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Community Science in Support of Ecosystem-Based Management: A Case Study from the Damariscotta River Estuary, Maine, USA

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Cover Page Footnote

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Community Science in Support of Ecosystem-Based Management of the Damariscotta River Estuary in Maine

by Sarah C. Risley, Kara E. Pellowe, Melissa L. Britsch, Meredith M. White, and Heather M. Leslie

Abstract

We report how a community science program in Maine offers a model of organizational innovation to expand capacities for shellfish research and create robust social and ecological data to support ecosystem-based management. Since 2019, we have collaborated with local students, shellfish harvesters, and other community members in data collection, interpretation, and application that contributes to municipal shellfish management and broader ecosystem sustainability. By developing and testing community science data collection, we highlight the importance of local knowledge as well as the value of monitoring both the social and ecological domains. Our approach can be adapted to other social-ecological contexts, particularly in data-limited contexts that are experiencing observable social and ecological change.

INTRODUCTION

Marine coastal areas are dynamic and highly variable social-ecological systems that present unique stewardship and conservation challenges (Stuchtey et al. 2023). They are places of deep cultural and historical significance, and host diverse industries, like tourism, fisheries, and aquaculture, that are important drivers in coastal economies (Stoll et al. 2019). Yet knowledge of coastal and marine social-ecological systems is often incomplete, due to challenges created by the marine environment and the high spatial and temporal variability of these systems. Difficult-to-monitor marine environments, like the deep sea or intertidal mudflats, are referred to as data-poor or data-limited because baseline knowledge of species abundance and distribution is often nonexistent or sparse (Aylesworth et al. 2017). Both fine-scale and long-term information about ecosystems is essential for identifying patterns or trends and informing decision-making. Information gaps challenge those who manage human interactions with marine ecosystems, whether they are managing at the local, regional, or larger geographic scales (Young and Gasser 2002).

Marine systems are complex and require innovative approaches that are inclusive of diverse actors and link multiple levels of management and governance. Past research has demonstrated that effective approaches to marine conservation challenges often match the scale and scope of the management and supporting data with the scale of the social-ecological systems (Wilson 2006). Increasingly, researchers and managers are moving towards ecosystem-based management approaches that integrate social and ecological data to address challenges in marine coastal social-ecological systems (USCOP 2004). Ecosystem-based management considers the entire scope of the ecosystem and recognizes the interconnectedness within systems—among species and habitats and among the ecological, economic, and social dimensions of a system (McLeod and Leslie 2009). Many have sought novel methods to support ecosystem-based management approaches in data-limited marine systems or in marine fisheries contexts. One approach is the inclusion of local knowledge through community science.

LOCAL RELEVANCE AND BENEFITS

Community-based approaches to conservation and management have the potential to support sustainable solutions to challenges in complex social-ecological systems due to their ability to foster collaboration and enhance opportunities for social learning and adaptation. These approaches can support innovative institutional arrangements across spatial and temporal scales, incorporate diverse forms of knowledge, and provide opportunities to link social and ecological methods for both research and management

(Quintana and Basurto 2021). Numerous studies in coastal and marine ecosystems show that local knowledge and community participation are effective approaches for filling knowledge gaps and providing new social and ecological data to complement existing knowledge, particularly in data-limited systems (Beaudreau and Levin 2014; Dey et al. 2020). Research approaches that center local knowledge and address community-generated questions and concerns are increasingly applied to the fields of stewardship and conservation in coastal marine ecosystems. Local knowledge refers to place-based, experiential learning, and development of relevant information by the people who live, work, and depend upon an ecosystem (Berkes et al. 2001). Local knowledge studies can span wide geographic and temporal scales and provide fine-scale, locally relevant information with potentially less financial burden and physical effort than traditional ecological methods (Aylesworth et al. 2017). While local knowledge may be uncertain or imprecise and its legitimacy is still questioned by some, it is a valid and rich source of information that can support ecosystem-based management and coastal stewardship (St. Martin et al. 2007).

Community science research often arises from the documentation of local knowledge and is viewed as a source of comprehensive social and ecological information in support of ecosystem-based management. Community science is defined as scientific research or monitoring grounded in inquiry that is (1) community-led, (2) centered on place-based local knowledge, collective action, and community empowerment, and (3) aimed at improving governance processes with the goal of stewardship and social-ecological sustainability (Charles et al. 2020). Community science exists within the broader context of engaged research, which emphasizes collaborative inquiry and knowledge generation grounded in diverse perspectives for the purpose of problem-solving (Barge and Shockley-Zalabak 2008). In the context of marine fisheries specifically, researchers have used community science to address questions in multiple social-ecological contexts, including investigating variation in species distribution and abundance (Naasan Aga Spyridopoulou et al. 2020), and generating fisheries stock assessment datasets at large geographic scales (Fairclough et al. 2014). These studies demonstrate the value of community science, particularly to gather, analyze, and interpret data in ways that meet local community needs and management goals.

COMMUNITY SCIENCE FOR INTERTIDAL SHELLFISH FISHERIES

Maine's marine intertidal shellfish fisheries are a rich context to explore local knowledge and community science applications in marine coastal social-ecological systems given the scale and organization of the comanagement structure, the diverse challenges faced by these fisheries and the people who are part of them, and their inherent connections to community and place (McGreavy et al. 2018). Studying the application of local knowledge in these systems provides invaluable insights into the process, conditions, and outcomes of community-based research. Our goals in doing this work are not only to contribute to the community but also to generate knowledge and approaches that can be applied elsewhere to enhance capacity and support marine management and stewardship.

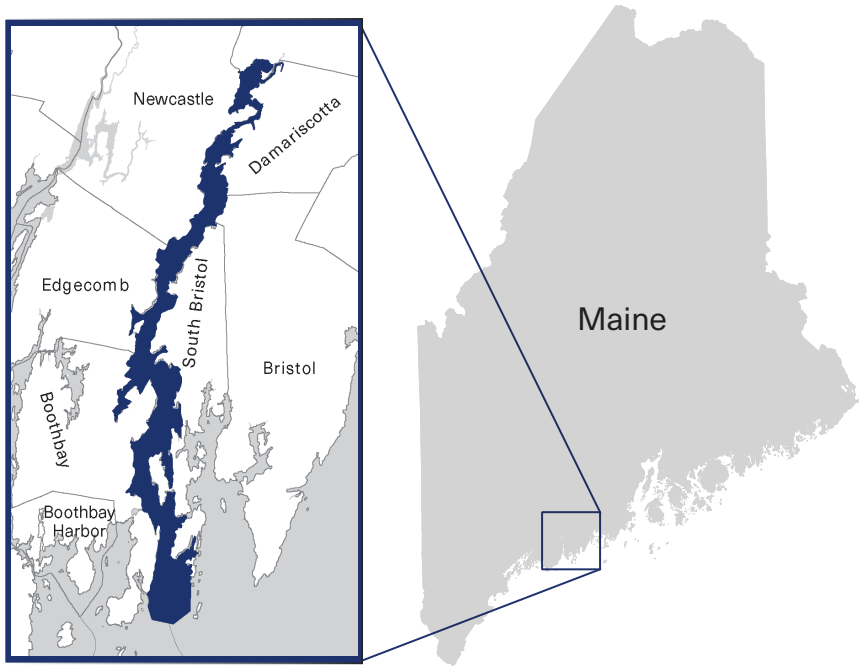
History and Background

Maine's shellfish fisheries are community-based in nature and have integrated local knowledge and locally generated scientific information into their comanagement process throughout their history. Comanagement is a system of governance based on shared responsibility and power between government institutions and resource users (Berkes et al. 1991). It has a long history in Maine, dating back to the 1641 Massachusetts Bay Colony Ordinance, which established intertidal fishing, fowling, and navigation rights for all residents. Today, the state has enacted a statute (Title 12, Part 9, Chapter 623, §6671) that allows coastal towns to establish municipal shellfish ordinances and shellfish conservation committees (Hanna 2000). Committees are composed of volunteers who are often themselves shellfish harvesters. Committees make recommendations to the municipal governing board to charge license fees, establish areas open or closed to harvest, and create harvesting limits, among other activities. The Maine Department of Marine Resources (DMR) provides guidance to the towns and sets broad standards for the fisheries, including a license requirement, a minimum harvest size and tolerance, accepted harvest tools, as well as monitoring public health. Together, DMR and Maine's coastal towns comanage the shellfish populations across the state, including soft-shell clams (*Mya arenaria*), quahogs (*Mercenaria mercenaria*), surf clams (*Spisula solidissima*), razor clams (*Ensis directus*), and wild European and American oysters (*Ostrea edulis, Crassostrea virginica*). Seventy-two coastal townships and municipalities have

shellfish ordinances and participate in the comanagement process; the others are managed more directly by the state.

Coastal Maine is a site of significant socio-ecological change, including warming ocean temperatures (MCC 2021), shifting human uses, like the expansion of aquaculture across the state (Hanes 2018), and changing demographics (MDF 2023). Here, we focus on the changes in Maine's Damariscotta River estuary and its wild intertidal shellfish fisheries (Figure 1). The shellfish fisheries are experiencing changes linked with both climate change and changes in human uses, including increased predation (Beal 2006), overexploitation (Congleton et al. 2006), and water pollution (Evans et al. 2016). These factors have made it more challenging to manage the fisheries. Additionally, Maine's shellfish fisheries are data-poor, as many managers have little to no current or historical information on the abundance, size structure, or distribution of shellfish populations. As a result, managers must make conservation and stewardship decisions without information to guide the decision-making process. Ecosystem-based approaches to management that use community science research as a tool are an effective strategy in rapidly changing coastal social-ecological systems and may be an appropriate fit for Maine's shellfish fisheries. The Damariscotta River estuary has a long history of citizen and community science initiatives, including projects on water quality, invasive species identification, and ecosystem health and change. The project we describe adds to this rich tradition.

FIGURE 1: **Damariscotta River Estuary and Surrounding Towns**



Source: Maine Boundaries Town and Townships Polygon, 2019; States Shapefile, 2015).

The Beginning of a Community Science Project

The Joint Damariscotta-Newcastle Shellfish Conservation Committee, in partnership with the state of Maine, comanages the wild shellfish populations within the towns' municipal boundaries along the Damariscotta River estuary. Commercially harvested shellfish species in the estuary include soft-shell clams, quahogs, razor clams, and wild American oysters. Maine's comanagement process is unique in that it is adapted to the specific ecological and cultural conditions of each municipality. Comanagement recognizes the expertise and experience of harvesters, while also relying on scientific knowledge provided by the state and other organizations (McGreavy et al. 2018). It is also shown to be an adaptive management approach that can effectively respond to environmental change (McClenachan et al. 2015).

Comanagement's capacity to be locally tailored and the structure of municipal shellfish conservation committees make engaged research approaches and community science initiatives an apt fit for Maine's shellfish fisheries. Further, the walk-in accessibility of intertidal shellfish habitats makes community science a feasible option for studying these environments and engaging participants with varied life experiences to enhance the committee's capacity. Engaged approaches have already been employed to address challenges facing the fishery and have modeled methods to engage harvesters and the community in research efforts in Maine (Hillyer et al. 2021).

In 2019, the Joint Damariscotta-Newcastle Shellfish Conservation Committee initiated a collaboration with researchers at the University of Maine Darling Marine Center to assess the status of the Damariscotta River

estuary's wild shellfish populations. This collaboration was catalyzed by a call for proposals from a Maine-based foundation for community-scale projects focused on shellfish restoration and resilience. Shellfish harvesters working in the Damariscotta had observed changes in shellfish abundance and diversity, including a decline in soft-shell clam populations and parallel increases in quahog and wild oyster populations (Risley 2022).

The 2019 study included a field study of shellfish populations and interviews with shellfish harvesters (n=7). The results of the 2019 study were presented to the committee and to the town's leadership, the board of selectmen (Pellowe and Leslie 2019). The research partnership continued in 2020 through a local knowledge mapping study to document knowledge of harvesters and other river users of shellfish populations and human use activity (Britsch et al. 2021). The results of the 2020 study highlighted the importance of local knowledge. After the completion of the 2019 and 2020 studies, the committee and its university partners identified that community science would be an appropriate way forward and sought support from the University, local donors, and other funders to support a pilot community science project.

In 2021, the committee and university researchers began a community science project to study shellfish populations in collaboration with a local high school, Lincoln Academy. The program was designed to gather ecological data and to document local knowledge about how the estuary's shellfish populations are changing through time. With this project, the Damariscotta-Newcastle Shellfish Conservation Committee is seeking to answer the following questions:

1. How many harvestable shellfish are on the flats now, and how many can we anticipate in the future?
2. How diverse are our shellfish resources (i.e., how many different species are harvested and where)? And how does this diversity influence harvester behavior–where they harvest, which species, how much–and earning potential?
3. What environmental factors affect shellfish populations, and on what temporal and spatial scales?

Additional goals include enhanced community engagement with the shellfish fisheries by

1. Increasing local student engagement in the Damariscotta ecosystem and civic involvement through place-based experiences and connections with local shellfish harvesters and the committee, and
2. Increasing capacity for long-term and ecosystem-level information by enhancing collaborations with scientific and educational institutions in the area.

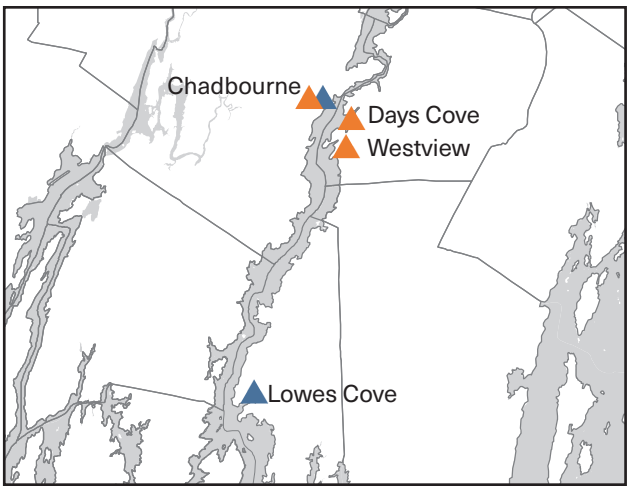
The community science project is designed to expand the committee's scientific and volunteer capacities while simultaneously addressing pressing social and ecological questions posed by shellfish fisheries managers.

COMMUNITY SCIENCE PROJECT MODEL

The results of the 2019–2020 studies inspired several community science activities. These activities are led by university researchers and high school and undergraduate students, harvesters, and other community members who are involved in collecting data and analyzing information for management and scientific purposes.

First, we developed a shellfish ecological survey to address the committee's key questions. The survey itself is grounded in the results of the 2019 and 2020 studies in that it (1) seeks an effective, but less labor- and time-intensive, survey that can realistically be accomplished by high school student researchers; and (2) employs local knowledge to guide scientific methodology, generating information that meets local needs. This survey approach is specifically proposed as a potential alternative to the traditional DMR survey methodology that focuses on soft-shell clams (Webber et al. 2021). Local knowledge informed the development of survey methods that target multiple shellfish species and specific shellfish habitat identified by local harvesters, rather than an exhaustive survey across the intertidal zone. The survey also documents information on environmental variables relevant to the shellfish populations, including sediment type of the marine intertidal habitats where they are living, the extent of algal and bare cover in those habitats, and the presence of other species like marine worms. Second, we employed an existing survey methodology (McMahan 2020) to quantify the abundance and distribution of green crabs (*Carcinus maenas*), a primary predator of soft-shell clams. Third, we developed a survey to document local harvester knowledge of shellfish populations and harvesting effort and behavior. And fourth, we quantified how many young clams recruit onto the flats managed by Damariscotta

FIGURE 2: **Long-Term Monitoring and Recruitment Sites**



Note: Orange triangles are monitoring sites; blue triangles are recruitment sties.

and Newcastle, using an established protocol (Beal et al. 2020). We compiled these methods in a community science handbook geared towards high school educators and students to facilitate future collaboration (Risley et al. 2022).

Project Results and Initial Outcomes

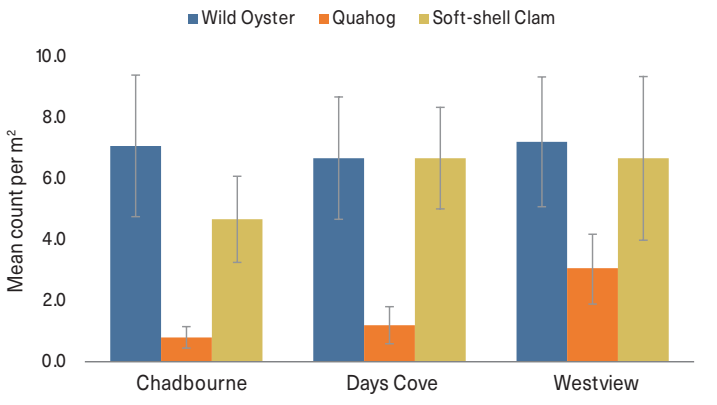
Thus far, we have generated information that addresses the committee's key questions concerning the shellfish fisheries and provided information in three key areas: (1) long-term trends, (2) seasonal trends, and (3) future projections. Additionally, the social science research results also have generated contextual and historical information to frame the ecological results and guide further refinement of the ecological methods. Together, these data informed a recent deliberation by the committee and a required review by the Maine DMR regarding a change in the number of licenses allocated to nonresident and resident commercial shellfish harvesters.

The ecological shellfish survey results provided information on shellfish species abundance and size structure and frequency of differently sized shellfish at multiple study sites in the upper estuary. We collected these data during the summer at three monitoring sites in 2021 and 2022, and for two of the three sites in 2019, the project's pilot year (Figure 2). The results help illuminate long-term trends in shellfish species abundance, addressing the question: How many harvestable shellfish are on the flats now, and how many can we anticipate in the future? The results from the project to date showed declines in soft-shell clam and oyster abundance.

The ecological and social survey data also provided insight into the diversity of harvested shellfish in the estuary through time, answering the Committee's second question: How diverse are our shellfish resources (i.e., how many different species are harvested and where?) (Figure 3). The Damariscotta is distinct from many estuaries in Maine because it hosts wild oyster populations, as well as soft shelled clams and quahogs. These wild oysters represent a new shellfish product for Damariscotta-Newcastle commercial shellfish license holders, most of whom previously focused their activities on soft-shell clams.

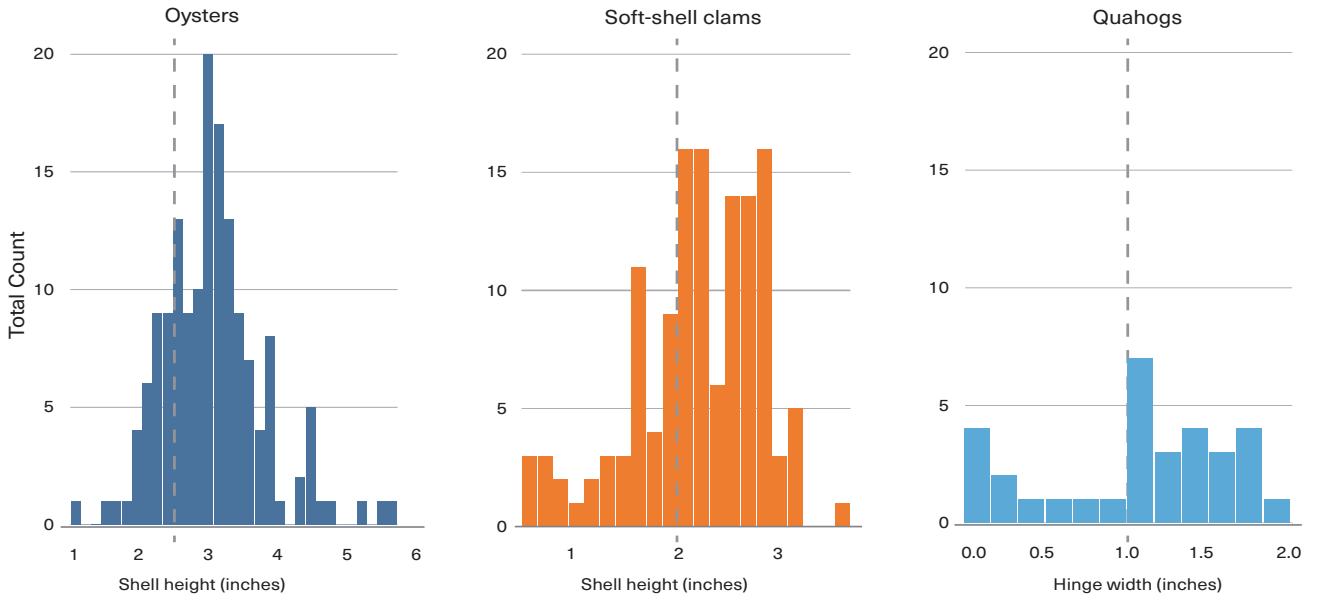
The green crab surveys conducted June–October generated information on seasonal trends and distinctions between study sites. At all sites, crab abundance was higher in the summer than the fall Additionally, the Days Cove site had the fewest green crabs. This information can inform the timing of conservation activities and may assist the committee in determining where conservation efforts, e.g., re-seeding and harvest closures, should be focused. For example, if green crab abundance is lower in October and is consistently low at a particular site, then conservation activities like seeding mudflats with juvenile clams could focus on that specific time and location.

FIGURE 3: **Shellfish Abundance in the Damariscotta River Estuary**



Notes: Shellfish populations were quantified in the upper Damariscotta River estuary via ecological surveys in the summers of 2021 and 2022 (n=3 sites). Error bars represent standard error of the sample means.

FIGURE 4: **Size Frequency Distribution for Shellfish in the Damariscotta River Estuary, 2021–2022**



Notes: Gray lines represent the legal size for harvest (2.5 inches length for wild oysters, 2 inches length for soft-shell clams, and a 1-inch hinge width for quahogs). Note variation in axis values. Note variation in x-axis values. Data from the three upper estuary sites were pooled.

Both size frequency data from the ecological survey and recruitment data from the soft-shell clam recruitment study can help to predict how shellfish populations may change in the future. Size frequency data helps managers predict the current and future abundance of harvestable shellfish populations (Figure 4). These results show the distribution of shellfish that are of harvestable size and the proportion that will reach harvestable size in the coming years. Size frequency distributions can help managers anticipate future changes in shellfish abundance and enact appropriate conservation measures if stocks are predicted to increase or decrease. The soft-shell clam recruitment study quantifies the larval supply and the number of juvenile clams reaching the mudflats (known as recruits) at two sites, one in the upper and another in the lower portion of the estuary. These data illustrate spatial variability among sites. Mean number of soft-shell clams per square meter found in recruitment boxes ranged from 3.36 to 45.73 across sites (n=2) for 2021 and 2022. This range of values is comparable to neighboring estuaries, where a range of 5.4 to 471.5 mean number of soft-shell clams per square meter has been reported (Beal et al. 2020). Within this range, the Damariscotta has relatively lower recruitment rates compared to other midcoast Maine estuaries. Soft-shell clam recruitment data offer insights into the committee's key questions concerning future shellfish abundances and variables influencing shellfish populations.

We also synthesized local knowledge information on harvesting behavior and observations of the variables influencing shellfish populations. Damariscotta harvesters reported that they harvest shellfish on average four days a week but could range from a minimum of one to seven days to a maximum of three to seven days a week (n = 6). Harvesters explained that they typically only harvest one tide a day but may go out for two tides depending on the timing and intensity of the tide and market prices of shellfish. Harvesters also shared information about the species they harvest, and which species are their primary targets for harvesting.

Information on harvesting behavior, including the primary species targeted by harvesters and harvester effort, helps to address the committee's key questions, and provides essential contextual information for the design and analysis of the ecological studies. For example, because of observations shared by the harvesters, we have developed the ecological studies to gather data on all the commercial species identified by harvesters as important (soft-shell clams, quahogs, and oysters) while also collecting information on potential shellfish predators observed by harvesters: green

crabs and other crabs, ribbon worms (milky ribbon worm, *Cerebratulus lacteus*), and boring moon snails (*Euspira heros*). Therefore, the social dimensions of this project are imperative for tailoring project methods and analyses to address locally relevant questions and concerns as expressed by shellfish harvesters and the committee. Harvester input is also a vital component of the engaged research process that facilitates opportunities for feedback and refinement of both goals and methods as the project changes and develops through time. In the future, we anticipate that these data may help the committee explore relationships among environmental variables and shellfish abundance, diversity, and distribution and forecast future abundance of harvestable shellfish. Such analyses could help inform decisions about future conservation and management measures, which the committee is required to consider as part of the state statute.

KEY TAKEAWAYS

Centering Local Knowledge and Needs

Local knowledge was and continues to be fundamental to the development of meaningful hypotheses and community-based understandings of the factors driving change in the Damariscotta. The 2020 participatory mapping study grounded the project in the needs and questions of the community and emphasized the importance of beginning first with local knowledge when entering engaged research partnerships. We found that local knowledge is uniquely positioned to highlight social-ecological challenges and guides research towards an ecosystem level of thinking, inclusive of diverse human experiences and ecological processes. It also initiated a process of listening and learning through which project leaders and collaborators could establish shared visions and goals. Although shellfish harvesters may not be involved in every step of the community science project, their voices have shaped and continue to shape the scope and direction of the research. We hope that the continued engagement with local knowledge can foster equity among actors in the research process and ensure that the project process is rooted in the voices, concerns, and questions of local knowledge holders.

Building Capacity and Knowledge

The inclusion of local high school students—as well as undergraduate and graduate students—in the project increased the committee's volunteer capacity significantly. Historically, the committee relied on harvesters, by way of required conservation hours for commercial shellfish license holders, to carry out conservation activities. Although many towns across the state have requisite conservation hours associated with commercial shellfish licenses, the Damariscotta-Newcastle Committee currently does not require them. The partnership with local schools as well as the University of Maine's Darling Marine Center has enabled us to complete the project activities each year and envision them as a long-term, community-led monitoring project. Due to this enhanced capacity, the committee now can obtain fine-scale information through time at the geographic scale needed to make management decisions. Monitoring systems at the local scale may provide early warning systems and local knowledge is positioned to inform local management activities in ways that large, centralized systems of knowledge cannot (Lebel et al. 2006). At the core of the Damariscotta community science project is the question, Does the project provide the committee with the information that it needs? We are in a unique position because the scale of our research matches the scale of the comanagement system: the municipality. Since data collection and data analysis are occurring at the same scale as management, the results can directly answer management questions with a specificity that is difficult to reach in research-management relationships at the state, regional, or national level.

Building Trust and Learning Communities

Community-based management approaches rely on collaboration, communication, and feedback. If designed to be intentionally collaborative, community science research can create social networks where collaborators can address problems through an iterative learning-by-doing process of knowledge sharing, evaluation, and course modification (Cretney 2014). Information should be provided in an accessible way and information sharing should occur in culturally appropriate environments for community members to maintain leadership and project control. For example, a town hall meeting may be a more appropriate site for information sharing and feedback than an academic conference. We have communicated the project results through meetings with the committee, Damariscotta's select board, and members of the public, as well as through presentations at related professional venues at the university, the Maine Fishermen's Forum, and the Maine Sustainability & Water Conference. We have also produced technical reports to share our results. However, there is still a gap in communicating information that is immediately useful and

meaningful to the committee. For example, we are reflecting on questions such as Is it meaningful to share shellfish abundance data as the number per square foot or square yard, or is there a more effective metric? And how can shellfish ecological survey data best inform site selection for conservation efforts? These are questions that we will continue to tackle in the coming years and mirror challenges that other communities engaged in community science for shellfish comanagement will surely encounter.

Both improved communication and trust improve social-ecological outcomes for management and conservation initiatives (Innes 1996). Once trust is established, collaborative groups can deliberate and arrive at shared understandings of what steps must be taken to mobilize initiatives. The partnership and trust between the committee and the university grew in large part out of the working relationship established during the 2019 and 2020 studies. Short-term projects of this nature help establish trust through the sharing of knowledge, authentic requests for feedback, and the establishment of clear roles for the various parties involved (Cucuzza et al. 2021). Trust in this project was demonstrated by participants' willingness to connect with university researchers and engage with the studies from the recruitment phase to the sharing of results and the solicitation of feedback. Their desire to continue to interact with university researchers indicates the development of trust.

The integration of local knowledge into the work has also helped build trust between researchers and shellfish harvesters. However, tensions and skepticism still exist between academic researchers and commercial harvesters. Continued efforts over the coming years to elicit harvester input and validate local knowledge will be necessary to build and strengthen the trust that has been established. Further, efforts to involve harvesters in the research process as experts, will be an essential part of the trust-building process.

SUSTAINING INTERTIDAL SHELLFISH FISHERIES

Our project demonstrates that community science can be an appropriate option to support comanagement by municipal shellfish committees. Shellfish committees with low volunteer engagement and limited shellfish harvester participation in conservation activities may be most able to benefit from community science and the contributions of volunteer student scientists. This is a model that may present a solution when other models (for example, required conservation hours) fail to produce desired results.

The development of this project revealed compelling connections between community science approaches to research and comanagement systems for fisheries. For one, comanaged fisheries are inherently community-based. The Damariscotta-Newcastle joint Shellfish Conservation Committee includes diverse members of the local community, including shellfish harvesters and marine researchers. Through existing connections and their local scale, comanaged fisheries are well positioned to serve as springboards for community science programs. The committee is also an accessible institution with a collective leadership structure—any community member may attend these meetings—and the horizontal structure of the committee itself allows for community voices to be shared and heard, particularly those of local knowledge holders. Second, because comanaged fisheries systems often lack the capacity to obtain current data on species populations, community science programs are an effective means to increase capacity by involving volunteers, students, and researchers in the management process.

Community science is also effective for coastal ecosystems, particularly intertidal ecosystems because they are accessible environments in which community members already engage through other activities. For example, a boat or other costly equipment is not required to access our study sites. Students and volunteers can simply walk into the intertidal mudflats and begin their research. These habitats are also extremely visible and familiar to the community at-large. The Damariscotta estuary and the shellfish fisheries are of great cultural and historic importance to many residents. Through our work, we found that these conditions were well-suited to conducting community research because local community members are already invested in these habitats and species. This focus on the environment is advantageous because it lays the foundation for a research project that emphasizes the importance of the ecosystem, including its human uses, from the program's inception, which positions the project to address real-world questions by generating information that extends beyond a single species assessment.

Although a promising approach, it is also important to remember that community science and community-based approaches are not a panacea. These approaches may begin with lofty goals but can fall short of improving equity and expanding resource management capacity. Based on our experiences and our observations of other community-based initiatives, we recognize that these projects may encounter challenges and that their outcomes depend on the capacity

and energy of the collaborative group at a given point in time. Community science projects can wax, wane, or entirely transform, and our reflections here merely represent a snapshot in time of the development of a single project. We also wish to highlight that it is often challenging for community-based approaches to establish shared recognition that both local knowledge and scientific knowledge are legitimate and important sources of knowledge to support conservation and management. Connecting local knowledge with scientific knowledge may be challenging, but valuable insights can be gained through the process. By directly addressing these challenges through the design and development of collaborative research endeavors, community science and local knowledge approaches to intertidal shellfish fisheries may be a promising approach for coastal communities in Maine and beyond.

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