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Collaborative Learning Strategies To Overcome Barriers To Science Translation In Coastal Watershed Management: A Final Report Submitted To The NOAA/UNH Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET)

Christine Baumann Feurt
University of New England, cfeurt@une.edu

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A Final Report Submitted to

The NOAA/UNH Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET)

Submitted by

Dr. Christine B. Feurt
Director, Center for Sustainable Communities
Department of Environmental Studies
University of New England
11 Hills Beach Road, Biddeford, Maine

Coordinator, Coastal Training Program
Wells National Estuarine Research Reserve
342 Laudholm Farm Rd
Wells, Maine 04090

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1. Expanded Executive Summary and Key Findings

What is the coastal resource issue the project sought to address?

Coastal watersheds experience intense development pressure, cumulative impacts from land use decisions and climate change impacts from alterations in the hydrologic cycle and sea level rise. The municipal system for land and water management is a proving ground for innovation and adaptation to environmental change. Within this municipal system, timely application of scientific research and adoption of technological innovations with potential to contribute to improvements in coastal water quality can be blocked when potentials adopters of the information fail to recognize or understand the relevance or benefits. This project used an innovative interdisciplinary approach to understand and overcome barriers to science translation in municipal decision-making about non-point source pollution. This project combined and evaluated methodology and theory concerning the role of cultural models in environmental decision-making (Kempton, et al., 1995) with the process and strategies of Collaborative Learning[1] (Daniels & Walker, 2001) to facilitate science translation and the diffusion of innovative management strategies in coastal watersheds.

What is the tool? **Collaborative Learning for Ecosystem Management**

Collaborative Learning is an interdisciplinary approach adapted by this project to facilitate community based ecosystem management. This project adapted and expanded the principles and practices of Collaborative Learning developed by Steven Daniels and Gregg Walker (2001). Collaborative Learning is an expert practice for designing, implementing and evaluating the dialogues that support ecosystem management. Collaborative Learning consists of techniques designed to facilitate shared understanding of complex environmental issues. This project integrated enthnographic methodologies and cultural models theories with Collaborative Learning to develop a systems understanding of barriers to science translation. Collaborative Learning combines presentation of information with dialogue to allow participants to clarify the scope and definition of problems. These techniques are designed to stimulate creative discussion despite conflict and controversy. The surprising goal of Collaborative Learning is not consensus but group-generated strategies for improving a situation, a key goal for adaptive ecosystem management. This project applied and evaluated the process of Collaborative Learning in the Protecting Our Children's Water project in southern Maine with the goal of distilling key elements that can be adapted to other multi-stakeholder ecosystem management projects.

How does it address the problem?

Facilitating collaboration among scientists, planners, regulators, policy makers and managers is a key ingredient of ecosystem management. These dialogues develop the shared vision and desired future outcomes that guide the practice of ecosystem management. Collaborative dialogues create bridges connecting diverse areas of expertise and knowledge. The resulting network of

[1] Whenever Collaborative Learning appears in the text as capitalized it refers to Daniels and Walker (2001).

connections, the "kaleidoscope of expertise", can be cultivated and maintained as a resource for the adaptive learning process that characterizes ecosystem management. The Protecting Our Children's Water project evaluated the Collaborative Learning approach as a methodology to understand the ways that people in southern Maine valued water, the different kinds of knowledge people applied in their jobs protecting water and the interconnected system for water management operating at the municipal level. Recognizing this kaleidoscope of expertise as a resource for problem solving facilitates science translation, diffusion of innovative technologies and improved water management.

How is it an improvement over existing tools?

This "tool" is a unique interdisciplinary approach for multistakeholder environmental problem solving. The cultural models methodology builds systems understanding important for ecosystem management. Enthnographic methodologies (Weiss, 1994) and grounded theory analysis (Strauss and Corbin, 1990) provides a rich baseline understanding of stakeholder knowledge, values, perceptions and attitudes. Collaborative Learning supports problem solving that recognizes and accommodates these differences among stakeholders as a resource for developing action strategies for improving environmental outcomes. Collaborative Learning used over time to develop a collaborative knowledge network provides the social infrastructure to facilitate the co-creation of knowledge and diffusion of science and technology among network members. Scientific research needs are communicate through the same network. Collaborative Learning requires a facilitator to engage and support the collaborative knowledge network within which ecosystem management operates. This project provides a tool for those facilitators.

This project developed and evaluated cultural models based Collaborative Learning as one tool for structuring the complex dialogues that drive ecosystem management. Collaborative Learning improves upon education and outreach techniques that deliver scientific information to a "target audience." Collaborative Learning supports systems thinking and recognizes diverse expertise as a *resource* for problem solving, rather than a *receptacle* for science information. The process of Collaborative Learning is a bridge that connects the science and technology generating system to the management system where the new information and tools can be put to work. The Collaborative Learning process can produce positive outcomes for public participation and stakeholder engagement and is well suited to long term engagement dedicated to complex or conflict laden issues. Collaborative Learning benefits from integration with the principles and theories associated with community bases social marketing (Mackenzie-Mohr, 1999), but is better suited to ecosystem management because of the focus on multi-party and interdisciplinary problem solving as opposed to discrete behavior change.

What is the current stage of development? (Technology Transfer)

Collaborative Learning for Ecosystem Management has been synthesized into a practitioner's guide available as in PDF format and in print. A Collaborative Learning training workshop was conducted for coastal managers attending The Coastal Society meeting in 2006. Training is available on request by contacting Dr. Christine Feurt cfeurt@wellsnerr.org.

Who are the end user groups for this tool?

End users include science translators, outreach professionals, designers of public participation and stakeholder engagement processes, environmental communication specialists, science impact coordinators and facilitators of ecosystem management. Funders with goals of ecosystem management can use this tool to evaluate the stakeholder engagement qualities of proposals.

Key Findings

Cost and Speed: Collaborative Learning can be applied within diverse temporal, spatial and organizational scales by a facilitator who is part of the group or one who approaches the process as an outside facilitator. These variables affect cost. Organizational and temporal scales can include focused work within an established group to move that group past an impasse or toward innovation over a short time period. At a broader scale, a process can convene a regional or representative group like a watershed council that works on issues across municipal boundaries to achieve long-term water quality goals. Cost depends upon geographic scale, time frame and the availability of in-house expertise to conduct Collaborative Learning compared to engaging an outside facilitator for the process.

Accuracy: Collaborative Learning supports and facilitates ecosystem management by engaging interdisciplinary teams in the process of problem identification, generation of improvement strategies and a method for evaluating progress toward shared goals. If accuracy is defined as making progress to *improve environmental conditions* associated with water quality, habitat conservation, source water protection or land use planning, Collaborative Learning can provide strategies for improving a situation that are developed by the people responsible for implementing the strategies. Learning and feedback for adaptive management are part of the Collaborative Learning process.

End user capacity requirements and ease of use: Facilitators of Collaborative Learning processes that support the goals of ecosystem management should be grounded with a set of core competencies for negotiating the complex social and organizational challenges at the science - policy & management interface. Meeting facilitation and conflict resolution training support Collaborative Learning. Grounding in adult learning principles, curriculum development and program evaluation are important when there is a wide disparity in the knowledge levels of participants and significant content information must be infused into the process. The assessment phase of the process benefits from expertise in interviewing and discourse analysis techniques. The practitioner guide developed for this project is designed for Coastal Training Program Coordinators, NEMO practitioners, Sea Grant and Cooperative Extension professionals and includes sufficient background material for conducting a pilot Collaborative Learning process.

Describe the advancement of science over current level: The science translation paradigm is undergoing unprecedented transformation in response to increasingly complex environmental challenges (Kuhn, 1962). Science that supports decisions for adapting to changing climate cannot follow the pathways of the past (NRC, 2009). The Collaborative Learning approach developed by this project represents the new generation of science translation. Information needs of decision makers are given precedence and are determined using practical qualitative methods within the reach of coastal outreach professionals. The process accommodates interdisciplinary perspectives, allows for conflict and uncertainty and builds a collaborative knowledge network within which solutions can be formulated as experiments to be tested, evaluated and revised. Collaborative Learning is dynamic, adaptive and rigorous yet practical enough that projects designed with adequate funding and staff time can be implemented by practitioners working in the fields of watershed, coastal and ecosystem management.

2. Project Development

Abstract

An important non-point source pollution challenge facing municipal officials in southern Maine is the conversion of forested and undeveloped land to development (Krum & Feurt, 2002; Wells NERR, 2003; 2001). There is a critical need, during the next decade, to apply science-based knowledge and facilitate the adoption of practices associated with low impact development, protection of riparian buffers, preservation of wetlands and innovative stormwater management technology to land use decision-making. The science and technology that supports municipal efforts to preserve the ecological services provided by an undeveloped landscape as it is converted to what is considered economic use are the focus for science translation and technology transfer by the Coastal Training Program of the Wells National Estuarine Research Reserve (NERR) in Wells, Maine (Krum & Feurt, 2002).

Barriers to watershed stewardship that protects ecosystem services are frequently misunderstood. Timely application of scientific research and technological innovations with potential to sustain or restore coastal water quality can be blocked when potential adopters of the information fail to recognize or understand the relevance or benefits. This project used an interdisciplinary approach to understand and overcome barriers to science translation in municipal decision-making about land use and water management. This project combined knowledge about the cultural models used by southern Maine water managers in environmental decision-making (Feurt, 2007) with the process and strategies of Collaborative Learning (Daniels & Walker, 2001) to facilitate watershed stewardship and community based ecosystem management. Project objectives included creation of watershed councils to support collaboration across municipal boundaries, implementation of watershed management plans, identification of action strategies to reduce non-point source pollution, and adoption of innovative stormwater management technologies.

Collaborative Learning is a stakeholder engagement process designed to make progress to improve environmental problems. The practice of Collaborative Learning employs a toolkit of techniques to stimulate creative discussion, foster dialogue despite conflict and controversy, and develop group-generated implementation strategies. Collaborative Learning is especially amenable to issues involving conflict and scientific uncertainty (Daniels & Walker, 2001).

A previous CICEET project examined the role that cultural models play in the production, transmission and application of knowledge related to water management (Feurt, 2006a & b; 2007). Cultural models are shared perceptions and attitudes about how the world works. They are implicit, taken for granted and operate below the level of consciousness (Holland and Quinn, 1987; Strauss & Quinn, 1997). Results of that research provided an understanding of the knowledge and cultural models of water used by water managers in southern Maine and the ways that knowledge and cultural models influenced the use of science in decision-making.

This project tested, refined and disseminated the cultural models based Collaborative Learning approach through engagement with southern Maine watershed councils and presentations and trainings to coastal managers at national and international conferences and meetings. A practitioners' guide, *Collaborative Learning for Ecosystem Management,* and training module

were developed and are available upon request through the Wells National Estuarine Research Reserve Coastal Training Program.

2b. Introduction: The Search for New Tools for Ecosystem Management

Twenty-first Century Challenges

Global environmental change presents unprecedented challenges for 21st century scientists, policy makers and environmental managers (NRC, 2009). The complexity and interconnectedness of the social and ecological systems that underlie environmental change are forcing the redefinition of issues, fostering new liaisons that transcend traditional boundaries, and transforming environmental management (Gunderson and Holling, 2002). Nowhere is this change more evident than in coastal and estuarine systems. Here population pressure, and the environmental waste outputs of human economic and social systems deposited into land, water and atmosphere are concentrated and delivered by the hydrologic cycle. Ecological systems responses include harmful algal blooms, eutrophication, hypoxia and accumulation of toxins, all of which reflect back to the human system through health effects, economic loss and consequences for future generations (Fluharty, et al, 2006; USCOP, 2004).

Integrative theories in ecology and ecosystem management propose frameworks that encompass understanding of ecological, economic and institutional systems and the dynamic, cross-scale interactions that contribute to unpredictability and complexity (Gunderson and Holling, 2002; Allen and Hoekstra, 1992; Meffe, et al., 2002). Recognition of the role of resilience in ecosystems, fluid and responsive institutions and management linked to learning evolve from practices aligned with these new theoretical frameworks (Lee, 1993; Machlis, et al., 1997; Wondolleck and Yaffee, 1994, Beatley, 2009).

Trends in ecological research, ecosystem management and environmental policy increasingly incorporate systems approaches, adaptive management, and innovative policy strategies developed through collaborative processes (NRC, 2002a & b; Allen and Hoekstra, 1992; Berkes and Folke, 2000; Gunderson, et al., 1995). These trans-disciplinary approaches engage the people involved in environmental problem solving in deliberative processes to foster social learning and civic science (Lubchenko, et al., 1998; Endter-Wada, et. al., 1998; Lee, 1993; NRC 1996; Boesch, 1999 & 2001; Costanza, et al., 1998; Visser, 2004).

Learning through adaptive management is the cornerstone for theories and practices that embrace uncertainty by framing policy and management decisions as experiments (Lee, 1993; Gunderson, et al., 1995; Holling, 1978 & 1995; Walters and Holling 1990; Gunderson and Holling, 2002). In his essay on learning in the edited volume *Barriers and Bridges to the Renewal of Ecosystems and Institutions* (Gunderson, et al., 1995), social psychologist Donald Michael calls for profound learning that includes an examination of the role that beliefs, unconscious needs and motives play in personal, organizational and social change directed toward the goal of environmental sustainability (Michael, 1995).

> *Among the major categories of barriers and bridges are those pertaining to learning: learning what needs to be done, how to do it, whether it worked, and*

how to apply the learning to the emerging consequences; learning that must be unlearned and learning what must be learned anew
and by whom; learning about how to learn under the conditions that shape humans, on the one hand, and the environment, on the other.
(Michael, 1995 p. 461)

Institutional and organizational learning depends upon similar adaptive frameworks that include recognition and reflection on mental models, systems assumptions and unconscious habits of practice (Senge, 1990; Argyris & Schon, 1996). Learning that contributes to the kind of social change required for environmental sustainability requires an understanding of the epistemology underlying current thinking and practice in environmental management. As Michael states in the quote above, we must learn what "must be unlearned." Learning through the practice of adaptive management is difficult. Recent research examining the application of adaptive management in watershed management and in business practice identifies both individual and institutional resistance to underlying premises and theory. Adaptive management seems to be *easier said than done*[2] (Allan, 2004; Allan & Curtis, 2005; Argyris & Schon, 1996). Genuine learning associated with adaptive management is constrained by strongly entrenched habits of practice, or what Allan (2004) calls *imperatives*, including an orientation to action and progress over reflection, the need to control and simplify complex human and social systems, and self-deception to maintain the status quo rather than challenge established practices. That self-deception frequently manifests in ineffective attempts at science translation and application based upon "telling" a "target audience" about scientific data or findings and expecting the information to be incorporated into decision-making and management action (Feurt, 2007).

Learning in Coastal Watersheds

This project focuses on learning in the decision-making arena of coastal watershed management. Across the United States, municipal officials, environmental management agencies and the public make land use decisions that affect coastal waters. Local land use practices and development contribute to coastal ecosystem degradation from non-point source pollution caused by sediment, nutrients, toxins and microbial contaminants (Fluharty, et al, 2006; USCOP, 2004). This coupling of land use and coastal water quality provides a litmus test for land management and locally instituted environmental practices.

Considerable research examining watershed management documents learning that occurs through interaction and deliberation that encourages participation by key stakeholders, collaborative problem definition and strategy development, and design of processes that are both fair and competent (Webler & Tuler, 1999, 2001; Wooley and McGinnis, 1999; Wondolleck and Yaffee, 2000; Rhoads, et al., 1999; Habron, 1999, 2003). A transition from top down approaches to watershed management driven by government agencies to bottom-up or collaborative approaches that are more locally based is reflected in watershed approaches encouraged by the US Environmental Protection Agency and ecosystem approaches to management under development in the multiple agencies within the National Oceanic and Atmospheric Administration (Rhoads et al., 1999; USEPA, 1995, 1996; Fluharty, et al., 2006).

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[2] Propositions and proverbs like this are linguistic clues for underlying cultural models and stereotypical ways of thinking. Despite their simplicity, such propositions encapsulate complex concepts implicitly understood by those who share them.

Knowledge is a significant resource that stakeholders bring to watershed management. Knowledge of the effects and consequences of land use decisions varies among the groups of decision makers whose actions influence watershed conditions. Professional expertise, formal training and education, and local knowledge accumulated through direct relationships with places contribute to watershed decision-making. Knowledge interacts with values and attitudes to influence actions taken to address local land use impacts on water quality (Feurt, 2007). Actions to protect water through land use occur within a complex social environment (Rhoads et al., 1999; Feurt, 2007). This social environment is culturally distinct from the social environment of science. Cultural barriers at the science-management interface affect communication between scientists investigating coastal watershed issues and municipal officials able to implement changes in land use practices (Corbett, 2006; Feurt, 2007).

The communication of scientific findings to decision makers is considered vital to the practice of ecosystem management (Lubchenco, et al, 1998, Meffe, et al., 2002; Fluharty, 2006). Institutions generating science based information focus attention on municipalities and local governments in an effort to foster the incorporation of ecosystem management principles into decision-making and policy. Scientists, technology developers, regulators and environmental non-governmental organizations (NGOs) have information and prescriptions for effective local action. Municipal officials can feel bombarded by these prescriptions when they are added to the already overwhelming task of "running their towns[3]."

Science translation travels a pathway fraught with cultural barriers. Implementation of technological innovations and application of scientific findings to policy and management depends upon connecting with people with power, motivation and ability to act. Outcomes that produce desired environmental results benefit from the two-way transfer of knowledge captured by the *bridging* metaphor (Gunderson, et al., 1995). Local decision makers seeking relevant findings from scientific research to inform and guide environmental decision-making are as frustrated by *inaccessible* science as the scientists bemoaning under utilization of science (Feurt, 2007).

Cultural understanding of the knowledge, values and beliefs of people working at the municipal level can facilitate science translation and technology transfer that is directly linked to actions that improve environmental outcomes. Cultural understanding defines the nature of the barriers to implementation and Collaborative Learning provides design specifications for building a network of bridges to span those barriers. Such bridges serve the equally important function of linking management practices to scientific research by providing opportunities for dialogue and deliberation (NRC, 2009).

<u>Understanding the Role of Culture in Science Translation</u>

Each of the propositions in the box below represents a cognitive key that unlocks doors leading to complex mental libraries where ideas, attitudes, values and perceptions are organized (Feurt, 2007). Psychologists and educational theorists call these units in our mental libraries *mental models* (Collins & Gentner, 1987). Mental models function like maps, templates and field guides as we move through the world, allowing us to *unconsciously* recognize the familiar, categorize

[3] This sentiment, often expressed with frustration, captures the reaction of a number of the municipal officials interviewed for this research.

without thinking and link novel experiences to what we already know. Our mental models allow us to recognize a borzoi as a dog the first time we see one. When we order lunch, eat and pay the check in a restaurant we draw from script-like mental models that guide and constrain our behavior (Holland and Quinn, 1987).

Cultural Models of Water

- Water is the basis for life on earth.
- Nature makes water.
- Water is a resource to be used.
- Water is a commodity.
- Water is landscape.
- Water is waste.

Excerpt from *Collaborative Learning for Ecosystem Management* (Feurt, 2008)

Cultural anthropologists are interested in the ways mental models are learned and transformed within a social group to become shared cultural models. Cultural models are taken for granted and are implicit within the social groups where they are shared (Holland & Quinn, 1987). They are used without *thinking*, causing us to pay attention to select aspects of our surroundings, recognize objects and patterns, and assign meaning to our experiences. Cultural models have motivational force and guide our behavior (D'Andrade, 1995). As one of the cognitive tools in our problem solving toolbox, cultural models of environmental issues have been the focus of increased research attention for more than a decade (Kempton, et al., 1995; Feurt, 2007).

Environmental conflicts can arise from cultural differences associated with values, beliefs and knowledge (Corbett, 2006). An understanding of conflicts arising from different cultural models can be used to improve dialogue. Science represents only one *way of knowing* about environmental issues. Research has shown that the cultural models of nature held by farmers and watermen demonstrate an understanding of the resilient and chaotic attributes of nature that is in line with modern complexity theory. Perspectives of these people who are in daily contact with nature are unique and valuable for collaborative learning applied in the context of co-management of natural resources (Paolisso and Maloney, 2000; Paolisso and Chambers, 2001; Paolisso, 2002; Feurt, 2007).

Cultural models research examines the complex interaction of attitudes, values, and modes of understanding surrounding an array of environmental issues including global climate change (Kempton 1991 a & b, 1993, 1997); protected areas management (Pfeffer, et al., 2001); and landscape conservation (Dailey, 1999), blue crab management (Paolisso, 2002) and non-point source pollution (Bunting-Howarth, 2001; Feurt, 2007). This research has the broad goal of understanding how humans make sense of and understand environmental issues and how this understanding is translated into decision-making and action. Applying an understanding of conflicting cultural models to participatory and collaborative processes can improve dialogue among stakeholders and create policies and environmental solutions that benefit from a combination of different kinds of knowledge (Bunting-Howarth, 2001; Paolisso, 2002; Feurt, 2007). Research techniques, including interviews, transcription and coding of discourse, and participant observation are used to make explicit the divergent cultural models that contribute to conflict among stakeholder groups (Weiss, 1994; Bernard, 1998).

Coastal and estuarine related cultural models research has been used to determine: perceptions of effective coastal planning (Christel, et al., 2001); stakeholder and public perceptions of toxic dinoflagellate blooms (Falk et al., 2000; Paolisso & Chambers, 2001; Kempton & Falk, 2000; Paolisso & Maloney, 2000); farmers' understanding of nutrient enrichment in the Chesapeake Bay (Paolisso & Maloney, 2000), and perceptions of watermen about the role of science and regulation in management of the Chesapeake Bay blue crab fishery (Paolisso, 2002). Understanding the cultural models used by the lay public has helped scientists and resource managers communicate with important stakeholder groups, and has facilitated collaborative learning and public participation in decision-making related to nutrient management plans for Delaware coastal bays (Bunting-Howarth, 2001), implementation of watershed management plans in the Gulf of Maine (Feurt, 2007) and co-management of the blue crab fishery in Chesapeake Bay (Paolisso, 2002).

Integrating Collaborative Learning and Cultural Models

Collaborative Learning is firmly grounded by an integration of systems theory, conflict theory and adult learning theory. This theoretical framework supports a robust collection of design principles that guide but do not constrain the practice of Collaborative Learning, one strength of which is its situational adaptability. The practice of Collaborative Learning employs a toolkit of techniques to stimulate creative discussion, foster dialogue despite conflict and controversy, and develop group-generated implementation strategies for improving a situation. Collaborative Learning aims to facilitate the negotiation of shared meaning among stakeholders with diverse and often conflicting interests. This approach is designed to clarify problem scope and definition and support the development of strategies that reconcile conflict in order to focus on the design and implementation of actions that improve environmental problems (Daniels & Walker, 2001).

A key premise of Collaborative Learning is that successful learning processes must recognize and accommodate knowledge, value, perception and attitude differences among stakeholders. Acknowledgement of differing knowledge bases and worldviews is one of the primary criteria for effective facilitation of Collaborative Learning (Daniels & Walker, 2001). Cultural models contribute to Collaborative Learning because of their relevance to shared perceptions and attitudes about how the world works. The enthnographic methods used to understand cultural models provides insights valuable for social learning and environmental communication. The enthnographic methods used in the project provided a rich understanding of the system within which water decision-making was embedded from the perspective of the people working inside the system. This proved invaluable in designing Collaborative Learning to create a collaborative knowledge network for problem solving, diffusion of technology and science.

2c. Objectives

This technology transfer project disseminated and expanded the results of a previous project - *Science Translation for Non-point Source Pollution Control, A Cultural Models Approach with*

Municipal Officials (Feurt, 2006). The two projects combined knowledge about the cultural models used by southern Maine water managers in environmental decision-making (Feurt, 2007) with the process and strategies of Collaborative Learning (Daniels & Walker, 2001) to facilitate watershed stewardship and community based ecosystem management. Long term project objectives linking the two projects include creation of watershed councils to support collaboration across municipal boundaries, implementation of watershed management plans, identification of action strategies to reduce non-point source pollution, and adoption of innovative stormwater management technologies.

Objectives of the current project:

1. Implement Cultural Models-based Collaborative Learning workshops in coastal watersheds to refine methodology and facilitate implementation of coastal watershed management plans in the Gulf of Maine region.

2. Develop a national Collaborative Learning training for coastal and marine protected area education and outreach professionals.

3. Evaluate strengths and weaknesses of Collaborative Learning and disseminate resulting lessons learned to a national audience through publication in journals and participation in conferences and meetings.

4. Develop and evaluate a conceptual framework for *science to management* that incorporates knowledge of cultural models and decision support processes like Collaborative Learning.

2d. Methods

<u>1. Implement Collaborative Learning Watershed Workshops</u>

The Collaborative Learning process, designed using cultural models knowledge, was applied within sub drainages of the Gulf of Maine under the broad project umbrella of "Protecting Our Children's Water." Cultural models findings informed the title of the project in order to capture the work of diverse disciplines, organizations and activities that when combined foster sustainable watershed management.

The staff of the Wells National Estuarine Research Reserve and the Maine Sea Grant Cooperative Extension specialist co-located at the Wells Reserve implemented the Collaborative Learning process. Collaborative Learning activities occurred regularly throughout the period of the grant. Performance measures developed for the Coastal Training Program of the NERR system provided feedback and evaluation of effects of the Collaborative Learning events on increased science-based knowledge, intent to apply knowledge gained and satisfaction with the content and format of each event.

More importantly, the projects were measured by the creation of group-generated action items and subsequent sharing of progress on action items as watershed groups met at least annually to track progress. Watershed management plans and the action items identified in those plans guided the MBLR and York River Watershed Councils. Groups also identified action items dictated by municipal and organizational priorities that were not identified in the plans.

2. Develop Collaborative Learning Training

Drs Steven Daniels and Gregg Walker created a training course, "Collaborative Learning for Coastal Managers" and presented it to 30 coastal managers as part of the 2006 Coastal Society Conference. Dr. Christine Feurt built upon that workshop to create Collaborative Learning training available through the Wells National Estuarine Research Reserve Coastal Training Program.

3. Evaluate strengths and weaknesses of this methodology and disseminate resulting lessons learned to a national audience through publication in journals and participation in conferences and meetings:

The principal investigator for this project worked with a graphic designer to develop Power Point images based upon the cultural models research and lessons learned from implementation of the Collaborative Learning approach in the venues described above. The graphics capture key elements of the Collaborative Learning approach that reflect new ways of thinking about municipal decision-making for water management. Many of the graphics represent cutural models of the social system of municipal water management in southern Maine based upon the analysis of data from the project. The data analysis used to develop the graphic images included grounded theory analysis of interview transcripts, meeting minutes, participant observation field notes and analysis of organizational mission statements, strategic plans and comprehensive plans (Strauss and Corbin, 1990; Feurt, 2007).

4. Develop and evaluate a conceptual framework for *science to management* that incorporates knowledge of cultural models and decision support processes like Collaborative Learning.

The conceptual framework developed for this project is synthesized in *Collaborative Learning for Ecosystem Management.* This 20-page practitioner's guide describes Collaborative Learning as a methodology for building communication and collaboration bridges that take into account perceptual, organizational and disciplinary barriers to ecosystem management. The enthnographic methodologies used to develop cultural models of water provided data to build a systems understanding of the diverse job and volunteer responsibilities and practices that operate to produce the mosaic of land use practices and policies that impact water (Feurt, 2007). The ways this systems knowledge can be used in Collaborative Learning to facilitate community based ecosystem management is presented as an action strategy in the guide.

The guide is designed to make the Collaborative Learning process accessible for outreach, education and science translation professionals. Step-by-step instructions for developing a pilot Collaborative Learning process are covered by the guide. Outreach professionals will recognize familiar skills and techniques used by many experienced outreach professionals. The guide is included as an appendix to this document and is available as a hard copy or PDF on the Wells Reserve webpage. One hundred copies of the guide have been distributed at meetings and conference in 2008 and 2009.

2e. Results[4]

Result #1. Implement Collaborative Learning Watershed Workshops.

[4] See Appendices for additional results.

Collaborative Learning was developed and evaluated from 2005 - 2009 in multiple meetings with the following watershed based groups in southern Maine:

- Merriland River, Branch Brook and Little River (MBLR) Watershed Council: Towns of Kennebunk, Wells and Sanford
- York River Watershed Council: Towns of Kittery, Eliot, York and South Berwick
- Spruce Creek Watershed Association: Towns of Kittery and Eliot
- Kennebunk River Action Coalition: Towns of Kennebunk and Kennebunkport
- Sanford Conservation Planning Process: Town of Sanford

This project diffuses the research and methodology by involving end users in the design, implementation and evaluation of Collaborative Learning events. The *Protecting Our Children's Water* project partners include Maine Sea Grant, Maine NEMO, Maine DEP, US Fish and Wildlife Service, Southern Maine Regional Planning Commission, the Mount Agamenticus to the Sea Partnership and eight municipalities in southern Maine.

An example of a typical Collaborative Learning workshop was conducted on April 16, 2008 for the York River Watershed Council towns of York, Kittery, South Berwick and Eliot. Twenty people participated in the workshop to evaluate progress on implementation of watershed management plan goals selected during the 2007 planning period. Town Planners from York and South Berwick presented work on mapping headwater streams and implementing new ordinances for storm water. The Spruce Creek Association of Kittery presented progress on watershed management plan development for an adjacent watershed. The GIS consultant for Eliot presented work on stream mapping. The collaborative structure of the meeting allowed leaders from each town to showcase success stories and share innovative approaches across town boundaries. This approach builds upon the expertise within each town and fosters collaboration across town boundaries. The Town of York offered GIS and mapping assistance to neighboring towns, the Spruce Creek Association used lessons from the York watershed to guide their efforts and the Town Planner from South Berwick was able to share the complexities of compliance with the Clean Water Act Stormwater Phase II requirements with towns unfamiliar with those requirements.

What is different about this Collaborative Learning workshop compared to other approaches? Each of the towns participating in the Watershed Council have support from elected officials. Before the Watershed Council was formally convened, each of the Select Boards and Town Councils for the four watershed towns viewed a *Protecting Our Children's Water* Power Point presentation prepared by the Principal Investigator. This presentation included the images based upon cultural models of water. Participation in the Watershed Council was voluntary but elected official approval was required.

Cost to towns is one of the most important concerns for elected officials. The cost of participation was approximately 24 hours of staff time from the Town Planner, Public Works Director and Code Enforcement Officer of each town over a one year period. In each town Water Districts, who are quasi-municipal organizations were included as part of the Council.

The Watershed Council would address the action items in the York River Watershed Management Plan to address non-point source pollution issues in the watershed. Participation in the Watershed Council was framed as an experiment for one summer. During the fall the Principal Investigator returned to each elected board, reported on progress and asked the boards to continue participating after the experimental phase. All four towns elected to participate and voted to continue membership on the Watershed Council after the experimental period. The same pattern was followed, with the same results in the MBLR watershed towns of Wells, Kennebunk and Kennebunkport.

Result #2. Develop Collaborative Learning Training. (see methods section)

Result #3. Evaluate strengths and weaknesses of this methodology and disseminate resulting lessons learned to a national audience through publication in journals and participation in conferences and meetings.

The Principal Investigator made more than 50 presentations to diverse audiences of watershed, coastal and ecosystem managers, policy makers and scientists. A summary of these presentations is included in the appendix to this report. Presentations included national and international meetings, workshops, conferences, webinars, trainings and testimony to a state legislative committee. Each presentation was designed to use the results of the project to illustrate the underlying paradigm shift in science translation that emerged from and guided the project

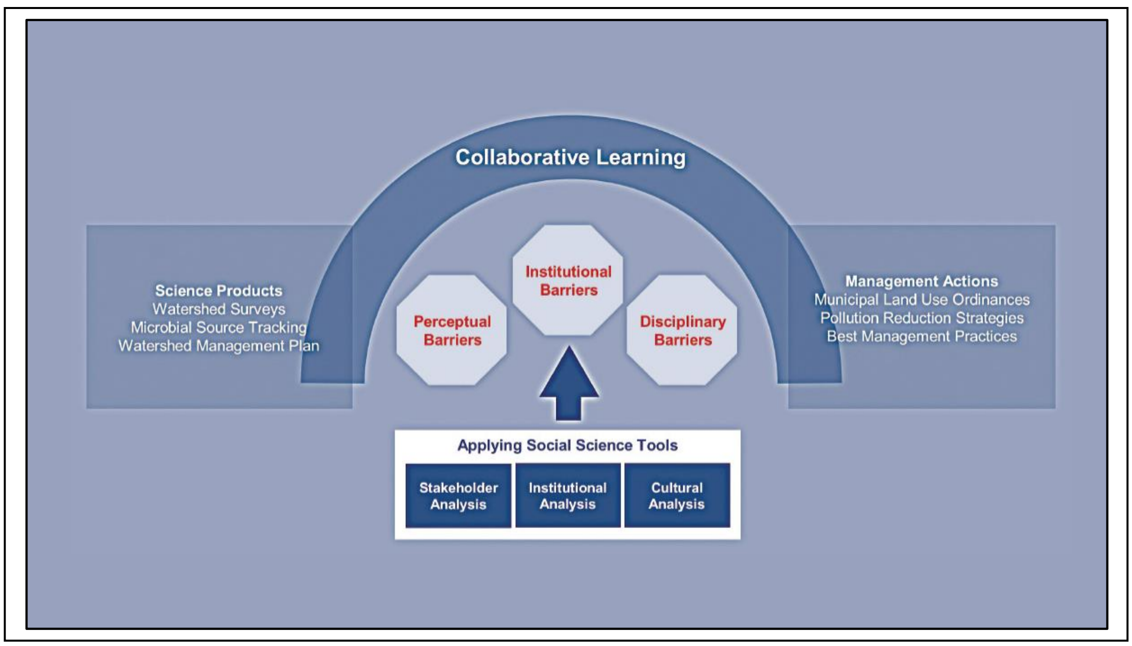
The images and presentations include the following core elements of Collaborative Learning for Ecosystem Management developed from research with water managers in southern Maine:

1. Cultural models influence how we perceive environmental problems and the kinds of solutions we can imagine.
2. Water managers in southern Maine use six cultural models to think about the importance of water.
3. Water managers categorize threats to water based upon the source, path and target of the threat.
4. Water managers diagnose threats to water based upon perceived impact of the threat on things they value.
5. Water managers bring seven types of knowledge to the decision-making arena.
6. Water managers act within eight domains of practice that combine to influence watershed management.
7. The knowledge and action systems of water management interact to create a "kaleidoscope of expertise"- a resource for collaborative problem solving.
8. Collaborative Learning recognizes and engages the "kaleidoscope of expertise" inherent in water management system in collaborative knowledge networks.
9. Ecosystem management benefits from the systems knowledge, expert communication practices and orientation to problem solving of the Collaborative Learning approach.
10. Collaborative Learning is a practical interdisciplinary approach for science translation and decision support that integrates problem identification, analysis

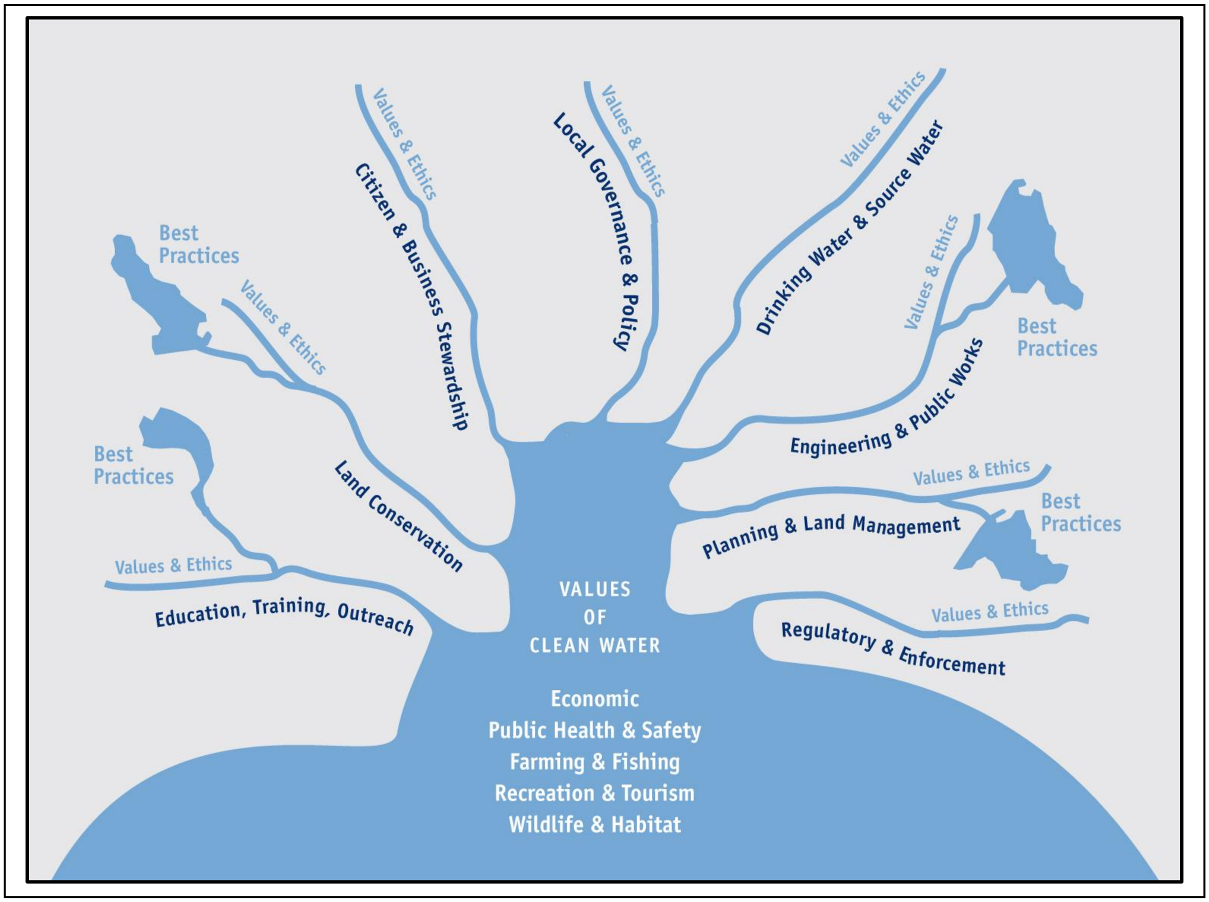
and deliberation to develop solutions in the face of conflict, uncertainty and environmental change.

Result #4. Develop and evaluate a conceptual framework for *science to management* that incorporates knowledge of cultural models and decision support processes like Collaborative Learning.

Collaborative Learning is an expert practice for bridging the systems of science and management. The graphic designs below are used to illustrate the conceptual framework presented in the *Collaborative Learning for Ecosystem Management* guide and Power Point presentations for the project. The role of Collaborative Learning as a bridge connecting the system of science and the science products with the system of management and policy depends upon analysis of the perceptual, institutional and disciplinary barriers separating the two systems. Social science methodologies and theories like the cultural models research associated with this project facilitate effective bridging by Collaborative Learning.



Community-based ecosystem management connects social capital and natural capital. Shared values about the importance of clean water motivate a social system of practitioners and advocates in southern Maine. Like the tributaries of a watershed, the elements of this social system affect the quality and quantity of water that collects and flows to estuaries at the land sea interface. The eight elements of this social system, shown below, interact to protect the values associated with clean water. Work within each element of the system is guided by professionally established best practices and a set of values and ethics that define the culture of the group. Science plays a role in this social system by shaping best practices and providing feedback about the ability of actions taken by each group to achieve goals in alignment with group values and professional ethics. The professional expertise of people working within this social system is augmented by commitment to the communities they serve and attachment to the places where they work, play and raise their families.



"Discovering" the *Kaleidoscope of Expertise*

Knowledge about how people in southern Maine value water came from a series of interviews with people involved in municipal water management. The initial idea behind the interviews was to identify gaps in the knowledge of municipal officials that could be addressed by providing science based information as portrayed in the traditional science translation model below. After only a few interviews, the limitations of the original model became clear. The Collaborative Learning Model represents the transformation of the linear concept of information delivery to a systems understanding of the knowledge and expertise residing in the municipal system for protecting and managing water. The metaphor of the *Kaleidoscope of Expertise* came from the realization that each person views water and their role in managing water through an individual lens affected by their education, training, work experience and the requirements of their job. Taken together, the combined knowledge and expertise of the people responsible for water is a resource for learning and problem solving. Collaborative Learning is a way to tap this resource.

Knowledge in the Kaleidoscope

Seven types of knowledge or *ways of knowing* about water emerged from analysis of the interviews of southern Maine water managers. The interviewees included people involved in scientific research and implementation of state regulatory programs, as well as municipal officials. During each open ended interview, people talked about their work, how they valued water, and their ideas about threats to water, the causes and effects of those threats and what could be done to protect water. The ways of knowing about water are described below and coded into the *Kaleidoscope of Expertise* model. People draw from multiple ways of knowing in their work.

1. Ecological Knowledge **ECO**: Understanding of the structure and functions of a watershed, the hydrologic cycle, connections between groundwater and surface water, and the value of ecosystem services provided by a watershed.
   People who use this knowledge: ecologists, farmers, hydrologists

2. Governance Knowledge **GOV**: Understanding the interrelationships among policy, regulations, government hierarchy, planning documents and ordinances, and the structures and processes in place to execute them.
   People who use this knowledge: town planners, code enforcement officers, elected officials, regulators

3. Land Use Knowledge **LAN**: Understanding the ways land management and conservation and the design of infrastructure and development can influence water quality and quantity, and the ways that the economic value and ecological value of land can be balanced.
   People who use this knowledge: Town planners, farmers, developers, public works directors, water district managers

4. Educational Practices Knowledge **EDU**: Understanding the ways knowledge is generated and transferred among the knowledge domains and designing and evaluating the effectiveness of education and outreach strategies.
   People who use this knowledge: Education and outreach specialists, trainers, science translators, town planners.

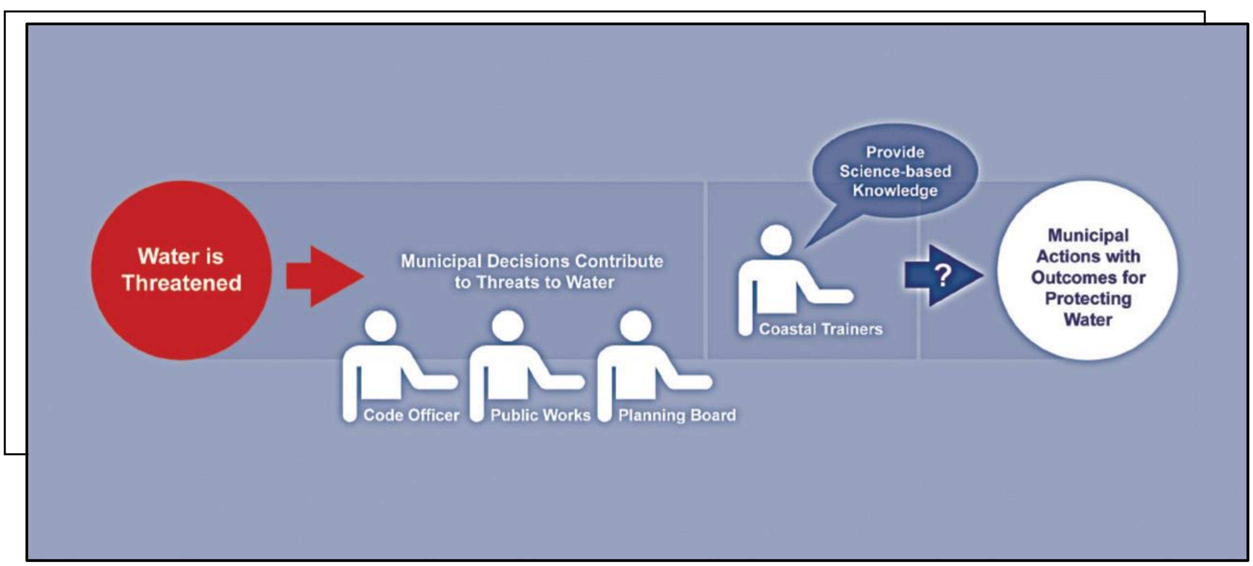
5. Science Knowledge **SCI**: Understanding the factors influencing water quality and quantity for the purpose of documenting conditions, monitoring change, understanding cause and effect relationships and evaluating the effectiveness of management practices and policies.

People who use this knowledge: Biophysical and social scientists, water quality monitors, regulators

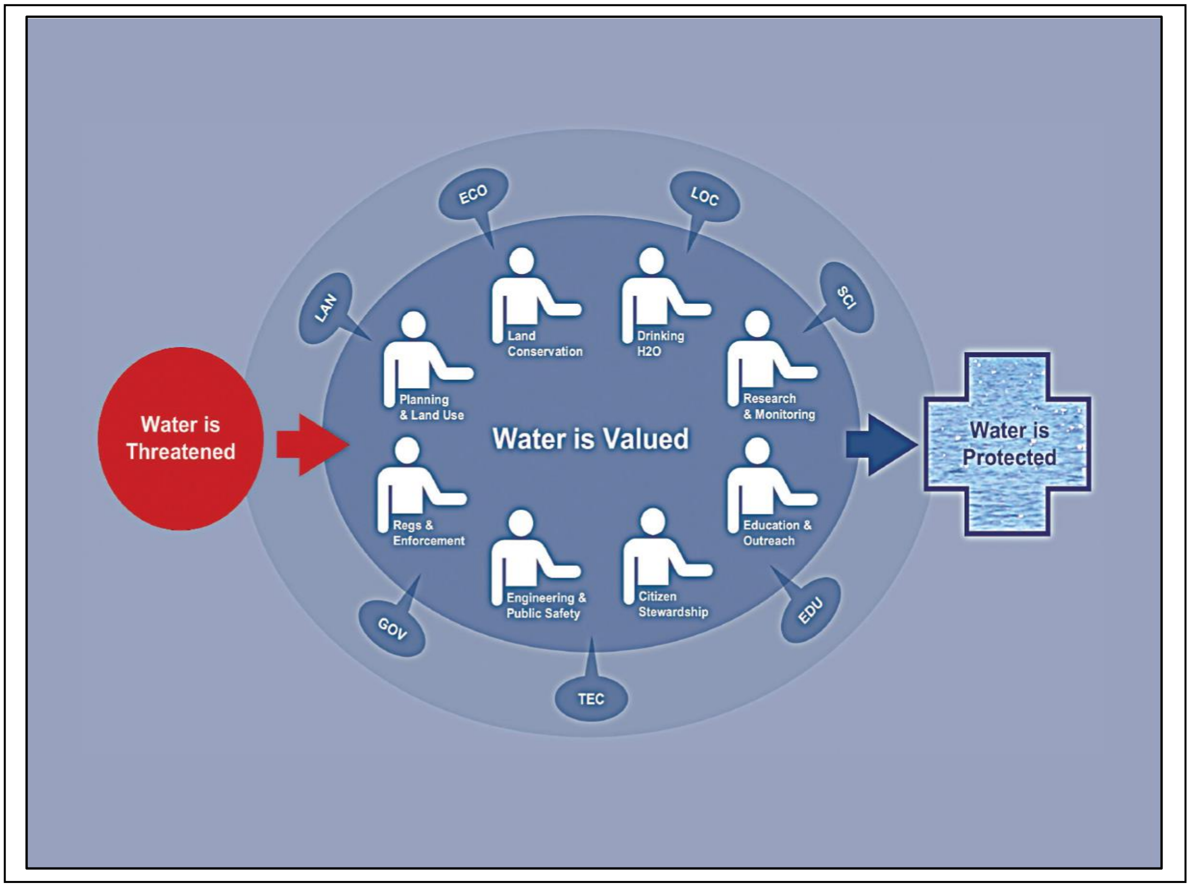
6. Technology Knowledge **TEC**: Understanding the use and application of engineering and computer technologies to the protection of water, mitigation of impacts, implementation of best management practices and restoration of lost structure and function in the watershed.
   People who use this knowledge: Engineers, public works directors, GIS specialists

7. Local Knowledge **LOC**: Understanding the connections between the people and places in the community, including familiarity with town history, values and conflicts.
   People who use this knowledge: Town planner, public works director, elected officials, farmers, developers.

A Model of Traditional Science Translation



The Collaborative Learning Model with the *Kaleidoscope of Expertise* -
The municipal system is a resource not a receptacle.



2f. Discussion

This project introduces Collaborative Learning as one tool for structuring the complex dialogues that drive ecosystem management. The National Research Council (2009) recognizes the unprecedented decision-making challenges associated with global climate change. Environmental conditions, stressors and responses will be shaped by events that have not previously existed and society will need new strategies for adapting to these changes. Collaborative Learning has the potential to be used by practitioners working on the front lines of climate change adaptation. These are the places where ecosystem management has a face and a place. People live work and play in the natural systems affected by daily decisions. When scientific findings give shape and meaning to the changes people see or can't see in the places they care about, Collaborative Learning is one way to foster the analysis and deliberation required to incorporate that knowledge into policies and management actions.

Collaborative Learning is part of the rapidly growing interdisciplinary field of Environment Communication. This field encompasses scholarly research and practical applications dealing with the ways society understands and responds to environmental messages and events. Environmental communication marries participatory and collaborative approaches with traditional environmental education and interpretation, taking the most effective practices and principles from the craft and framing them within interdisciplinary theories of learning and behavior. This rich interdisciplinary field addresses the communication of science and environmental risk, multi-stakeholder collaboration, public participation, conflict resolution, social marketing, environmental journalism, the representation of nature in popular culture, and environmental advocacy campaigns (Cox, 2006). Decision support as a discreet practice is emerging in a critical role for environmental communication in the context of climate change (NRC, 2009). These diverse approaches provide tools to educate, alert, persuade, mobilize and engage people in ecosystem management.

Three other approaches to Environmental Communication are highlighted here for comparison with Collaborative Learning. Because each approach is based upon different theoretical and applied traditions, they vary in their orientation to social learning, behavior change, knowledge flow and goals. See page 16 of the *Collaborative Learning Guide* for a conceptual model of environmental communication for ecosystem management.

These approaches can be applied within a matrix of scale and temporal conditions. The scale of this project was a small group of municipal officials working in their hometown watersheds. The temporal aspect of this project is engagement over an extended period. The Protecting Our Children's Water project is framed as 2005 - 2025 to foster intergenerational thinking. During this project Collaborative Learning was also applied with groups gathering for a one-time strategy session to develop consensus and overcome conflict in order to make progress on shared goals.

Public Participation and Civic Engagement

The history of public participation has strong roots in the New England town meeting. Public participation in federal environmental policy increased with the passage of the National Environmental Policy Act (NEPA) in 1969. The relationship among federal environmental agencies and public participation has evolved through a series of laws, policies, and on the ground experience during the past four decades. Political theorist Kai Lee (1993) captured the link between public participation, which he refers to as civic engagement, and ecosystem management using the metaphor of the compass and gyroscope. Science is the compass that guides ecosystem management toward goals of sustaining ecosystem structure and function. Civic engagement Is the gyroscope providing course corrections related to societal goals and priorities. Public participation consists of a rich collection of approaches aimed at improving the quality and legitimacy of decisions and increasing the capacity of federal agencies and their constituencies to engage in long-term policy dialogues. The Collaborative Learning process is one technique that can be adapted to facilitate public participation.

Community-based Social Marketing (CBSM)
Drawing from theory and practices associated with social psychology and marketing, Community-based Social Marketing can be applied to foster practices that support ecosystem management objectives. Conserving and restoring riparian buffers is an example of a project identified as an action item by the watershed councils in the Protecting Our Children's Water project. CBSM uses a rigorous four-step method that can be used to design and implement behavior change projects. The key to success with this method is preliminary research to identify the barriers and benefits of the desired action. Combining this knowledge with behavior change tools documented as effective by social psychology research results in a strategy designed to reduce barriers and increase benefits. The strategy for behavior change is tested and improved through a pilot project then implemented in a broader context. Evaluation of behavior change success depends upon knowledge of baseline conditions before the project.

While CBSM is most frequently applied to implement local projects that support ecosystem management, the approach can be adapted to a broader scale as a means of identifying and overcoming barriers to building capacity for ecosystem management. The Protecting Our Children's Water project applied elements of CBSM to initiate and support the development of Watershed Councils in southern Maine.

Technology Transfer and Science Translation
Knowledge flows from a source of expertise toward a user in the communication model for both technology transfer and science translation. Extension and outreach also follow this basic model of knowledge dissemination. The eloquent and well document theory of the diffusion of innovations provides rich empirical evidence for the elements and variables that interact to support effective diffusion and adoption of knowledge, practices and policies (Rogers, 1995). Facilitating technology transfer and science translation in support of ecosystem management requires that users perceive an advantage to the new knowledge or practice and that it is consistent with their values and experiences. Potential users need to recognize the relevance of new knowledge to their work. The complexity of new knowledge needs to be reduced to a point where the user can try the new idea (the Collaborative Learning Guide aims to do that for this project). Even more effective are opportunities to observe or participate with others using the new knowledge or practice. Collaborative Learning can be used as a means to introduce scientific findings or best practices with relevance to ecosystem management to groups of stakeholders. Collaborative Learning provides a structured opportunity for groups to analyze and deliberate about scientific findings and discuss the application of that information to management or policy (NRC, 2009). It can also facilitate ongoing relationships among policy makers, regulators, managers and scientists to address shared goals for ecosystem management.

3. Utilization

3a. End User Application (See Appendix I)

The end user concept does not adequately capture the way this "tool" or knowledge has been developed in collaboration with coastal managers and outreach professionals. The Action Research paradigm that guided this project is founded upon the principle that research is designed and executed in collaboration with a group that is trying to solve a problem or make progress changing a situation (Greenwood and Levin, 1998). Action research draws from the experience and knowledge of the group to define the problem, examine variables, develop a research question and design a program of research to answer the question. Because of dissertation research standards this project applied elements of action research in combination with traditional investigator driven research.

With that caveat in mind, the end users for this research are coastal management professionals and researchers motivated to integrate biophysical and social science with the Kaleidoscope of Expertise associated with the places and natural systems they are managing or studying. The project was developed and implemented with consistent end user contact with municipal officials working in southern Maine watersheds, regulators with Maine DEP, US Fish and Wildlife Service, Maine NEMO, Maine Coastal Program, Maine Sea Grant, Southern Maine Regional Planning Commission, and university students and faculty at the University of New England (UNE).

The tool was developed as the Coastal Training Program (CTP) of the National Estuarine Research Reserve System (NERRS) evolved to maturity. As a member of the professional cadre of CTP Coordinators from the program's inception in 2002, the principal investigator had unprecedented contact with the people who the tool was designed to support. At a minimum of twice each year, the ideas feeding into the tool were vetted with CTP Coordinators and other NERRS professionals at annual and sector meetings.

The cultural models research that underpins this project was used in consultations to provide technical assistance to Maine DEP watershed professionals, Maine Coastal Program outreach specialists, National Estuary Program managers, and researchers from UNE, the University of New Hampshire and the Ecosystem Based Management Tools Network. These consultations consisted of ways to incorporate knowledge of the cultural models of waters and the system of water protection at the municipal level into communication campaigns, research design and program development related to watershed management.

3b. Knowledge Exchange (See Appendix I)

3c. Intellectual Property and Partnerships

The principal investigator's dissertation, *"Protecting Our Children's Water" Using Cultural Models and Collaborative Learning to Frame and Implement Ecosystem Management* (Feurt, 2007) is copyrighted but readily available through any academic library using Dissertation Abstracts. The Collaborative Learning Guide is based upon the dissertation but is not copyrighted separately.

4. Barriers and Bridges to Application[5]

A New Paradigm

[5] See Appendix II for additional information on Barriers to Application.

Paradigm shifts are not easy or quick, as documented in some of the keystone literature of science and ecosystem management (Kuhn, 1962; Lee, 1993, Gunderson and Holling, 2002). The need for a paradigm shift in the way science is made available and used by society was clearly articulated by Dr. Jane Lubchenco, current Director of the National Oceanic and Atmospheric Administration (NOAA), in an article published in *Science* in 1998.

> " The whole system of science, society and nature is evolving in fundamental ways that cause us to rethink the way science is deployed to help people cope with a changing world. Scientists should be leading the dialogue on scientific priorities, new institutional arrangements, and improved methodologies to disseminate and utilize knowledge more quickly."
>
> Lubchenco, J. 1998. Entering the century of the environment: A new social contract for science. *Science* 279: 491-497.p. 496. (Emphasis added)

The Collaborative Learning methodology developed during this project is one such methodology. This project builds upon the work of Daniels and Walker (2001) by using ethnographic methods associated with cultural models to enhance the systems understanding required for robust collaborative problem solving processes. This project demonstrated the potential for integrating natural and social science to achieve the goals of ecosystem management. Some of the barriers to knowledge dissemination and utilization encountered during this project are described below.

Barrier #1: Underutilization of social science in ecosystem management.
One barrier to application of this method is overall underutilization of social science methodologies related to communication in ecosystem management. Environmental communication theories, principles and practices grounded in a variety of social science disciplines can facilitate the collaborative decision making required for complex environmental issues (NRC, 2009). Scientists and resource managers trained and experienced in the disciplines of biophysical science are less familiar with the ways environmental communication can be employed in ecosystem management. This lack of familiarity on the part of both funders of ecosystem research and biophysical researchers leads to less integration of both innovative and well-established communication strategies into ecosystem management projects. Interdisciplinary research that integrates social science and biophysical science can evaluate the effects of policy, regulation and management practices on ecosystem structure and function. This type of research fuels the process of adaptive ecosystem management.

Barrier #2: Traditional models of science delivery are strongly held.
Another barrier to application of this method is the strongly held, traditional model of science translation based upon the idea that "delivery of scientific information will cause decision-makers to change their behavior." This belief in deeply ingrained and would have been an interesting cultural model to document empirically for this project. The limits of this way of thinking about science translation are known (Mackenzie-Mohr and Smith, 1995). This project developed, tested and disseminated a two component conceptual model of the *Kaleidoscope of Expertise* and the *Collaborative Learning Bridge* as a way of using social science to implement communication objectives of ecosystem management. Graphic images of the Collaborative

Learning conceptual model as compared to the traditional conceptual model of science translation are part of every Power Point presentation given for this project (see Appendix I) and the Collaborative Learning for Ecosystem Management guide.

The Kaleidoscope of Expertise is a metaphor for the way members of a system view an environmental issue from many perspectives. The system within which an environmental issue is embedded includes the people experiencing the issue in the places where they live, work and play. These are places they care about, places they are responsible for and places where they connect regularly with other people who share a stake in the condition of that place. Knowing the components and boundaries of the Kaleidoscope of Expertise for a specific issue puts a *place* and a *face* on ecosystem management. This knowledge is critical for collaborative problem solving.

Environmental messages with prescriptions for management or stewardship that connect with the places where people live, work and play attract attention and have motivational power that abstract messages lack. Environmental decisions and actions that have been developed by people who have the opportunity to hear scientific evidence and deliberate about its meaning for their work and life are more likely to result in solutions to complex problems (NRC, 2009).

Barrier #3: The science generation system is largely independent of the science utilization system.

The notion that the system for creation of scientific knowledge tends to operate independently of the places where that knowledge might be used for management and stewardship is another barrier to application. Because these two systems are decoupled the need for science translation and technology transfer are long-recognized components of the science generation system. Collaborative Learning and methodologies like it represent the next generation of approaches for bridging the systems. These new methodologies do not replace science translation and technology transfer. They offer additional strategies that can function within the bounds of increasing complexity, uncertainty and conflict.

The second component of the conceptual model developed by this project uses a bridging metaphor in recognition of the nature of this barrier. The Collaborative Learning Bridge, uses the ethnographic knowledge about the Kaleidoscope of Expertise to understand the perceptual, organizational and disciplinary barriers separating the system of science generation from the system where that science can be *put to work* in management, stewardship and decision-making. Understanding the cultural models of water shared by the members of the Kaleidoscope of Expertise, how they view environmental threats, and the ways they view their work as part of a system for protecting water revealed the ways science was used and *not used* with in the system. Once understood, the knowledge and expertise within the system became a resource for problem solving. Knowledge of collaborative potential and underlying conflict was used to adapt the Collaborative Learning process to work more efficiently (Feurt, 2007).

The value of this type of systems knowledge to facilitate the use of science in decision-making is underappreciated. People may think that they know what the audience knows, what they care about and why they are not using science-based knowledge. Education programs, guidebooks, curriculums, brochures and websites are developed without important knowledge of the system within which these products are designed to work. Appendix II gives an example of the application of the Collaborative Learning model for this project.

Barrier #4: The organizational infrastructure for integrating collaborative problem solving and decision support processes like Collaborative Learning into community based ecosystem management is currently underdeveloped.

This project was developed within the National Estuarine Research Reserve System's Coastal Training Program. This project was possible because additional funding from CICEET and a dissertation program were combined with a half time positions as the Coastal Training Program Coordinator of the Wells NERR. Academic infrastructure that supported the project was available through the Principal Investigators position in the Center for Sustainable Communities in the Department of Environmental Studies at the University of New England. Two CICEET funded projects supported the research and technology transfer of the Collaborative Learning model. This innovative approach to "technology" development bridged each of the four barriers described in this section. CICEET funded social science that was tightly coupled to natural science that not only challenged the traditional model of science translation, but also developed an innovative alternative approach suited to community based ecosystem management. Funding from CICEET supported research that was directly connected to the NERRS goal of improving the use of science based information in coastal decision-making.

Coupling the science generation system and the science utilization system was the central research question guiding this project. Working within both systems benefited the development of a product that was tested *weekly* in the environment where it would be applied. Coupling the generation of knowledge and the use of that knowledge to solve problems is the foundation of the Action Research paradigm (Greenwood and Levin, 1998). Action Research is embedded in the system where the research questions arise. The people with a stake in problem identification and solution are engaged in research that aims to better understand the root causes of a situation in order to develop effective solutions. The wisdom of the people closest to the situation is treated as a knowledge and problem solving resource. This research approach benefited from the innovative program in Environmental Studies at Antioch University New England. Antioch doctoral students follow independent research under the guidance of their dissertation committee. Student research is supported but not driven by faculty priorities. Antioch students can remain in professional positions and pursue a course of study and research integrated with their work.

Building Bridges for Ecosystem Management

The Coastal Training Program of the National Estuarine Research Reserve System began as part of the interpretive education program of the system. The need to connect coastal decision-makers - professionals working in land use, coastal management and conservation, to science relevant to their professions, was recognized as an important objective for the system. The Coastal Training Program was developed to couple the science generation system and the science utilization system (Barrier #3).

Implementation of CTP at each NERRS site required use of social science methodologies. Coastal Training Program development used a Market Analysis and Needs Assessment to identify the issues and audiences relevant to each region. Most CTP Coordinators received training in Project Design and Evaluation provided by NOAA's Coastal Services Center that further strengthened the use of social science in the implementation of the program (Barrier # 1).

Bridging Barrier #4 to build the organizational infrastructure that supports collaborative decision-making like that called for in the recent National Research Council Report (2009) requires overcoming Barrier #2 - traditional models of science delivery. The Coastal Training Program of the NERRS is maturing into the role of providing critical decision support that brings scientists, managers and policy makers into settings where collaborative problem solving transcends the idea of delivery of science. In reserves across the country, CTP Coordinators convene and facilitate interdisciplinary groups that develop and participate in activities designed to bring scientific knowledge into discussions where people can examine the relevance and meaning of that knowledge in the context of their professional practice and expertise. CTP Coordinators are embedded within the systems where science is used to craft policy, develop best management practices and evaluate the response of ecosystems. They are in repeated contact with the planners, developers, public works directors and watershed managers who live, work and play in the natural systems where water quality, edible shellfish, clean beaches and wildlife are personally valued. The potential to contribute to the adoption of sustainable science-based coastal management practices is profound as evidenced by the documented successes of the program (CTP Briefing Book, 2008; GEARS, 2009).

The *Coastal Training Program External Evaluation* recognized Barriers #2 and # 4 as limiting the ability of the NERRS to achieve system objectives and realize the potential of the Coastal Training Program (GEARS, 2009). The external review panel specifically recommended building competencies in collaborative problem solving like the methodology developed for this project. Collaborative Learning processes that include key decision-support elements identified in the recent National Research Council Report (2009), *Informing Decisions in a Changing Climate*, are within the purview of Coastal Training Program. Most Coordinators have developed a network of decision-makers who participate regularly in NERRS sponsored training, workshops and meetings. The CTP Coordinators are skilled communicators and facilitators of processes characterized by the NRC report as *analysis and deliberation* (GEARS, 2008; NRC, 2009). CTP Coordinators are in direct contact with managers, policy makers, and government officials at the local, state and national level. The level of trust among these decision-makers for CTP Coordinators as a source of science-based information is high (GEARS, 2009).

A single CTP Coordinator at a NERR can adequately *deliver* science-based knowledge according to the traditional model of science delivery in accordance with performance measures applied throughout the system. Designing, implementing and evaluating Collaborative Learning in support of ecosystem management requires additional organizational infrastructure. A single CTP Coordinator implementing the program at a reserve can develop and implement collaborative problem solving processes. What they are less able to do, primarily because of time constraints, is to use social science or action research protocols to develop programs that support ecosystem based management. A number of CTP Coordinators (Elkhorn and Tijuana Slough NERRs in California; Padilla Bay NERR in Washington; and Wells NERR, in Maine are examples) have secured outside funding to accomplish research-based projects. These projects are models for the potential of the Coastal Training Program to support ecosystem-based management. The external review of CTP identified the need to secure additional resources to expand the reach and accomplishments of the system-wide objectives of CTP (GEARS, 2009). The same review recommended building core competencies for CTP Coordinators that support the ability to conduct processes like Collaborative Learning.

The nascent organizational infrastructure to support coastal community based ecosystem management exists within programs like the NERRS Coastal Training Program. University-based Sea Grant and Cooperative Extension, the National Estuary Program, the national network for NEMO (Nonpoint Education for Municipal Officials) and individual state coastal programs. Professionals within this network operate in varying ways as *couplers* of the science generation and science utilization systems. The Massachusetts Institute of Technology (MIT) - US Geological Survey (USGS) Science Impact Collaborative, nicknamed MUSIC, recently coined the term *Science Impact Coordinators* to capture this role. MUSIC is experimenting with a field-based graduate training program to develop the skills of the next generation of ecosystem scientists and managers by placing students in federal agencies where they apply action research principles to current policy and management issues (Susskind and Karl, 2009).

This project, *Collaborative Learning Strategies to Overcome Barriers to Science Translation in Coastal Watershed Management*, benefited from over seven years of engagement with members of the education, outreach and science translation system working in coastal ecosystems. The ways that professionals within these programs are currently working to support the co-creation and use of scientific knowledge provides evidence that the paradigm change in the way science is linked to society is occurring. The development, testing and evaluation of cultural models-based Collaborative Learning in the context of community based ecosystem management strengthened the application of the approach through on-going collaboration with the people using the technology.

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Collaborative Learning Strategies to Overcome Barriers to Science Translation in Coastal Watershed Management

Appendix I: Knowledge Exchange

Overview

The knowledge exchange portion of this project is outlined below. This project focused on the process of knowledge creation, dissemination and application. Because of that focus and the interdisciplinary competencies of the project team, the majority of effort on this project was devoted to knowledge exchange and evaluating the effectiveness of Collaborative Learning as a methodology for knowledge exchange in ecosystem management.

The watershed professionals, water managers and land use decision makers participating in the Protecting Our Children's Water project were partners in the effort to create effective strategies for reducing non-point source pollution in their sphere of work. They were committed to working collaboratively with others across municipal boundaries to make progress on action items developed by the group and identified in watershed management plans.

The results of the project, including the cultural models findings, and the application of Collaborative Learning as a tool for ecosystem management have been widely disseminated through national and international conferences, workshops, and trainings. These events are listed below.

Approximately 1,225 people involved in policy, management, research and education related to water and coastal management have been connected to this project through participation in Collaborative Learning workshops, presentations and meetings.

Manual

The *Collaborative Learning for Ecosystem Management* guide distills the key elements of the conceptual framework developed through this project. The guide was completed at the end of the project and will continue to be used in conferences, workshops and trainings. The guide is available on line through the Wells National Estuarine Research Reserve, University of New England and CICEET websites. One hundred hard copies of the guide have been distributed at conferences, workshops and trainings.

Students

The Principal Investigator received a Ph.D. in Environmental Studies from Antioch University New England. Her dissertation was based on this project. The dissertation "Protecting Our Children's Water, Using Cultural Models and Collaborative Learning to Frame and Implement Ecosystem Management" was deposited January 31, 2007.

Undergraduate students at the University of New England working with the Center for Sustainable Communities contributed to this project through the design of cultural models based outreach programs with the local community and through research and logistical support of the Protecting Our Children's Water project.

The Interdisciplinary Project Team

Principal Investigator:
Dr. Christine Feurt, Coastal Training Program Coordinator, Wells National Estuarine Research Reserve, Wells, Maine & Director, Center for Sustainable Communities, Department of Environmental Studies, University of New England, Biddeford, Maine

Additional Investigator(s): (March 2006 - March 2007)
Kristen Grant, Extension Specialist, University of Maine Cooperative Extension and Maine Sea Grant

Interdisciplinary Project Advisory Team: (March 2006 - January 2007)
Dr. Michael Paolisso, Assistant Professor of Anthropology, Department of Anthropology, University of Maryland, College Park, Maryland
Dr. Thomas Webler, Core Faculty Department of Environmental Studies, Antioch New England Graduate School, 40 Avon Street, Keene, NH

Workshops, Trainings, Conferences, Small Group Presentations

National Training:
Collaborative Learning – A Tool for Ecosystem Based Management

A workshop presented at the 20th International Conference of The Coastal Society in St Petersburg, Florida, May 14, 2006.

8 hours, 16 people: including coastal managers, academics, national and international attendees, representatives from local, regional, state and federal government

This training introduced the coastal management community to Collaborative Learning. Instructors Dr Steven Daniels and Dr. Gregg Walker are internationally recognized leaders in the field of Collaborative Learning and authors of the seminal work in the field. The training attracted people working in natural resource management, environmental, and community planning, decision-making, and conflict resolution situations characterized by the following features: multiple parties, deeply held values, cultural differences, multiple issues, scientific and technical uncertainty, and legal and jurisdictional constraints. The training focused on skills that encourage systems thinking, joint learning, open communication, constructive conflict management, and a focus on appropriate change.

Collaborative Learning Watershed Workshops
"Protecting Our Children's Water, 2005 - 2025"
Implementing a Watershed Approach in Two Southern Maine Watersheds

Watershed Workshops to Town Managers, Select Boards and Town Councils in watershed towns, 8 presentations March – June 2006. 40 attendees.

These 8 presentations to elected and appointed officials and municipal staff were designed to solicit feedback on the formation of a regional watershed council and to secure municipal buy-in for participation. This phase of the technology transfer process creates links between municipal governance and the science and technology aspects of watershed management.

Strategic Planning Workshops for Little River and York Watersheds February and June 2006. 45 attendees.

These two workshops focused on prioritization of annual action items for two southern Maine watershed councils. Participants included municipal, state and federal officials, non-profits and local watershed groups.

Protecting the Headwaters Tour Branch Brook Watershed May 2006. 12 attendees.

This field workshop included tours of ATV damage to the headwaters of the local drinking water source, visit to a mitigation project for a toxic clean up site, and tour of an innovative urban stormwater management project. Municipal, state and federal officials attended. Field workshops as part of this series incorporate place-based aspects of technology transfer and focus learning on local landscapes. This format allows local watershed managers to highlight successes and share challenges with peers in an informal session.

Stormwater Management Tour of UNH Stormwater Research Facility June & September 2006 17 attendees.

The UNH Stormwater Research Center is a CICEET funded demonstration project. This workshop included a field-based tour of 16 stormwater treatments being evaluated for effectiveness at removing sediment and pollutants. Demonstrations included the effects of porous pavement and the differences between wet and dry ponds, swales and engineered devices. A power point program given by the scientists that designed the facility followed the field session. Participants included state and federal regulators and coastal managers from municipalities, regional government and non-profits. The CICEET Stormwater Center is linked to actions in local watersheds through these workshops.

Since the inception of the POCW project, watershed council members who have attended the stormwater research workshop at UNH have proposed four pervious pavement projects. One of those projects is complete, one has been funded and is due for completion in 2007, one is on hold pending funding and one project was denied by DEP on the grounds of cost. We intend to investigate this barrier to technology translation during the coming months.

Protecting the Source Workshop York River Watershed, York, Maine
August 23, 2006, 22 attendees

The York and Kittery Water Districts hosted this workshop to acquaint the Watershed Council delegates with issues of source water protection. Local, state and federal officials joined conservation organizations for this workshop. This workshop targeted the value of land protection, regulatory enforcement and innovative strategies for social change.

Kittery Stormwater Road Trip Kittery, Maine
September 27, 2006, 25 attendees.
Federal, state and local government officials were hosted by the Spruce Creek Watershed Association for a tour of businesses and municipal stormwater treatments. The group visited a municipal site using new stormwater treatments designed by Dr. Rob Roseen. The group toured the Kittery Training Post and Robert's Maine Grill Restaurant were new stormwater management techniques had been adopted. The group had lunch together at Robert's Maine Grill where the owner discussed his choice of stormwater treatments for his property. Dr. Robert Roseen of the UNH Stormwater Research Center and Zack Henderson of Maine DEP were guest speakers leading the tour. This event extended the reach of the watershed council to include Maine DEP staff from Augusta, the Casco Bay Estuary Project and participation by a regional consulting engineer. This workshop demonstrated the interplay between citizen advocacy, business leadership, and the diffusion of innovations through social and institutional networks.

York River Watershed Council - Protecting Our Children's Water Workshop**,** October 4, 2006. York, Maine. 20 attendees.

This Collaborative Learning workshop convened municipal officials from the four towns surrounding the York River Watershed, and state and federal managers to evaluate the *Protecting Our Children's Water* project. This workshop included progress reports on action items, evaluation and future plans for the watershed council. The watershed council delegates decided to continue the watershed council approach as long as elected officials supported participation.

Kennebunk River Watershed - Action Plan Workshop October 26, 2006. 23 attendees.

The technology transfer project proposed adaptation of the Cultural Models-based Collaborative Learning methodology to one southern Maine workshop. We were able to apply and test the methodology in two additional watersheds. Members of the Kennebunk and Kennebunkport Conservation Commissions, Kennebunk River Committee, Maine DEP, Maine NEMO, municipal staff and community members gathered to develop a watershed action plan for the Kennebunk River Watershed. The Cultural Models-based Collaborative Learning methodology was used to facilitate the process. The group prioritized action items and delegated sub-groups with responsibility for each item. Progress on action items is ongoing and will be reported on in the final report.

Spruce Creek Watershed - Action Plan Workshop. November 29, 2006. Kittery Town Hall. 37 attendees.

Increased visibility of the Collaborative Learning methodology in southern Maine resulted in a request to adapt the methodology for the purpose of rapid assessment and action plan development. The methodology was applied in a fourth watershed, Spruce Creek. Members of the Spruce Creek Watershed Association, municipal officials and citizens gathered to review results of the Spruce Creek Watershed Survey and to prioritize action items for a Watershed

Management Plan. The Cultural Models-based Collaborative Learning methodology was used to design and implement the action planning process.

Presentations Given to Elected Officials
Eliot Board of Selectman Meeting November 9, 2006, 20 attendees
York Board of Selectman Meeting November 13, 2006, 20 attendees and televised on public access TV
Kittery Town Council Meeting November 27, 2006, 25 attendees and televised on public access TV

The above three presentations provided elected officials and town residents an update on the *Protecting Our Children's Water* project. Elected Officials were asked to decide if their town should continue to participate in the watershed council. Elected officials in all three towns voted unanimously to support the watershed council and continued to devote municipal staff time to the project. The cultural models research was incorporated into the PowerPoint presentation used to secure the commitment to participate in regional watershed management. The fourth town in the watershed has not scheduled a presentation and has not indicated a preference for continued participation in the watershed council. That town will be contacted during spring of 2007.

Jacques Cousteau NERR and Southern Maine Watershed Councils - Stormwater Management Tour of UNH Stormwater Research Facility. May 7 & 8, 2007 University of New Hampshire, 12 attendees from Maine.
The UNH Stormwater Research Center is a CICEET funded demonstration project. This workshop included a field-based tour of 16 stormwater treatments being evaluated for effectiveness at removing sediment and pollutants. Stormwater Managers from coastal New Jersey interacted with stormwater managers from southern Maine and scientists from the UNH Stormwater Center. This workshop was part of the *Protecting Our Children's Water* (POCW) project. The UNH Stormwater Research Center is integrated into the project to foster science translation. Since the inception of the POCW project, watershed council members who have attended the stormwater research workshop at UNH have proposed four pervious pavement projects. At the conclusion of the workshop Dr. Feurt participated in a planning session with NOAA Coastal Services Center and UNH Stormwater Center to develop training and outreach materials for audiences unable to visit the site at UNH.

York River Watershed Council - Protecting Our Children's Water Workshop**,** Kittery, Maine. June 18, 2007. 25 attendees.

This Collaborative Learning workshop convened municipal officials from the four towns surrounding the York River Watershed, consultants, NGOS and state and federal managers to evaluate progress on the York River Watershed action plan items. This workshop included progress reports on action items, evaluation and future plans for the watershed council.

Kennebunk River Action Coalition, Protecting Our Children's Water planning meeting. Wells NERR, October 31, 2008, 15 attendees. Kennebunk River watershed, including the towns of

Kennebunk and Kennebunkport. Fifteen people participated in the workshop to evaluate progress on implementation of watershed management plan goals and set priority action items for the coming year.

Kennebunk River Action Coalition, Protecting Our Children's Water planning meeting. Wells NERR, March 19, 2009 15 attendees. Kennebunk River watershed including the towns of Kennebunk and Kennebunkport. Fifteen people participated in the workshop to update on water quality monitoring, the Maine Healthy Beaches program and shoreline surveys to locate septic system pollution in the watershed.

<u>Presentations Given to Elected Officials</u>
Sanford Town Council Meeting June 18, 2007, 20 attendees and televised on public access TV.
South Berwick Town Council Meeting June 25, 2007 15 attendees.
Kennebunkport Town Public Meeting with Planning Board and Selectmen April 5, 2007, 30 attendees and televised on cable access TV

The above three presentations provided elected officials and town residents an update on the *Protecting Our Children's Water* project. The cultural models research was incorporated into the PowerPoint presentation used to secure the commitment to participate in regional watershed management. Elected officials are provided with project updates and given the opportunity for questions and feedback on project direction.

Conferences

2006
Maine Healthy Beaches Forum, Wells NERR, April 2, 2006.
Wells NERR collaborated with Maine Sea Grant, Maine Cooperative Extension, and the Maine Coastal Nonpoint Program to develop and implement this regional watershed forum to address beach water quality issues. The cultural models of water results were incorporated into this forum to create a framework for collaboration. 40 attendees

Maine Coastal Waters Conference, April 2006. Samoset Resort, Rockland, Maine. *"Protecting Our Children's Water" Bridging Disciplinary, Institutional and Perceptual Barriers to Improve Coastal Watershed Management Using a Collaborative Learning Approach.* 35 attendees**.**

The Coastal Society 20th International Conference, St Petersburg, Florida May 14, 2006
*"Protecting Our Children's Water," Bridging Disciplinary, Institutional and Perceptual Barriers to Improve Coastal Watershed Management Using a Collaborative Learning Approach***.** 30 attendees.

International Symposium on Society and Natural Resources (ISSRM), Vancouver, BC June 2006.
"Protecting Our Children's Water," Bridging Disciplinary, Institutional and Perceptual Barriers to Improve Coastal Watershed Management Using a Collaborative Learning Approach. 25 attendees.

National Estuary Program- NERRS Science Symposium July 17, 2006 *"Social Science and the NERRS"*. This webinar included coastal managers and scientists from across the NEP/NERRS system. The results of the cultural models research and application of the findings to the collaborative learning workshops was presented to a national audience. The PowerPoint for the presentation remains on the website for the lecture series. The final report and Cultural Models Primer prepared for the initial research are also posted on the seminar website. 16 people participated in the live webinar.

Coastal Training Program Oversight Committee Meeting August 29, 2006
NOAA-ERD Silver Spring, MD. *"CTP as a Tool for Adaptive Ecosystem Management"* Presentation of results of cultural models research and design of collaborative learning workshops with suggestions for adaptation of this methodology to further goals of ecosystem management at a national level through the Coastal Training Program. 20 attendees.

NERRS Annual Conference Old Woman Creek NERR Oct 15 – 20, 2006.*"Using Cultural Models and Collaborative Learning to Frame and Implement Ecosystem Management"* session with Coastal Training Program Coordinators. 30 attendees.

NERRS Annual Conference Old Woman Creek NERR Oct 15 – 20, 2006.*"Social Science and Ecosystem Management." 20 attendees.*

National Communication Association Conference, November 13 - 18, 2006; San Antonio, Texas "*Protecting our Children's Water*: *Learning collaboratively, bridging barriers, and improving coastal watershed management*." 20 attendees.

2007
Gulf of Mexico Alliance, Southwest Florida Community Workshop: Water Woes: Managing Water Resources & the Challenge of Changing Climates. February 20, 2007. Rookery Bay NERR, Environmental Learning Center. *The Value of Water, Learning collaboratively, bridging barriers and improving water management*. 20 attendees.

International Conference of the George Wright Society, St. Paul, MN, April 17, 2007. *Breakfast at the Cockpit Café and Other Innovations in Protected Area Outreach.* Collaborative presentation with Ward Feurt, Manager of Rachel Carson National Wildlife Refuge. 20 professionals and academics working with protected area management.

Non-point Source Pollution Conference (NEIWPCC), Providence RI, May 23, 2007.*Innovative Tools to Motivate Watershed Stewardship***.** 50 watershed managers, primarily from New England states.

Environmental Studies Summit, Syracuse University, Syracuse, NY June 15, 2007.*Innovative models for college/community collaborative research – experiences from the field.* Workshop for 12 people, primarily academic faculty from Environmental Studies programs.

CZ07, Portland, Oregon, July 23, 2007, Human Dimensions of Coastal Management Navigating From Policy to Practice. *Understanding Barriers and Bridges to Cross-scale Ecosystem Management Fostering Stewardship at the local scale.* 50 coastal managers and policy makers.

Washington State Legislative Policy Committee Public Hearing. October 28, 2007, Aberdeen, Washington. *Understanding Barriers and Bridges to Cross-scale Ecosystem Management Fostering Stewardship at the local scale.*

This synthesis presentation, developed for Coastal Zone 07, attracted the attention of the chair of the Washington State Legislative Committee on Natural Resources and Ocean Policy. The Senator invited Dr. Feurt to present to a public hearing on ocean policy held by the Senate Committee in Aberdeen, Washington. The session was attended by 50 people including local, state and federal officials and was recorded for rebroadcast on the legislative cable channel.

NOAA Brown Bag Seminar Series with webcast to NOAA Community
October 19, 2007 Silver Spring, Maryland. *Understanding Barriers and Bridges to Cross-scale Ecosystem Management – Fostering Stewardship at the Local Scale*. 25 participants from a variety of NOAA offices.

Coastal Connections: Linking Research and Education in Tropical Coastal Systems, an international symposium hosted at Antioch New England Graduate School November 3, 2007 Keene, New Hampshire. *The National Estuarine Research Reserve System – Linking Research, Education and Stewardship to Achieve Coastal Management Goals.* 35 attendees.

Estuarine Research Federation Conference, November 7, 2007 Providence, Rhode Island. Session title: Interdisciplinary Tools for Science Translation. Paper title: Fostering Coastal Stewardship: New Tools for Bridging the Science to Management Divide (a synthesis of the session). 45 attendees.

2008
NOAA Chesapeake Bay Program seminar, Annapolis, Maryland, January 18, 2008. *Understanding Barriers and Bridges to Cross-scale Ecosystem Management – Fostering Stewardship at the Local Scale.* The presentation was attended by 14 project partners and managers from NOAA's Chesapeake Bay Program.

Seamless Network of Marine Protected Areas. March 6 -7, 2008. Wells National Estuarine Research Reserve (NERR) Wells, Maine. Application of Collaborative Learning techniques to facilitate development of action plan for northeast conference of 40 participants from federal protected areas include National Marine Sanctuaries, National Parks, National Wildlife Refuge and NERRs in the northeast.

Maine Water Conference May 19, 2008, Augusta, Maine. *Connecting Stakeholders to Municipal Watershed Management*. 50 attendees including state, federal and municipal water managers, NGOs and academics

International Symposium on Society and Natural Resources (ISSRM). Presented in: Human Dimensions of Coastal and Marine Resource Management, June 12, 2008. Burlington, VT. *Understanding the "system" in ecosystem management - social science tools for natural resource managers.* 25 attendees: federal and state coastal managers, international academics, NGOs.

American Water Resource Association (AWRA) annual conference, June 30, 2008, Virginia Beach, Virginia. *Innovative Tools to Motivate Watershed Stewardship,* June 30, 2008. 25 attendees.

NERRS Coastal Training Program and Coastal Services Center Training External Review team September 16, 2008 Charleston, SC, *Collaborative Learning as a Tool for Ecosystem-based Management*. The Collaborative Learning project and funding by CICEET was acknowledged as an exemplary program supporting ecosystem-based management. 20 attendees participated in the review.

Wells NERR and Rachel Carson National Wildlife Refuge Science Symposium-Engaging Science in the Practice of ecosystem management. September 28, 2008. *Recognizing Ecosystem Management, A Social Science Perspective.* 40 attendees including state, federal and local government, NGOs and academia.

Wells NERR Reserve Management Authority (RMA), October 7, 2008. *Understanding Barriers and Bridges to Cross-scale Ecosystem Management – Fostering Stewardship at the Local Scale.* The RMA is the state governing body providing oversight to the Wells NERR and is comprised of federal, state and local government officials, the President of Laudholm Trust and University of Maine. 8 attendees.

4th National Conference on Coastal and Estuarine Habitat Restoration (Restore America's Estuarine), October 13, 2008, Providence, RI. *Facilitating Collaborative Partnerships - Building a Social Science Toolkit for Restoration Practitioners*. 50 attendees.

2009

Geological Society of America Northeast Section and Maine Water Conference. March 19, 2009, Portland, Maine. *Connecting Stakeholders to Municipal Watershed Management*. 50 attendees.

Non-point Source Pollution Annual Conference (NEIWPCC), Portland, Maine, May 19, 2009 *From the Headwaters to the Sea, Implementing a Watershed Approach in Southern Maine*. 35 attendees.

8th Bay of Fundy Ecosystem Partnership Science Workshop. Acadia University, Nova Scotia, Canada. May 29, 2009 *From the Headwaters to the Sea, Implementing a Watershed Approach in Southern Maine*. 20 attendees.

Lamprey River Watershed Workshop, Nottingham, NH, June 13, 2009 *Protecting Our Children's Water, Engaging the Kaleidoscope of Expertise*. 70 attendees.

Published

Feurt, C. and W. Feurt. 2008. "Breakfast at the Cockpit Café and other Innovations in Protected Area Management" in Harmon, David, ed. 2008. *Rethinking Protected Areas in a Changing World: Proceedings of the 2007 George Wright Society Conference on Parks, Protected Areas, and Cultural Sites.* Hancock, Michigan: The George Wright Society.

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Appendix II: Barriers to Application

What Municipal Officials Hear When Scientists Talk

Water researchers and municipal officials have different ideas about the application of science to decision-making about water. The statement, *"Just tell me what you want me to do!"* captures a busy town manager's reaction to the myriad scientific studies his town received for one very well researched watershed that falls within the Wells National Estuarine Research Reserve. This watershed has been part of the NERR System Wide Monitoring Program (SWMP)[6] for ten years (NERR, 2005). This program collects water quality data as part of a national system for monitoring key parameters of ecosystem health in estuaries. The same watershed was part of a microbial source tracking study to identify potential sources of coliform bacteria pollution (Whiting-Grant et al., 2004) and has been the focus of more than a dozen biophysical research projects and one social science project (Feurt, 2007). The town manager was briefed about most of the projects and received final reports for many of them. Non-point source pollution watershed survey and watershed management plans have been prepared for this watershed in accordance with Section 319 of the Clean Water Act (Wells NERR, 2003b; 2004).

These reports and plans are examples of what Peter Senge (1990) calls *detail complexity* providing a high level of analysis of some of the biophysical variables that characterize this estuary and its watershed. In the town manager's opinion, the studies have not helped him decide *what to do* to protect the watershed as development occurs. The quote above (and the remained of the interview in which it was embedded) captures a degree of frustration on the town manager's part when presented with research findings that to him don't readily translate into actions appropriate for town governance (Feurt, 2007).

Detail complexity in the water management system of southern Maine is exemplified by scientific research that concentrates on understanding ecosystem structure and function and the human impacts on that system. These investigations of detail complexity result in forecasting tools, research reports and water quality data. Such products may fail to produce innovative breakthroughs for ecosystem management because they fail to address the *dynamic complexity* of the system that is a function of the nature of the system as a whole. Dynamic complexity manifests as subtle cause and effect relationships that are acknowledged as unintended consequences or cumulative effects (Senge, 1990; Daniels and Walker, 2001). An understanding of the dynamic complexity of a system is the fuel for problem solving.

Daniels and Walker (2001) describe emergent properties, a concept developed by Checkland (1981), as those properties of a system that are undetectable when the system is viewed as a collection of discreet components. Emergent properties of a system become apparent and take on meaning when the system is viewed holistically at a larger scale. Viewed from a larger scale, the system may have qualities that are "*more than the sum of the parts*" (Daniels and Walker, 2001, p. 108).

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[6] Water quality, current, tide and weather data collected from remotely deployed data analyzers and relayed real time through an internet link.

Knowledge developed from the cultural models research for this project contributed to the ability to see the southern Maine municipal water management system holistically revealing emergent properties at work (Feurt, 2007). This had consequences for the ability to understand sources of conflict, root causes of problems and the collaborative potential of a situation based on shared values and perceptions. Collaborative Learning activities were designed using this knowledge of emergent properties providing a process for developing a shared systems perspective among stakeholders and using that perspective to work toward improved environmental conditions.

Emergent properties in the southern Maine system for managing water:

Collaborative Potential Exists for Municipal Water Management

What Daniels and Walker (2001) call the *substance* of a conflict includes the nature of the issue as tangible or symbolic, the complexity of the issue, and variation in meanings, knowledge gaps, and values among stakeholders. The findings provided four types of evidence in support of the collaborative potential within the water management system in southern Maine (Feurt, 2007).

1. **Shared values and recognition of treats**. The six cultural models of water and the diagnostic cultural model of threats provide evidence of shared values associated with clean water and shared reasoning about the types, sources and affects of threats that contribute to collaborative potential. These models provide a cognitive frame that is used in this adaptation of Collaborative Learning in much the same way that Daniels and Walker (2001) use the process triangle to transform understanding of a situation from a competitive to collaborative orientation. Understanding of these cultural models was also used to facilitate learning. The models provided familiar cognitive pathways used to efficiently translate new scientific findings and technological innovations that protect water.

2. **Appreciation of benefits of diverse expertise**. People use different knowledge domains to recognize, frame and reason about water and water protection. While expert knowledge within a domain is associated with experience and education, the interviews revealed that people appreciate the complexity of and have varying competencies in the domains outside of their primary expertise. Shared recognition that effective water management requires input from all domains in this knowledge system contributes to collaborative potential.

3. **Benefits to interdisciplinary and inter-jurisdictional collaboration**. The scope and complexity of the human activity system supporting municipal decision-making about water is an untapped resource. This system is under-appreciated by many people working both within the municipal system and by people working with municipalities from outside the system. Opportunities for people from different disciplines and different towns in the same watershed to interact are rare. The potential for collaboration is high. Participatory venues for deliberation and dialogue like that provided by Collaborative Leaning can tap the existing knowledge system as a source of innovative and practical solutions to water problems.

4. **The human activity system is motivated by service and commitment to place**. An eight-component human activity system functions at the municipal level to protect water. This system captures *the ways people act to protect water*. Combined with the knowledge system, which represents *what people know about water,* these two systems provide strong evidence for the collaborative potential in municipal water management. Within the human activity system, people work professionally and as citizen volunteers to accomplish tasks in alignment with personal and professional goals. Commitment to local places, and a focus on service to the community have motivational force for municipal officials.

Conflict as a Barrier to Collaboration

The cultural models data suggest six sources of conflict that could be barriers to municipal participation in both the Collaborative Learning process and implementation of regional watershed approaches to ecosystem management (Feurt, 2007).

1. **Conflicting ideas about the use of science in community based ecosystem management**. Municipal land use actions affecting water are governed by zoning standards, ordinances and codes. Scientists, educators and water program managers provide information to municipal officials about the impacts of land use on water quality. Scientific findings in support of changes in land use practices must follow a complex process of synthesis, translation and codification into the policies and practices guiding municipal land use decisions. The codification, and adoption of municipal governance documents is a participatory democratic process guided in southern Maine by the principle of home rule. Commitment and long-term engagement are required for this process to result in the translation of scientific findings into documents influencing municipal actions. This translation occurs most frequently in the form of state statutes that dictate municipal actions. The Collaborative Learning approach represents a novel and untested alternative to this established practice.

2. **Differences in decision-making associated with Designed Physical Systems and Natural Systems act as barriers to both learning and collaboration**. People whose work focuses on studying or managing natural systems can encounter conflict when they suggest actions that fail to consider work requirements dictated by the designed physical system within which municipal officials work. Within this system people work to maintain municipal infrastructure, develop subdivisions and conduct business. Perceptions of system boundaries and the role of humans as outside sources of threats versus the perception that humans are a productive part of the system act as barriers to both learning and collaboration. Perceptions of baseline conditions (e.g. pristine nature as an ideal type), tolerance for impacts, and motivation for action are examples of cross system barriers. These barriers effectively block communication and action despite shared values for clean water and mutual understanding of the nature and source of threats to water. Consideration of the ways multiple systems interact to protect and threaten water is difficult because of disciplinary and institutional barriers to systems thinking.

3. **Regulations produce standardized ways of thinking about responsibility**. Because of the role they play as drivers of municipal land use and water management, regulations and the regulatory framework within which they function are key determinants of municipal thinking about responsibility for protecting water. A complex regulatory framework applied within the hierarchical structure of federal, state and local governance has produced standardized ways of thinking about responsibility for environmental protection. Failure to take action may be linked to the perception that *someone else* within the hierarchy is protecting water, and the associated reasoning that state and federal regulations are adequate to protect local resources. Uneven enforcement of regulations at the municipal level is viewed as an institutional practice threatening water.

4. **Inappropriate blame.** Blame associated with single devil bias (Daniels and Walker, 2001) attributes failure to protect water to lack of knowledge or lack of commitment. Scientists and water managers identified education programs as a solution to this perceived lack of knowledge and/or commitment at the municipal level. Implicit in this education solution is the proposition that increased education will contribute to municipal actions that produce outcomes that protect water. While there may be differences in levels of knowledge related to science and technology, lack of knowledge was not perceived as the root cause of threats to water by municipal officials. Municipal officials cite lack of time and financial resources as root causes of failure to act. Making long term costs transparent can increase municipal attention.

5. **Property rights and property responsibilities**. Conflicting values associated with property rights and protecting the commons, as represented by water, are frequently unacknowledged and therefore unexamined with the result that property rights concerns dominate in debates about land use. People share the cultural model that water is the basis for life on earth, but the intergenerational consequences of cumulative and long-term threats to water are not always linked during dialogue and deliberation about property rights and land use. Resistance to enforcement of local land use regulations is linked to this value based conflict.

6. **Time and place**. Large scale and theoretical approaches to ecosystem management frequently dominate environmental problem definition and influence research priorities. Municipal land use decisions affecting water quality take place at the scale of individual properties, frequently under conditions of time pressure. Lack of knowledge of cumulative effects, unintended consequences, and scientific uncertainty about cause and effect relationships contributes to the exclusion of all but the most rigorously documented scientific results in the municipal decision making process. Linking municipal environmental actions to economic consequences that are part of the history of a place can provide retroactive evidence for considering long-term impacts and a rationale for precautionary action in the face of uncertainty. Local environmental histories provide morality tales that can bring the time scale of environmental decision-making into sharper focus. Science that connects indicators of environmental quality and cause and effect relationships with learning from past experience in local places puts a face and a place on ecosystem management.

Improving Dialogue and Deliberation

Scientists accept uncertainty as part of the scientific enterprise when working with complex natural systems. Science knowledge normally originates outside the boundary of the watershed management system within which municipal officials work. This makes science an *input* to the system rather than an element embedded within the system. Scientists can overestimate the motivational force of providing scientific information that does not include locally relevant management prescriptions.

Assimilation of science knowledge into watershed decision-making is handicapped further by framing water stewardship messages based upon the ideal conditions of the natural system as pristine and free from human impacts. This is considered unrealistic by many water managers working within a municipal environment to provide public services and protect public health and safety. These people are oriented to their primary responsibilities as town manager, town planner, and public works director. Science and ecological knowledge of water play a minor role in day-to-day decision making on the job.

Governance knowledge is important in this context. Water protection in considered in terms of compliance with regulations, local ordinances and approved plans. In cases where specific scientific or regulatory expertise is needed, staff, elected officials and volunteer citizen boards frequently defer to outside consultants to assist in interpretation of both science and regulations. Actions driven by compliance with regulations are influenced by citizen advocacy and demands for stewardship of local resources that may exceed what is required by law. Local knowledge of places and people in the community contributes to efficient governance by allowing municipal officials to navigate conflict and controversy.

This linking of science to governance is a well-documented aspect of adaptive management (Lee, 1993). Data from this project indicates that the complexities of adaptive management and mechanisms for the evaluation and incorporation of science into governance, or what Lee calls *civic science,* are not commonly practiced within the system of municipal water management documented by this research. Education practices that focus on *delivery of information* to increase knowledge fail to engage the full potential of adaptive management to facilitate the link between science and governance as civic science. The Collaborative Learning developed for this project offers a strategy for facilitating civic science.

Differences in the ways a water researcher and municipal water manager views the system of water protection are not based upon different ideas about the fundamental ways to protect water. Differences appear in the ways they define the boundaries of the systems they work within and where they place humans in relation to that boundary. Water researchers may pursue actions focused on studying the natural system, regulating human use of the natural system or educating people about the natural system and what they are doing to harm that system. People are not only outside the boundary of this system, they are perceived as the primary source of negative impacts. Municipal water managers orient their actions toward water within a system where people are perceived as being *inside* the boundary of the system. Managers orient their actions to serving the people within the system and are motivated to protect community values. Understanding and examining the ways that each group characterizes their respective systems reveals important emergent properties related to conflict and collaboration needed to build the Collaborative Learning Bridge.