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Collaborative and Engaged Research to Strengthen Equity and Adaptive Governance in Co-Managed Fisheries

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COLLABORATIVE AND ENGAGED RESEARCH TO STRENGTHEN EQUITY AND ADAPTIVE GOVERNANCE IN CO-MANAGED FISHERIES

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A DISSERTATION

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COLLABORATIVE ENGAGED-RESEARCH TO STRENGTHEN EQUITY AND ADAPTIVE GOVERNANCE IN LOCALIZED FISHERIES

By Gabrielle Hillyer

Dissertation Advisors: Dr. Bridie McGreavy & Dr. Anthony Sutton

An Abstract of the Dissertation Presented
in Partial Fulfillment of the Requirements for the
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Small-scale, co-managed fisheries are found throughout the world and often represent intertwining cultures, societies, communities, economies, institutions, and governments. They face complex issues, derived from ecological and social sources. Solving these issues requires diverse expertise, often developed through engaged methodologies which can facilitate collaborative solution creation between researchers, community members, and others. In this dissertation, I demonstrate the benefits of these engaged methodologies and review how they, when coupled with anticolonial approaches to research, can create more equitable solutions to complex issues. This dissertation focuses on multiple projects within the wild clam fishery in Maine including: (1) the creation of a learning network that could improve communication among individual communities, and (2) the use of boundary objects to develop oceanographic models and support adaptive policy related to restoration efforts. Additionally, this dissertation addresses how colonial ideologies impact these efforts and how recursive, reflective, and collaborative methods may provide one way to destabilize these ideologies. As such, this dissertation is organized into five chapters. First, I introduce sustainability science, knowledge

weaving, and the wild clam fishery as a unique case for studying co-managed fisheries facing complex issues. In the second chapter, I describe a comparative case study of four research frameworks related to fisheries science, and how they impact, shape, and support Indigenous sovereignty. Next, I describe the Maine Shellfish Learning Network, an organization developed by my advisors, myself, and other collaborators with the goal of creating new spaces for communication between communities and other related institutions. In the fourth chapter, I describe boundary object projects which influenced community-level adaptive capacities. In the final chapter, I present my conclusions. It is hoped the results from this research will inspire other institutions and industries to engage and reflect on similar choice making.

DEDICATION

This dissertation is especially dedicated to the number of voices near and far who told me

to keep going, keep pushing, and to never give up.

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especially thank all the staff at the Mitchell Center and beyond, including Carol Hamel and Ruth Hallsworth, without whom none of this work would be possible.

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AUTHORS NOTE

The sea is everything. It covers seven tenths of the terrestrial globe. Its breath is pure and healthy. It is an immense desert, where man is never lonely, for he feels life stirring on all sides. The sea is only the embodiment of a supernatural and wonderful existence. It is nothing but love and emotion; it is the 'Living Infinite'.... - p. 58 (Jules Verne, 20,000 Leagues Under the Sea)

My first day "on the job" as a graduate student I was terrified. I was driving to the coast of Maine from Bangor, which includes driving through small roads rarely seen on maps, taking hairpin turns, and watching trees fly past in a blur for around 2 hours. I was to meet a man named Glen Melvin, who I had emailed once or twice before. I had his cell phone number in my pocket, a notebook, and a jacket to ward off the chill of a Maine autumn. I made my way through Waldoboro, a town that felt at the time like a saving grace of gasoline, streetlights, and soon, a slice of Moody's pie. Glen and I met at the Waldoboro town landing (a spot that took a few different searches to find). We met at high tide in the afternoon, a requirement to meet with Glen on a weekday. He invited me on to his boat, which was completely unexpected. I jumped when the engine turned on, not used to the loudness of the sound, and realized I'd be leaning forward and yelling for the next hour or two as Glen showed me the Medomak River.

This conversation felt like the equivalent of jumping off a pier on a clear night in May in Maine, which I would do the following year. The water I remember felt welcoming, then freezing, then oppressive. My muscles all froze in shock, working against the water to move in the way I had my whole life to bring me to shore. I was drenched head to toe, grabbing a blanket to wrap around my shoulders, and sitting too close to the fire, to laugh off and warm up from my foolhardy dive.

The conversation that followed from Glen tested me in ways I had never experienced before. He asked questions about legislative documents by number, hurled facts, regulations, and

names at me like small sharp darts. His eyes were piercing, and his tone illuminated the fact that this was in fact a test. Perhaps the biggest test of my life. But he also laughed, joked with me about rock and roll, and mentioned how he was a "troublemaker." My hand cramped a few different times writing all my notes. I spent most of the time just nodding along, with a few answers that felt stuttering and awkward.

This dive into the world of the intertidal as a social, cultural, and economic phenomenon was welcoming, freezing, and ultimately life changing. I immediately recognized how my work as a researcher connected to people, livelihoods, and the shifting tides. I had started.

I was introduced to the ocean as a long legged and awkward kid, escaping the desert heat. I reached out my hand as any kid, shaky but sure, gripping as hard as I could with all the muster of an 8-year-old. The ocean, charmed, greeted me with deep blue water, foaming waves, sand, and of course, bashing salt water up nostrils. I don't remember the first time I stuck my head under the waves and opened my eyes, or tasted the salty abrasive water, but I do know that the ocean and I had a bond that I would consistently revisit, pursue, and love for the rest of my life.

After that initial handshake and quick goodbye hug, I returned to the desert. Far away from ocean waves I began reading, letting the works of famous men, and lesser-known women shape my understanding of the ocean. I studied every story, comic, movie, tv show, documentary and science article I could find. I was voracious. As with most relationships however, the distance made the heart grow fonder, and I returned to marine sciences as a comforting supportive presence when asked "what do you want your future to be?".

This graduate research, along with my previous undergrad studies, and a multitude of visits to the coast is the growth of that relationship. Over the course of these efforts, my world

has grown, my thoughts changed, my perceptions altered, but my love of the ocean remains, developing over the years from a timid childlike awe to the deep respect and gratitude of today.

This work was not done in a vacuum, instead like seawater, it represents thousands of organic and inorganic materials that shaped myself, the team of researchers I was lucky enough to work with, and the number of teachers, including writers, scientists, artists, musicians, clam harvesters, clams, seaweed, and mud, who all helped me learn how to do this work. It also represents the multitude of friends and family members that supported my thinking, allowing me to reach out along the winds of the internet and phone lines to breathe new life into my conclusions.

As you read this dissertation, note that this work is coming from a young white woman who has let the desert winds push her to a muddy, sandy coast. I am American, in the way that the spaces I have called home are stolen from Indigenous communities, and my upbringing was steeped in racism, sexism and homophobia. I am still in the process of unlearning these structures, a process which has occurred through this work, and continues to occur personally. If nothing else deserves to be taken from this dissertation, I hope you as a person are similarly inspired to grow, unlearn, and in doing so, learn more.

For in the popular way of thinking, history draws a time "line," as if time marched in lockstep in only one direction. Some people say that time is a river into which we can step but once, as it flows in a straight path to the sea. But Nanabozho's people know time as a circle. Time is not a river running inexorably to the sea, but the sea itself—its tides that appear and disappear, the fog that rises to become rain in a different river. All things that were will come again." – p. 200, (Robin Wall Kimmerer - Braiding Sweetgrass)

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LIST OF ACRONYMS

ADCP – Acoustic doppler current profiler

COVID-19 – Coronavirus Disease, caused by SARS-CoV-2

DACF – Maine Department of Agriculture, Conservation, and Forestry

DB – Drifter bucket

DHHS – Maine Department of Health and Human Services

DMR – Department of Marine Resources

DSSF – Maine Department of Sea and Shore Fisheries

E/TES – Etaupmunk

eDNA – Environmental Deoxyribonucleic Acid

GRSC – Georges River shellfish committee

HWT/DC – He Waka Taurua

IADF – Institutional Analysis and Development

IAPH – Institute of Aboriginal Peoples' Health

IEK – Indigenous Ecological Knowledge

IK – Indigenous Knowledges

LPA – Limited purpose aquaculture

LPAW – Limited Purpose Aquaculture Workbook

MITSC – Maine Indian Tribal State Commission

MSLN – Maine Shellfish Learning Network

MSRRF – Maine Shellfish Restoration and Resilience Fund

NSSP – National Shellfish Sanitation Program

NRT – National Research Traineeship

SESF – Social Ecological Systems Framework

ShAC – Shellfish Advisory Council

SK – Dominant scientific knowledge

W-NAIS – Wabanaki and Native American and Indigenous Studies

WQDT – Water Quality Decision Tree

CHAPTER 1

INTRODUCTION

1.1 Background

Fisheries globally are facing complex issues stemming from social, cultural, ecological, and economic shifts. Often these issues are caused or exacerbated by non-adaptive forms of governance, which often originate from colonial ideologies and minimize opportunities for future resilience. This is especially true of co-managed fisheries, which often have less resources and capacity than their counterparts and have additional forms of local governance within their managerial systems. This layering effect can create further complexity across scale, where communities are making progress to sustain coastal livelihoods, but unable to share new insights with other communities, or implement large-scale policy without additional support. Supporting the adaptive capacities for these communities through engaged, collaborative, and anticolonial research can lead to new equitable solutions to complex issues such as climate change, food insecurity, gentrification, and others. Within this dissertation I focus on developing and maintaining relationships with communities, including harvesters, managers, and others as an integral part of understanding the ecological, social, and governance issues co-managed fisheries face. To do this, I conducted multiple engaged and collaborative projects within the wild clam fishery, which is a co-managed fishery with a complex governance system that has roots in the colonial settlement of the area now known as Maine. Major findings from this dissertation include:

- Multi-knowledge frameworks that embody colonial logics commonly used in sustainability and conservation science impact Indigenous knowledge through the use

generalizable language, practices of knowledge incorporation, and choices made during collaborative efforts. Multi-knowledge frameworks that embody Indigenous paradigms and worldviews consider diverse knowledge more equitably and facilitate cross-cultural collaboration.

- Learning networks created with considerations of equity, communication, and anticolonial approaches to knowledge and learning can enable the emergence of adaptive and anticolonial governance strategies and support communication across diverse communities.

- Relationships and collaborative spaces developed while creating boundary objects influence adaptive capacities, showcasing a gap in boundary object literature, namely, the focus on the product rather than the dialogical process the object embodies may lead to a limited understanding of how boundary objects influence adaptive capacities.

The following sections of this chapter outline: my research questions, broad aspects of my approach, including anticolonial, engaged, and sustainability science approaches, defining knowledge as relation, and finally, the wild clam fishery, in which this work was developed.

1.2   Research Questions

My overarching research question is, "How can scientists better support and engage with community-driven innovations in a fisheries context for a more adaptable and equitable future?" I have identified related sub-questions including, (1) what practices and processes, especially considering communication, anticolonial science, and sustainability science can be adapted to develop relationships between scientists and communities? (2) what orientations, frameworks, or

paradigms may be more relevant for scientists engaging with anticolonial community-driven research? (3) what informal organizations can be facilitated by researchers with an interest in communication that support community-driven solutions and anticolonial governance? (4) how do choices, negotiations, tensions, and decisions during boundary spanning projects influence adaptive capacities? This research seeks to address these components, and primarily develop new insights that can destabilize systems of power that limit community adaptation. To do this, I first reexamine assumptions and frameworks used within fisheries science that can reinforce inequities; second, co-conduct multiple collaborative research efforts related to specific issues emergent within the wild clam fishery; and third, offer new discussions as to how each of these efforts have supported adaptive capacities and adaptive governance strategies. I also work across each of these components to consider how relational efforts, driven by engaged research practices, cultivate a more equitable and impactful research process, which can lead to political action and relationships that outlive the lifetime of an individual research project.

1.3   Research Philosophy

Across my graduate career I have engaged in work that is often complex, nuanced, and messy. It pushes and pulls in multiple directions, requiring different methodologies and approaches to emergent issues. Liboiron wrote, "On the ground, it is easier because my obligations are clear…Obligations do not exist and are not enacted in atomized and individualized one-on-one relationships but in a diversity of relationships where some relations matter more than others," (p. 137, 2021). Drawing from this statement (and others like it) and my experiences, I often describe my research philosophy as one of service, in which I develop research that is salient for communities and supports collaborative solution creation. My "obligations" are the relationships developed through this work (Liboiron, 2021). To develop

these relationships, I follow multiple practices, including listening, reflexivity, iterative sharing, as well as drawing on multiple theoretical and methodological orientations. Some of these practices, such as the use of qualitative and quantitative methodologies, as well as my general focus on emergent issues is reminiscent of pragmatic research philosophies, namely, an understanding that knowledge is created through action (Corbin and Strauss, 2014), a focus on problem-oriented research (Kaushik & Walsh 2019; Creswell, 2011) and a recognition that the "interplay of practice and inquiry is also continual," (Corbin and Strauss, 2014, p. 21).

However, as described by William James, an early pragmatic orientation to truth is, "True ideas are those that we can assimilate, validate, corroborate, and verify. False ideas are those that we cannot…" (James, 2004). These original orientations to truth highlight why I feel consistent friction in identifying as a pragmatist.[1]. While pragmatists are focused on doing, problem-solving, and using a variety of methods to develop solutions, there is no orientation to collaboration, or attention to power dynamics that shape which truth is "assimilated." This became particularly difficult to deal with as I learned more about how power dynamics between different institutions, people, and places shaped the communities I was engaging with. For example, I had many conversations with shellfish harvesters about how their input wasn't considered by state institutions they were supposed to be "co-managing" with. They felt their voices weren't heard. This, coupled with my previous experience recognizing scientists' privilege in communities, led me to make different choices about how to do research, namely

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[1] It is also important to note the voices being heard during these debates and original descriptions. Largely, white male voices dominated these debates of "truth", "knowledge" and how scientists should incorporate these philosophical debates within their approaches to inquiry. Modern debates have started to destabilize this tradition, most especially with the inclusion of black and indigenous discussions of feminist and native ethnographic approaches. This disruption, destabilization, and critical examination of classic, western, or dominant scientific inquiry appeals to me, most especially, as I work to cultivate anticolonial or more inclusive research practices.

through practices such as active listening, reflecting on my own positionality and biases within research, and taking steps to support disenfranchised voices in multiple spaces.

These practices highlight my tack[2] towards a critical paradigm. A critical paradigm generally "promote[s] ethically and politically sensitive study of the relationships among power, knowledge and discourse that are produced in situations of historical and cultural struggle," (Lindlof and Taylor, 2011, p. 10). When I was introduced to a critical paradigm through a book by Lindlof and Taylor (2011), two things struck me. First, as they state, "research can never be isolated from its values," and "researchers should consider their *complicity* in reproducing oppressive conditions….instead they should adopt dialogic methods that encourage the development of authentic and collaborative relationships with their participants," (p.11). Those two statements align with my own internal philosophy, of considering science as a service, specifically producing research that supports communities and people who are underrepresented in decision-making contexts (Lindlof and Taylor, 2011; Creswell, 2011; Densin and Lincoln, 2000). It also follows my experience of engaged research, where my own focus is on relationships and collaboration. Critical research has also been described as one that produces, "undeniably dangerous knowledge, the kind of information and insight that upsets institutions and threatens to overturn sovereign regimes of truth," (Denzin and Lincoln, 2000, p. 279). Drawing from these statements, this research seeks to disrupt institutions and power dynamics that that embody colonial acts of violence, racism, homophobia, xenophobia, and other similar prejudices. A critical lens forces me to consider who is participating in each of the spaces I embody, listen to, or speak in, and, consider who constitutes as a fisher, a manager, or coastal

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[2] My advisors and others have consistently described my work as building a boat while trying to float, meaning, I am working across many disciplines and philosophies to develop a structurally sound foundation to pursue my research. In this case, tacked means to change course to turn a boat.

community member. In this way, critical research, or the identity as a "critic" is the most relevant for my research. It also attributed to my approach to science, as described below.

1.4   Anticolonial, Engaged, and Sustainability Science Approaches

Anticolonial or decolonized methodologies focus on cultivating space for multiple forms of knowledge and orientations to knowledge creation. Indigenous methodologies and paradigms are intrinsically valuable for this work, and other similar efforts, because I seek to disrupt the repercussions of colonial rationality described above (Liboiron, 2021). This process reshapes the scientific method to include more alternative forms of seeking knowledge, through storytelling, engagement, and collaboration (Burkhart, 2019; Smith, 2013; Kovach, 2017; Simonds and Christopher, 2013). I will refer to this research as anticolonial, and not decolonized, as it does not inherently grant land back to Indigenous communities, which is more aligned with decolonization (Tuck and Yang, 2012) More specifically, I aim to stand with, move over, and make room (Latulippe and Klenk, 2020; Todd, 2016; TallBear, 2014). Each of these practices is more deeply defined in individual chapters, however, "standing with" refers to iterative engagement, critical conversations, and the production of new knowledge (TallBear, 2014); "moving over" is a commitment to also not represent, and instead support Indigenous scholarship in an academic or research setting (Latulippe and Klenk, 2020); and, "making room" is a common practice for decolonization, where I as a researcher would make room for Indigenous knowledge, in a collaborative, and equitable manner, often leading to transformation in the practice of research (Latulippe and Klenk, 2020; Smith, 2013; Simonds and Christopher, 2013). Each of these practices is evident to a certain extent in the following chapters. For example, Chapter 2 is focused on revisiting research frameworks and governance orientations and drawing connections to colonial ideologies and/or Indigenous worldviews and practices, which aligns

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with "making room". Throughout this dissertation I also critically examined references, and whenever possible, cited diverse voices and resources to support arguments, including Indigenous scholarship, aligning with "moving over,".

With an anticolonial orientation to science, I also want to highlight my orientation to science as a service for communities or populations that are impacted by this research. Using engaged and sustainability science as a form of relationship building, I shaped this work around forming new relationships to co-produce knowledge. There are multiple commitments I used, along with my anticolonial practices, to form this research. These include: (1) designing research questions to align with collaborator interests (Ostrom et al., 2007; Cash et al., 2002); (2) not creating a burden on the time or resources of collaborators and practicing mindfulness (Wamsler et al., 2018; Lang et al. 2012); (3) meeting regularly with collaborators to discuss research progress and make adjustments as needed (Cash et al., 2002); (4) co-producing knowledge and combining diverse forms of expertise (Brandt et al., 2013; Lang et al., 2012), and; (5) promoting equity within the process (Wamsler et al., 2018). These commitments are reminiscent and can overlap with developing anticolonial research partnerships (Smith, 2013; Kovach, 2021; Simonds and Christopher, 2013; Adams and Faulkhead, 2012; Cochran et al., 2008). Along with each of these commitments, I use (and continue to practice) reflexivity to continuously reflect, renegotiate, and shape research to meet partner needs. Reflexivity is defined as the constant process of contemplating and situating new knowledge within the research context (Montana et al., 2020; Enosh and Ben-Ari, 2016; Rose, 1997). This practice is intentional, and in my work, is used to reflect on my own internal biases and generate new connections between new information (Enosh and Ben-Ari, 2016; Rose, 1997). This practice is integral to knowledge co-production, as I form new relationships and connect information across boundaries.

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1.4.1   Knowledge as Relation

In the context of this research, I am defining knowledge as a relation, or knowledge by acquaintance (Zagzebski, 2017; Russell, 1910). Knowledge as a relation is created through relationships an individual would have with an object or reality (Zagzebski, 2017). This runs counter to propositional knowledge, or knowledge created by understanding specific components of a reality (Russell, 1910). In addition, knowledge as a relation is often considered knowledge created through experience (Zagzebski, 2017). For example, when swimming, people often draw on their individual experience with water, or previous memories of swimming (relational knowledge), rather than calculations of buoyancy or density of water (propositional knowledge).

Using this definition of knowledge, learning and co-producing knowledge is the result of cultivating relationships, where individuals (both human and non-human) collectively engage with reality together. This definition removes the need to define knowledge as traditional, local, scientific, or other which creates silos between different orientations to knowledge creation and creates ways to exclude different forms of knowledge from governance (Star and Griesemer, 1989; Kirmayer et al., 2012; Cooke et al., 2021). Moving across these silos can be inherently difficult, creating the need for boundary objects, engagement, or other strategies for equity in knowledge co-production and learning (Reid et al., 2006; Cooke et al., 2021; Kirmayer et al., 2012; Star and Griesemer, 1989). Using relational knowledge as a definition, I can focus on the relationships individuals (both human and non-human) would have with each other using boundary objects and engagement as a way of creating new relationships. From this orientation, understanding a complex system, such as the wild clam fishery, becomes a process of attending to relationships, knowledge, and therefore power. Foucault (1972) highlights that, "…power is 'always already there,' that one is never 'outside' it, that there are no 'margins' for those who

break with the system to gambol in," (p.141). By defining knowledge as relational, I can explore how power structures within relationships shape knowledge access or knowledge co-production (Foucault, 1972).

Governance and colonialism shape relationships and by extension create discrepancies in knowledge sharing. For example, in 1820 Lieutenant Governor John Neptune of the Penobscot Nation, through an interpreter said, "One thing in particular I wish to say to day. Perhaps we get nothing for it. The white people take the fish in the river so that they no get up to us. They take them with wares [weirs], they take them with dip nets. They are all gone before they get to us," (Treat and Pawling, 2007; p. 280). Governor William King responded saying, "What you have said about…the injury they have done your fishery, will be attended to; we hope they will not be much longer a subject of complaint; when the white people are as well informed on this subject as you are, these obstructures will disappear," (Treat and Pawling, 2007; p.281). This conversation highlights how the merging of knowledge around fisheries and food access was seen as one way to avoid conflict and overharvesting. However, this conversation also alludes to the importance of relationality and power. This knowledge exchange, where "white people are as well informed" could only come from the forming of relationships between Wabanaki people and white people. Additionally, "obstructures" would only disappear when white people enter into relations with Wabanaki people with a sense of listening, consideration, and learning, which disrupts the governance structure of the time. This conversation offers a path forward, namely, focusing on relationships and knowledge sharing, while situating the multiple histories of Indigenous and colonial practices together in an equitable manner, to create new understandings and relationships. These new relationships may result in new solutions to the complex problems fisheries face.

1.5 Wild Clam Fishery

The wild clam (essok[3], *Mya arenaria*) fishery plays an important role in coastal communities (Hanna, 2000; Dow and Wallace, 1961). It is unique across Maine as it accessible to those with a lower socioeconomic status, and has historically a lack of data compared to other fisheries. Localization, where harvesters visit similar mudflats over years, even decades, creates a body of knowledge that is not fully recognized in the current governance structure. Eclipsing this, Wabanaki traditions and stories are often placed in a historical context, and therefore separated from the current fishery despite being recognized as having multiple relationships and therefore knowledges of the fishery (Spiess, 2017). This provides a unique opportunity, through partnership and engagement, to create a more complete understanding of the dynamics of this system. It should be noted however that the impacts or challenges faced by this fishery persist outside the mudflat.

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[3] Essok, meaning clams in Passamaquoddy-Maliseet language, found at the Passamaquoddy-Maliseet Language Portal at: https://pmportal.org/about-language-keepers
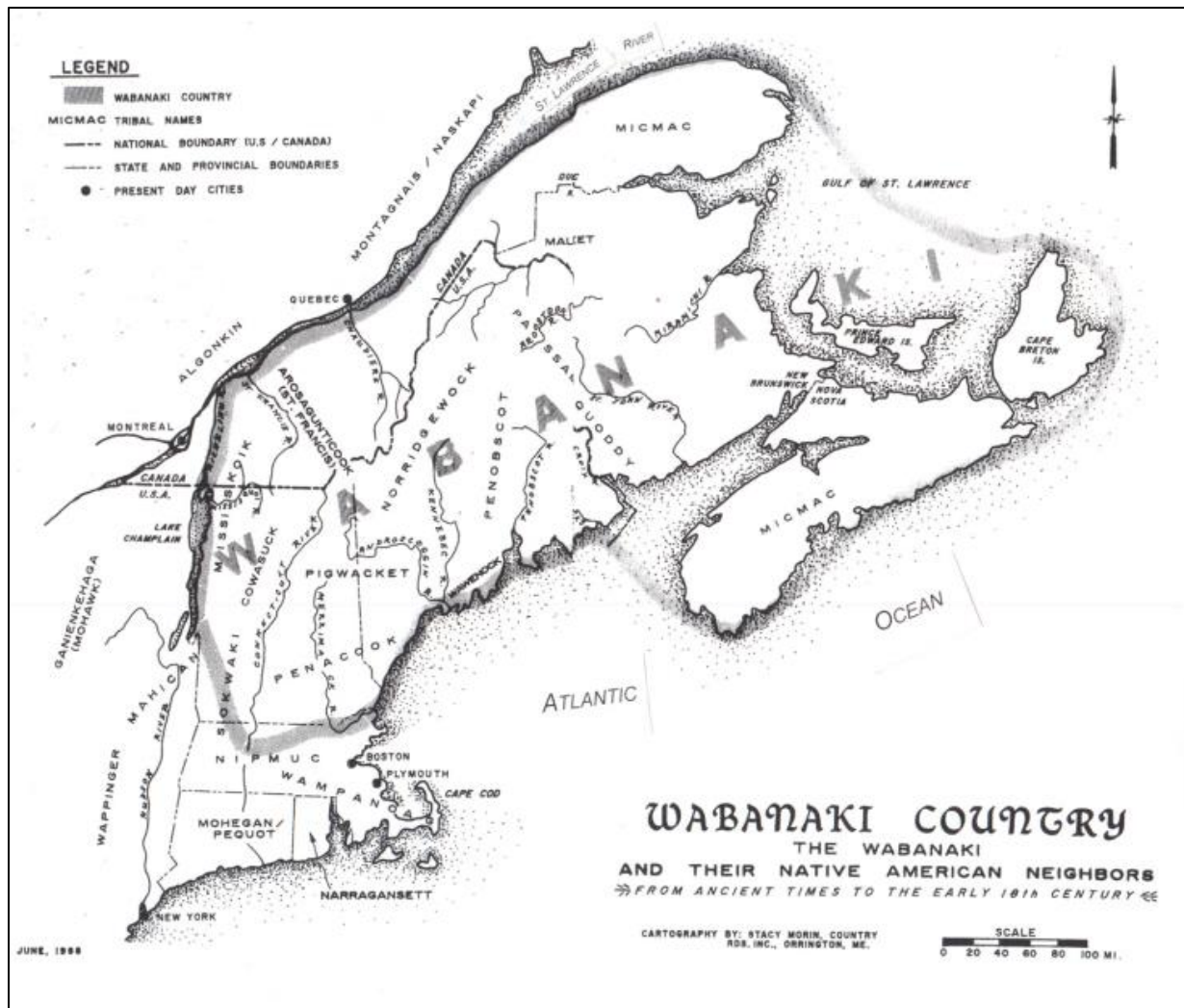
Figure 1.1. Wabanaki homelands – Map from the Wabanaki Collection
https://www.wabanakicollection.com/about/

The practice of harvesting wild shellfish originated over 10,000 years ago, supporting diverse livelihoods and cultural practices for the Wabanaki people. Wabanaki peoples refers to members of the Wabanaki Tribal Nations, namely the Mi'kmaq, Maliseet, Passamaquoddy, Penobscot, and Abenaki who are the Indigenous people to the Dawnland, which includes the area now known as Maine. The mobility of the Wabanaki people generally followed the seasonality of different food sources (Pawling, 2016), including shellfish such as clams, mussels, crabs and lobsters. Clams and other shellfish also may have impacted the settlement pattern of the coast, as they provide sustainable, accessible forms of protein (Spiess, 2017).

The governance of the wild clam fishery has shifted through time. The mobility of the Wabanaki people generally followed the seasonality of different food sources, which directly influenced the governance of these food sources. Within Wabanaki traditions the wild clam fishery was technically open access and self-governed, but the value system inherent to Wabanaki culture far exceeds those definitions. Wabanaki culture centers on an understanding of space founded on relationships, reciprocity, and use. Places, such as a home, harvesting access points, and others were not contained to one owner (Pawling, 2016). For example, in shellfish, Wabanaki peoples moved up and down the coast, harvesting from and maintaining shellfish populations that historically are considered very productive and sustainable (Speiss, 2017; Pawling, 2016; McBride and Prins, 2009). This type of governance was built on relationships between the environment and the Wabanaki people. However, colonization, serving as a form of governance, siloed off multiple forms of knowledge and Wabanaki presence, and brought new ideals that shaped relationships between colonists and natural resources.

Colonial systems of governance and their modes of extraction rather than relation have impacted historic and current shellfish populations. The foundation of the Massachusetts Bay Colony in 1628, largely disrupted Wabanaki relationships, instead creating formalized structures that continue to influence governance in the current colonial system. Colonial development in Maine was restricted to coastal spaces, where inland areas were left to Penobscot authority. This restricted access to historical harvesting spaces for the Wabanaki people while colonists continued to develop new relationships with shellfish and coastal spaces (Pawling, 2016; McBride and Prins, 2009; Brennessel, 2008). Until 1894, clams were considered an open-access resource initially for "Freemen" (white, male, Christian landowners, as defined in the 1641 Body of Liberties) and later coastal community members, where individual townships took precedence

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and set up authority for management. In 1894 however, the Maine Department of Sea and Shore Fisheries (DSSF) took over many of those responsibilities (Crouch et al., 2001). The fishery continued to be managed statewide, and similar to Wabanaki traditions, harvesters were able to move across town lines, up and down the coast with a state license (Crouch et al., 2001; Hanna, 2000; Wallace, 1984). In the 1950s however, the state of Maine developed a new shellfish program in accordance with the National Shellfish Sanitation Program (NSSP), creating a top-down hierarchical governance structure focused on water quality. Outside of water quality, the wild clam fishery currently operates under a co-management structure (Carlsson and Berkes, 2005) developed in the 1960s, where municipalities and DMR share responsibilities in managing the fishery. In this system, municipalities adopt municipal shellfish ordinances with approval from the state through the Department of Marine Resources (DMR) (Hanna, 2000; Wallace, 1984).

Currently, 75 municipalities have adopted a shellfish program, therefore engaging with this co-management system and creating new relationships between municipalities and state managers. Within this system, harvesters are required to get a state license, and an additional municipal license if they are to harvest in areas where a municipality has an ordinance.[4] Tribal members can technically access the fishery (within municipal spaces) by applying for a non-resident license, however this is often cited as a non-functional form of access. The municipality can determine certain restrictions on the "local" license, including residency requirements, fee structure, among others. Municipalities are also responsible for restoration and conservation projects. Multiple scientific institutions lead and support these efforts, and state agencies maintain oversight on each of the projects and on water quality monitoring. Restoration projects

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[4] There are 40 coastal towns that do not have a municipal shellfish ordinance, but the majority of those areas are closed to shellfish harvesting due to water quality issues.

include: the use of eDNA sampling to determine pollution sources, the planting of juvenile clams

to flats to restore populations, the use of tree branches and brush to facilitate shellfish settlement,

among many others. Outside of the co-management system, Passamaquoddy communities in

Sipayik maintain their own management system that resembles municipal ordinances and

includes the development of restoration projects, such as a clam garden.
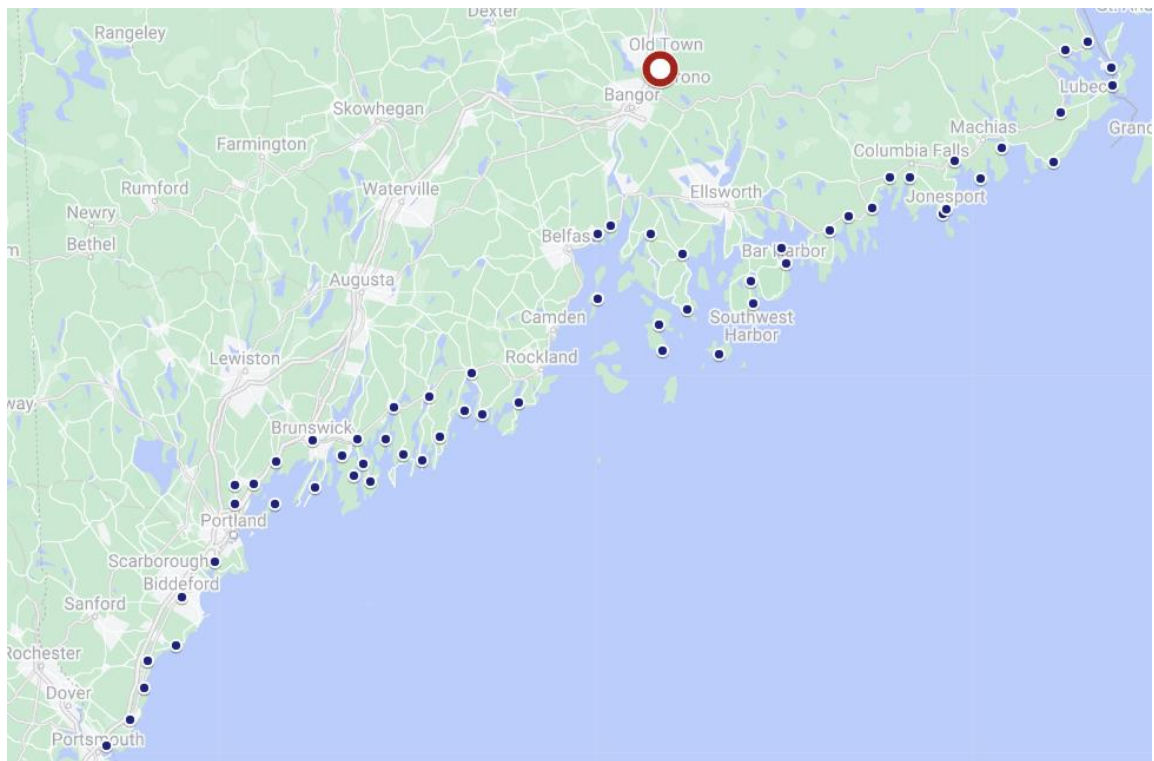
Figure 1.2. Map of Shellfish Municipalities. Map of municipalities with approved shellfish ordinances. Towns identified with dark blue dots. University of Maine identified with red circle for reference.

This fishery holds historic, cultural, economic, and social importance both as a practice

and as a food source. For time immemorial, Wabanaki people consider clams foundational to

their diet, particularly as a source of protein (Spiess, 2017). This idea has persisted into the

present, where sustainable shellfish harvest and shellfish aquaculture is seen as a major

component of global food security in the context of climate change (Azra et al., 2021; Gomez-

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Zavaglia et al., 2020). In the area now known as Maine, the harvesting of wild clams currently supports the soft-shell clam fishery, employing over 1500 clammers and producing around 60% of the total U.S. soft-shell clam supply (Evans et al., 2016). While over the last few decades this fishery has declined in value, it sits usually within the top five of the most valuable fisheries in the state. This decline is attributed to several biological, social, and economic factors that are changing the accessibility and productivity of this fishery. Some of these factors would include population increases of the invasive green crab (*Carcinus maenas L.*) initially introduced through colonial shipping lanes, climate change impacts such as warming temperatures and ocean acidification, declining license sales, gentrification, and water quality closures (Tan et al. 2015, McClenachan et al., 2015; Hanna, 2000). Each of these issues has links to overarching colonial ideologies that silo, exclude, and restrict knowledge systems and knowledge exchange across complex geographies. The work presented in this dissertation offers a unique lens to consider these issues, and solutions that recenter Wabanaki traditions, including developing relationships, practicing listening, and supporting communication.

1.6 Dissertation Organization

This dissertation is organized into three major studies that reexamine scientific paradigms and roles in community-driven collaborative solutions and provide new insights including: (1) assessing multi-knowledge frameworks in the context of anticolonial research, (2) the development of learning networks, and (3) the use of boundary objects to support adaptive policy solutions. Chapter 2 is a comparative-case study analysis and literature review of commonly used frameworks in fisheries science, and their perceived ability to support anticolonial research. Chapter 3 describes the Maine Shellfish Learning Network (MSLN) and shares key findings from engaged research and interviews that describe impacts anticolonial learning networks can have on adaptive capacities in fisheries. Chapter 4 describes three boundary objects used to

support adaptive policy development in terms of water quality and limited purpose aquaculture. The fifth and final chapter reflects conclusions drawn across the previous chapters as well as my own reflections. Additional appendices include data, reference lists, figures, and other pieces relevant to these chapters.

CHAPTER 2

ANTICOLONIAL KNOWLEDGE WEAVING AND CO-CREATION: REVISITING MULTI-KNOWLEDGE FRAMEWORKS

2.1. Introduction

Throughout ecology and sustainability sciences, theoretical frameworks are used to bridge the gap between localized research and disparate dialogues focused on resilience or adaptation. A framework is defined as "a set of assumptions, concepts, values, and practices" that create an orientation to reality (Binder et al. 2013; p. 2). As described in McGinnis and Ostrom (2014), "…a framework helps scholars and policymakers to accumulate knowledge from empirical studies and assessments of past efforts at reforms and to organize their analytical, diagnostic, and prescriptive capabilities," (p.1). In scientific literature broadly, some frameworks have emerged as dominant, either because of feasibility of application, or permeation and prioritization within academic training. These frameworks create new foundations for future research, by shaping the multiple structures researchers engage with, including funding sources, academic institutions, scientific publications, and others. They also shape practices outside of research, supporting and shaping governance structures, managerial strategies, and others. Based on this process, the assumptions, ontologies, and epistemologies associated with specific frameworks become embedded into research, often prioritizing quantitative knowledge gathered through classical modes of western, dominant science and excluding others thereby promoting, and reconstituting colonialization, racism, sexism, among other social and cultural phenomena (Henri & Provenchar et al., 2021). The exclusion of knowledges only perpetuates socially constructed inequities, creating malformed solutions to complex issues such as climate change or food insecurity (Fleischman et al., 2020) that continue to promote different people over another

(Reed et al., 2022), and in short, create more violence (Union of B.C. Indian Chiefs, 2021; Smith, 2012). By reevaluating and acting on gaps in curriculums in commonly colonial educational institutions and reexamining frameworks used within management and decision-making processes, managers, educators, scientists, Indigenous and non-Indigenous peoples can start to decolonize these spaces and create new frameworks that allow for collaborative and equitable solutions (Rozance et al., 2020; Held, 2019; Mji, 2017; Kimmerer, 2002).

This is particularly true within fisheries science, where fisheries often represent multiple histories, cultures, social structures, economies, and places. As Silver et al. (2022) describe, there are deep connections between fisheries, territorialism, colonialism, and the emergence of fisheries science, and in particular, the dispossession of Indigenous territories to support growing industrial fisheries. For example, frameworks such as maximum sustainable yield (MSY) create assumptions about fishing catches and reproduction calculations, reflect the intertwined nature between fisheries science efforts, government efforts to seize territories and subsidize industrial fishing, and support the adoption of policies reflective of dominant science thinking (Finley and Oreskes, 2013). Many scholars believe that adoptions of these frameworks or assumptions have led largely to the decline of fisheries globally (Finley and Oreskes, 2013; Post, 2013; Dadswell, 2021; Villasante et al., 2022). As fisheries are positioned within discussions about food sovereignty (Lowitt et al., 2023; Levkoe et al., 2017; Grey and Patel, 2015), food security (Lowitt et al., 2023; Loring et al., 2018), and climate change (Woods et al., 2022; Galappaththi et al., 2021), it is more important than ever to reflect on fundamental paradigms and frameworks to determine if and how fisheries science can pursue more holistic, nuanced, and anticolonial strategies to research, which in turn, can support new institutions and policies within fisheries governance.

Within multiple areas of science, individuals, research groups, and others have worked against colonial ideologies in an academic space by describing (Reid et al., 2021; Smith, 2012; Agrawal, 1995), conducting (Popp et al., 2020; Bartlett et al., 2012), and teaching anticolonial or decolonized research (Datta, 2018, Mackinlay & Barney, 2014; Smith, 2012) (among many others). Relevant to the actual practice of research, anticolonial and decolonized methodologies focus on the centering of Indigenous voices, epistemologies, and issues within the research process (Latulippe & Klenk, 2020; Battiste, 2000; Held, 2019; Simonds and Christopher, 2013). These methodologies often resemble frameworks, as they embody Indigenous paradigms and value systems (Pidgeon and Riley, 2021). These methodologies focus on reshaping the dominant scientific methods to stand with, move over, and make room for alternative forms of knowledge through storytelling, engagement, and collaboration. (Pidgeon and Riley, 2021; Latulippe & Klenk, 2020; Held, 2019; Todd, 2016; TallBear, 2014; Smith, 2012). They also include engaging in relationship building, as well as iterative dialogue with Indigenous partners (Pidgeon and Riley, 2021; McGreavy, Ranco et al. 2021). Decolonized methodologies are distinct from anticolonial science, as decolonizing efforts have the goal of "repatriating land to sovereign Native tribes and nations, abolition of slavery in its contemporary forms, and the dismantling of the imperial metropole," (Tuck and Yang, 2012 p.100). With this emergent process, Indigenous and non-Indigenous scholars have discussed how the dominant frameworks within the scientific community can be problematic, exclusionary, and reinforce oppressive structures that go beyond Indigenous communities. This includes the separation of Indigenous knowledges and paradigms from perceived "data" or knowledge which removes the values and cultural significance to those knowledges. This extraction is often related to the idea of incorporating Indigenous knowledges

into western science frameworks or models as opposed to knowledge weaving which is supported by Indigenous frameworks.

2.1.1. Incorporation vs. Weaving

One example of issues compounded by frameworks is the recognition of Indigenous Ecological Knowledge (IEK) that is being "incorporated" into broader research efforts to solve complex environmental problems (Johnson et al., 2016; McGregor, 2004). The frame of incorporation, whereby Indigenous knowledge is decontextualized into broader scientific enterprises which force Indigenous knowledge to "conform to western conceptions about knowledge," (Bohensky & Maru, 2011, p. 1; Latulippe & Klenk, 2020; Nadasdy, 1999) has created a need to look towards new ways to more equitably consider both IEK and dominant sciences within research.

To do this, Indigenous, and non-Indigenous scholars have called on a new frame of knowledge weaving (Hilchey, 2022; Latulippe & Klenk, 2020; Henri & Provencher et al., 2021; Johnson et al., 2016). Within this frame, weaving knowledge systems refers to bringing multiple knowledge systems together, creating space for exchange, mutual learning and understanding, and centering equity and respect within the knowledge co-production process (Reid et al., 2021; Johnson et al., 2016). When practiced by researchers, knowledge weaving puts Indigenous knowledges (IK) and western or dominant scientific knowledges (SK) on equal footing, where each are considered for their own inherent values (Johnson et al., 2016). Knowledge weaving has been linked to an improved understanding of socio-ecological issues (Popp et al., 2020), and a greater possibility for equitable action based on that research (Latulippe & Klenk, 2020). Knowledge weaving can create more equity between Indigenous knowledge holders and

decision-makers by also creating new decision spaces where knowledge systems are viewed equally (Henri & Provencher et al., 2021; McGregor, 2004; Kimmerer, 2002).

Choosing frameworks that center weaving as a metric for considering Indigenous knowledge (or other forms of knowledge exclusions) strengthens Indigenous sovereignty and has direct implications to our ability as a society, community, or researcher to solve complex issues (Tuck & Yang et al., 2012; Johnson et al., 2016; McGregor, 2004). The goal of this research is to review multi-knowledge frameworks, or frameworks that aim to mobilize multiple forms of knowledge to create models or assess sustainability or resilience. I am focused on Indigenous knowledge and sovereignty to understand how frameworks can recreate colonial practices of exclusion with Indigenous and non-Indigenous peoples. This leads to my overarching research question, "How does the choice of framework shape co-production of knowledge and anticolonial impacts of research?" Responding to this questions I: (1) describe four multi-knowledge use frameworks as cases including Institutional Analysis and Development Framework (IADF, Ostrom, 1982), Etaupmunk[5][6] (E/TES, Greenwood et al., 2015), He Waka Taurua[7] (HWT/DC, Maxwell et al., 2020), and Social Ecological Systems Framework (SESF, Ostrom, 2009); (2) compare how these frameworks shape Indigenous and non-Indigenous research collaborations, the treatment of data, and how they could work in tandem in a research context; and (3) offer steps forward or calls to action to create more inclusive and anticolonial academic programs and research.

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[5] For Indigenous terms, I will be using the term, identifying its language of origin, and providing a brief translation or description in the footnotes. I am following Max Liboiron's (2021) structure to create reader disruption, forcing recognition for non-Indigenous readership of Indigenous knowledge systems
[6] two-eyed seeing
[7] HWT/DC is an acronym following the structure used by Bartlett, 2012 for the Etauptmumk framework

2.2. Methods

The process for reviewing these four frameworks for specific parameters related to anticolonial research emerged in two stages. Following a comparative case study methodology outlined in Goodrick (2014) I developed key evaluative questions, defined, and outlined each of the four frameworks as cases, collected data through a systematic literature review, and then provided insights based on those key evaluative questions. These stages of research are described more thoroughly below.

2.2.1. Developing Key Evaluative Questions

Following Goodrick (2014), and other example comparative case studies (Bartlett and Vavrus, 2017; Tsurusaki et al., 2012; Lee, 2007), I developed key evaluative questions (KEQs) to understand how each of the cases impacted Indigenous sovereignty or considered knowledge weaving. These questions emerged after reviewing books (5+), articles (20+) as well as having informal scoping conversations (5+) with university faculty and students who engage in anticolonial or decolonized methodologies. The books and articles used are listed in Appendix I. Conversations with researchers and faculty included questions such as "How do you define decolonized or anticolonial science?", "What do you think the most important characteristics are of anticolonial science?", and "What are specific traits of research that you believe are anticolonial or decolonial?". Based on multiple forms of information, I determined three common parameters which could be used to assess if research could be considered anticolonial including: (1) Indigenous leadership within the research process, (2) Indigenous ownership of data during and after the research process, and (3) the presence of a research epistemologies that creates space for multiple worldviews, including Indigenous ontologies (Table 2.1). From these

three parameters, I developed three open-ended KEQs which compares each of the cases and their impact.

Table 2.1: Key Evaluative Questions. Questions developed for the comparative case study between multi-knowledge frameworks.

Research Parameter	Question	Citation
Presence of Indigenous worldviews	How do each of these frameworks consider multiple forms of knowledge, paradigms, or worldviews? Particularly, how is collaboration or collaborative science considered within each of these frameworks?	Smith, 2021; Ogar et al., 2020; Burkhart, 2019; Walter and Suina, 2018
Indigenous leadership	In the application of each of these frameworks, how is Indigenous leadership considered?	Robinson and Toney, 2021; Latulippe and Klenk, 2020; Gerlach, 2018; Bohensky, 2011; Agrawal, 1995
Indigenous Ownership of data or Indigenous Data Sovereignty	How is data conceptualized in each of the frameworks? Are any additional considerations described related to Indigenous Data Sovereignty?	Carroll et al., 2020; Davies et al., 2019; Walter and Suina, 2018;

2.2.2. Defining Cases and Systematic Literature Review

Following a case study methodology as described in Yin (2018), each of the frameworks is presented as a concrete entity case, specifically, a set of practices that are easily specified and definable. Following comparative case study methodology (Bartlett & Vavrus, 2017; Maxwell, 2013; Goodrick, 2014) I analyzed each of the cases based on key evaluative questions. Developing the information for each case, I conducted a systematic literature review following the literature design methodology developed by Galvan and Galvan(2017)[8]. Initial frameworks were chosen based on prevalence in literature and relevance to small-scale fisheries including

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[8] While this book was highly informative regarding writing literature reviews, even this book includes a quote "If there are understudied groups such as Native Americans, you might call for more research on them," (p. 105). Once again, I am hoping to draw attention to viewpoints that would create a question that positions Native Americans solely as subjects, rather than collaborators.

Etuapmumk, (Two-Eyed Seeing in Mi'kmaw, Acadia, Eastern Canada, Bartlett, Marshall, and Marhsall., 2012); Waka-Taurua (Double Canoe in Māori, Aotearoa, New Zealand) the Institutional Analysis and Development Framework (Ostrom, 1982) and the Social Ecological Systems Framework (Ostrom, 2009). I used the WorldCat online database and the University of Maine Fogler library databases to find articles referencing each of the frameworks listed above. In the search bar, I identified key terms to gather peer-reviewed articles published in the last 40 years referencing the frameworks (Table 2.2). In addition, search terms such as "Indigenous," "aboriginal," "native" and others were used to identify articles that engaged with Indigenous communities, and "fisheries", "ocean," "coastal" were used to identify articles that researched fisheries. Articles were then excluded based on misidentification by keywords, lack of institutional access, and language.

Once identified, I reviewed 59 articles and categorized them based on type, either as a description, critique, or application of a framework. Description articles are articles that introduce the frameworks in academic literature, as well as follow up articles focused on specific components of each framework. Critique articles are written without the original author that offer alternative approaches or recommendations for application to the original framework which are later incorporated into the broader description of the framework. Finally, operationalization articles are more recently published articles (last 10 years) that include research applications of the frameworks in a fisheries and Indigenous contexts. Once categorized, I analyzed description and critique articles for common components, including base assumptions, terminology, and the ontologies and epistemologies of each framework, which are then described below in each section describing a framework. These articles were also revisited to discern the limitations of each framework.

I used operationalization articles to better understand how each framework is applied to research methodologies within an ecological or sustainability science context, and how the research engaged with Indigenous ecological knowledge (IEK). From this pool of operationalization articles, I chose one or two cases to describe how each of the frameworks is applied in a research space, based on their similarity with other applications of the framework as well as their unique research context that included natural resource use, space planning, and Indigenous communities. I also evaluated these articles based on inclusion of Indigenous paradigms, particularly the cultivation and support for dialogue across cultural spaces (Wilson, 2008).

Table 2.2: Search terms to identify papers for literature review.

Framework	Keywords identified for article gathering
Etuaptmumk/ Two-Eyed Seeing (Bartlett 2006)	"two eyed seeing" "two-eyed seeing" "Bartlett 2006" "Marshall" "framework"
He Waka Taurua / Double Canoe (Maxwell et al., 2020, Aotearoa, New Zealand)	"double canoe" "He waka taura" "waka-taura" "Maxwell 2020"
Institutional Analysis and Development Framework (Ostrom, 1982)	"Ostrom" "Institutional Analysis and Development" "Institution" "Ostrom" "Framework"
Social Ecological Systems Framework (Ostrom, 2009)	"Ostrom" "Social Ecological Systems" Social-Ecological Systems" "framework" "Ostrom 2009"

2.3. Results

As part of my results from the literature review, I describe the four frameworks listed above, focusing on four features. These features include: (1) Paradigms; (2) Purpose of the Framework; (3) Elements, Definitions, or key features within the framework; and (4) how each

framework is applied. The first three features are consolidated into a table below and described

more fully in following sections (Table 2.3).

Table 2.3. Features of frameworks reviewed

Frameworks	Features		
	Paradigms	Purpose	Elements
Etauptmumk (E/TES)	Indigenous worldview that draws from Mi'kmaq teachings. Described by Elder Dr. Albert Marshall as "learning to see from one eye with the strengths of Indigenous knowledges and ways of knowing, and from the other eye with strengths of mainstream knowledges and ways of knowing, and to use both of these eyes together, for the benefit of all," (Bartlett, Marshall and Marshall, 2012, p. 335; Bartlett 2006, 2011).	Promote the recognition of Indigenous knowledge (IK) and offer space to critically examine assumptions embedded within western scientific knowledge (SK)	Relational codes of conduct that prioritize equity, care, and inclusivity, collaborative group that includes researchers, Indigenous Elders, and others for decision-making Considerations around "eyes" or expertise in applying, gathering, and sharing knowledge
Institutional Analysis and Development (IADF)	Post-positivistic paradigm (Creswell, 2011), used to develop models that represent singular truth, developed as tool to critique "Tragedy of the Commons" (Hardin, 1968)	Describe institutional arrangements, assess actions based on those arrangements, and their impact on the overall resilience of systems	Model focused on external variables, action situations, and interactions
He Waka Taurua (HWT/DC)	Indigenous worldview that draws from Māori teachings related to three-house governance structures, where houses are characterized by knowledge systems they embody, and additional spaces are created for cross cultural knowledge co-creation	Co-develop knowledges and tools to assess and respond to emergent issues in shared spaces, particularly in discussions around access to waterways (rivers, oceans, etc.) and Indigenous food systems	Relational codes of conduct, shared decision-making, Conceptual model focused on multiple structures that represent different bodies of knowledge and shared places for solution creation

Table 2.3. Continued

Social Ecological Systems Framework (SESF)	Post-positivistic paradigm (Creswell, 2011), develops model to represent complex system, focuses on relational work and draws from ecology and sustainability science fields	Assess resilience of social-ecological systems by defining communities or systems through tiered variable system	Multi-tiered variable system to define social, ecological system entities, model that provides multi-directional relationships between individual entities

2.3.1. Etauptmumk (Mi'kmaq, Eastern Canada)

2.3.1.1. Paradigms

Etuaptmumk, (E/TES) is a guiding principle, cultural ethic, and Indigenous worldview that spans across an individual or communities' life, shaping the responsibilities, actions, social, economic, ecological, environmental, and cultural impacts an individual would have on themselves and their community (Greenwood et al., 2015, p. 18). This worldview centers a spiritual and physical self, where both selves have co-existing and complimentary knowledges that shape a person's being (Bartlett, Marshall, and Marshall, 2012). It also has been described as an approach to research (Maxwell et al., 2020). This framework grew from teachings of the late chief of the Mi'kmaq Acadia First Nation Charles Labrador, who said, "Go to the forest, you see the birch, maple, pine. Look underground and all those trees are holding hands. We as people must do the same," (Greenwood et al., 2015, p.17), as well as belief systems embedded within the Mi'kmaq peoples (Syliboy, 2021). This idea of collaboration, partnership, co-existence, and difference between knowledge systems such as the birch, maple, and pine, highlight that this framework not only centers the natural world as teachers, but beyond, creates space for weaving of "roots" to better understand or cultivate a "forest" of knowledges. E/TES emerged from a long history of L'nuk, or Mi'kmaq(w) peoples where they, "had to coexist with the rapidly changing

landscape of their ecosystem with which they had to now share with settlers. Their co-existence ebbed between conflict and peace, which eventually benefited the settler enfranchisement as a dominant society," (Syliboy, 2021, p.1)

2.3.1.2. Purpose of Development

This conceptual framework broadly promotes the recognition of Indigenous knowledge (IK) as a distinct knowledge system that can stand "side by side" or surpass western science knowledge (SK), without excluding or demoting other knowledges (Bartlett, Marshall, and Marshall, 2012, p. 335). In this sense, its "purpose" is to support Indigenous sovereignty within the scientific process. E/TES promotes the knowledge co-existence or complementarity as opposed to knowledge assimilation or incorporation (Milligan et al., 2022; Syliboy, 2021). E/TES focuses on reflexive consideration of IK and SK and embodies Indigenous concepts of maintaining ecological integrity for seven generations (Milligan et al., 2022). E/TES also offers a space for western, or dominant[9] science to reexamine its own biases with a critical lens, with particular attention to the relationships between SK and the world around it (Broadhead and Howard, 2021). Broadhead and Howard (2021) state, "What if, we need the courage to ask, one of the *two eyes* you wish to see with is essentially health, and the other is partly diseased?", (p.1). In this case the diseased eye would be western or dominant science, where a lack of critical views on process, impact, and limitations of SK has created the "disease," (Broadhead and Howard, 2021). E/TES offers a unique space for Indigenous and non-Indigenous scientists to revisit SK collectively, creating new relationships and partnerships between knowledge systems that can complement each other equitably.

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[9] Wilson (2008) and Liboiron (2021) among other scholars have pointed out that the term "dominant" is more appropriate to describe constructions of science derived from Eurocentric worldviews and ideals. The word "dominant" shifts from western as a descriptor to incorporate the power relations which are shaping how dominant science relates to other forms of inquiry.

2.3.1.3. Elements within Framework

In terms of conducting research, E/TES promotes a relational code of conduct, prioritizing the recognition of rightful ownership of Indigenous knowledge, and understanding how knowledge is gathered or used to benefit and support Indigenous peoples (Syliboy, 2021). When conducting research as a non-Indigenous SK specialist, there are many important considerations. First, implementation of this framework by a non-Indigenous researcher requires at least one other individual with Indigenous knowledge and perspectives (Wright et al., 2019; Bartlett, Marshall, and Marshall, 2012; Bartlett, 2006). Researchers within an E/TES project need skills in communication, building trust, and recognition or development of equitable relationships. One important reason for this is that a researcher, particularly one that specializes in SK is not centered within this framework, they do not own rights to data, and therefore integrated relational work is required from the outset. Syliboy et al., (2021) highlight eight recommendations for researchers or organizations planning on conducting or implementing E/TES. These rules are described in Table 2.4, and incorporate this idea of diverse skillsets, as well as new considerations of community engagement. In addition, E/TES presents a new role for the non-Indigenous SK researcher, a "follower, listener, and learner," as opposed to leader (Wright et al., 2019, p.1).

2.3.1.4. Operationalization

This framework has been implemented in health care system reviews (Institute of Aboriginal Peoples' Health (IAPH)), determining new styles or efforts in the classroom (Government of Nunavut's Department of Environment's efforts to provide educational opportunities for Nunavut youth), governmental efforts to create new inclusive strategies for natural resources (Collaborative Environmental Planning Initiative, Government of Nova

Scotia's Natural Resources Strategy entitled "The Path We Share"), as well as more recently in a fisheries context (Reid et al., 2020). In each of these contexts, non-Indigenous researchers are asked to take a follower and learner role and are encouraged to "tack back and forth" between forms of knowledge, while understanding that perspectives in a specific situation should be prioritized more than the other, but that both SK and IK are of equal importance and emphasis to broader contexts of understanding world systems (Wright, et al., 2019).

For example, Abu et al., used the E/TES framework to assess environmental shifts in the Saskatchewan River Delta in Canada (2020). Multiple river dams were developed throughout the 1960s and 1980s, and communities (both Indigenous and non-Indigenous) cited multiple changes to river flow and the loss of important fish and wildlife habitats (2020). There were also growing concerns that SK was still being prioritized over Indigenous and community-based observations and studies. To better understand the long-term changes, a group from Cumberland House (a community within Saskatchewan River Delta), and researchers, drew from instrumental observations, Indigenous knowledge (as shared through interviews with Elders and other members of the Indigenous community) and archival records to understand shifts in hydrology, fish and wildlife population shifts, and vegetation changes (Abu et al., 2020). The multiple forms of information did not always agree, instead researchers, with the guidance of other members from the community further explored these discrepancies to understand the limitations of each for of information. Information from this research was provided to the Delta Dialogue Network, a group of policy makers, researchers, and other communities that are focused on developing a set of action items across to support the sustainability and conservation of three inland deltas.

Table 2.4: Recommendations for Conducting Research on Indigenous Lands: Adopted from Syliboy et al., 2021. Syliboy et al., 2021 identified recommendations, I have provided a description drawing from Syliboy et al., 2021, Wright et al., 2019; Bartlett, Marshall and Marshall, 2012.

Recommendation		Description
1.	Community Engagement is All About Relationships Building	Create new relationships with community, either by creating capacity through funding a "kinship year" or join with other organizations who already have historical relationships. Organizations and researchers are recommended to consider uniqueness of each case, implement trial and error, and recognize relationships exist outside of typical timelines
2.	Community Protocols and Ethics	Create space to implement community-based protocols within research process, including establishing advisory committees that include Elders, community members, and other relevant researchers to establish protocols and practices in a project or within an area
3.	Capacity Development is about Reciprocity	Create space for shared learning, spaces where researchers can learn from community members, community members can learn from Elders, and with time and cultivated trust, learn from researchers
4.	Indigenous Research by Design	Use Indigenous framework to set research priorities, determine methods, and guide other, including a broad implementation of E/TES or something similar across all levels of decision making
5.	Data Considerations, Protection & Pathways	All IK is sacred, culturally and context driven, and cannot be separated from individuals, so allow for Indigenous ownership exceeding research spaces, including ways to maintain spirituality of knowledge outside of research
6.	Data Interpretation & Analysis	Include Elders, community members, and others in safe and supportive environment to analyze collected knowledge; **non-Indigenous peoples should not be independently interpreting Indigenous Peoples information**
7.	Community Knowledge Validation	Create processes where Elders and community members can tell researchers broad findings, and lead discussions on what data is shareable outside current context
8.	Gardening, Dissemination & Benefit of Interpretations	Some knowledge is not to be shared outside of Indigenous spaces with Indigenous researchers. Knowledge that is determined as shareable may be translated into other languages and is determined by ongoing conversations between Elders, Knowledge Holders and researchers; Gardening should be seen as a space to revisit original goals and intentions and determine future steps as necessary

Implementing E/TES follows similar patterns. First, groups and relationships are formed between Indigenous and non-Indigenous researchers so they can gather multiple forms of knowledge to create a more holistic view of a system (Abu et al., 2020; Forbes et al., 2020; Syliboy et al., 2021; Wright et al., 2019; Marsh et al., 2015). Often, this group then applies qualitative and quantitative methodologies, meets iteratively, and discusses the findings from the data with Indigenous and non-Indigenous leaders (Syliboy et al., 2021; Abu et al., 2020; Peltier, 2018). Like other frameworks that will be described later, E/TES creates space for partnerships across disciplines, and in this case, across cultures, and situates multiple knowledge systems equitably across contexts. While there are limitations in the implementation of this work, outcomes from E/TES guided projects create broader benefits for multiple peoples and provide a reflexive and collaborative structure (Abu et al., 2020; Kutz and Tomaselli, 2019; Rowan et al., 2015). As described by Syliboy et al., research that focused on relationships and relationships building needs to be prioritized broadly, as Indigenous knowledge evolves from relationship (2021). So, when relationships built on trust are prioritized in a research context, there is higher likelihood for better outcomes across diverse interests (Syliboy et al., 2021).

2.3.2. Institutional Analysis and Development Framework

2.3.2.1. Paradigm

The Institutional Analysis and Development Framework (IADF) prioritizes SK to determine aspects of a broader model of institutional arrangements. IADF relies on positivistic or post-positivistic assumptions to pursue a singular truth or get as close to the truth as possible (Creswell, 2011). This is evident by the centering of SK to build a model of relationships and institutions in a complex system, which is then used to offer explanations and predictions, a common trait in discussions around post-positivism (Creswell, 2011). This paradigm often leads

to the exclusion of other forms of knowledge (Lindlof & Taylor, 2011). In terms of a post-positivistic paradigm, IADF uses qualitative and quantitative methodologies to pursue truth and objectivity (Lindlof & Taylor, 2011). IADF also derives itself from institutional analysis theory and often is positioned as a framework to prove aspects of the theory, another common trait of post-positivistic science (Creswell, 2011).

2.3.2.2. Purpose of Development

The IADF was first developed in 1982, and is situated to understand the variables that govern how individuals or groups make decisions in specific contexts (Ostrom, 2011; Ostrom, 2009; Ostrom, 2005, Ostrom, 1982). The IADF creates space to describe alternative solutions where private interest, or government intervention from outside a community are not the only solutions to the "Tragedy of the Commons" (Hardin, 1968). Instead, Ostrom describes systems that are centered on community self-governance, where social groups create and impose their own rules that are centered on trust across relationships (Ostrom, 2011; Ostrom, 2009, Imperial, 1999). The IADF emerged from this and Ostrom's firm belief in embracing complexity, most especially within institutions, stating that institutional diversity should reflect local knowledges that are rich in diverse ecologies.

2.3.2.3. Elements with Framework

Within the IADF, there are basic structures that set up and support shared language (Blomquist & deLeon, 2011; Ostrom, 2009). Governance structure, development, and actions are translated and documented within this shared language. The IADF defines action arenas, or arenas that contain action situations and participants, exogenous variables including ecological, social, and cultural contexts that shape the action arena, interactions, and evaluative criteria (Ostrom, 1982, Figure 3). It is outside the bounds of this paper to describe fully each of the

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variables, pathways, and interactions that have been articulated or identified throughout the tenure of the IADF. Instead, each broad category, including exogenous variables, action situations, interactions, and outcomes will be described more fully.
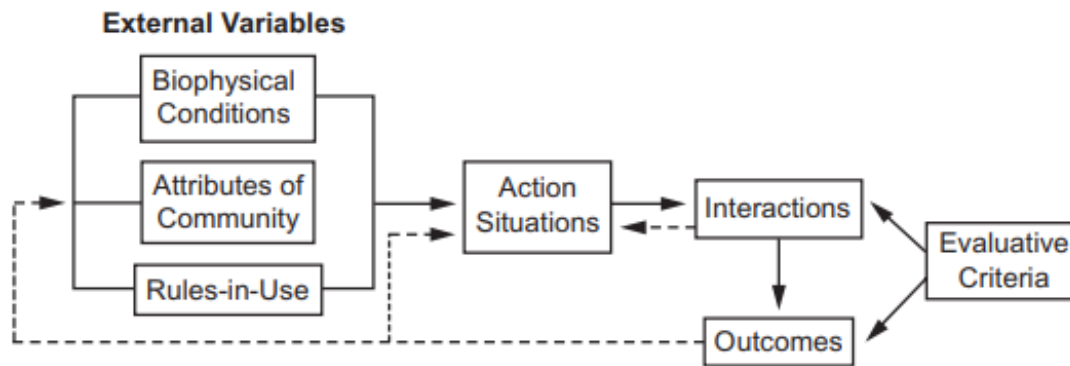
Figure 1. A Framework for Institutional Analysis.
Source: Adapted from E. Ostrom (2005, p. 15).

Figure 2.1. Screenshot of Figure 1, Ostrom, E. (2011). *Source* Ostrom, E. (2011). Background on the Institutional Analysis and Development Framework. Policy Studies Journal, 39(1), 7–27. https://doi.org/10.1111/j.1541-0072.2010.00394.x

Exogenous variables or external variables include a broad spectrum of social, ecological, economic, and cultural factors that all shape individual actions and participants within an action arena (McGinnis, 2011; Ostrom, 2009). These can include laws that govern institutional structures, the biophysical conditions of a space, including air or water quality, size of an area, or the location of an area that an action situation is confined to. Attributes of a community could include the socioeconomic status of community members, types of employment, etc., usually identified by data or a researcher, not by the community itself (McGinnis, 2011). This could inhibit participation by community collaborators, instead promoting a shared language across research disciplines. Rules could include laws or regulations, as well as everyday rules that individuals use to govern their everyday life (Ostrom, 2007, 1982). This could include

community or cultural norms, as well as rules that are informal across community members. An important part of exogenous variables is that they are determined to be quantifiable, meaning they can be measured, and incorporated into calculations for action situations (McGinnis, 2011). These variables also can create separation, where the different understandings or definitions of each of these variables can inhibit participation or the development of shared language with research participants. For example, if researchers define each attribute themselves, there is less space for shared understandings of a variable. This is particularly true of the "rules of use" where cultural norms that impact management may not be incorporated if those individuals are not considered in the overarching research (McGinnis, 2011; Ostrom, 2007, 1982).

Action situations are a simplification of action arenas, action situations, and participants (Ostrom, 2011; McGinnis, 2011). Within an action situation, actors and actions are assigned to positions, which, using information about or control over situations they are linked to, create new potential outcomes, and assign cost and benefits to those outcomes (Ostrom, 2005). Action situations in this case could include the passing of legislation, the formation of a new collaborative, the development of a new business, and others. Action situations are the unit used broadly to analyze a problem, including the explanation and predication within institutional arrangements (Ostrom, 2011). For example, with information regarding actors, actions, and the information they have access to, analysis focuses on how individuals behave in a specific structure. From this initial space, IADF is often used to then understand which variables effect the overall action situation, including external variables, or how the outcomes may affect new strategies over time. Within my previous Master's work (Hillyer, 2022), this could include first understanding how water quality classification decisions are made, determining if or when any additional information could be included in that decision-making process, why that additional

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information was concluded, and how did that affect the outcome of the classification or reclassification process.

2.3.2.4. Operationalization

When using IADF, researchers are often asked to consider working components of action situations as well as the rules within an action situation. For example, researchers should consider the participants in an action situation, positions among participants, links participants draw to different outcomes, as well as the rules around positions (how one would enter or leave that position) or rules of authority, or how actions are attributed to different participants (McGinnis, 2011). Moving past the action situation, Ostrom identifies goods or services as physical or material conditions that shape action. For example, 8.1.2 in McGinnis (2011) states that *exclusion* as a point of reference could be defined as "How costly is it for A to exclude B from access to that resource?" (p. 174). In this way, the IADF can be utilized by researchers to understand various institutional dynamics, including individual scale or institutional scale decision making across contexts.

When reviewing how IADF can be used to analyze governance structures within fisheries systems, Imperial and Yandle both highlight that IADF is a value-free framework, despite studying institutional arrangements that have embedded value systems (2005). They also highlight that IADF creates space for researchers to follow the scientific process more explicitly, stating, "institutional analysis is similar to theory-seeking literature in that it should use conceptual or theoretical frameworks to encourage systematic analysis of data and strive toward the aggregation of knowledge and the generalization of research findings," (Imperial and Yandle, 2005, p. 502). In this sense, multiple forms of knowledge are not considered, specifically IK

which often cannot be separated into other spaces (Watkins and Westphal, 2016; Blomquist and deLeon, 2011; Carter et al., 2016).

To understand how IADF is applied in Indigenous communities, I review Ouedraogo's and Mundler's (2018) application of IADF in Burkina Faso, West Africa. Within this study, researchers review multiple governance strategies of an open-access resource, namely, gold, and how that did or did not lead to the Tragedy of the Commons (Hardin, 1968). These governance structures included: community-based groups that were self-regulated; more colonial, or hierarchical arrangements where an individual manager has the most power, and privatization, or the arrangements created by private companies. Ouedraogo and Mundler tested these assumptions based on extensive qualitative research within three artisanal gold mines that were found within Indigenous communities. Following the IADF framework, researchers gathered knowledge of individual attributes of the overall governance and effectiveness of governance strategies through interview and additional literature reviews within each area. Also following the IADF framework, researchers used language reflective of colonial thought, such as "resource" which implies a focus on extraction.

Overall, this study had many different discussions around the impacts of artisanal mining on Indigenous communities. However, there were no perceived connections to Indigenous communities outside of the interviews. Of the respondents of the study, less than 30% were Gourmantche[10], which I believe is the term used to identify members of Indigenous communities, but it is not discussed within the context of the publication. Outside of this inferred connection, no members of the research team are Indigenous, or were able to help analyze or

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[10] A common term used to describe the bigourmantcheba (or Gurma) people, and indigenous group living in Ghana, Burkina Faso, and other areas of Africa

describe any information emerging from interviews. Instead, assumptions were made based on the interview data and observations. From interview data, if IK was shared (again assumed based on labeling of interview respondents) it was stripped of any cultural context to be assimilated within the other interviews. This is a similar trend with other applications of the IADF framework, where Indigenous views, when considered, are stripped of cultural context to be incorporated into a broader model of the system (Oñate-Valdivieso et al., 2021; Sarr et al., 2021; Shah et al., 2020).

2.3.3. He Waka Taurua (Māori, Aotearoa, New Zealand)

2.3.3.1. Paradigm

He Waka Taurua, (HWT/DC) is a framework designed between kaitiakitanga[11] and ecosystem-based management equitably (Maxwell et al., 2020) It is situated in space to develop or assess co-governance or co-management arrangements between Indigenous peoples and settler colonial structures (Maxwell et al., 2020). HWT/DC has been presented as a metaphorical framework for collaborations between Indigenous and non-Indigenous scholarship, particularly within a co-management system (Maxwell et al., 2020). Within this publication, HWT/DC serves as a framework that can guide various forms of inquiry into understanding participation, action, and decision-making when developing or evaluating co-management or co-governance systems in fisheries, both marine and freshwater.

2.3.3.2. Purpose of Development

HWT/DC draws from Raukawa-Mihingare[12], where there is a house for Māori, a house for non-Māori, and then a "treaty house" where parties can work together with mutual respect for

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[11] a concept of care between Māori peoples and the environment that encompasses spiritual, environmental, and physical considerations of care
[12] three-housed model of governance, Māori

each knowledge system and values (Maxwell et al., 2020). This governance arrangement has been cited as laying the foundation for many more modern institutional arrangements within Aotearoa, New Zealand's management system, particularly in the context of natural resources or ocean spaces. HWT/DC also draws from waka-hourua[13] which isn't cross-cultural but instead describes metaphors for exploring how individuals with complimentary spiritual and physical selves as well exist within environments (Rata, 2012). This framework, like E/TES situates knowledges from environments, non-humans, and humans as equals spaces for gathering knowledge. Waka-hourua does not fit within the context of collaborations between non-Indigenous and Indigenous scholars, but instead serves as an initial thinking place for many of the Māori researchers that designed the HWT/DC. HWT/DC brings Raukawa-Mihingare and waka-hourua together in a new framework that supports development of marine management systems.

2.3.3.3. Elements with Framework

HWT/DC was first situated to create new spaces of collaboration and communication from IK within Māori Indigenous communities to influence and reshape resource management systems built on exclusion of mautauranga[14] Māori principles (Harcourt et al., 2021). HWT/DC refers to tying two canoes together temporarily to a common purpose, at other times canoes can be used separately to travel or understand moana[15]. As described by Best (1925), "the term taurua was applied to a temporary form of double canoe, as when two canoes were lashed together for some specific use, such as the manipulation of large seines. These seine-boats would

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[13] Double-hulled voyaging canoe, Māori
[14] Embedded cultural norms of Māori people that guide an individual's or communities' interaction with the environment. This is a broad belief system, cultural practice, and this simplified and non-Indigenous prescribed definition should not be used to describe this practice outside of the context of this paper.
[15] Ocean, or context of issues within the HWT/DC framework

at other times be used as two single canoes," (p. 425). In this framework, each waka[16], represents differing worldviews and values, IK or SK, who are coming together to understand a whainga[17]. As shown in Figure 2.2, borrowed from Maxwell et al., 2020, Waka Māori[18] and Waka Tauiwi[19] are coming together using individualized tools, hoes[20] or paddles to understand the whainga. Future visioning within the framework highlights the stability created between connecting two canoes, where individually they may tip, the collective vessel including the shared space and individual autonomous canoes lashed together are more resilient (Maxwell, et al., 2020). This connection is developed through the Papanoho[21], where individuals from either Waka can discuss, develop, and act with equitable consideration across both Wakas. Distinctly within this framework, wakas are kept separate. Each waka has right of rangatiratanga[22] and represents multiple forms of inquiry, historical and cultural knowledge practices, and actions derived from the knowledge system (Maxwell et al., 2020) Instead, the papanoho becomes the 'negotiated space' where actions can be decided upon and knowledges shared and discussed (Harcourt et al., 2021, Maxwell et al., 2020). This is like the E/TES concept of prioritization among IK and SK in different contexts, or the 'treaty house' in Raukawa-Mihingare.

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[16] Canoe, or worldview within the HWT/DC framework
[17] Common purpose among wakas
[18] The Māori canoe within the HWT/DC framework, representing Maori worldviews and knowledge systems (Maxwell et al., 2020)
[19] The non-Indigenous canoe within the HWT/DC framework, representing western science knowledge systems (Maxwell et al., 2020)
[20] Māori paddles or tools within HWT/DC framework
[21] Deck, or shared space between Waka Māori and Waka Tauiwi
[22] Self-autonomy, independence, and to an extent sovereignty over knowledge systems
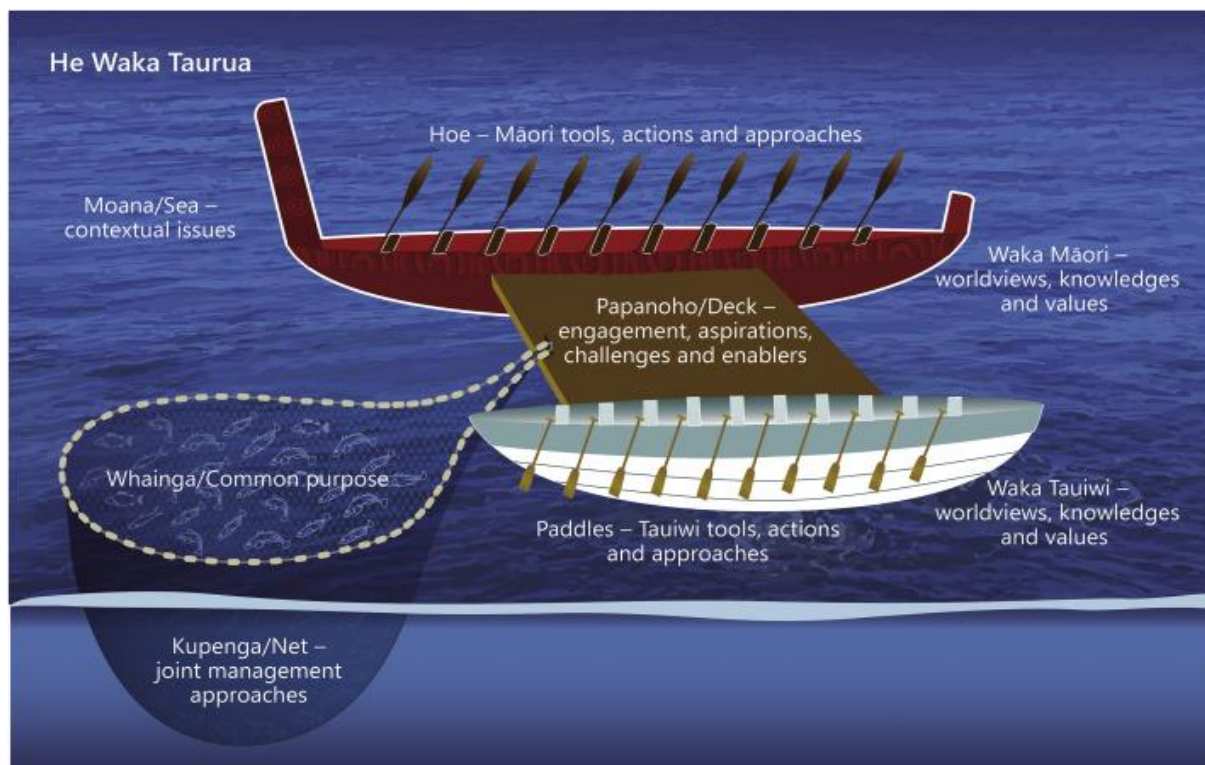
Figure 2.2. Screenshot of Figure 2. He Waka Taura *Source:* Maxwell, K., Awatere, S., Ratana, K., Davies, K., & Taiapa, C. (2020). He waka eke noa/we are all in the same boat: A framework for co-governance from aotearoa New Zealand. Marine Policy, 121, 104213. https://doi.org/10.1016/j.marpol.2020.104213

Foundational to this framework is acknowledgement of shared histories and commitment to ongoing relationships within the negotiated space. Only from the papanoho can kupenga[23] occur. This means differing actions, plans, or collective thinking on a whainga are centered from the papanoho and require the presence of both Waka Māori and Waka Tauiwi. It also means that outside a very specific whainga, the two wakas may separate to explore more individualistic actions in different moanas. This framework has been applied heavily in Aotearoa, New Zealand maritime management as a way on consistently and equitably considering multiple viewpoints across Indigenous and non-Indigenous people (Maxwell et al., 2020). It has more recently been applied in coastal land management as well, creating shared understanding and models of

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[23] Net, as shown in Maxwell et al., 2020

decision-making systems (Harcourt et al., 2021). He Waka Taura creates structures and systems where individuals, institutions, and cultures can be understood on an equitable basis, and provides a framework for researchers (both Indigenous and non-Indigenous) to understand institutional arrangements that are impacting whainga in a variety of contexts.

2.3.3.4. Operationalization

As previously mentioned, He Waka Taura has been applied in a variety of contexts within natural resource management, particularly in Aotearoa, New Zealand. As an initial case study for understanding the implementation of He Waka Taura, I review a case study on Whakatāwai Station, East Coast, Aotearoa, New Zealand (Hancourt et al., 2022). This study focused on current land use activity, after colonial practices had disrupted and decayed environmental systems in this area. HWT/DC was used to guide new collaborations within a decision-making context, specifically to guide researchers and managers in choosing new land use plans.

Within this case, Indigenous and non-Indigenous managers and researchers collaborated to understand the condition of the place. First, Maori researchers engaged in IEK methodologies to center Maori values within the land resource assessments. This included working with elders, facilitated community discussions, and IEK considerations for land planning. Non-Indigenous scientists conducted soil assessments, topographical surveys, and other SK based methodologies. After both wakas conducted multiple forms of knowledge gathering, each waka came together to create a new list of potential planting options. This process created space for multiple considerations, especially within a social, cultural, and economic context. After both wakas created lists of potential planting options within the context of the land-plan, a joint committee with Māori and non-Māori members refined the land-use list, using a scoring process where points were allocated to each land use scenario based on the consideration posed by the original

research teams. Over the next few years, Harcourt et al. mentioned that management plans with multiple collaborators will move forward with a broader consideration of implementing some of the land-use scenarios (2022).

As a second case, He Waka Taura was implemented in Tauranga Harbour in Aotearoa, New Zealand as described by Maxwell et al., (2020b). In this context, the HWT/DC was used to understand how explicitly, or implicitly Indigenous community values were being applied within co-governance arrangements, most especially in terms of participation, and how various Indigenous and non-participants were involved in the process of developing a co-management arrangement for Tauranga Harbour, a space with multiple Indigenous and non-Indigenous communities. Researchers used social science research methods, including semi-structured interviews, focus groups, and short adopted surveys in terms of information sheets provided with interviews. After data was gathered from both Indigenous and non-Indigenous research participants, researchers analyzed data for specific traits, issues, threats, or other comments, and applied them to the HWT/DC framework. This included describing each waka, the papahnoho, whainga, among other components of the framework. As a final product, this model of co-governance was then used to understand participation of Māori peoples within the decision-making process researchers recommended that New Zealand needed to provide more support for kaitiaki[24] to engage in the current co-management process to secure future equitable consideration of Māori and non-Māori needs.

Both cases have strong examples of Indigenous leadership within the research context. The space cultivated by the implementation of the HWT/DC was welcoming to Māori worldviews,

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[24] Guardians, refers to kaitiakitanga (stewardship or guardianship) within Māori culture for fishing grounds that is active (Maxwell et al., 2020b)

knowledges, and knowledge keepers, as evident by the Māori participation in both the data gathering and data analysis within both research efforts. As a result, each case had broader impacts in terms of Indigenous sovereignty, where participation was more fully understood, recommendations for targeted support were given, (Maxwell et al., 2020b) and Māori knowledge impacted and shaped land-use planning (Harcourt et al., 2022). Ownership of interview data was reserved for interview participants, where analysis, transcripts, and results were all actively shared and discussed with participants (Maxwell et al., 2020b). Similarly, in Harcourt et al., (2022), knowledge centered on the original reasoning behind Māori recommendations was kept within the Waka Māori, and later complimented or readjusted by additional SK from non-Indigenous researchers. Overall, the HWT/DC framework creates a space for inclusivity across IEK and SK, cultivating in more holistic, impactful, and equitable results when analyzing management systems or creating new management plans for complex natural resource systems.

2.3.4. Social Ecological Systems Framework

2.3.4.1. Paradigms

SESF, like IADF, focuses on identifying quantitative and qualitative datasets that can be incorporated into a broad model to understand complex systems. In this way, SESF prioritizes SK, relying on a post-positivistic frame, where scientists pursue truths (Lindlof and Taylor, 2011; Creswell, 2011). SESF draws from a social-ecological systems theory, a theory combining resilience, sustainability, and vulnerability literature (Berkes et al., 2000; Holling and Gunderson, 2002), where SESF is used to understand complex systems that change, especially to determine how to manage these systems in a more sustainable manner (Ostrom, 2009).

2.3.4.2. Purpose of Development

The Social Ecological Systems Framework (SESF) was first described by Elinor Ostrom in 2009 as a way of studying and understanding complex social-ecological systems with a focus on sustainability (Ostrom, 2009). In that piece, SESF should be considered a method of gathering different forms of knowledge as well as "dissect and harness complexity, rather than eliminate it from such systems," (Ostrom, 2009, p. 420). This framework responds directly to Hardin's Tragedy of the Commons, stating that the "tragedy" creates a need to study and describe complex systems in this way, with a particular focus on analyzing the outcomes within social-ecological systems. In this way, the SESF also reflects post-positivistic paradigm, where again SK is centered in the pursuit of a "truth" that can explain behavior and predict outcomes (Lindlof and Taylor, 2011; Creswell, 2011).

2.3.4.3. Elements within Framework

Briefly, SESF creates a nested framework of subsystems for defining the multiple components within a complex social-ecological systems (Figure 2.3). These subsystems include resource systems (RS), governance systems (GS), users (U) and resource units (RU). Each of these subsystems is connected by specific interactions (I) which will inevitably lead to outcomes (O). Each of these subsystems also operates with a system of social, economic, and political settings (S) and related ecosystems (ECO). In this way, the framework organizes complexity, and can accumulate information from diverse studies to describe each subsystem and their interactions (Ostrom, 2009). Ostrom highlights this framework can also determine the sustainability of complex social-ecological systems (McGinnis and Ostrom, 2014). These components also orient themselves into "action-situations" or spaces where these variables

interact and create new actions or activities, essentially the building blocks of SES functions (Nabavi and Daniell, 2017).

The framework continues to breakdown each subsystem into second-level variables, which can individually be studied by a variety of research methods. For example, governance systems can include variables such as: government organizations, nongovernment organizations, network structure, property-rights systems, and constitutional rules. The example used in Ostrom's original piece is "When will the users of a resource invest time and energy to avert 'a tragedy of the commons'?" (2009). In a fisheries context, this often focuses on fishers, rather than consumers of fish. Within this framework, if enough variables are identified and articulated, these trends can be predicted outside of the usual theoretical structures, and instead be grounded in data from applied research on users' livelihoods, or ability to self-organize.

One of the largest assumptions that is reminiscent of the system highlighted in IADF, is a well-defined boundary across a common pool resource management context. This means that resource units, action situations, resource systems, governance systems, and users need to be discrete, meaning identifiable and finite. This includes factors stemming from social, political, economic systems as well as related natural resource ecosystems. Boundaries within the SESF allow for the SESF to be a diagnostic tool for complex systems and communities, as well as the integration and shared language across many different disciplines. However, these boundaries often do not consider multiple political orientations or differing relationships and instead prioritize management systems that can be understood within institutional arrangements that were described originally in IADF. This means that while different political orientations could be considered, but generally formal governmental arrangements are prioritized in terms of inclusion within the model. In a space like a mudflat, where Wabanaki and non-Wabanaki have different

political relationships to that mudflat, applying SESF would most likely consider them collectively, as parts of a whole, rather than highlight differences culturally, economically, or attune to power dynamics between them.
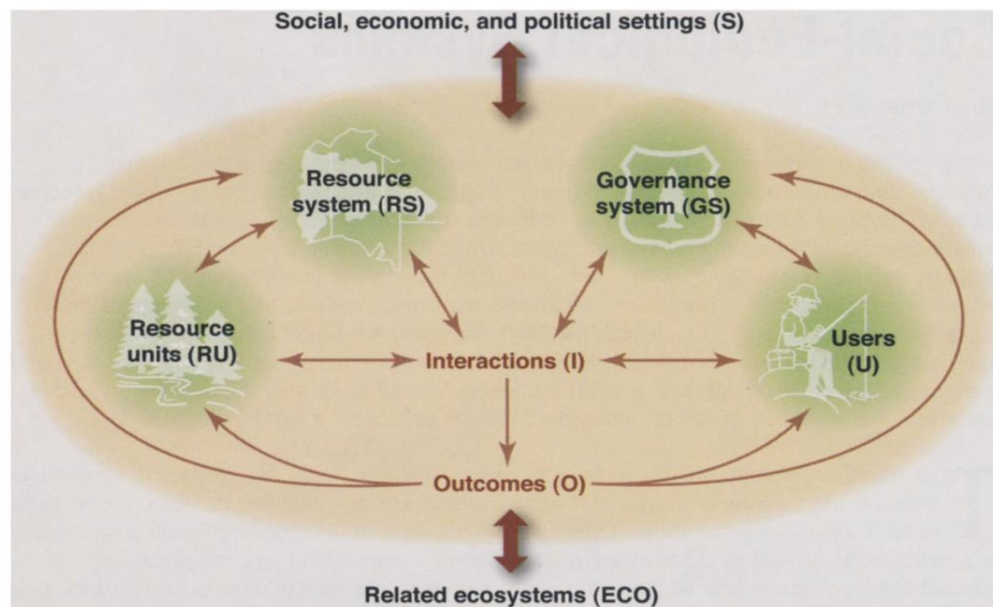
Figure 2.3. Screenshot of Figure 1, Ostrom, E. (2009). The core subsystem is a framework for analyzing social-ecological systems *Source:* Ostrom, E. (2009). A General Framework for Analyzing Sustainability of Social-Ecological Systems. Science, 325(5939), Article 5939. JSTOR.)

2.3.4.4. Operationalization

The SESF framework has been applied in a multitude of contexts across natural resource systems to assess the overarching sustainability of the current management structure. This framework has also been incorporated into management plans in a fisheries (Botto-Barrios et al., 2020; Basurto et al., 2013; Kittinger et al., 2013), forestry (Copes-Gerbiz et al., 2021), and land use context (Fabinyi et al., 2014). In each of these contexts, researchers drew on diverse forms of data (both qualitative and quantitative) (Copes-Gerbitz et al., 2021; Sharma et al., 2016), often presented findings to local governance officials (MacGregor et al., 2022; Delgado-Serrano and

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Ramos, 2015; Klain et al., 2014) and developed an overarching model of the system based on definitions outlined in Ostrom, 2009.

For example, SESF has been applied in Santiago de Camltepec, in Oaxaca, Mexico, in Bajo Calima and Alto y Medio Dagua in Chocó, Columbia, and in Bahia Blanca estuary in Argentina, as described by Delgado-Serrano and Ramos (2015). This publication reviewed the application of SESF in each area, highlighting the complicated nature of identifying different variables that have a shared meaning across the different contexts. Within this publication, 53 second-tier variables were identified as having joint meaning across contexts. Each variable was discussed among a group of natural and social scientists of mixed disciplines. A broader research group was also created for each case, this included "researchers from different disciplines and the so-called-co-researchers (local people involved in the research," (p. 812). After the initial team research team was formed, the groups went through methodological trainings in SESF with specific attention to how variables could be understood across disciplines. Afterwards, participatory workshops were conducted, along with interviews to create variables' definitions with local stakeholders. After iterative discussions between research groups around identified variables, and iterative coding and other analysis, a final list of variables was shared. The authors highlighted that there is difficulty in operationalizing the SESF in a place-based research context, particularly as it does allow for the combination of local and scientific knowledge but creates multiple difficulties in defining variables across contexts. However, the authors also highlighted that the iterative process of discussion across stakeholders and researchers created new joint understandings around future planning within a community-based management. In terms of Indigenous leadership, no mention was made of the diversity of stakeholders engaged throughout the research process, or if Indigenous leaders were centered within the research process.

Commonly, the language used refers to "local knowledge" which could be a mix of local and IK across the communities engaged with but does not center Indigenous worldviews or identified any specific "co-researchers" as Indigenous. At the same time, multiple communities within the study were identified as Indigenous. This includes Chinantec Indigenous community in Oaxaca, with multiple unique practices in terms of forest management (Delgado and Ramos, 2015).

This shows one example of how SESF is commonly applied in different resource management contexts, and how often Indigenous communities are described or involved within the research process (Sharma et al., 2016; Delgado and Ramos, 2015; Leslie et al., 2015; Basurto et al., 2013). There are two examples of more equitable inclusion of Indigenous leadership and paradigms within the research process coupled with the implementation of SESF (Copes-Gerbitz et al., 2021; Klain et al., 2014). In these examples, additional participatory methods are used to include Indigenous voices throughout the research process (Copes-Gerbitz, et al., 2021) and diverse histories are included in social analyses (Klain et al., 2014). However, most operationalization articles gathered were more reflective of Delgado and Ramos (2015) example, where Indigenous people were research participants, but not collaborators.

2.4. Discussion

As described above, all four cases incorporate different approaches to collaboration, data gathering and ownership, knowledge weaving, and have different overarching research goals. In the following sections, I first respond to the key evaluative questions presented earlier by examining how collaboration and multi-knowledge is contextualized within each case and describing how each case characterizes Indigenous leadership and data ownership. Second, I draw additional connections between cases by exploring their development of language within

each framework and offer how I as a graduate student consider using frameworks together within my research context.

2.4.1. Collaborations and Multi-Knowledge Frameworks

Sustainability science, environmental science, and conservation science literature highlight that solving complex and multifaceted issues requires multiple individuals with diverse knowledges to collaborate and create spaces for new solutions to emerge (Hart & Silka, 2020; Domik & Fischer, 2010). One strategy to solve complex issues facing communities today is collaborative science, or science that engages across institutions and disciplines to solve issues (Rozance et al., 2020; Hart & Silka, 2020; Hara, et al., 2003). Each of the frameworks have been applied during collaborative research efforts. However, the overarching goal of collaborative spaces differs. Both IADF and SESF incorporate diverse data sets from qualitative and quantitative research methodologies to create models of complex systems. This centers collaboration as a tool to bring together different disciplines to measure or describe variables. This methodology can cultivate new applied solutions (Rozance et al., 2020; Hart & Silka, 2020). IADF and SESF also highlight the importance of shared language across scale, where definitions are incredible rigid, and therefore seen as comparable across contexts (MacGregor et al., 2022; Brisbois et al., 2019). This allows for multiple studies to feed into a broader model of the system. However, this also means that collaboration within a research effort is not necessarily required. For example, within the SESF application in Deglado-Serrano (2015), variables were compared across three relatively separate case studies, within which, individual scientists assumed specific roles regarding specific types of data. Once again, the primary goal of SESF is to collect and articulate information from a variety of sources, so that a researcher can begin to answer broader questions of the entire system. In that case, Indigenous perspectives would get

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reconstituted into this broader view, therefore losing cultural or social significance. This is similar and dissimilar to the E/TES framework. Both prioritize gathering from multiple sources. But E/TES states no one person can see with both eyes at the same time, while SESF makes no similar stipulation. This process of generalization or shared language is helpful to formalized government institutions, who often support and fund these research projects, and who create policy based on recommendations from these efforts (Brisbois et al., 2019; Ouedraogo and Mundler, 2018; Andersson, 2006). For example, in Ouedraogo and Mundler (2018), recommendations on conflict resolution in mining communities were eventually adopted by different companies and communities within Burkina Faso, West Africa.

In terms of HWT/DC and E/TES, these frameworks center diverse knowledges, where collaborative spaces are often cross-cultural, and both IEK and SK are woven together in different contexts. This creates more nuanced research with diverse data sets, but more specifically opportunities for knowledge weaving (Bingham et al., 2021; Reid et al., 2021; Maxwell et al., 2020; Abu et al., 2020). These frameworks also prioritize relational work, a foundational piece for long lasting collaborations, which decenters the researcher and instead prioritizes a group of diverse decision-makers who shape the research process (Harcourt et al., 2022; Moorman et al., 2021; Forbes et al., 2020; Wright et al., 2019; Held, 2019; Rowan et al., 2015). For example in the case of the Aboriginal Children's Hurt & Healing Initiative, new projects have emerged out of this work including developing a documentary to share findings from this work titled "Shift Ground through Art: Safe Approaches to Share & Manage Pain" http://youtu.be/C8Mb_9TNcM, and a new mobile app focused on creating new ways youth can convey emotional or physical pain (Syliboy et al., 2021). These follow-up projects involved

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researchers from the initial effort in different roles, highlighting the importance of relational work embedded in both HWT/DC and E/TES frameworks.

The trend of incorporating diverse worldviews outside of western scientific methods is **not seen commonly in either the IADF or SESF applications**. This is vitally important to consider as we move forward as a scientific community, where Indigenous voices that have long been excluded are now being recognized as incredibly important and powerful in the context of complex issues such as climate change, rural poverty, and commons management (Reed et al., 2022; Fleischman et al., 2020; Ogar et al., 2020; Burkhart, 2019; McGregor, 2004; Nadasdy, 2003). For example, Nadasdy draws connections between mismanagement of Dall sheep in the Ruby Range in Yukon and a focus on "incorporating" Kluane First Nation participation rather a focus on weaving diverse knowledge understandings together into an applied management scheme that reflects multiple perspectives, resulting in further exclusion for Indigenous peoples despite being cited as "success" of co-management (2003). This speaks to a trend where theoretical framework and methodological choices may result in exclusionary practices to support capitalistic economic structures derived from colonial thought (Sou, 2022; Bernauer, 2022; Mauer, 2021; Tuck and Yang, 2012). For example, in the Peruvian anchoveta fishery, the Tragedy of the Commons was used as a need for external state-run regulation to facilitate long-term sustainability, and profits. When local artisanal fishers disrupted this formalized governance in places like the port of Ancón through activism, "capital simply moved to other places where it is easier to enact the displacements necessary for new development," (Viatori and Bombiella, 2019 p. 109).

2.4.2. Indigenous Leadership and Data Ownership

Each of these frameworks have been applied within research contexts that include and impact Indigenous communities. However, within the application process, Indigenous leadership varies and data ownership. There are examples of SESF using additional techniques to center collaboration and more equitably design research (Copes-Gerbitz et al., 2021; Klain, 2014). For example, in Copes-Gerbitz et al., researchers focused on a "collaborative experiment research design" that incorporated many of the ideals from E/TES and HWT/DC, including working with T'exelc Elders and community members to identifying protocols of data collection and data ownership (2021). This application had presence of Indigenous leaders and community members throughout the research process and identified community practices that impacted the methodology of the research itself. However, within other applications of IADF and SESF frameworks Indigenous communities often remain "participants" if identified at all (Ouedraogo & Mundler, 2018; Teitelbaum et al., 2017; Sharma et al., 2016; Nabavi & Daniell, 2016; Klain et al., 2014). For example, the Ouedrapgo and Mundler (2018) study, identified Indigenous groups as respondents, but no mention was made of inclusion of Indigenous leaders within the research planning, data gathering, or data dissemination process.

HWT/DC and E/TES applications implicitly include Indigenous worldviews and voices within research contexts. Within each of the application-oriented articles Indigenous leaders were identified and included within the research process, primarily determining research protocols, data ownership procedures, and creating questions relevant to their communities (Harcourt et al., 2022; Moorman et al., 2021; Forbes et al., 2020; Abu et al., 2020; Reid, 2020; Kutz & Tomaselli, 2019; Wright et al., 2019; Hall et al., 2015; Rowan et al., 2015). In addition, within these applications, Indigenous language is present, either from the frameworks

themselves, or from Indigenous participants as well as SK, including qualitative and quantitative research (Bingham et al., 2021; Reid, 2020; Maxwell et al., 2020; Marsh et al., 2015; Rata, 2012). Based on this presence alone, we can conclude that HWT/DC and E/TES create a more inclusive space for IEK and SK to be weaved together rather than one incorporated into another, resulting in relevant solutions for Indigenous and non-Indigenous communities (Moorman et al., 2021; Kutz and Tomaselli, 2019).

By including Indigenous leaders and community members throughout the research process it is more likely results from that research effort will support Indigenous sovereignty. This means that considerations around the foundation for that research effort are vital to create, maintain, and promote inclusive spaces for knowledge weaving across cultures. As highlighted by the disparity in Indigenous leader presence within application articles of SESF and IADF either as authors or in the writing. These frameworks do not consistently include Indigenous worldviews or voices, as opposed to HWT/DC and E/TES which consistently do include Indigenous voices, and often create new protocols around data ownership and data dissemination. This allows for Indigenous community members to control their own data, promoting Indigenous sovereignty and pushing back against colonial ideologies of the scientific method.

2.4.3. Generalization vs. Transformation

Each of the key evaluative questions describe aspects of relationality. Specifically, they focus on aspects of Indigenous leadership, data ownership, and presence of diverse worldviews as a way of considering each of these frameworks and their perceived use in anticolonial research. However, there are other relational aspects that emerged throughout the analysis. In this section I

describe how language created by each framework is an important feature that should be recognized in this discussion.

Both IADF and SESF focus on creating a shared language that can be used across disciplines and is independently defined. This reinforces a focus on generalization, where data is immediately separated and organized within model definitions to feed into broader conversations (Watkins & Westphal, 2016; Partelow, 2016; McGinnis & Ostrom, 2014; McGinnis, 2011; Blomquist & deLeon, 2011; Ostrom, 2011; Ostrom, 2009). This generalization allows models to permeate across discipline-based conversations and makes findings from projects using IADF or SESF more recognizable to current governmental structures. This is important, as common goals within these research projects are to create new policy recommendations based on formalized policy structures and model variables (Partelow et al., 2021; Botto-Barrios & Saavedra-Díaz, 2020; Ovitz et al., 2019; Aguilera, 2018). This generalization is also important as multiple disciplines are inherently drawn upon to determine different variables and subsystems. As stated previously, the IADF is generally used to explain and predict outcomes of social behaviors by exploring and documenting governance structures (Sarr et al., 2021; Grossman, 2019; Ostrom, 2009). Ostrom and others offer variables that follow a system-wide view, explaining individual behavior by rules in place formally and informally, involvement of other events, and how individuals or communities are impacted (Sarr et al., 2021; Brisbois et al., 2019; Morrison and Hardy, 2014). The IADF also creates opportunities for shared language across multiple disciplines to better understand broad patterns within institutions. As described by Ostrom (1982), "…if every social science discipline or subdiscipline uses a different language for key terms and focuses on different levels of explanation as the "proper" way to understand behavior and outcomes, one can understand why discourse may resemble a Tower of Babel rather than a

cumulative body of knowledge…" (p.11). This challenge of creating a shared language was contextualized in ongoing research to understand sustainable governmental regulation practices, which were being studied from a variety of viewpoints within diverse scientific fields (Ostrom, 1982).

However, this generalization removes place-based knowledge and influences. Both E/TES and HWT/DC focus instead on resolving governance issues, situated within a specific context where multiple worldviews can come together in facilitated and planned spaces to share and weave information and knowledges (Reid et al., 2021; LeHeron et al., 2020; Maxwell et al., 2020; Martin et al., 2017). These projects often lead to transformative changes, where they create new governmental structures or committees to follow research into action rather than broad assessments (Reid et al., 2021; Kutz & Tomaselli, 2019).

In addition, this generalized language supported by the prevalent use of SESF and IADF may inadvertently lead to new emergent forms of cognitive imperialism. Cognitive imperialism as described by Dr. Battiste is a form of colonization that maintains the superiority of a single form of thought or language while denying access to diverse forms of knowledge (Battiste 2000, Battiste 2005). This concept is structurally embedded in academic institutions. This is seen historically through the targeted and violent forced assimilation of Indigenous peoples through religious schools (Battiste, 2005; Held, 2019). In contrast collaborations that center multiple forms of knowledge, and multiple ways of pursuing, gathering, or teaching that knowledge combat this trend, by creating collaborative spaces where different ideas can be shared (Battiste 2005, Mackinlay & Barney, 2014). Such collaborations are universally evident when E/TES and HWT/DC frameworks are used.

2.4.4. Looking Back to Think Forward- Do They Work Together?[25]

As a graduate student working in the wild clam fishery on Wabanaki homelands, considering these multiple frameworks initially drew me back to the question of, "What is the purpose of a framework?". As described briefly above, a framework shapes research goals, research questions, and the overarching process for seeking knowledge. With this idea in mind, I would conduct my dissertation differently with more exposure to these frameworks at an earlier time. In this section I describe how I would have approached a research question based on my current experience with emergent conversations in the fishery, namely, "How can we create and support Wabanaki participation in governance for the wild clam fishery?".

I should state that I did not get to this reflective practice alone.[26] Instead, this question was built based on the relations I have developed throughout my doctoral program and beyond. To start in my Masters program, I first learned how local knowledge held by clam harvesters was being excluded from decision making spaces and the predominant scientific process. I disrupted this practice by using engaged research methods. However, with further education, conversation, and experience, it became increasingly obvious that the questions and concerns harvesters were having were based on governance structures that have colonial origins, and as such were designed to exclude diverse knowledge systems. In this area, Wabanaki people were the first to experience this structural exclusion. Coming from the privilege of learning this, I feel it is (and was) my responsibility to attune to Wabanaki perspectives and support ongoing efforts that recognize Wabanaki sovereignty. Considering the restrictions developed by my education to that point, as well as the COVID-19 pandemic, I did not explore these relations fully. Revisiting and

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[25] This section was inspired by conversations with my committee member Jessica Jansujwicz, where she asked, "How, if at all, would I put any of the frameworks together?" Thank you Jessica!

[26] This entire paragraph is inspired by a conversation (had over email and through comments) that I had with my advisor Anthony Sutton, who encouraged me to consider how I started on this path that resulted in this overall chapter, and what relations I drew from to develop that critical lens. Thank you Tony!

reflecting beyond that context, I would have done my research differently. Most especially I want to reiterate this reflection and consideration would not be possible without the relationships I was able to form with mentors such as Anthony Sutton, Bridie McGreavy, Jan Paul, Darren Ranco, and many others.

Given that context, in this hypothetical project, I would have started with working with Indigenous and non-Indigenous leaders in the fishery, including members of my own research community such as Tony Sutton, Bridie McGreavy, Darren Ranco, Chris Johnson, Jan Paul, and others who have worked and been present in Wabanaki spaces, to determine if and how my skills/efforts should be applied in this context. Based on recent conversations at the Shellfish Management Sessions[27], as well as a recent report on Wabanaki fish practices and access published by the Maine Indian Tribal State Commission (2022)[28], one emergent question could be, "How can we develop a Wabanaki shellfish license or licensing system that supports Wabanaki access to shellfish areas?" With that question in mind, I might suggest the HWT/DC framework to first, decenter researchers, and second, cultivate conversation spaces for equitable sharing and discussion of diverse knowledge systems. After kinship years, where best practices, cultural norms, and relationships were built, a decision-making body may form in charge of the project, or as a subcommittee within the Maine Indian Tribal State Commission (MITSC). As a researcher with facilitation and relational work skills, my responsibility could include facilitating and planning meetings, taking notes, and sharing these with and for the decision-making body. I may also use qualitative research methods to speak with (both formally and informally) Indigenous and non-Indigenous actors within this group about the different ways access to the

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[27] Shellfish Management Sessions were a series of meetings convened during 2022 by the Department of Marine Resources to assess the wild shellfish co-management governance system, share information with municipal leaders, and understand any emergent issues municipalities were facing.

[28] Maine Indian Tribal-State Commission Special Report, "Sea Run, A Study Regarding the Impact of Maine Policies on the Quality and Quantity of Traditional Tribal Fish Stocks and Sustenance Practices." December, 2022

shellfish fishery would be reshaped by the presence of a new Wabanaki license. With expertise in policy analysis, I may also start a side project of reviewing similar licenses or license systems developed in other fisheries or in other states to better understand who may need to be in the room and what specific policy needs are required. Additionally, I could connect with ongoing efforts such as a recent Harvard study that determines the economic impact ongoing colonial governance policies have on the Wabanaki people, including their access to fisheries or other economic opportunities (Kalt et al., 2022). In this policy analysis section (if approved by the broader decision-making body developed through HWT/DC) I may apply the IADF to identify who was making decisions related to Indigenous fishing licenses, and when, where, how, and what the outcome of policy documents or legislation was for Indigenous livelihoods and the fishery. This information could then be brought back to the decision-making body as a resource while developing the HWT/DC model. This model could be used as a boundary-spanning tool in a cross-cultural space between Wabanaki and non-Wabanaki managers to identify different ways the State of Maine and Wabanaki governance systems could share information, facilitate communication, and cultivate formal and informal structures that support equitable access to the shellfish fishery.

As described above, I believe these frameworks can work in tandem with each other, however, for truly equitable and anticolonial research and for broader knowledge sharing, Indigenous frameworks need to be positioned as a starting point and guiding structure for research. In my work, this would mean centering HWT/DC, E/TES, or others as the initial plan for collaborative and engaged research planning across Indigenous and non-Indigenous contexts. Within these Indigenous structures, other frameworks may be applied to facets of the research, but findings from those applications should only be used as one among many resources for

further decision-making. This system is also more reflective of the graduate research process, where a non-Indigenous student may be incorporated into an ongoing research process that includes building relationships, learning cultural norms, and considerations of Indigenous questions, and still may be able to complete a targeted research goal for the overarching group.

2.5. Recommendations

On an institutional scale, undergraduate and graduate level programs across all disciplines, but particularly in fisheries science, marine science, conservation science, and ecology should reevaluate curriculums for inclusivity of Indigenous voices and thought. Both the HWT/DC and E/TES frameworks can create more equitable collaboration and knowledge weaving between Indigenous and non-Indigenous scientists. However, neither of these frameworks can be taught or operationalized solely from a non-Indigenous perspective. This means that current western science curriculums should work to become more open, either fostering and supporting programs such as the Wabanaki Youth in Science (WaYs) program at the University of Maine[29], acting and standing with Indigenous educators, and broadening the reading curriculum for undergraduate and graduate students to include Indigenous scholars and voices (carr et al., 2017). This should also include programs that provide for Indigenous communities, for example, supporting Indigenous youth's entry into university spaces by providing tuition, or supporting the adoption and permanence of Indigenous-led degree programs or courses. For example, in conservation science, creating courses that dig into the origins of conservation science, why "conservation" is needed, and how the exclusion of Indigenous leadership created that need.

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[29] This is a program at the University of Maine to support Wabanaki students through peer mentorship and paid internships. More information can be found at https://umaine.edu/nativeamericanprograms/ways-internships/

As individual non-Indigenous scientists, I would recommend starting by reading, listening, and observing different ways in which Indigenous voices can/should impact ongoing efforts within our perspective fields. I have developed some scientific literature and books as resources (Appendix 1). In addition, non-Indigenous scientists could review the broader ontological and epistemological assumptions of western science-based frameworks and comparing that to Indigenous scholarship to identify if they align. Alternatively, I encourage non-Indigenous scientists to seek out Indigenous literature and share with fellow non-Indigenous scientists to discuss these issues and work on cultivating unique and place-based solutions. Beyond this, researchers that are currently working with Indigenous communities should work to create space for Indigenous leadership from that community and supporting changes that result in a broader collaborative space. This also may mean giving up ownership of data or creating new criteria for co-authorship, where Indigenous and non-Indigenous community members can influence research including the writing and dissemination of results.

2.6. Conclusions

The frameworks analyzed above have one important commonality. Each framework was initially designed to incorporate broader voices within a research and decision-making context. The SESF and IADF frameworks focus on including community voices, particularly those that are not commonly heard within a decision-making context and focused on using participatory methods to gather diverse forms of information. However, they still fall short in terms of engaging with Indigenous communities in an equitable manner. In this sense, E/TES and HWT/DC serve as examples of frameworks that weave IK and SK together to make more holistic representations of complex systems. As systems face environmental and social shifts, it

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is paramount to critically consider how frameworks shape the inclusivity of Indigenous voices,

knowledge systems, and leaders and what this means for the future.

CHAPTER 3

PROMOTING JUST AND ADAPTIVE FISHERIES GOVERNANCE: A CASE STUDY OF LEARNING NETWORKS AS AN ANTICOLONIAL GOVERNANCE STRATEGY

3.1. Introduction

Small-scale fisheries connect and are shaped by cultures, histories, economies, and forms of governance. These fisheries face complex issues based on social-ecological factors that span across institutions and contexts (Jentoft & Cheunpagdee, 2009). In many places, small-scale fisheries are demonstrating signs of decline that are due, in part, to inabilities to adapt to social ecological changes in ways that would sustain and transform these fisheries into the future (Folke et al., 2010). Colonialism can impede adaptive governance thereby reducing opportunities for future community resilience (Sou, 2022; Mauer, 2021; Chandler and Reid, 2019; Bell et al., 2019). For example, intertidal shellfish fisheries in Nunavut lands have experienced ecological degradation and do not receive the financial and political support they need, owing to colonial power structures at the federal level which hinder adaptation and transformation at a community level (Bernauer, 2022). In contexts like these, resilience studies have highlighted the interplay between adaptive capacities, adaptive and anticolonial governance, and social-ecological systems (SES) resilience (Sou, 2022; Mauer, 2021).

Adaptive capacities refer to communication-based interactions that facilitate social processes like information sharing, learning, leadership, and anticipating and planning for future changes. Though adaptive capacities and governance are mutually influencing, Olsson et al. (2004) describe how strengthening adaptive capacities can help prepare actors for windows of opportunity that allow for more adaptive governance to emerge. Additionally, Sou (2022) describes how colonialism can hinder this process, and where community-level actions related to

adaptive capacity can constitute a resistance to colonial governance structures. Thus, focusing on strengthening adaptive capacities can be an important step to prepare for policy and governance changes and as part of processes to foster anticolonial governance strategies. By adaptive governance we mean the informal and formal institutional arrangements, relationships, and actors that facilitate strategies that respond to variability and changes within complex systems (Chaffin et al., 2014). Despite the potential influence of adaptive capacities and governance for SES resilience, these strategies often remain localized within communities, without expanding or scaling up to coordinated statewide efforts. This is particularly challenging in small-scale fisheries contexts that are shaped by complex and proximally distant geographies (Chaffin et al., 2014) and oppressive power relations, such as colonialism, Indigenous land dispossession, and wealth inequality (Mauer, 2021) where there are multiple intersecting barriers to the formation of adaptive governance.

The soft-shell clam (essok, *Mya arenaria*) fishery within Maine (U.S.A.) and Wabanaki homelands is a small-scale fishery grappling with intersecting forces related to climate change, wealth inequalities, rural poverty, and colonialism. Sustaining these fisheries is significant for numerous reasons. As the presence of the more than 2,000 shell mounds along the coast attest, wild shellfish have supported coastal livelihoods for millennia (Reeder-Myers et al., 2022). Further, the soft-shell clam fishery is the third largest in the state in terms of economic value ($17 million in 2022) and employs more than 1,500 commercial shellfish harvesters. This fishery is governed through a complex co-management approach established in the 1960s. Within the shellfish co-management system, municipalities work in coordination with Department of Marine Resources (DMR) to develop municipal ordinances that specify shellfish management strategies, such as licensing, enforcement, stock assessments, conservation activities, and then

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collaborate with DMR to implement these strategies (Hanna, 2000). Co-management arrangements like this can facilitate adaptive capacities and governance (Armitage et al., 2009; Berkes, 2009). For example, in Uruguay co-management of the yellow clam (*Mesodesma mactroides*) helped promote an increase in clam abundance and unit price is perceived as more stable through time (Defeo et al., 2016). However, these successes in co-management rely on partnerships that are based in equitable and inclusive relationship (Trimble et al., 2014; Berkes, 2009; Nadasdy et al., 2003) and where material resources and infrastructures support a functioning co-management approach (Defeo et al., 2016; Pomeroy, 1995). The situation in Maine's shellfish co-management system is mixed in terms of these considerations. Maine's shellfish co-management approach helps create structures that likely would not otherwise exist, including municipal shellfish committees. When, for example, green crab (*Carcinus maenas*) populations exploded in 2013, shellfish communities were influential in coordinating municipal and state-level responses to this event (McClenachan et al., 2015). In contrast, there are structural inequities that limit adaptation, including the relative standing of shellfish committees within their towns, between DMR and towns, as well as between DMR, towns and Wabanaki Tribal Nations, namely the Mi'kmaq, Maliseet, Passamaquoddy, and Penobscot (McGreavy et al., 2018; McGreavy, Ranco et al., 2021). It should be stated that Wabanaki tribal nations also include Abenaki people, who do not have an institutional mechanism for participating in co-management or interfacing with DMR.

Colonialism is a complex set of structures and processes that recur across time and place (Wolfe, 1999, Tucker, 2018; Kauanui, 2016; Quijano, 2007, Taiwo, 1993). As Quijano (2007) notes, "In the beginning colonialism was a product of systematic repression…The repression fell, above all, over the modes of knowing, of producing knowledge, of producing perspectives,

images and systems of images, symbols, modes of signification, over the resources…" (p. 169). Tucker (2018) expands on this point stating that the "patterns of repression, expropriation, and imposition of knowledge established in the colonial period" have continued, shaping current international negotiations, including resource management and knowledge systems (p. 219). Some of these recurrent structures and patterns include racialized logics of categorization, division, and domination of peoples and knowledges (TallBear, 2013); the formation of property and disruption of Indigenous land and water relations (Goeman, 2013; Pawling, 2016); assumed rights to access, use, and pollute "natural resources" (Liboiron, 2021; Tucker, 2018), and how these logics are continuously reinforced through treaty negotiations that (re)center the settler state (Coulthard, 2014).

Introducing the much longer and complex history of colonization in the place now called Maine is beyond the scope of this paper. However, there are important legal structures and policy processes that constitute both municipal and state governance and the municipal shellfish co-management regime that are relevant for the anticolonial approach we intend to take. Identifying and tracing these interconnections was essential for beginning to understand how colonization occurred within Wabanaki homelands and what, then, an anticolonial approach to fisheries governance would require. One of the most significant legal documents was the 1641 Body of Liberties associated with the Massachusetts Bay Colony ordinance. This document created a legal structure that continues to serve as the foundation for the State of Maine's municipal shellfish management system and the guiding legal principle of "home rule," which allows for municipal oversight on all matters not delegated to the state (Maine State Constitution Article VIII, section 1). Additionally, the 1641 Body of Liberties attributed rights to access intertidal mudflats for fishing, fowling, and navigation to white, male, landowning colonists. These rights

have been codified and reaffirmed by modern Maine court processes. Residency requirements for shellfish licenses reflect these rights and reaffirmations. Residency requirements are set by municipal governments, include residing and paying taxes within a specific municipality through which, Wabanaki peoples, unless they live in a town, are defines as "non-residents" who must apply for a limited number of more costly non-resident licenses. Gentrification along the coast is now pushing settler communities to reconsider their definition of residency, as harvesters may not be able to afford housing within municipal justifications. This is one example among many possible that intends to give an initial sense that there are complex histories and relationships between colonialism and state-based co-management systems. Further, as both Murphy (2017) and Liboiron (2021) argue, colonial structures and processes that negatively affect Indigenous peoples, such as within state-based fisheries governance, create mutual and different inequities for other groups of people who participate in these same spaces, and thus anticolonial approaches can help address multiple, interconnected injustices that stem from colonialism.

In this paper, we share insights from an engaged communication research project to develop an anticolonial approach to the formation of the Maine Shellfish Learning Network (MSLN), a network whose collaboratively-defined mission focuses on supporting learning, leadership, and equity in Wabanaki and Maine wild clam fisheries. In this paper we draw from interdisciplinary literature in resilience studies, communication studies, sustainability science and Wabanaki and Native American and Indigenous Studies (W-NAIS) (Figure 3.1). This work is situated within a sustainability science and knowledge co-production approach, so we begin by introducing core commitments to research design within these methodologies. We then briefly connect with perspectives in communication studies to create a framework for learning network design choices that intend to promote adaptive capacities and the formation of anti-colonial

governance approaches. We define our research question and methodology and share insights from our qualitative analysis, focusing on communication processes and practices that shaped the MSLN, how communication influenced the formation of adaptive capacities, and evidence for the emergence of adaptive and anticolonial governance approaches associated with learning network efforts. We conclude by identifying tensions, challenges, and future considerations related to how learning networks can contribute to adaptive, just, and anticolonial approaches to fisheries governance.
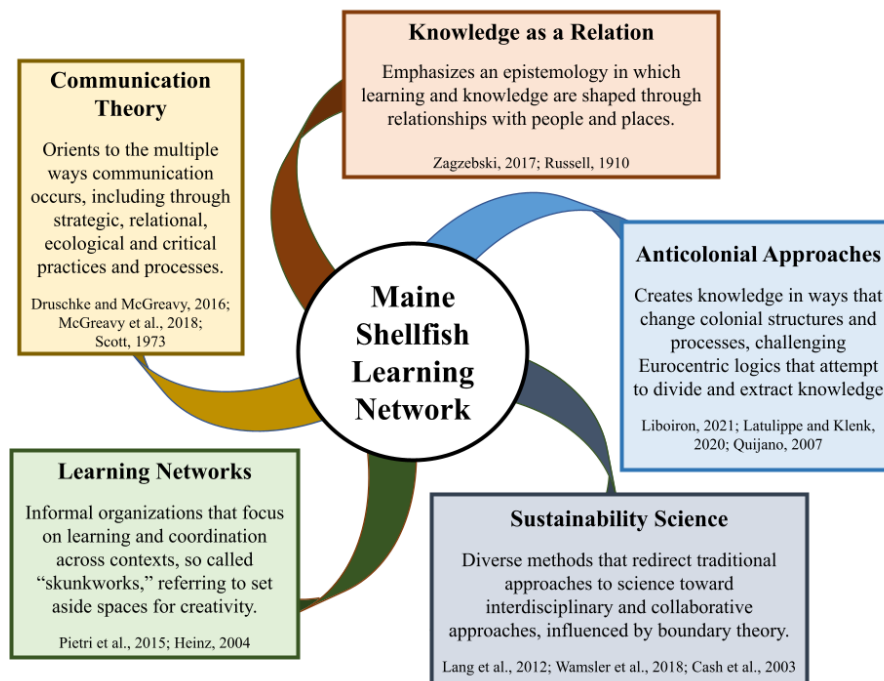
Figure 3.1: Theoretical Framework. This figure represents the dynamic nature in which we draw on different literatures, where each is connected, and often combining or bounding off each other before settling towards center.

3.1.1. Knowledge, Power, and Sustainability science

As a global project, knowledge has long been produced in ways that create and reinforce intersecting forms of oppression, including colonialism (Liboiron, 2021; Smith, 2012; Yusoff, 2014; Quijano, 2007). As Quijano (2007) argues, "the European paradigm of rational knowledge,

was not only elaborated in the context of, but as part of, a power structure that involved the European colonial domination over the rest of the world," (p. 174). Further this colonial process impeded communication of knowledge where the paradigm of rationality limited, "every relation of communication, of interchange of knowledge, and of modes of producing knowledge between the cultures, since the paradigm implies that between 'subject' and 'object' there can be but a relation of externality," (Quijano, 2007, p. 174). Following a rational paradigm, knowledge is categorized as traditional, local, scientific, or other, which reinforces European rational logics, where individuals are separate from their knowledges (Quijano, 2007; Olsson & Folke, 2001). These logics serve as a colonial foundation for extractive modes of relation, including in the context of Land relations (Liboiron, 2021), scientific methodologies (Smith, 2012); and governance (Sou, 2021). Defining knowledge in this manner also created silos between different orientations to knowledge creation, as well as ways to define and exclude different forms of knowledge from governance (Cooke et al., 2021; Kirmayer et al., 2012; Star & Griesemer, 1989).

Thus, changing the ways in which knowledge is created or co-created is a crucial commitment for disrupting colonial structures and processes. Research within sustainability science has increasingly been identifying commitments that constitute more relational and potentially anticolonial approaches to knowledge, including knowledge co-production and related approaches to shape research in ways that promote justice and anticolonial governance (Chapman & Schott, 2020; Johnson et al., 2016; McGreavy, Ranco et al., 2021; Sze, 2018; Tengö et al., 2014). Sustainability science pushes against siloed structures of knowledge by using strategies such as the use of boundary objects (Wilson & Herndl, 2007; Star & Grisemer, 1989), engaged research (McGreavy et al., 2018), and member checking (Cash et al., 2002) which allow

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for shared learning and promote relationality across different orientations to knowledge (Cooke et al., 2021; Kirmayer et al., 2012;). Additional core considerations within sustainability science that challenge dominant assumptions and practices include: (1) designing research questions to align with collaborator interests (Ostrom et al., 2007); (2) trying to avoid creating burdens on collaborators and practicing mindfulness (Lang et al., 2012; Wamsler et al., 2018); (3) meeting regularly with collaborators to discuss research and make adjustments (Cash et al., 2002); (4) co-producing knowledge and combining diverse expertise (Brandt et al., 2013; Lang et al., 2012), and; (5) promoting equity within the collaboration (Wamsler et al., 2018). Each of these commitments also highlight the need to critically attend to power dynamics within the research process (Lang et al., 2012). We tailor these commitments to acknowledge that our research occurs within Wabanaki homelands, and frequently also with/in the Penobscot River. As we describe in related research, in this context we identify the crucial importance of centering Wabanaki values of listening and dialogue; attending to ecological influences on meaning making, including how we understand time; and connecting with Wabanaki and Indigenous students and partners as researchers and leaders (McGreavy, Ranco, et al., 2021).

Colonialism continues to influence how power and knowledge intersect, in part through the ongoing structural inheritance of rationality, objectivity, and categorizations of knowledge into discrete disciplines and units. These histories and structures create a need to develop methodologies that change how knowledge feeds into and sustains colonialism. Methodologies that emphasize communication and relationality, and in particular knowledge co-production, between multiple knowledge systems can serve as a starting point to change dominant and exclusionary patterns (Chapman and Schott, 2020). In this way, focusing on communication in

the context of learning networks offers a more relational, and potentially anticolonial, path forward for knowledge.

3.1.2. Learning Networks and Communication: Processes and practices for relationships, critical thinking, and anticolonial governance

Learning networks have emerged as a powerful strategy for preparing actors for more adaptive forms of governance, and their focus on communication and power also demonstrate potential to challenge myriad forms of oppression, including colonialism (Berkes, 2009; Ostrom et al., 2007). Learning networks come in diverse forms, all of which exhibit similar commitments to information sharing, learning, and collaborative approaches to knowledge making, (Pietri et al., 2015; Davidson-Hunt, 2006; Heinz, 2004). For example, the Fisheries Joint Management Committee facilitated learning processes between groups like the Tuktoyatuk Hunters and Trappers Committee, a group consisting of Inuvialuit community members and leaders, and governmental institutions such as the Department of Fisheries and Oceans Canada to create new solutions within the context of the Husky Lakes beluga entrapment issues (Kocho-Schellenberg & Berkes, 2015). This broader managerial learning network supported anticolonial and adaptive governance strategies including the exchange of ideas across multiple groups for collective solution building, and the recognition of Indigenous rights through the implementation of a co-management body between Indigenous and federal entities (Kocho-Schellenberg & Berkes, 2015). Drawing from this example and others, activities such as facilitated knowledge exchange and supported participation of diverse members led to reflexivity, cross-cultural communication, and collaboration (Kocho-Schellenberg & Berkes, 2015; Manring, 2007; Davidson-Hunt, 2006; Pietri et al., 2015).

But not all learning networks are created equally, and the values that come to circulate within a learning network are often connected to the original approach to its formation. Thus, the early choices about how networks form, who is involved, what the objectives are, how participants will communicate, and so forth matter for what the network becomes and the function it serves (Bessan and Tskouras, 2001). As Pahl-Wostl et al., (2009) learned in Tisza, Hungary, the bottom-up participatory approach to learning networks created new spaces for integrating diverse knowledges around flood mitigation. However, by centering charismatic individuals rather than values, the network's impact degraded over time (Pahl-Wostl et al., 2017). Thus, learning networks serve as an important strategy for intentionally building adaptive capacities and governance, and there remains a need to identify intentional design choices that support how learning networks influence anticolonial research and governance approaches.

Focusing on communication can help guide learning network design. Communication, network formation, and adaptive capacities are inherently connected, especially networked capacities that are particularly salient in small-scale fisheries and shellfish co-management such as information access, leadership, learning, and anticipatory capacities (McGreavy et al., 2018; Wilson et al., 2006). These capacities are all shaped by communication. For example, Nursey-Bray et al. (2018) found that when conducting interviews in South Australian fisheries, interviewees (who included harvesters and managers) connected diverse forms of communication with successful mutual learning and future planning across institutions in co-management arrangements. Patterns of communication within this fishery were conceived as a "precondition for adaptive capacity," (p.77). However, there remains a need to more fully consider what communication means and how these definitions relate to adaptive capacities. In our use, communication is a process and set of practices that shape how actors create meaning,

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connect and negotiate across differences, engage in coordinated action, and address power. We refer to these as strategic, relational, and ecological and critical considerations of communication's inherent multiplicity and briefly elaborate how each of these orientations relate to and help shape adaptive capacities (Druschke and McGreavy, 2016; Scott, 1973).

A strategic orientation to communication attends to the practical techniques that are used to share information and connect across many forms of difference, including practices like meeting design, and the tailored use of symbols. These strategies shape the formation of adaptive capacities most notably information access, which we define as the ability for actors to engage with, learn from, and contribute to data resources (Olsson, Folke & Berkes, 2004). For example, designing a meeting by using strategies that allow participants to review data in advance, ask questions about what the data show, and that use symbols in ways that make sense or the intended audience (for example, written in a language they understand, using colors in ways they can see) then these practices can strengthen information access.

A relational approach emphasizes the co-construction of and negotiation of meaning, and for us listening is a core process and practice that constitutes this approach (Ratcliffe, 1999). Listening fosters the emergence of diverse capacities, including two that have been identified as particularly influential in fisheries governance, namely learning and leadership (McGreavy et al., 2018). Learning describes how individuals or institutions encourage informed planning, action, and create spaces for shared learning from diverse voices (Gupta et al., 2010; Holling & Gunderson, 2002). Leadership includes how individuals or groups foster collaboration and action, and who engage in long-term visioning for future generations (Folke et al., 2005; Olsson, Folke & Hahn, 2004). Anticipatory capacities are the capacities related to future considerations

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and future planning for possible disturbances and often require collective decision-making (Kim et al., 2022; Tschakert and Diertrich, 2010).

Ecological approaches to communication pay attention to how environments continuously shape communication within a context. Ecological influences can include endless entities and processes, and in our context, we focus on the influence of policy infrastructures, the COVID-19 pandemic, intertidal ecosystems, and tidal cycles. In a more interdisciplinary vein, boundary theory has long recognized ecological influences on communication, where boundary objects participate in and create spaces for learning and knowledge co-productions (Star & Grisemer, 1989; Wilson & Herndl, 2007). Boundary objects take on a life of their own and can circulate in ways that help coordinate efforts across diverse actors and forms of knowledge (Wilson & Herndl, 2007). Finally, as a fourth consideration, a critical orientation to communication brings together the strategic, relational, and ecological orientation to pay attention to how communication connects with power (McGreavy and Hart, 2017; Sandler et al., 2007; Senecah, 2004). In this sense, power is not something that any actor or institutions holds over another. Instead, power is relational and felt in forms of resistance and negotiations across differences (Fassett and Nainby et al., 2017). Attention to power is especially important in co-management where differences in role contribute to negotiations that reproduce differences in power. This is a crucial focus in contexts where historic and ongoing injustices, such as those related to rural poverty and Indigenous land dispossession, contribute to power-based inequities. A multi-dimensional approach to communication also challenges colonial orientations to communication and knowledge. Assumptions about linear flows of information, including the assumed rationality and objectivity associated with Eurocentric logics, are interrupted, allowing

for conceptions of information sharing that include cyclical and other rhythmic patterns that are shaped in relation with the environments in which our work takes place.

In sum, sustainability science and knowledge co-production approaches offer opportunity for changing colonial patterns in knowledge. But there remains a need to identify strategies for linking these anticolonial commitments to knowledge with structural and procedural changes in fisheries governance. The design of learning networks that draw insights from communication studies and boundary theory may provide strategies for connecting anticolonial approaches to knowledge with changes in governance.

Our primary research question thus asks: How can learning networks foster anticolonial approaches to fisheries governance? Further we identified three related sub-questions (SQ):

SQ1: Within a sustainability science methodology, how can communication processes and practices shape learning network formation;

SQ2: To what extent and in what ways can a learning network promote adaptive capacities, specifically information sharing, leadership, anticipatory capacities, and learning;

SQ3: How do these capacities relate to the emergence of anticolonial approaches to fisheries governance?

We address these sub-questions in the analysis and return to the overarching research question to identify broader insights about learning networks as an anticolonial approach to fisheries governance in the concluding section.

3.2. Engaged Methodology

To address the above research questions, we used an engaged approach to sustainability science that also intends to uphold anticolonial commitments to knowledge co-production (Liboiron 2021; Lang et al., 2012; McGreavy, Ranco et al., 2021). We draw from case study methodology in our analysis of the formation and changes associated with the development of the Maine Shellfish Learning Network (MSLN) (Yin, 2009). We used mixed qualitative methods to shape iterative engaged research practices, including conducting participany observations during engagement activities; organizing and attending diverse meetings, including community, municipal, and state-based and/or legislative shellfish meetings; attending and presenting at local conferences related to fisheries; volunteering for shellfish-related conservation activities to inform our collective efforts; and developing boundary objects when supporting communication or policy development across institutions.

We also conducted 20 semi-structured interviews from January 2020-December 2020 (Corbin and Strauss, 2014; Creswell, 2011; Galletta & Cross, 2013). We used a key informant and snowball sampling strategies to invite participation in the interviews (Corbin and Strauss, 2014). Interview participants including state agency representatives, municipal shellfish wardens, technical support staff, shellfish committee members, and shellfish harvesters. Interviews were coded using a collaboratively developed codebook and Dedoose (Version 9.0.17, 2019). To ensure trustworthiness of interpretations, we engaged in peer-debriefing and member-checking (Krefting, 1991; Lincoln & Guba, 1985). The research team also used triangulation, where multiple data sources confirmed overarching themes, including newspaper articles, legislative documents, meeting minutes, and transcribed field notes from participant observations (Carter et al., 2014).

3.3. Results and Discussion

In this section we describe three key insights from our qualitative research. First, we describe how communication-based processes and practices influenced design choices for the MSLN. Second, we describe how our design commitments, and communication strategies shaped the use of three specific boundary objects and their subsequent influence on adaptive capacities. Third, we identify changes in learning network activities that serve as evidence of the emergence of anticolonial approaches to fisheries governance including an increased presence and circulation of Wabanaki histories and knowledge systems and the formation of state-led and listening-based shellfish management workshops that are co-creating priorities for structural and processual changes in shellfish co-management.

3.3.1. Communication processes and practices to create the MSLN

An anticolonial approach to sustainability science evaluates how communication shapes participation, knowledge sharing, and leadership within a complex system, like a small-scale fishery. We identified four communication processes and practices that helped constitute this anticolonial approach to sustainability science and that fed into the development of the learning network, including (1) iterative and diverse meetings that leverage existing processes and that exhibited specific meeting design strategies, (2) co-identification of priorities or what we termed "action items" each of which also used a boundary object approach, (3) demonstrated listening before, during, and after meetings, and (4) practice of decentering researchers within knowledge making, each of which we more fully describe in this section.

Iterative and diverse meetings that consider ecological, relational, and strategic dimensions of communication are very common in our work. These meetings happen systematically along the research process, often at a pace that is relevant for collaborators. For

example, when working with harvesters there are more meetings during the winter and fall, with less during the summers, reflecting the shellfish season. We also include other considerations around timing and discussion. For example, we schedule meetings with harvesters meeting at high tide so harvesters do not miss a day of work, and create agendas that have multiple sections for small group and large group discussions. During the COVID-19 pandemic, we often employed phone calls or zoom to connect remotely with collaborators, or when possible, would meet outside on the coast. As an additional communication practice, often used in meetings, we consistently co-identified priorities with collaborators. This was done using collective decision making, often facilitated using charettes, World Café, or small group discussions coupled with larger group debriefs. This, coupled with additional conversations with community partners outside of meetings created consensus around our priorities. Demonstrated listening is another foundational practice within the MSLN. This occurs using iterative drafts, reflective discussions with collaborators, direct action responding to questions or concerns and other practices. For example, products or documents used by the MSLN are often sent out in draft form to collaborators to ask for any additional feedback or comments. Whenever possible, that feedback is incorporated into a final document. Finally, we strive to decenter ourselves within the research process or any other efforts. We prioritize harvester and community leader voices within all our meetings often by situating them as the experts within small group discussions.

Each of these processes culminated in the launch of the Maine Shellfish Learning Network. This process started with considering and leveraging the Maine Shellfish Restoration and Resilience Fund (MSRRF), a small-grant programs that supported community-led projects to sustain shellfish livelihoods and strengthen shellfish co-management. During the first year (2019), the MSRRF funded seventeen community-led restoration projects. Conjecting with this

existing process, we had numerous informal conversations with project leaders to identify how we could connect with and support them as they were launching their projects. While we recognize that the presence of the MSRRF was unique to this context and thus could limit the generalizability of this approach, the strategy of trying to connect with existing processes is transferable. As an alternative, we could have connected with processes going on with the state shellfish advisory council, associated with conservation activities within shellfish committees, or regional climate adaptation efforts to name just a few comparable opportunities.

Through the initial scoping conservations, we identified a need for regional discussion groups focused on water quality, shellfish restoration techniques, and how to strengthen leadership and participation in projects. For these meetings we determined a central geographic location and identified key project leaders and participants. We scheduled meetings for high tide so harvesters would not miss a low tide and thus lose income and provided compensation for shellfish harvesters missing a tide due to travel. We also provided food and drinks. The agendas included multiple opportunities for dialogue and for demonstrated listening within and beyond the meeting. For example, we held a meeting focused on water quality issues. To start, we mapped out each where water quality projects were happening on the coast and identified a central location (Ellsworth, ME). During that meeting we had two open discussion sections set on the agenda, including: Discussion #1 which focused on "What challenges are you running into your project? How can we address these challenges as a group?" and Discussion #2 which focused on "What do you need to learn to support your own project and/or about the different community project?". We also all partook in some coffee, tea, and snacks while speaking.

In terms of demonstrated listening, we followed up these meetings with a report that we generated with meeting participants and then shared with a listserv that we created for

information sharing within the growing network. These early meetings built capacities for information sharing, listening, and learning. The practical and process-based communication approaches described above, including the selection of location, timing, structure, reporting, and sharing insights help initiate the multi-dimensional approach to communication that then fed into the ongoing formation of the learning network.

Following this initial process, we hosted a launch meeting in Milbridge, ME at the Seaworthy Event Center on September 20, 2019. Thirty-three participants attended from multiple sectors, including municipal officials, harvesters, researchers from Maine and New Hampshire, representatives from DMR and business owners such as shellfish dealers and aquaculturalists. During this meeting, we asked partners to lead small group discussions on shellfish conservation, finding and fixing pollution, communicating the value of clamming, partnerships for civic and municipal leadership, and climate adaptation and shellfish science. These topics included those we heard referenced in our initial outreach to project leaders in MSRRF projects. After lunch, participants were asked to come together and report on discussions as well as identify priority action items, which became a core focus for the MSLN (Table 3.1). Discussions from this meeting were gathered in a report, where harvesters, managers, and others who were unable to attend could participate in follow-up one on one conversations.

This meeting built on the communication approaches and design choices described above. In the context of learning, we curated spaces where individuals could choose the topics they were interested in, share their expertise, or learn for their own community. We also brought individuals back together after these individual conversations to share insights. This gave participants a sense of issues that were most important to their community, and overarching trends that were impacting other communities in their region or state. In terms of leadership, we

supported experts from individual communities as leaders within small groups. This included

meeting with small-group leaders multiple times leading up to the event, pairing each with a

notetaker so they could focus on talking and sharing their experiences. As one shellfish

committee member described in an interview:

> "I mean it was good, I learned a lot. And I think that what I was particularly
> impressed was, was the diversity of the attendees. You had voices from all the
> groups that I would have liked to have seen there, for sure." MSLN7 (SC)

We invited community leaders to lead small groups as one way of decentering the researchers.

This created space for voices who had not been heard in a statewide context, and instead had

only been heard by their individual communities or groups. During follow up conversations,

small group leaders stated they felt the meeting was an important one, where harvesters were

learning, listening, and seeing other harvesters positioned as experts.

After this large group sharing, priority action items were collaboratively identified as

participants ranked and voted for themes that emerged out of the large group discussion. This

process was in keeping with an important insight from one of the clam harvesters who attended.

As he advised, the learning network should be a doing network, and the shared identification of

these priorities helped demonstrate a commitment to diverse actions (Table 3.1). Specifically, we

cultivated spaces where knowledge co-production consisted of forming new relationships

between communities and decentered the researcher. This is evident based on our iterative

engaged practices and meeting structures, which curated support for emergent forms of

leadership and developed priority action items through participant voting. From this process, we

then identified three specific projects that served as a focus for intensifying the connections

between communication, adaptive capacities, and specific changes in governance, namely,

facilitating a process to co-identify a Water Quality Decision Tree, creating a website called The

Mudflat (themudflat.org) and initiate a collaborative policy development process to change how shellfish restoration activities are regulated as Limited Purpose Aquaculture. Each of these projects have had observed impacts on information access, leadership, learning, and anticipatory capacity, described in the following sections.

Table 3.1. Priority action items co-identified during the MSLN launch meeting

	Priority Action Items	*Shorthand Description*
1	Connect key actors in water quality decision making and shellfish project permit regulations	Water Quality Related
2	Strength communication between towns and DMR through improved annual reporting and information systems	Boundary Spanning Communication
3	Conduct research focused on marketing strategies, market-based solutions, and additional policy options for wild clam and mussel fishery	Market-based Policy Options
4	Continue to build learning resources, including technical briefs, digital media techniques, and water quality decision support, to share and archive information about applied shellfish projects and water quality efforts in coastal towns	Building Learning Resources
5	Continue to develop relationships with governmental and municipal partners and grow the network	Develop New Relationships

3.3.2. Changes in Adaptive Capacities

In addition to the focus on a multi-dimensional approach to communication to shape learning network design, we also actively worked with boundary objects to create linkages between learning network activities and the formation of adaptive capacities. This section describes these objects and the processes used to develop them, specifically the Water Quality Decision Tree (WQDT) which provides access to information regarding water quality decisions; web-based technological resources like the Mudflat which have enabled learning across shellfish communities; and collaborative spaces developed within the LPA workbook project which shifted power dynamics and supported diverse forms of leadership. Finally, we discuss how each

of these projects have provided evidence for increased anticipatory capacity within and across shellfish communities.

3.3.2.1. Water Quality Decision Tree

The Water Quality Decision Tree (WQDT) is a document that tracks how water quality classifications are made. It supports communication between state and municipal institutions and provides tips for municipal shellfish committees working to reopen closed clam flats. This document is the result of applying our communication practices, namely iterative meeting design, co-identified goals, and demonstrated listening. For example, we followed previously described meeting practices to gather a group of state managers from different institutions, schedule meetings in a central location (Augusta, ME), provide coffee or snacks, and set agendas with multiple areas for discussion. During our initial meeting, the group co-determined the goal, namely developing a document, decision tree, or something similar that could gather information from all the state departments and present it to shellfish communities to support future water quality restoration projects. In terms of demonstrating listening, the WQDT was developed iteratively, where initial drafts were shared with the group to illicit feedback, and later drafts were additionally sent to those outside the group. The final product is reflective of this feedback, and is housed on the MSLN website the Mudflat, including a downloadable and printable packet that has been shared with interested shellfish communities.

In terms of adaptive capacities, the WQDT continues to influence information access (Folke et al., 2005; Olsson, Folke & Berkes, 2004) and anticipatory capacities (Kim et al., 2022; Tschakert and Diertrich, 2010). From the beginning, we gathered a group of state managers from different institutions to first: determine the full scope and nuance of water quality decision-making, and second, brainstorm ideas related to sharing this information with shellfish

communities. This group included representatives from DMR Department of Public Health, DMR Water Quality and Biotoxin, the Maine Department of Environmental Protection (DEP), the Department of Health and Human Services (DHHS), and the Maine Department of Agriculture, Conservation and Forestry (DACF). This created shared learning, where first state agency members learned about each other (some had never met face to face), different parts of the water quality decision-making process, who was responsible for those parts of the process, and what gaps may exist. This learning resulted in new insights that became part of the final product. For example, state agency members collectively remarked that there was a gap in remediation projects where paperwork supplied to the town by DMR was not being received by DHHS or the state plumbing inspector. To address this gap, we added in contact information for the state plumbing inspector's office, discussed if DMR could work more directly with the shellfish committee and share information (they could not for confidentiality reasons), and added information about how to contact a local plumbing inspector and town manager to determine if this gap may be a reason for a persistent water quality closure.

Small group activities within meetings (Figure 3.2) brought disparate state managers together and created new spaces for learning and improved information sharing across institutional boundaries. For example, in the second meeting individuals from different state agencies were asked to draw out the decision-making process for a point-source pollution-related closure. Each person was given a specific marker (their choice) and asked to contribute as they wanted. This allowed us to see a layering effect of expertise, where one state agency member was able to start the process, and then others were able to add additional information. Through the WQDT, municipal shellfish committees also have new access to information such as understanding of which institutions are involved with various points in water quality

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classifications and contact information for specific people within those institutions who can answer questions. This type of information has supported anticipatory capacities, where municipalities are planning new water quality restoration projects, and citing the WQDT as one way they were able to determine which technique would be most effective for their specific situation.
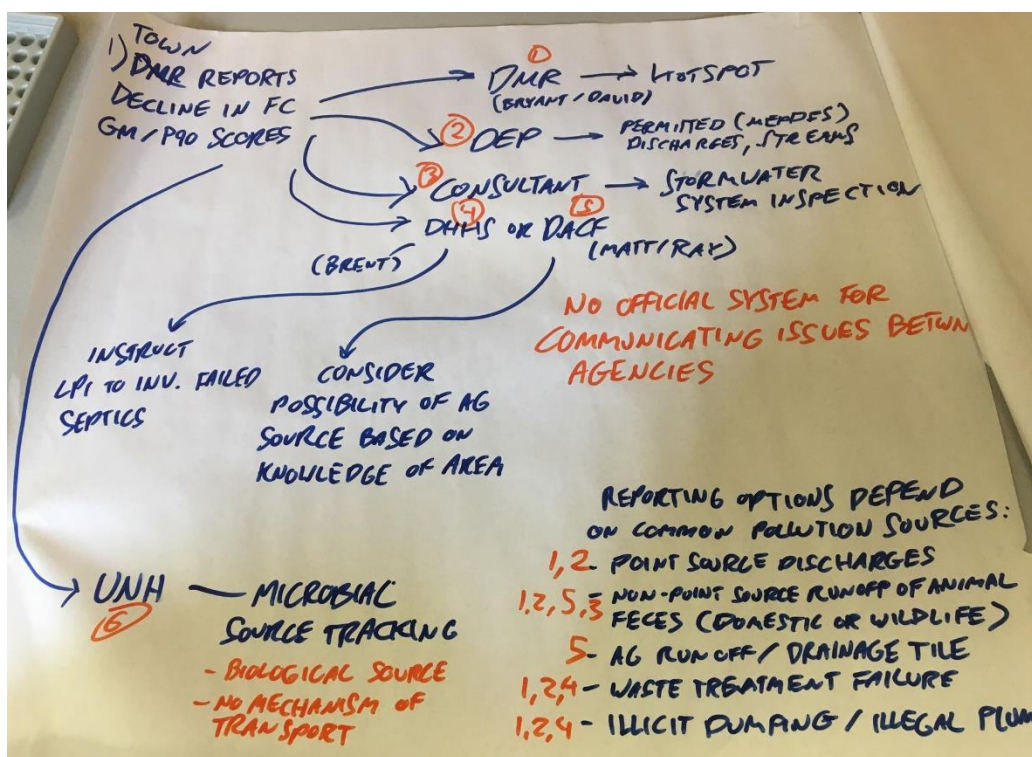
Figure 3.2. Sketch of decision related to water quality closure. Collaborators were given the prompt of "drawing out how decisions are made about reopening a closed clam flat". Small groups included members of different state institutions.

3.3.2.2. The Mudflat Website

The Mudflat (themudflat.org) is a website designed to share information about community-driven research projects, policy changes, and other issues emergent in the wild clam fishery. It engages with shellfish harvesters, community managers, state agency members, and the broader public. This effort grew out of an earlier engaged digital project where we worked

closely with clammers and identified the need for website that would communicate about clamming livelihoods and shellfish co-management (Quiring et al., 2020). This effort also demonstrates many of the MSLN's communication practices. For example, we demonstrated listening and co-identified priorities by first talking with harvesters, managers, scientists, and other people engaged in the shellfish fishery to understand how they viewed web resources and what they wanted on a website related to shellfish. We also collaboratively developed information on the website, decentering the researchers so that other partners and community representatives could share their views and stories within the media space. For example, we developed project profiles, or online web pages which shared details and outcomes from community-driven research. For each profile, MSLN team members met iteratively with community-leaders to draft descriptions of the project, develop timelines, and share photos.

The processes and practices used to develop the Mudflat influenced adaptive capacities, including learning capacities (Gupta et al., 2010; Pelling et al., 2008) and anticipatory capacities (Kim et al., 2022; Tschakert and Dietrich, 2010). In terms of learning, the Mudflat contact page is often populated by questions from members of shellfish communities and the broader public. For example, we were contacted by a coastal landowner who is focused on preserving working waterfront. They asked us how their efforts could support shellfish harvester, and now members of our team are working with this landowner to determine what forms of access are possible for shellfish harvesters in their area, and how to broaden the effort into regional considerations of access. Shellfish harvesters are also learning from each other on our website. Communities are citing project profiles in their future plans, including grant applications and conversations with other researchers and state managers. This shows that shellfish community members recognize the Mudflat website as a gathering place for various knowledges and information, like a

conference room, or a mudflat (hence the name). In addition, the project profile home page (which provides an overview of many of the projects) is visited with an average 350 views per year from 2021 and ranked within the top five of pages visited on the Mudflat since 2020.

As an additional mechanism tied to the Mudflat, we also created an online listserv. Anyone can join the listserv, and we send out periodic updates with information related to the fishery, including the location of state advisory board meetings, relevant news articles, and information about shellfish related policy efforts. As described by a shellfish warden,

> "You guys have the mechanism to reach out to so many people just with an email, with the list that you're developing, and get people to start thinking, and maybe get more participation at these meetings. Because if we don't do something as a state, the Maine soft shell clam is gonna struggle, maybe to the point of near extinction, if we don't work together."

When asked about the motivation for attending an MSLN meeting, interviewees highlighted learning, for example, "I would like to learn – I just like to know what other towns are doing, and what their problems are, what their issues are, and what they're doing to resolve them." The Mudflat represents one of the MSLN's response to that motivation, creating a new space for learning and community planning through our communication practices.

3.3.2.3. Limited Purpose Aquaculture (LPA) Workbook

The Limited Purpose Aquaculture (LPA) workbook supports municipal shellfish committees that are using aquaculture related technologies to enhance local shellfish populations. This document was developed collaboratively following MSLN communication practices including iterative meetings, demonstrated listening, and co-identification of priorities. For example, we met and interviewed state agency members from DMR Nearshore Fisheries Program, DMR Aquaculture, and DMR Public Health, as well as shellfish harvesters and project

leaders who had used LPAs. During these conversations we collaboratively outlined the timelines and steps in the LPA application process, connected free online resources that could be used to create a successful application, and heard recommendations about how to improve the process so municipalities could successfully obtain an LPA license. As one way of demonstrating listening, we compiled these recommendations into a second document titled "the Report to the Shellfish Advisory Council (ShAC)." This document outlined short-term and long-term recommendations. As another communication practice, we, along with municipal managers, harvesters, and state agency members, co-identified which policy recommendations should be prioritized and which required legislative changes.

The LPA Workbook, and the process used to develop the document, has influenced adaptive capacities such as information access (Folke et al., 2005), leadership (McGreavy et al., 2018), and anticipatory capacities (Tschakert and Dietrich, 2010). In terms of information access, this document gathered new information about the LPA application process. For example, we created an online video that shows step by step how to develop a vicinity map (a required component of the application) using the Aquaculture Online GIS map tool. This video includes how to add specific components to a map and transfer it to a Google slides or Microsoft PowerPoint slide to add labels. Each of the tools used in the video are available free and online. This work also supported diverse forms of leadership. For example, this work was cited during a unique collaborative policy process, where municipal project leaders worked with state agency members to develop legislative solutions based on the recommendations developed in the Report to ShAC. Based on the relationships built during our research, we were also invited to participate in this policy effort. Additionally, the LPA workbook influenced municipal shellfish committees' anticipatory capacity. Since its development, more communities have been planning new LPA-

related projects to support clam populations, or alternatively, considering these efforts alongside other more historic methods such as brushing. The active and reiterative recognition of local expertise through the development of boundary objects and other MSLN projects reinforced and expanded information access, learning, leadership, and anticipatory capacities. This led to the development of adaptive and anticolonial forms of governance, described in the next section.

3.3.3. Emergence of adaptive and anticolonial forms of governance

The MSLN's presence, practices, commitments, and projects have led to the adoption of more adaptive and anticolonial forms of governance on a statewide scale. In this section, we describe: how the Mudflat and related listserv articulates Wabanaki knowledge within Maine clamming communities and shellfish co-management; how our listening practices have been taken up by shellfish management workshops and processes of co-identification; and the formal and informal policy changes related to the LPA workbook.

The Mudflat and the associated listserv have shifted knowledge hierarchies present in the wild clam fishery by weaving together Wabanaki and non-Wabanaki perspectives equitably. On the website, we have included Passamaquoddy-Maliseet language words as part of our headings and within text on individual pages. We have also woven together Wabanaki and non-Wabanaki perspectives when building content on the website. One example of this is the section titled "A History of Clamming" on the Mudflat website, which is a title intentionally designed to think about all relationships with this fishery. We chose "*A* History of Clamming," not *The* History of Clamming. This choice highlights our focus on making space for new and ongoing conversations, and diverse viewpoints, where people engaging with the website can see that this is one of many histories of clamming in this area. We also included project profiles about ongoing efforts led by the Sipayik Environmental Department to restore shellfish populations in

Half Moon Cove using clam gardens, a technique used traditionally in the Pacific Northwest. This inclusivity is one way we hope to support Wabanaki presence and inclusion in shellfish management into the future.

The listening, learning, and responding practice embodied by the MSLN is permeating into the shellfish co-management system. Shellfish co-management workshops, facilitated by DMR, were three meetings held at different areas across the coast, where DMR managers asked for feedback about the current co-management system, as well as shared updated information about municipal management practices. These meetings greatly resembled MSLN meetings, including an agenda with open discussion sections, small group discussions, and spaces where people could write down their ideas about what DMR's priorities should be to improve the co-management system. Additionally, one outcome from these multiple meetings was an extended list of actions or topics (75+) that meeting participants felt should be considered or implemented. This connection demonstrates how the practices and processes used by the MSLN are accepted and promoted within the fishery. It also connects to Wabanaki values of listening and learning. However, there are key differences as well. Small group facilitators were not leaders from individual communities in the region, but instead a mix of state agency members and volunteers often from scientific institutions or other related state organizations. Additionally, it has been noted that the ranking system for actions or topics (where stickers are placed by actions participants deemed most important) may further marginalize individual voices., most especially as that later ranking is developed by a select group of people at the Shellfish Advisory Council, not a broader public group.

Finally, the efforts related to the LPA workbook and Report to ShAC fed into the formation of formal and informal policy changes that are facilitating intertidal restoration. The relationships

built during the development of the LPA workbook created a space for negotiation between state agency members and ourselves, where we were able to share recommendations made by research participants, and state agency members listened. This trust resulted in informal changes that support municipalities applying for or using LPAs. For example, municipal LPAs no longer have a restricted number of helpers, or individuals who are able to be on an LPA, which is more reflective of the volunteer dynamics commonly found in shellfish restoration projects. Additionally, these efforts led to collaborative policy development. After recommendations were presented to ShAC, shellfish community leaders determined that they would move forward with legislative action, drafting policy and submitting it to the Maine State Legislature. At the same time, we were asked to contribute to draft language and share that language with state agency members. From these later discussions, where we served as a bridge between state agency members and community leaders, we co-created LD 581, titled "An Act to Assist Municipal Shellfish Conservation Programs,". The Marine Resource Committee voted unanimously to pass this LD, after a public hearing in which state agency members and community leaders shared their joint approval. This collaborative policy action, which included iterative meetings and demonstrated listening, is evidence of adaptive governance, where communities and state agencies worked together to address issues within the wild clam fishery and support local restoration activities. This, as well as the Mudflat and Shellfish Management workshops reflect the communication practices and boundary objects developed through the MSLN, which destabilize common institutions of power, create new opportunities for collaborative learning and sharing, and result in collective action.

3.4. Conclusions and Future Considerations

The MSLN serves as an example of a learning network that draws from anticolonial, sustainability science, and engaged research approaches to create a unique presence within a small-scale fishery. The MSLN serves as supportive and connective tissue across communities and within the broader governance system. This impact was cultivated by centering the organization around principles of listening, reflection, and presence, and shaped by clammers themselves. Focusing on multiple dimensions of communication, including strategic, relational, ecological, and critical allowed the MSLN to effectively form relationships among diverse actors, create spaces for knowledge sharing, and develop priority action items collaboratively. These practices carried forward into applied research projects and boundary object development, or the "doing". The WQDT, the LPA Workbook, and the Mudflat, among others created new capacities for learning, improved information access, anticipatory capacities and diverse forms of leadership. These capacities led to the emergence of anticolonial and adaptive governance structures and processes, which center flexibility and listening-based modes of participation by state agencies. Our analysis demonstrates that specific strategies within the formation of learning networks, namely attending to multiple dimensions of communication, and using boundary objects, can strengthen the anticolonial commitments in sustainability science and foster more anticolonial approaches to fisheries governance. However, despite these successes, there are also tensions and challenges in this approach, and especially related to the temporality of these efforts, the contingency with participation choices, and the possibility of individuals being centered more than the organization. The approaches demonstrated by the MSLN may not work for every context. However, learning networks developed in a similar way can cultivate diverse expertise and remain flexible to attune to multiple emergent topics as necessary. Most especially, relational commitments within learning networks can lead to embedded structures that support

broader participation and the inclusivity of diverse voices in decision-making spaces within

small-scale fisheries as well as other localized natural resource management spaces.

CHAPTER 4

BOUNDARY OBJECTS IN PRACTICE: THREE CASE STUDIES FROM THE SOFT-SHELL CLAM FISHERY

4.1. Introduction

Knowledge co-production has emerged as a unique solution to address the complex issues facing fisheries (Mills et al., 2022; Cooke et al., 2021; Trimble and Berkes et al., 2013; Armitage et al., 2011). Knowledge co-production can be defined as the practice of bringing together meanings, realities, and other bodies of knowledge across multiple perspectives (Jasanoff 2004; Jasanoff 1997). As implied in this definition, knowledge co-production requires drawing on diverse forms of expertise and considering forms of knowledge exchange (Nel et al., 2016; Young et al., 2014; Fazey, 2013). It also means moving away from linear patterns of communication derived from colonial logics (Tucker, 2018) and instead using new methodologies and paradigms to consider the multi-dimensional aspects of knowledge exchange and communication, especially the strategic, ecological, and relational aspects (Drushke & McGreavy, 2016; Young et al., 2014). This is particularly true in co-governance arrangements, like those found within the wild clam and mussel fisheries (Trimble and Berkes et al., 2013; Armitage et al., 2011). Sustainability and conservation science have offered many methodologies to facilitate knowledge co-production. This includes social-ecological systems frameworks (Ostrom, 2007), collaborative research (Reed and Abernethy, 2018), transdisciplinary research (Domik and Fischer, 2010), reciprocity (Diver and Higgins, 2014), and community-based participatory research (Wilson et al., 2018), among many others that draw from other fields, including communication (McGreavy et al., 2013). Additionally, movements related to Indigenous knowledge sovereignty and decolonized environmental governance have offered additional practices such as "Making room and moving over," (Latulippe and Klenk, 2020), or

frameworks such as Etaupmumk (Bartlett, Marshall, and Marshall, 2012). Each of these practices focus on diversifying knowledge systems and developing research methods that facilitate credibility, legitimacy, saliency (Cooke et al., 2021; Norström et al., 2020; Clark et al., 2016) and equity (Latulippe and Klenk, 2020). In each of these practices there is an implied need for boundary spanning techniques.

Boundary spanning is efforts that seek to create links between knowledge creation and action across bounded social spaces (Clark et al., 2016). This definition focuses on the boundary between perceived research spaces and policy-decision making spaces (Posner and Cvitanovic, 2019, Clark et al., 2016). However, when governance and decision making is understood as a spectrum of social, economic, institutional and other arrangements that shape modern societies and spaces (Kooiman et al., 2008; Jentoft and Cheunpagdee, 2015), boundary spanning must recognize the boundaries that exist between scientific efforts and policy development, but also boundaries that exist within science, such as those between sustainability and communication sciences (McGreavy et al., 2013). For example, Kourantidou et al., describe socioecological indicators used in fisheries management as boundary objects that can incorporate diverse forms of knowledge and connect across managerial boundaries between Inuit Nunangat communities and state governance (2020). Boundary spanning also means recognizing boundaries constructed through violence and colonization, especially those that have siloed and excluded Indigenous knowledges from decision making spaces and from places (Latulippe & Klenk, 2020; Smith, 2013; Bohensky & Maru, 2011; Nadasdy, 1999).

The development of boundary objects serves as one boundary spanning methodology. A boundary object is defined as an artifact or object (maps, observation notes, etc.) that can support efforts in multiple spaces, crossing multiple perspectives and paradigms, and often represent

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multiple forms of knowledge (Mark et al., 2007; Wilson & Herndl, 2007; Star & Griesemer 1989). These objects adapt to the needs of creators, or boundary "actors", while remaining recognizable outside a specific space and time (Wilson & Herndl, 2007; Laine et al. 2002; Star & Griesemer, 1989). Boundary objects also are developed to be translatable to outside participants (Roux et al., 2017; Bresnen, 2009; Star & Griesemer, 1989). The knowledge created represents cumulative and compounding realities, including power relationships, and social dynamics (Gal et al., 2005; Jasanoff, 2004). For example, Gal et al. described 3D models developed by diverse departments within architectural firms as boundary objects which created more equitable social identities, where power and decision-making became more dispersed (2005). Co-production of knowledge is a vital piece to understanding how to engage with communities and span the boundaries between researchers and stakeholders (Clark et al., 2016). Within a co-production space, boundary objects serve as identifiable products that represent multiple knowledge constructions (Holford, 2014). It is important to note that the co-creation of knowledge is not always equal, and this remains true within the process of boundary objects (Jasanoff, 2004). For example, Abson et al. recognize that while the concept of ecosystem services serves as a boundary object between decision-makers and scientists, the traditional use of value judgements while articulating ecosystem services reflects individual participant own interests and approaches, rather than more integrated or objective evaluation (2014).

More recently, boundary objects were defined as "a sort of arrangement that allow different groups to work together without consensus" (Star, 2010, p. 610). They are framed as fixed objects or static, where objects meet diverse needs but has a singular identify across multiple spaces (Akkerman and Bakker, 2011; Star & Griesemer, 1989). However, concepts such as resilience (Baggio et al., 2015; Brand and Jax, 2007), stewardship (Enqvist et al., 2018),

ecosystem services (Abson et al., 2014), are being treated as boundary objects. This pattern draws attention to additional nuances in the definition of a boundary object, where not only is it an individualized object, but additionally a set of practices that seek to negotiate across differences (McGreavy et al., 2013; Star, 2010; Star & Grisemer, 1989).

Boundary work and by extension, boundary objects, often support adaptive capacities by promoting knowledge exchange, social learning, information access, and transparency in decision-making (Lynch et al., 2008; Pelling et al., 2008). Adaptive capacities refer to interactions that facilitate learning, leadership, anticipatory planning, and information sharing. Gupta et al., described adaptive capacities as multi-faceted, with dimensions like leadership (McGreavy et al., 2018; Folke et al., 2005), information access (Barnes et al., 2019), capacity to improvise (Oestreich et al., 2019), and institutional memory (Ostrom, 2005) (2010, Table 4.1). Each of these dimensions is dependent on the resources to facilitate and engage in these interactions and the ability to respond to or plan for disturbances that influence these interactions (Nursey-Bray, 2018; Hinkel, 2011). Adaptive capacity processes are also inherently connected to dimensions of communication, namely, strategic, relational, and ecological (Druschke and McGreavy, 2016). This has direct implications for boundary objects, which can be considered the material embodiment of dialogic processes (Star & Grisemer, 1989) and communication dimensions, such as practices related to meeting design and use of symbols (strategic), the social construction of relationships (relational) and the environments or governmental structures that shaped those dialogic processes (ecological).

Table 4.1. Adaptive capacities and working definitions. Drawing from tables developed by Gupta et al., 2010, this table shows adaptive capacities, working definitions, and related literature used to develop definitions.

Adaptive Capacities	Working Definition	Related Literature
Leadership	Diverse forms of leadership that facilitate collaboration, visioning, or entrepreneurial action, can be socially constructed around one person or a group	McGreavy et al., 2018; Folke et al., 2005; Olsson et al., 2004
Anticipatory Capacity	Considerations for the future, both in the context of governance and planning, but also individual learning and decision-making	Kim et al., 2022; Tschakert and Diertrich, 2010; Quay, 2010
Information Access	Access to diverse forms of information during a decision-making process, as well as access to institutional information, including how institutions make decisions	Barnes et al., 2019; McGreavy et al., 2018; Folke et al., 2005; Olsson, Folke & Berkes, 2004
Capacity to Improvise	Capacity for institutions, individuals to adapt, self-organize, and create new solutions or strategies when faced with social-ecological shifts	Oestreich et al., 2019; Folke et al., 2005
Institutional Memory	How institutions monitor and evaluate ongoing processes, as well as how individuals are able to understand past actions taken by institutions	Gupta et al., 2010; Ostrom, 2005; Gunderson and Holling, 2002
Legitimacy	Acceptance of decision-making, perceived respect and consideration for diverse forms of input within a decision-making context, can be dependent on access to information that shaped a decision, access to the decision-making space, as well as policy structures that support transparency	Cash et al., 2002; Hansson and Polk, 2018; Senecah, 2004
Responsiveness	How institutions, managers, or individuals are able to respond to social-ecological shifts, how responsive governance structures are to emergent issues	Pentz and Klenk, 2017; Ebbin, 2009;
Multi-Actor, Multi-Level Involvement	Involvement of multiple actors, levels, or institutions within decision-making spaces, related to participation of diverse groups in governance	Pahl-Wostl, 2009; Armitage, 2008; Folke et al., 2005
Accountability	Structures where individuals or institutions can discuss doubts with various decisions or actions, as well as provide critique or input into future considerations	Brewer et al., 2017; Ensor et al., 2015; Gupta et al., 2010;

Table 4.1. Continued

Learning Capacities	Related to information access and dimensions of communication, capacity of community, group, individual, or institution to reflect and engage with diverse forms of information and knowledge,	Thi Hong Phuong et al., 2017; Gupta et al., 2010; Pelling et al., 2008

Abson et al. articulates, "as a transformative concept, ecosystem services will need to engage not only with literature on governance, but also with work on engagement, motivation, communication, and education – themes that, to date, remain marginal," to understand the nuances of its use for boundary spanning (p. 36, 2014). This gap can be expanded to boundary object theory, where the primary focus has been on defining or describing the object or product itself (Akkerman and Bakker, 2011; Star et al., 2010; Bergman et al., 2007), or defining concepts such as resilience (Baggio et al., 2015; Brand et al., 2007), models (Wohlrab et al., 2019; White et al., 2010), human rights (ten Oever, 2018), ecological indicators (Turnhout, 2009) or informational technologies (Huvila et al., 2017; Forgues et al., 2009) as boundary objects. Work is still needed to understand the negotiations, relations, and social spaces that lead to the emergence of a boundary objects (Dar, 2018), and how they influence adaptive capacities.

To better understand these types of questions, I present three case studies in which boundary objects were used to facilitate knowledge co-production in the wild clam fishery as part of my engaged research efforts. These include, two documents related to fisheries management titled, "the Water Quality Decision Tree", and "the Limited Purpose Aquaculture Workbook," and an oceanographic drifter bucket designed for research within the coastal community of Thomaston, ME. My overarching research question is, "How does the use of engaged research practices in the creation of boundary objects influence community-level

adaptive capacities?". To answer this question, I: (1) describe three cases of developing boundary objects through engaged methodologies, (2) discuss the respective boundary objects, the social spaces they embody, and their collective influence on adaptive capacities and (3) offer insights into future discussions related to the theory of boundary objects.

4.2. Methods

This research follows a comparative case study methodology, where each research project that resulted in a boundary object is being considered a case (Yin, 2009). Comparative case studies have been used to explore the impact of boundary objects (Tsurusaki et al., 2012; Turnhout, 2009) particularly in engaged (Halpern et al., 2013; Lee, 2007); and sustainability science research (Peçanha Enqvist et al., 2018). This research follows this trend, presenting a comparative case study, whereas I draw connections across each boundary object project (Bartlett and Vavrus, 2017; Goodrick, 2014; Yin, 2009). Comparative case study methodology emphasizes inductive emergent processes drawing from experiences (Bartlett and Vavrus, 2017). Bartlett and Vavrus describe comparative study as a "process orientation" (Maxwell, 2013), where researchers draw connections based on causality, for example, how did boundary objects (or the situation or process surrounding them) impact decisions made in a relevant context. In addition, Bartlett and Vavrus develop a tracing logic, whereas themes and analysis focus on the multidimensionality of the cases, including dimensions such as temporality, relation to power, impact of the cases, and others (2017). This orientation is reinforced by Goodrick, where key evaluative questions are used in comparative case study analysis to focus on outcomes from each of the cases (2014). In addition, case study, and in particular comparative case study, has been used to explore and refine theories that had previously been defined in the literature (Kaarbo and Beasley, 1999).

Based on the short literature review of boundary objects and adaptive capacities above, and drawing on these methodological concepts, I have developed evaluative questions (Table 4.2). These questions focus on comparing individual boundary object projects to the definitions outlined in the introduction to determine if/how the cases represent new insights to the application of boundary object theory in engaged research projects. To answer these questions I first, present detailed descriptions of each case, including the context, methods used, boundary object developed, and the outcomes of the case. Second, I discuss the overarching similarities and differences between each case, focusing on the temporality, engaged methodologies used, and impact on adaptive capacities. I frame this discussion around each of the key evaluative questions (Table 4.2). I draw on observations, field notes, documents such as meeting agendas, legislative proposals, and presentations, as well as follow up informal conversations with research partners.

Table 4.2: Key evaluative questions. Questions were developed following methods outlined in Goodrick, 2014 and drawing on boundary object theory and case experience.

Key Evaluative Questions	
#	Question
1	What patterns related to practices, processes, or methodology occur across all three cases? How do these patterns shape the outcome for each project?
2	To what extent did these boundary object projects have an influence on adaptive capacities?
3	What insights emerge from using boundary objects about the connection between relationality, boundary objects, and adaptive capacity?

4.3. Cases

I present three case studies of the processes through which boundary objects are created within the wild clam and mussel fisheries in Maine. Each case is described through three

sections, (1) context[30], (2) process or practices used to develop the boundary object, (3) outcomes and influence on adaptive capacities.

4.3.1. Water Quality Decision Tree (WQDT)

The Water Quality Decision Tree (WQDT) is a document developed by a collaborative group and myself to create more transparency around water quality decision making in the soft-shell clam fishery. The WQDT now serves as unique resource for municipalities who are engaging in water quality restoration projects, as well as a touchpoint for state managers to use in conversations related to water quality decision making. In the following sections, I describe the context for which the WQDT was developed, the process we used to develop this boundary object, and its reception and impact.

4.3.1.1. WQDT Context

The wild clam fishery has two intersecting governance systems operating at the same time, including a co-governance system between DMR and municipalities with an approved shellfish ordinance, and a hierarchical system in which DMR determines water quality closures. This hierarchical system is the application of the National Shellfish Sanitation Program (NSSP) a series of nationwide laws that protect consumers from shellfish contaminated with pollution and determine the requirements for states to participate in interstate trade of shellfish. As a participating member, Maine is obliged to create laws within the state in accordance with the NSSP. The DMR Bureau of Public Health oversees the application of the NSSP within Maine's shellfishery. This includes the monitoring for biotoxins such as red tide (derived from harmful algal blooms), and the monitoring of fecal coliform bacteria, a bacteria derived from runoff and,

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[30] I will also be including additional information or short stories from the research in the form of footnotes. The hope is that by including some of these on-the-ground stories, I can include more of the context and actions that existed outside of the methods described.

human and animal fecal matter (Hillyer et al., 2022). Based on these scores, the DMR assigns water quality designations to various water bodies, including conditional, restricted, prohibited, and open. Prohibited areas are areas that are permanently closed to all fishing based on fecal coliform scores. Restricted areas are areas between prohibited and conditionally approved (in terms of fecal coliform scores) in which you can get a special DMR permit for depuration digging to harvest. Open areas have no closure and can be harvested from freely in accordance with municipal or statewide policy. Conditional closures are areas that are temporarily closed due to environmental conditions as well as runoff. For example, conditional closures can be related to high tides, river flow, floods, the presence of a marina, or rainfall. Additional research may shift the timing of these closures. For example, in the Medomak River in Waldoboro, conditionally approved areas are closed when rainfall meets or exceeds 1" within a 24-hour period and are closed for nine days. This is based on fecal coliform testing, as well as a clam-meat study that was conducted[31].
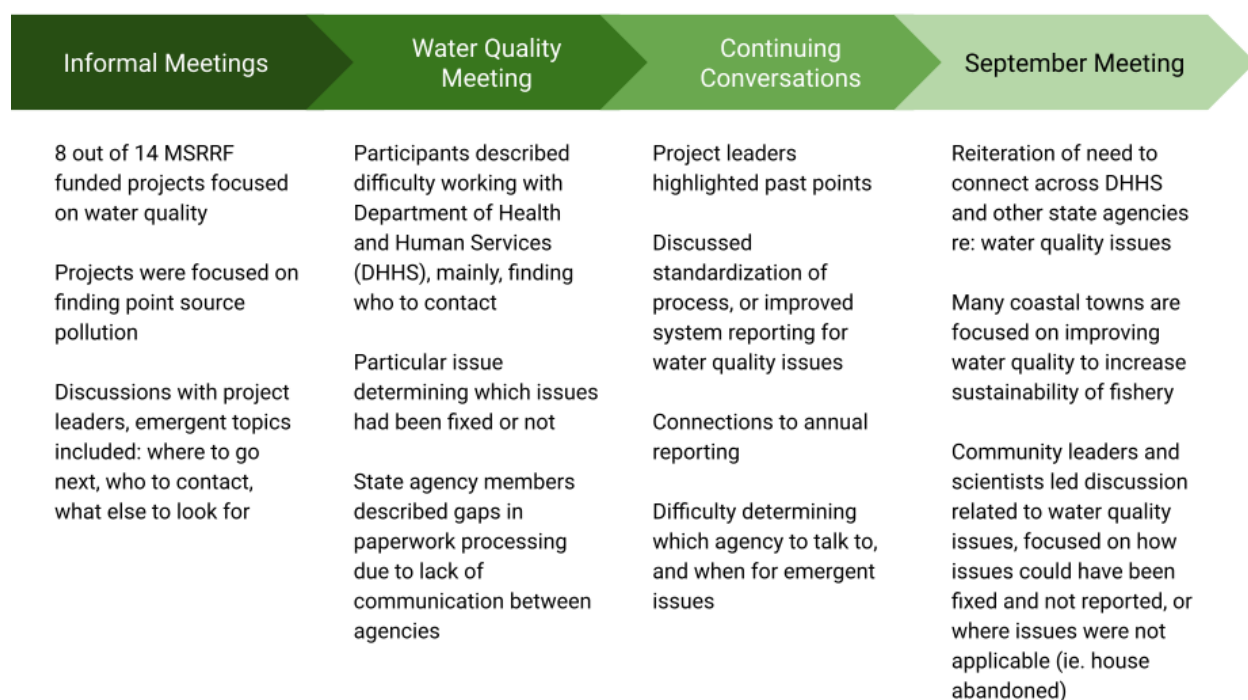
It is important to note that in this system, municipalities are often considered responsible for finding and fixing pollution sources that are impacting water quality.[32] This type of restoration work is often conducted collaboratively, where local managers work with state scientists and others to determine sources of pollution and the best approach to mitigating or resolving the issue. However, it has been cited by multiple communities that this type of effort is often cumbersome and difficult to navigate. This is especially true within the context of the development of the Maine Restoration and Resilience Fund (MSRRF), a project that funded

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[31] This clam meat study was largely pushed for by harvesters. Waldoboro, ME, the adjacent town to the Medomak, hosts the largest number of clam harvesters in a single municipality (~150), or 10% of the entire industry. This study would not have been conducted without the extensive pressure developed through public, private, and press related communication from shellfish harvesters to members of the DMR.
[32] This perception is drawn from state managers who have consistently stated that they manage water quality, classify it, but are not in responsible for cleaning it up. This has shift responsibility for any efforts to improve water quality to municipalities, who often have less capacity and resources related to these efforts.

community-led projects related to shellfish conservation from 2017-2021. Out of the original fourteen projects that were funded, eight were focused on finding and fixing pollution sources to reopen closed clam flats. While some of these projects were successful, many participants cited the difficulty in navigating the water quality decision process and determining which state agency to contact for more information or assistance. These difficulties were cited again during the launch meeting of the Maine Shellfish Learning Network (MSLN) in 2019, where thirty participants from different sectors within the wild clam fishery identified priority action items for the organization to pursue. The first item on the list was, "Connect key actors in water quality decision making and shellfish project permit regulations." We tracked these emergent concerns as they were reiterated by state agency members and shellfish harvesters throughout the MSRRF projects, a water quality theme meeting facilitated by the MSLN, informal conversations afterward, and how it was articulated in the MSLN September launch meeting (Figure 4.1).

Informal Meetings	Water Quality Meeting	Continuing Conversations	September Meeting
8 out of 14 MSRRF funded projects focused on water quality	Participants described difficulty working with Department of Health and Human Services (DHHS), mainly, finding who to contact	Project leaders highlighted past points	Reiteration of need to connect across DHHS and other state agencies re: water quality issues
Projects were focused on finding point source pollution	Particular issue determining which issues had been fixed or not	Discussed standardization of process, or improved system reporting for water quality issues	Many coastal towns are focused on improving water quality to increase sustainability of fishery
Discussions with project leaders, emergent topics included: where to go next, who to contact, what else to look for	State agency members described gaps in paperwork processing due to lack of communication between agencies	Connections to annual reporting	Community leaders and scientists led discussion related to water quality issues, focused on how issues could have been fixed and not reported, or where issues were not applicable (ie. house abandoned)
		Difficulty determining which agency to talk to, and when for emergent issues	

Figure 4.1. Tracking Water Quality Conversations. This figure shows how informal meetings led to the efforts to develop the WQDT

As part of the development of the MSLN, theme meetings were held on important topics, which were determined by the scope and focus of MSRRF projects conducted in 2019. Water quality was considered "most important" due to the prevalence of projects focused on water quality (8 out of 14). At theme meetings focused on water quality, which included bringing members of state departments and community project leaders, multiple issues were discussed[33]. These included a lack of transparency around water quality decision making and how it related to restoration efforts, issues related to understanding open/closed barriers, and a lack of coordination with local and state inspectors.[34] This conversation, and others with the MSLN

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[33] These theme meetings were developed and facilitated by myself and other members of the MSLN. This meeting was held at the Darling Marine Center, near Walpole, ME.

[34] Multiple meeting participants stated that state inspectors were hard to find, and difficult to schedule around. Often, they felt that septic inspectors, local and state, did not communicate, creating looping conversations that were difficult to keep track of and make progress through.

launch meeting led to the action item #1 titled, "connect key actors in water quality decision making and shellfish project permit regulation."

From this origin point, members of the MSLN gathered members of state agencies related to water quality decision making, including representatives from DMR Public Health, the Department of Health and Human Services (DHHS), state plumbing inspectors, the Department of Environmental Protection (DEP), and the Department of Agriculture, Conservation, and Forestry (DACF).[35] When asked "what do you believe could respond to emergent conversations and concerns related to water quality management?", this group responded by stating that a decision tree could help highlight how decisions are made, at which points efforts from communities are considered, and how communities could open previously closed clam flats. In the following section, I describe how members of the MSLN developed the boundary object the Water Quality Decision Tree, and how specific practices helped improve knowledge co-production and its later impact.

4.3.1.2. WQDT Processes and Practices

Following an adopted version of charettes (Mara, 2009) or World Café (Löhr et al., 2020), we held four meetings periodically from spring to winter of 2020. Members were collectively invited to each meeting and were consulted for meeting time and location. When relevant, we met with members who were unable to attend larger group meetings to illicit additional feedback. At each meeting, we first reviewed and adapted listening agreements which included respecting others' opinions, focusing on using language everyone could understand, and avoiding acronyms. Second, we co-defined agendas with participants. Then we posed different

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[35] At this first meeting, many mentioned that this was the first time they met, despite working in their respective departments for several years.

activities or discussion questions to the group. We facilitated discussions and took extensive notes. Meetings closed with determining next steps.

After the first meeting, described briefly above, the group focused on the overarching question "what is the process for opening up closed clam flats after a point source has been identified and fixed?". After determining that a decision tree should be used to communicate this information to communities, the group focused on how to translate their decisions and expertise into a decision tree[36]. During the second meeting, held in person in March 2020, focused on a small group activity, where the larger group was split into two and tasked with sketching out initial decision tree pathways based on two scenarios[37]. The scenarios were chosen based on discussions with municipal water quality project leaders and reviewing applications for the MSRRF projects. Scenario 1 was a town manager finding a point source such as a broken straight pipe. Scenario 2 was a municipal shellfish committee wants to improve water quality with a non-point source. After each group sketched out both scenarios, MSLN team members facilitated a discussion between the groups about the accuracy of each pathway. After this meeting, I developed a digital version of these pathways. It was determined by the group that two pathways would be easier to communicate and develop, one focused on each of the scenarios posed during the second meeting.

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[36] This was the first meeting that I led and facilitated as a doctoral student. Because I wanted to focus on neutrality, I worked with an administrator outside of any of the departments invited to find a conference room. I ended up booking a conference room that was no larger than a closet (despite being explicit about the number of people attending) that all the participants and I had to squeeze into. After elbowing each other constantly to share coffee and donuts, everyone collectively felt more at ease, which may have influenced a more productive discussion.

[37] At this meeting we used large post its and markers to sketch on, materials that had been used in previous MSLN meetings. In future years, we would see similar materials and techniques throughout other shellfish-related policy and collaborative meetings.

At the third meeting in April 2020, which was held virtually following COVID-19 protocols[38], these initial drafts were shared with the group. Using the whiteboard feature on Zoom, meeting participants were able to add comments directly to the draft decision tree (Figure 4.2). Screenshots were taken of these notes, and later incorporated into updated versions that were shared back with the group. Additionally, it was during this meeting that meeting participants determined it was going to be better to make two resources, first, a printable PDF with the information relevant to the WQDT, and a series of online webpages that could include additional information. At this time, the MSLN was developing an online web resource titled the Mudflat (themudflat.org) in response to a priority action item that identified a need for web media and web-based information repositories. The Mudflat became a natural home for these efforts, as state agencies felt they could include the PDF, but not add multiple pages to their online platforms.

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[38] This was the first of many meetings and conversations held virtually. The WQDT serves as one example of how MSLN members, state agency members, and others-maintained progress during the COVID-19 pandemic.
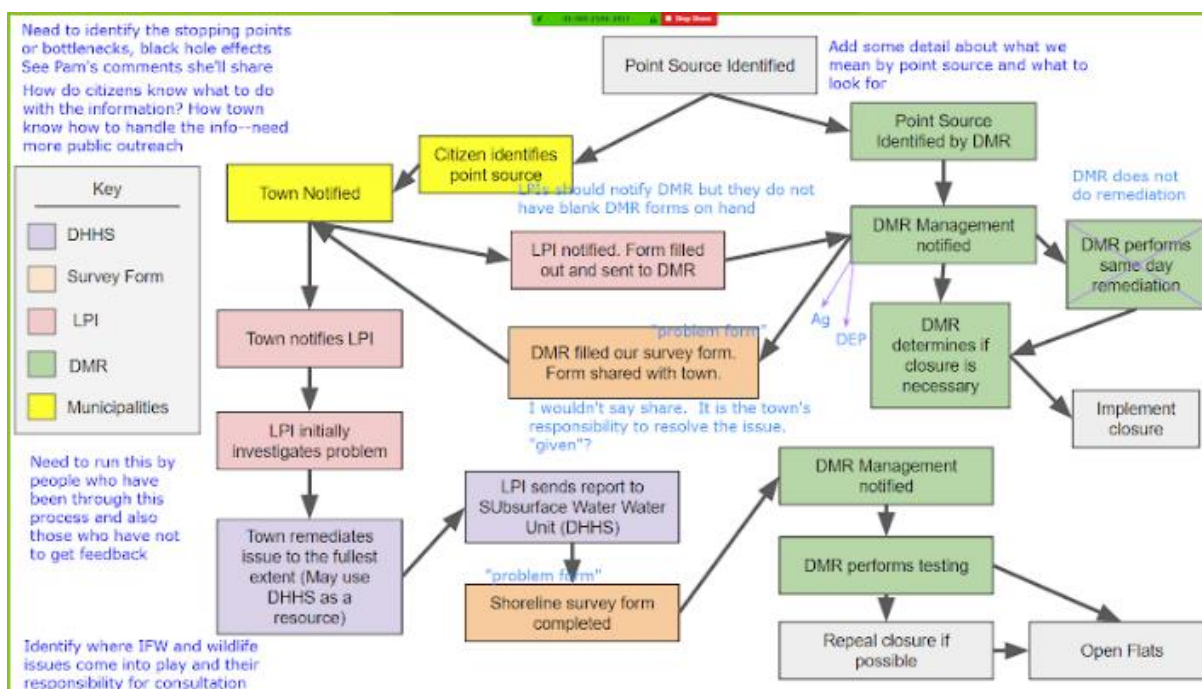
Figure 4.2. WQDT Meeting Three. Notes in blue were left by meeting participants after reviewing the figure. This is a screenshot from a zoom meeting which unfortunately has a lower resolution.

Throughout the summer of 2020, smaller informal conversations were had with individual members of the WQDT group, as well as municipal water quality project leaders. From these discussions additional elements were added, including links to relevant documents, contact information for specific state personnel, and others.

In October 2020, finalized versions were shared for a final round of edits. This included a final WQDT downloadable document that could be printed and shared easily with municipal managers or other interested parties. Additionally, the group was able to provide feedback on the webpages developed that were included in the MSLN website, the Mudflat (themudflat.com, Solet, 2022). Since that meeting additional conversations have been held related to these products, where updates have been made based on additional policy developments, or new contact information.

4.3.1.3. WQDT Influences and Outcomes

In the context of adaptive capacities, the WQDT has supported communication and transparency between municipal managers and state managers, influencing and improving information access (Folke et al., 2005) creating more accountability (Brewer et al., 2017) for state institutions in relation to water quality projects. In terms of information access, the WQDT contains information related to multiple state departments, their authority in the context of water quality issues. This document was presented at the state level during a Shellfish Advisory Council meeting in early 2021. During follow up discussions, this document has been used by state managers to share information with municipalities who are interested in engaging in water quality restoration work, and it has been cited on the DMR website. In terms of accountability, municipal shellfish committee have information (presented in the WQDT) about how and when to engage with state institutions at different stages of a water quality restoration project. With this information, municipal managers have an easier time asking state agencies questions related to water quality decisions and collaboratively plan remediation projects.

Additionally, the practices used to develop the WQDT contributed improved collaborative leadership (Gupta et al., 2010; Folke et al., 2005) and new learning capacities, including the discussion of doubts (Paul-Wostl, 2009) and improved institutional memory (Ostrom, 2005) related to water quality decision making. For example, the use of co-defined agendas, iterative meetings, and group activities contributed to a shared sense of authority and collaborative leadership. State agency members involved in the process cited that they learned more about their individual roles, and felt they had a better understanding of what municipalities were facing in the context of water quality restoration. In terms of institutional memory, the process of developing the WQDT created space for state agency members to reflect on the water

quality classification decision-process, determine gaps or pathways within it, and come to a shared understanding that could be communicated to municipalities. The practices embedded in the WQDT also influenced multi-actor and multi-level variety dimension of adaptive capacities (Armitage, 2008; Folke et al., 2005; Pahl-Wostl, 2009). However, this effect has been limited, most likely related to the overarching approach, which engaged state managers more directly, rather than a mix between municipal managers and state managers.

4.3.2. Drifter Buckets (DB) in the Georges River Estuary

Drifter buckets are an oceanographic technology first developed by MacDonald et al., 2007, and then redesigned for work within coastal mudflats (Hillyer et al., 2022, Figure 4.3). These buckets have been used more recently during a study within the Georges River estuary jointly conducted by myself and members of the Georges River Shellfish Committee (GRSC). This study was incorporated into an oceanographic model developed by Dr. Lauren Ross and myself, which has been used to answer additional questions about the estuary. As a boundary object, the drifter bucket helped facilitate trust in the oceanographic model. In the following sections I will describe the context for which the study developed, the method for using the drifter buckets in addition to other technologies, and the reception of the oceanographic model developed using drifter bucket results.

Figure 4.3. Drifter buckets in the field. The photos above show drifter buckets during deployment in Thomaston, ME. Photo credit: David Taylor

4.3.2.1. DB Context

The Georges River Estuary supports harvester livelihoods from multiple towns including Thomaston, Cushing, St. George, South Thomaston, and Warren, ME. Over the last few years, an area known as the "Bay" (Figure 4.4), has been classified as conditionally restricted by DMR to protect consumers from higher pollution scores. This means that a depuration company[39], or a specially certified company that has access to purging facilities in which shellfish may be kept and processed before sold, was able to harvest in this area, while other harvesters are unable year-round. This area is considered crucial by shellfish harvesters. It has been cited that while shellfish harvesters have a four-bushel limit in other harvesting areas, depuration companies do not. This led to perceived overharvesting[40]. Based on conversations with state managers, the Georges River shellfish committee focused on water quality related projects to resolve non-point source pollution sources, which could lead to a reclassification of the Bay. Projects included

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[39] At the time of this writing, there are two depuration companies in Maine.
[40] I was told that in one year, the depuration company had harvested over 80,000 pounds of shellfish.

developing education materials related to agricultural or lawn fertilization and dog feces. Additionally, the Georges River shellfish committee worked with Dr. Steve Jones at University of New Hampshire to conduct a DNA study. This study would serve as a basis to find non-point sources of pollution, unfortunately there were delays in receiving results.[41]
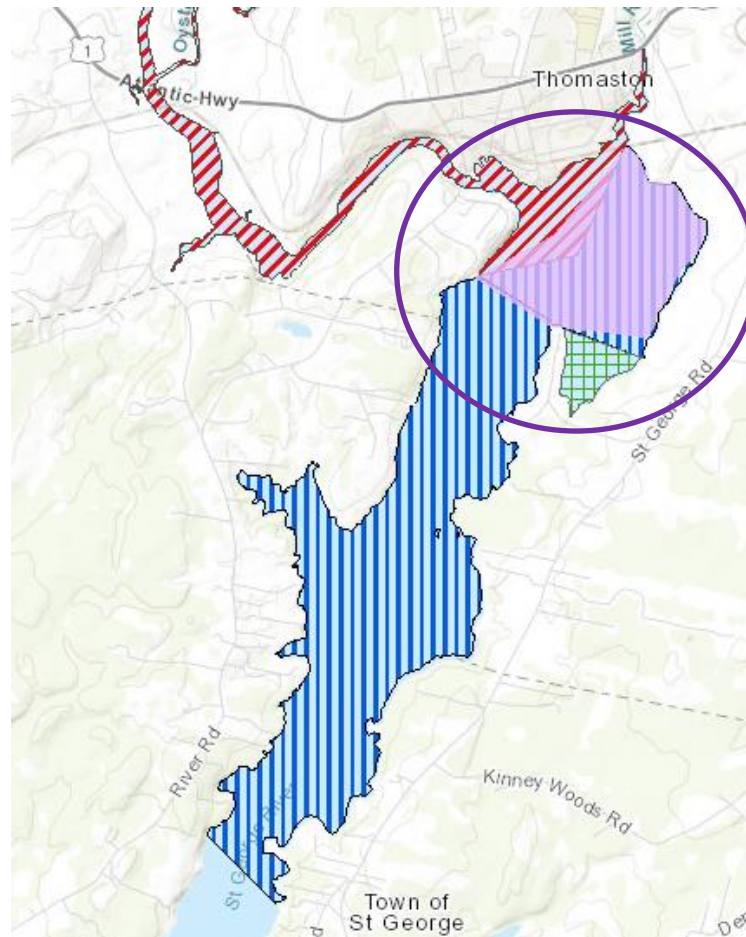
Figure 4.4. Georges River Closure Area Map. This map is downloaded from the Shellfish Closures and Aquaculture Leases Map | Department of Marine Resources (maine.gov). The area circled is the "Bay"

In the spring of 2019, the Georges River shellfish committee (GRSC) reached out to me and other members of the MSLN team to determine next steps in resolving water quality issues

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[41] Most of these delays were related to the pandemic, as well as the overwhelming sample number gathered by Thomaston, ME and many other municipalities. Every sample was sent to this lab, and this lab only. This created a bottleneck in which many towns experienced delays.

within the St. Georges River. During these discussions, the Georges River shellfish committee proposed developing a model like work that had previously done in Waldoboro, ME (Hillyer et al., 2022). Additionally, the GRSC had pursued and received an abatement from the state, so that no harvesting could occur in the Bay. The GRSC applied and received a MSRRF grant in 2020 to conduct the study, however it was delayed until 2021 due to the COVID-19 pandemic.

4.3.2.2. DB Processes and Practices

Drifter buckets were developed earlier during a project conducted in Waldoboro, ME, described in Hillyer et al., 2022. Drifters were deployed in and around the Bay, as well as other areas to understand the estuary. Deployment locations were based on conversations with harvesters who highlighted which areas they deemed most important. Additional locations were chosen based on initial releases. Drifters were deployed for 12-48 hours at different tidal schemes. Additionally, drifters were deployed collaboratively, where me and other harvesters went out at different tidal stages together.[42] In this way, the harvesters also recognized how the drifters were being used and could see how conversations with me shaped the research process. As drifter buckets were being deployed, Dr. Lauren Ross, Neil Fisher, and myself deployed an Acoustic Doppler Current Profiler (ADCP). An ADCP measures vertical profiles of horizontal currents. This ADCP was deployed to provide the model with a vertical dataset, as the drifter buckets only floated on the surface. ADCPs are a commonly used oceanographic technology but

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[42] Drifter buckets were deployed collaboratively. This often involved myself, and members of the GRSC on boats for an extensive amount of time, talking about the research as well as many other things. One day, the boat we were on broke down. Three different boats had to come out and help us back towards shore. I and the other harvester had been operating it with a few paddles and floated together for about an hour. During that time, we spoke about the weather, the model, as well as deeper topics such as religion, and our favorite meal. I was later invited over to try some homemade smoked mussels.

is made up of sensors that are not commonly understood. This ADCP was deployed during April and was left for three days.

As drifter buckets were deployed, tracks generated by individual releases were shared back with the GRSC. This often led to future conversations where I, and shellfish committee members, were able to talk about environmental factors impacting water direction and speed, how their hypotheses were being tested and largely found true, and how this information may inform future decision-making. As these datasets were incorporated into the model, I would drive back to Thomaston to share the results with the GRSC as well as members of the Joint Selectboard, which had members representing each of the five towns. This reiterative practice developed trust in me (as a frequent presence within the town) and in the model. During these meetings, harvesters would share additional questions they wanted to ask the model. I would then bring these questions back to Dr. Ross, who would develop new results for me to share back with the GRSC.

4.3.2.3. DB Influences and Outcomes

The DB project, specifically the drifter buckets and model had impacts on information access (Barnes et al., 2019) and multi-actor involvement (Pahl-Wostl, 2009). In general, the model and the bucket drifters contributed an improved understanding of how water circulation could impact shellfish populations, creating new information sources that municipal managers and state agency members could draw from to inform their decision making. Results from the model also provided the foundation for multiple discussions about vulnerability, particularly, which areas may be susceptible to bacterial pollution. This visioning process is evidence of anticipatory capacities (Kim et al., 2022; Tschakert and Dietrich, 2010), where the GRSC is now working with those susceptibilities in mind. The use of bucket drifters also contributed multi-

actor involvement, namely that researchers, municipal managers, and shellfish harvesters engaged in the research process. Consisting of a ten-gallon bucket, a GPS unit, a counterweight (usually a brick or bag of rocks) and a recycled lobster buoy, these buckets consisted of materials familiar to harvesters. This created transparency, where harvesters understood the technology being used for the research project.

The processes and practices embedded within the DB project have also influenced adaptive capacities. Specifically, multi-actor involvement (Pahl-Wostl, 2009), collaborative leadership (McGreavy et al., 2018), learning capacities (Folke et al., 2005), and legitimacy (Senecah, 2004; Cash et al., 2002). In terms of multi-actor involvement and collaborative leadership, the co-deployment, where harvesters worked directly with researchers during the deployment of monitoring equipment, created new relationships between research collaborators. Collectively, both harvesters and municipal managers that were part of the deployment, and researchers who provided the technology, were able to answer questions about findings from the later model, as they could collectively draw on shared field experiences. In the context of learning capacities, as state agency members were engaged to discuss the ongoing closure, municipal managers, shellfish harvesters and researchers had new opportunities to discuss their doubts, concerns, or agreements with the water quality testing process. This space was created because research collaborators had maintained connections with state agency members and kept them updated about the progress of the model. This space was also created because researchers chose to maintain that the model was owned, including the data from that model, by the GRSC, and so state agency members had to engage with the GRSC to get any information about the model. Finally, in terms of legitimacy, the acceptance and use of the model results in the water quality decision making by state agency members created a new air of legitimacy, where

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harvesters and municipal managers better understood the constraints of the testing mechanisms cited by state agency members, but also could connect their efforts with water quality decisions.

In terms of outcomes, this research contributed to the reclassification of the Bay. There were multiple meetings with DMR representatives where results from the model were shown. Results related to the Warren Wastewater treatment plant (which is near the Bay) (Figure 4.5), as well as results showing the circulation patterns in the Bay corroborated the reopening (Figure 4.6). In terms of the Warren wastewater treatment plant, DMR representatives asked myself and Dr. Ross to calculate the transport time between the plant and the Bay. After reaffirming that the model was property of the GRSC, and that the calculations would have to be approved by the GRSC, we proceeded to determine the transport time. Based on the calculations conducted by Dr. Ross, the transport time would average to about 3 hours and max ebb conditions in April (meaning the water was flowing as fast as environmentally relevant). Based on this flow data, DMR was able to support their decision to reclassify the by with a small closure related to the outflow of the wastewater treatment plan that would occur seasonally. With these results, as well as lower fecal coliform scores, the DMR reclassified the Bay starting in 2022.
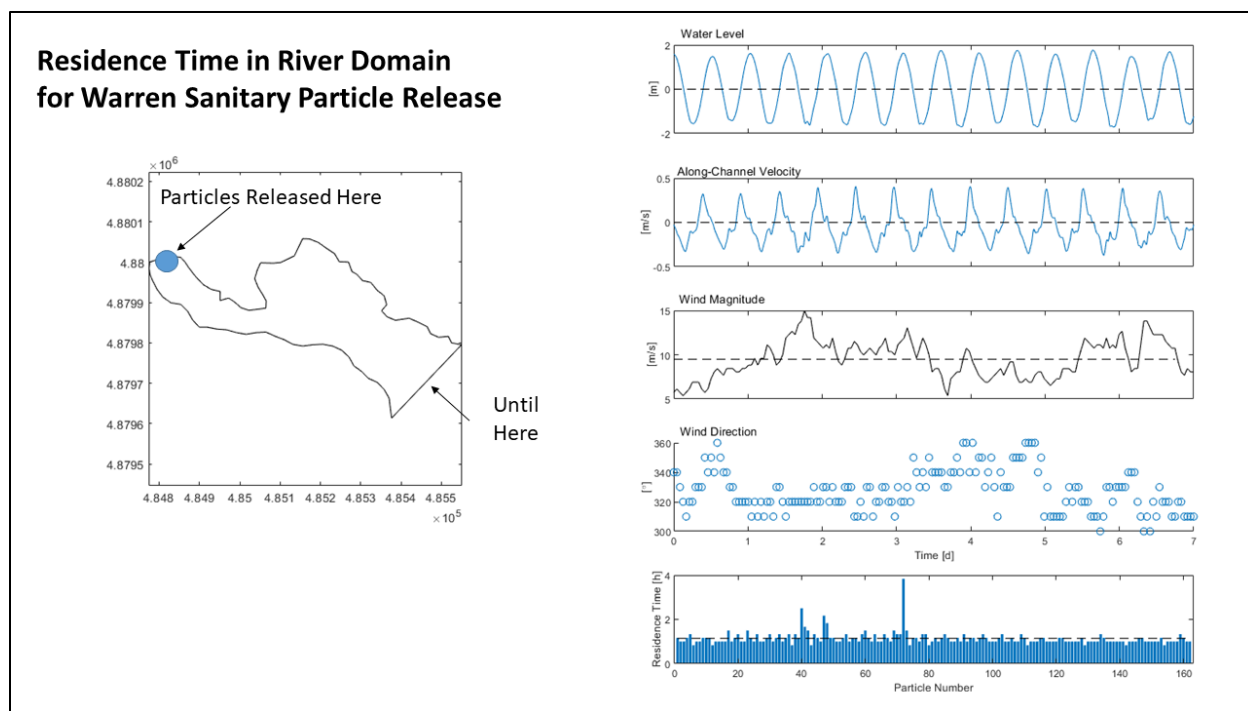
Figure 4.5. Residence and Transport Time Calculations for Warren Treatment Plan. Map on left highlights how particle releases from the edge of the model domain were tracked until entering the bay. Graphs on left from bottom to top show tidal stage, water velocities, wind magnitude, wind direction, and average time particles took to reach the Bay.

Additionally, these discussions generated new insights regarding shellfish population dynamics. The GRSC was very interested in spawning populations of shellfish, and if protecting the populations of shellfish in the Bay could increase populations downriver. This is a complex question, which involves future study related to biogeochemical dynamics, experiments that include the measurement of juvenile shellfish, as well as research into the density of spawn after a spawning event. However, the model can develop insights related to residence time, or how long water stays within an area. In this case, Dr. Ross ran multiple experiments with the model, showcasing how spat (juvenile floating clams) may circulate throughout the Georges River estuary.

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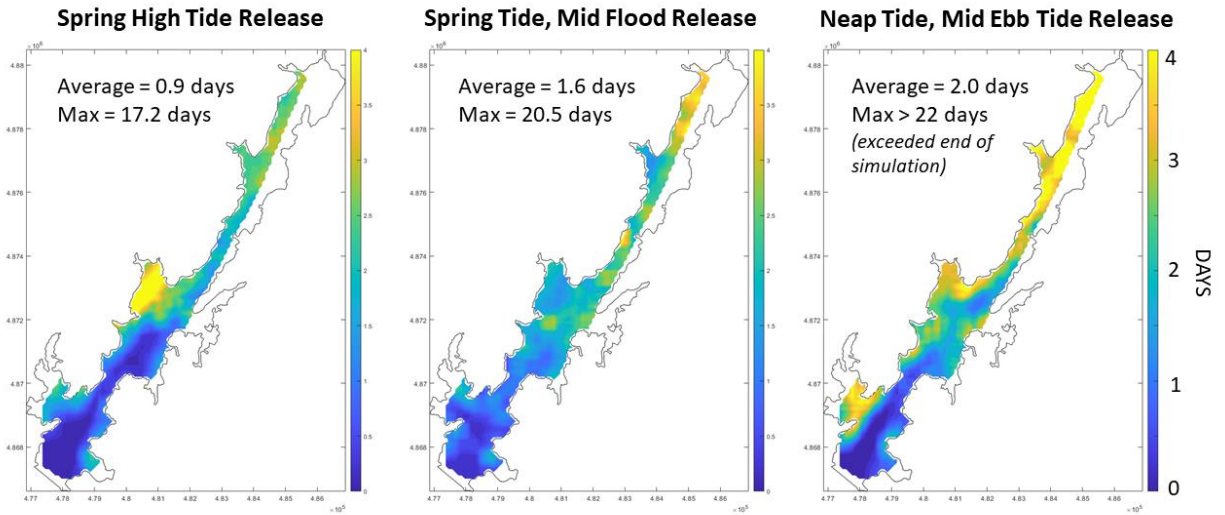
Figure 4.6. Residence Time Calculation. Each of these figures shows residence time in days under different tidal regimes, where lighter colors have longer residence times.

As shown in Figure 3.9, the average time particles representing spawn spent in the estuary was fairly low, generally around 2 days. However, the range in which particles persisted in the estuary was quite large, with a maximum of 22 days depending on tidal stage. This insight reinforced clammer conceptions about spat, namely that a portion of it, however small, may persist in the estuary and eventually settle. These insights were shared over a series of meetings during the winter of 2022-2023.[43]

In terms of relationships, this project initiated additional conversations with communities in and around the region related to oceanographic modelling as well as the deployment of drifters. For example, bucket drifters were cited during a DMR regional meeting in Belfast, ME on October 12, 2022. At this meeting, I was asked many questions about bucket drifters, how they shaped oceanographic models, how the GRSC has used the model to make decisions, and

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[43] These winter meetings were crucial in maintaining momentum related to shellfish restoration projects. For example, meetings held in January 2023 were held during a snowstorm. While most people would have stayed indoors, myself and Dr. Ross drove 2 hours to Thomaston, met with selectboard members, the Thomaston town manager, and other land trust and conservation group members, and presented these findings. During that meeting, 4 different people offered to house us overnight, pay for a hotel, or even follow us all the way back to Orono in their truck. One harvester made us some road snacks.

other questions. This led to other conversations with communities beyond Midcoast Maine (where both the Waldoboro and Georges River are located) about deploying drifters in their local waterways.

4.3.3. Limited Purpose Aquaculture Workbook (LPAW)

The Limited Purpose Aquaculture Workbook (LPAW) is the culmination of an ongoing collaboration between myself, members of the MSLN, shellfish harvesters, and state managers. Specifically, this workbook was developed to support municipal shellfish communities who must undergo the limited purpose aquaculture (LPA) license application process to develop conservation and restoration activities that use aquaculture technologies like upwellers or nursery trays, which are used to grow shellfish. In the following sections I describe the context for this collaboration, the process in which the LPAW was developed, additional materials that were developed based on this workbook and the research it represented, and the impact that boundary object and engaged methodologies had on how the LPAW was received.

4.3.3.1 LPA Context

As stated previously, municipal shellfish committees across the coast are engaging in restoration projects to develop applicable and localized solutions. More recently, restoration projects have been inhibited by the entanglement of multiple management structures related to Limited Purpose Aquaculture (LPA) permits. This is due in part to the use of technology traditionally used by aquaculturalists, now being used by municipal shellfish committees to sustain their wild harvest practices. This is also due in part to the difference in governance structures and institutions related to aquaculture and wild harvest shellfish management. For example, municipal shellfish programs are supervised by DMR Public Health, specifically the DMR Shellfish Management Program. Aquaculture and LPAs are instead managed by DMR

Division of Aquaculture.[44] Another example is the definition of aquaculture in Maine State laws, namely Chapter 2:

> "A. Aquaculture. "Aquaculture" means the culture or husbandry of marine organisms by any person. In order to qualify as aquaculture, a project must involve affirmative action by the individual to improve the growth rate, survivability or quality of the marine organism. **These activities do not include impounding lobsters, wet storage or activities conducted under the authority of municipal shellfish conservation programs in accordance with 12 M.R.S.A. §6671(3)(A)(3).**"

In the DMR's definition of aquaculture, it highlights an exemption for activities conducted under the authority of municipal shellfish conservation programs, which includes restoration activities. However, the restoration activities are limited to predator prevention and seeding, among others, not the use of upwellers. Because upwellers are seen as aquaculture technology, the DMR is limited to manage the use of these within the Division of Aquaculture, rather than the Bureau of Public Health[45]. The intersection of the two management structures, aquaculture and municipal co-management, have inadvertently created limitations on municipal conservation activities and created new interactions between the DMR Division of Aquaculture and shellfish committees. In this case, the easiest path for municipalities engaging with aquaculture is seemingly using the LPA, based on the low cost and shorter decision time (Table 4.3).

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[44] This was true at the time of the LPA Project. More recently (February 2023), it has been announced that the Division of Aquaculture will now be housed within DMR Bureau of Public Health.

[45] This is currently in the process of changing. As stated previously, DMR Aquaculture now falls under the umbrella of the Bureau of Public Health. This change, while recent and with some growing pains, has led to improved communication between DMR aquaculture and DMR Nearshore Fisheries. It is expected that this, coupled with policy developments later described, will improve the accessibility of the LPA license for municipalities.

Table 4.3: Comparison of Aquaculture Lease Types

Characteristic	Aquaculture Lease Type		
	Standard	**Experimental**	**Limited Purpose**
Application Fee	$1000-$1500	$100	$100-400
Space Allowed	100 acres	4 acres	400 square feet
Length of Lease	20 years	3 years	1 year
Turn Around Time	~120-300 days	~60-100 days	~60 days
Public Hearing?	Yes	Yes	No

This process is designed for experimentation by companies, not municipalities, which often exacerbates other municipal capacity limitations. For example, harvesters describe how limited municipal personnel, particularly personnel familiar with aquaculture regulations and application materials, have impacted their ability to pursue an LPA. Harvesters have also cited that this process takes an extensive amount of time, especially compared to other approval processes for municipal conservation work such as conservation closures that could be completed in a week or so working directly with DMR Area Biologists. Shellfish committee members have also cited how difficult it is to communicate with the DMR Division of Aquaculture the justification for these projects based on the current application process. This communication issue is compounded by the separation of the DMR Bureau of Public Health and the DMR Division of Aquaculture. In this case, municipalities are trying to engage in an unfamiliar management structure, with unfamiliar state government actors, and have had to wait a long time to do what they see as part of their shellfish ordinance and therefore, jurisdiction.

4.3.3.2 LPAW Process and Practices

Responding to several emergent conversations, I, along with Anne Hayden and Marissa McMahan at Manomet, developed an internship project during the summer of 2021 that could be collaboratively conducted as part of the National Research Traineeship (NRT) program. This project sought to address issues related to LPAs by achieving two overall research goals. First, we developed a collaborative guide for applying for LPA permits that incorporated shellfish harvester, aquaculture manager, and local manager feedback. Second, we developed a report to the Shellfish Advisory Council, a statewide committee that addresses policy concerns related to the wild clam and mussel fishery, with long term and short-term recommendations developed through the research process.

This internship occurred in three phases. First, we reviewed community-based aquaculture processes in Massachusetts, the LPA permitting process in Maine, and other spaces with similar co-management arrangements, and outlined the multiple legal frameworks supporting these efforts. Second, I conducted nine semi-structured interviews with shellfish harvesters, scientists, and local managers who had engaged in the LPA application process. During these interviews, I asked questions related to the application process, outcomes related to engaging in the LPA application process, and efforts related to improving the LPA application process. After thematically coding these interviews, our research team sorted recommendations into two categories, namely long-term and short-term, or those requiring major legislative changes or those only requiring changes in internal DMR policy. After this research was conducted and analyzed, our team met with multiple members of DMR Public Health, DMR Aquaculture, shellfish committee members, and others to share the information gathered through the internship, and collaboratively identify which recommendations could be acted upon within a

short time frame. Additionally, we developed a rough draft of an LPA application guide titled "The Limited Purpose Aquaculture Workbook". This included developing a PDF version, as well as created a series of online pages on the MSLN website, themudflat.org[46]. This workbook was shared back with research participants to gather feedback on clarity of language used, accessibility, and any additions still needed, which eventually included contact information for Area Biologists and DMR Aquaculture representatives. After iterative drafting and redrafting based on feedback, the final workbook draft was completed. A report to ShAC was developed in a similar manner, based on feedback from research participants and other interested harvesters (Appendix 3).

4.3.3.3 LPAW Influences and Outcomes

The LPAW influenced adaptive capacities such as information access (Barnes et al., 2019), and responsiveness (Pentz and Klenk, 2017). The LPA Workbook focuses on sharing information related to the application process. In this way, it functions as a type of repository boundary object as defined by Star & Grisemer (1989), geared towards municipal shellfish committees, but it could still serve anyone who is interested in applying for an LPA. The LPA Workbook and Report to ShAC also contributed to governance responsiveness and diversity of solutions, namely, it supports community driven adaptation using aquaculture technologies by providing clarity around the LPA application process and develops a diverse range of policy solutions by providing directionality and shared prioritization.

In the context of this project, engaged practices such as interviews, group meetings, and iterative sharing influenced leadership (McGreavy et al., 2018; Olsson et al., 2004), anticipatory capacity (Kim et al., 2022; Quay, 2010) and the capacity to improvise (Oestreich et al., 2019;

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[46] The pages can be found here: https://themudflat.org/limited-purpose-aquaculture-workbook/

Armitage, 2005). During the development of the Report to ShAC and the LPA Workbook, we worked extensively with state and municipal managers. In the context of leadership, these engagement practices contributed to an improved sense of entrepreneurship and collaboration. During this research project, shellfish harvesters who had not engaged in LPAs learned more about the process and had examples of what had worked in other communities. Additionally, state agency members had a better understanding of what municipalities are working with in terms of developing and conducting these projects, and in particular the value system focused on public good that is present in each municipal LPA. The practice of bringing state agency members and municipal managers into the same room, where they could hear from each other, has created a foundation where these institutions can work together to procure LPA permits and conduct research related to it. The process of engaging with ShAC, DMR representatives, and municipal managers also created a space for future planning, or anticipatory capacity, across the previously mentioned institutions. DMR representatives used the space created through iterative meetings to review the LPA application process, and plan for a future where more municipalities may engage in the process. Additionally, municipal managers were able to learn about strategies used by municipalities who have successfully applied for an LPA license.

Those involved in the initial drafting process have been able to maintain relationships, often working together to determine new avenues municipalities should take, and how LPAs may intersect with those efforts. For example, aquaculture managers have continued to work with municipalities such as Brunswick and Gouldsboro to determine how upwellers may be used to restore clam populations. This development relates to the capacity for municipalities to adapt and act in the face of shellfish population declines, as well as create new strategies to manage shellfish in their area.

In terms of outcomes, these documents and the processes embedded within them serve as a touchstone for multiple policy development efforts. First, short-term recommendations were discussed and implemented through updated DMR statute. For example, exemptions were adopted that removed limitations on helpers for LPAs held by municipal shellfish committee[47]. This means that projects developed by municipal shellfish committees that use LPAs would no longer have to name three specific people who can work on the LPA. This promotes community involvement and allows for municipalities to do things like invite school groups to engage with the project. Second, this Report to ShAC is cited in ongoing efforts related to implementing other short-term and long-term recommendations. For example, there are current collaborative policy efforts to exempt municipal shellfish committees from fees related to LPAs. In each of these policy efforts, the MSLN members who facilitated the original research and developed the Report to ShAC and the LPA workbook have been invited and cited during negotiations and discussions. This includes the recently passed LD 581, titled "An Act to Assist Municipal Shellfish Conservation Programs," which removes educational requirements for municipalities and creates fee exemptions for municipal LPA projects. This LD has been unanimously supported by the Committee on Marine Resources and will most likely be implemented in 2023[48].

4.4. Discussion

Each boundary object represents multiple engaged and facilitation efforts that responded to individual contexts and needs.[49] Additionally, each boundary object and the practices used to

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[47] During this process I submitted testimony in support of this exemption. It was my first-time drafting testimony as a researcher! (Appendix IV)

[48] As part of my efforts on this project, I testified "Neither for nor against" to share insights related to my research on municipal LPA projects during the public hearing on LD 581. My testimony is in Appendix IV.

[49] As stated during the drafting process, this reflects the diversity of estuaries, "Estuaries function differently and so do the needs of the people around them." – was said by one of my advisors during the editing process.

develop it have had different contributions to adaptive capacities. In this section, I discuss trends across all three cases, including methodological patterns, outcomes, and how the cases influenced adaptive capacities. Finally, drawing back to boundary object theory, I discuss how these cases represent new insights into engaged-research work, and, how relationships and practices used to develop boundary objects are integral to future conceptions of boundary spanning.

4.4.1. Patterns in Process

Each of the cases described above follows engaged research practices (Lang et al., 2012; Cash et al., 2002), where researchers and other collaborators actively shaped the research process (Stokols, 2006). This included practices such as iterative meetings and the use of familiar materials or language. As a result, the social spaces surrounding each of the boundary objects were collaborative, meaning individuals were able to create relationships, share information, and learn from one another (Lang et al., 2012; Stokols, 2006). In this section I will describe each of the common practices used across all three projects.

Each of the boundary object projects used iterative meetings to facilitate information sharing and create spaces for initial relationship building. Within the WQDT and LPA projects, meetings had a similar structure including spaces for open discussion, co-defined agenda items, and small group break out sessions. Iterative meetings within the DB project were a bit different, where I met with harvesters and shellfish committee members often on the dock before or after deployment in a less structured way. Later within the DB project, I was invited to meet with the Joint Selectboard, the entire Shellfish Committee, and present to an audience of shellfish harvesters and state agency members. During these meetings and others present in the LPA and WQDT projects, I was asked questions by the audience, shared my contact information and

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materials to illicit any follow-up, and co-defined next steps in the research process. These meetings were developed using specific relational practices. For example, meetings were scheduled for high tide or late evening so that harvesters did not have to miss a tide. When we met in person, a central location was chosen, which often meant that researchers were driving far to coastal communities. Meeting time was also reflective of each group involved. Meetings with state agency members during the WQDT were shorter, often one hour or less but happened more frequently, while meetings during the DB project happened less frequently, but could often take up to 2 hours. This consideration of time, both in scheduling and in length of meeting is common across each project.

The WQDT, LPA Workbook, and DB project used familiar materials and language for each collaborative research group. For example, the DB project used materials such as a ten-gallon bucket and recycled lobster buoy to develop the bucket drifter, which created a shared understanding of its purpose across shellfish harvesters and oceanographers and cultivated a sense of trust in the results of the model. The LPA workbook and WQDT was drafted and edited after multiple rounds of input from state agency members, shellfish harvesters, and others. This drafting process supported the emergence of a shared language, where each draft provided additional clarity and transparency about the terms used. For example, the term upweller, defined as a floating platform used to grow out shellfish, was negotiated between state agency members and shellfish harvesters, most especially because original definitions used by state agency members were tied to an economic outcome, rather than the ecological context the harvesters were focused on.

Collaboration often means the engagement of diverse voices and demonstrated listening practices to weave and consider each of those voices into broader efforts (Stokals, 2006).

Iterative meetings, familiar language, and the use of familiar materials each facilitated collaboration within the boundary object projects. They created shared spaces in which people could discuss the complexities of the issues, share information or insights, and learn collectively. These spaces and the resulting boundary objects influenced adaptive capacities, described in the next section.

4.4.2. Influence on Adaptive Capacities

Boundary objects serve as one approach to support processes such as learning, anticipatory planning, and information access. Each of the cases describe above have influenced adaptive capacities, including collaborative leadership (McGreavy et al., 2018), information access (Barnes et al., 2019), and multi-actor involvement (Pahl-Wostl, 2009). However, which adaptive capacities were influenced often differed between the product (the boundary object) and the social spaces or practices used to develop that boundary object. This trend exists across all three boundary object projects. In this section, I describe how each of the boundary object projects and the social spaces they embodied influenced leadership, information access, and learning capacities.

Leaders, meaning diverse individuals, institutions, or groups that foster action and collaboration as well as engage in future visioning (McGreavy et al., 2018; Folke et al., 2005), are supported in each of the cases presented. Leadership was connected to the relations created in social spaces surrounding the boundary objects. For example, during the DB project, we consistently identified the model as the GRSC model, rather than owned or affiliated with the University of Maine. This practice of decentering the researcher along with iterative meetings created spaces where local leaders could lead conversations about future restoration projects.

GRSC members also leveraged this model (and their ownership of the model) to discuss water quality classifications with state agency members.[50]

Information access was consistently influenced by each of the boundary spanning projects, specifically, the final product of each project. For example, the LPA and WQDT created more transparency around decision-making, specifically the intersecting powers between state departments and most importantly, who is involved in the decision-making process. The oceanographic model developed through the DB case also demonstrates new forms of information access. In this case, the model created computer-generated images of water circulation which now support community-based planning and water quality decisions. Importantly, this information access was enhanced in the LPAW case and the DB case because of the practices used to develop each product. For example, the model within the DB case was most likely incorporated into the GRSC decision-making process because of the familiar materials used in the drifter buckets, and the decision to co-deploy drifter buckets and ADCPs with members of the GRSC or other shellfish harvesters. This created trust, where GRSC members and shellfish harvesters could see how their actions fed into the model and could also connect more deeply with researchers through field work.

Each of these cases demonstrate how boundary objects can promote future-planning and learning capacities within a decision-making process. As described by Gupta et al., learning, "allows for changed understanding based on experiences," and are often connected to information access and anticipatory capacities (2010; p. 463). In each case, the final product and the practices used to develop that final product supports learning, most especially across

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[50] For example, the chair of the GRSC shared that he was able to talk with state agency members who previously would not return his calls about the Bay, because they called him to ask about model results. During these conversations, he was able to share insights from community-driven work that exceeded the DB project.

institutional boundaries. For example, municipal managers engaging with the WQDT could learn more about water quality decisions, plan how to respond to non-point source and point source pollution issues and connect with state agencies at different points during their restoration projects. The practice of gathering multiple state agency representatives in a room and asking them to sketch out their individual responsibilities together created shared learning across state agency institutional boundaries as well. This type of learning is also seen in the LPAW case. The product, the LPAW, shares information about the LPA application, and how that LPA can be used, so anyone, but most especially municipal shellfish committees, can reflect and determine if the application process makes sense for their community project. Beyond this, the connections developed between us, state agency members, municipal managers, harvesters, supported our collective learning, where each collaborator was able to learn more about the LPA application process, municipal struggles with the process, and the policy requirements to support this type of adaptation into the future. These connections led to a policy success, namely LD 581, as well as other informal changes. Before this project, attempted policy changes to support municipal governance on this particular issue had been denied at the state level.

Each boundary spanning project responded to a call for the development of relationships, specifically, supported or facilitated spaces where state agency members and municipal managers or shellfish harvesters could engage with each other on a specific topic. For example, the WQDT emerged as a response to the MSLN Priority Action #1, "Connect key actors in water quality decision making and shellfish project permit regulations." Once we connected these actors through facilitated meetings, the group collectively decided to create a product, or the WQDT. This is important, as it draws back to the gap in the literature described in the introduction. The boundary object projects' influence on adaptive capacities differs slightly

between the product itself, and the dialogical practices and relations developed before, during, and after the development of the product. For example, during the WQDT project, the initial solution described by the priority action item was relationships and connections across key actors, not a document or decision tool. It was only through that initial connection and group decision-making that the WQDT emerged.

4.4.3 New insights and future considerations

Each case above highlights how engaged research practices can be used to develop boundary objects. In the context of boundary object theory, there have been extensive studies related to how boundary objects are developed, types of boundary objects, and other aspects of the theory in the context of knowledge sharing and knowledge co-creation. But the primary focus has been on the object itself, centering the boundary object before considering any relationality, collaborations, or partners to support the learning within the product. These cases provide a new focus instead on how social spaces and relationships develop, which in turn lead to a specific object. Reflecting on the origins of each of the cases, the goal was to create relationships, facilitate conversations, or provide new information for decision-makers, *not develop boundary objects.* This orientation, which eventually led to the emergence of boundary objects, could be studied in follow-up explorations of boundary object theory, where a focus on the dialogical rather than the product could promote new insights into collaborative and engaged research.

This draws back to other nuances within boundary object theory, namely those that focus on practices and communication. Specifically, there are multiple important connections between boundary object theory, engaged research, and considerations of ecological dimensions of communication, such as the COVID-19 pandemic, political developments, and aspects of the environment such as geography, tides, and others. In this sense, each of the cases above

demonstrates how considerations of ecological dimensions can lead to more successful outcomes. For example, shifting shellfish populations and invasive species drove the initial LPA work, which ultimately turned into an open policy conversation that empowered local knowledge and decision-making. Further work could be done to describe how these considerations, specifically those related to rhetorical understandings of communication, happen during the boundary-object development project. When combined with considerations of engaged research, and shared ethics or practices, this could lead to more active identification and equitable development of boundary objects.

4.5. Conclusion

Each of these cases highlight how engaged-research approaches can create impactful boundary objects. The LPA Workbook, drifter buckets, and the WQDT each emerged from collaborative and inclusive spaces, developed through methods described above and outlined in previous chapters. Each of these objects had important outcomes. The model developed through the DB project and report to ShAC served as touchpoints for conversations across institutional boundaries, namely the DMR and municipal shellfish managers. Additionally, the WQDT created transparency across the multiple institutions involved in water quality decisions and water quality restoration. So, while each case serves as a good example of how engaged-research methods could be applied to develop boundary objects, they also highlight how the process in which boundary objects are developed, namely through iterative, equitable, and relational efforts, cultivate more impactful, long-lasting, and engaging boundary objects that can support adaptive capacities and anticipatory capacity within local and state institutions. Future efforts focused on improving learning, leadership, information access, and other similar communication-driven processes should focus on the process of developing equitable partnerships rather than focusing

on the product. As these cases attest, often boundary objects emerge naturally from such contexts.

CHAPTER 5

CONCLUSIONS

I beg you, to have patience with everything unresolved in your heart and to try to love the questions themselves as if they were locked rooms or books written in a very foreign language. Don't search for the answers, which could not be given to you now, because you would not be able to live them. And the point is to live everything. Live the questions now. Perhaps then, someday far in the future, you will gradually, without even noticing it, live your way into the answer. – Rainer Marie Rilke, Letters to a Young Poet

When I was designing this dissertation my original research question was, "How can scientists better support and engage with community-driven innovations in a fisheries context for a more adaptable and equitable future?" I have lived that question and each dimension of it over the last four years of my doctoral program. I haven't lived that question alone, which is how I came up with a short answer. Scientists can better support and engage with community-driven innovations for a more adaptable and equitable future by **developing and valuing relationships**.

This is apparent in each of my chapters. Chapter 2, which discusses frameworks and their impact on Indigenous sovereignty and knowledge weaving was developed in conversations with committee members, advisors, and other mentors. The Maine Shellfish Learning Network (MSLN) would not exist without my advisors, myself, and collaborators from across the coast who answered questions, responded to emails, and showed up at meetings and shared their ideas. Each of the boundary objects presented in Chapter 4 would not have been possible without collaborators who helped develop each of the products, and who agreed to sit with me and think collectively on those issues. Within each of these projects and beyond, I strived to listen to voices all around me, as a first step toward building relationships. I have spent time on mudflats, in conference rooms, in classrooms, in cars, in boats, in planes, on rivers, on islands, in labs, on Zoom, and so many other places with people and by myself. This time was dedicated to

engagement, where I was listening, considering, and working with people and ecologies around me, including the oceans, tides, mud, buckets, clams, and others, then weaving together insights across all these conversations.

That focus on listening provided the foundation to co-create things that didn't exist before in the wild clam fishery. Water quality classifications have been reconsidered in Thomaston, ME because of the collaborative work conducted by myself, David Taylor, and Lauren Ross, along with many other members of the Georges River Shellfish Committee. This effort has led to the reclassification of "The Bay" and the institution of a conservation closure, which should support shellfish populations in the Georges River for years to come. The Mudflat, as a virtual space, was designed by myself, my advisors, Katelin Moody, B Lauer, and so many others. This website serves as a one-stop-shop for anyone who is interested in learning about the wild clam fishery or ongoing community restoration projects and get resources to pursue community-level action. It has been cited in discussions with shellfish harvesters, municipal managers, and state agency members alike and has supported communication, information access and learning across boundaries in the fishery. The MSLN, an organization focused on learning, communication, and equity across the wild clam fishery, has uniquely served as connective tissue within the shellfish co-management system for the last four years. During each of those years, I co-facilitated meetings, took notes, and led multiple discussions about the emergent issues within the fishery. I also co-led multiple projects to address those issues which have influenced community-level adaptive capacities. This includes the LPA Workbook and Report to ShAC which led to successful policy changes such as LD 581, "An Act to Assist Municipal Shellfish Conservation Programs."

The relationality baked into each facet of my work will mean that progress will not stop. In the past, when I was an early graduate student, I was tasked by an advisor to "solve all the problems within the wild clam fishery." Of course, that's not possible. But I have made progress, co-creating solutions that have been implemented, and created momentum towards future solutions. The work, meaning the idea of solving problems within the wild clam fishery, isn't done. It's living, breathing, and changing shape every day. It may never be done. But, solutions are emerging and people are connecting, creating new spaces from which other solutions can emerge. Those relations, and the social fabric surrounding each of these projects, will outlive me. And that's exactly what it should do. As I leave this space for new adventures and opportunities, I'll carry my experiences and memories of my part in this work knowing it has influenced the people, places, structures, and environments around me.

Reflecting on this process, of building relationships, learning from diverse voices, and sharing my experiences to inspire others, I have one final story. On March 2, 2023, I headed to my last Shellfish Focus Day, a conference I had been attending for the last 7 years (first as a Master's student, now as a doctoral candidate). On this drive down to the Samoset hotel, I was joined by two fellow graduate students, one who had been working in the wild clam fishery for about two years, and another who had not engaged with the fishery at all. While we bemoaned the early drive, the snow, and described our collective snacks, I asked what each student was expecting. They made similar comments about how excited or nervous they were. After responding, they asked me my thoughts about the event, and I stated simply, "I'm a bit melancholy, I feel like this will be my last time at Shellfish Focus Day, which feels like the end of an era." This melancholy drove me to look quietly at the snow outside in the backseat, trancelike, while the other passengers talked about their lives. Upon arriving though, I felt at

ease. I knew all the ins and outs of this event, where to get my badge, where the bathrooms were, the best seat for hearing the panels, and other little bits I'll keep to myself. In between frantically writing notes, talking with folks, waving hello to others I realized I knew most of the people in that room. I knew every speaker; I knew all the state agency personnel that were there. I knew all the harvesters in attendance. I knew so many folks in the room that I felt a bit at home. More importantly, those folks knew me. They introduced me to newcomers as a multitude of different things; some titles include graduate student at UMO, the person working with Bridie and Tony, our resident expert, the girl with the buckets, our collaborator in crime, or my friend Gabby. At one point during this conference, I was asked by a filmmaker, "who should I speak with to understand Wabanaki perspectives on fisheries in Maine?" I shared coffee with state agency members while we talked about their website updates. I was pulled into a side room where one of my close friends Marissa McMahan, introduced me to someone who shared their green crab bisque with me out of a backpack. It was chaotic, informative, loud, and messy. But it wasn't stressful. I felt a sense of calm and ease. I knew what to do, how to do it. I also knew that while this may be my last Shellfish Focus Day, this would not be the last time I interacted or thought with any of the folks in this room.

That day was special, and I think it shows how I have fit into this fishery. I can safely say I am an expert in this fishery, but that expertise is the culmination of the relationships I have grown with along the way. It is built on being known by so many people within the fishery and most importantly, learning from them. I will carry these relationships with me forever. I hope that this relationality, the learning, support, and fun created from it, inspires other researchers to seek out similar networks, and learn from them.

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APPENDIX I. Key Evaluative Question Literature

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APPENDIX II. Literature Review Table

TABLE A.1. Literature Review Table

Framework	Type	References
Etaupmunk (Two Eyed Seeing)	Descriptive	Wright, A. L., Gabel, C., Ballantyne, M., Jack, S. M., & Wahoush, O. (2019). Using Two-Eyed Seeing in Research With Indigenous People: An Integrative Review. International Journal of Qualitative Methods, 18, 1609406919869695. https://doi.org/10.1177/1609406919869695
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	Application	Sylliboy, J. R., Latimer, M., Elder, A. M., & MacLeod, E. (2021). Communities take the lead: Exploring Indigenous health research practices through Two-Eyed Seeing & kinship. International Journal of Circumpolar Health (Online), 80(1). https://doi-org.wv-o-ursus-proxy02.ursus.maine.edu/10.1080/22423982.2021.1929755

TABLE A.1. Continued

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He Waka Taurua / Double Canoe	Description	Maxwell, K.H., K. Ratana, K.K. Davies, C. Taiapa, S. Awatere (2020) Navigating towards marine co-management with Indigenous communities on-board the Waka-Taurua *Marine Policy 111* http://doi.org/10.1016/j.marpol.2019.103722
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		Maxwell, K., Awatere, S., Ratana, K., Davies, K., & Taiapa, C. (2020). He waka eke noa/we are all in the same boat: A framework for co-governance from aotearoa New Zealand. Marine Policy, 121, 104213. https://doi.org/10.1016/j.marpol.2020.104213
	Application	Harcourt, N., Awatere, S., Hyslop, J., Taura, Y., Wilcox, M., Taylor, L., Rau, J., & Timoti, P. (2022). Kia Manawaroa Kia Puawai: Enduring Māori livelihoods. Sustainability Science, 17(2), 391–402. https://doi.org/10.1007/s11625-021-01051-5
Institutional Analysis and Development (IADF)	Description	Ostrom, E. (2011). Background on the Institutional Analysis and Development Framework. Policy Studies Journal, 39(1), 7–27. https://doi.org/10.1111/j.1541-0072.2010.00394.x
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TABLE A.1. Continued

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TABLE A.1. Continued

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Report for Shellfish Advisory Council concerning:

Limited Purpose Aquaculture Permits

Developed in collaboration with the Maine Shellfish Learning Network (MSLN) and Manomet

Introduction

This document contains the findings generated from a short-term research project conducted by Gabrielle Hillyer (Maine Shellfish Learning Network - MSLN) and Marissa McMahan (Manomet). The goal of the research project was to gather more information about limited purpose aquaculture permits (LPA) from a diverse group of participants.

This research responds to a number of conversations happening across the coast where municipalities are engaging in enhancement and conservation activities that require an LPA. Both the MSLN and Manomet decided to work together to create resources for municipalities as well as gather more information about the realities of the application process. This research had three goals: 1) develop a LPA Workbook, which goes into detail and serves as a guide for municipalities applying for LPAs; 2) develop subsequent web pages on themudflat.org (MSLN website) that create an online platform for the information in the workbook; and 3) interview key informants, as well as engage in many off-the-record conversations about the LPA application process to gather recommendations on how to improve it.

This report contains the recommendations and comments gathered during the interview and subsequent engagement process. They have been grouped into four different sections, an overview of recommendations, potential short-term changes to the application process as it stands now, longer term changes that could include legislative action, and finally additional findings and comments.

We would like to thank all the participants and collaborators who contributed to this project for their insight and time. Thank you!

For any questions about this report, please contact:

Gabrielle Hillyer - MSLN
gabrielle.hillyer@maine.edu

Marissa McMahan - Manomet
mmcmahan@manomet.org

Recommendations - Overview

Based on our outreach, interviews, and other conversations, it is agreed that LPAs create a hurdle for municipalities and scientists to conduct enhancement and conservation activities particularly in the intertidal. Recognizing that using structures requires an LPA under the current management system, municipalities vary in their capacity to take the time to fill out the application, as well the technological expertise required for various parts of the application. It is the hope that these recommendations when implemented could ease some of the burden for municipal shellfish committees in the current process. Alternatively, suggestions were made to create a unique process for municipal shellfish committees, creating a "municipal LPA" (m-LPA) which could be submitted to the DMR Municipal Shellfish Program as opposed to the DMR Division of Aquaculture.

Overall, it is recommended that a working group or subcommittee be formed to evaluate and when applicable, enact the changes described in this report. This working group could potentially consist of members of the Shellfish Advisory Council, municipal shellfish committee representatives, and state agency members although this is still being explored.

The quote below from one of our participants exemplifies this suggestion:

> "I think that when they started talking about aquaculture they were not thinking about municipal shellfish...So when they made these rules they didn't make the consideration for municipalities to have to do this, to think outside the box. And it needs to be revisited and it needs to be a serious discussion not with just DMR and the aquaculture committee. You need to have municipal shellfish programs involved to...make recommendations of what makes sense to them...I'm not using it [LPA] for profit. I'm not growing them out, and I'm not selling them on the open market. We're using them to replenish a resource." - Shellfish Warden

Changes - Short-Term

There were multiple recommendations made for short term changes that could support municipal shellfish committee applications. These include:

- Minimize payments for municipal shellfish committee applications, as well as extend the renewal process so that municipalities do not have to re-apply for LPAs every year

- Discuss the potential impacts riparian landowners may have on municipal LPAs and potentially develop a unique notification that highlights municipal jurisdiction and efforts (letters of support, etc.)

- Fast track municipal shellfish committee applications, particularly in seasons with numerous LPA applications from private individuals

- Create more standardization across the application process, including but not limited to: providing more clarity for what is required in the application; having more clarity around who is reviewing applications; and work to mitigate inconsistencies in reviewer comments (what is sufficient one time is not sufficient the next)

- Generate recommendations for municipalities on when to apply for fastest turnaround time

- Allow for students to be able to participate on municipal LPAs similar to LPAs that are run by university professors in order to facilitate community outreach within the context of conservation projects

- In general, remove limitations for the number of people listed on a permit and therefore legally allowed to touch gear in an LPA as municipalities do not always know how many harvesters may work on a project

Changes - Long-Term

During many of the interviews and follow up conversations, participants and collaborators brainstormed what a unique municipal LPA process could look like. The hope is that by creating a unique process, it can more closely reflect the co-management system municipalities have with the Department of Marine Resources (DMR) while still maintaining the required oversight for the use of structures in the intertidal.

In general, participants recommend creating a separate process that could improve turnaround time, as well as work within the DMR Municipal Shellfish Program as opposed to the DMR Division of Aquaculture. This could include:

- Change the definition of LPA to exclude 'public aquaculture' and add a municipal LPA lease type (M-LPA)

- Develop criteria for the M-LPA, including dimensions, structures, and similar criteria that could be developed collaboratively with a subcommittee of the ShAC and DMR

- Having Area Biologists or similar DMR Municipal Shellfish Program personnel be the reviewer for a M-LPA application as well as set up system for Army Corp approval

Additionally, it is the hope of the authors of this report that the working group previously described works to clear up "gray areas" of overlapping management and provide that

information to the larger shellfish community. These "gray areas" could include but are not limited to: more information on when municipalities are required to get an LPA for conservation activities, what defines aquaculture, ownership of the intertidal, and the municipal aquaculture permit process.

Comments and Additional Findings

Overall each interview, conversation, and observation generated unique and important information about how municipalities are engaging in the LPA process. Below, we have listed a few conclusions that should be considered in continuing conversations.

- There is growing frustration across the multiple groups, including state agency members, municipal managers, and other shellfish harvesters with the LPA process. It is recommended by all participants that this needs to be a priority for the Shellfish Advisory Council and the Department of Marine Resources.

- LPAs are not universally accessible to municipalities. A variety of collaborators and participants mentioned that the time and technical expertise required to fill out the application as it is now, makes the application inaccessible to municipalities with less capacity. Because conservation projects using upwellers, or similar aquaculture technology require an LPA, this inherently limits municipal conservation projects.

- Multiple participants mentioned that private property should mitigate the requirement for an LPA. This includes lobster pounds or the intertidal, when agreements with riparian landowners can be made.

It is the hope of the authors of this report that this document highlights the next steps to find solutions to the problems highlighted above. We feel this report can support future brainstorming and conversations centered on finding solutions and evaluating the short term and long term impacts of those changes.

APPENDIX IV: LPA Related Testimony

January 5, 2022

RE: Public Comment for Proposed Change to Ch. 2 2.90 Limited Purpose Aquaculture

To whom it may concern

My name is Gabrielle Hillyer (she/her pronouns) and I am providing comment on behalf of the Maine Shellfish Learning Network (MSLN) in support of the change to 2.90: Limited Purpose Aquaculture (LPA). The Maine Shellfish Learning Network has a mission to promote learning, leadership, and equity in Maine and Wabanaki wild clam and mussel fisheries. In alignment with this mission, we believe that this change will support municipal shellfish conservation and management.

Over the last year, the MSLN along with Manomet has engaged in collaborative and participatory research in order to provide support for municipal shellfish committees who are engaging in applying for limited purpose aquaculture leases (LPA). This research had three goals: 1) interview key informants, as well as engage in many off-the-record conversations about the LPA application process to gather recommendations on how to improve it; 2) develop a LPA Workbook, which goes into detail and serves as a guide for municipalities applying for LPAs; 3) develop subsequent web pages on themudflat.org (MSLN website) that create an online platform for the information in the workbook. Based on this research multiple recommendations were drafted including removing limitations on the number of shellfish harvesters, students or research participants that can work on a LPA held by a municipal shellfish committee meeting.

Based on this research, as well as follow up meetings with staff members of the Maine Department of Marine Resources Aquaculture Group, the Maine Department of Marine Resources Public Health Bureau, and the Maine Department of Marine Municipal Shellfish Management Group, we have recommended this proposed change, to exempt a municipality if they are the license holder from the number of individuals that can be declared as helpers, as a first step in alleviating the burden for municipalities engaging in the LPA process. Municipal shellfish committees are using LPAs in a unique way, to promote the conservation and restoration of wild shellfish populations across the coast. We believe this change will support these efforts moving forward.

Thank you.

Gabrielle Hillyer

5724 Dunn Hall, Room 438
Orono, Maine 04469-5724
Tel: 207 581-1283 or 207-581-1935
Fax: 207-581-1286
www.cmj.umaine.edu
www.umaine.edu

To: Committee on Marine Resources

From: The Maine Shellfish Learning Network

Re: Neither for nor against LD 581: An Act to Assist Municipal Shellfish Conservation Programs

To Whom it May Concern:

My name is Gabrielle Hillyer, and I am here providing informational testimony regarding LD 581: An Act to Assist Municipal Shellfish Conservation Programs.

I am here today on behalf of the Maine Shellfish Learning Network, an organization developed by myself, Dr. Bridie McGreavy, and Dr. Tony Sutton at the University of Maine that is focused on supporting communication and collaboration within Maine's wild clam fishery. Over the last four years we have conducted multiple engaged research projects focused on learning and understanding emergent issues within wild clam fishery, and it's our intention to share the findings from that research today as it relates LD 581.

As you likely know, the wild clam fishery is managed through a co-management system, where municipalities work with the DMR Nearshore Marine Resources Program to manage shellfish within intertidal mudflats. In this system, municipal shellfish committees are able to conduct restoration and conservation projects that support wild shellfish populations, including developing new solutions to complex issues such as predation or pollution. More recently, municipal shellfish committees have been trying to use aquaculture-related equipment such as upwellers to grow clams that they then seed onto mudflats, requiring a Limited Purpose Aquaculture (LPA) license.

However, many municipal shellfish managers and harvesters have described challenges in applying for and maintaining the necessary LPA license to do these projects. Over the last two years, our team has conducted research with state and local shellfish managers to understand the complexities of this issue. This work included a review of community-based aquaculture management practices in other states, key informant interviews, and meetings with state and local managers. Specifically, we worked with shellfish harvesters, scientists, selectboard members, municipal shellfish committee leaders, and members of DMR aquaculture, DMR Public Health, and others.

This work included numerous conversations with the stakeholders listed above about the LPA application process, and specifically what recommendations they would share about how to improve the process to support municipal shellfish conservation. Responses included: minimizing or removing the fees for municipal shellfish committee applications, allow for student participation on municipal LPAs to facilitate community outreach, exempt municipal shellfish committees from educational requirements required for LPA renewal, and remove limitations on helpers (or people who are legally allowed to touch gear on an LPA) for municipal shellfish committees as they are often working with volunteers who fluctuate through time. Of these, the most frequently cited recommendation was the exemption of municipal shellfish programs from fees related to LPAs. The majority of interviewees identified fees as particularly challenging due to the construction of municipal budgets. Additionally, interviews emphasized that while they had considered undergoing the process to get an LPA permit, they considered the fees as an impediment.

In addition, we gave multiple presentations to the Maine Shellfish Advisory Council about this research, shared technical documents that described these recommendations and gave information to towns trying to apply for LPAs for shellfish restoration. I brought print copies of these recommendations and can share them if you would like a copy. I could also share these electronically if you prefer.

Thank you to the committee members for considering this testimony. If there is anything I or my organization can do to be a further resource to the Committee we would welcome the opportunity. Finally, thank you for your investment in UMaine which makes my work possible.

Gabrielle Hillyer

Ph.D. candidate in EES: NRT Program

University of Maine Orono

Project Coordinator: Maine Shellfish Learning Network

Room 111B 5710 Norman Smith Hall

Orono, ME 04469

gabrielle.hillyer@maine.edu

APPENDIX V: Letter to Municipal LPA Holders

STATE OF MAINE
DEPARTMENT OF MARINE RESOURCES
21 STATE HOUSE STATION
AUGUSTA, MAINE
04333-0021

JANET T. MILLS
GOVERNOR

PATRICK C. KELIHER
COMMISSIONER

Via email to:

Greetings,

You are receiving this letter because your municipal shellfish program holds or has recently applied for a Limited Purpose Aquaculture (LPA) license for activities related to municipal shellfish conservation work. As you know, the law requires an LPA to conduct the suspended culture of organisms regardless of the overall purpose of that work. The Aquaculture Division is charged with processing LPA applications consistent with existing law and rule. Federal permits are also required for this work and the Aquaculture Division has established processes to help coordinate state and federal review of these projects.

The Department has received a lot of feedback from municipalities regarding the LPA application process and associated requirements. Specifically, municipalities have expressed concerns about paying the required application fee, completing educational requirements, and trying to effectively engage with the application process. I wanted to let you know that staff from programs across the Department are working to address these concerns and make changes to the LPA program.

Some of these changes are programmatic and do not require modification to statute or rule, which means they can be implemented in the near term. Other changes will require modifications to statute and rule, which requires additional time because there are formal procedures that must occur prior to any statutory or regulatory change taking effect. I have outlined these changes below, so you can get a sense of what I am referencing. I am also excited to announce that effective February 1, 2023, the Aquaculture Division has been moved to the Bureau of Public Health (BPH). This will further help streamline some of the changes noted below and leverage the expertise of staff within BPH.

AQ Programmatic Changes (Near term):
- Reach out to applicable holders that are renewing for 2023 and update the content/format of their LPA license. This way, everything is consistent, holders know we're working on addressing concerns, etc.
- Create an LPA application that is more tailored to the information we talked about collecting. For example, rather than having them list individual assistants we would have them select from categories of municipal affiliations (i.e. shellfish wardens, town staff, etc.)

AQ and BPH (Midterm):
- Creating process for towns to work directly with area biologists on development of applications so that the area biologists would conduct the initial review and work with them on making sure it was complete, etc. This would cut down on processing times, because AQ would likely be getting an application that contains all the requisite information.

Rule/Statute Changes (Longer term-statute changes are being pursued this legislative session):
- Exemption from the application fee.
- Exemption from the educational requirement.

We are currently working on the near-term changes noted above, which means any LPA you have renewed for 2023 will be reformatted. At the end of this letter is a draft of what the LPA license would look like for municipalities and an explanation of each field that is being updated. We are also working on updating the LPA application, so that it is more tailored to the work municipalities are conducting and reflects the exemptions we are pursuing. I am also aware that some municipalities have submitted new applications for 2023. We will be working with those applicants to ensure that these licenses are also formatted consistently, which will help streamline any subsequent renewals.

You do not need to take any additional action. Staff within the Aquaculture Division will contact you to update any existing LPAs in accordance with the new format provided below and will work to make sure any new licenses are reformatted accordingly. I wanted to let you know these changes are coming and that you can expect to hear from staff soon.

I recognize the changes listed above may not satisfy all concerns raised by the municipality, but the Department did consider all the concerns we have been made aware of and is moving forward with changes that are programmatic and legally feasible. We are looking forward to pursuing changes that make this process more streamlined for municipalities. Thank you for sharing your feedback and your patience as we work through these changes.

If you have any questions, please contact me.

Sincerely,
Amanda Ellis
Acting Director, Aquaculture Division
21 SHS
Augusta, ME 04333-0021
207-624-6573
amanda.ellis@maine.gov

2023 Limited-Purpose Aquaculture License
Expires December 31, 2023

Holder:
Pleasantville Shellfish Committee

Acronym: PVSC323

LPA Health Area: 5

Point of Contact:
John Sample
PO Box 01
Pleasantville, ME 0000
Johnsample@email.com
207-000-0000

Purpose: Municipal

Latitude: 43.820667N **Longitude:** -69.95096W

Outer Dimensions: 4'W x 50'L

Location:
North of Golden Road Bridge in Pine Tree
Narrows/Gable Sound, Pleasantville, Vienna
County

Assistants: Individuals authorized by the municipality to help conduct the activities.

Species: Hard clam (*M. mercenaria*)

Gear Type: shellfish tray racks and over wintering cages; soft bags, semi rigid bags, and/or floating trays

Gear Description: 6 floating cages (3' x 4.5' x 2') with 36 mesh bags inside (18" x 36" x 3") deployed on the surface April to December and sunk to the bottom December to April. Gear orientation is SW-NE.

Description of the Changes:

Holder: This field will list the name of the committee that holds the license.

Point of contact: This individual is the primary contact for the LPA. DMR staff would contact this person with any questions about the LPA, they would be sent information about renewal, etc. Please note that email is the primary method of contact, so this person needs to have an email account that they check regularly.

Assistants: Instead of listing individuals by name, this field would be restructured so that it covers any individual the municipality may elect to designate. This eliminates the need to send us updates and is intended to reflect the fact that more than three persons may help with the LPAs. However, we recommend that the municipality keep a record of the persons authorized to help with the LPA. This way, if there was an enforcement or other issue it would be clear who the municipality had authorized to participate in the operation of the LPA.

BIOGRAPHY OF THE AUTHOR

Gabrielle Hillyer was born in Las Vegas, NV in 1994. She was raised in Las Vegas and graduated from Bishop Gorman High School in 2012. She attended Boston University and graduated in Fall 2015 with a Bachelor's degree in Marine Science, minoring in Earth Science and Biology. She won the Lara Vincent Prize for Outstanding Undergraduate Research from Boston University. She moved to Maine and attended the Dual Degree University of Maine Marine Science Program in the fall of 2016. She completed a Master of Science degree in Oceanography and a Master of Science degree in Marine Policy in December 2019. In January 2020, Gabrielle began attending the University of Maine Ecology and Environmental Sciences doctoral program as part of the National Research Traineeship focused on Conservation Science. After receiving her degree, Gabrielle will be applying for the Knauss fellowship in Washington, D.C., where she hopes to focus on national policy development and its impact on localized fisheries. Gabrielle is a candidate for the doctoral degree in Ecology and Environmental Sciences from the University of Maine in May 2023.