the skin and the muscle layers of whales and other marine mammals. It insulates the animal from heat loss and serves as a food reserve.

Boat—all watercraft used or capable of being used as a means of transportation on the water, including a seaplane on the water (not in flight) but NOT including boathouses, floating homes, air mattresses, beach and water toys, or single inner tubes.

Booms—a temporary floating barrier used to contain an oil spill and prevent it from reaching the shoreline. Booms help to concentrate oil in thicker surface layers so that skimmers, vacuums, or other collection methods can be used more effectively.

Buoyancy—the ability or tendency to float in water or air or some other fluid.

Capsize—to overturn in the water.

Catch limits—also known as bag limits; laws imposed on fishermen restricting the number of animals within a specific species or group of species they may kill and keep. Size limits and fishing seasons sometimes accompany catch limits.

Chemical dispersants— a common tool used after oil spills to break up oil slicks on the water surface into smaller particles and increase the oil's rate of degradation by wind or wave action.

Cold water immersion—When one's body completely enters cold water. The definition of cold water is variable. For practical purposes, significant risk of hypothermia usually begins in water colder than 77° F.

Density—the degree of compactness of a substance.

Deposition—the geological process in which sediments, soil and rocks are added to a landform or land mass. Wind, ice, and water, as well as sediment flowing via gravity, transport previously eroded sediment, which, at the loss of enough kinetic energy in the fluid, is deposited, building up layers of sediment.

Drought—a prolonged period of abnormally low rainfall; a shortage of water resulting from this.

Equilibrium—a state in which opposing forces or influences are balanced.

Erosion—A type of weathering in which surface soil and rock are worn away through the action of glaciers, water, or wind.

Force— In physics, something that causes a change in the motion of an object.

Friction—the resistance that one surface or object encounters when moving over another.

Habitat—the natural home or environment of an animal, plant, or other organism.

Hydrologic cycle—the storage and movement of water between the *biosphere* (the regions of Earth occupied by living organisms), *atmosphere* (the blanket of gases surrounding the Earth), *lithosphere* (the rigid outer part of the earth, consisting of the crust and upper mantle), and the *hydrosphere* (all the waters on the earth's surface, such as lakes and seas).

Hyperventilation—a condition characterized by abnormally prolonged and rapid breathing, resulting in decreased carbon dioxide levels and increased oxygen levels that produce faintness, tingling of the fingers and toes, and, if continued, alkalosis and loss of consciousness.

Hypothermia—a medical emergency that occurs when your body loses heat faster than it can produce heat, causing a dangerously low body temperature.

Incapacitation—occurs within 5 – 15 minutes in cold water. Vasoconstriction decreases blood flow to the extremities in an effort to preserve heat in the core, thereby protecting the vital organs but allowing the periphery to cool. Within this critical time frame you will lose meaningful movement in your hands and feet, and then your arms and legs.

Inertia—a tendency to do nothing or to remain unchanged.

Invasive species—an organism (plant, animal, fungus, or bacterium) that is not native and has negative effects on our economy, our environment, or our health.

Involuntary reaction—there are two types of involuntary reactions, *autonomic* and *reflex.* The autonomic nervous system controls the body's internal environment without conscious intervention and helps to regulate vital functions. A reflex is an involuntary response to a stimulus, such as withdrawing your hand from a hot surface before you become aware of the heat.

Irrigation— is the watering of land to make it ready for agriculture.

List—a nautical term for when a boat tilts towards one side.

Marine mammals—a diverse group of species including whales, polar bears, dolphins, and otters that rely on the ocean for their existence. All of these species have the five characteristics of mammals: they are warm-blooded, have hair or fur, give birth to live young, nourish their young with mother's milk, and breathe air.

Mass—a measure of the number of atoms in an object. The basic unit of measurement for *mass* is the kilogram.

Mitigation—The elimination or reduction of the frequency, magnitude, or severity of exposure to risks; the minimization of the potential impact of a threat or warning.

Morphology—the shapes of river and stream channels and how they change over time.

Native species—an organism (plant, animal, fungus, or bacterium) that is naturally found in a region. These can be either endemic (found only within a particular region) or indigenous (found both within the region and elsewhere).

Natural resources—anything that people can use which comes from nature. People do not make natural resources, but gather them from the earth. Examples are air, water, wood, oil, wind energy, hydro-electric energy, iron, and coal.

Newton's First Law—every object will remain at rest or in uniform motion in a straight line unless compelled to change its state by the action of an external force.

Newton's Second Law—The acceleration of an object as produced by a force is directly proportional to the magnitude of the force, in the same direction as the force, and inversely proportional to the mass of the object.

Newton's Third Law—For every action, there is an equal and opposite reaction. The statement means that the size of the forces on the first object equals the size of the force on the second object.

Non-point source pollution—water and air pollution from many diffuse and sometimes unknown sources.

Oil skimmers—a machine that separates a liquid from particles floating on it or from another liquid, such as oil.

Organic materials—matter composed of organic compounds that has come from the remains of organisms such as plants and animals and their waste products in the environment.

Overfishing—a non-sustainable use of aquatic or marine resources in which the supply of fish and other animals is depleted or exhausted.

Plankton—small and microscopic organisms drifting or floating in the sea or fresh water, consisting chiefly of tiny plants and algae, small crustaceans, and the eggs and larval stages of larger animals.

PFD—Personal Flotation Device

Point source pollution— a single identifiable source of air, water, noise or light pollution.

Porous—having minute spaces or holes through which liquid or air may pass.

Reservoir—a large natural or artificial lake used as a source of water supply.

Resource manager—a person who develops conservation and rehabilitation plans for nature reserves, land, rivers, and other natural resources, so that people can use these resources in an ecologically sustainable way.

Shock—lasts for only about a minute after entering the water and refers to the effect that cold water has on your breathing. Initially, there is an automatic gasp reflex in response to rapid skin cooling; this can lead to hyperventilation. If the head goes underwater, water may be breathed into the lungs during the gasp.

Slicks—a film or layer of oil floating on an expanse of water, especially one that has leaked or been discharged from a ship.

Stakeholders—people who can affect, be affected by, or have personal interest in an issue.

Strainer—a common river hazard consisting of sticks or branches. Water passes through these but solid objects like boats or people do not, similar to a kitchen strainer. Even boaters wearing life jackets can drown if they are washed into a strainer, because they can get trapped underwater against the branches by tons of water pressure.

Sustainable—capable of being maintained at a steady level without exhausting natural resources or causing severe ecological damage.

Town Hall Meeting—an informal public meeting at which community members discuss issues and concerns.

Vectors—a pathway by which non-native species are transported or carried to new environments. This can include currents, boats, humans, or other organisms.

Volume—the amount of space that a substance or object occupies, or that is enclosed within a container.

Water scarcity—the lack of sufficient available water resources to meet the demands of water usage within a region.

Woody debris—large wood that falls into a stream or river, including logs, branches, and root balls. This debris

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APPENDICES

APPENDIX A: RESEARCH INSTRUMENTS

Formative Survey Items

Please rate the following curriculum features based on how important you feel they are (rated as Not Important, Slightly Important, Important, Very Important, or Critical):

<u>Ease of use</u>

Easy to adapt to varying student skill levels

Requires only inexpensive and easy to find materials

Can be related to students' personal lives and experiences

Provides built-in resources to extend the learning experience beyond the classroom

Instructions are easy to follow as written

Appropriate for the skill levels of my students

Clearly aligned to state/national education standards

Please describe any other aspects of a curriculum's EASE OF USE which are important to you when considering a new curriculum:

<u>Professional development</u>

Helps me to meet state/national education standards

Provides opportunities for collaboration with other educators

Enhances my education practices/pedagogy

Expands my teaching skills and abilities

Increases my knowledge about boating/water safety issues

Increases my interest in boating/water safety issues

Increases my knowledge about environmental stewardship issues

Increases my interest in environmental stewardship issues

Increases my knowledge about STEM topics

Increases my interest in STEM topics

Please describe any other aspects of a curriculum's opportunities for PROFESSIONAL DEVELOPMENT which are important to you when considering a new curriculum:

Content

Addresses major boating and water safety issues

Instills an environmental stewardship ethic in my students

Emphasizes STEM concepts

Includes interdisciplinary (multiple-subject) topics

Relevant to current local and/or global issues

Prepares students to make good decisions about using aquatic and marine resources

Engaging for different learning styles

Please describe any other aspects of a curriculum's CONTENT which are important to you when considering a new curriculum:

Which grade level(s) do you teach? (Select all that apply):

Kindergarden-2nd Grade

Grades 3-5

Grades 6-8

High School

Which subject(s) do you teach? (Select all that apply):

Science

Math

Social Studies

Language Arts

AP Environmental Science

Other (please list below):

How did you find out about the Water Wits program?

Scuttlebutt Listserv

Personal communication with student researcher

Oregon Coast STEM Hub

NAME website or Facebook ad

Sea Grant WISE Program

Straub Environmental Program

Other (please describe):

Do you plan to attend the Water Wits training workshop on November 7^{th} in Salem, OR?

Yes

Maybe

No

Do you have any additional feedback, questions, or concerns about the Water Wits program you would like to share?:

Website (Summative) Survey Items

Based on your experiences with the Water Wits curriculum, please rate how you feel about each of the following statements concerning the program's content and ease of use (rated as Strongly Disagree, Disagree, Neither Agree nor Disagree, Agree, or Strongly Agree). The Water Wits Program:

<u>Ease of use</u>

Was easy to adapt to varying student skill levels

Required only inexpensive and easy to find materials

Could be related to students' personal lives and experiences

Provided built-in resources to extend the learning experience beyond the classroom

Included instructions which were easy to follow

Was appropriate for the skill levels of my students

Was clearly aligned to state/national education standards

<u>Professional development</u>

Helped me to meet state/national education standards

Provided opportunities for collaboration with other educators

Enhanced my education practices/pedagogy

Expanded my teaching skills and abilities

Increased my knowledge about boating/water safety issues

Increased my interest in boating/water safety issues

Increased my knowledge about environmental stewardship issues

Increased my interest in environmental stewardship issues

Increased my knowledge about STEM topics

Increased my interest in STEM topics

<u>Content</u>

Addressed major boating and water safety issues

Instilled an environmental stewardship ethic in my students

Emphasized STEM concepts

Included interdisciplinary (multiple-subject) topics

Was relevant to current local and/or global issues

Prepared students to make good decisions about using aquatic and marine resources
Was engaging for different learning styles

Finally, we would like to ask a few questions about your overall satisfaction with the Water Wits program. Please rate how much you agree or disagree with the following statements:

Satisfaction
I am pleased that I participated in this program.
I feel the time I spent teaching this curriculum was time well spent.
I would recommend the Water Wits program to other educators.
I am likely to use some of the ideas or resources provided by this curriculum in my future teaching.
I am likely to use one or more Water Wits lessons again in the future.

Which grade level(s) do you teach? (Select all that apply):
Kindergarden-2nd Grade
Grades 3-5
Grades 6-8
High School

Which subject(s) do you teach? (Select all that apply):
Science
Math
Social Studies
Language Arts
AP Environmental Science
Other (please list below):

Please list which Water Wits lesson(s) you used with students:

Approximately how many students did you deliver the Water Wits curriculum to, in total?:

Did you use the Water Wits curriculum in combination with any other aquatic/marine education resources? (select all which apply):

Oregon Coast STEM Hub programs (please list below):

Sea Grant's WISE Program

Other (please list below):

Did you collaborate with other teachers at your school/organization to implement this curriculum? If yes, please describe:

Do you have any additional feedback about the Water Wits program you would like to share?

Semi-structured interview protocol

Which "Water Wits" lesson(s) did you test?

What were your initial goals and expectations for this program – for yourself and for your students?

If you could name the one characteristic or outcome of this curriculum that you believe was the most valuable, what would it be?

Can you describe any notable successes resulting from using any of the curricula, and why you believe these were achieved?

Can you describe any notable failures and what, if anything, you did to overcome these challenges?

Did anything about the implementation of this program in your classroom/site surprise you?

Do you plan to use any of the activities again, and if so, is there anything you will change?

Do you have any other comments, suggestions, or criticisms for any of the activities?

APPENDIX B: QUALITATIVE DATA CODING SCHEME

Theoretical categories

Professional development
- Collaboration with others
- Pedagogy
- Expansion of knowledge/abilities

Motivations
- Intrinsic
- Extrinsic
- Rational/practical
- Driven by educators' interests/needs
- Driven by their students' interests/needs

Curriculum content
- Education standards
- STEM
- Integration across subjects
- Specific concepts (environmental stewardship, boating/water safety, STEM, etc.)

Substantive categories

Perceptions of experiences
- Teachers
- Students
- Challenges
- Successes

Formative feedback
- Motivations for choosing curricula
- Suggested modifications or changes

Summative feedback
- Flexibility
- Timing
- Student engagement
- Relatability
- General ease of use/classroom implementation