ABSTRACT

Title of Dissertation:	**SHELLFISHERIES AND CULTURAL ECOSYSTEM SERVICES: UNDERSTANDING THE BENEFITS ENABLED THROUGH WORK IN FARMED AND WILD SHELLFISHERIES**
	Adriane Kristen Michaelis, Doctor of Philosophy, 2020
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As commercial shellfish aquaculture continues to expand in the United States (US), industry supporters promote the ability of bivalve shellfish to provide ecosystem services, suggesting aquaculture's potential to ecologically and economically supplement wild shellfisheries (Beck et al., 2011; van der Schatte Olivier et al., 2018). Within this discussion of bivalve-related benefits, sociocultural benefits are largely absent (Alleway et al., 2018). This oversight hinders industry growth as it: 1) ignores evidence suggesting sociocultural benefits are more salient to individuals than other types of ecological benefits (Daniel et al., 2012) and 2) does not acknowledge the high level of job satisfaction associated with fisheries-based livelihoods precisely because of their many linked sociocultural benefits (Pollnac & Poggie, 2006; Smith & Clay, 2010). It is reasonable to assume that shellfish aquaculture might provide similar benefits, but this has not been considered in aquaculture's promotion and development.

To address this lapse, this dissertation detailed sociocultural benefits related to aquaculture and wild shellfisheries using an ethnographic approach framed by ecosystem services. Three complementary studies blending semi-structured interviews, photovoice interviews, participant observation, and Q methodology were conducted, targeting US shellfisheries at three scales: 1) within the state of Maryland, 2) within seven total states in the Chesapeake Bay, Gulf of Mexico, and New England regions and 3) throughout the US. Results illustrated that cultural ecosystem services are important to individuals working with shellfish and were used to create the first comprehensive list detailing the benefits enabled through work with shellfish. Project participants perceived the value of these benefits differently, and views were most strongly linked to participant role in the industry rather than other attributes. Results showed that, for the most part, shellfish aquaculture was able to provide similar benefits to a wild shellfishery. Findings from this study are relevant to both shellfisheries promotion and management as results highlight not only the range of benefits enabled through shellfisheries, but also the diversity of views and values held by industry members. Additionally, this project provided an excellent case study with which to investigate the complexity of linked and changing ecosystem services.

SHELLFISHERIES AND CULTURAL ECOSYSTEM SERVICES: UNDERSTANDING THE BENEFITS ENABLED THROUGH WORK IN FARMED AND WILD SHELLFISHERIES

by

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Dedication

This dissertation is dedicated, first, to the many people involved in shellfisheries who gave their time and thoughts to this project while working hard to put food on the tables of others as well as their own. It is also dedicated to my field assistants, Ruca and Lucy, whose support never faltered throughout this adventure.

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List of Abbreviations

AL	Alabama
AK	Alaska
CES	Cultural Ecosystem Services
CICES	Common International Classification of Ecosystem Services
C/PES	Cultural/Provisioning Ecosystem Services
ES	Ecosystem Services
FAO	Food and Agriculture Organization of the United Nations
FFWCC	Florida Fish and Wildlife Conservation Commission
FL	Florida
GSMFC	Gulf States Marine Fisheries Commission
IPBES	Intergovernmental Platform on Biodiversity and Ecosystem Services
LA	Louisiana
MA	Massachusetts
MA DMF	Massachusetts Division of Marine Fisheries
MD	Maryland
MD ACC	Maryland Aquaculture Coordinating Council
MD DNR	Maryland Department of Natural Resources
ME	Maine
MEA	Millennium Ecosystem Assessment
MS	Mississippi
MS DMR	Mississippi Department of Marine Resources
NC	North Carolina
NJ	New Jersey
NOAA	National Oceanographic and Atmospheric Administration
NY	New York
PA	Pennsylvania
PCA	Principal Components Analysis
PES	Provisioning Ecosystem Services
RES	Regulating Ecosystem Services
RI	Rhode Island
RI CRMC	Rhode Island Coastal Resources Management Council
RI DMF	Rhode Island Division of Marine Fisheries
RSES	Regulating and Supporting Ecosystem Services
SES	Supporting Ecosystem Services
TEEB	The Economics of Ecosystems and Biodiversity Project
US	United States
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
VA	Virginia
WA	Washington

Chapter 1: An Introduction to US Shellfisheries and Cultural Ecosystem Services

Rationale

Bivalve shellfish are documented providers of ecosystem benefits. As ecosystem engineers, their associated benefits are frequently cited to promote the continued development of shellfish aquaculture, the farming or cultivation of shellfish, in the United States (US) and elsewhere (e.g., Beck et al., 2011; Coen et al., 2007; Grabowski & Peterson, 2007; Grabowski et al., 2012; Northern Economics, Inc. 2009; van der Schatte Olivier et al., 2018). Within this discussion of bivalve-related benefits, sociocultural benefits are largely absent (Alleway et al., 2018). This oversight is problematic for several reasons. First, sociocultural benefits are important, and potentially more salient to individuals than other types of ecological benefits (Daniel et al., 2012; Gould et al., 2015; Milcu et al., 2013). Second, fisheries-based livelihoods are notable for their many linked sociocultural benefits that contribute to high levels of job satisfaction and well-being relative to other jobs (e.g., Acheson et al., 1980; Gatewood & McCay, 1990; Pollnac & Poggie, 1988; Poggie & Gersuny, 1974; Pollnac & Poggie, 2006; Smith, 1981; Smith & Clay, 2010). It is perhaps reasonable to assume that shellfish aquaculture might provide similar benefits, but this possibility has not been adequately considered in shellfish aquaculture's promotion and development. This dissertation research aimed to address this lapse and detail sociocultural benefits related to shellfish aquaculture as well as wild shellfisheries through an ethnographic exploration, initially centered on oyster aquaculture.

Ecosystem benefits are discussed in this dissertation using the ecosystem services framework. Though the concept of ecosystem services was introduced earlier, the commonly used framework was established with the Millennium Ecosystem Assessment (MEA, 2005). Ecosystem services are the benefits people obtain from ecosystems (MEA, 2005). They are categorized into four types and are generally defined as follows:

- **Cultural ecosystem services (CES)**: the nonmaterial benefits people obtain from an ecosystem.
- **Provisioning ecosystem services (PES)**: the products obtained directly from the ecosystem.
- **Regulating ecosystem services (RES)**: the benefits received through regulation of ecosystem processes.
- **Supporting ecosystem services (SES)**: those services necessary for the production of other services.

These categories of ecosystem services will be detailed in Chapter 2, along with more recent developments beyond the MEA related to the ecosystem services framework. Overall, the framework provides a means of incentivizing good resource management by highlighting and typically valuating the goods, benefits, and services provided by an ecosystem. Often, however, services that do not lend easily to monetary valuation, particularly cultural ecosystem services, are given limited attention (Chan et al., 2012a). This is also true as it relates to bivalve shellfish (Gentry et al., 2019; van der Schaate Olivier et al., 2018). The ecosystem services framework was selected to underpin this dissertation precisely because it is so prevalent in discussions of bivalve shellfish aquaculture (e.g., Alleway et al., 2018; Carranza et al., 2009; Castilla et al., 2007; Coen et al., 2007; Dumbauld et al., 2009; Gentry et al., 2019; Higgins et al., 2011; Humphries et al., 2016; Plew et al., 2005; Rose et al., 2014; Tallman & Forrester, 2007; Tang et al., 2011; van der Schaate et al., 2018). Operating within the same framework allows greater opportunity for results and recommendations to be considered by resource managers, shellfish biologists, and others involved in the direction of US shellfisheries.

Cultural ecosystem services (CES) were the focus of this research, and represent one conception of sociocultural benefits. As introduced, wild fisheries provide an array of sociocultural benefits that many other professions do not, and these benefits have been detailed as they relate to perceived job satisfaction and well-being (e.g., Kaltenborn et al., 2017; Pollnac & Poggie, 1988; Pollnac & Poggie, 2006; Smith, 1981). ‘Wild fisheries’ is used here and throughout this dissertation to describe public commercial fisheries that rely on wild harvest or capture. Typically, individuals working in wild fisheries self-identify as commercial fishermen and women, or similar regionally-specific terminology, and are licensed to target particular species using approved gear. In addition to job satisfaction and well-being, social scientists have approached fisheries-related benefits through discussions of different types of capital, cultural benefits, cultural values, social values, cultural dimensions, as well as cultural services (See Chapter 4 for detail and complete references.). Though these studies may be framed using different terminology and theoretical approaches to discuss benefits, all emphasize that fisheries-based work entails certain features and experiences that enhance these benefits relative to other work. Characteristics unique to fisheries-based occupations include local heritage, place identity, adventure, challenge, independence, and many others as discussed in Chapter 4 (e.g., Apostle et al., 1985; Bryce et al., 2016; Paolisso & Dery, 2010; Smith & Clay, 2010). This begs the question, does shellfish aquaculture possess similar characteristics, and likewise provide comparable benefits?

This question is especially relevant to US shellfisheries because throughout the US, many wild fisheries are reduced relative to historic populations (Beck et al., 2011). At the same time, public demand supports the continued growth of the US shellfish aquaculture industry in most coastal states (USDA, 2018). The number of mollusk farms in the US has increased from 756 to 884 between the 2013 and 2018 USDA Aquaculture Censuses (USDA 2013, 2018). For the purposes of the Census, the USDA (2018) defines an aquaculture farm as "any place from which $1,000 or more of aquaculture products were produced and sold or produced and distributed for restoration, conservation, enhancement, or recreation during the census year" (p. V). These farms produce oysters, clams, mussels and other mollusks. Annual sales increased from $328.6 million to $441.8 million between 2013 and 2018 (USDA 2013, 2018). Oyster farms represent the largest component of this industry in both number of farms and annual sales.

Shellfish aquaculture is presented as an alternative or complementary livelihood to wild shellfisheries in many areas. Yet, previous work has shown that the attraction and satisfaction associated with wild fisheries is such that commercial harvesters will stay in a wild fishery even when it does not make economic sense (Pollnac & Poggie, 2006). Thus, for shellfish aquaculture to be a realistic option for existing shellfishermen and women, it must have a similar appeal and match the benefits experienced through work in a wild fishery. Even though shellfish aquaculture production continues to grow, it faces obstacles and does not expand unchecked. Regulatory hurdles, particularly for states with newer industries, represent one challenge, but public opinion may be equally problematic.

Community or social acceptance can greatly limit opportunities for fisheries, both wild and aquaculture (Knapp & Rubino, 2016). This is true even in communities historically supported and identified by commercial fisheries (Northern Economics, Inc., 2009; Shumway et al., 2003; Smaal & van Duren, 2019). In cases where existing ecological benefit arguments have not prevailed, showcasing the cultural benefits or cultural ecosystem services may help. With these thoughts in mind, this project involves a series of objectives, detailed below.

Dissertation Objectives

This dissertation research was framed by four guiding questions:

1. Are cultural ecosystem services important to individuals working with shellfish?
2. What are the cultural ecosystem services obtained through work in shellfish aquaculture?
3. Are some services and benefits more important or valuable than others, and what drives these perceived values?
4. Can shellfish aquaculture provide the same types of cultural ecosystem services as wild fisheries in similar systems?

A mixed-methods approach was used to answer these questions, relying on large scale ethnographic fieldwork paired with Q methodologically driven surveys and analyses. Three studies, presented here as three separate chapters, were undertaken at multiple scales: within a single state (Chapter 3), across multiple regions (Chapter 4), and nationwide (Chapter 5). Together, these studies respond to the questions posed and contribute to the advancement of knowledge in both a theoretical and applied context.

Theoretical Relevance

Theoretically, this research extended development and application of the ecosystem services framework at large. It centered on resource-based livelihoods, specifically shellfish-based livelihoods, because discussion of ecosystem-based practices has been demonstrated as an effective means to elicit cultural services (Gould et al., 2015). Throughout the dissertation, ‘livelihood’ is used in place of the more general ‘employment’ or ‘occupation’ to emphasize the significance of this type of work to the majority of participants. As will be illustrated, and as is typical of fisheries-based livelihoods broadly, this work is more than ‘just a job’ for participants and represents a way of life that provides benefits beyond income.

With shellfish aquaculture as its focus, the project enabled a rich description of cultural services that, through specific examples and expanded discussion, contributed to equally rich conceptions of cultural services and benefits. It also provided the opportunity to investigate topics related to ecosystem service complexity, particularly the effects of a dynamic social-ecological system on ecosystem service delivery. Thus far, there has been inadequate treatment of changing services in a social-ecological system and some argue that this is the key factor in adequately assessing ecosystem services (Chan et al., 2012b; Small et al., 2017). As a system changes, be it via some sort of biophysical catalyst such as increasing water temperatures or a social catalyst like a change in a fishery’s catch quota, associated ecosystem services are likely to change also. The continued growth of shellfish aquaculture across the US represents one part of an integrated series of system changes.

In many areas, shellfish aquaculture developed as an alternative to local fisheries that experienced dramatic catch declines or extremely restrictive regulations. Providing alternate sources of income as well as seafood, regulatory and policy changes have enabled opportunities for shellfish aquaculture. The expanding industry will have cascading effects on the system, including its ecosystem services. Expansion of shellfish aquaculture involves an increase in the direct ecosystem services provided by shellfish as more shellfish are present in the water, but how might indirect services be affected, and how might this affect human communities within the system? Shifting livelihoods and livelihood opportunities from a wild fishery to aquaculture may entail a different suite of cultural ecosystem services. Potential exists for both enhancement and diminishment of cultural services with a transition into shellfish aquaculture, as documented in other shifting livelihood and landscape change studies (Auer et al., 2017; Dwire 1996; Garrity-Blake, 2000). As such, the expanding US shellfish aquaculture industry provides an especially useful case study with which to investigate social-ecological change and ecosystem service delivery.

This dissertation research also extended analysis and discussion of linked ecosystem services. Within the ecosystem services framework, individual services are inherently linked and dependent to some extent on other services for their provision (Costanza et al., 1997; Turner & Daily, 2008). It is argued that this is especially true for cultural services, and for some, it is justification to remove cultural services from the framework (Fisher et al., 2009). These linkages are only problematic if one is attempting to tally or quantitatively valuate ecosystem service delivery. Though this project did not involve ‘ecosystem service accounting,’ its ethnographic approach provided rich detail regarding how individuals perceive ecosystem services and illustrated their complexity and integration. It is only through such an approach that cultural ecosystem services and their potential links can be adequately understood.

More broadly, this research contributed to the expansive body of literature within fisheries anthropology and did so in a way that encourages engagement with other disciplines. By injecting anthropology into ecosystem services discussions, researchers studying shellfish-oriented systems will have the opportunity to engage with different methodologies and framings of ecosystem services, ideally contributing to a more comprehensive understanding of bivalve shellfish and ecosystem services.

Applied Relevance

From a more applied perspective, this project focused on benefits associated with shellfisheries. As such, it emphasized the positive aspects of shellfisheries and what they mean to individuals and communities. Results are useful for promotion of both wild and farmed industries. End products from this research provide rich details, engaging quotes, and striking photos created by participants. Sharing these sorts of data and outcomes may be more compelling than nitrogen sequestration for some communities and individuals (ElShafie et al., 2018; Moezzi et al., 2017; Moloney & Unger, 2014). Stories and imagery, paired with supporting data, will serve to highlight the people behind shellfisheries and shellfishing communities, encouraging industry support.

A further extension of this project relevant to industry application involves the outcomes related to wild and aquaculture shellfisheries distinctions. Results illuminate the extent that benefits provided by aquaculture are similar to a wild fishery and industry promoters can use that to encourage participation by wild harvesters. At the same time, the results highlight particular benefits that aquaculture may not match. This awareness is useful so that commercial fishermen and/or communities considering aquaculture can have a realistic expectation of the sociocultural implications of a livelihood transition into aquaculture. They may opt to adjust or compensate with additional activities to fulfill absent or diminished benefits.

With emphasis on management and policy decisions, this research helps to better understand how values are shaped relative to shellfisheries. Data highlights the nuances guiding viewpoints relative to shellfisheries and shellfish management, and underscores the idea that resource managers must acknowledge and respond to multiple value-systems shaping the perspectives of stakeholders. Resource managers and policy-makers can use these data to understand possible stakeholder responses to regulatory changes and ideally be inspired to account for multiple sets of values when making management decisions.

Dissertation Overview

This dissertation is presented as a series of five additional chapters followed by an appendix. **Chapter 2: The Ecosystem Services Framework and Shellfish** provides background information on the ecosystem services framework. It summarizes the history of the framework's development as well as its associated critiques and challenges. This chapter also provides an overview of the ecosystem services documented in association with bivalve shellfish. In doing so, it illustrates the relevance of the ecosystem services concept to discussions of sociocultural benefits associated with shellfisheries. The shellfish-associated cultural services summarized in this chapter were also used as the foundation from which to expand the understanding of shellfish and cultural services in chapters 3 and 4.

The next three chapters each present separate studies designed to collectively answer the research questions previously introduced. **Chapter 3: The Role of Ecosystem Services in the Decision to Grow Oysters** investigates whether ecosystem services influence decision-making when individuals choose to enter the shellfish aquaculture industry, with a case study of Maryland oyster growers. This study framed responses to the question, “Why did you get started in oyster aquaculture?” under a lens of ecosystem services to understand if shellfish growers consider ecosystem benefits when making that livelihood choice, either consciously or subconsciously. As a component of this study, the prevalence of different types of ecosystem services in participant motivations – cultural, provisioning, regulating, and supporting – were evaluated.

Chapter 4: Cultural Ecosystem Services Enabled through Work with Shellfish presents a study that detailed the cultural ecosystem services obtained and created through work with shellfish in three different industry roles. Semi-structured interviews paired with photovoice interviews were employed in the Chesapeake Bay, Gulf of Mexico, and New England with shellfish growers, wild harvesters, and others in roles supportive to shellfisheries. The resulting list described not only cultural ecosystem services, but also provisioning, regulating, and supporting services with their associated benefits. This study highlighted the complexity associated with linked services and how the delivery of certain benefits may shift with a transition from wild shellfisheries to aquaculture. In this chapter, methods were also compared to evaluate the utility of photovoice and semi-structured interviews to elicit cultural services.

The final study is **Chapter 5: Evaluating the Benefits of Shellfisheries**. This study utilized the list of benefits presented in Chapter 4 to conduct a nationwide survey using a Q methodological approach. It aimed to understand how individuals involved in shellfisheries-based work perceive and value related benefits. Again focusing on three industry roles (shellfish growers, wild harvesters, and industry support), this study compared Q sort ranking patterns to deduce whether different viewpoints existed within the sample population relative to the importance of benefits. Understanding these viewpoints and the relative importance of different benefits is critical to holistically conceptualizing the value of shellfisheries for individuals and communities.

Chapter 6: Conclusion summarizes each study's findings and extends discussion of the implications of this work. It also relates challenges associated with individual studies and how this dissertation research can be transitioned to subsequent research.

Following the standard chapters is an appendix. **Appendix 1: List of Ecosystem Services Enabled through Work with Shellfish** presents all services and benefits discussed in interviews. Each benefit is presented with: 1) an example quote, 2) an overall summary, 3) how the benefit was discussed in interviews, 4) linked services, 5) perceived diminishment or enhancement of the benefit with a shift from wild fisheries to aquaculture, 6) the frequency of mention, and 7) its related Q sort statement

Overall, this dissertation research describes the findings of a substantial ethnographic effort and its results contribute not only to ongoing conversations surrounding the application and conceptions of ecosystem services, but also bring to focus the multitude of benefits that active and healthy shellfisheries can provide to individuals and communities.

Chapter 2: The Ecosystem Services Framework and Shellfish

This dissertation is structured using the ecosystem services framework, both in the development of methods and interpretation of results. This section provides an overview of the framework, including critiques, and highlights its relevance in detailing the sociocultural benefits associated with bivalve shellfisheries. In addition, it introduces how this dissertation research responds to existing framework critiques and challenges.

The Ecosystem Services Framework: A Brief History

Although discussion of the relationship between humans and nature began much earlier, the first description of the ecosystem delivering 'services' to humans was in the 1970s (Lélé et al., 2013; Mooney & Ehrlich, 1997; Study of Critical Environmental Problems, 1970; Wilson & Matthews, 1970). This initial list of 'environmental services' linked to ecosystem function included: pest control, insect pollination, fisheries, climate regulation, soil retention, flood control, soil formation, cycling of matter, and composition of the atmosphere (Mooney & Ehrlich, 1997). Holdren and Ehrlich (1974) added maintenance of soil fertility and maintenance of a genetic library, and the list was subsequently referred to as 'public services of the global ecosystem' (Ehrlich et al., 1977), 'nature's services' (Westman, 1977), and eventually 'ecosystem services' (Ehrlich & Ehrlich, 1981; Ehrlich & Mooney, 1983).

Since its introduction, the concept of ecosystem services continues to be refined (Balvanera et al., 2014; Small et al., 2017). Early understandings focused on features of the biotic environment that are essential for human survival (Ehrlich & Mooney, 1983; Lélé et al., 2013). This approach expanded to include indirect benefits that humans acquire from ecosystem functions and placed ecosystem service benefits as something distinct from the value of biodiversity conservation for its own sake (Lélé et al., 2013). Lélé at al. (2013) discuss this as the 'conservation biology approach', which emphasized the effects of biodiversity loss on ecosystems, and ultimately on humanity.

Consideration of ecosystem function expanded into discussion of the associated value of ecosystem services, with interest from the field of environmental economics (Gómez-Baggethun et al., 2010). An 'environmental economics approach' developed in parallel to the 'conservation biology approach' and focused on human dependence on the environment along with the link between human actions toward the environment and well-being (Lélé et al., 2013). The field of ecological economics arose in the 1980s and, with its emphasis on ecosystem services, provided a way to bridge the gap between ecosystem ecologists and environmental and resource economists (Costanza et al., 2017). As ecosystem services became a more prominent area of interest, attempts to quantify their economic value did also, with shifts from emphasis on biodiversity conservation to valuation, monetization, and potential payment for environmental services (e.g., Child, 2009; Costanza et al., 1997; Costanza & Daly, 1992, Daly, 1997; Gómez-Baggethun et al., 2010; Kosoy et al., 2009; Martínez-Alier, 2002; Perrings et al., 1992; Soma, 2006; Vatn & Bromley, 1994). This shift and its associated concerns are discussed further within the "Critiques" section of this chapter.

More recently, a series of international ecosystem service initiatives have put ecosystem services at the forefront of resource management and policy discussions, namely the Millennium Ecosystem Assessment (MEA), The Economics of Ecosystems and Biodiversity project (TEEB), and the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) (Lélé et al., 2013; Sukhdev, 2008). These initiatives have not emphasized the monetization of services, but instead promote a broader consideration of ecosystem services and human well-being to guide environmental policy discussions. The framework introduced by the MEA (2005) is used throughout this dissertation, with slight modification. This decision was made because the MEA (2005) framework provided the foundation for initiatives that followed; much of the existing literature cites the MEA and it continues to be used to ground ecosystem services discussions today.

The MEA (2005) both highlighted how ecosystem degradation jeopardized human well-being and provided a structure to describe the array of services that ecosystems provide to people (Small et al., 2017). Relative to earlier uses of ecosystem services, the MEA framework is similar to the 'environmental economics approach' but expands 'services' to include products and existence values, identified in the framework as provisioning and cultural ecosystem services (Lélé et al., 2013). The MEA framework also excludes purely abiotic resources and introduced supporting services as fourth category. Supporting services represented what were previously identified as ecosystem functions.

An ecosystem services approach integrates environmental, economic, and sociocultural aspects of ecosystem management, often with the aim of valuation (Beaumont et al., 2007; de Groot et al., 2002). It highlights the role that healthy ecosystems play in human well-being, economic development, and poverty alleviation. Effective application of the ecosystem services framework can help to avoid privileging short-term economic gain over environmental protection and long-term well-being

(Turner & Daily, 2008). Effective application, however, is problematic and not necessarily an easy task.

An Overview of the Ecosystem Services Framework

The MEA (2005) defines ecosystem services as “the benefits people obtain from ecosystems” (p. 27). More recently, Costanza et al. (2017) describe ecosystem services as “the ecological characteristics, functions, or processes that directly or indirectly contribute to human well-being: that is, the benefits that people derive from functioning ecosystems” (p. 3). Throughout this section, this paper (Costanza et al., 2017) is referenced because it is a follow-up to an earlier paper authored by many of the same individuals, which was extremely influential in bringing attention to ecosystem services (Costanza et al., 1997). In both the MEA (2005) and Costanza et al. (2017), ecosystem services are understood quite broadly and are categorized into four types: cultural, provisioning, regulating, and supporting services. Throughout this dissertation, ‘cultural services’ and ‘cultural ecosystem services’ are used interchangeably and likewise for the other three types of ecosystem service.

Cultural Ecosystem Services

Cultural ecosystem services are the focus of this dissertation, and as such, receive the most attention in this chapter. They represent the nonmaterial benefits people obtain from an ecosystem (MEA, 2005). While all ecosystem services are identified and evaluated according to human perception and valuation (Brondizio et al., 2010; Small et al., 2017), cultural services especially are actively created and perceived by people (Bieling, 2013). They are directly experienced and intuitively appreciated (Daniel et al,. 2012).

The list of benefits recognized as cultural ecosystem services is continually expanding as cultural service research progresses, but there is some degree of variability among recent frameworks. Costanza et al. (2017) compared four of the more commonly cited ecosystem service frameworks: 1) Costanza et al. 1997, 2) MEA 2005, 3) TEEB 2010, and 4) Common International Classification of Ecosystem Services (CICES) 2017. Even though these frameworks are regularly referenced and fairly recent, the combined frameworks fail to capture the developing understanding of cultural services (Table 1). Barnes-Mauthe et al. (2015), for example, have introduced social capital as an ecosystem service. They cite trust, community involvement, social cohesion, reciprocity, exchanges, common rules, norms, and sanctions, which are all embedded in networks of relationships. Gould and Lincoln (2017) suggest additional services of ingenuity, perspective, and life teaching. Others have introduced cultural service-specific frameworks that capture a broader range of services, with the goal of better conceptualizing and subsequently detailing cultural services (Bryce et al., 2016; Chan et al., 2011, 2012a; Fish et al., 2016).

Table 1. Categories of Cultural Ecosystem Services as Detailed in Prominent Frameworks
Cultural services as detailed in four prominent ecosystem services frameworks are summarized (Adapted from Costanza et al., 2017).

Cultural Ecosystem Services
Recreation; including ecotourism and outdoor activities (Costanza et al., 1997) Recreation and ecotourism (MEA, 2005; TEEB, 2010) Physical and experiential interactions (CICES, 2017)
Cultural; including aesthetic, artistic, spiritual, education, and science (Costanza et al., 1997) Aesthetic values (MEA, 2005) Aesthetic information (TEEB, 2010)
Cultural diversity (MEA, 2005) Inspiration for culture, art, and design (TEEB, 2010)
Spiritual and religious values (MEA, 2005) Spiritual existence (TEEB, 2010) Spiritual and/or emblematic interactions (CICES, 2017)
Knowledge systems (MEA, 2005) Information for cognitive development (TEEB, 2010) Intellectual and representative interactions (CICES, 2017)
Educational values (MEA, 2005)

Relative to other ecosystem services, cultural services have received less research attention, but recent work aims to rectify that difference (Costanza et al., 2017). Still, the reduced presence of cultural services in ecosystem services literature is problematic, as cultural ecosystem services may be more significant to individuals than more easily quantifiable examples of regulating, provisioning, or supporting services (e.g., Daniel et al., 2012, Gould et al., 2015, Martín-López et al., 2014; Milcu et al., 2013; Small et al., 2017). Especially within coastal and marine ecosystems, cultural ecosystem services are poorly understood and are excluded from or minimized in ecosystem services discussions (Barbier et al., 2012).

As cultural services have become a more common research focus, their basic definition has expanded. Chan et al. (2012b) define cultural services as "an ecosystems' contributions to the nonmaterial benefits (e.g., capabilities and experiences) that arise from human-ecosystem relationships" (p. 11). They emphasize that cultural services are context-dependent, messy, and integrated. Others describe cultural services as the "interactions between environmental spaces and the activities that occur there" (Bryce et al., 2016, p. 259; Fish et al., 2016). They contribute to human well-being in ways beyond those discussed in the MEA (Bryce et al., 2016). Cultural services yield *cultural ecosystem benefits* through the interaction of *cultural practices* and *environmental spaces* – all three of these features enable and shape the others (Bryce et al., 2016). Cultural practices and environmental spaces contribute to well-being and can be understood through "the *identities* they help frame, the *experiences* they help enable, and the *capabilities* they help equip" (Fish et al., 2016, p. 213). Cultural services are coproduced or cocreated outcomes of people's interactions with the ecosystem (Fish et al., 2016). This understanding of cultural ecosystem services is presented in a conceptual framework by Fish et al. (2016; Figure 1). This framework emphasizes the interaction of its components. It is also the framework used to structure cultural service data analysis in this dissertation.

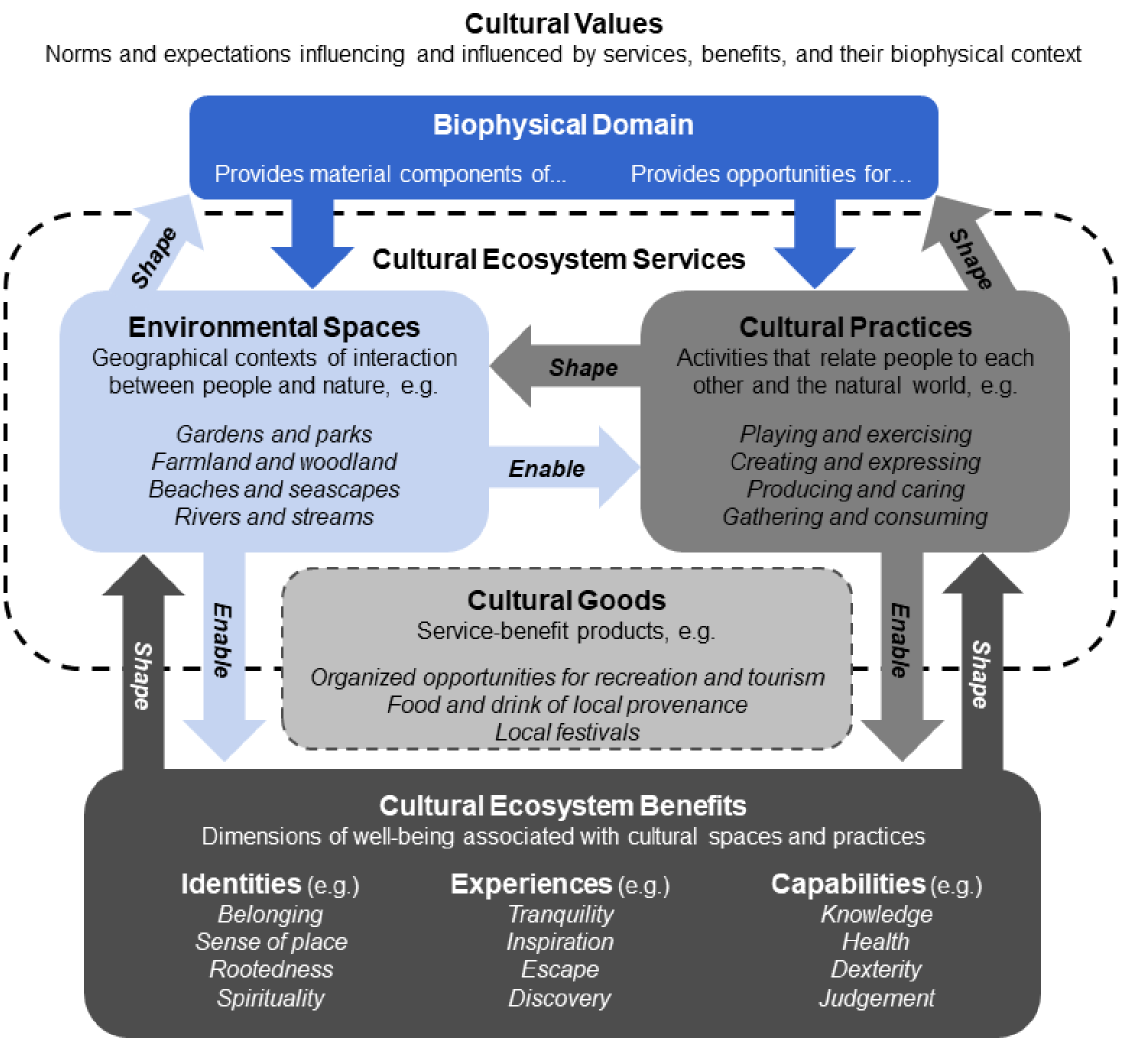


Figure 1. Components of a Cultural Services Framework (Adapted from Fish et al. 2016)

The cultural ecosystem services conceptual framework introduced by Fish et al. (2016) is shown.

Some suggest a renaming of cultural ecosystem services as ‘non-material ecosystem services’ because of the complexity and ambiguity associated with the term ‘culture’ (Small et al., 2017). In addition, consideration of ‘culture’ as an ecosystem service also portrays culture as a commodity to be economically valued, a proposition readily rejected by anthropologists and other social scientists (Winthrop, 2014). Overall, confusion surrounding terminology of services, benefits, and values is a critique of the ecosystem services framework and with cultural services in particular (Chan et al., 2012b). The framework proposed by Fish et al. (2016) attempts to avoid such conflation of terms and remedy critiques elsewhere that terms like ‘sociocultural value’ and ‘cultural ecosystem services’ are used interchangeably in ecosystem service literature despite their conceptual differences (Costanza et al., 1997; de Groot et al., 2002; Scholte et al., 2015; Small et al., 2017). This problem of language surrounding the ecosystem services framework is expanded upon in the “Critiques” section.

Others have argued that cultural services can only be derived through other services and thus should be removed from the ecosystem services framework entirely (Fisher et al., 2009), but one can make the argument that the same is true for nearly all services. As with an example introduced by Costanza et al. (2017), to consider the provisioning service of fish through a commercial fishery, water quality and productivity (regulating and supporting services) must be sufficient to support a fish population. The fish are harvested through human means – labor, gear, etc. Thus, fish harvested as a provisioning service does not represent a simple single service. Chan et al. (2012b) do not focus on the problem of linked services, but suggest that the current ecosystem services framework is designed for material values. Including non-material services requires a new vision and methods. The need for separate frameworks for non-material ecosystem services has been echoed by others (e.g., Kirchhoff, 2012; Pröpper & Haupts, 2014; Small et al., 2017; Winthrop, 2014).

Provisioning Ecosystem Services

Provisioning services are the products obtained directly from the ecosystem (MEA, 2005). They take shape as food, water, fiber, and fuel, and are typically market-mediated goods (Chan et al., 2012b; MEA, 2005; Table 2). These services are often the most easily recognizable as raw materials and products for direct use. The Economics of Ecosystems and Biodiversity project (TEEB) describes provisioning services as "ecosystem services that combine with built, human, and social capital to produce food, timber, fiber, or other 'provisioning' benefits" (2010). Potentially unique to provisioning services, access and consumption of provisioning services may be detrimental, or a 'trade-off', to and for other services (Howe et al., 2014). As an example connected to this dissertation, overharvest or 'over-provisioning' of wild oysters is detrimental to the local ecosystem and has an array of impacts on ecosystem service delivery (see "Shellfish and Ecosystem Services" below).

Table 2. Categories of Provisioning Ecosystem Services as Detailed in Prominent Frameworks
Provisioning services as detailed in four prominent ecosystem services frameworks are listed (Adapted from Costanza et al., 2017).

Provisioning Ecosystem Services
Food production (Costanza et al., 1997; MEA, 2005; TEEB, 2010) Biomass – nutrition (CICES, 2017)
Water supply (Costanza et al., 1997; TEEB, 2010; CICES, 2017) Fresh water (MEA, 2005)
Raw materials (Costanza et al., 1997; TEEB, 2010) Fiber, etc. (MEA, 2005) Biomass – fiber, energy, and other materials (CICES, 2017)
Ornamental resources (MEA, 2005; TEEB, 2010)
Genetic resources (MEA, 2005)
Biochemicals and natural medicines (MEA, 2005) Medicinal resources (TEEB, 2010)
Biomass – mechanical energy (CICES, 2017)

Regulating Ecosystem Services

Regulating services are the benefits received through regulation of ecosystem processes (MEA, 2005; Table 3). They contribute to flood control, storm protection, water regulation, human disease regulation, water purification, air quality maintenance, pollination, pest control, and climate control (TEEB, 2010). Regulating services, in general, are not readily perceived by individuals (Costanza et al., 2017).

Table 3. Categories of Regulating Ecosystem Services as Detailed in Prominent Frameworks

Regulating services as detailed in four prominent ecosystem services frameworks are listed (Adapted from Costanza et al., 2017).

Regulating Ecosystem Services
Gas regulation (Costanza et al., 1997) Air quality regulation (MEA, 2005) Air purification (TEEB, 2010) Mediation of gas- and air-flows (CICES, 2017)
Climate regulation (Costanza et al., 1997; MEA, 2005; TEEB, 2010) Atmospheric composition and regulation (CICES, 2017)
Disturbance regulation; storm protection and flood control (Costanza et al., 1997) Natural hazard regulation (MEA, 2005) Disturbance prevention or moderation (TEEB, 2010) Mediation of air and liquid flows (CICES, 2017)
Water regulation; e.g., natural irrigation, drought prevention (Costanza et al., 1997; MEA, 2005) Regulation of water flows (TEEB, 2010) Mediation of liquid flows (CICES, 2017)
Waste treatment (Costanza et al., 1997) Water purification and waste treatment (MEA, 2005) Waste treatment; esp. water purification (TEEB, 2010) Mediation of waste, toxics, and other nuisances (CICES, 2017)
Erosion control and sediment retention (Costanza et al., 1997) Erosion regulation (MEA, 2005) Erosion prevention (TEEB, 2010) Mediation of mass-flows (CICES, 2017)
Pollination (Costanza et al., 1997; MEA, 2005; TEEB, 2010) Life cycle maintenance; including pollination (CICES, 2017)
Biological control (Costanza et al., 1997; TEEB, 2010) Regulation of pests and human diseases (MEA, 2005) Maintenance of pest- and disease-control (CICES, 2017)

Supporting Ecosystem Services

Supporting services are those necessary for the production of other services and typically describe basic ecosystem processes (MEA, 2005; Table 4). They represent ecosystem functions that contribute indirectly to human well-being by maintaining the processes necessary for the delivery of cultural, provisioning, and regulating services (Costanza et al., 2017). Because they are by definition linked to other services, it is possible that their inclusion can lead to 'double-counting' if one is tracking services in a valuation attempt (Costanza et al., 2017).

As mentioned above, supporting services were a new addition to the discussion of ecosystem services in the MEA. Some have argued that supporting services should be removed from the framework to effectively and consistently link ecosystem processes to human well-being (Lélé et al., 2013). The CICES framework emphasizes potential final services in its ecosystem services classification. Supporting services are intermediate services or 'underpinning structures' and are thus excluded from the main classification (Haines-Young & Potschin, 2018). Others include supporting services as a category, but identified as 'habitat' (Costanza et al., 1997; TEEB, 2010).

Table 4. Categories of Supporting Ecosystem Services as Detailed in Prominent Frameworks
Supporting services as detailed in four prominent ecosystem services frameworks are listed (Adapted from Costanza et al., 2017).

Supporting Ecosystem Services
Nutrient cycling (Costanza et al., 1997) Nutrient cycling and photosynthesis, primary production (MEA, 2005)
Refugia; nursery, migration habitat (Costanza et al., 1997) 'Biodiversity' (MEA, 2005) Lifecycle maintenance, esp. nursery (TEEB, 2010) Lifecycle maintenance, habitat, and gene pool protection (CICES, 2017)
Gene pool protection (TEEB, 2010)

Critiques of the Ecosystem Services Framework

In addition to the challenges cited above specific to each ecosystem service category, the framework itself faces several critiques; included here are those critiques relevant to this dissertation work. For further discussion of challenges refer to: Lélé et al., 2013; Costanza et al., 2017; Schröter et al., 2014; Small et al., 2017.

Effects of Commodification and Monetization

Some argue that the entire concept, predicated on valuation of environmental services, is flawed (Kosoy & Corbera, 2010; Lebreton et al., 2019; Lélé et al., 2013; McAfee & Shapiro, 2010). Opponents suggest that the notion of ecosystem services leads to an unwelcome commodification of nature. When Costanza et al. (1997) first attempted to value the world's biomes to make a point for global policy-makers, it "divided ecological economists among those who accepted valuing nature in monetary terms as a pragmatic choice, and those who rejected it on methodological and ethical grounds" and likewise ecologists also took issue (Gómez-Baggethun & Martín-López, 2015, p. 260). Those opposed suggested that framing ecological problems via market strategies affects the human-nature relationship, potentially in a way detrimental to conservation (e.g., Gómez-Baggethun et al., 2010; Kosoy & Corbera, 2010; Martínez-Alier, 2002; McCauley, 2006; Rees, 1998; Robertson, 2004; Soma, 2006; Spash, 2008; Turner & Daily, 2008). Kallis et al. (2013) warn that "monetary valuation techniques…are not neutral categories" and "frame the society–nature relationship into one of utility and exchange prefiguring commodification as a reasonable response" (p. 99). Finally, services that do not lend easily to monetary valuation, particularly cultural ecosystem services, are given limited attention (Chan et al., 2012a).

Need for Pluralistic Valuation

Others extend the discussion of valuation beyond the basic "should or should we not?", and instead propose consideration of socio-political context, goals, and potential social-ecological outcomes when proposing the valuation of nature (Kallis et al., 2013; Lebreton et al., 2019). Valuation itself is complicated, because individual values and preferences vary; likewise the values of individuals may not reflect that of a community (Small et al., 2017). To remedy this, approaches that move away from monetization and aim to better reflect the plurality of values are recommended (Raymond et al., 2014; Small et al., 2017). This includes consideration for integrated sociocultural, ecological, and economic valuation of ecosystem services and highlights the need for interdisciplinary approaches rather than isolated studies by field (e.g., Bockstael et al., 2000; Boeraeve et al., 2015; Jacobs et al,. 2016; Ludwig, 2000; Small et al., 2017; Villegas-Palacio et al., 2013). Ecosystem service initiatives like the MEA and IPBES provide a foundation for what could be more pluralistic valuation through the integration of biophysical, sociocultural, economic, health, and holistic values (Díaz et al., 2015).

Complexity: Dynamic Systems

Incomplete valuation attempts are particularly problematic because of the complexity inherent in ecosystems, which many contend the ecosystem services framework simply does not allow for (Lebreton et al., 2019; Villegas-Palacio et al., 2013; Winthrop, 2014). To reasonably address complexity, effective use of ecosystem services may be limited to well-described systems (Lebreton et al., 2019). Ecosystems, and social-ecological systems more appropriately, are dynamic. Conceptualization of ecosystem services thus far has also not given due treatment to understanding how services may change within a dynamic social-ecological system, even though this may be a more practical approach to study ecosystem service provision (Small et al., 2017). Ecosystem services are context-dependent and have the potential to vary based on an infinite number of social and environmental factors (Chan et al., 2012a). As one example relevant to this dissertation research, de Paiva et al. (2018) illustrated how oyster reef morphology influences the provision of regulating services. This study emphasized the conditionality of ecosystem service delivery, however, overall efforts have not addressed this type of variability and have given undue attention to how a changing system can result in both the enhancement and diminishment of services (Alleway et al., 2018; Balvanera et al., 2014; Berbés-Blázquez et al., 2016; Chan et al., 2012b; Cranford, 2019; Small et al., 2017). Additionally, ecosystems respond to drivers of change in a variety of ways and these responses may be stochastic, gradual, or otherwise unpredictable (Villegas-Palacio et al., 2013).

Complexity: Linked Services

The ecosystem services framework, if applied in a 'service accounting' approach, does not adequately allow for another form of complexity, linked services. Linked services describe when the delivery or receipt of one service or benefit is partially or completely dependent upon another service (Turner & Daily, 2008). In Costanza et al.'s (1997) oft-cited paper on the value of the world's ecosystems, they warn that ecosystem functions and services are not necessarily a one-to-one process and are thus poorly represented by a linear cascade. In other words, several functions may yield a single service. Some describe linkages as ecosystem service bundles, and stress that a social-ecological approach is essential to understand the linkage and delivery of ecosystem services (Reyers et al., 2013). Linkages exist among all ecosystem service categories, and additional effort is needed to comprehend these relationships completely, especially with cultural services (Baulcomb et al., 2015).

Complexity: Social-Ecological

As noted in earlier sections of this chapter, to address some of the challenges within the ecosystem services framework, many scholars recommend a social-ecological approach rather than a simple ecosystem approach. Though the framework outlined by the MEA (2005) aims to address sociocultural aspects of ecosystem services, in practice, the social component has received less attention and can be equally problematic as it relates to complexity. As cited above, valuation is dependent upon individual and community perceived values, and those may differ from one another as well as from those outside the community (Small et al., 2017). With cultural services especially, the value attached may be fluid, spatially varied, and scale- and context-dependent (Church et al., 2014; Small et al., 2017).

An additional complication is the disconnect between those most impacted by ecosystem services and those who make decisions that affect service provision. This relationship may not be well understood and local social-ecological context is often not given enough consideration (Blicharska et al., 2017; Turner & Daily, 2008). Routinely, the beneficiaries of ecosystem provision are not the same as those who benefit from ecosystem transformation (Turner & Daily, 2008). Similarly, power differentials exist in a social-ecological system, and decision-makers may not be aware of all ecosystem values or may face external pressures that influence resource management decisions (Lélé et al., 2013). Thus far, there has been limited effort to understand how power and social relations influence access to and control over ecosystem services (Berbés-Blázquez et al., 2016).

Directionality of Human-Ecosystem Relationships

Other critiques emphasize the one-way relationship often discussed with ecosystem services. Work that focuses on the benefits an ecosystem provides ignores the benefits that humans provide to the system. Benefits are often co-produced and, in most cases, researchers use ecosystem services frameworks that fail to account for this fact (Lélé et al., 2013). Instead, a transactional or relational understanding of ecosystem services may be more appropriate. Ecosystem services and benefits are not unidirectional. Research tends to emphasize what humans receive or obtain from the ecosystem, but, while doing so, humans are actively creating, shaping, and enabling services. This relational understanding is emphasized in more recent literature, particularly as it pertains to cultural ecosystem services (Bieling, 2013; Chan et al., 2012b; Comberti et al., 2015; Fish et al., 2016).

Disservices

Ecosystem disservices are ecosystem processes or functions that affect humans in negative ways, causing damages and costs (Costanza et al., 2017). Examples of ecosystem disservices may include pathogens or destructive wildlife (Lélé et al., 2013). In such cases, an increase in natural capital (e.g., more deer that are carrying and spreading Lyme disease) may not correlate to an increase in human well-being. Though such issues are studied by ecologists, they have not been addressed within the ecosystem services framework (Lélé et al., 2013). Ecosystem services research tends to focus on positives rather than potential negatives and many view this as an unwise oversight

(Schaubroeck, 2017; Shapiro & Báldi, 2014). Some scholars point out that public media does the opposite, and broadcasts disservices (Lyytimäki, 2014). Specific to marine aquaculture, Gentry et al. (2019) suggest that studies of negative ecosystem impacts of mariculture exceed studies on the positive impacts. Others propose that the binary framing of services and disservices is counterproductive to conservation aims and does not adequately explain the complex interrelationships between humans and nature (Villa et al., 2014). Reframing disservices with consideration for ecosystem change may be a better approach, instead focusing on how services are diminished or enhanced given certain social-ecological shifts.

Language and Terminology

The ecosystem services approach is further hindered by unclear and conflated terminology (Chan et al., 2012b; Small et al., 2017). Broadly, some recommend the use of socioecological services and benefits, to emphasize the importance of considering a complete social-ecological system and the fact that benefits occur through the interaction of the ecosystem with social, cultural, and economic systems (Reyers et al., 2013; Wainger et al., 2017). More specifically, services, benefits, and values are often conflated; some practitioners have made great efforts to clarify while others have argued it is not necessary. Lélé et al. (2013) note that the words themselves provoke certain connotations about the relationship between nature (or the ecosystem) and humans. Benefits are perceived as something that humans *derive from* nature, while services are something *provided by* nature, thus services cast “nature in the role of active, purposeful agent” (Lélé et al., 2013, p. 347).

Others call for a unified approach among disciplines and practitioners, not only of the framework but also the language (Nahlik et al., 2012). They suggest that discrepancies exist in the theory guiding the framework itself, which affects the perception of ecosystem services as benefits versus something that leads to benefits. They contend that 'ecosystem service' as a phrase is used so haphazardly that everything can be classified as an ecosystem service, thus more clarification is necessary. To make a point, Nahlik et al. (2012) illustrated the difference in the mere definition of 'ecosystem service' throughout the literature. Citing 10 unique sources, they detailed 10 different definitions that yield alternating perceptions of the connection between services and benefits, i.e., are services the same as benefits, or do services provide benefits? The unclear terminology is problematic for both researchers and the public (Nahlik et al., 2012). Chan et al. (2012b) point out the importance of distinguishing services, benefits, and values from one another. Services are the ecosystem processes that create benefits, while benefits are the valued goods, experiences, and activities through which individuals "can most easily relate ecosystems to themselves" (Chan et al., 2012b, p. 10). Lastly, values as a category are the "preferences, principles, and virtues" that individuals or groups hold (Chan et al., 2012b, p. 10).

On the other hand, Costanza et al. (2017) argue that ecosystem services represent the ecosystem functions and processes that benefit people and distinguishing services from benefits yields "far too narrow a conceptualization of benefits and values" (p. 5). They contend that cascade models, which suggest linear relationships between services, benefits, and values, do not accurately allow for the complex connections between these ecosystem outputs. Others argue for a more organized, linear, understanding of services and benefits, with explicit bounds of what can be considered as each (Potschin & Haines-Young, 2017; Small et al., 2017).

Even with the many critiques of the ecosystem services framework, it provides a useful foundation for studies centered on ecosystem-related benefits. For bivalves in particular, the body of literature and research surrounding ecosystem services is immense relative to other marine ecosystems (Beck et al., 2011). Where it is lacking, however, is in social-ecological knowledge, as opposed to merely ecological. The remainder of this chapter provides an overview of the recognized role of bivalve shellfish as ecosystem service providers and illuminates how this dissertation research contributes to a more comprehensive understanding of this role.

Shellfish and Ecosystem Services

The ecosystem services framework is particularly relevant as it pertains to discussion of bivalve shellfish. Bivalves - mollusks typified by a hinged shell, e.g., oysters, clams, mussels, and scallops - are noted providers of ecosystem services, though most research emphasizes regulating, supporting, and provisioning services (Alleway et al., 2018; Gentry et al., 2019). Many bivalves are ecosystem engineers, and their critical role to local systems is well-documented (e.g., Beck et al., 2011; Coen et al., 2007; Grabowski & Peterson, 2007; Grabowski et al., 2012; Northern Economics, Inc., 2009; van der Schatte Olivier et al., 2018). This section provides an overview of the suite of ecosystem services associated with bivalve shellfish. Though a majority of the available literature focuses on oysters, other bivalve shellfish are also considered in this overview of shellfish-related services.

Shellfish Cultural Services

Cultural services related to bivalve shellfish are understudied in comparison to other ecosystem services but include a wide array of services and benefits (Alleway et al., 2018; Gentry et al., 2019; van der Schaate Olivier et al., 2018). Within cultural services, employment, recreation, and tourism have received most attention and shellfish benefit all three. Shellfish contribute to local livelihoods and, in some cases, enable the continuation of family traditions of work (e.g., Alleway et al., 2018; Gentry et al., 2019; Krause et al., 2019; Wijsman, 2008). Krause et al. (2019) indicate the potential of shellfish aquaculture-based livelihoods to contribute to meaning-making, cultural identities of place, and identities of ownership. Shellfish also heighten opportunities for recreation (Brumbaugh & Toropova, 2008). Specifically, habitat associated with shellfish beds enhances recreational fishing opportunities and the contribution of shellfish toward improved water quality may enrich beach experiences (Alleway et al., 2018; Lipton, 2004; Northern Economics, Inc., 2009; van der Schaate Olivier et al., 2018). Shellfish contribute to tourism both through recreational fisheries and food culture (Krause et al., 2019). Improved water quality and fish abundance associated with shellfish beds and reefs may inspire increased tourism targeting recreational fishing, in addition to recreational shellfish harvesting (Alleway et al., 2018; Lipton, 2004; van der Schaate Olivier et al., 2018). Gastronomic tourism associated with oysters and other shellfish is another form of cultural service (Gasparri, 2019). The growing number of seafood festivals and related tourism is also evidence for the benefits obtained through shellfish (van der Schaate Olivier et al., 2018).

Seafood festivals, celebrations and other traditions tied to local food culture not only recognize the significance of local food systems, but they also strengthen place-based identities (Buestel et al., 2009; Krause et al., 2019; Northern Economics, Inc., 2019; van der Schaate Olivier et al., 2018). In some cases, place-based identities connected to shellfish are also integrated with cultural heritage. Many Native American and First Nations groups have extended histories that involve a variety of relationships with shellfish, including subsistence, emblematic, and spiritual uses (Barry, 2008; Dubin, 1999; Kingzett & Salmon, 2002; Kuhm, 2007; Marlett, 2019). As two examples, the Winnebago of the Midwestern United States had multiple uses for mussel shells and the Wampanoag of Massachusetts historically placed scallops of high cultural importance (Haard, 1978; Kuhm, 2007). The Wampanoag are now culturing bay scallops, and a number of Midwestern tribes have been involved in freshwater mussel propagation (USFWS, 2012). Family traditions and heritage may also be linked to shellfish (Bauer, 2006; Buestel et al., 2009). Elsewhere, evidence of spiritual and emblematic associations with shellfish can be found. As the symbol of St. James, the scallop is an emblem carried by and visible to pilgrims on their way to the shrine of Santiago de Compostela in Galicia, Spain; the ridges or lines on the shell are thought to represent pathways similar to the routes which lead to the shrine (Fulcanelli, 1984). Others point to the connection that existed for Romans between scallops and the goddess Venus (Hoena, 2003). An extensive review of historic and religious texts would likely reveal even more spiritual bivalve connections.

The history of human relationships with shellfish has also contributed to cultural services related to knowledge creation, research, and education. Though not often identified as a cultural service in action, bivalve shellfish are regularly used in archaeological research to understand marine resource use and environmental change

(Faulkner et al., 2019). Shells unearthed from layered ‘natural archives’ help inform about the past (Butler et al., 2019). More recently, and emphasizing the importance of shellfish to humans, mussel health concerns provided the opportunity for First Nations people and resource managers to ‘learn together’ through participatory research to understand problems in local mussel populations (Hopkins et al., 2019).

The associated benefit of education continues with community restoration projects such as oyster gardening and shell-recycling (Alleway et al., 2018; DeAngelis et al., 2019; Northern Economics, Inc., 2009). Community-based oyster reef restoration programs can enhance community investment and support and provide physically and psychologically rewarding experiences, on top of the ecological benefits acquired through restoration (DeAngelis et al., 2019; Reynolds & Goldsborough, 2008; Saurel et al., 2019). Additionally, projects may heighten public awareness and contribute to an overall stronger environmental ethos (DeAngelis et al., 2019; Reynolds & Goldsborough, 2008; Saurel et al., 2019; Shumway et al., 2003).

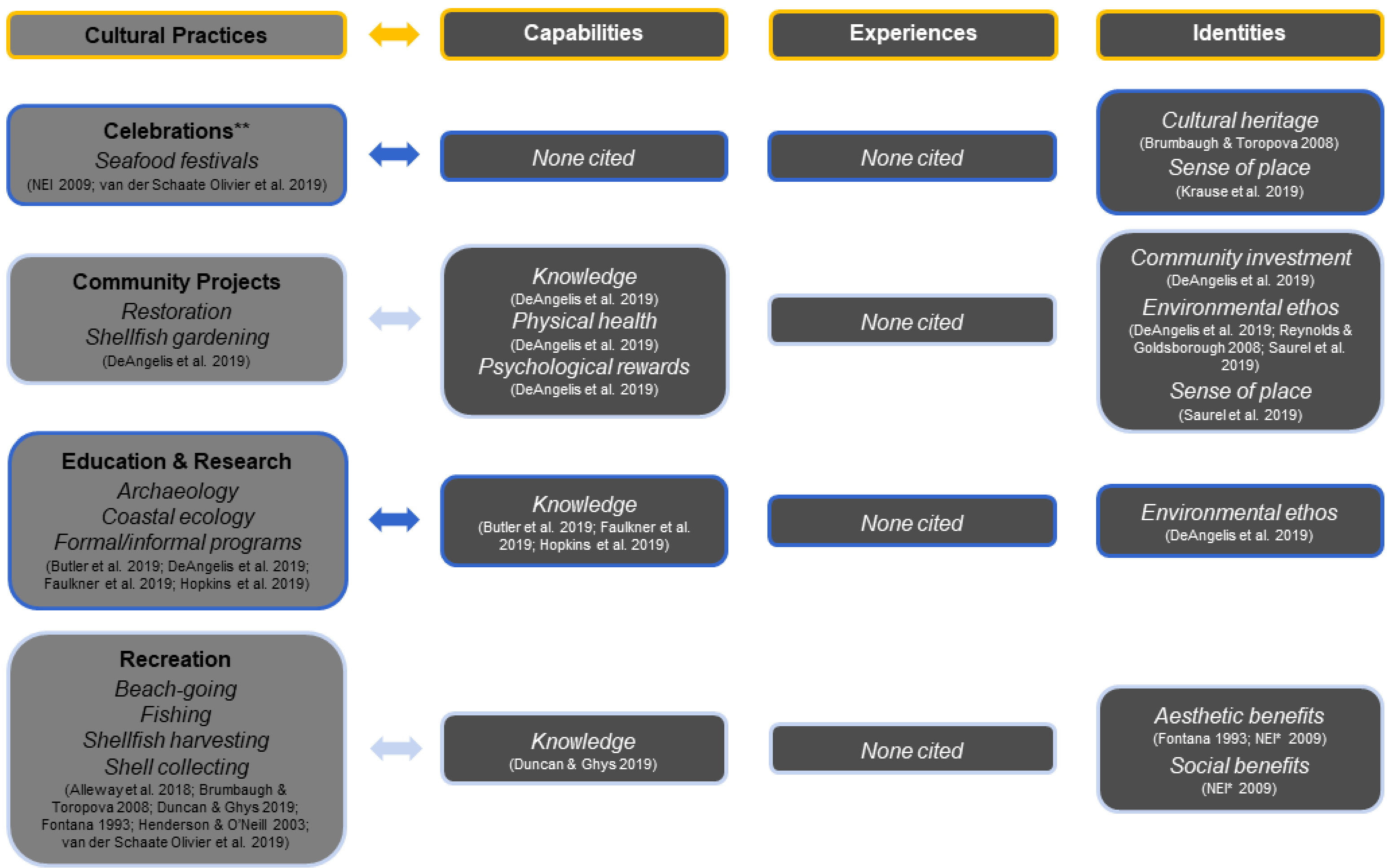
A final cultural service associated with bivalve shellfish is through the hobby of shell collection and other forms of aesthetic appreciation (Duncan & Ghys, 2019). Throughout history, shellfish have been used for more than just subsistence, as archaeological evidence indicates (Dupont et al., 2019). As another form of emblematic use, bivalve shells have been featured as symbols in architecture, furniture, and fabric design (Fontana, 2003). Shell collecting overall is a hobby that involves economic input, scientific components, education, and recreation (Duncan & Ghys, 2019).

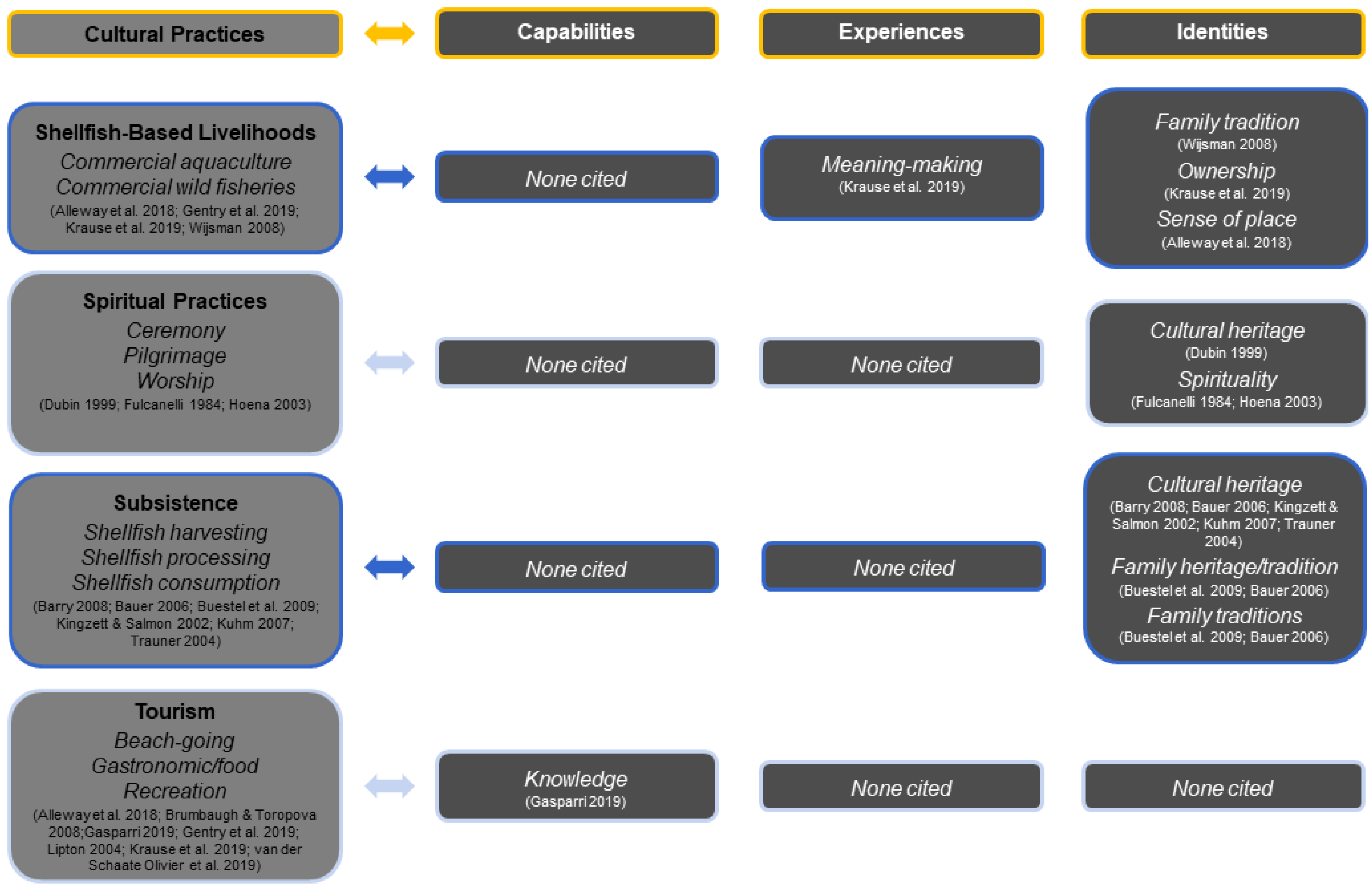
Although this summary of bivalve-related cultural services gives the impression of a large body of research on the topic, it is important to point out that much of this work was not conducted with cultural ecosystem services in mind. Instead, it represents a review of existing literature, some explicit to ecosystem services, but much of it emphasizing the relevance of the human-shellfish relationship. As already noted, cultural ecosystem services related to bivalve shellfish are poorly researched, and related to bivalve aquaculture, “not assessed in any capacity yet” (van der Schaate Olivier, 2019, p. 2).

This dissertation research addresses this absence in knowledge. As indicated above, the project bases its cultural service conception on the framework introduced by Fish et al. (2016; Figure 1). The existing literature on shellfish-related cultural services was not generated with this framework in mind, thus it does not completely fit this conception, however one can see how these types of benefits may be organized. To illustrate this, Figure 2 focuses on the cultural practices discussed and how they contribute to cultural benefits as capabilities, experiences, and identities.

Figure 2. Shellfish-Enhanced Cultural Practices and Potential Connections to Capabilities, Experiences, and Identities

The summarized literature is adapted into the framework proposed by Fish et al. (2016). Here, cultural practices and cultural benefits (as capabilities, experiences, and identities) are explored using the existing literature. *Northern Economics, Inc. (NEI) is abbreviated as a reference for this and subsequent tables. **Seafood festivals and events are recognized as "cultural goods" by Fish et al. (2016), but here are presented as another type of ecosystem-based activity.





Cultural Practices
Capabilities
Experiences
Identities
Shellfish-Based Livelihoods
Commercial aquaculture
Commercial wild fisheries
(Alleway et al. 2018; Gentry et al. 2019; Krause et al. 2019; Wijsman 2008)
None cited
Meaning-making
(Krause et al. 2019)
Family tradition
(Wijsman 2008)
Ownership
(Krause et al. 2019)
Sense of place
(Alleway et al. 2018)
Spiritual Practices
Ceremony
Pilgrimage
Worship
(Dubin 1999; Fulcanelli 1984; Hoena 2003)
None cited
None cited
Cultural heritage
(Dubin 1999)
Spirituality
(Fulcanelli 1984; Hoena 2003)
Subsistence
Shellfish harvesting
Shellfish processing
Shellfish consumption
(Barry 2008; Bauer 2006; Buestel et al. 2009; Kingzett & Salmon 2002; Kuhm 2007; Trauner 2004)
None cited
None cited
Cultural heritage
(Barry 2008; Bauer 2006; Kingzett & Salmon 2002; Kuhm 2007; Trauner 2004)
Family heritage/tradition
(Buestel et al. 2009; Bauer 2006)
Family traditions
(Buestel et al. 2009; Bauer 2006)
Tourism
Beach-going
Gastronomic/food
Recreation
(Alleway et al. 2018; Brumbaugh & Toropova 2008;Gasparri 2019; Gentry et al. 2019; Lipton 2004; Krause et al. 2019; van der Schaate Olivier et al. 2019)
Knowledge
(Gasparri 2019)
None cited
None cited

Shellfish Provisioning Services

Shellfish yield provisioning services in the form of tissue, seed, shells, pearls, and biomedicine. These raw materials, for the most part, are most easily recognized relative to other services. Shellfish meat or tissue provides a healthy source of protein harvested through commercial, recreational, and subsistence fisheries and sourced from both the wild and aquaculture (Alleway et al., 2018; Brumbaugh & Toropova, 2008; Northern Economics, Inc., 2009; van der Schaate Olivier et al., 2018; Wijsman et al., 2019). Bivalve aquaculture is suggested as one means to replace provisioning services lost due to a declining wild harvest (Gentry et al., 2019). Wild seed, juvenile shellfish, may also be used for shellfish culture (Kamermans & Capelle, 2019).

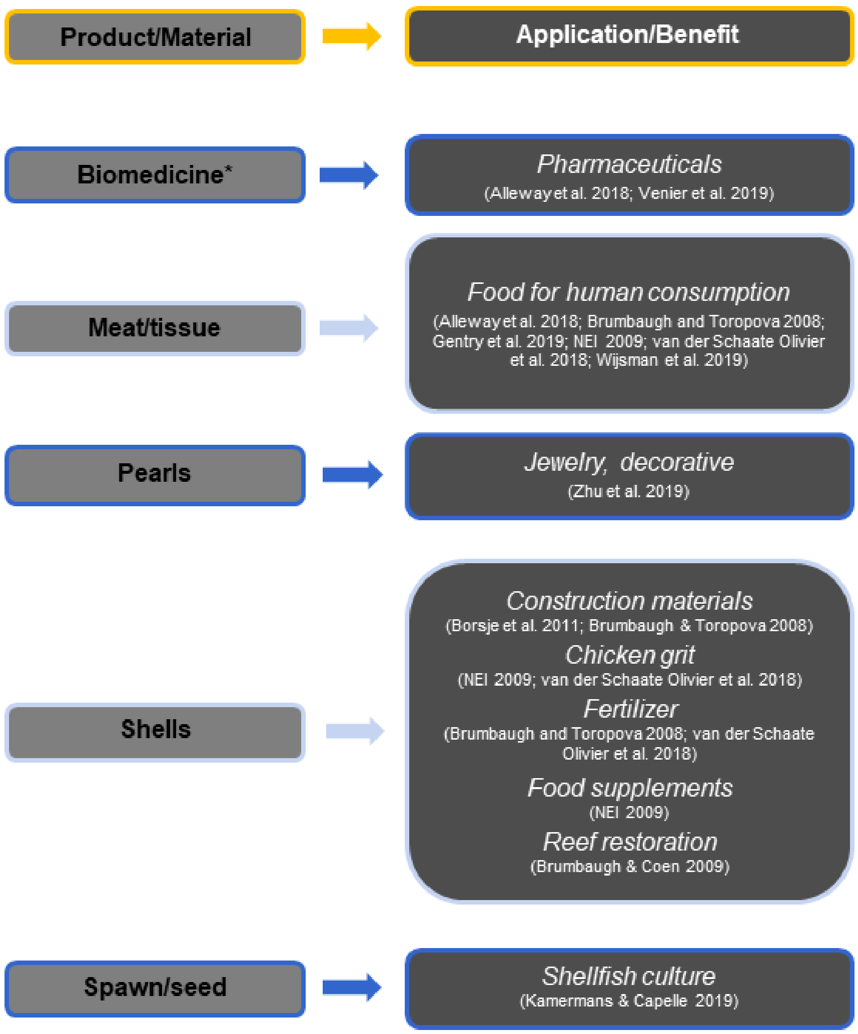
Shells produced by shellfish are increasingly used in restoration and coastal protection efforts. Oyster shell especially is collected and used as substrate for reef restoration as well as for aquaculture operations (Brumbaugh & Coen, 2009). Shells also provide construction material for shoreline protection projects (Borsje et al., 2011; Northern Economics, Inc., 2009). Crushed shell may be used for fertilizer and building materials (lime), chicken grit, calcium carbonate food supplements, and mulch (Brumbaugh & Toropova, 2008; Northern Economics, Inc., 2009; Sheehan & Sickles-Taves, 2002; van der Schaate Olivier, 2018). Shells may also be used for more decorative purposes and in jewelry (van der Schaate Olivier, 2018). Likewise, pearl-producing bivalves supply pearls used in jewelry (Zhu et al., 2019).

The third utility of bivalve shellfish as direct provisioning services is through the possibilities of biotechnology and biomedicine (Alleway et al., 2018; Venier et al., 2019). Though not as common, this area of research has potential as investigators work to find ways to implement the structure and material qualities of bivalve shells in engineering designs and continue the search for biotechnological innovation (Venier et al., 2019). As one example of the biomedical potential, antimicrobial peptides that have been identified in mussels are being explored for their utility in human medicine (Venier et al., 2019).

The provisioning services provided by shellfish as documented in the literature are summarized in Figure 3. Services are presented according to the product or material shellfish provide to fulfill each application or benefit. Relevant to prior discussion of ecosystem services framework critiques, all benefits obtained through these provisioning services are realized only when paired with human capital or labor.

Figure 3. Provisioning Services Generated by Shellfish

The literature review of shellfish provisioning services is summarized. *Biomedicine is listed as a product or material, however in practice the material is microlevel components of bivalve shell and tissue.



Shellfish Regulating and Supporting Services

Because of their linkages, regulating and supporting services are often comingled when presenting shellfish-related ecosystem services. As noted above, some ecosystem services frameworks do not include supporting services (e.g., CICES) and others group supporting services with (or as) habitat and genetic diversity (Alleway et al., 2018; Costanza et al., 1997; Haines-Young & Potschin, 2018; TEEB, 2010). With shellfish, the greatest complication occurs when attempting to distinguish 'nutrient cycling' as a supporting service from the various aspects of their filter-feeding role, such as nutrient sequestration, denitrification, subsequent phytoplankton control and overall water quality maintenance. This latter group, though typically identified as regulating services, is also denoted as supporting services in some sources. With these connections in mind, and with the knowledge of how participants regarded these types of services as discussed in chapters 3, 4, and 5, regulating and supporting services are presented here together.

As will also be done in upcoming chapters, regulating and supporting services are grouped according to the bivalve function or role that provides the service. These include three functions: 1) habitat creation, 2) filter-feeding, and 3) reproduction or spawning. Another approach to simplifying the distinction between supporting and regulating services might be to consider these functions or processes as supporting services. Regulating services are then the resulting benefits that occur through these processes.

Regulating and supporting services are well-documented relative to other bivalve-associated ecosystem services. Though there are still unanswered questions regarding the conditionality of service delivery for many of these benefits, a lengthy series of references are provided for each example to demonstrate the amount of research that has been done on these services. These do not represent the complete body of literature on these topics, but illustrate the relative attention given to them.

Filter-Feeding

As filter or suspension-feeders, bivalve shellfish play an important role in water quality maintenance overall (e.g., Brumbaugh et al., 2006; Brumbaugh & Toropova, 2008; Grabowski et al., 2012; Northern Economics, Inc., 2009). Studies indicate how the loss or decline of filter-feeding shellfish, like the eastern oyster (*Crassostrea virginica*) might negatively impact a system (zu Ermgassen et al., 2013). Water clarity is enhanced as bivalves filter and feed on phytoplankton, reducing the presence of algae in the water as well as other suspended solids (Brumbaugh et al., 2006; Cranford, 2019; Gentry et al., 2019; Newell, 2004; Ulanowicz & Tuttle, 1992). Bivalves can reduce the effects of harmful algal blooms like red and brown tides (Cerrato et al., 2004; Newell & Koch, 2004; Peabody & Griffin, 2008). As water clarity improves, the expansion of submerged aquatic vegetation, another critical habitat type, is also enhanced (Newell & Koch, 2004; Peabody & Griffin, 2008). Schröder et al. (2014) even demonstrated how water clarity impacts extend beyond the footprint of the shellfish farm itself, in a case with mussels.

The benefits provided to systems by filtering bivalves continue with their role in nutrient cycling. Shellfish reduce the effects of eutrophication as they filter and sequester excess nutrients, like nitrogen and phosphorus (e.g., Alexander, 1976; Beseres Pollack et al., 2013; Brumbaugh & Toropova, 2008; Carmichael et al., 2012; Cerco & Noel, 2007; Daskin et al., 2008; Fukumori et al., 2008; Gifford et al., 2004, 2005; Haamer, 1996; Jansen et al., 2019; Kovacz et al., 2010; Lindahl et al., 2005; Petersen et al., 2016; Petersen et al., 2019; Rose et al., 2014; Silva et al., 2011; Songsangjinda et al., 2000). Bivalves have received most attention for their role in nitrogen sequestration and denitrification, so much so that bivalves are increasingly offered as an approach to nitrogen mitigation (e.g., re: nitrogen sequestration - Bricker et al., 2018; Carmichael et al., 2012; Higgins et al., 2011; Humphries et al., 2016; re: denitrification - Alleway et al., 2018; Grabowski et al., 2012; Kaspar et al., 1985; Newell et al., 2005; Nizzoli et al., 2006; Piehler & Smyth, 2011; Shumway et al., 2003; re: nitrogen mitigation - DePiper & Lipton, 2016; Ferreira & Bricker, 2016, 2019). Bivalves sequester nitrogen from the water in their shells, tissue, and biodeposits (feces and pseudofeces) and when harvested, much of the nitrogen is removed from the system (Carmichael et al., 2012; Kesler, 2015; Shumway et al., 2003). Biodeposits are also utilized by nitrogen-fixing bacteria in the sediment to contribute to denitrification (e.g., Carmichael et al., 2012; Cerco & Noel, 2007; Kellogg et al., 2013; Newell, 2004; Nizzoli et al., 2006).

To a lesser extent, the role of bivalves in carbon sequestration is also highlighted (e.g., Alleway et al., 2018; Gentry et al., 2019; Hickey, 2008, 2009; Peterson & Lipcius, 2003; Tang et al., 2011). The relationship between carbon sequestration and storage relative to carbon dioxide released during bivalve respiration, however, is still unclear. Thus, the net effect of bivalves on carbon is uncertain (Han, 2017; van der Schaate Olivier et al., 2018). The sequestration of carbon dioxide in the shell may not compensate for its release during the respiration of organic matter (Filgueira et al., 2019).

Finally, bivalve shellfish filter substances other than nutrients and phytoplankton. They also filter and bioaccumulate things that may be harmful to humans, such as bacteria, protozoa, viruses, and more generally sewage (e.g., Clements et al., 2013; Daskin et al., 2008; Fukumori et al., 2008; Hassard et al., 2017; Kovacz et al., 2010; Roslev et al., 2009; van der Schaate Olivier et al,. 2018). This benefit could also pose a risk to humans if shellfish in unhealthy or unsafe waters were consumed, but represents another aim of shellfish aquaculture and restoration - to mitigate and improve unclean waters (Kellogg et al., 2014). A slightly different type of waste-management with bivalves involves integrated multitrophic aquaculture that uses bivalves specifically to allow for the biogeochemical processing of waste in the system (Strand et al., 2019). Overall, bivalves play a substantial ecosystem role as filter-feeders.

Habitat Creation

The second functional grouping for regulating and supporting services is the provision of habitat and structure. Again, habitat is usually identified as a supporting service or alongside supporting services, but the many benefits associated with shellfish reef and bed structures are at times indicated as regulating services. Shellfish-generated habitat, particularly for mussels and oysters, often provides benefits of shoreline protection against erosion, wave action, and severe weather events (e.g., Arkema et al., 2013; Brumbaugh & Toropova, 2008; Gentry et al., 2019; La Peyre et al., 2015; van der Schaate Olivier et al., 2018; Ysaebert et al., 2019). These natural breakwater benefits occur through several finer scale processes facilitated by shellfish habitat (Grabowski & Peterson, 2007; Marsh et al., 2002; Meyer et al., 1997).

Shellfish beds reduce effects of erosion along adjacent marshes and shorelines (Alleway et al., 2018; Northern Economics, Inc., 2009). They also contribute to stabilized sediment of submerged lands (Brumbaugh & Toropova, 2008; Grabowski et al., 2012). Oyster and mussel reefs only several centimeters above the sea floor help delaminate water flow and influence sediment, as well as assist in water column mixing processes (Atlantic States Marine Fisheries Commission, 2007). Both natural reefs and shellfish farms absorb wave energy and reduce the impacts of boat wakes, rising sea levels, and storms on adjacent shorelines (Piazza et al., 2005; Plew et al., 2005).

Habitat created by shellfish contributes to enhanced biodiversity across trophic levels through the provision of refuge and settlement substrate (e.g., Brumbaugh et al., 2006; Grabowski et al,. 2012; Herbert et al., 2012; Luckenbach et al., 2005). Typically, shellfish beds are structurally complex, providing surface area and hiding places for a diversity of invertebrates including worms, snails, sea squirts, and crabs, in addition to small fish (e.g., Cranford et al., 2007; Henderson & O'Neill, 2003; Peterson et al., 2003; Rodney & Paynter, 2006; Snover & Commito, 1998). Mud associated with some shellfish beds, e.g., mussels, also enhances opportunities for soft-bottom species (Bick & Zettler, 1994; Koivisto & Westerbom, 2010). Shellfish beds provide nursery habitat for a variety of species (Brumbaugh & Toropova, 2008). They can even contribute to secondary habitat types. As one example, macroalgae and epifauna growing upwards from on-bottom clam nets can substitute for natural sea grass habitat and provide refuge and nursery areas for mobile invertebrates and juvenile fish (Coen et al., 2007). These secondary habitats are temporary until harvest, but because clam crops are being continually replaced, new habitats are always present. Likewise, other shellfish farming structures provide habitat for diverse communities (Craeymeersch & Jansen, 2019). Community dynamics may differ slightly from a wild reef, but shellfish farms also host higher levels of biodiversity than surrounding areas (Tallman & Forrester, 2007).

Both wild and farmed shellfish habitat supports enhanced densities of other species like juvenile fish and large crustaceans (Hancock & zu Ermgassen, 2019; Shumway et al., 2003; Tallman & Forrester, 2007). Bivalve habitat also provides foraging opportunities for larger fish, birds, and marine mammals (e.g., Fernandez-Gonzalez et al., 2014; Díaz López, 2017). Many of the fish that rely on oyster reefs as a nursery or feeding grounds are commercially important (Grabowski & Peterson, 2007). These trophic connections range from bivalve production of waste, as with oyster biodeposits or 'mussel mud', all the way to top-tier trophic levels (Kesler, 2015; Koivisto & Westerbom, 2010; Mainwaring et al., 2014; Waser et al., 2016). Additionally, other filter feeders that live on shellfish reefs as fouling or encrusting organisms also contribute to the overall filtering capacity of the reef (Northern Economics, Inc., 2009).

Shellfish reefs and beds have added effects beyond the reef itself. In addition to diversifying bottom types, they provide corridors between shelter and foraging grounds (Peterson & Lipcius, 2003) and protect the ecological integrity of other adjacent habitat like seagrasses and marsh (Scyphers et al., 2011; Turner et al., 1999; Ysaebert et al., 2019). Trophic level support likewise extends to the surrounding areas (Ragnarson & Raffaeilli, 1999).

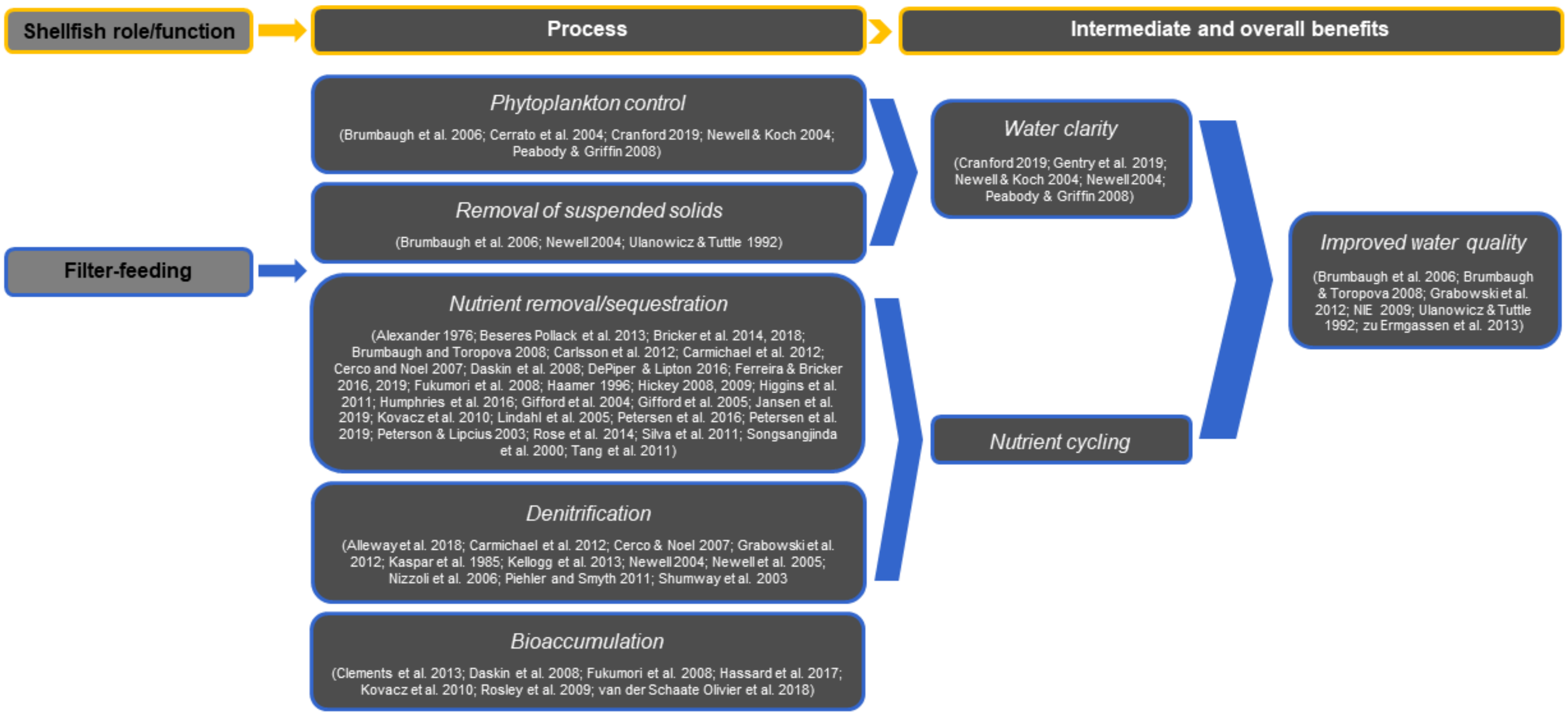
Spawning

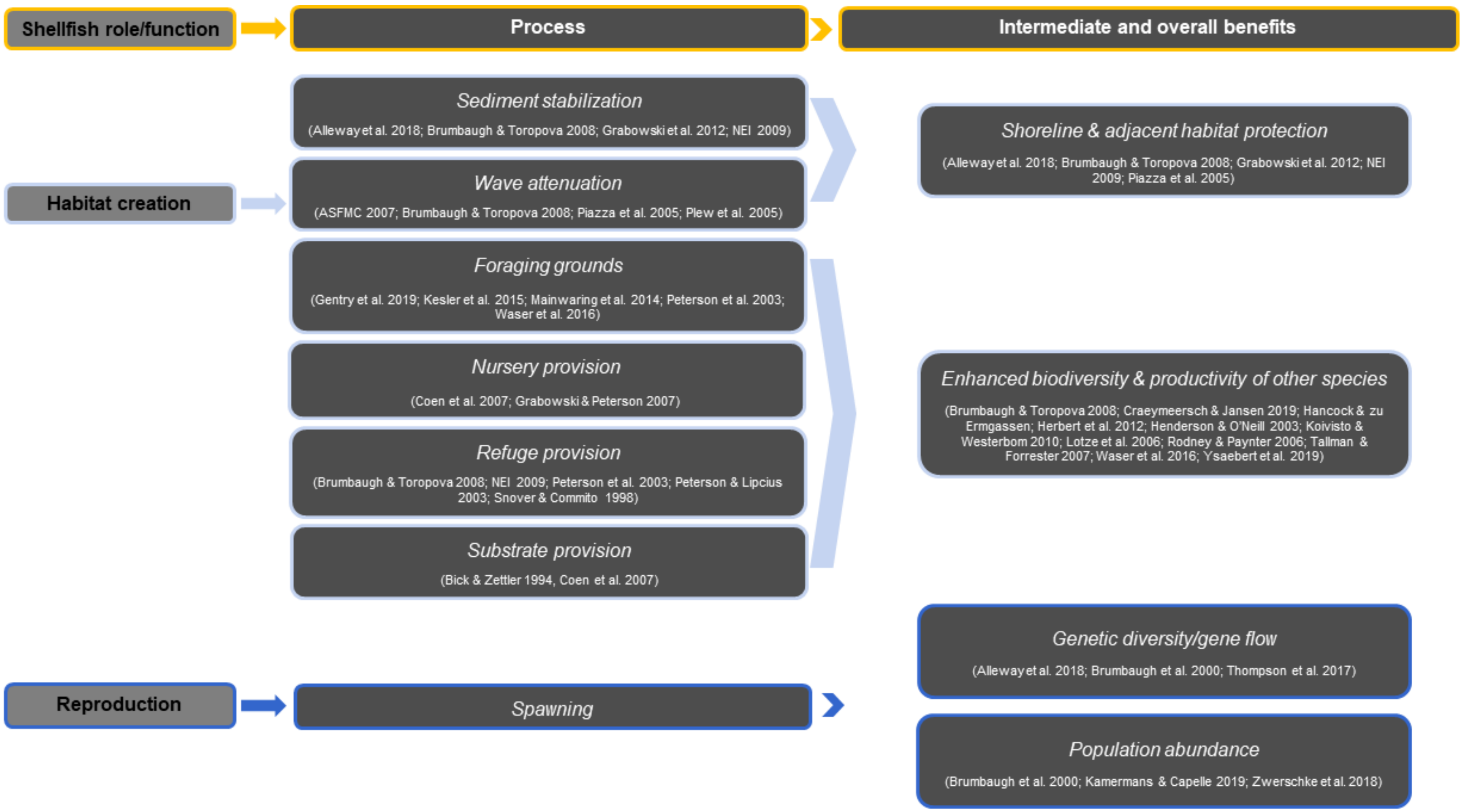
The final function that bivalve shellfish provide to fulfill a supporting service role is that of spawning. Spawning or reproducing shellfish contribute to genetic diversity and overall gene flow (Alleway et al., 2018). Spawning may be more associated with wild seed, particularly with the prevalence of triploid oysters (Nell, 2002), but some aquaculture operations utilize diploid animals that can contribute to wild populations (Thompson et al., 2017). Genotypes created for aquaculture could benefit wild populations through enhanced genetic diversity, disease resistance, or other traits being targeted (Brumbaugh et al., 2000; Thompson et al., 2017). As mentioned within the provisioning section, some aquaculture operations also rely on wild seed (Kamermans & Capelle, 2019).

Through the combined processes of filter-feeding, habitat-formation, and spawning, bivalve shellfish provide many regulating and supporting services that influence the systems they are part of. These examples are summarized in Figure 4, grouped first by these three roles, then by the specific processes shellfish are carrying out, and lastly the benefits provided.

Figure 4. Regulating and Supporting Services Provided by Shellfish

The literature review of shellfish regulating and supporting services is summarized. Services are presented by shellfish roles, associated processes, and benefits delivered.




Shellfish role/function
Process
Intermediate and overall benefits
Sediment stabilization
(Alleway et al. 2018; Brumbaugh & Toropova 2008; Grabowski et al. 2012; NEI 2009)
Habitat creation
Wave attenuation
(ASFMC 2007; Brumbaugh & Toropova 2008; Piazza et al. 2005; Plew et al. 2005)
Shoreline & adjacent habitat protection
(Alleway et al. 2018; Brumbaugh & Toropova 2008; Grabowski et al. 2012; NEI 2009; Piazza et al. 2005)
Foraging grounds
(Gentry et al. 2019; Kesler et al. 2015; Mainwaring et al. 2014; Peterson et al. 2003; Waser et al. 2016)
Nursery provision
(Coen et al. 2007; Grabowski & Peterson 2007)
Refuge provision
(Brumbaugh & Toropova 2008; NEI 2009; Peterson et al. 2003; Peterson & Lipcius 2003; Snover & Commito 1998)
Substrate provision
(Bick & Zettler 1994, Coen et al. 2007)
Enhanced biodiversity & productivity of other species
(Brumbaugh & Toropova 2008; Craeymeersch & Jansen 2019; Hancock & zu Ermgassen; Herbert et al. 2012; Henderson & O'Neill 2003; Koivisto & Westerbom 2010; Lotze et al. 2006; Rodney & Paynter 2006; Tallman & Forrester 2007; Waser et al. 2016; Ysaebert et al. 2019)
Genetic diversity/gene flow
(Alleway et al. 2018; Brumbaugh et al. 2000; Thompson et al. 2017)
Reproduction
Spawning
Population abundance
(Brumbaugh et al. 2000; Kamermans & Capelle 2019; Zwerschke et al. 2018)

Shellfish Disservices and Conditionality

The concept of disservices as defined by Costanza et al. (2017, p. 3), as "ecosystem processes or functions that affect humans in negative ways, causing damages and costs" is not easily translatable to bivalve shellfish, or at least is not well-represented in the literature. Shellfish on their own, are not noted to provide specific disservices, however examples exist, largely hypothetical, related to shellfish aquaculture, wild harvest, and restoration practices. One potential disservice includes the unwanted spread of nonnative species. Nonnative species may outcompete native species, negatively affect food webs, or bring in new diseases and undesirable species (Beck et al., 2011; Brumbaugh et al., 2006; Cross et al., 2008; Straus et al., 2008; Zwerschke et al., 2018). Regulations reduce the risk of this potential interaction in most states. There is also the possibility that physical disturbance associated with oyster aquaculture gear may inhibit submerged aquatic vegetation growth (Getchis, 2005). In a wild fishery setting, mechanical harvesters for various shellfish species could create environmental stress and negatively affect benthic communities (Brumbaugh et al., 2006). Finally, there is always the risk that a human could consume contaminated or mishandled shellfish (Northern Economics, Inc., 2009).

With all of these possible disservices, the challenge is the unknown. As indicated above as a critique to the ecosystem services framework, there is an unknown degree of conditionality associated with ecosystem service delivery. Even in systems as well-studied as these shellfish-based examples, there is still much to learn (Alleway et al., 2018). Many factors, including the scale and density of operation, spatial or temporal variation, shellfish species, water current, and others, can potentially influence ecosystem service delivery (e.g., Bendell-Young, 2006; Cranford, 2019; Dumbauld et al., 2009; Gentry et al., 2019; Forrest et al., 2009; Lenihan et al., 1996; Morris & Humphreys, 2019; Newell, 2004; Puckett et al., 2018; Rose et al., 2014; Ruesink et al., 2005). Several projects, including de Paiva et al. (2018) cited earlier, have attempted to understand potential disservices and the factors that may affect ecosystem service delivery. In a study of natural intertidal oyster reefs, the effect of reefs on sediment accretion patterns varied according to local erosional conditions, reef morphology, and oyster coverage within the reef (de Paiva et al., 2018). Turner et al. (2019) investigated potential impacts, both positive and negative, on local water quality by oyster farms. They found greater effects on water quality were associated with environmental-setting related differences among sites and season rather than the farms themselves and concluded that low-density oyster farms, similar to those in their study, were unlikely to negatively impact water quality.

As illustrated through this overview of the ecosystem services typically associated with shellfish, bivalve shellfish provide a broad diversity of benefits. For the most part, these benefits are similar whether they are wild or farmed shellfish. Most studies comparing the services of wild and farmed, unsurprisingly, feature regulating and supporting services (e.g., Coen et al., 2007; Higgins et al., 2001; Humphries et al., 2016; Plew et al., 2005; Rose et al., 2014; Tallman & Forrester, 2007; Tang et al., 2011). No work has been carried out to evaluate potential differences within cultural services.

Consideration of Ecosystem Service Critiques

The research presented in this dissertation does not promise to provide a solution to the aforementioned critiques of the ecosystem services framework. These critiques, however, were in mind throughout the research process. In the following three chapters, the methods and discussion will clarify and detail how this project considers each of these critiques, but they are also briefly summarized here.

With regard to commodification or monetization, this dissertation makes no attempt to monetize any ecosystem service, but research did involve asking participants to think hypothetically about benefits they receive or enable that they cannot "put a dollar value on". This project was participatory, and relied on interviews and fieldwork with individuals working in many aspects of shellfisheries, including: wild harvesters, shellfish farmers, hatchery employees, extension personnel, research scientists, gear manufacturers, non-profit organizers, lobbyists, and more. It also covered a wide geographic range. As such, the open-ended interview questions, which allowed for a discussion of all types of ecosystem services, provided a means of achieving pluralistic valuation, even if no dollar value was assigned. The study presented in Chapter 5, specifically, illustrates the importance of considering multiple value systems as they relate to fisheries development and management.

Shifts occurring in each system are emphasized, as interviews included discussion of how local systems were changing and whether such social-ecological changes have influenced delivery of benefits. Benefits discussed in interviews were analyzed to understand connections among different benefits, not as an attempt at 'counting' but instead to showcase how integrated these different services are. Benefits were discussed both as how participants perceived that they receive benefits, as well as how they contributed to the delivery of benefits through their work.

In general, bivalve shellfish, as detailed, are noted to positively influence their local biological system, and one can contend the local economy as well. Specific to bivalve aquaculture, there is a need to understand ecosystem disservices and the drivers that affect perception and receipt of services (Diana, 2009; Naylor et al., 2000). This dissertation employed a livelihood-based approach to understanding cultural services, in that it oriented the discussion of ecosystem services around shellfish-based livelihoods or employment. It is here where reformulating the notion of disservices into diminished (or enhanced) services is pertinent. This dissertation conceptualized disservices by considering how services and benefits noted by participants are enhanced or diminished through work in shellfish aquaculture relative to a wild shellfishery.

Finally, in considering the ongoing discussions related to language and terminology within the ecosystem services framework, although clarity is preferred, this research aligns with the mindset that the end goals are more important. Following Costanza et al. (2017) who suggested that there is and should not be a single ‘right’ way to assess ecosystem services, this dissertation employs an approach and conception that makes sense for the social-ecological system(s) in question. As such, it uses ecosystem services to extend understanding of social-ecological relationships, with shellfisheries as the focus (Lélé et al., 2013).

Conclusion

This overview of the ecosystem services framework and its relevance to shellfish illustrates that the framework, as it has existed thus far, is dynamic. Much like a social-ecological system, the ecosystem services concept has responded to input in ways that might be perceived as both positive and negative, depending on one’s perspective. The ecosystem services framework is not without obstacle or critique, but its utility in this dissertation research is still appropriate. Rather than be hindered by the challenges inherent to the framework, this research adapts the ecosystem services framework to the objectives of the project, while still acknowledging the role this research plays in responding to prevailing framework questions. Building on the existing knowledge surrounding shellfish-associated ecosystem services, this dissertation research provides a more comprehensive understanding of shellfish and ecosystem services, in addition to novel application of the ecosystem services framework.

Chapter 3: The Role of Ecosystem Services in the Decision to Grow Oysters

Overview

Ecosystem services provided by oysters are regularly cited to gain support for the continued development of oyster aquaculture, but there is limited understanding of whether and how these benefits influence those who grow oysters as they decide to enter the industry. Semi-structured interviews and participant observation occurred with 57 oyster growers in Maryland (United States) to detail factors motivating entry into the oyster aquaculture industry. Results, framed under a lens of ecosystem services, indicated that cultural services were more likely to motivate aquaculture participation than provisioning, regulating, or supporting services. This study emphasized the significance of cultural ecosystem services and defined the need to better understand those provided by oysters and other farmed shellfish.

Introduction

Oyster aquaculture, the growing or cultivation of oysters, is promoted as a sustainable complement or alternative to wild harvest oyster fisheries, many of which have declined relative to historic production (e.g., Alleway et al., 2018; Beck et al., 2011; Northern Economics, Inc., 2009; Shumway et al., 2003; van der Schatte Olivier et al., 2018). Underlying the idea of oyster aquaculture's sustainability is an emphasis on the suite of benefits provided to the social-ecological system, as detailed in Chapter 2. The study presented in this chapter sought to understand whether and how these benefits affect the decisions that lead individuals to enter the industry and begin growing oysters. An ethnographic approach with oyster aquaculturists, hereafter referred to as oyster growers, in Maryland was used to investigate the motivation behind participation in oyster aquaculture and how perceived ecosystem benefits, within the framework of ecosystem services, influenced that decision.

Chapter 2 introduced the ecosystem services concept and highlighted its ongoing development through various iterations of the ecosystem services framework. In this study, the framework as outlined by the Millennium Ecosystem Assessment (MEA, 2005) was used as the conceptual foundation with which to guide analysis, but this was done with the expectation that the MEA framework would be adapted to more appropriately fit the research objectives and participant-provided views. This is in line with framework critiques that application should consider project objectives and overall contributions to understanding social-ecological relationships (Costanza et al., 2017; Lélé et al., 2013). It was important to not simply ‘apply’ a framework, but to do so in a way that was appropriate for this system and the interactions that participants have within it, rather than force conceptualization into less than ideal categories. As noted in Chapter 2, the MEA framework is lacking in its ability to address cultural ecosystem services. For this category of service, the conceptual framework proposed by Fish et al. (2016; Figure 1) was utilized to structure understanding of cultural services. This idea of cultural services emphasizes the interaction of environmental spaces and cultural practices as they contribute to the production of cultural benefits. Cultural benefits, in turn, are outputs of the identities, experiences, and capabilities that human-ecosystem interactions enable (Fish et al., 2016). In this study, cultural practices centered on work as an oyster grower.

A wealth of literature exists describing the benefits humans derive from oysters through ecosystem services, and likewise the ecosystem services provided by oyster aquaculture, but there has been no effort to examine whether ecosystem services affect individual decisions to begin oyster aquaculture. It is important to correct this omission. If resource managers and others involved in industry development hope to maximize industry access and participation as they continue to build shellfish aquaculture opportunities throughout the US and elsewhere, it is critical to understand the motivations and values guiding those involved and those who would be potentially involved. The concept of ecosystem services is relevant to industry development discussions because of its utility in policy-making and frequent usage in shellfish aquaculture promotion (e.g., Jones, 2019; Ogrodnek, 2019; Preston, 2019; Sheehan et al., 2019; Theuerkauf et al., 2019).

Related existing research is limited and aims to understand questions of motivation and participation in wild fisheries, recreational fisheries, and even finfish aquaculture, but rarely are these studies framed to incorporate ecosystem services or bivalve shellfish aquaculture. Scholars note that fisheries managers often unwisely ignore fisher motivation, instead presupposing economic rationality when making management decisions (Peterson, 2014). This disregards other variables that shape livelihood-related decision-making, such as the pressures of economic markets, family and community expectations, and cultural and personal value systems (Peterson, 2014). Research suggests that individuals remain in commercial fisheries, even though it may not make good economic sense, due to a suite of other factors (Cinner et al., 2009; Cinner, 2014; Pollnac & Poggie, 2006; Young et al., 2016). In a study centered on livelihood diversification as a means to reduce coral reef overfishing, Cinner (2014) emphasized the importance of nonmaterial benefits afforded through work in fisheries, citing identity, lifestyle and social norms. He concluded that effective fisheries management needs to account for these types of benefits and relies on understanding livelihoods through "analyses of the incentives, constraints, and aspirations that drive people's behavior" (Cinner, 2014, p. 69). Young et al. (2016) showed that subsistence fishers in the Solomon Islands fish largely based on motivation for food and income, but 75% of their motivations paralleled recreational fishers interviewed in the same study (i.e., those not dependent on fishing for food). Subsistence fishers were also eager to pursue fishing despite existing opportunities of alternative incomes (Young et al., 2016). Other researchers have focused on the motivational factors behind recreational fishing as a means to promote more effective management of recreational fisheries and enhanced affiliated economies (e.g., Arlinghaus, 2011; Fedler & Ditton, 2011; Schramm & Gerard, 2004).

Fewer researchers, however, have looked at motivation and decision-making related to involvement in aquaculture. In a study with Vietnamese terrestrial farmers, Bosma et al. (2004, 2006) used ethnographic methods paired with model simulation to better understand how farmers made decisions to diversify their crops and potentially incorporate fish ponds. They suggested that many farmers added ponds after first altering their land to accommodate other needs (i.e., they needed higher elevation, less flood prone sites for their homes or other crops and dug ponds to fill land elsewhere); many who did not add ponds were restricted by limited water or inappropriate conditions. Bosma et al. (2004) also stressed that making the effort to understand the factors that influence decisions such as these is critical to effective resource management, research, and extension (Bosma et al., 2004). In another study related to fish aquaculture, Harrison et al. (1996) investigated the observation that many people were initially interested in taking part in fish pond development projects in Zambia, but over time stopped maintaining the ponds and farming fish. Likewise, the authors suggested that understanding why individuals were choosing to get involved but not continue was essential to improve long-term success of development efforts.

Specific to oyster aquaculture, however, case studies and cited examples do not exist that describe why individuals choose to participate. Research may indicate *who* is growing oysters (with emphasis on gender), but not *why* beyond the potentials of additional income, livelihood diversification tied to income, etc. (e.g., Felsing & Baticados, 2001; Siar et al., 1995; Szuster et al., 2008). Even though motivation may seem apparent – oyster aquaculture is a source of income, it is sustainable, etc. – no effort has been made to understand and detail why individuals choose to enter the oyster aquaculture industry. This is problematic because oyster aquaculture specifically, and bivalve aquaculture generally, continues to expand due to market demand and industry promotion (USDA, 2018). It is important to understand not only who shapes this growing industry, but why they are doing so. Are the ecosystem services so frequently cited in the literature and industry marketing as motivational for oyster growers as they are for scientists, regulators, and policy-makers? Does oyster aquaculture provide even more for growers than the documented services? Answering these broad questions can support shellfish aquaculture industry development and management, as well as contribute to greater understanding of ecosystem services perception and value.

Study Objectives

This study aimed to answer questions of motivation as they relate to oyster aquaculture and contributed to a relatively understudied component of aquaculture development research. The study was grounded by two simple questions:

- Do oyster growers think about ecosystem services, directly or indirectly, when deciding to engage in oyster aquaculture?
- If so, what ecosystem services influence their decision to get involved in oyster aquaculture?

In answering these questions, this study helps to show if ecosystem services relevant to those entering the oyster aquaculture industry are similar to the services so often promoted about it. Do the individuals driving these ecosystem benefits also recognize them as important? As suggested, cultural services have been understudied and poorly articulated relative to other types of ecosystem services. Is that absence of knowledge an obstacle to the continued expansion of oyster aquaculture? This work was conducted with the hypothesis that cultural services were more likely to motivate participation in oyster aquaculture than other types of ecosystem services. If this is true, additional effort to understand the cultural services and benefits obtained through work in oyster aquaculture is warranted. If cultural services are important to oyster growers, then it is in the best interest of resource managers and policy-makers to be aware of such services when making decisions related to aquaculture policy.

Methods

Site Characterization

The state of Maryland (United States) has a 200-year history of oyster aquaculture on leased bottom alongside its wild oyster fishery, however, legislative changes in 2009 enhanced opportunity for aquaculture industry growth and inspired an increase in actively managed leased bottom and oyster aquaculture production throughout many coastal areas (Michaelis et al., *accepted*). These changes followed nearly 200 years of alternating policy that both enhanced and stalled aquaculture opportunities in Maryland (Figure 5). Most notably, changes in 2009 eliminated all county moratoria, enabled subsequent changes to allow water column leasing, increased acreage allowances for leased bottom, and instilled an active use requirement. An oyster aquaculture lease is bottom that has been individually applied for and permitted through state and federal governments to allow for private cultivation of oysters either directly on bottom, classified as submerged land leases, or in off-bottom containers, as water column leases (Code of Maryland Regulations [COMAR] Section 08.02.23.02).

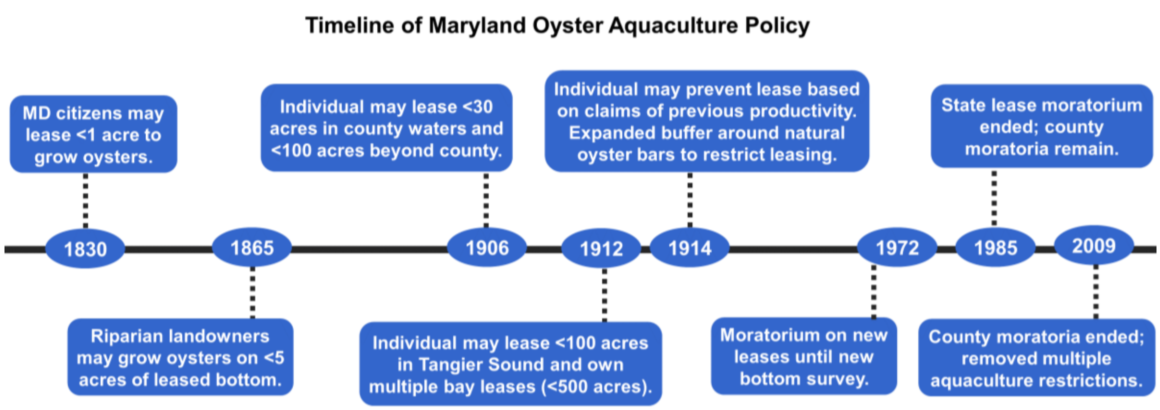


Figure 5. Timeline of Maryland Oyster Aquaculture Policy
Policy related to Maryland shellfish aquaculture has vacillated with efforts to expand aquaculture opportunities countered by restrictive legislation (Brooks 1891; Code of Maryland Regulations [COMAR] Section 08.02.23.00; Keiner 2009; Kennedy & Breisch 1983).

The 2009 legislative changes correspond to a steadily growing aquaculture industry in Maryland. As illustrated in Figure 6, total aquaculture production has increased since oysters reached market size after revised leasing policies (Green & Tracy, 2013; MD ACC, 2019). Wild harvest numbers are also shown for reference (MD DNR, 2019). Aquaculture production in Maryland has not yet matched wild harvest, however the potential exists. Numbers are not available for the current season (2019-2020), but more restrictive regulations limited potential harvest days for commercial fishermen, hereafter watermen, and it is not unreasonable to predict a harvest comparable to prior years. When considering the number of harvesters involved in each industry, absolute totals are difficult to track as oyster surcharge permits do not necessarily correlate to active wild harvesters and individuals may work on oyster leases without a harvester card if the leaseholder or approved farm managers are present. Even with this uncertainty, patterns illustrate that participation in the wild fishery varies with expected harvest while the number of aquaculture harvesters continues to increase (MD ACC, 2019; MD DNR, 2019).

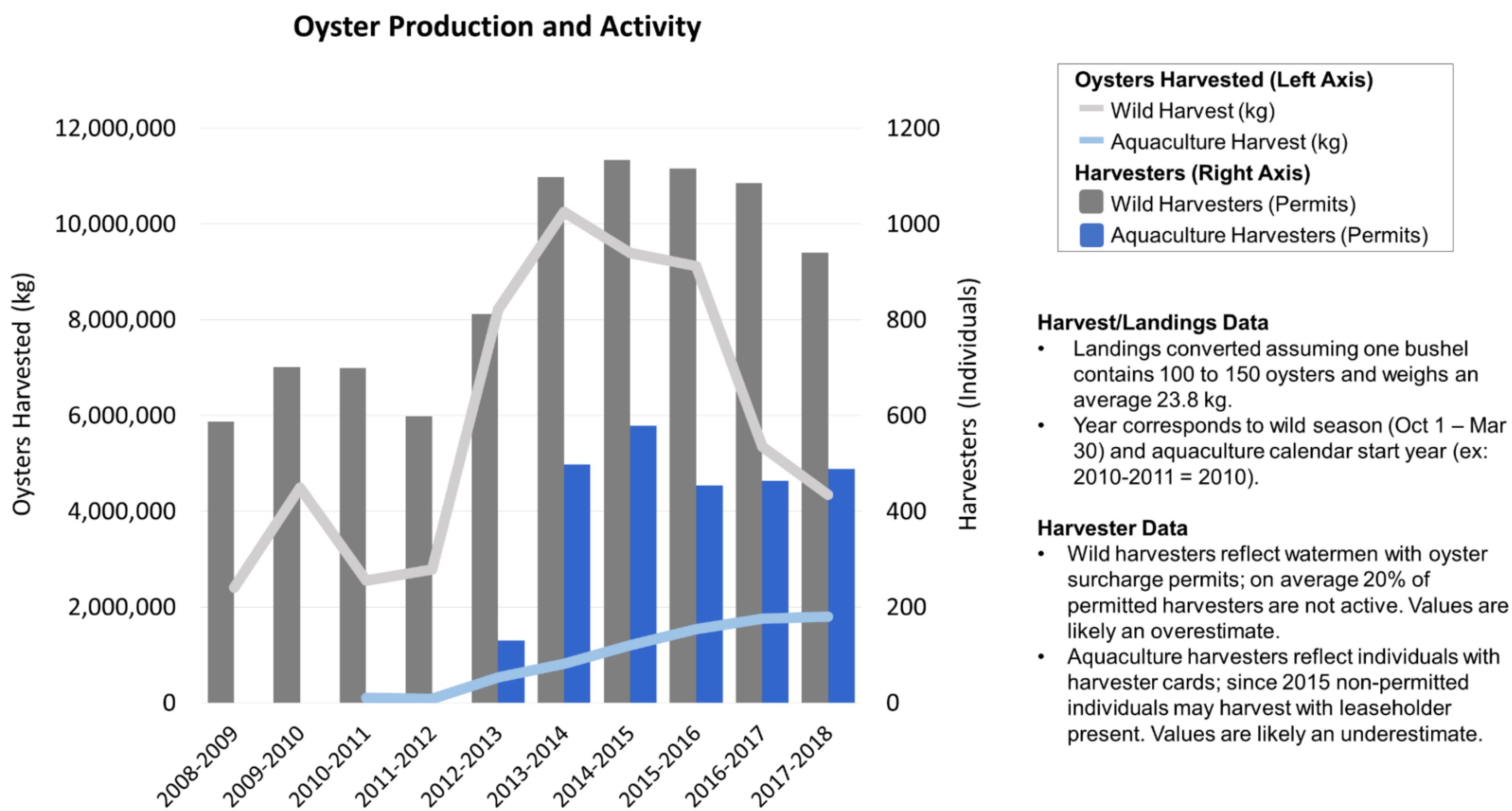


Figure 6. Oyster Production and Activity

Lines show harvest totals for Maryland wild (upper/gray) and aquaculture (lower/blue) oysters. Aquaculture data were not available for years prior to 2010. Columns depict the number of harvesters involved in each industry, though these numbers are likely overestimates for active wild harvesters and underestimates for active aquaculture harvesters (MD ACC, 2019; MD DNR, 2019b).

Fieldwork and interviews occurred with eastern oyster (*Crassostrea virginica*) growers working in Maryland's portion of the Chesapeake Bay and its Atlantic coastal bays (Figure 7). This included participants in the tidewater counties of: St. Mary's, Calvert, Anne Arundel, Kent, Talbot, Dorchester, Wicomico, Somerset, and Worcester. Other coastal counties (Baltimore, Harford, and Cecil) were not represented, but low salinity water conditions near those counties render aquaculture operations unlikely, thus few oyster growers reside in these upper bay counties. Prospective participants were contacted in Queen Anne's county, but none took part in the project.

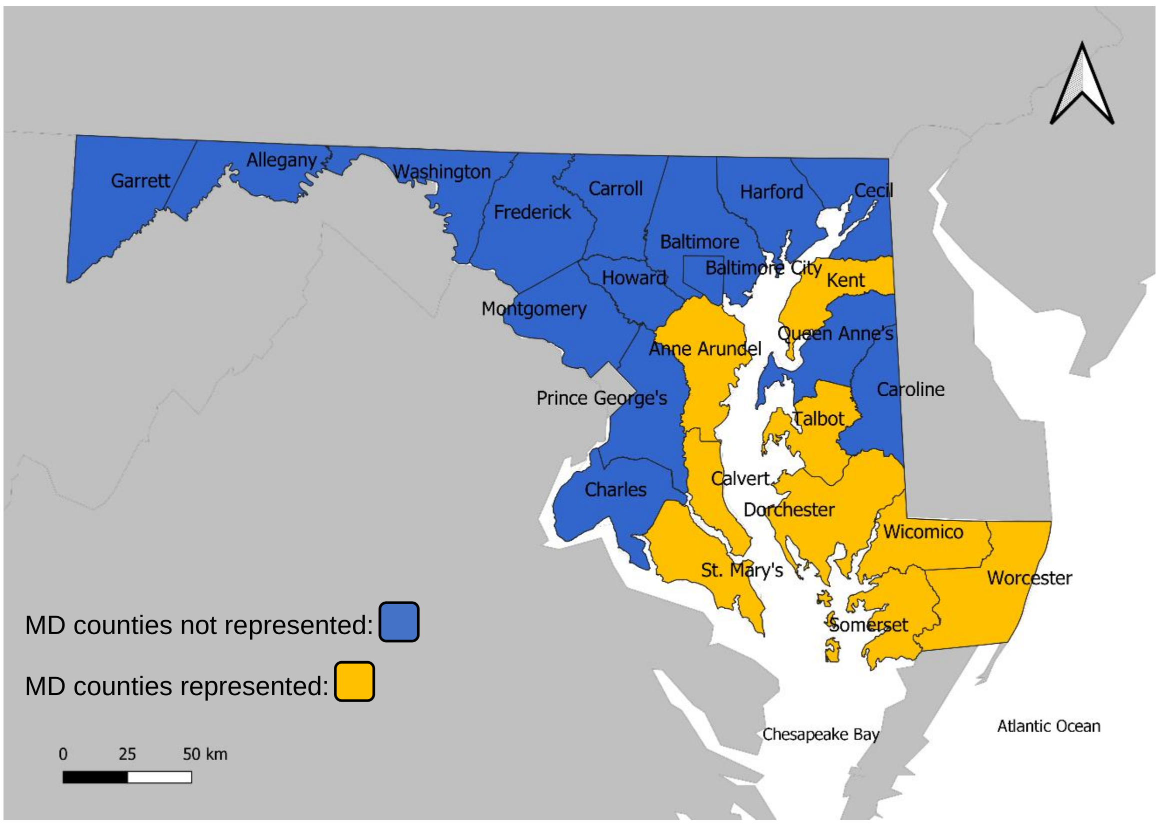


Figure 7. Study Area and Maryland (MD) County Representation

Participants were located in nine tidewater counties in Maryland, indicated in yellow. Other Maryland counties are shown in blue (Map created using QGIS, 2019).

Participant Selection and Solicitation

Participants were identified through a combination of snowball sampling and targeted solicitation to create a diverse participant sample by location, age, involvement in wild fisheries, and scale of aquaculture operation. Based on previous work with Maryland watermen, the researcher had existing relationships with industry members and began interviews for this study with them. They subsequently helped to recommend and make introductions to other potential participants. University of Maryland Extension personnel assisted with new introductions to oyster growers and allowed the researcher to attend all offered extension programs, which facilitated opportunities for introductions as well as participant observation. All aspects of participant solicitation were approved by the University of Maryland Institutional Review Board (Project Number 917459).

In total, 57 participants were interviewed for this study. They represented nine tidewater counties, with the majority of participants from Dorchester, Talbot, and St. Mary’s counties (Figure 8). These proportions were a reflection to some extent of the researcher’s prior industry connections in Dorchester and Talbot counties, but also paralleled the relative number of oyster growers in each county as these three counties contribute most to the overall industry.

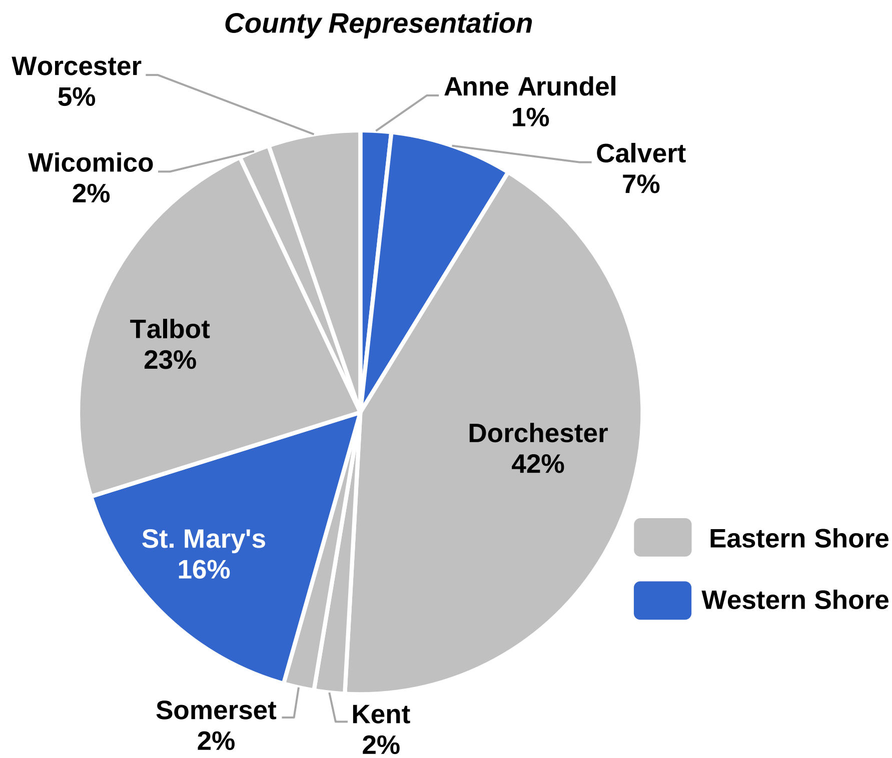


Figure 8. Participant Representation by County

Proportions of participants from nine counties are shown (N=57). Counties in blue are located on the western shore of the Chesapeake Bay. Counties in gray are located on the eastern shore of the Chesapeake Bay and Atlantic coastal bays.

Approximately half of participants had a background in wild commercial fisheries, in that they are or were commercial watermen (Figure 9). Most participants added aquaculture as an additional source of income, but for 25% of participants, aquaculture was their sole source of income (Figure 9).

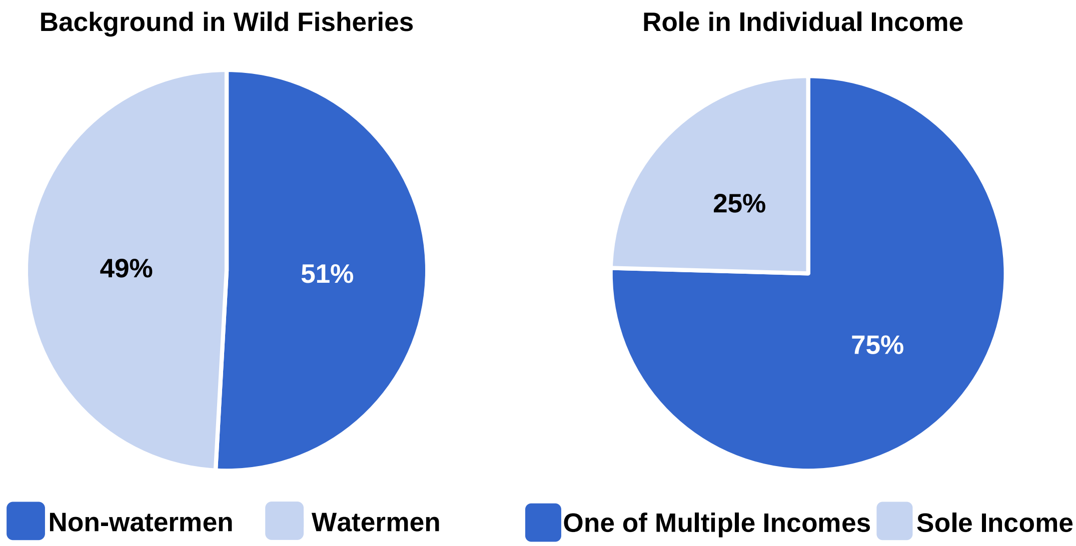


Figure 9. Participant Representation by Fisheries Background (Left) and Role Aquaculture Plays in Income (Right)

The proportion of participants who have worked or continue to work in wild fisheries (watermen, light blue) is shown relative to participants who have not worked in wild fisheries (non-watermen, dark blue) (Left). The figure on the right depicts the role that aquaculture plays in each participant's income or livelihood portfolio. Participants who earned money from aquaculture in addition to other incomes are shown in dark blue. Participants who only worked in aquaculture are shown in light blue. (N=57)

The majority of participants were relatively new growers, and entered the industry after 2009 legislative changes (Figure 10). This was reflective of Maryland's industry overall, as can be inferred from Figure 6. Within the group who had been involved less than one year, four had lease applications in progress. Most participants had water column leases (62%) (Figure 10). Whether the proportion of lease types shown in this study mirrored the industry is uncertain based on available data. In terms of acreage, submerged land leases exceeds water column, but in terms of labor, water column generally involves more personnel, based on observations and discussions throughout this dissertation research. Because harvester cards are not required of every individual working on an oyster farm in Maryland, the total number of industry participants according to lease type cannot be determined. Within the overall group of participants, 39 were leaseholders while 18 did not have their own lease but worked on someone else's lease. Fifty-three were involved in oyster farm operations, while six worked in oyster hatcheries. Two were involved in both hatcheries and farm work. Nine participants also made oyster gear and eight bought and sold other oysters in addition to selling their own. Thus, while all participants were oyster growers, a subset were also involved other aspects of the oyster aquaculture industry.

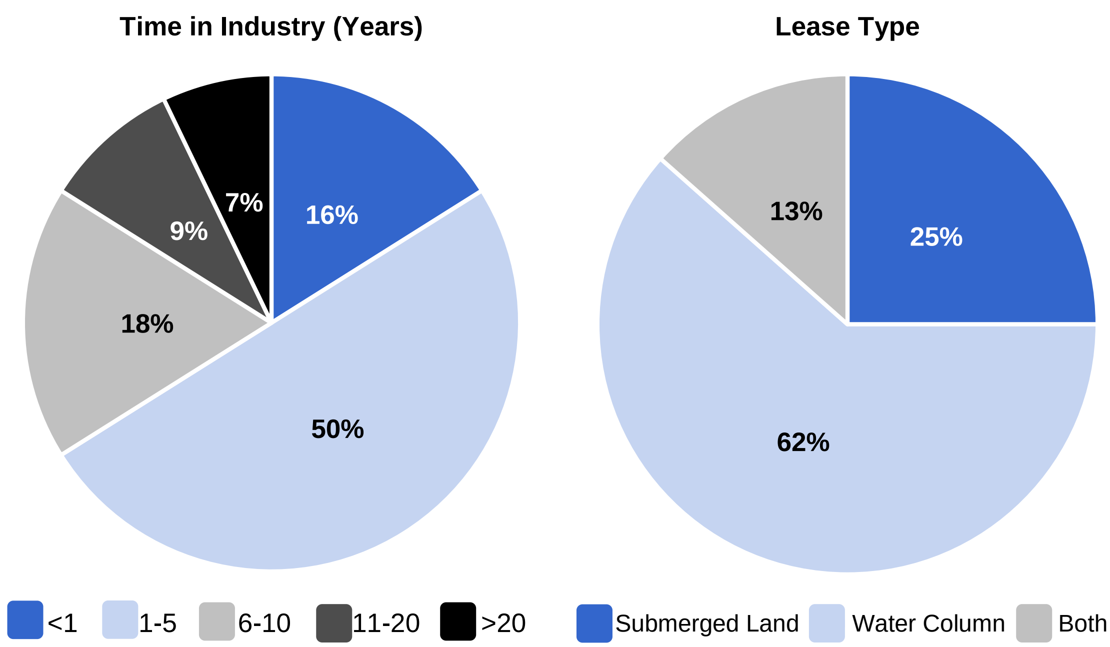


Figure 10. Participant Representation by Time in Industry (Left) and Lease Type (Right)
Participants are depicted according to how long they had been working as an oyster grower (left) and the type of lease they worked on (right). (N=57)

Data Collection

Fieldwork involved a combination of participant observation and semi-structured interviews that occurred between June 2016 and September 2018.

Participant Observation

Participant observation is the "process of learning through exposure to or involvement in the day-to-day or routine activities of participants in the [research] setting" (Schensul et al., 1999, p. 91). It is a means of establishing rapport in a community and enables the researcher to better understand the research setting or community as well as resulting data (Bernard, 1994). In this project, participant observation occurred in an array of settings. The researcher worked with participants on their boats and oyster farms, attended extension programs, and spent time with participants over meals, etc., as invited. This included repeat interactions with many participants throughout the two year fieldwork period and beyond.

Semi-Structured Interviews

As indicated, 57 shellfish growers were interviewed using a semi-structured interview approach. A semi-structured interview uses a guide that contains topics, themes, or areas to be covered rather than a sequenced script of standardized questions typically associated with a structured interview (Lewis-Beck, 2004). Open-ended prompts have demonstrated utility in enabling participants to express a diversity of ecosystem-related values, including those for which the researcher did not explicitly target (Gould et al., 2015). This study was part of a larger project intended to understand multiple aspects of participation in Maryland oyster aquaculture. Interviews were guided by questions that investigated motivation for participation, but did not target ecosystem services directly. Participants were not guided to talk about ecosystem services in general, or specifically. Results thus indicate whether ecosystem services played a part in the decision to grow oysters without prompting from researchers. For the purposes of this study, only one question is considered for analysis: "Why did you decide to start growing oysters?”. As such, the full interview guide is not relevant to this study and is not presented here.

Data Analysis

Interviews were audio-recorded and subsequently transcribed. Interview text was coded to identify examples of each type of ecosystem service within participants’ responses to the basic question of “why did you decide to start growing oysters?”. In examples where multiple services were mentioned, all those described were coded. The MEA definition of each type of service was used to guide coding, however, service classification was amended to incorporate more recent views on cultural services and to better suit this system and analysis (Table 5) All data were coded using MAXQDA (VERBI Software, 2019).

Table 5. Ecosystem Service Code Guidelines for Data Analysis

MEA (2005) definitions of each service type were used as the foundation for coding, however slight modifications were made and are reflected here.

Ecosystem Service Category	Description for Coding
Cultural Service	Participant mentions that their involvement in aquaculture was motivated by, or contributes to, identities, experiences, and/or skills (Fish et al. 2016).
Provisioning Service	Participant mentions their role in the production of a food item or raw material (e.g., shell) as motivation.
Regulating/Supporting Service	Participant mentions desire to improve water quality, restore wild oyster populations, help the bay in general, or other environmental benefits.

Cultural services represent a broad group of ecosystem services whose categorization only expands as they continue to be better understood. In this initial analysis to determine how cultural services influence the decision to grow oysters, the aim was not to redefine them or develop a new framework of understanding. Instead, this study drew upon existing literature to identify these non-material benefits. Following Fish et al. (2016), cultural services were defined as "the contributions ecosystems make to human well-being in terms of the identities they help frame, the experiences they help enable, and the capabilities they help equip" (p. 212). Using these categories to frame the identification of cultural services – identities, experiences, and capabilities –any such examples connected to the decision to grow oysters were coded.

Cultural services were then recoded to more nuanced subcategories (Table 6 in Results). For example, a cultural service motivation may have first been coded as contributing to "identities" and recoded to designate how or what type of identity. Subcategories of cultural services were generated from examples in existing literature as well as through open-coding to incorporate novel subcategories as appropriate (e.g., Alleway et al., 2018; Barnes-Mauthe et al., 2015; Bryce et al., 2016; Fish et al., 2016; Raymond et al., 2009). Open-coding is a component of grounded theory analysis which allows key themes and concepts to emerge during data collection and analysis (Birks et al., 2008; Morse et al., 2009; Shaffer et al., 2010). In this case, data collection was complete but subcategories of cultural services were added to the codebook as new, more descriptive, and more appropriate themes arose during the coding process. Once a complete list of subcategories was created based on emerging themes, all interviews were reanalyzed to enable comprehensive subcategorization.

Employment or livelihoods are typically recognized as cultural services, however, they were not coded as such in this scenario. In this analysis, every participant was employed in oyster aquaculture, thus such coding would bias results toward cultural services. Instead, it was more important to understand what services - cultural or otherwise - made aquaculture a more appealing source of income than other occupations and inspired participants to enter the industry.

Provisioning services were coded when a participant mentioned the harvest or production of a food item or shell resulting from processing as motivation to grow oysters. Because most participants referred to regulating and supporting services in a broad sense, and with conflation of related benefits as discussed in Chapter 2 in mind, regulating and supporting services were coded as a single group. Participants who acknowledged their role in or desire to improve water quality, restore wild oyster populations, or help the bay were coded as mentioning regulating and supporting services.

To identify potential differences among mention of ecosystem service types, Cochran's Q extension of the McNemar test was used. Cochran's Q test is a nonparametric test that enables comparison of two or more matched samples when the response variable is dichotomous and there are either: 1) multiple times for a repeated measure or 2) multiple categories with paired responses (Mangiafico, 2016). For this study, response variables were "mentioned" or "did not mention" for each of the three types of ecosystem service categories. Chi-square analyses were used to test for differences among participant groups based on attributes that might influence the types of ecosystem service mentioned. All analyses were completed using R statistical software with α equal to 0.05 (R Core Team, 2019).

Results

In response to the question of "why did you decide to grow oysters?" most participants mentioned cultural ecosystem services rather than provisioning, regulating, or supporting services. The mention of each service type differed from one another (Figure 11; Cultural: Provisioning P<0.001; Cultural: Regulating/Supporting P<0.001; Provisioning: Regulating/Supporting P=0.02). Patterns were similar when comparing data within and among groups based on participant attributes.

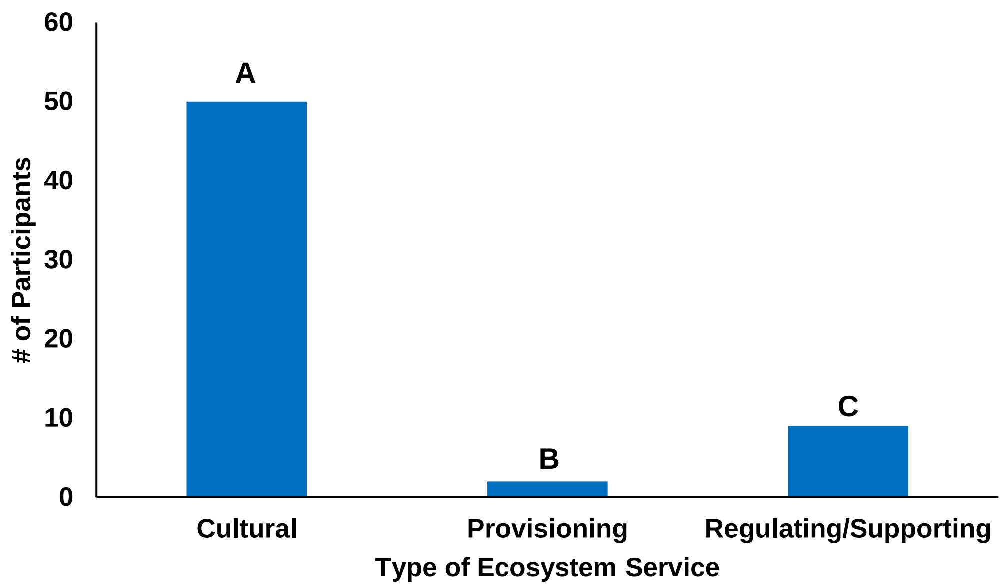


Figure 11. Ecosystem Services Mentioned by Oyster Growers

Cultural services were mentioned more frequently than any other service in response to the question of "why did you decide to grow oysters?" (P<0.001). All types of ecosystem services were different from one another in frequency of mention (Groups A, B, and C).

Qualitatively, a larger range of services was mentioned within the category of cultural services relative to others (Table 6). Cultural services were mentioned as they relate to identities, experiences, and capabilities in a variety of ways; some of these easily fit into examples from the literature while others were novel and possibly situation or aquaculture-specific. Provisioning services were rarely mentioned and featured examples related to food production. Regulating and supporting services were discussed infrequently but broadly and connected to how aquaculture benefits the bay in several ways.

Table 6. Ecosystem Services that Connected to Motivation

Ecosystem services mentioned by participants are presented. Cultural services are presented according to cultural benefits as identities, experiences, and capabilities. Other services are presented according to generalized benefit categories based on participant responses.

Ecosystem Service	Benefit Category	Sub-Category	How Discussed Relative to Aquaculture
Cultural	Identities	Cultural heritage	Connection to fishing communities.
		Family heritage	Family history in seafood industry.
		Past experiences	Previously worked the water.
		Responsibility of care	Desire to leave something for children or community.
		Sense of place	Working in an area they feel connected to.
		Sense of purpose	Sense of being part of something larger than self.
	Experiences	Aesthetic appreciation	Beauty of physical land/bayscape and wildlife.
		Freedom	Freedom associated with being own boss.
		Inspiration	Hobby inspired commercial expansion.
		Lifestyle/Job Satisfaction	Lifestyle connected to job satisfaction. Ex: hours, perceived reward, on the water.
		Relationship with nature	Connection to outdoors/nature/water and pleasure in related activities.
		Security	Additional/replacement income in case of other failures.
		Social bonds/capital	Introduced to industry by, or entered with, a friend or family member.
		Transformation	Looking for a change of life/livelihood.
		Variety	Diverse and variable daily activities.
	Capabilities	Knowledge	Able to apply/acquire knowledge.
		Skills	Able to apply/acquire skills.
Provisioning	Food production	Food	Able to produce food for self/others.
Regulating and Supporting	General	Environmental good	Environmentally beneficial.
		Oysters	Helping restore wild oyster population.
		Restore bay	Helping restore bay overall.
		Sustainable fisheries	Sustainable relative to others.
	Habitat	Habitat provision	Contribute habitat for other species.
	Water quality	Water improvement	Help with bay water quality.

Discussion

Oysters, both wild and farmed, provide many ecosystem services, yet no effort has been made to understand the role ecosystem services play in the decision to engage in oyster aquaculture. Eliciting perceptions of ecosystem services can be challenging, and addressing this through a resource-based livelihood or activity is one means of more effectively capturing these values (Gould et al., 2015). In this study, oyster aquaculture served as a resource-based activity, or cultural practice, to gauge the importance of ecosystem services to Maryland oyster growers.

In response to the question of "why did you decide to start growing oysters?" most participants described cultural ecosystem services rather than provisioning, regulating, or supporting services. The data suggest that cultural services created and acquired through work in oyster aquaculture are more important than other ecosystem services in influencing the decision to begin growing oysters. While perhaps unsurprising, it is useful in directing future research as well as highlighting challenges related to ecosystem services, as will be detailed below. Each type of ecosystem service is summarized as discussed in interviews and is illustrated with a participant quote. All quoted participants represent unique oyster growers.

Cultural Ecosystem Services and Oyster Aquaculture

Cultural services were discussed as they relate to identities, experiences, and capabilities. In this way, the framework introduced by Fish et al. (2016) was useful in trying to understand these oyster-related services and provided more structure than found in other framework possibilities. Within the contributions made to identities, oyster growers discussed how aquaculture connected them to the fishing communities that they grew up in, and, for some, family members who worked in commercial fisheries. Notions of heritage and sense of place were frequently mentioned by those who previously worked in wild fisheries as well as those who did not. Several participants discussed the legacy that aquaculture enabled them to leave, both in terms of a healthier Chesapeake Bay and a business they could pass down to their children. Additionally, some growers talked about being part of a more abstract community, in that aquaculture allowed them to be part of something outside of or larger than themselves.

> *"People in my family have been in the seafood business for 10 generations. Watermen. My grandfather…he was a commercial fisherman. They fish trapped... He fish trapped by Cove Point, over there by Holland's Island. And his father before him was an oyster dredger, and his father before him was an oyster dredger, and his father before him was an oyster dredger…They all made their living on oysters and fish… So the answer to how did we get here, is we've always been here. This is what we've always done for a living."*
>
> *-Maryland Oyster Grower 1*

Growers talked about the experiences that their involvement in aquaculture enabled. Many experiences were connected to job satisfaction, although in different ways. Beyond mere lifestyle, the career or trade of an oyster grower gave participants the opportunity to experience nature in multiple ways, contributed to perceptions of freedom as well as security, and in some cases was transformative, leading to more fulfilled and enriched lives overall. Many growers were introduced to the industry by friends or family, or entered it with them, and emphasized the importance of these social bonds.

"Everything felt like I wanted a change…I went from [my previous job], which was very egocentric and not really bettering the world…to finding something that was so environmental it actually restored part of its environment rather than minimize its impacts. …It was something for me to get excited about again."

-Maryland Oyster Grower 2

Aquaculture contributed to individual capabilities through both knowledge and skills. Growers discussed the ability to apply previously acquired knowledge or skills to their new aquaculture endeavor. They also mentioned the opportunity to develop additional knowledge and skills not only for themselves, but also for their employees. Included in these mentions were several participants who were attracted to aquaculture because of its potential to bring jobs and skills to rural communities, and provide training and opportunity to people with limited options for employment.

"My goal is to educate people, young people. One of the problems here in these coastal communities, these working waterfronts, is that we have a lot of urban drift. Kids are going out of the area to get jobs in the city. They could make a sustainable living here staying on the water in aquaculture."

-Maryland Oyster Grower 3

Provisioning Ecosystem Services and Oyster Aquaculture

A small number of oyster growers (N = 2) discussed the associated provisioning services that interested them. In one example, the grower liked the visible outcomes of his work as oysters created both habitat in the water and a food product for people. Another grower shared how his family's passion for oyster consumption led them to think about a more reliable way to harvest or supply oysters.

"We were harvesting wild oysters and wanted to make sure we had a sustainable amount next year. We were just eating them for ourselves. We love oysters. So we were just pulling oysters out of the water... It was great. And we started asking ourselves, are there going to be oysters there next year? If we just keep taking them?"

-Maryland Oyster Grower 4

Regulating and Supporting Ecosystem Services and Oyster Aquaculture

Regulating and supporting services were discussed broadly as motivation for entering the aquaculture industry and included examples such as environmental benefits or bay health. In some cases, growers mentioned their role in contributing to the wild oyster population or sustainable fisheries overall. Several growers discussed specifically how their oysters provide habitat for other animals as one of the features that drew them to the business.

"[At my last job] you were just caught up in the process and couldn't…really see any tangible environmental improvements. Whereas here with the farm, you see all the oysters, you see all the habitat you're creating, you see the food product you're producing. So I think from the very beginning it was 100% environment. With the idea that you could make enough to live on, too."

-Maryland Oyster Grower 5

Implications for Ecosystem Services Research

This analysis revealed several findings relevant to ecosystem service studies overall and cultural services in particular. It showed that cultural services are important, though infrequently studied as they relate to oysters (van der Schatte Olivier et al., 2018). This is in line with other work that acknowledges the rank of cultural services over others for many people (Daniel et al., 2012; Gould et al., 2015; Milcu et al., 2013; Pascua et al., 2017). Results also support earlier work that illustrates the substantial effect that cultural services have in fishing communities, relative to the provisioning services delivered by commercial fisheries that economically drive many working waterfronts (Urquhart & Acott, 2014).

Understanding motivation to participate in aquaculture using the framework of ecosystem services is challenging because participant responses, as well as the services themselves, were not cut and dried. Ecosystem services are complex and integrated; participant responses, including the examples shared above, reflect that, as many featured more than one example of an ecosystem service. Additional effort is needed to understand the linkages between ecosystem services, especially cultural services (Baulcomb et al., 2015). This underscores arguments that the ecosystem service framework does not adequately account or allow for complexity and illustrates that if one were to explore linked services further, oyster aquaculture provides an excellent potential case study (Lebreton et al., 2019; Winthrop et al., 2014). Thorough understanding of linkages may only be possible within well-studied systems (Lebreton et al., 2019) and the effort put into at least three types of ecosystem services related to oyster aquaculture thus far provides a detailed, though incomplete, library on the topic.

A second aspect of the complexity of ecosystem services that was featured in Chapter 2 is the idea that benefits are not unidirectional. A two-way or transactional relationship was recognized in this study by participants. Oyster growers emphasized both what oyster aquaculture provides for them as well as their role in generating benefits to the system. Even if the typical ecological benefits were not mentioned as frequently, growers acknowledged their role in providing them.

Continued work investigating the relationship between ecosystem services and oyster-based livelihoods would benefit the oyster aquaculture industry through a greater understanding of its connection to the local social-ecological system, as well as build knowledge surrounding ecosystem services in general. Oyster-based livelihoods are of particular relevance to perceived ecosystem services because of the oyster's role as an ecosystem engineer. This initial study demonstrated that cultural services are strongly connected to oyster aquaculture and additional research is needed to better detail this relationship and understand how different participant or social-ecological system attributes may influence the perception of cultural services.

Conclusion

This analysis was the first to investigate the role of ecosystem services in motivating participation in oyster aquaculture. As the many ecosystem services provided by oysters continue to be studied and promoted, it is important to understand their perception by members of the social-ecological system, especially those involved in oyster production. Results showed that cultural services are the most important type of ecosystem service in leading individuals to oyster aquaculture rather than other livelihoods, at least in Maryland. This result is problematic, however, because little attention or research has focused on cultural services related to oysters, or shellfish aquaculture in general.

These findings are relevant to dimensions beyond that of the oyster aquaculture industry itself. Extending this discussion to consider community leaders, regulators, and other decision-makers in social-ecological systems shaped by oysters provides another utility of this research. As stated above, the suite of environmental benefits provided by oysters are regularly cited to support development of oyster aquaculture. Failure to integrate cultural services into these discussions creates a critical gap in understanding what oyster aquaculture may provide at the community-level, as well as any linked disservices. Better recognition and description of oyster-related cultural services would provide an important component to community planning related to working waterfronts with both wild and/or aquaculture oyster fisheries. Inclusion of cultural services may also refine understanding of external obstacles to both oyster fisheries. Decision-makers impact community and industry development according to their own perception of oyster-related services in addition to their constituents. Incomplete information can influence decisions in ways that may negatively impact communities and social-ecological systems more broadly. As such, there is a need for more focused efforts to build and share knowledge related to oysters and cultural ecosystem services. It is also pertinent to understand nuances in the creation and delivery of ecosystem services related to oysters in multiple arenas – not only aquaculture, but also wild harvest, and restoration.

Continued work to recognize the cultural services associated with oysters, and enabled through oyster-based livelihoods, is essential. A more comprehensive approach that incorporates multiple regions, industries of varying ages and scales, as well as a larger participant sample would greatly enhance the understanding of cultural services enabled and shaped through work with oysters. More broadly, results presented here illustrate that pursuit of additional work in this area would enhance the understanding of integrated or linked services as well as the factors that influence their access and delivery. The list of cultural services created as an outcome of this study provides more detail than previously existed related to oyster aquaculture, but it is not complete. This study demonstrated the need and provided the necessary foundation for subsequent studies within this dissertation research, which can be found in chapters 4 and 5.

Chapter 4: Cultural Ecosystem Services Enabled through Work with Shellfish

Overview

Cultural ecosystem services are understudied relative to other types of ecosystem services in general and this is also true as they relate to bivalve shellfish. Approaching these services through shellfish-based livelihoods, this study utilized ethnographic field methods to detail the benefits received and enabled by individuals through work with shellfish. A total of 218 shellfish growers, wild harvesters, and others working in roles that support shellfisheries in the Chesapeake Bay, Gulf of Mexico, and New England were interviewed to create a list of cultural, provisioning, regulating, and supporting ecosystem services as well as their related benefits. A subset of participants (N=38) also took part in photovoice interviews intended to elicit further discussion of work-related benefits. Results illustrated that individuals involved in both wild and aquaculture shellfisheries perceive and receive similar benefits, though the interpretation of these benefits may vary depending on industry role. The combined approach of semi-structured and photovoice interviews was effective in targeting cultural services, but semi-structured interviews resulted in a wider range of benefits detailed than photovoice alone. In addition to describing benefits overall, special attention was given to linked services as well as how services and benefits may be enhanced or diminished with a changing social-ecological system. The comprehensive dataset is useful for understanding the myriad benefits associated with shellfisheries and provides the foundation necessary for continued research and analysis of shellfish-associated services.

Introduction

Chapter 2 introduced the ecosystem services framework and detailed the many ecosystem services associated with bivalve shellfish. As described, the important role played by bivalves in supporting ecosystems is well-documented, but ecosystem services discussions tend to focus on the ecological role rather than the social-ecological role. Chapter 3 illustrated that though underrepresented in research and literature, cultural services were important motivators toward participation in oyster aquaculture and that more effort is needed to document these shellfish-associated services. In response, this chapter presents a study that detailed the cultural ecosystem services associated with shellfish, and did so with a focus on shellfish-based livelihoods.

Cultural services are challenging to quantify and even qualify, however, discussing them through ecosystem-based practices is suggested as an effective approach (Gould et al., 2015). Because cultural services are more directly experienced than other ecosystem services, it is imperative to understand them from the perspective of those who interact with the ecosystem (Daniel et al., 2012). Ecosystem-based practices, also described as cultural practices, allow for more focused discussion of what could be a very expansive task to detail the cultural ecosystem services associated with an ecosystem (Bryce et al., 2016; Fish et al., 2016; Gould et al., 2015). Here, shellfish-based livelihoods were used as the focal cultural practice. Within the framework outlined by Fish et al. (2016), individuals working with shellfish take part in multiple activities that qualify as cultural practices and relate individuals to the natural world. Primarily, shellfish-based livelihoods involve gathering and consuming, but as this study will show, they also entail producing and caring, creating and expressing, and even playing and exercising. Individuals who work in shellfisheries are engaging with the ecosystem in myriad ways and, likewise, the benefits they enable and receive are numerous.

A discussion of the benefits that individuals receive by working in fisheries is not unprecedented. This study was the first, however, to focus on shellfish aquaculture using the concept of cultural ecosystem services at this scale. Considering fisheries overall, one can find a history of social science work focused on topics similar to cultural services. Anthropologists, in particular, have studied aspects of fisheries-based livelihoods including job satisfaction and well-being, noting that fisheries provide certain benefits to both individuals and communities that land-based occupations do not (Pollnac & Poggie, 1988; Pollnac & Poggie, 2006; Smith, 1981). The various approaches used to study these benefits are summarized below.

Fisheries and Sociocultural Benefits

Efforts to understand the social dimensions of fisheries feature a collection of conceptual approaches used to examine the benefits obtained and experienced by both individuals working in fisheries and their communities. Most commonly, research has focused on: job satisfaction, well-being, social and other capitals, cultural benefits, cultural values, and cultural services. The sections that follow are intended to introduce each of these themes as they relate to fisheries.

Job Satisfaction

Many projects that focus on the benefits perceived and received through work in fisheries emphasize high levels of job satisfaction relative to other jobs, driven by noted characteristics of fisheries-based livelihoods (Pollnac & Poggie, 1988; Poggie & Gersuny, 1974; Pollnac & Poggie, 2006; Smith, 1981). These characteristics can also be considered as cultural ecosystem services or benefits and were used to help frame the understanding of cultural services in this project. In early work on job satisfaction, Pollnac and Poggie (1988) illustrated how measures of satisfaction were influenced by variables such as age, education, years of fishing experience, type of fishing, ethnicity, and home port and concluded that "there is more to the occupation of fishing than simply making money" (p. 898). More recent work by Pollnac and Poggie (2006) reiterates this, noting that fishers resist changing to alternative sources of income even when it would make economic sense. Investigation into job satisfaction associated with work not only as commercial fishers, but also seafood processors and charter boat operators indicated differences in relative job satisfaction among different types of fisheries-oriented jobs. Higher perceived well-being among commercial fishermen and charter boat operators was connected to ladder of life and self-actualization. The ladder of life concept emphasizes where an individual feels they are on a hypothetical ladder, with the top rung representing their best life scenario. Self-actualization reflects their perceived ability to reach that rung. Both ladder of life and self-actualization perceptions influence overall job satisfaction, which was also dependent upon job experiences. Particular experiences, like adventure and challenge, were strongly tied to commercial fisheries work (Pollnac & Poggie, 2006).

Other anthropological work reiterates that job satisfaction is often more important than income to fishermen (Acheson et al., 1980; Gatewood & McCay, 1990; Smith & Clay, 2010). In some cases, fishermen may take on additional work to subsidize their income in order to continue fishing (Anderson, 1980; Smith, 1981; Smith & Clay, 2010). Apostle et al. (1985) noted that independence, work quality, earnings, trip length and time, offshore versus inshore work, time available for family, and crowding all contribute to perceived job satisfaction. Likewise, Binkley (1995) discussed relative job satisfaction for Nova Scotian trawl, scallop, and mid-shore fishers, illustrating how perceptions of 1) survival and security, 2) belongingness and esteem, and 3) self-actualization translated to variable levels of job satisfaction within this group. Other factors that may influence job satisfaction include public perception. In a case involving West Coast gill-netters, job satisfaction was diminished due to public perception that gill-netters were to blame for the salmon decline (Gilden & Smith, 1996a, b; Smith & Clay, 2010). Overall, work as a commercial fisher represents a highly valued occupation associated with higher than average perceptual well-being as measured according to ladder of life, self-actualization, and job satisfaction (Smith & Clay, 2010).

Well-being

Ultimately, all ecosystem services are noted for their contribution to human well-being, but many research efforts have focused on well-being specifically associated with work in fisheries (MEA, 2005). In a discussion of ecosystem services in a Norwegian fishing community, well-being was linked to the maintenance of identity through harvesting fish (Kaltenborn et al., 2017). Much work involving fisheries-related benefits and well-being focuses on marine protected areas (MPAs). These cases often involve evaluation of the effect of MPAs on well-being and other conceptions of benefits. Some have explored how participatory management influences perception of ecosystem services and well-being, suggesting that individuals who were more engaged in MPA planning perceived more positive impacts of the MPA on ecosystem service delivery and resulting well-being (Mahajan & Daw, 2016).

Breslow et al. (2016) discussed connections, capabilities, conditions, and cross-cutting domains as four major constituents of well-being. Within each of these domains were multiple examples of cultural services or benefits, though they were not identified as such. Within connections, as one example, were: tangible connections to nature, intangible connections to nature, culture and identity, and social relationships. They detailed examples within these subcategories even further, and included commonly recognized benefits like stewardship, heritage, and sense of place. Framed via identities, experiences, and capabilities, Bryce et al. (2016) targeted cultural services using well-being indicators to evaluate the benefits provided by marine sites to recreational anglers and divers, with resulting indicators like engagement with nature, place identity, and therapeutic value. Biedenweg et al. (2016) used a large suite of well-being indicators summarized within six domains: physical health, psychological health, cultural, social, economic, and governance. Within these domains were many benefits that are also cultural services. In this study, they emphasized the connected nature of these well-being components, similar to linked ecosystem services (Biedenweg et al., 2016). As with the characteristics that contribute to job satisfaction, indicators such as these are important as guides to help detail the cultural ecosystem services and benefits enabled through work in shellfisheries.

Capitals

Like the ecological economists initially working with ecosystem services, some fishery-benefits work focuses on the perception of and impact on different types of capitals. Pierce and McKay (2008) revealed that oyster aquaculture is viewed by members of an Australian community as adding positive social and human capital. Community members saw any negative aspects of the industry on the other capitals, such as an untidy farm land site, as minor. Other work aims to introduce new concepts or benefits into cultural service discussions. Social capital, though present in the notion of capitals, has been understudied as it relates to ecosystem services. Social capital is linked to ecosystem service delivery; activities enabled by ecosystems are associated with interactions between individuals, i.e., social capital, that contribute to rich, cultural networks of relationships (Barnes-Mauthe et al., 2015).

Cultural Benefits and Values

Both within and outside of the context of ecosystem services, another line of research emphasizes the cultural benefits and values provided by and associated with fisheries. Specific to oysters, Paolisso and Dery (2010) proposed a cultural model of oyster restoration that includes cultural benefits, based on a large number of study respondents who identified oysters as an important component of Chesapeake history and heritage. Cultural models of environmentalism shape not only individual values related to the environment, but also perceived benefits (Paolisso, 2006). Paolisso and Dery (2010) emphasized that “culture plays a significant role in defining what is ecological and economic for most environmental stakeholders” (p. 178). This synopsis is important in this dissertation research, as the multi-regional aspect of it may yield different ways of perceiving cultural services, and ‘cultures’ may exist in ways defined beyond geographic bounds.

Using the designation ‘cultural ecosystem benefits’, Ainsworth et al. (2019) explored benefits tied to marine and coastal places, practices, experiences, and management principles. They cited benefits of: sense of place, aesthetic pleasure, and cultural identity, all of which contribute to a ‘fulfilled human life’. Like Fish et al. (2016), they framed numerous cultural ecosystem benefits according to capabilities, identities, and experiences. Rose et al. (2016) emphasized cultural practices and values as they demonstrated how restoration of a historic eel aquaculture industry in Australia provided benefits to the local community including: enhanced connection to country and culture, opportunities for economic development and employment, and increased capacity for traditional owners to progress. Cultural values were also the focus by Satterfield et al. (2013), elicited in order to understand ‘cultural services, benefits, or values’ for marine spatial planning. Values discussed included: place/heritage, educational, activity, inter-generational, identity, spiritual, and artistic. In this dissertation, through the work described in this chapter as well as Chapter 5, cultural benefits are discussed as a result of cultural services, though not necessarily linearly. The values influencing their perception will also be investigated (Chapter 5).

Cultural Services

This dissertation research was framed using cultural services, but drew from discussions of sociocultural benefits from fisheries at large. Multiple studies target cultural services precisely because fisheries are so relevant to their understanding. Fishing fleets that harvest provisioning services have an influence on their port-communities beyond the economic value of their catch, as they shape cultural heritage, identities, and a sense of place (Acott & Urquhart, 2014). Thus the provisioning service is important, but the associated cultural services help to create the community. Through work with fishing community stakeholders in Cornwall, England, Urquhart and Acott (2014) discussed community features that exemplify cultural services including, occupational identity, collective identity and social cohesion, and the influence of physical environment on identity. Paralleling some of the points mentioned with job satisfaction, they went further to suggest that communities often depend on fisheries for their cultural identity, even when it is no longer a main source of income. With a focus on recreational fisheries, Liu et al. (2019) showed how the fishing of sea trout provided social-cultural ecosystem services of local cultural heritage, folkways and lore, local ecological knowledge transfer, and skills transfer. As mentioned in Chapter 3, Cinner (2014) discussed nonmaterial benefits and noted that within coral reef fisheries, benefits of identity, lifestyle, and social norms were obtained by fishers through their work.

Various framings have been used to understand cultural services and fisheries. Emphasizing the link between ecosystem health and identities, Baulcombe et al. (2015) detailed how the sense of ‘being Turkish’ was strongly linked to perceived overall health of the Black Sea and how anchovy consumption and traditional meals were identified with Turkish culture. They emphasized the cultural linkages to ecological factors like: species visibility and populations, ctenophore blooms, and anchovy availability. These linkages also represent different categories of connected ecosystem services. In an analysis of willingness to pay for use of hypothetical marine sites, Jobstvogt et al. (2014) suggested that MEA (2005) categorization of cultural ecosystem services is problematic because of the intangibility of categories, overlap, and biased assessment. In order to provide more structure to discussion of CES, they framed their study around: marine landscape, underwater objects, sea life, vulnerable species protected, access, other restrictions, size of protected area, and travel distance. In a study with indigenous fishers in Madagascar and willingness to pay for ecosystem services, bequest, or the idea of preserving the environment for future generations, was identified as highest valued (Oleson et al., 2015). As a final example, Pike et al. (2015) used Q methodology to understand cultural services associated with two marine protected areas and framed conceptions as narratives of care, spirituality, and freedom to identify the three different perspectives shaping perception of cultural services.

Additional Descriptions of Sociocultural Benefits

Qualities of coastal ecosystems that resonate with conceptions of cultural ecosystem services have also been detailed as the ‘cultural dimensions of ecosystems’ including: meanings, values, and identities; knowledge and practice; governance and access; livelihoods; interactions with biophysical environments (Poe et al., 2014). Others have focused on place- and occupation-based identities, which together denote fishing (in this case shellfishing) as a ‘way of life’ (Blount, 2007). In a study that utilizes Q methodology, MacDonald et al. (2015) discussed perspectives on the ocean, seafood, and community in the seafood sector of a community in British Columbia using ‘social values’. They shifted from values associated with particular ecosystem service bundles to a more holistic, actor-centered approach that engages with individuals’ multiple interacting values, ultimately concluding that values were not driven by role in the seafood sector. With an emphasis on a restored alewife fishery in Maine, McClenachan et al. (2015) described the social benefits gained across the community through restoration, including economic diversification, fisheries community building, enhanced local pride, and increased recreation opportunities.

In some cases, consideration of cultural disservices is more appropriate. Though not discussed via any particular conception of services, benefits, satisfaction, etc., a case study that focused on proposed clam aquaculture development of a particular site in North Carolina described how the idea of ‘sacred space’ was used to prevent development (Garrity-Blake, 2000). Sowman and Sunde (2018) discussed social impacts. They looked at the negative impact MPAs have had on South African communities in terms of: lost tenure rights, reduced food exchange, reduced household income, and reduced participation in governance.

Regardless of the terminology, it is evident that fisheries-based livelihoods contribute to unique and valuable human-nature relationships that result in an array of benefits. One concern is the potential for these benefits to change with social-ecological system changes. These benefits are not solely experienced by individuals working in fisheries, but transfer throughout communities and regions that rely on local fisheries for food, economic input, identity, and much more. Through this project, the human-nature relationship was further explored focusing on individuals who work with shellfish.

Project Objectives

This study detailed the cultural ecosystem services provided by and enabled through work with bivalve shellfish. It did this using a multiregional ethnographic approach. Though designed to target communities with varying stages of oyster aquaculture development, all work with shellfish was considered. Work included individuals commercially harvesting wild shellfish in a public fishery, those growing or cultivating farmed shellfish commercially, and those involved in roles outside of commercial shellfish production but still supportive to shellfisheries. In addition to creating a comprehensive list of benefits enabled through work with shellfish, this study aimed to help understand whether farmed shellfisheries provide the same kind of benefits as those already noted of wild fisheries.

In doing so, this study used the case of shellfish aquaculture to better understand linked services and ecosystem disservices, both areas in need of research within the ecosystem services framework. In this case, however, the idea of 'ecosystem disservices' did not appropriately capture the changes associated with a shift from wild shellfisheries to shellfish aquaculture. Instead, it was more reasonable to think in terms of diminished and enhanced ecosystem services. In this way, rather than focus on disservices, the emphasis was on changing services associated with a dynamic social-ecological system.

Expansion of bivalve shellfish aquaculture involves an increase in the direct ecosystem services provided by bivalves as more shellfish are present in the water, but how might indirect services be affected, and how might this affect human communities within the system? Shifting livelihoods and livelihood opportunities from a public to private fishery via aquaculture may entail a different suite of cultural ecosystem services. Potential exists for both enhancement and diminishment of services with a transition into oyster aquaculture (Dwire, 1996; Garrity-Blake, 2000). A thorough understanding of the full suite of ecosystem services associated with a system and its affiliated fisheries is imperative to predicting how potential changes will affect the social-ecological system.

This component of the dissertation involved a sizeable effort to document the cultural ecosystem services associated with shellfish. It also provided an opportunity to evaluate different methods of eliciting cultural ecosystem services. Project aims can be summarized through a series of guiding research questions:

- What are the cultural ecosystem services obtained through work with shellfish?
- Can shellfish aquaculture provide the same types of cultural ecosystem services as wild fisheries in similar systems?
- How might a transition from wild shellfisheries to shellfish aquaculture affect the delivery of ecosystem services?
- What is the most effective method to elicit cultural services when comparing semi-structured and photovoice interviews?

Methods

Site Selection and Characterization

As mentioned in Chapter 1, the initial focus of this work was oyster aquaculture. Many participants, however, worked with multiple species of shellfish, rendering it impractical and scientifically unsound to limit discussion to only oysters. Even so, study sites were initially selected with oyster aquaculture in mind. Limiting the scope to the natural range and aquaculture production of the eastern oyster (*Crassostrea virginica*), research was conducted in three geographically disparate regions: New England, the Chesapeake Bay, and the Gulf of Mexico (Figure 12). In each area, the eastern oyster is both the native wild oyster and the dominant aquaculture oyster. In addition to selecting sites that would allow possible regional differences to emerge, locations also provided oyster aquaculture industries of different states and corresponding scales.

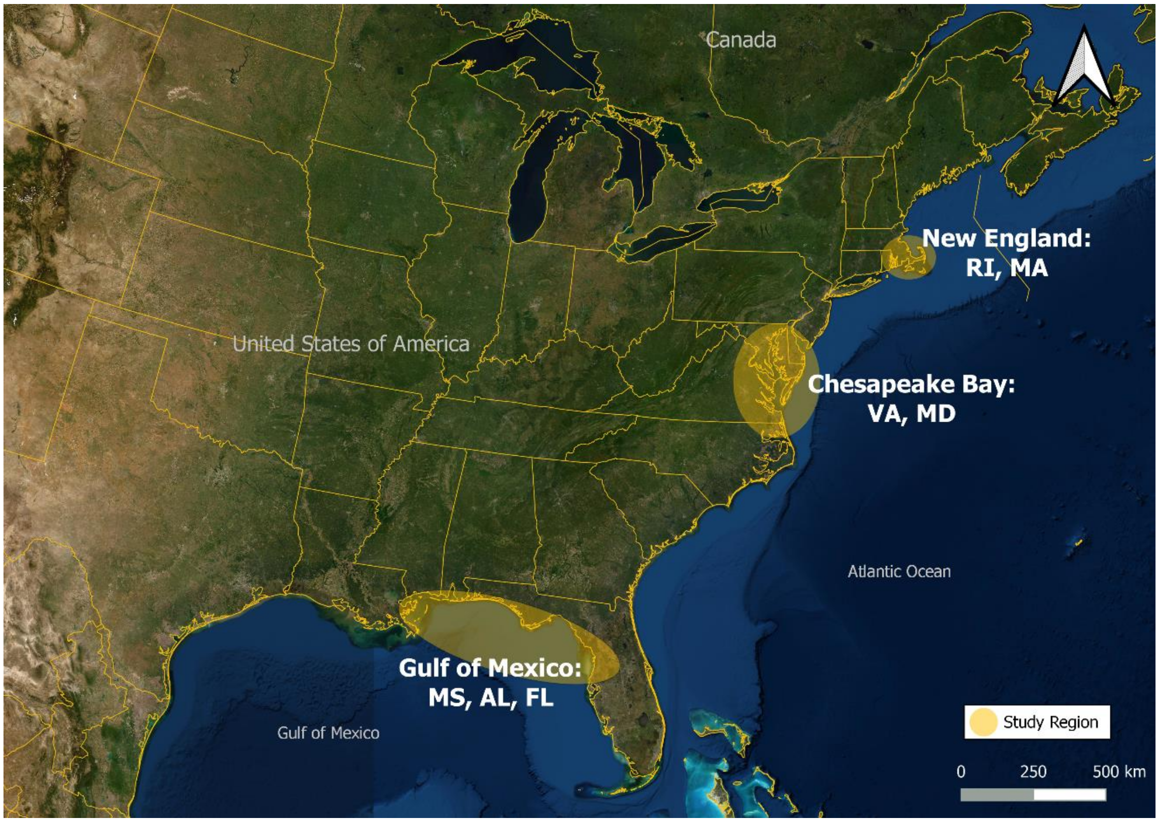


Figure 12. Regional Study Sites

Three regions within the US, emphasized in yellow, are shown with the corresponding states that served as study sites: New England (RI and MA), Chesapeake Bay (VA and MD), and the Gulf of Mexico (MS, AL, and FL).

Initially, two states were identified in each region to allow for comparison of a larger or more established industry state in each region with a relatively younger, less established state in the same region. The most recent United States Department of Agriculture (USDA) aquaculture census available prior to fieldwork detailed that the number of documented mollusk-producing farms in Massachusetts (138), Virginia (53), and Florida (154) were greater than their project counterparts of Rhode Island (11), Maryland (6), and Alabama (0) (Vilsack & Reilly, 2013). These numbers may not accurately reflect absolute totals, since the USDA defines a farm according to a minimum annual production value, but they provide an idea of scale among state industries. Since the 2013 census, the number of mollusk aquaculture farms in many states has increased, and the most recent report shows: Alabama (3), Florida (115), Maryland (30), Massachusetts (157), Rhode Island (25), and Virginia (152) (USDA, 2018). Mississippi did not have an industry at the time of the recent census, however, at the time of fieldwork an oyster aquaculture park had been established by the state and Mississippi's initial group of farmers were within several months of their oysters reaching market-size. In each state, one site or community was identified as the focal site, but interviews extended beyond the individual city or town. As will be detailed in each state's corresponding section below, in some states that meant a statewide range, in others that meant a second community. Geographic range within a state was dependent upon travel time and participant interest.

The site descriptions below are intended to provide context to each state's shellfish industries and the communities visited as part of this study. As available, metrics are provided for each of the seven study states' shellfisheries, both wild and aquaculture. Harvest data tracking varies from state to state; units of measurements may differ, in addition to location-specific regulations that structure harvests. Landings data maintained by NOAA were available for all seven states, but combine wild and aquaculture shellfisheries (NOAA, 2020). These nationally compiled data metrics are not always identical to state-provided data; such discrepancies could be related to differences in how the reporting season versus calendar year were distinguished, as well as the reporting sources for landings (harvesters versus processors, for example). Although absolute metrics may not exist, the data illustrate relative patterns and give ideas of industry scale from state to state.

The information provided does not detail a full history of each state's shellfish industry, but gives an overview to help understand some of the distinctions observed between regions, states, and communities. Site descriptions include observations based on the researcher's experience at each site and topics discussed in interviews that fall outside of the data presented in this dissertation but are relevant to understanding local dynamics, challenges, and industry prospects. To some degree, all shellfishing communities face similar obstacles of potentially unpredictable markets, the impact of severe weather events, regulatory hurdles, and user conflicts. States and communities that were featured in this research also face unique challenges, and these local distinctions are also noted.

Chesapeake Bay

Chesapeake Bay fisheries are managed according to a state boundary that divides the bay between Maryland and Virginia, and leaves management of the Potomac River, a natural boundary between the two states, to the Potomac River Fisheries Commission. Both Maryland and Virginia have histories of bottom culture of oysters, with oysters transferred as wild or hatchery-produced seed, to be grown out on individually leased bottom (Keiner, 2010; Kennedy & Breisch, 1983). More recently, the introduction of container gear has led to more new growers utilizing container culture methods. The majority of operations involve on-bottom culture or submerged gear, but surface-floating gear is also expanding (MD ACC, 2019; Hudson, 2019). Study sites in this region are shown in Figure 13.

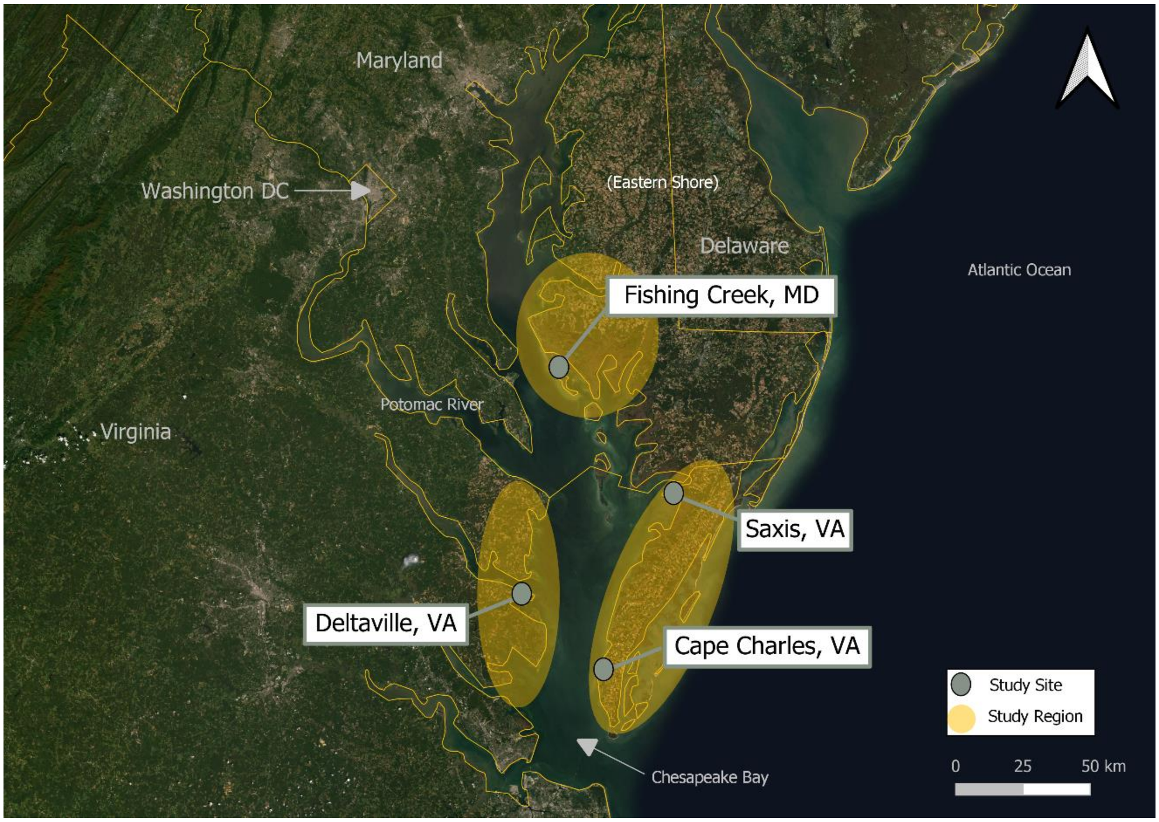


Figure 13. Chesapeake Bay Study Sites

The map shows the Chesapeake Bay region and four focal communities described in the text below. Yellow lines represent state boundaries and yellow ovals indicate study areas covered.

Maryland

In this study, two months were spent at each field site, making statewide coverage at most sites impractical. In Maryland, efforts centered on the eastern shore community of Fishing Creek and its associated islands, but fieldwork included participants working with shellfish throughout Dorchester County. Dorchester County is also the location of the University of Maryland's Horn Point Laboratory Oyster Hatchery, which provided proximity to shellfish biologists, extension associates and others involved in industry supportive roles who participated in this project.

The eastern oyster (*Crassostrea virginica*) is Maryland's largest bivalve shellfishery and state management dates back to 1820 (Kennedy & Breisch, 1983).

Operating at a smaller scale alongside the public oyster fishery are a sea scallop (*Placopecten magellanicus*) fishery and several clam fisheries: soft shell clam (*Mya arenaria*), hard clam (*Mercenaria mercenaria*), and razor clam (*Tagelus plebeius*). Contemporary shellfisheries face increasingly restrictive management, declining shellfish populations, and a legacy of negative environmental impacts that make wild oyster and clam fisheries more and more unpredictable sources of income (Michaelis et al., *accepted*). Maryland's most recent wild oyster harvest totaled less than 200,000 bushels in 2018 (MD DNR, 2019). While there were just under 1,000 licensed commercial oyster harvesters in Maryland during that season, the total is likely an overestimate of the number who were actively harvesting (MD DNR, 2019; Green & Tracy, 2013). Maryland's overall oyster landings in 2018, including both wild and aquaculture, totaled 464.6 thousand pounds with a dockside value of $6.7 million (NOAA, 2020). Other shellfisheries with 2018 landings data available include soft clams (131.5 thousand pounds; $9.1 million) and sea scallops (144.2 thousand pounds; $1.2 million) (NOAA, 2020).

Shellfish aquaculture in Maryland is not new; private leases for oyster aquaculture were first approved in 1830 (Keiner, 2009) The current approach to aquaculture management, however, is more recent. As mentioned in Chapter 3, in 2009 legislative changes removed multiple prior restrictions and expanded opportunity for oyster aquaculture. Prior to 2009, leased bottom was used mainly for on-bottom planting of oysters and many leases were inactive. After 2009, inactive leases were returned to the state and the industry expanded with a combination of on-bottom planting paired with container culture. Though Maryland introduced the idea of "Aquaculture Enterprise

Zones" to identify target areas that would be suitable for oyster aquaculture, Maryland leaseholders identify and apply for their own parcel of leased bottom and do not grow shellfish in aquaculture zones or parks as in some other states. Shellfish culture in Maryland includes eastern oysters and hard clams, but clams are limited to a small number of operations along the Atlantic coastal bays. Aquaculture sales continue to rise and in 2017 annual aquaculture production was estimated at approximately 74,000 bushels (MD ACC, 2019).

Initial research in Maryland began with an interest in participation in aquaculture by wild harvesters. At the time, it appeared that many wild harvesters were not getting involved in aquaculture, however in comparison to some states, Maryland may have moderate to high wild harvester participation. In this study, 10 of 19 Maryland shellfish grower participants also worked in wild fisheries. Earlier research suggested that wild harvesters were more likely to take on submerged land leases than non-watermen, and many watermen were doing that in addition to working in wild fisheries (Michaelis, unpublished). Wild harvesters also worked on water column leases using container gear; many of these wild harvester-water column participants transitioned into full-time oyster growers.

In terms of relations between the two types of shellfisheries, there is some degree of conflict over bottom rights. At the time that lease laws were changed, sanctuaries were also implemented on certain sections of historic public shellfishery bottom. The timing was unfortunate for the perception of aquaculture, as many wild harvesters viewed it as a joint "bottom-grab" (Michaelis, unpublished). The concern from wild harvesters was less over aquaculture as a practice, but more what it might mean for public fishery access and ability. In one of the early interviews in Maryland as part of the study introduced in Chapter 3, one wild harvester offered that “oystering is oystering” whether it was aquaculture or wild. Not all wild harvesters saw the two as similar, particularly for container culture, but the hesitancy toward aquaculture was more linked to what the expansion of aquaculture might mean for public fisheries.

Ongoing challenges to both wild and farmed shellfisheries as discussed in interviews include user conflicts with adjacent landowners and the impacts of heavy rain and low salinity. Though severe weather events like hurricanes are possible, landfall is infrequent in Maryland. During the course of fieldwork for this project, watermen and oyster growers alike made preparations for Hurricane Florence, which ultimately made landfall further south in the Carolinas. Specific to aquaculture, the lease application process is regularly delayed by protests by nearby property owners and to a lesser degree, concern over interaction with wild fisheries (Michaelis et al., *accepted*). The state offers guidance as well as legal support on behalf of potential shellfish growers, but the length of the process is a barrier to some.

Virginia

Virginia was the regional counterpart to Maryland in the Chesapeake Bay. The focal site was Deltaville, a town in Gloucester County on the western shore of Virginia. Fieldwork extended beyond Deltaville through the coastal regions of the Middle Peninsula and Northern Neck along Virginia’s western shore. Travel was kept to within a 90 minute drive and covered a wider range than in Maryland in order to have a comparable number of interviews. As in Maryland, the Virginia field site was near a university shellfish hatchery, the College of William and Mary’s Virginia Institute of

Marine Science. The eastern shore of Virginia provided a secondary study site during a subsequent one-week trip to meet with interested participants. Study locations on Virginia's eastern shore included Cape Charles at the southern end, and Saxis toward the northern end.

Like Maryland, Virginia has a long history of both wild and farmed shellfisheries that include eastern oyster (*C. virginica*), soft shell clam (*M. arenaria*), hard clam (*M. mercenaria*), and the blood ark (*Tegillarca granosa*). Unlike Maryland, however, Virginia's watermen adopted bottom culture and seeding earlier as a means to enhance their wild fishery and income. As such, Virginia's aquaculture industry, though only recently expanding with floating gear, exceeds Maryland's in scale. Virginia leads the US in clam aquaculture production and leads the East Coast for eastern oyster aquaculture production (Hudson, 2019). Virginia's hard clam aquaculture industry, based largely on its eastern shore, generated $38.8 million in 2018, while farmed oysters generated $14.5 million (Hudson, 2019). Although their farmed oyster industry is smaller than the state's farmed clam industry, oyster aquaculture is rapidly expanding (Hudson, 2019).

Interviews in Virginia suggested less distinction between their public oyster fishery and oyster aquaculture than in Maryland. Often, the difference between public and private or wild and aquaculture needed to be clarified in interviews to be sure that the researcher and participants were on the same page. Floating gear, which has only recently begun to expand in Virginia, was more distinct, but Virginia's history of on-bottom culture likely contributes to a broader perception of an oyster fishery. Within this study, of the 30 participants growing shellfish, 9 were also wild harvesters. Virginia's wild oyster fishery has experienced much of the same obstacles as Maryland's, but their annual landings are typically slightly higher, with close to 500,000 bushels in 2018 (Schulte, 2017). NOAA-cited landings data from 2018 indicate wild and farmed shellfishery totals of: 3.8 million pounds and $43.5 million for oysters; 33.8 thousand pounds and $25.8 thousand for blood arks; 3.3 million pounds and $26.1 million for hard clams; and 3.9 million pounds and $35.1 million for sea scallops (NOAA, 2020).

Adjacent or upland property owners were noted as one of the bigger obstacles to Virginia shellfisheries (NOAA, 2019). Western shore participants indicated that many of the protests were from "weekenders" who had second homes on the water in traditional fishing communities. On the eastern shore, however, no participants (N=8) incurred such issues. The eastern shore's clam aquaculture industry is extensive, and this, paired with lower population numbers, may contribute to a better perception and greater acceptance of aquaculture in general on Virginia's eastern shore.

Gulf of Mexico

The Gulf of Mexico also has a history of productive shellfisheries, including oyster production that increased during the 1950s to meet the needs of northern markets whose local supply had declined (GSMFC, 2012). The Gulf Coast continues to supply much of the nation's wild oysters, but Louisiana drives that production and also utilizes leased bottom to do so (GSMFC, 2012). In this study, however, Alabama, Florida, and Mississippi were the focal states (Figure 14).

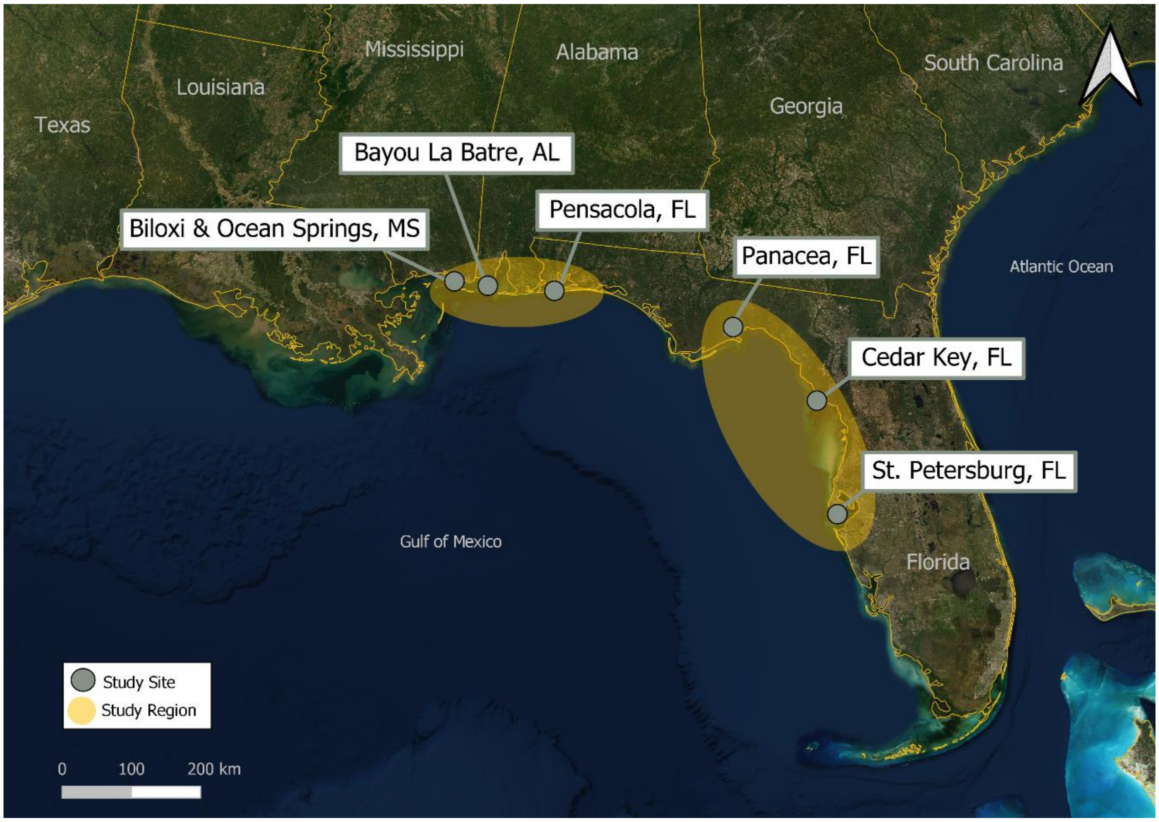


Figure 14. Gulf of Mexico Study Sites

The map shows the Gulf of Mexico region and seven focal communities described in the text below. Yellow lines represent state boundaries and yellow ovals indicate study areas covered.

Diversions, dams, and other management approaches to the waters that lead into the Gulf have altered watershed dynamics (Cerny-Chipman, 2019). Heavy rain events, or prolonged rain, can lead to extremely low salinities for extended periods of time, which is bad for both wild and farmed shellfisheries. When salinity is high, however, and complemented by warmer waters, the grow-out time for shellfish aquaculture producers in the Gulf is much faster than regions north. Barring severe weather events, a Gulf oyster can reach market size in under two years; many growers reported less than one. Weather events, severe and prolonged, posed the biggest challenge for this region based on interviews. Very few growers mentioned issues with adjacent property owners, in part because many of the study sites in the Gulf region involved aquaculture parks.

Alabama

The entire coastline of Alabama was included in the study area. Bayou La Batre was the initial focus, but the length of the coast and willingness of study participants were such that all oyster-farming areas could be covered. The Auburn University Shellfish Lab is located not far from Bayou La Batre, on Dauphin Island, and provided an additional shellfish research hub within the study area.

Though Bayou la Batre is recognized as one of the leading seafood processing communities in the country, much of the wild shellfish being processed is harvested from outside of Alabama. This was a concern voiced by wild harvesters, who wished to see more Alabama seafood being caught and consumed. In recent years, Alabama's wild oyster harvest has been limited to a few week window or less; during the study period, the entire oyster season was closed. Though 2018 had no oyster harvest, the 20-year totals range from 9,500 pounds of meat to 1.5 million pounds harvested per year (Wallace, 2018). As with all study sites, the native oyster is the eastern oyster (*C. virginica*); this is also the species farmed in Alabama. No other marine bivalve shellfisheries exist in Alabama.

Oyster aquaculture is a fairly recent addition to Alabama's seafood industry. The first farm started in 2009 and in 2018 the state had over 20 farms. This total is greater than the USDA (2018) metric cited above, likely due to the annual production requirement for the USDA definition of farm. No other shellfish are currently being farmed in Alabama, but in 2018, oyster aquaculture had a farm gate value of $1.1 million, selling nearly 2 million single oysters, based on the 13 farms who completed the industry survey (Grice & Walton, 2019). This corresponded to NOAA-documented landings of 25.3 thousand pounds and $914.4 thousand (NOAA, 2020).

In Alabama, oyster aquaculture is largely occurring in surface floating gear and long line systems. Several farms are located within designated aquaculture parks. According to wild harvesters interviewed, the siting of the parks and the fact that oysters are being grown at the surface made aquaculture unlikely to overlap with wild bottom, and thus less likely to create conflict. Commercial fishermen also noted that since the wild harvest was so limited, any Alabama oyster was good for Alabama, even if it went to a different type of market. Market, however, was suggested as one of the potential challenges by interviewees, as local customers were accustomed to wild Gulf oysters and additional marketing was necessary to sell their farmed oyster to local markets. In terms of participation, most oyster growers interviewed in Alabama did not work in wild harvest fisheries prior to oyster aquaculture. Within this study, only 6 of the 24 shellfish growers were also connected to wild fisheries

Both wild and farmed shellfisheries face obstacles of periodic low salinity in Alabama. Prolonged rainfall also contributed to runoff-related closures that several growers indicated were routine problems for their site. Wild harvesters simply wanted an oyster season again.

Florida

Fieldwork in Florida took on a different regional approach. Cedar Key, the original site, is located in Levy County along Florida's Gulf Coast. Upon arrival, however, it was discovered that many of Cedar Key's oyster growers were no longer growing oysters. These growers had previously diversified and added oysters to existing clam aquaculture operations, but for various reasons (largely related to markets and associated labor), opted to grow only clams. Since the project's focus was oysters, one month was spent in Cedar Key and a second month was spent in Panacea, an oyster-farming community further north along the coast. While in Cedar Key, a trip was made to meet with shellfish growers near St. Petersburg. Additionally, while in Alabama, Pensacola was within a few hour drive and the opportunity was taken to interview oyster farmers in the Pensacola area. The University of Florida's Shellfish Aquaculture Research and Extension office was nearby in Cedar Key and provided an additional industry support connection.

Florida's wild fisheries include eastern oyster (*C. virginica)*, hard clam (*M. mercenaria*), and bay scallop (*Argopecten irradians*) (FFWCC, 2020). In 2018, over 38,000 pounds of wild oysters were harvested on the east coast and over 498,000 pounds of wild oysters were harvested on the west coast (FFWCC, 2020). Wild hard clams totals in 2018 were 108 pounds on the east coast and 253 pounds on the west coast (FFWCC, 2020). Aquaculture production in 2018 included 765 pounds of oysters from the east coast while the west coast produced 9,204 pounds of farmed hard clams and 19,675 pounds of farmed oysters (FFWCC, 2020). Additional wild and farmed species landed in Florida with a lower yield in 2018 include: Atlantic thorny oyster (*Spondylus americanus*), rough fileclam (*Ctenoides scabra*), spiny fileclam (*Lima lima*), southern quahog or hard clam (*Mercenaria campechiensis*), jewel box clam (*Arcinella cornuta*), pen shell clam (*Atrina rigida*), lions-paw scallop (*Nodipecten nodosus*), and other scallop species.

Though very few wild harvesters farmed oysters in Cedar Key, wild harvester involvement in clam aquaculture was high. One reason to promote clam aquaculture initially was the ‘net ban’ of 1994. Floridians voted to eliminate the use of gill and other entangling nets inshore and this affected 1500 commercial fishers and their families (Shivlani et al., 1998; Smith et al., 2003). Since the net ban, fishermen involvement in aquaculture has increased and Florida has become one of the nation’s top farmed clam producers, second only to Virginia (Adams et al., 2014). The net ban also influenced wild harvesters in Panacea, who began growing clams in nearby Franklin County. Many of these clam growers, however, have transitioned into oyster aquaculture and are contributing to a rapidly growing oyster aquaculture industry in Franklin and Wakulla counties. In Pensacola and St. Petersburg, a smaller number of growers are initiating the local aquaculture industry.

One of the biggest challenges faced by Florida growers is hurricanes. In October of 2018, Hurricane Michael caused significant damage to Florida’s coastline and in the spring of 2019, many oyster growers were still recovering financially from the loss they incurred. Several shared stories of the storm and the extent to which they were able respond and prepare for future storms.

Mississippi

Mississippi was not an original target site, however its proximity to Alabama and the state’s first group of oyster farmers made it an additional opportunity worth exploration. Mississippi currently has a single oyster aquaculture park on the ocean side of Deer Island near Biloxi and Ocean Springs. In addition to visiting the aquaculture park and meeting with growers, participant observation took place at one of the grower training workshops and provided an overview of the plans ahead for this new industry.

Mississippi's wild oyster fisheries mirror Alabama's. There was no harvest in 2018, and the prior year only yielded 40,165 sacks (MS DMR, 2020). NOAA indicates a 2018 landings total of 2,552 pounds valued at $19,050 (NOAA, 2020). This discrepancy for the year 2018 is likely a reflection of differences between the calendar year (NOAA) and harvest season (MS DMR). Mississippi had on-bottom oyster leases that contributed to the wild harvest totals, but in 2018 the Mississippi Department of Marine Resources (MS DMR) began a new aquaculture training program for surface-grown oyster aquaculture. The new program targeted wild harvesters, but was open to applications from anyone interested in learning how to grow oysters. Students had the opportunity to acquire a lease within the aquaculture park and begin a new business.

During the time of fieldwork, Mississippi oyster farmers were awaiting their first oysters to go to market. They were a few months away from their first sale when freshwater input disrupted their plans; the opening of the Bonnet Carre spillway in Louisiana released large quantities of freshwater into Lake Ponchartrain and ultimately the Gulf of Mexico. The freshwater influx forced farmers to relocate their oysters or risk losing them. Many moved their oysters to Alabama. These travelling oysters have since returned to Mississippi and many have gone to market. Freshwater events affect both wild and farmed oyster fisheries in Mississippi (Roberts, 2019).

Also, as with Alabama oyster growers, Mississippi growers face potential obstacles related to local markets accustomed to wild Gulf oysters rather than cultivated aquaculture oysters. At the time of interviews, growers were not yet ready to sell their oysters, but many were excited by the prospect of introducing a locally grown, Mississippi oyster and did not acknowledge the need to shift local perspectives as a potential hurdle. Several growers had interested clients (chefs and wholesalers) awaiting their oysters.

New England

Shellfisheries of New England are notable for their influence on other regional industries. As indicated above, Gulf Coast oyster production increased to meet northern demand. This demand occurred after New England oyster fisheries were depleted, and many processors relied on Chesapeake product until that was also unreliable. These connections illustrate that though geographically distant, US shellfisheries are inherently linked.

New England shellfisheries have achieved a different level of notoriety when it comes to branding that many of the participants in other states look forward to achieving. Place and product names associated with New England oysters are recognizable in restaurants and markets across the US, arguably more than other regional shellfish products. The regional focus in New England included sites in Massachusetts and Rhode Island (Figure 15). Though these states have smaller coastlines than other sites, they boast productive wild and farmed shellfisheries.

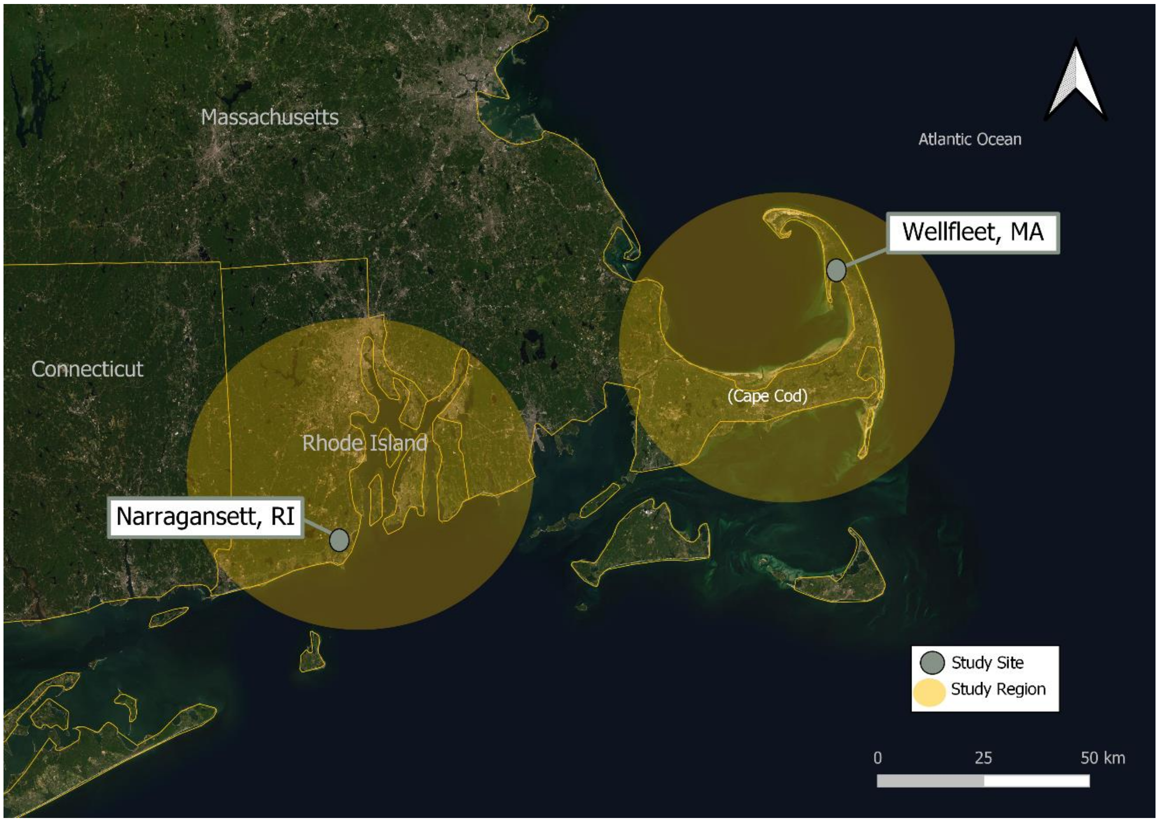


Figure 15. New England Study Sites

The map shows the New England region and two focal communities described in the text below. Yellow lines represent state boundaries and yellow ovals indicate study areas covered.

Massachusetts

In Massachusetts, Wellfleet was the focal site but fieldwork was conducted all along Cape Cod. Unique to Massachusetts (among the field sites), shellfisheries are managed at the municipal level, albeit with state oversight. In other words, Wellfleet managed their wild and farmed shellfisheries, Barnstable managed theirs, etc. As such, not all towns had shellfish aquaculture and they had varying degrees of active shellfisheries. Also unique to Massachusetts were shellfish constables. Affectionately referred to as ‘clam cops’, town constables were responsible for regulation and enforcement, and potentially shellfish propagation, depending on the town. Many towns helped to maintain commercial and recreational shellfisheries for oysters and clams (Massachusetts Division of Marine Fisheries, 2018).

In 2016 Cape Cod's 249 shellfish farms produced over 19.3 million oysters (*C. virginica*), with a landing value of $10.9 million, and 5.3 million quahogs or hard clams (*M. mercenaria*) that had an associated landing value of $1.2 million (Cape Cod Cooperative Extension, 2020). The state overall produced $21.7 million of oysters and $1.36 million worth of clams (Cape Cod Cooperative Extension, 2020). Additional aquaculture species in the state include soft shell clams (*M. arenaria*), blue mussels (*Mytilus edulis*), and bay scallops (*A. irradians*).

Though every community is unique, shellfisheries along the Cape stood out a bit more. Their management approach, as mentioned, was different. What was particularly striking, however, was the intertidal nature of many of the farms. Most farms transitioned from completely submerged to completely exposed in the span of a tide, and farmers were required to work around that schedule. As such, the start of the work day varied with the tide and a number of participants shared that as something they enjoyed about the work. Other areas depend on the tide also, but not to the same extent as many towns along the Cape.

There was much overlap between wild harvesters and shellfish growers on Cape Cod, and many participants were involved in both types of fisheries. Of the 21 shellfish growers interviewed, 18 were also wild harvesters. Wild shellfisheries were a bit more expansive in Massachusetts and included sea scallop (*P. magellanicus*), surf clam (*Spisula solidissima*), Arctic or ocean quahog (*Arctica islandica*), soft shell clam (*M. arenaria*), razor clam (*Ensis leei*), and blood clam (*T. granosa*), along with eastern oyster

(*C. virginica*) and hard clam (*M. mercenaria*) (Massachusetts Division of Marine Fisheries, 2018). In 2018, 8.7 million pounds of eastern oysters, 336 million pounds of sea scallops, 89.6 million pounds of Atlantic surf clams, 3.6 million pounds of soft shell clams, 6 million pounds of northern quahogs, and 733 thousand pounds of Atlantic razor clams were landed in Massachusetts (Massachusetts Division of Marine Fisheries, 2018). NOAA's documented overall wild and farmed landing data for 2018 differs slightly, again likely due to differences in the calendar year and season, as well as reporting sources. NOAA landings indicate 2018 totals of: 650.6 thousand pounds and $28.4 million for eastern oyster; 62.4 thousand pounds and $130.4 thousand for blood ark; 580.4 thousand pounds and $4.9 million for northern quahog; 259.1 thousand pounds and $3.2 million for Atlantic razor clams; 750.2 thousand pounds and $6.2 million for soft clams; 17.1 million pounds and $17.2 million for Atlantic surf clams; 1 million pounds and $1 million for blue mussels; 110.5 thousand pounds and $1.6 million for bay scallops; and 40.4 million pounds and $373.8 million for sea scallops (NOAA, 2020).

One of the bigger challenges as perceived by an outsider might be winter on the Cape. Shellfish farmers need to overwinter their animals, many burying them in large storage pits underground. If not, the tidal exposure and ice may be too damaging for their crop to survive. Shellfish growers, however, recognized that challenge as simply part of the work. The challenge that received more attention during the time of fieldwork was concern over a statewide shellfish initiative. Community members, particularly in Wellfleet, were worried about what this initiative designed to expand aquaculture opportunities might mean for their town. Specifically, community members were concerned that amendments to state shellfish regulations would subvert local authority and enhance the opportunity for large, corporate acquisition of leases (referred to as grants in Massachusetts). This potential was discussed as detrimental to the character and identity of communities like Wellfleet, as well as for access and opportunity to acquire a grant and begin a shellfish farm. This perspective was not shared by all communities along the Cape, most notably in some towns whose shellfisheries were not yet as developed as Wellfleet.

Viewshed and adjacent property owner concerns were not mentioned in interviews along the Cape. This is surprising, given the number of seasonal residents and vacation homes, however it is likely reflective of the age of shellfisheries and their prominence on Cape Cod. Incidentally, conversations with visitors and seasonal residents suggested that they were aware and proud of the Cape's shellfisheries, but ignorant to the presence and practice of shellfish aquaculture.

Rhode Island

Narragansett, Rhode Island, more specifically the community of Point Judith, was the final site of the project. Though most fieldwork occurred on the western side of Narragansett Bay, fieldwork and interviews occurred throughout coastal Rhode Island with the exception of Block Island. Point Judith was also the focus of much of the early work on job satisfaction in fisheries as cited throughout this dissertation. Two universities with strong shellfish research programs were nearby and contributed to industry support discussions and perspectives: the University of Rhode Island and Roger Williams University.

Though oysters, and especially farmed oysters, are an important shellfish product in Rhode Island, quahogs (*M. mercenaria*) have historically been the most economically important species (ShellfishRI, 2020). As aquaculture was being introduced to Rhode Island in the 1980s, quahoggers were one of the groups concerned about its impact (Korney, 1981). This introduction was more of a re-introduction, as, like many states, leasing existed in Rhode Island, but not in the same form as it exists today (Korney, 1981). Now, a mix of backgrounds shape Rhode Island's shellfish industry and vocational training programs exist for both aquaculture and wild fisheries. Within this study, 10 out of 28 shellfish growers were also involved in wild harvest. In addition to hard clams or bay quahogs and oysters, soft shell clams (*M. arenaria*), blue mussels (*M. edulis*), bay scallops (*A. irradians*), sea scallops (*P. magellanicus*), surf clams (*S. solidissima*), and razor clams (*E. leei*) are also wild harvest bivalve species (RI DMF, 2019). NOAA landings data for 2018 provide information on some of these species, again combined with aquaculture totals: eastern oyster (226.1 thousand pounds and $5.8 million); northern quahog (511.9 thousand pounds and $4.8 million); soft shell clams (1 thousand pounds and $16.5 thousand); blue mussels (6 thousand pounds and $32.4 thousand); and sea scallop (2.5 million pounds and $22.1 million) (NOAA, 2020).

Oyster aquaculture takes place in floating gear, submerged containers, and directly on bottom in Rhode Island's salt ponds and bays. Some shellfish growers also grow clams, mussels, and scallops. In 2018, oysters were the number one aquaculture product in Rhode Island and over 8.5 million were sold for consumption. These oysters sold for a farm gate value of $5.85 million. Numbers reflect a sharply increasing trend in production and value (Beutel, 2018).

Challenges in Rhode Island mentioned by participants largely centered on user conflict but in more diverse ways than simply viewshed concerns from adjacent land owners. Property owner problems existed, but shellfish growers also cited challenges with dock and slip space because of marine use complaints and some growers mentioned opposition from recreational users. Much of the noted conflict occurred on the state's salt ponds. These ponds line Rhode Island's south-facing coastline and within each pond, less than 5% of the total area is eligible for shellfish aquaculture (RI CRMC, 2018).

Participant Selection and Solicitation

Participant solicitation occurred via a combination of targeted, snowball, and opportunistic sampling. In each region, local extension personnel and other industry contacts assisted with initial introductions to potential participants. Many participants assisted with subsequent introductions. Potential participants were also contacted via email, social media, and telephone using contact information of shellfish farms, fishermen's associations, and other industry associations found online. All aspects of participant selection and study involvement were approved by the University of Maryland Institutional Review Board (Project Number 1242746).

Participants were selected to represent a broad suite of individuals working in shellfisheries. This included shellfish growers or farmers (aquaculturists), wild shellfish harvesters, and others who earn an income from shellfish in ways beyond production and harvest (Figure 16). This latter group, categorized as industry support, included individuals involved in research, regulation, extension, wholesale, gear manufacture, lobbying, industry associations, and other roles. Because in many regions commercial fishermen were entering aquaculture from wild fisheries other than shellfish, commercial fishermen involved in all types of wild fisheries were included, but are grouped here as "wild harvesters" (Figure 17). Participants classified as wild harvesters were involved in a variety of fisheries, and noted the use of multiple types of harvest gear or methods, including: digging, dragging, rod and reel, pot fisheries, longline, gill net, purse seine, haul-seine, and dredge (Table 7). In many cases, participants were involved, either presently or in the past, in multiple roles and were designated as combined roles as appropriate. For example, an individual who has worked both in wild commercial fisheries and industry support was categorized as "Support/Wild Harvester".

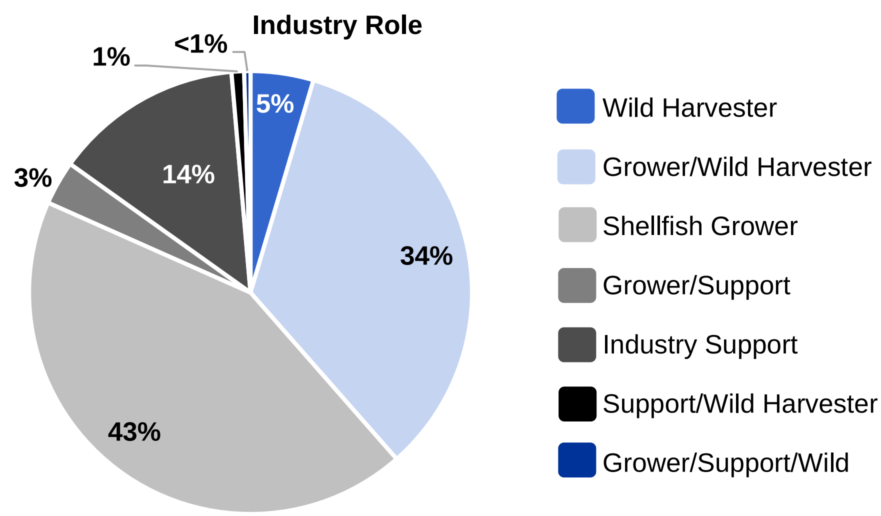


Figure 16. Participant Representation by Industry Role

Participants are presented by role as: 1) wild harvesters exclusively (includes all commercial fishermen), 2) shellfish growers who are/were also wild harvesters, 3) strictly shellfish growers, 4) shellfish growers also involved in industry support, 5) strictly industry support, 6) those involved in wild harvest and industry support, and 7) those involved in all three roles. Only one participant had worked in all three roles, and while shown on the chart in navy blue, the section is very thin and indicated with "<1%". (N=218)

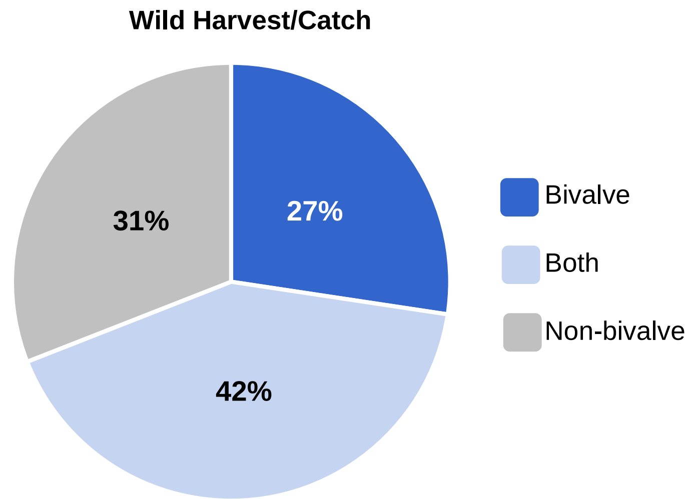


Figure 17. Wild Harvester Participant Representation by Fishery Type

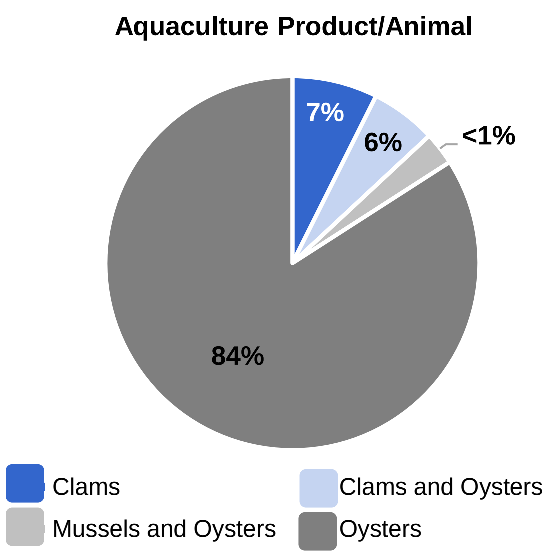
Participants are presented as the proportion of all wild harvester participants according to the type of fishery they work or have worked in: 1) bivalve shellfisheries, 2) non-bivalve fisheries, or 3) both. (N=84)

Table 7. Fisheries Represented by Wild Harvester Participants

Species harvested or caught by participants in wild or public commercial fisheries are listed by type of animal, common name, and scientific name. Common names were provided by participants; information in [brackets] was added for species clarification.

	Common Name(s)	Scientific Name
Clam	Atlantic surf clam, sea clam	*Spisula solidissima*
	Blood clam, blood ark	*Tegillarca granosa*
	Hard clam, littleneck clam, quahog	*Merceneria merceneria*
	Soft-shell clam, longneck clam	*Mya arenaria*
Conch/Whelk	Not specified	Not specified
Crab	Alaskan king crab	Not specified
	Blue crab	*Callinectes sapidus*
	Stone crab	*Menippe mercenaria*
Finfish	American eel	*Anguilla rostrata*
	[Atlantic] Bluefin tuna	*Thunnus thynnus*
	[Atlantic] Cod	*Gadus morhua*
	[Atlantic] menhaden	*Brevoortia tyrannu*
	Baitfish (general)	Not specified
	[Black] Sea bass	*Centropristis striata*
	Florida Pompano	*Trachinotus carolinus*
	Flounder	Not specified
	Groundfish (not specified)	Not specified
	Grouper	Not specified
	Gulf reef fish (not specified)	Not specified
	Halibut	*Hippoglossus spp.* (Not specified)
	Herring (not specified)	Not specified
	King Mackerel	*Scomberomorus cavalla*
	Mullet (not specified)	*Mugil spp.* (Not specified)
	[Northern] Red Snapper	*Lutjanus campechanus*
	Perch (not specified)	*Perca spp.* (Not specified)
	Reef fish (not specified)	Not specified
	Rockfish, Atlantic striped bass	*Morone saxatillis*
	Salmon (Pacific, general)	*Oncorhynchus spp.* (Not specified)
	Shark (general)	Not specified
Lobster	American lobster	*Homarus americanus*
Mussels	Blue mussel, common mussel	*Mytilus edulis*
Oyster	Eastern oyster	*Crassostrea virginica*
Scallops	Bay scallop	*Argopecten irradians*
	Sea scallop	*Placopecten magellanicus*
Shrimp	Shrimp (not specified)	*-penaeus spp.* (Not specified)
Squid	Squid (not specified)	Includes *Ilex spp.*

Participants involved in shellfish aquaculture, categorized as shellfish growers for this project, were largely oyster growers, but also included clam and mussel growers (Figure 18). In addition to products mentioned in Figure 18, some participants were involved in the aquaculture of shrimp and crawfish in the past. For the majority of shellfish grower participants, aquaculture was their only form of income (Figure 18). Shellfish grower participants entered the industry from a diversity of professions. Of those who left another job to work in aquaculture, 21 were formerly wild harvesters, while 71 entered from other industries.



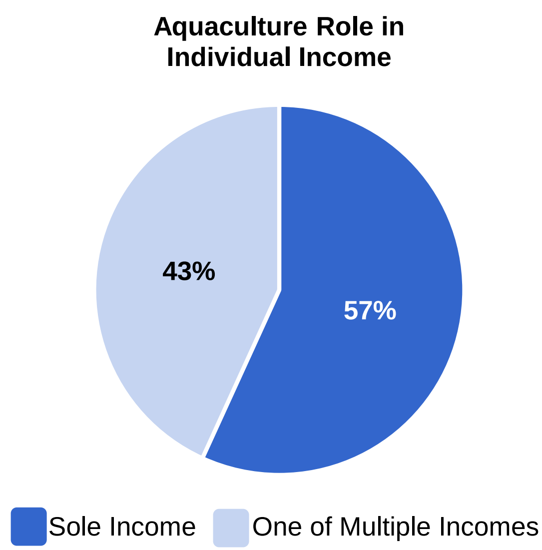


Figure 18. Aquaculture Production by Product/Animal (Left) and Aquaculture Contribution to Income (Right)

Animals produced by shellfish growers are shown (left) with the role of aquaculture in individual participant incomes (right). (N = 176)

Good representation from all three study regions was obtained, with slightly more participants from the Gulf of Mexico (Figure 19). Seven states were represented, with more participants from Florida than other states. As noted in the site description, Mississippi participants were added opportunistically while working in Alabama; their industry was in its first year, and thus much smaller than other industries. As such, Mississippi was not as well represented as other states but provided an interesting perspective from participants who were brand new to the industry.

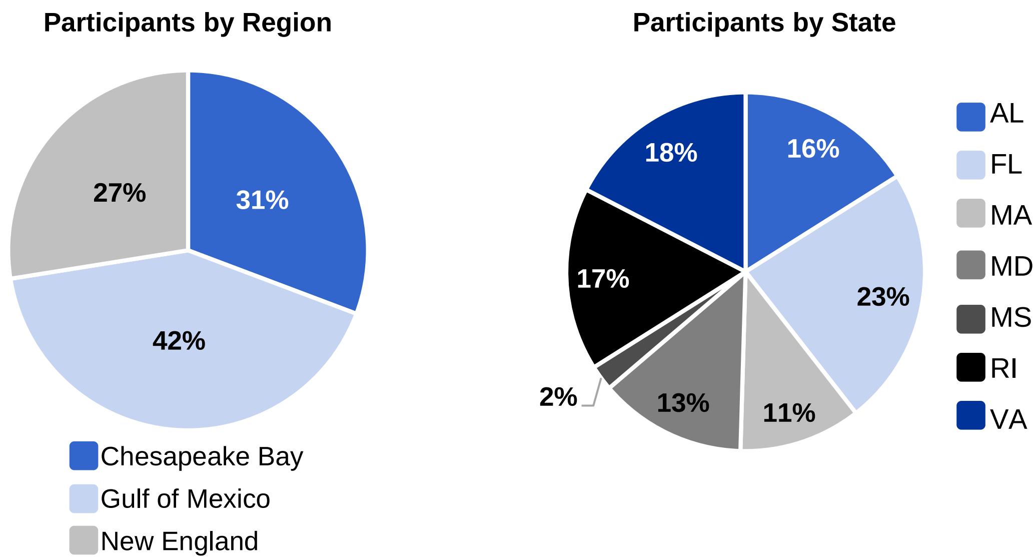


Figure 19. Participant Representation by Region (Left) and State (Right)

The proportion of participants from each of the three study regions (left) and seven study states (right) are shown. (N=200)

More male participants took part in the project than female, and this is representative of fisheries at large (Figure 20; FAO, 2013). In terms of age, the number of participants over 70 was less than other age groups, but all other ages were evenly represented (Figure 20).

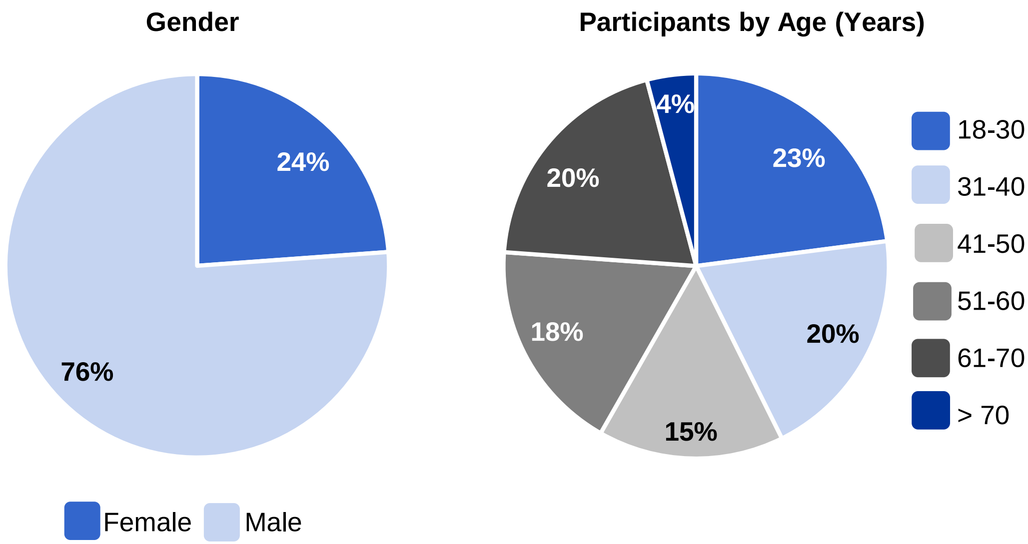


Figure 20. Participant Representation by Gender (Left) and Age (Right)

The proportion of participants represented by gender (left) and age (right) are shown. (N=218)

Data Collection

Recent literature suggests that a thorough description of cultural services can best be achieved through a discursive, open-ended, and participatory approach (Bieling, 2014; Chan et al., 2012b; Daniel et al., 2012). A participatory qualitative approach is particularly effective in describing cultural ecosystem services for a variety of reasons. It allows for prioritization of what matters to individuals, not simply of what can be easily assigned a monetary value (Chan et al., 2012b). Participatory data collection provides a richness of detail that cannot be achieved with closed-ended questions (Chan et al., 2012b). Relevant to the question of linked services, it allows for the understanding of influences and interactions between services, activities, and benefits (Chan et al., 2012b). Finally, through its embedded rapport-building it enables a better understanding of research between researchers and participants (Chan et al., 2012b). With that in mind, a series of complementary data collection methods were employed in this project.

Fieldwork took place between June 2018 and September 2019, when approximately two months were spent in each study state.

Participant Observation

Participant observation assisted in further site characterization and enhanced the ability to build rapport with participants. As detailed in Chapter 3, it allowed for greater familiarity with the research site and topic, and ultimately enabled a more thorough interpretation of data. As with the Chapter 3 study, participant observation occurred in an array of settings. The researcher again worked with participants on their boats and shellfish farms, attended extension programs, and spent time with participants over meals, etc., as invited. This study also presented opportunities to attend industry association meetings and town hall meetings relevant to shellfisheries in several states (Florida and Massachusetts). This included repeat interactions with many participants, as well as conversations with and observations of individuals who did not participate in interviews. These additional conversations with individuals not interested in being formally interviewed were useful even if they did not result in data to be compared in the analyses presented below. Informal conversations helped provide additional context and affirm patterns or group opinions in certain cases, particularly for those wild harvesters not involved in shellfish aquaculture.

Semi-Structured Interviews

In total, 218 participants were interviewed using a semi-structured interview approach. Interviews involved a short series of broad questions intended to inspire discussion of work-related benefits that were later coded as ecosystem services by the researcher (Table 8). Interviews occurred with individual participants as well as in groups, depending on participant preferences. Interviewed participants were also asked to complete a supplementary form that requested information on their involvement with shellfish, specifically: 1) type of shellfish work, 2) length of time in industry, 3) species harvested or cultivated, 4) full or part-time status, and 5) previous occupation if it was left for aquaculture. All interviews were documented via handwritten note-taking and transcribed to an electronic document within 48 hours.

Table 8. Semi-Structured Interview Guide

Interview questions used to guide semi-structured interviews are listed.

Semi-Structured Interview Questions
What do you like best about your job?
What are some of the good things about [*working on the water*]/[*working on an oyster farm*]/[*working in (other shellfish-related role)*]?
Why did you decide to [*fish*]/[*work on an oyster farm*]/[*work in (other role)*] instead of another job?
What sort of things do you like about your job that you can't quite put a dollar value on?
Do you think farming oysters is much different from other fisheries? How so?
What sort of benefits do you get from farming oysters that you can't get from a public fishery? (And vice-versa, as applicable.)

Photovoice Interviews

Participants who were willing also took part in photovoice interviews. Photovoice is a form of participatory research in which participants use photographs and stories about their photos to identify and represent issues, according to researcher prompts (Nykiforuk et al., 2011). Noted advantages associated with photovoice methods include that it allows participants to share through photos what may be difficult to explain through words alone (Wang & Burris, 1997). Its enhanced engagement with participants relative to other methods also demonstrates to participants their value and role in the research (Moffitt & Robinson-Vollman, 2004). For researchers, photovoice allows them to better understand the issue at hand as different ideas may be discussed through photos that were not mentioned in other interview approaches (Nykiforuk et al., 2011).

Photovoice interviews occurred at least one week after initial semi-structured interviews as participants were ready with photos. All participants were invited but a total of 38 participants took part in photovoice interviews, representing all three regions, all seven study states, and all three general industry role designations. Photovoice participants were asked to provide three to five photos that represented some of the good things, benefits, or aspects they enjoyed about their work. These could be new pictures taken with the project in mind, or older pictures they already possessed that represented these sorts of benefits to them. Some participants had fewer than three photos, some had more than five, but many had three total. They were informed that they would discuss their photos in a second interview, when they would be asked to explain what their images show and why they chose them.

The researcher met with participants again to discuss the photos. Photovoice interviews took place largely in-person, though several occurred over the phone after the researcher had left that study state. Participants were asked to describe their photos through a series of prompts (Table 9). In addition, they were asked questions about the interview approaches for methods comparison. Photovoice interviews were audio-recorded with participant permission and transcribed. Phone interviews were not audio-recorded, but notes were taken by hand. All interviews were transcribed into an electronic format within 48 hours. Participant photos were also saved electronically with participant permission for future presentation use and the eventual publication of an online story map detailing the benefits described.

Table 9. Photovoice Interview Prompts

Questions used to guide photovoice interviews are listed.

	Photovoice Interview Prompts
Photo Discussion	Please describe the image and what it shows.
	Why did you choose this image?
	What benefits or good aspects of your work are shown?
	Is the quality or characteristic you've captured in the image something unique to your work? Why or why not?
Method Discussion	Were there benefits from your work that you wanted to show, but couldn't find or take a photo to capture them?
	Was it easy to select photos? Did you know what type of photos you wanted to use when given the interview prompts?
	Overall, what did you think about the two different interviews? Did you prefer one to the other? Was one easier?

Data Analysis

All interviews were transcribed and coded via an open-coding approach using MAXQDA (VERBI Software, 2019). This entailed a first round of coding in which interviews were coded using primary themes of cultural, provisioning, and regulating/supporting services. Regulating and supporting services were coded as a single theme because of results detailed in Chapter 3 that indicated participants often think of these types of services more broadly. During this initial round of coding, interviews were also coded to identify a secondary level of detail beyond ecosystem service categories. Using themes that the researcher had compiled throughout fieldwork and interviews, all interviews were additionally coded to identify secondary benefit themes (Lewis-Beck, 2004). These themes were based on other cultural service examples identified in the literature as well as novel benefit conceptions that arose through interviews and discussions (Alleway et al., 2018; Barnes-Mauthe et al., 2015; Bryce et al., 2016; Chan et al., 2012b; Fish et al., 2016; Raymond et al., 2009). In addition, new benefits were added as they were identified during the initial coding process.

The complete list of secondary benefits was used to re-code all interviews. This resulted in a list of all four types of ecosystem services and the related benefits they provide, as discussed by participants in interviews. These benefits were examined and organized to fit within the Fish et al. (2016) cultural services framework, which groups cultural services by their influence on capabilities, experiences, and identities. Likewise, provisioning and regulating/supporting services were further categorized to represent the process that yielded each benefit type, similar to the format used in Chapter 3. All coded themes, presented as ecosystem service types, benefit categories, and benefit sub-categories, can be found below in Results (Table 10). Coded data were also used to identify linked services as discussed in interviews and potential changing services, identified in interviews as ways that aquaculture may diminish or enhance particular benefits relative to a wild fishery. This additional information on linked and diminished or enhanced services is detailed in Appendix 1.

The list of benefits was qualitatively analyzed to compare patterns in frequency of mention. Because interviews were designed to create an overall list of benefits for use in a subsequent study (Chapter 5) with quantitative analysis, statistical analysis of frequency data was not practical, mathematically or theoretically. For a general understanding and relative comparison, however, the frequency of mention for each benefit was totaled and plotted from the most mentioned to the least mentioned benefits (Figures 21, 22, and 23). To show how frequency of benefits differed between shellfish aquaculture and wild fisheries, these data were also plotted, separating the two groups using only data from participants with roles in exclusively wild harvest or shellfish aquaculture (Figures 24, 25, and 26).

It was not prudent to attempt to quantitatively analyze linked services, but it was important to illustrate their complexity and integration. In order to create a suitable visual display of linked services data, because a table would not suffice, linked services data were converted to resemble a network dataset. They were organized as a network adjacency matrix and visualized to illustrate benefit relationships as a network plot (Figure 27; Flourish Studio, 2020). This was not carried out as a network analysis and was strictly for data visualization.

To evaluate the utility of semi-structured interviews relative to photovoice interviews as a means of eliciting cultural services, frequency of mention was assessed specifically to see whether total number of benefits mentioned by participant and overall diversity of benefits mentioned varied between methods. The average number of benefits mentioned by the 38 participants who took part in both photovoice and semi-structured interviews were compared to evaluate differences between the two interview methods. A one-way ANOVA with paired t-test was used to test this difference using R software ($\alpha = 0.05$; R Core Team, 2020). Additionally, frequency data were qualitatively compared to investigate patterns in benefit mention by interview type. Data were inspected to see if certain types of benefits were mentioned more frequently in each interview type. The overall number of benefit types mentioned per interview was used to understand differences in the diversity of benefits mentioned. Finally, interview methods were evaluated according to participant preferences. The overall interview preference by method was totaled and compared (Figure 28). Qualitatively, responses were examined to identify common themes related to associated difficulties and comfort level, as well as other related features.

Results

The complete list of ecosystem services and related benefits mentioned in interviews are provided in Table 10. A more detailed version that includes the benefit summary, how each benefit was discussed, linked services, enhanced or diminished services, frequency of mention, and related Q sort statement number (Ch. 5) can be found in Appendix 1. Below Table 10, benefits are presented by their frequency of mention and split into three separate plots according to relative frequencies (Figures 21, 22, and 23). Frequency designations were selected to create plots with similar numbers of benefits that could be visualized, thus most common (high), moderate, and least common (low) are relative terms.

Table 10. Ecosystem Services and Benefits Mentioned in Interviews
All benefits that were mentioned in interviews and coded are presented by ecosystem service type and benefit categories.

Ecosystem Service	Benefit Category	Sub-Category
Cultural	Identities	Contribution to community
		Cultural heritage
		Family heritage
		Novel occupation
		Occupation
		Responsibility of care - environment
		Responsibility of care - husbandry
		Sense of belonging
		Sense of place
		Sense of purpose
	Experiences	Adventure
		Aesthetic appreciation
		Challenge
		Independence
		Innovation
		Job satisfaction
		Lifestyle
		Pride
		Relationship with nature
		Safety
		Security and reliability
		Shared experiences
		Social capital
		Spiritualism
		Therapy
		Transformation
		Variety
	Capabilities	Income
		Knowledge
		Mental health
		Physical health
		Skills
Provisioning	Food Production	Food (general)
		Healthy product
		High quality product
		Local product
		Safe product
		Sustainable product
	Shell Production	For decorative purposes
		For hobby trade
Regulating and Supporting	General	Environmentally positive
	Filter Feeding	Improved water quality
	Reef Formation	Shoreline protection
		Supports other species and fisheries
	Spawning	Contributes to wild shellfish population
		Supports other species and fisheries

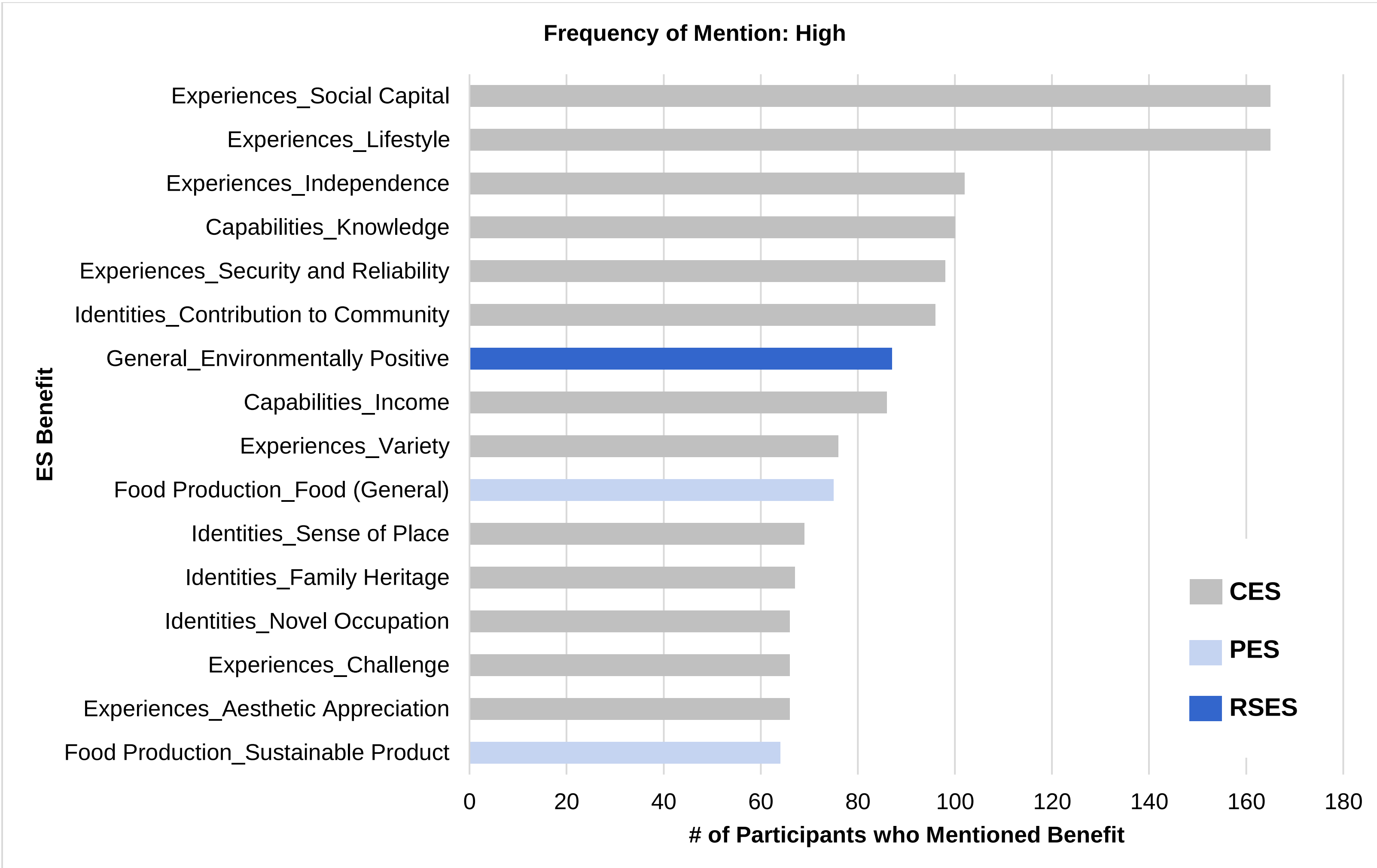


Figure 21. Benefits Mentioned in Interviews: Most Common

The 16 most commonly mentioned benefits are shown by frequency of mention. Bar colors correspond to different ecosystem service (ES) categories. Cultural ecosystem services (CES) = gray, provisioning ecosystem services (PES) = light blue, and regulating and supporting ecosystem services (RSES) = dark blue.

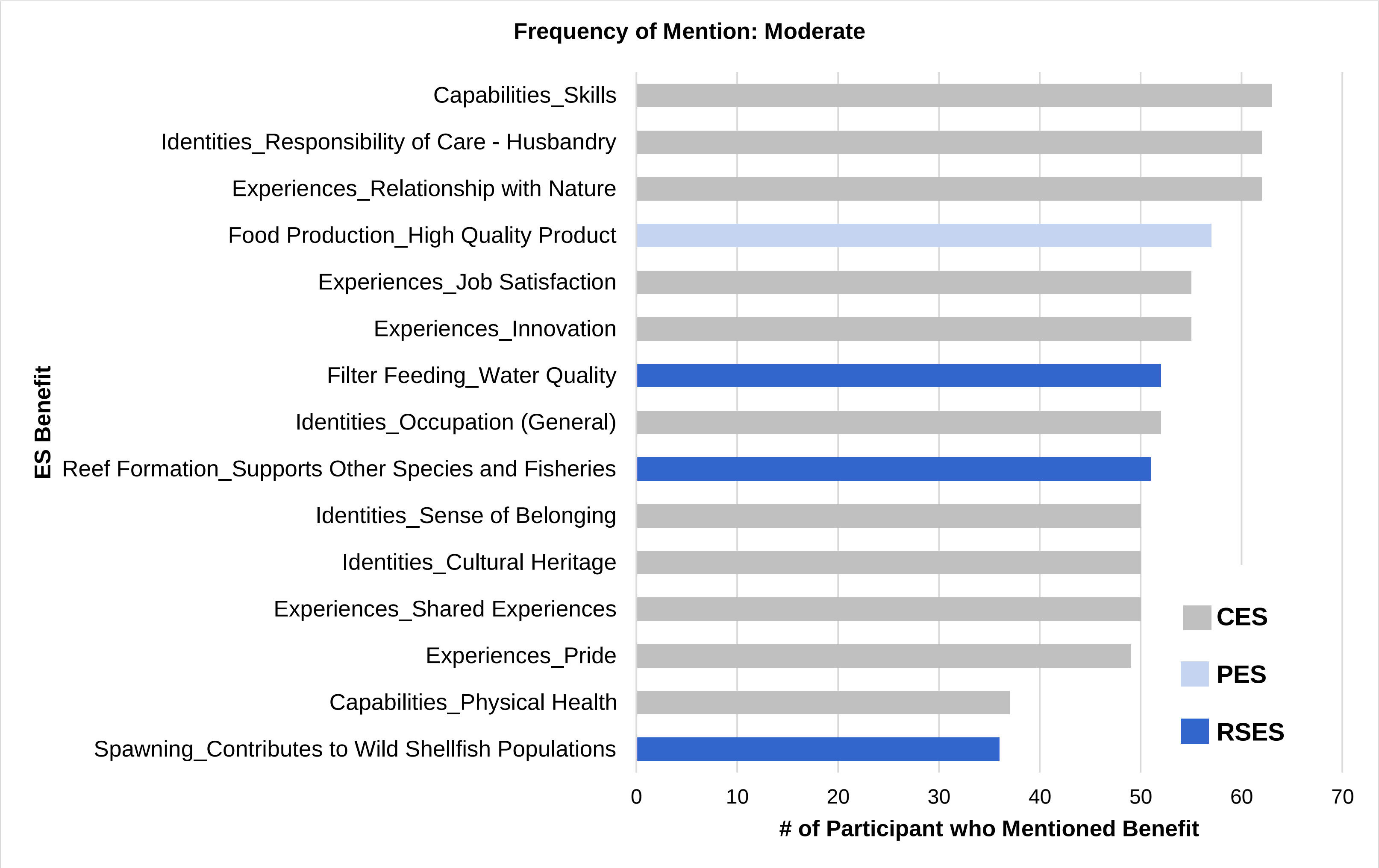


Figure 22. Benefits Mentioned in Interviews: Moderate Mentions

The 15 moderately mentioned benefits are shown by frequency of mention. Bar colors correspond to different ecosystem service (ES) categories. Cultural ecosystem services (CES) = gray, provisioning ecosystem services (PES) = light blue, and regulating and supporting ecosystem services (RSES) = dark blue.

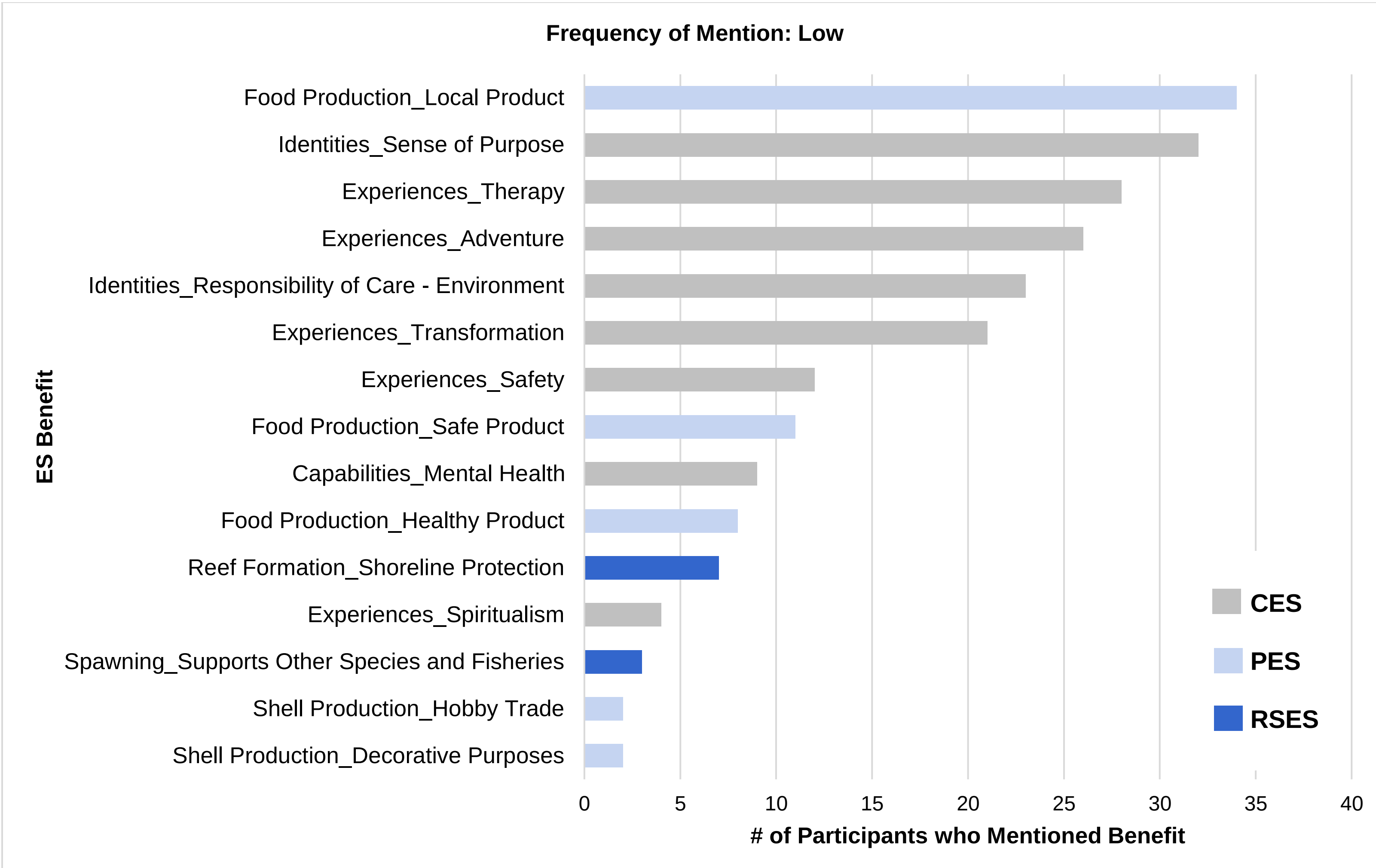


Figure 23. Benefits Mentioned in Interviews: Least Common

The 15 least commonly mentioned benefits are shown by frequency of mention. Bar colors correspond to different ecosystem service (ES) categories. Cultural ecosystem services (CES) = gray, provisioning ecosystem services (PES) = light blue, and regulating and supporting ecosystem services (RSES) = dark blue.

Frequency designations were further organized to illustrate frequency of mention by type of fishery, aquaculture or wild (Figures 24, 25, and 26). Because many participants were involved in combinations of aquaculture, wild fisheries, and industry support, for this comparison only those participants who were involved strictly in wild harvest (N=10) or shellfish aquaculture (N=94) are shown. Data are presented as percentage of participants within each group who mentioned benefits to adjust for the difference in group sample size. Benefits that were identified in interviews as potentially diminished, enhanced, or simply changed with a transition from shellfish aquaculture to wild shellfisheries are also highlighted on Figures 24, 25, and 26.

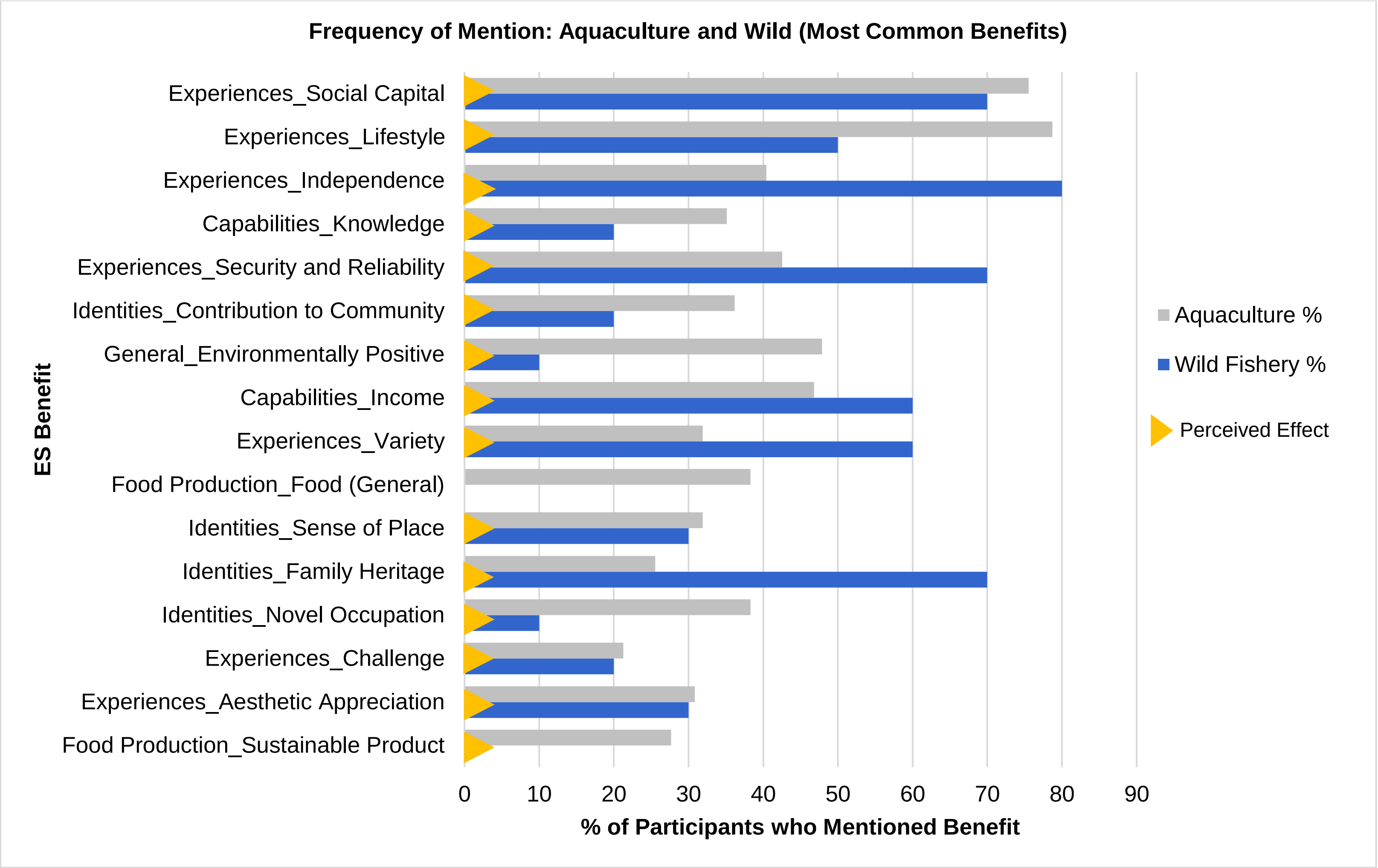


Figure 24. Wild and Aquaculture Comparison of Commonly Mentioned Benefits

The 16 most commonly mentioned benefits based on overall mentions are shown by frequency of mention relative to aquaculture (gray bars) and wild fisheries (blue bars). Yellow triangles indicate benefits potentially influenced by a shift from wild fisheries to aquaculture, based on participant interviews.

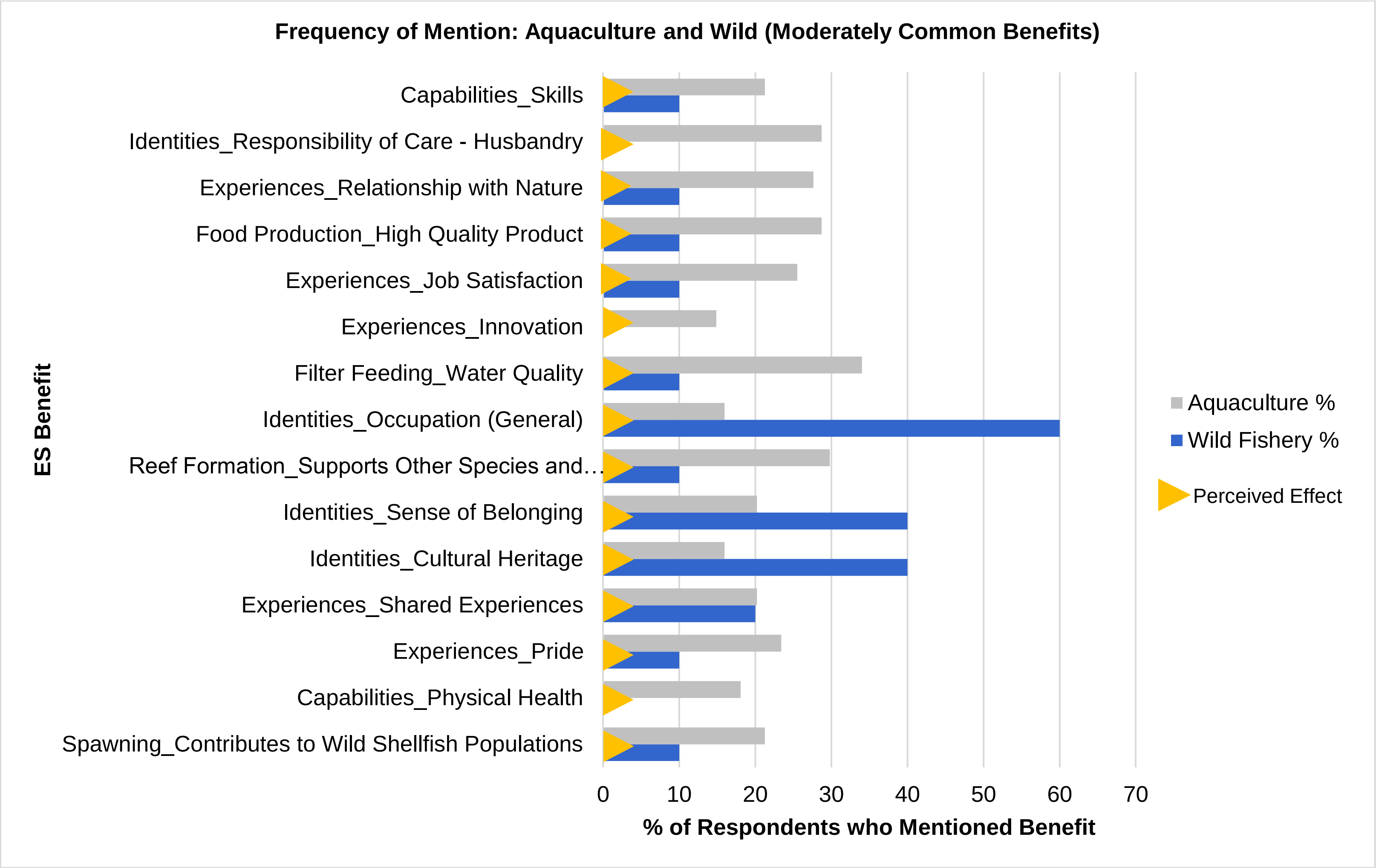


Figure 25. Wild and Aquaculture Comparison of Moderately Mentioned Benefits

The 15 moderately mentioned benefits based on overall mentions are shown by frequency of mention relative to aquaculture (gray bars) and wild fisheries (blue bars). Yellow triangles indicate benefits potentially influenced by a shift from wild fisheries to aquaculture, based on participant interviews.

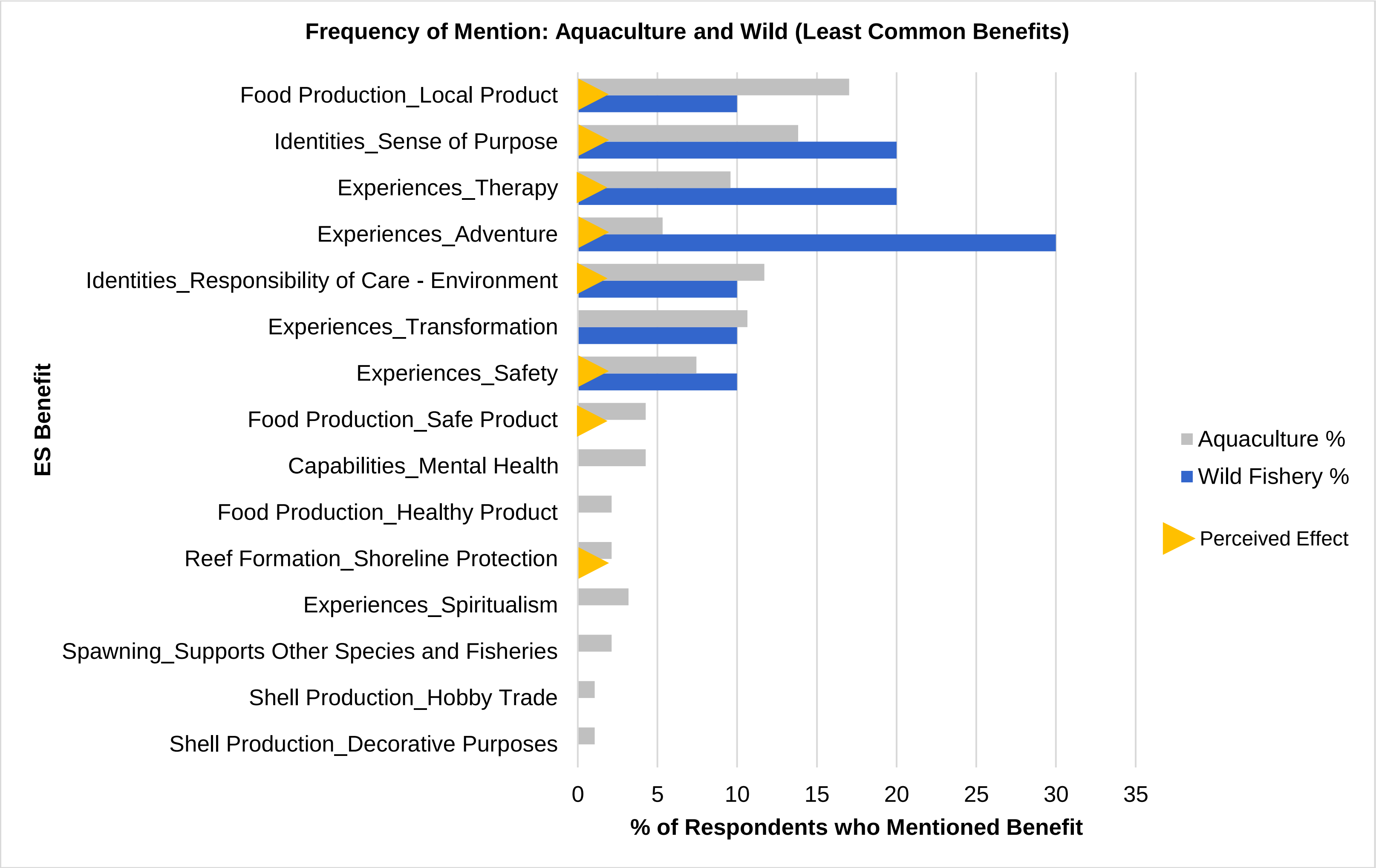


Figure 26. Wild and Aquaculture Comparison of Least Commonly Mentioned Benefits

The 15 least commonly mentioned benefits based on overall mentions are shown by frequency of mention relative to aquaculture (gray bars) and wild fisheries (blue bars). Yellow triangles indicate benefits potentially influenced by a shift from wild fisheries to aquaculture, based on participant interviews.

As detailed in Appendix 1, linked services were identified as discussed in interviews. Figure 27 depicts these services as a network of linkages. Job satisfaction is not included, as it was assumed to connect to all services. Benefits are labeled in Figure 27 according to “Link ID” as listed in Table 12.

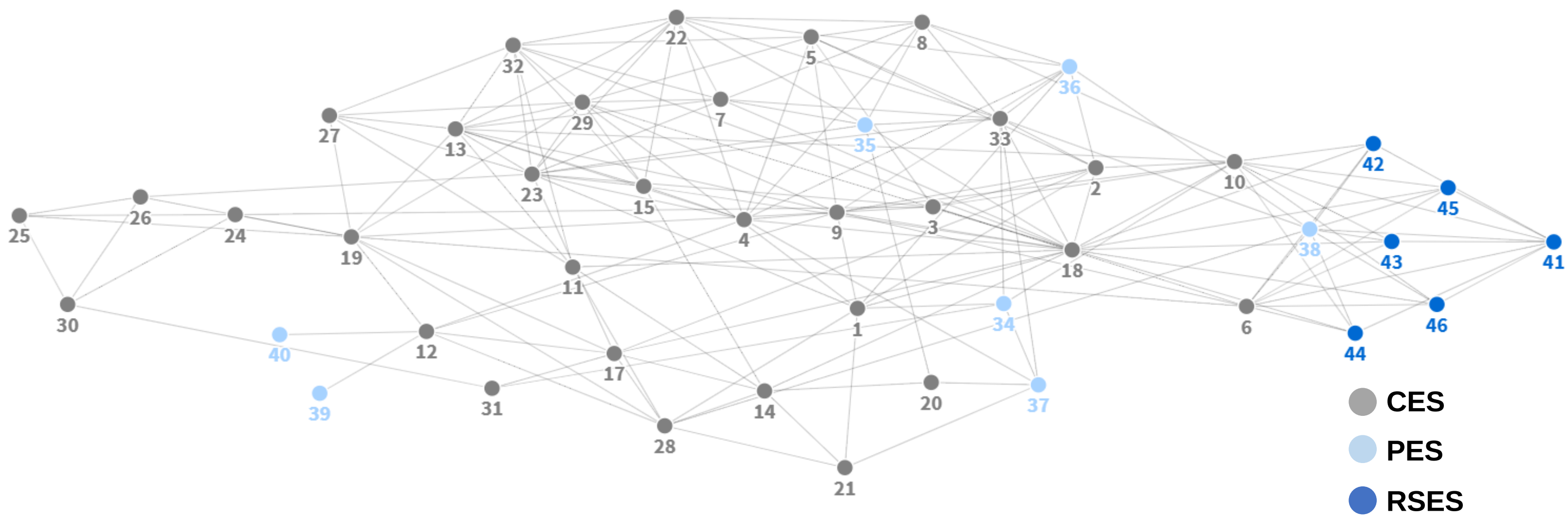


Figure 27. Visualization of Linked Services

Each circular node represents a different benefit, as identified in Table 11 (below). Cultural ecosystem services (CES) are shown in gray, provisioning ecosystem services (PES) in light blue, and regulating and supporting ecosystem services (RSES) in dark blue. The intent of this illustration is to show how connected benefits are, rather than focus on specific connections. For full details on connections refer to Appendix 1.

Table 11. Linked Benefit Label Identification

Benefits are listed with corresponding label numbers for reference with Figure 27 (above). Job satisfaction* (16) is not included in the image above because it was assumed to be linked to all benefits.

Link ID	Type	Benefit Sub-Category
1	CES	Contribution to community
2	CES	Cultural heritage
3	CES	Family heritage
4	CES	Novel occupation
5	CES	Occupation
6	CES	Responsibility of care - environment
7	CES	Responsibility of care - husbandry
8	CES	Sense of belonging
9	CES	Sense of place
10	CES	Sense of purpose
11	CES	Adventure
12	CES	Aesthetic appreciation
13	CES	Challenge
14	CES	Independence
15	CES	Innovation
16	CES	Job Satisfaction
17	CES	Lifestyle
18	CES	Pride
19	CES	Relationship with nature
20	CES	Safety
21	CES	Security and reliability
22	CES	Shared experiences
23	CES	Social capital
24	CES	Spiritualism
25	CES	Therapy
26	CES	Transformation
27	CES	Variety
28	CES	Income
29	CES	Knowledge
30	CES	Mental health
31	CES	Physical health
32	CES	Skills
33	CES	Food (general)
34	CES	Healthy product
35	PES	High quality product
36	PES	Local product
37	PES	Safe product

Link ID	Type	Benefit Sub-Category
38	PES	Sustainable product
39	PES	For decorative purposes
40	PES	For hobby trade
41	RSES	Environmentally Positive
42	RSES	Improved water quality
43	RSES	Shoreline protection
44	RSES	Habitat. Supports other species and fisheries
45	RSES	Contributes to wild shellfish population
46	RSES	Spawning. Supports other species and fisheries

Benefits mentioned in semi-structured interviews relative to photovoice interviews were compared. On average participants mentioned 12.18 +/- 3.04 (SD) benefits in semi-structured interviews and 6.97 +/- 2.38 (SD) benefits in photovoice interviews (Figure 28). Averages were based on the entire photovoice interview, not individual photos. This difference was significant at $P < 0.0001$.

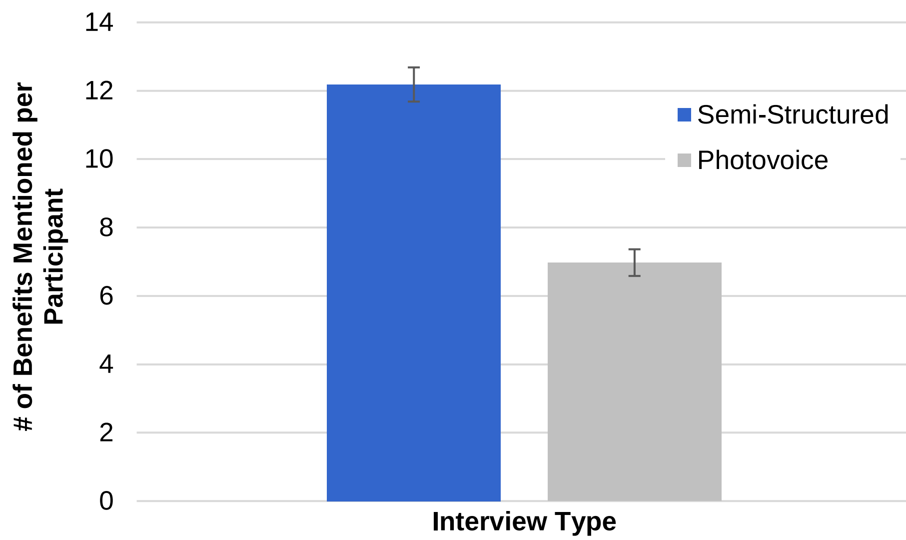


Figure 28. Number of Benefits Mentioned by Interview Type

The average number of benefits mentioned per participant are shown for semi-structured (blue) and photovoice (gray) interviews. Averages were different between interview types (P<0.0001). Error bars indicated standard error of the mean.

In terms of the diversity of benefits mentioned in each interview type, 42 unique benefits were mentioned in semi-structured interviews and 32 unique benefits were mentioned in photovoice interviews. Three benefits were not mentioned in either interview by the 38 participants who did both photovoice and semi-structured interviews. These benefits are: spiritualism, shells for decorative purposes, and spawning contributing to wild shellfish populations. Benefits mentioned in each interview type are presented in Figures 29, 30, and 31.

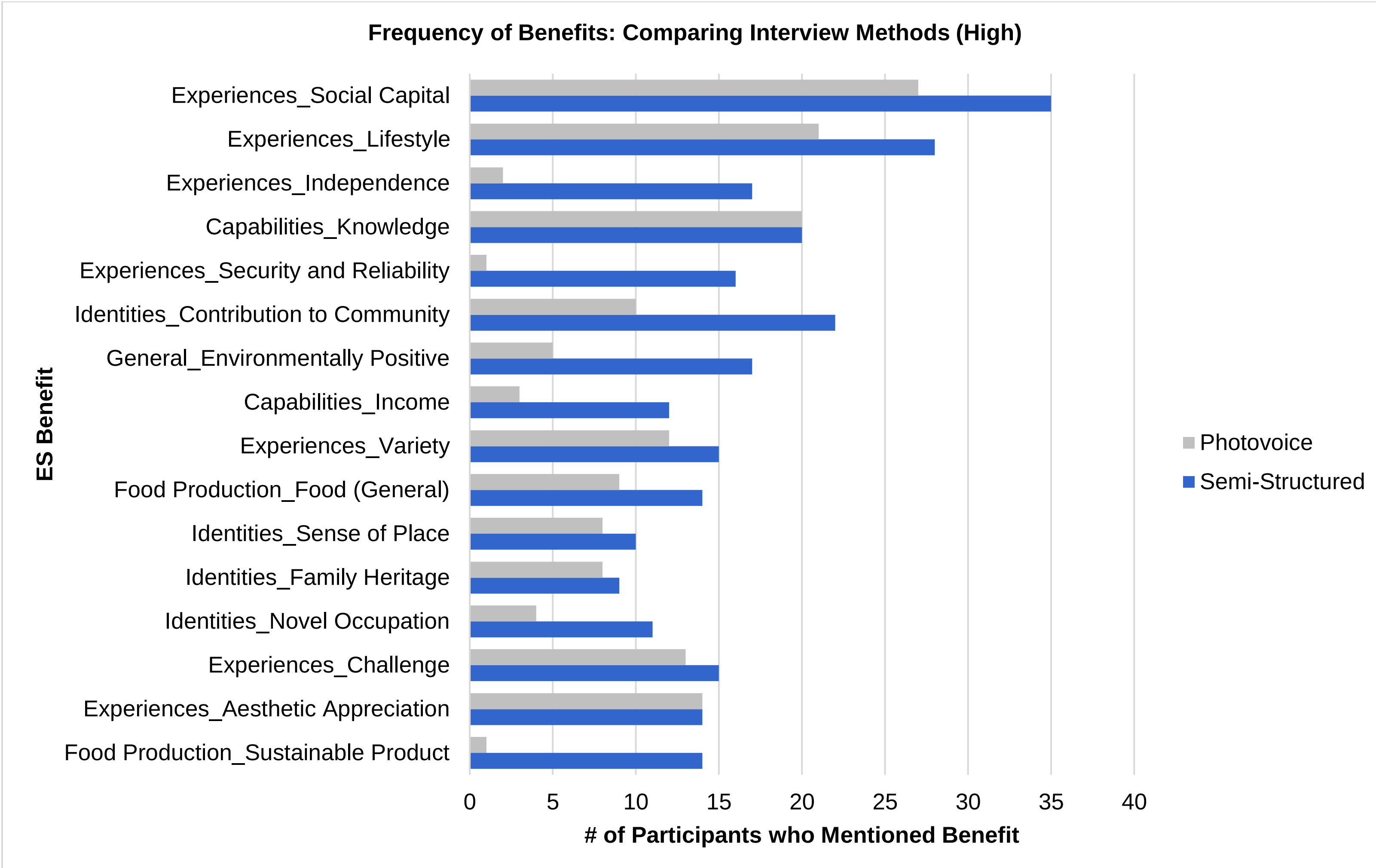


Figure 29. Photovoice and Semi-Structured Interview Comparison of Most Commonly Mentioned Benefits

The 16 most commonly mentioned benefits based on overall mentions are shown by frequency of mention relative to photovoice (gray bars) and semi-structured (blue bars) interviews.

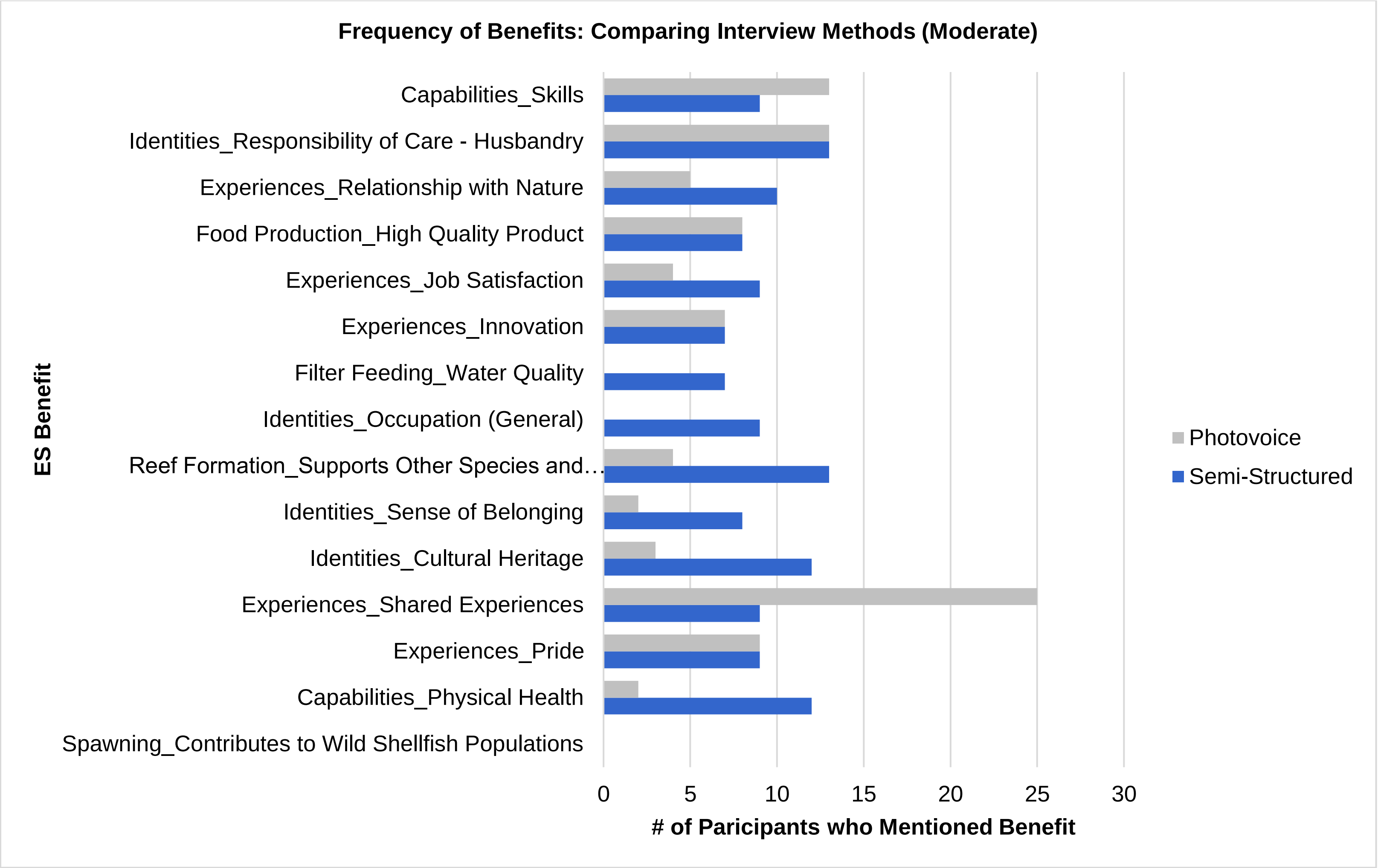


Figure 30. Photovoice and Semi-Structured Interview Comparison of Moderately Mentioned Benefits

The 15 moderately mentioned benefits based on overall mentions are shown by frequency of mention relative to photovoice (gray bars) and semi-structured (blue bars) interviews.

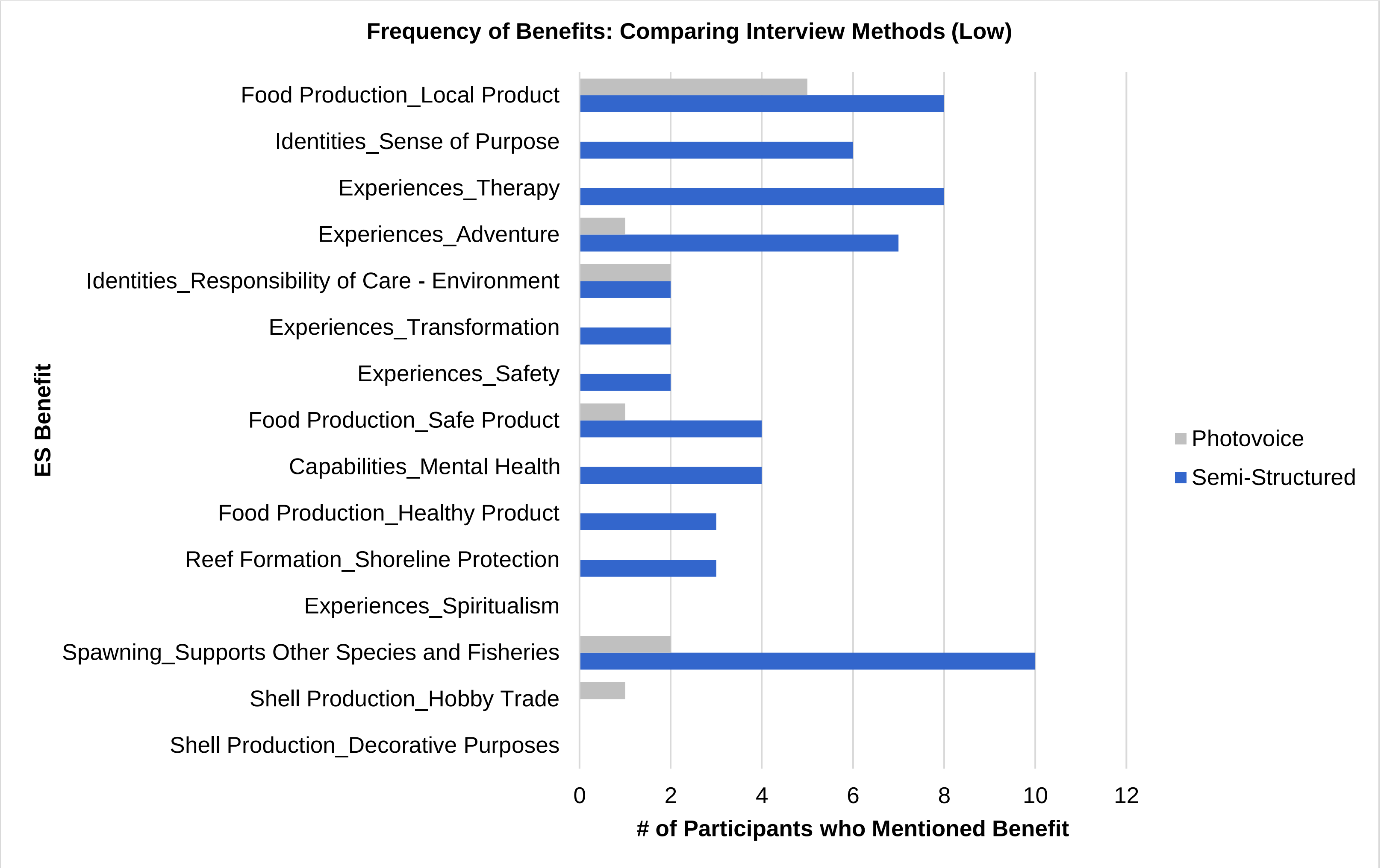


Figure 31. Photovoice and Semi-Structured Interview Comparison of Least Commonly Mentioned Benefits

The 15 least commonly mentioned benefits based on overall mentions are shown by frequency of mention relative to photovoice (gray bars) and semi-structured (blue bars) interviews.

Following the photo discussion in the photovoice interviews, participants were asked their opinions of the two interview types. General preference by participants is shown below (Figure 32).

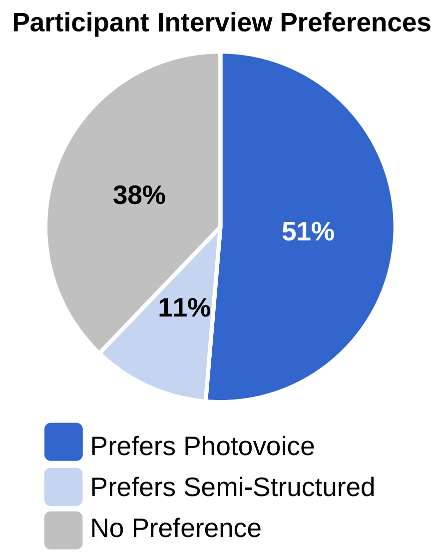


Figure 32. Interview Method Comparison: Participant Preferences
Participants were asked which interview approach they preferred; responses are shown here. The proportion of participants who preferred the photovoice interview are shown in dark blue, semi-structured interview preferences are in light blue, and no preference is shown in gray.

Discussion

List of Services and Benefits Enabled Through Work with Shellfish

Shellfish harvesters, growers, and others connected to shellfisheries in three regions contributed to the creation of a detailed list of cultural ecosystem services (CES) enabled through work with shellfish (Table 10, Appendix 1). Because interviews targeted the benefits that individuals receive through their work, the list also included provisioning ecosystem services (PES) as well as regulating and supporting ecosystem services (RSES). The complete list is too lengthy to discuss each benefit in detail here. As such, this section features several noteworthy examples with quotes from unique participants. For full detail, refer to Appendix 1. The benefit categories represented were not surprising, but the range and variety of benefits found within the "sub-category" was impressive. Many reflected benefits discussed in more recent conceptions of cultural services (Barnes-Mauthe et al., 2015; Bryce et al., 2016; Chan et al., 2012b; Fish et al., 2016; Raymond et al., 2009). Several however, were novel, unique to work with shellfish, and were identified in this project.

Though occupational identity is not new to CES discussions, the idea of a novel occupational identity is. Participants discussed their occupational identity as a benefit beyond simply *being* a fisherman, a shellfish grower, or a shellfish biologist, for example. They appreciated the fact that a limited number of people worked in their profession, and that provided a sense of notoriety or even celebrity as described by some.

> *"We're also bringing a product to market that Mississippi chefs can have. Who else is doing that? This is the first opportunity to do that. We're breaking new ground. We're pioneers. I never would have thought that."*
>
> *-Shellfish Farmer*

Responsibility of care as it related to animal husbandry was also a benefit not seen in other cultural service lists. This was largely connected to shellfish aquaculture, both for commercial growers and those involved in industry support. One may argue that it is not truly an ecosystem service, because these are often hatchery-produced seed rather than the result of wild spat sets. It is the ecosystem, however, that allows for this benefit to be enabled through human labor. Suitable water quality and available food supply allow shellfish growers and others to have this relationship with their animals and take on this welcomed identity as a caretaker.

“I think that’s the most fun part for me about this job - it’s a challenge and I look forward to coming in every morning and being able to see the differences between the previous day and the next day. To see if those larvae have progressed a little bit more. It takes usually about two and half weeks to get through that larvae stage, so anything that I can be doing to help them get to that stage… and there’s a lot of different variables that go into growing these guys. Some variables we control and some variables we can’t control. But, that’s kind of the job and that’s what I like most about it.”

-Shellfish Hatchery Employee

As previously discussed, some scholars have indicated the need for better inclusion of social capital in the discussion of ecosystem services (Barnes-Mauthe et al., 2015). Here, social capital was listed as an experience enabled through work with shellfish, and was the most frequently mentioned benefit. Chapter 5 helps to investigate whether frequently mentioned correlates with high importance, but results here suggested that social capital, as the relationships strengthened through work with shellfish, was an appreciated aspect of work.

“The most gratifying part is the camaraderie. The band of brothers. The shared hardship. I can trust these guys with my life. It’s that shared experience of hardships. Figuring out your limits and pushing through them.”

-Shellfish Farmer

Another interesting component of this list of services were its provisioning services. Although participants mentioned PES, with 2 in the 16 most commonly benefits, what was noteworthy was that participants discussed these services beyond their mere involvement in food production. Many valued being part of the food production process, but often this general benefit was paired with another descriptor that linked it to cultural services. Participants were involved in the production of healthy, high quality, local, safe, and sustainable food. This category of ecosystem service highlights the complexity inherent in understanding ecosystem services. Most benefits were not discussed as a stand-alone benefit, and Figure 27 underscores that integration.

> *1: "Having something you know you grew. There's something cool about eating your oysters or clams."*
>
> *2: "And sharing that with other people. Like a pie that you made or a cookie. Sharing your work with them, you know it's important."*
>
> *1: "I think you nailed it. Giving someone something [you produced] carries more weight."*
>
> *-Shellfish Farmers*

Linked services were present throughout the list of services and benefits enabled through work with shellfish. Using data strictly from interviews, every single benefit was connected to at least one other benefit. If one wanted to unpack these detailed benefits further, it is likely that additional benefits would be identified as linked, beyond those coded in interviews. For example, supporting services provide the foundation to all other ecosystem function, and thus are technically linked to all other services. All of these benefits were proposed here as contributing to overall job satisfaction, thus job satisfaction was also heavily embedded in this 'network' of linked services. Additional investigation and theoretical analysis of each individual benefit would likely yield even more relationships among benefits. This illustrates the difficulty in trying to count or tabulate benefits as is often attempted with economic valuation. In such cases, additional analyses are warranted to appropriately weight benefits relative to their contribution to the delivery of other services. It is easy to see how such a task can become quickly complicated.

Frequency of Benefits Mentioned

The methodological approach for this component of dissertation research discouraged placing too much emphasis on frequency of mention for any one benefit, but the data warranted broad qualitative examination. In terms of ecosystem service types, CES, PES, and RSES were located throughout frequency charts. More specific ecosystem function-based RSES were less frequently mentioned relative to other services and also less than the general RSES benefit of ‘environmentally positive’; this may be indicative of a valuation pattern but it cannot be assessed until the analysis in Chapter 5.

Focusing on the low end of the frequency plot, several benefits were mentioned by fewer than five participants. Comparing to the 218 total, it may be safe to assume that these were not particularly valuable benefits, however, if every participant was asked about them specifically, they may have a different opinion. Uncommon benefits included two PES connected to the use of shells, one RSES emphasizing how shellfish spawning supports other species, and one CES that focuses on spiritual experiences enabled through work with shellfish.

> *“The nonverbal stuff is very large with oysters. There’s a deep connectivity to everybody and everything before us. When you handle something associated with them, that ain’t of this time. There was a time when mostly everybody of the world was eating oysters. The spiritual presence. It’s there.”*
>
> *-Shellfish Farmer*

It is interesting that the CES-enabled experience of independence was the third most frequently mentioned benefit overall, but was also one of the benefits most associated with wild fisheries in the wild fishery-aquaculture comparison. Since there were only 10 exclusively wild harvesters in the overall sample, it is possible that shellfish grower-wild harvesters influenced that high frequency of independence mentions. Closer inspection of the data showed that shellfish grower-wild harvesters did, in fact, represent the highest number of participants who mentioned independence associated with their work as a benefit, however not much more than shellfish growers.

> *"The best thing I guess is the freedom. I have the ability to work at my own pace. I can do what I want to do – It's not like I'm dedicated to a 9 to 5. I work when I want to work. Sure, if I don't go out, I don't make money. [But ultimately, I'm in control]."*
>
> *- Wild Harvester*

Shellfish Aquaculture and Wild Fisheries

Comparing strictly the frequency of benefits mentioned by those working exclusively in wild harvest (N = 10) and those working exclusively as commercial shellfish growers (N = 94), one might assume that 11 benefits were perceived to be diminished from a shift to a wild fishery to aquaculture. This total is based on the number of benefits mentioned by a greater percentage (more than 10% difference) of wild harvesters relative to shellfish growers. Likewise, the numbers suggest that 19 benefits were enhanced with a shift from wild fishery to aquaculture, while 16 benefits had little to no effect.

When comparing these numbers to actual discussions of perceived changes, however, they differed slightly. Based on interview questions targeting differences, only two benefits were largely recognized as diminished with a transition from a wild fishery to shellfish aquaculture. The first of these was adventure. Although characteristics resembling the excitement associated with adventure were shared related to aquaculture, the thrill of the hunt and risk associated with a wild fishery was perceived as typically not replicated in aquaculture. The second was aesthetic appreciation, but what was unique about this "diminished" benefit was that participants discussed it not from their own perspective, but thinking about the industry and more specifically, industry opponents. Participants noted that floating aquaculture gear has been critiqued by upland property owners who do not wish to see aquaculture operations in their viewshed. Based on interviews, the same is true of property owners' desires to hear and see commercial fishing boats, but participants offered this as one of the aquaculture-associated concerns.

Benefits recognized as enhanced through work with aquaculture in interviews totaled 14 and included a number of benefits connected to the positive ecological effects tied to adding oysters to the water (N = 5). They also included three PES, emphasizing local, safe, and sustainable food products. The other six benefits identified as enhanced via aquaculture were CES. Of these, two represented benefits associated with responsibility of care and two connected to the quality of seafood being produced. The majority of benefits (N=22) were discussed in contrasting ways by participants, suggesting how specific benefits were both enhanced and diminished in aquaculture relative to a wild fishery. Only eight were not identified as changed with a transition into aquaculture. Of these, seven were within the least commonly mentioned benefits. Full discussion of all enhanced and diminished benefits can be found in Appendix 1.

One challenge in trying to evaluate changes in these benefits between wild and aquaculture shellfisheries was that the distinction between the two types of fisheries was not always that clear. Wild and aquaculture fisheries were not recognized as two different concepts in certain communities. In some locations, this was because there was no wild fishery or it was small enough that participants may not have been aware of it. In other communities, individuals were involved in both wild shellfisheries and aquaculture and each just represented a different method of the same trade. Further blurring the two fisheries, some participants collected or transferred wild seed for their aquaculture operation. Even the simple description as a "public," "wild," or "commercial" fishery had different meanings to participants that often needed to be clarified.

A further complication involved distinguishing benefits associated with a wild oyster reef versus a wild oyster fishery. A wild fishery can only succeed with healthy wild reefs, however the role of the fishery itself in creating healthy reefs was debated in interviews. Some participants, even those who worked in wild fisheries, saw wild fisheries as utilizing a reef, but not enhancing it. Others disagreed on the premise that either: 1) working the reef helped to clean and unearth shell, providing ready substrate for oyster spat to settle on or 2) certain public fisheries relied on the return of shell to the water and even planted oyster seed to assist with restoration efforts.

Understanding the likelihood of enhanced or diminished services in a shifting social-ecological system is challenging because, especially with cultural services, it is dependent on perceptions. Incorporating another group with interest in shellfisheries, such as adjacent or upland property owners, would likely yield another perspective on diminished services associated with either type of shellfishery. The data from this study showed that the majority of benefits were interpreted differently according to different participant roles or interest. This both complicates and enhances the ability to answer the question, “do farmed shellfisheries provide the same sort of benefits as wild shellfisheries?” The quick answer is maybe. The data here suggested that overall, yes, individuals working with shellfish in an aquaculture setting experienced a similar suite of benefits to those working in a wild fishery. This potentially contributes to similarly high levels of job satisfaction. In fact, the data suggested that shellfish growers received those benefits and then some, as there were more benefits enhanced through work with aquaculture than diminished. The adventure associated with a wild fishery may be the dominant characteristic not shared by shellfish aquaculture. For those benefits identified as both enhanced and diminished with a hypothetical transition into aquaculture, results underscore the effect of perception and interpretation.

Methods to Elicit Cultural Services

The inclusion of two approaches to elicit cultural services was designed to provide a more complete understanding of the benefits enabled through work with shellfish. It also provided the opportunity to compare the advantages and disadvantages of these two methods. All participants took part in semi-structured interviews prior to photovoice, thus, in a way they were trained to consider the type of benefits already discussed as they planned what photos to use. The majority of participants (N = 36) introduced new benefits in their photovoice interviews that they did not mention in the earlier semi-structured interviews, suggesting that they put additional thought into the project questions as they reviewed and selected photos.

In semi-structured interviews, participants were given unlimited time and discussion. This was also the case with photovoice interviews, but they were limited in a different way. Participants were asked to focus on only a small number of photos (five or fewer). As such, the photovoice interviews should have been more limiting, but perhaps more indicative of importance for those benefits shown in photos. Overall, participants discussed more benefits in semi-structured interviews than photovoice, with an average of 12.18 +/-3.04 benefits mentioned in each semi-structured interview relative to 6.97+/-2.38 in each photovoice interview. Still, given the range allowed for semi-structured interviews, it was surprising that the averages were as close as they are, even with significant differences.

In terms of diversity, 42 unique benefits were mentioned in semi-structured interviews, while only 32 were mentioned in photovoice interviews. This suggests some limitation or possibly refinement for photovoice interviews. To evaluate which is the more likely influence, inspecting the types of benefits discussed in each interview method may help to clarify. Within the photovoice interviews, the top 10 benefits, which were mentioned by 10 or more people, were not necessarily the easiest topics to photograph. If difficulty of photography were limiting options, one might expect food production photos to be common, as it is easy to take a picture of a bivalve on a plate. Yet, no food production benefits were mentioned by more than 10 people. Countering that argument however, ‘social capital’ was common among both interviews. It may be a particularly salient benefit, but may also reflect the tendency of participants to have pictures taken of or in groups of people. This latter thought was also evident with more ‘shared experience’ mentions in the photovoice interviews than semi-structured. ‘Shared experience' was the only benefit mentioned in more photovoice interviews than semi-structured interviews (by a margin of at least 10%). Within semi-structured interviews, the top 10 most frequently mentioned were all CES with one RSES, 'environmentally positive'. Seven of these CES were also in the top ten for photovoice interviews. Thus, there did not appear to be a big difference in frequency patterns by interview type, with exception for some benefits that may be frequently photographed.

As a whole, photovoice interviews may be better suited to represent CES and PES rather than RSES. It may be difficult to photograph examples of RSES, though there were 11 RSES mentions in photovoice interviews. It may also be that RSES-related benefits were not the first that come to mind when asked to provide three photos. Chapter 5 analyses will help to understand whether RSES are perceived of low-importance, or simply hard to photograph.

In terms of participant preferences, just over half (51%) of participants who took part in the photovoice component preferred photovoice. Only 11% preferred the semi-structured interview. The remaining 38% had no preference. For a number of participants, the sequence of the interviews was what they appreciated. Conducting the semi-structured interview first gave them time to think about work-related benefits and return with new benefits to discuss. Participants who preferred the photovoice interview noted that the photos helped to frame or guide their discussion. A common opinion was that having a photo to pair with their discussion helped them to explain their ideas better and be confident that they were relaying their message clearly. Some participants said they felt like they had more control over or were providing a larger contribution to the photovoice interview because it was guided by the photos they provided. A number of participants simply enjoyed the task of taking and selecting photos.

Among the participants who preferred the semi-structured interview, some felt that the photos were limiting in that a single image cannot capture everything you want to describe. Others thought the exact opposite, that there was too much within a photo to try and detail. Some participants thought that photos represented only a moment in time, whereas the semi-structured interviews allowed them to discuss things more broadly and provide a more complete understanding.

Photovoice interviews were clearly not for everyone, as a much smaller number of participants completed them. For those who did however, the majority enjoyed the exercise and the additional involvement in the project. Photovoice yielded a smaller number of overall benefits discussed, but allowed individual participants to think more deeply about the benefits they would like to emphasize. The data suggest that semi-structured interviews were more effective at capturing the range of benefits associated with work in shellfisheries, but photovoice interviews provided slightly more pleasure or fulfillment for participants. The order of interviews was also helpful for photovoice participants to reflect before choosing their images. Rather than choose one method or the other, this combined approach is particularly useful to not only detail CES and related benefits, but also to foster research partnerships with participants. If the researcher spent more time in each location, additional photovoice interviews may have also occurred. Photovoice interviews may be better suited for longer-duration projects, or repeated visits over the course of a longer timeframe.

Conclusion

The study detailed in this chapter was introduced and framed by four guiding questions. These questions have each been answered, with varying degrees of certainty, and provide a useful means of framing these concluding thoughts:

What are the cultural ecosystem services obtained through work with shellfish?

The list of ecosystem services provided is long and wide-ranging (Appendix 1). Approaching this topic targeting ‘benefits’ more broadly revealed that individuals involved in shellfisheries receive a wide range benefits from their work, which includes many cultural ecosystem services (CES) and benefits, along with benefits enabled through provisioning ecosystem services (PES), as well as regulating and supporting ecosystem services (RSES). Many of the benefits described coincide with recent conceptions of CES as well as benefits discussed in various ways related to wild fisheries. Several novel benefits were mentioned, which may be unique to shellfisheries or possibly to shellfish aquaculture.

Additionally, interviews with participants produced a highly integrated list of benefits. Linked services were abundant as no single benefit was recognized as a stand-alone category. This connectivity makes counting benefits and services extremely complicated, possibly even ill-advised, echoing the predictions of others (Chan, 2012b; Costanza et al., 2017). This list of ecosystem services and benefits enabled through work with shellfish, however, can now be used in more quantitative analyses. It will be used to understand how benefits are perceived and valued by individuals working in shellfisheries (Chapter 5). Are the benefits that were mentioned frequently by participants in this study also highly-valued?

Can shellfish aquaculture provide the same types of cultural ecosystem services as wild fisheries in similar systems, and how might a transition from wild shellfisheries to shellfish aquaculture affect the delivery of ecosystem services?

This study showed that for the most part, yes, shellfish aquaculture can provide similar benefits to a wild fishery. This was complicated however, by differences in interpretation of benefits and how they may be enhanced or diminished with a hypothetical transition from work in wild fisheries to aquaculture. Most benefits (22 out of 46) were discussed as both diminished and enhanced, depending on participant perspective. It is important to understand how ecosystem services change within dynamic social-ecological systems. This study illustrates how complex this task may be with cultural ecosystem services, a group of benefits noted for their associated quantification difficulty. Because cultural services are so dependent upon personal experiences, documenting changing cultural services beyond a homogenous participant population may be a challenging undertaking. In this case, shellfish growers and wild harvesters had different perspectives on how livelihood changes would impact the delivery of cultural services and benefits.

What is the most effective method to elicit cultural services when comparing semi-structured and photovoice interviews?

Finally, in the comparison of two interview approaches used to elicit cultural ecosystem services, it was deduced that the combination of methods was actually best. Semi-structured interviews on their own elicited a larger variety of CES and other ES, but the subsequent photovoice interviews gave participants the opportunity to consider benefits of their work in more detail as well as become more involved in the project. The utility of these methods can also serve an additional purpose in the future, from a more applied standpoint. These interviews created a substantial and rich dataset that describes the many benefits and all-around good aspects of local shellfisheries. Both wild and farmed shellfisheries face pressures of social acceptance and support (Knapp & Rubino, 2016; Shumway et al., 2003; Smaal & van Duren, 2019). Data gathered for this project can be used to create engaging and compelling depictions that highlight just what a shellfishery can provide not only for its harvesters and growers, but also its overall communities.

The study presented here was the first to generate a comprehensive list of cultural ecosystem services associated with shellfish aquaculture. Its participatory approach paired with its broad geographic range and participant sample suggest that these benefits should be salient for shellfisheries at large, at least within the eastern US. The next step in this research trajectory was to try and identify how relevant these benefits were to an even larger set of industry members and how individuals involved in shellfisheries value this collection of benefits.

Chapter 5: Evaluating the Benefits of Shellfisheries

Overview

Q methodology was used to understand how individuals working with shellfish perceive and value benefits obtained through their work. An online survey was administered to 74 participants involved in shellfisheries throughout the United States (US). Participants were asked to rank benefits, previously identified through large-scale ethnographic fieldwork, in terms of relative importance and relevance. Participants included individuals working as shellfish growers, wild shellfish harvesters, and others in roles that support US shellfisheries. Factor analysis yielded three viewpoints shaping benefit rankings, which were detailed as: 1) Improvers of Self, Society, and (Eco)Systems, 2) Sustainable Providers, and 3) Shellfisherfolk. Each group valued benefits differently, highlighting that the value or importance of particular benefits provided and enabled through work with shellfish are not universal. Groups varied in their participant attributes, most notably by industry role, suggesting that type of work with shellfish and these viewpoints are closely related. Factor groupings also suggested that wild shellfish harvesters perceive benefits similarly to shellfish growers, indicating that work in shellfish aquaculture may yield benefits of comparable value as a wild fishery. These overall benefits were analytically framed as ecosystem services and this study provided needed information on how individuals with shellfish-based livelihoods value the many ecosystem services enabled through their work.

Introduction

Chapter 4 introduced the multitude of benefits that individuals with shellfish-based livelihoods obtain from their work, and, with its focus on cultural services, provided an important component of understanding shellfish-related ecosystem services that was previously lacking. In addition to contributing to a more complete conception of ecosystem services provided by bivalve shellfish, such data on perceived benefits is critical to understanding why individuals choose to work in shellfisheries, both farmed and wild. It also illustrated how perceived benefits may change with a shift from a wild to farmed shellfishery, but more notably how perception of change varies depending on individual perspective. As mentioned in Chapter 4, while some systems may experience such a shift due to changing regulations, limited wild resource, and other drivers, others continue to maintain integrated shellfisheries where individuals are active in both wild and farmed shellfish work. The rich dataset introduced in Chapter 4 and detailed in Appendix 1 showcases how individuals perceive both similar and unique benefits from each type of shellfishery (wild and farmed).

Chapter 4 demonstrated that the number of benefits obtained through work with shellfish are many, and that they span all categories of ecosystem service: cultural, provisioning, regulating, and supporting services (MEA, 2005). Cultural services were more commonly mentioned, indicating that they are an important group of benefits and reiterating the findings of Chapter 3, however cultural services are also a very broad and diverse group relative to other types of ecosystem services. As such, it is not unexpected that participants mentioned a greater variety of cultural services in their discussions. The aim of Chapter 4’s research was to qualitatively detail the benefits obtained through work with shellfish. Participant observation and semi-structured interviews along the US East and Gulf coasts were designed to develop this holistic list of benefits relevant to a large, multiregional industry. This task was accomplished, but invited further questions and provided the foundation for related work.

The ethnographic approach employed in Chapter 4 yielded a large sample size representing multiple geographic regions, but do individuals in other states and regions working with shellfish perceive the same benefits? Are there noted differences in perceived benefits based on type of work with shellfish, whether it be wild or farmed, clam or oyster, small or large scale of operation, etc.? Are some benefits consistently viewed as more important or valuable than others? The next step in conceptualizing the benefits obtained through work with shellfish was to understand how these benefits are valued.

Project Objectives

The aim of this study was to use the data gathered in Chapter 4 to survey a larger population of people working in shellfisheries than could be reached through in-person interviews in an attempt to understand whether the benefits detailed were fairly universal to people working in US shellfisheries and how the perception and value of benefits may vary among individuals. This objective was targeted with several themes (1-3) and questions in mind:

1. **Benefits obtained through work with shellfish:**
    a. How are the benefits obtained through work with shellfish valued by individuals?
    b. What types of benefits are valued most?
    c. Do common ranking patterns exist?
    d. What types of viewpoints shape ranking patterns?

2. **Benefits perceived based on industry role**:
    a. Do benefits obtained through work with shellfish vary (in value and presence) based on type of work?
    b. Are those working in a farmed shellfishery perceiving and valuing benefits similar to a wild shellfishery?
    c. Do those whose work supports shellfisheries without being directly involved in shellfish harvest/production (e.g., researchers, wholesalers, etc.) perceive and value benefits similarly to shellfish growers and wild harvesters?
3. **Benefits perceived based on other participant attributes**:
    a. Do benefits obtained through work with shellfish vary (in value and presence) regionally?
    b. Do other patterns exist re: scale of industry, length of time in industry, type of shellfish, type of fishery (wild or farmed), etc.?

In this study, benefits from working with bivalve shellfish were evaluated at a national scale and included consideration for both farmed and wild shellfisheries, as well as for those whose work supports shellfisheries without directly producing commercial shellfish. Participants were asked to rank the benefits they obtain from their work in order of importance to them, adding another layer of knowledge within this dissertation to determine what benefits are most important to those working with shellfish. Data were framed using ecosystem services, but as in Chapter 4, discussion and understanding extends beyond traditional conceptions of bivalve shellfish-based ecosystem services.

A Q methodological approach was employed to understand the different viewpoints shaping perception and individual value of shellfisheries-related benefits. Value is discussed here not as a price point or dollar amount, but instead as the importance placed on a benefit by participants. Q methodology is particularly well-suited to a discussion of cultural ecosystem services and understanding their relative value among other services provided by shellfish. Though increasingly popular among scholars, Q methodology is still an unfamiliar approach for many (van Exel & de Graaf, 2016). With this in mind, an overview on Q methodology is provided.

Background on Q Methodology

Q methodology utilizes qualitative and quantitative methods to allow for the systematic study of subjectivity (Brown, 1993; Newman & Ramlo, 2010). It enables researchers to translate large amounts of data into patterns that highlight views on a particular topic, representing individual feelings, belief systems, value positions, opinions, perspectives, mental models, or ways of thinking (McKeown & Thomas, 1988; Newman & Ramlo, 2010; Stenner & Stainton-Rogers, 2004; Stephenson, 1953; Zabala et al., 2018). It collates and correlates individual responses to extract 'idealized' viewpoints latent within the data (Addams, 2000). Q methodology can reveal a diversity of views, even those typically hidden from common discourse (Zabala et al., 2018). Frequently described as an inversion of conventional factor analysis, Q correlates participants rather than test items or variables (Stephenson, 1935; van Exel & de Graaf, 2005). Though factor analysis is a critical aspect of Q methodology, describing it as merely inverted is an over-simplification.

Q methodology places both the researcher and participant in active roles, and this is one of its strengths (Coogan & Herrington, 2011; Zabala et al., 2018). Through typically ethnographic methods, including interviews, focus groups, or participant observation paired with thematic analysis, participants provide researchers with the information and knowledge necessary to create the ‘concourse’ of a Q study. The concourse is a series of statements that represent all viewpoints on a topic. It is compiled by the researcher, but drafted in participants’ own words; it can also be comprised of images, video, or audio depending on the study (Brown, 1993; Newman & Ramlo, 2010; van Exel & de Graaf, 2005).

The concourse is created directly from participant contributions, but the researcher must decide which statements from the concourse shall be used in the Q set (also referred to as the Q sample; Addams, 2000; Brown, 1993; Newman & Ramlo, 2010; van Exel & de Graaf, 2005). The Q set is a series of statements to be sorted and should be representative of all views on the topic. Participants, generally including those who helped create the concourse, are asked to sort Q set statements in order of increasing agreement into a grid that resembles a quasi-normal distribution (Coogan & Herrington, 2011; Figure 33). Comparative studies have demonstrated that the forced structure of the grid is not a critical component, however many researchers rely on a grid resembling a normal distribution for ease of statistical analysis (Watts & Stenner, 2005).

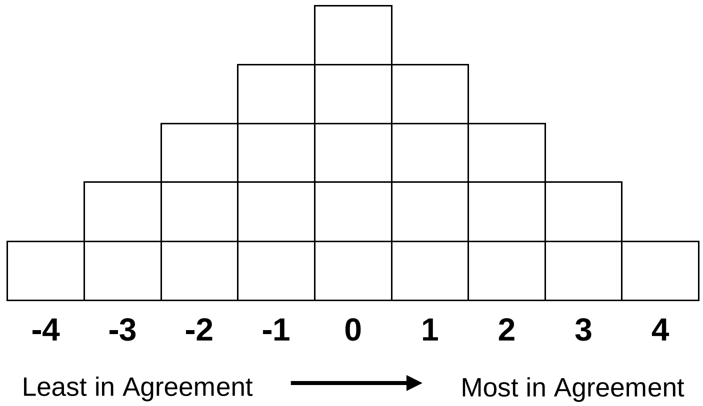


Figure 33. Example Q Sort Grid

Q participants are asked to arrange cards, each with a single statement, within the gridded cells, one per cell. Statements should be ordered from left to right in terms of relative agreement; vertical placement in the grid does not matter; i.e., all statements within the same column are assigned the same level of agreement by the participant.

Each participant 'sort' is translated into a correlation matrix and factor analyzed to identify how many basically different Q sort structures exist in the sample (Brown, 1993). Sorts with similar, highly correlated rankings are grouped into factors, which indicate segments of subjectivity (i.e., shared viewpoints) that exist in the sample (Brown, 1993; Newman & Ramlo, 2010). Each factor is presented as a composite sort with corresponding factor scores; in other words, each factor is shown as an 'average' of all the sorts that loaded on that factor (Newman & Ramlo, 2010). The researcher must decide how many factors are an appropriate fit, statistically and theoretically. Researchers often use eigenvalues, the presence of distinguishing statements, and the number of participants who load on each factor to evaluate best fit (Adams, 2000; Coogan & Herrington, 2011; Watts & Stenner, 2005; Wainger et al., 2017). Still, the best mathematical fit may not make sense for the research question or topic and secondary qualitative evaluation is also important (Newman & Ramlo, 2010; Watts & Stenner, 2005).

Once an appropriate number of factors are selected, each factor is described to explain the shared viewpoint of that group. Good descriptions evaluate not only patterns in overall ranking, but also the placement of distinguishing and consensus statements. These statements are identified by differences in z-scores, the weighted average of scores that grouped participants gave to an item, which offer slightly more precision than normalized factor scores (Newman & Ramlo, 2010). Consensus statements are individual statements that do not distinguish between any of the factors based on their insignificant z-score differences, while distinguishing statements are ranked in a way significantly different from at least one other factor as indicated by their large z-score differences between factors (Newman & Ramlo, 2010). In other words, consensus statements are ranked similarly among factors while distinguishing statements are uniquely ranked for a particular factor relative to one or more other factors. The researcher's goal is to understand what types of viewpoints influenced the organization of each sort. In this way, understanding viewpoints can be done separately from typical variables or surface characteristics and can yield unexpected profiles or groupings within the sample population (Newman & Ramlo, 2010). Depending on the objective of the study, it may also be warranted to look at participant attributes and more standard characteristics to identify patterns among those whose sorts loaded on each factor. Through this process, no *a priori* meanings are assigned, and instead *a posteriori* interpretation occurs, grounded in the researcher's knowledge of the study system (Coogan & Herrington, 2011; Zabala et al., 2018).

The novelty of the researcher-participant relationship within Q methodology lends to a greater sense of involvement for participants, which they often view positively (van Exel & de Graaf, 2005). A further benefit of a Q methodological approach is that it does not require a large sample size. Because its intent is to determine differences among participants not among items, it is important to have a sufficient number of items to sort rather than sufficient numbers of participants (Brown, 1993; Newman & Ramlo, 2010). Underlying Q methodology is the idea that a limited number of distinct viewpoints exist on a single topic and thus, a well-structured Q set will reveal these perspectives without need for a large sample size (van Exel & de Graaf, 2005).

Q methodology has demonstrated its utility in exploring and helping to understand "highly complex and socially contested concepts and subject matters from the point of view of the participants involved" (Watts & Stenner, 2005; p.70). As such, its application to understanding the perception of shellfish-related ecosystem services is certainly appropriate. This is affirmed with other projects using Q methodology to target ecosystem services broadly and cultural services specifically (Bryce et al., 2016; MacDonald et al., 2015; Pike et al., 2015; Wainger et al., 2017).

Methods

Participant Selection

Participants were solicited from across the US in all aspects of shellfisheries. This included wild shellfish harvesters, shellfish growers or farmers, hatchery staff, research scientists, extension specialists, wholesalers, gear manufacturers, regulatory personnel, etc. In all cases, participants earned some form of income through work with shellfish. This approach was taken to account for the myriad benefits provided by shellfisheries, noting that benefits extend beyond those individuals directly involved in shellfish harvest or production. For the purposes of subsequent analyses, participants were considered as working in three possible roles:

1) **Shellfish growers**: individuals directly involved in the commercial production of shellfish who generate income from commercial shellfish aquaculture.
2) **Wild harvesters**: individuals involved in wild/public commercial fisheries, including shellfish and non-shellfish.
3) **Industry support**: individuals not directly involved in the commercial production or harvest of shellfish who support the industry in other ways such as research, extension, regulation, wholesale, lobbying, gear-manufacture, etc.

Participants were solicited in a variety of ways. All 254 unique participants who took part in earlier parts of the project were contacted via email or postal mail. They were also asked to share the survey link with anyone who might be interested. New participants were further solicited via social media: on Facebook, Instagram, Twitter, and the project blog site. Additionally, targeted emails were sent to more than 20 commercial fishermen's associations, shellfish research groups, shellfish grower's associations, and other relevant groups based throughout the US. Participants were contacted on day 1 of the survey period and sent a reminder on day 14, one week before the survey closed. All aspects of participant selection and study involvement were approved by the University of Maryland Institutional Review Board (1242746).

Participant Description

In total, 74 participants completed the Q sort. All coastal regions of the continental US were represented, with greater participation from the three original study sites of Chapter 4: Chesapeake Bay, Gulf of Mexico, and New England (hereafter categorized as Northeast; Figure 34). Regional trends were driven largely by participants in Maryland, Alabama, and Massachusetts. The full breadth of participant involvement included 46 shellfish growers, 27 wild harvesters, and 32 industry supporters because individuals were involved in multiple roles, but data are presented according to the roles participants sorted as.

Beyond regional information, demographic data revealed that participants were fairly evenly distributed in age, with those under 30 and over 70 least represented (Figure 35). The majority of participants were male (61%; Figure 35) and overall, participants were mainly white and non-Hispanic/non-Latino (Figure 36). Although the US Census categories for race and ethnicity do not adequately represent the diversity within the US, for the purposes of this analysis results indicate a fairly homogenous sample in terms of race and ethnicity. As such, patterns among participant race and ethnicity are not included in subsequent analyses within this chapter.

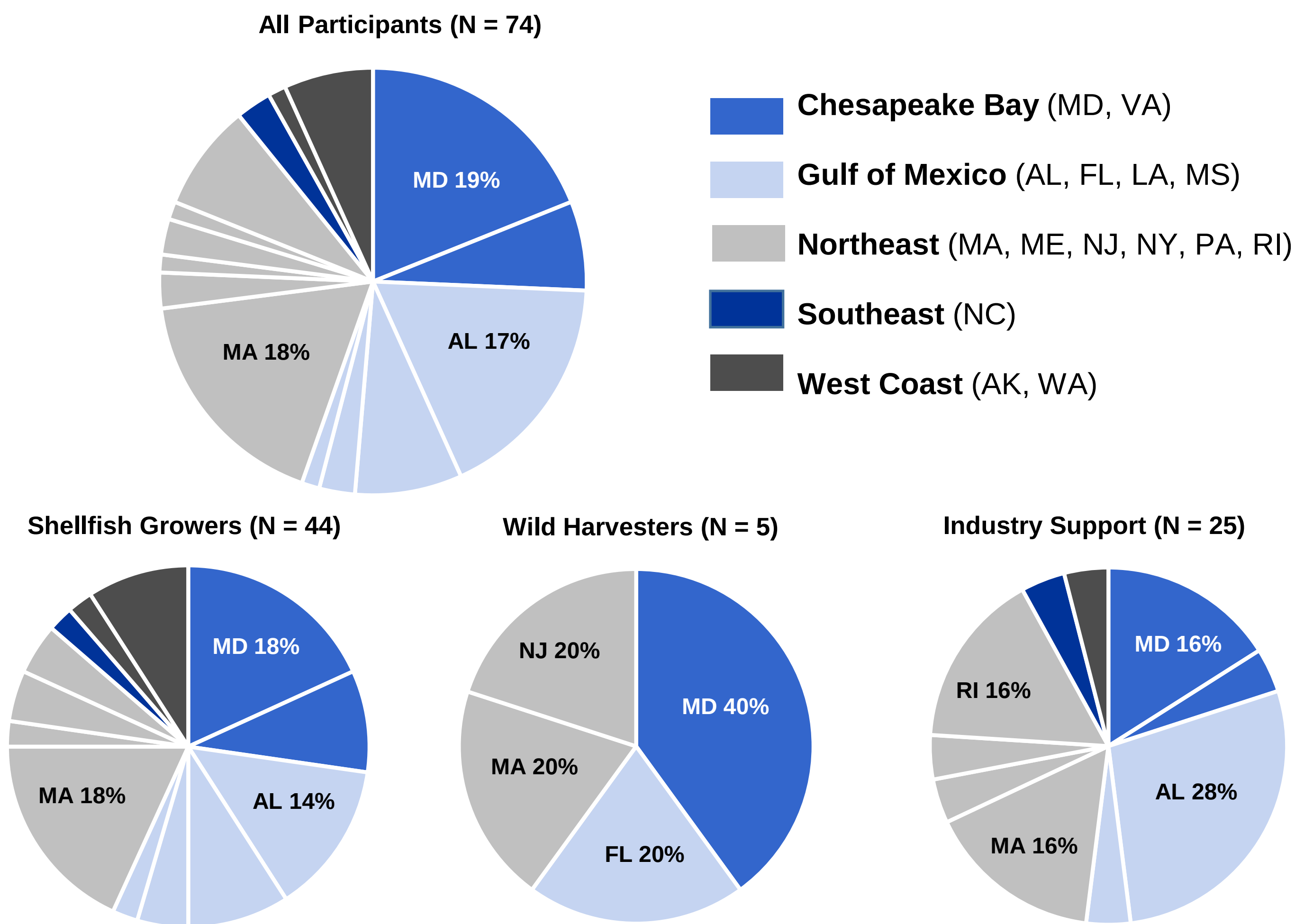


Figure 34. Geographic Distribution of Participants Overall (Top) and by Industry Role (Bottom)

Participant representation is shown by five regions (see legend) as: 1) all participants, 2) participants who sorted as shellfish growers, 3) participants who sorted as wild harvesters, and 4) participants who sorted as industry support. States with greater representation in each chart are identified with state abbreviations and percentages. There were no shellfish growers from NJ or PA and no industry support from LA, MS, NJ, NY, or AK. All other states are presented clockwise in alphabetical order by region.

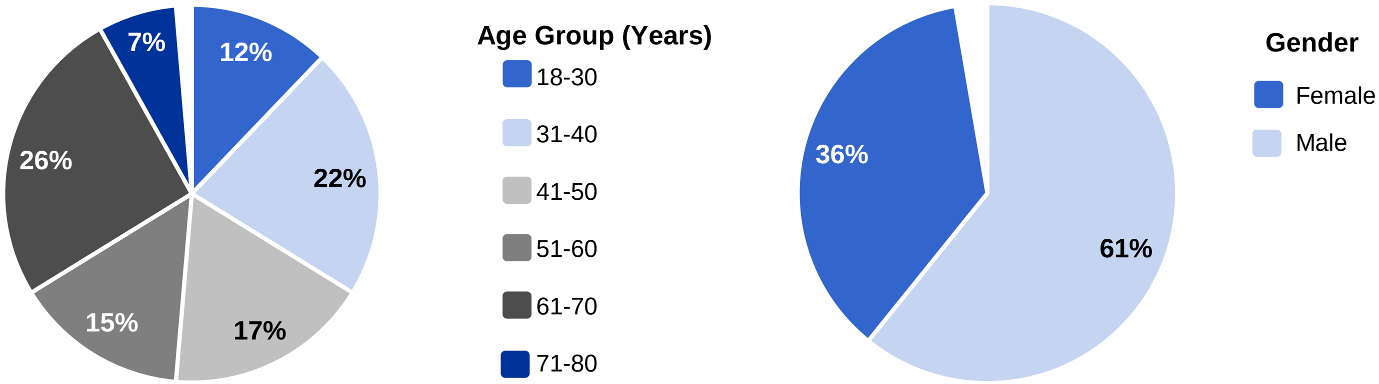


Figure 35. Participant Distribution by Age and Gender

Participant representation is shown by age group (left) and gender (right) [N = 74]. In both cases, participants could opt to not disclose information; this absence of data is represented by the missing section of the chart (white).

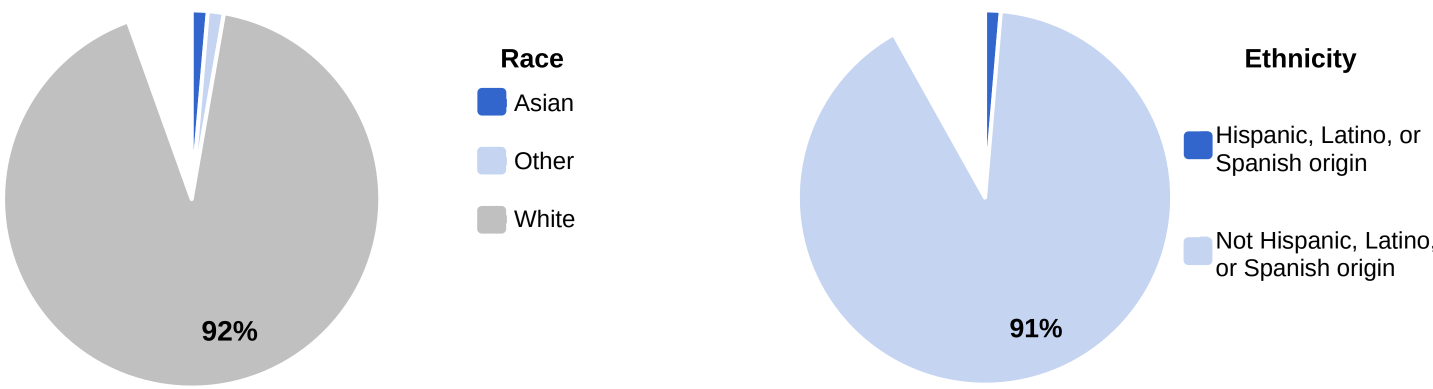


Figure 36. Participant Distribution by Race and Ethnicity

Participant representation is shown by race group (left) and ethnicity (right) according to US Census categories [N = 74]. In both cases, participants could opt to not disclose information; this absence of data is represented by the missing section of the chart (white).

The 44 participants who completed the sort as **shellfish growers** were involved in aquaculture production of oysters (N = 38), clams (N = 12), and scallops (N = 6) (Table 12). The majority had been in the industry for 1 to 5 years, but participants ranged from less than 1 to more than 30 years growing shellfish (Figure 37). All levels of production were represented, with the majority of growers producing between 100,000 and 500,000 animals annually (Figure 37).

Table 12. Shellfish Species Grown by Participants

Shellfish species produced as commercial aquaculture products by participants are listed by type of animal, common name, and scientific name. Common names were provided by participants.

Aquaculture Product	Common Name(s)	Scientific Name
Clam	Atlantic surf clam	*Spisula solidissima*
	Hard clam, littleneck clam, quahog	*Mercenaria mercenaria*
	Manila clam	*Venerupis philippinarum*
Oyster	Eastern oyster	*Crassostrea virginica*
	Olympia oyster	*Ostrea lurida*
	Pacific oyster	*Crassostrea gigas*
Scallop	Bay scallop	*Argopecten irradians*

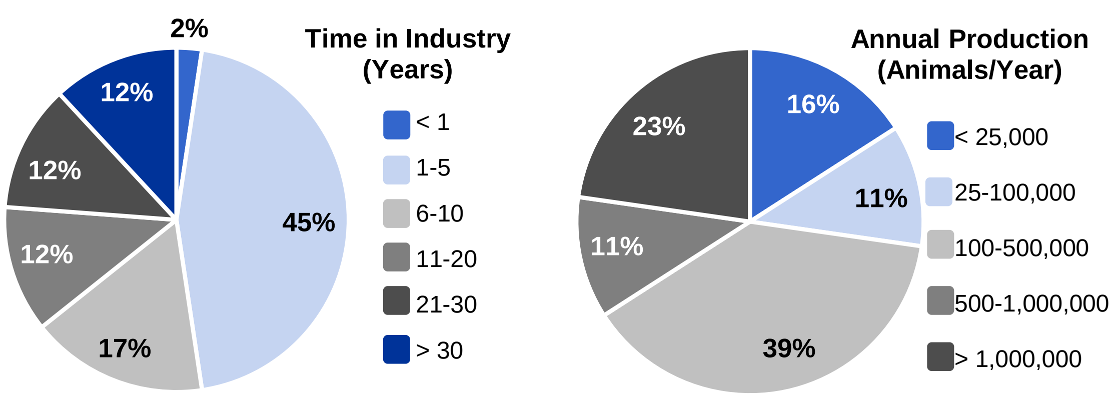


Figure 37. Shellfish Grower Participant Distribution by Time in Industry and Production

Shellfish grower participant representation is shown by length of time in industry (left) and annual production (right) [N = 44].

Of the five **wild harvesters** who completed the sort as such, all were involved in multiple wild fisheries, including: oyster (N = 3), clam (N = 1), scallop (N = 2), crab (N = 2), finfish (N =1), and eel (N = 1). Additional participants who are or were wild harvesters, but did not sort as that role, were involved in these fisheries and more (Table 13). Three of the five participants who sorted as wild harvesters had spent more than 20 years in the industry and the majority who took part in the survey were full-time wild harvesters (Figure 38). Full-time was defined as someone for whom commercial fishing was their only source of income. Though not all sorted as wild harvesters, 27 participants were affiliated with wild harvest.

Table 13. Species Wild Harvested/Caught by Participants

Species harvested or caught by participants in wild or public commercial fisheries are listed by type of animal, common name, and scientific name. Common names were provided by participants; information in [brackets] was added for species clarification.

Species Wild Harvested/Caught by Participants		
	Common Name(s)	**Scientific Name**
Clam	Atlantic surf clam, sea clam	*Spisula solidissima*
	Blood clam, blood ark	*Tegillarca granosa*
	Hard clam, littleneck clam, quahog	*Mercenaria mercenaria*
	Soft-shell clam, longneck clam	*Mya arenaria*
Crab	Blue crab	*Callinectes sapidus*
	Rock crab	*Cancer spp.* (Not specified)
Lobster	American lobster	*Homarus americanus*
Mussel	Not specified	Not specified
Oyster	Eastern oyster	*Crassostrea virginica*
Scallop	Bay scallop	*Argopecten irradians*
	Sea scallop	*Placopecten magellanicus*
Finfish (General)	American eel	*Anguilla rostrata*
	[Atlantic] Bluefin tuna	*Thunnus thynnus*
	[Atlantic] Cod	*Gadus morhua*
	[Atlantic Spiny] Dogfish	*Squalus acanthias*
	Groundfish (not specified)	Not specified
	Halibut	*Hippoglossus spp.* (Not specified)
	Perch (not specified)	*Perca spp.* (Not specified)
	Reef fish (not specified)	Not specified
	Rockfish, Atlantic striped bass	*Morone saxatillis*

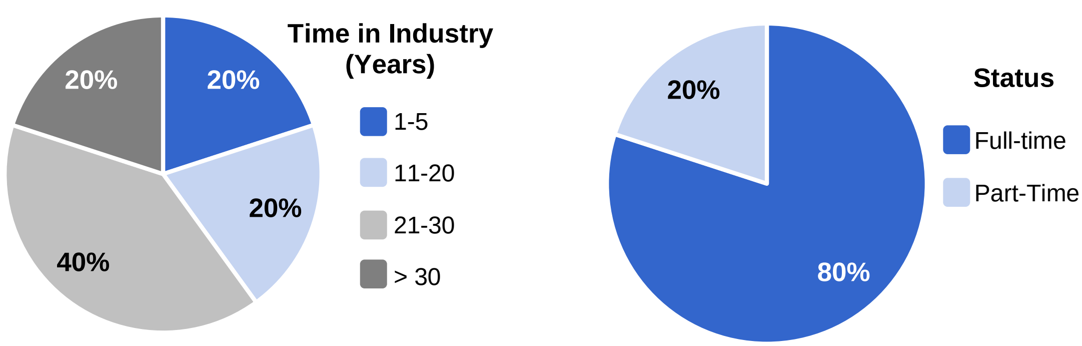


Figure 38. Wild Harvester Participant Distribution by Time in Industry and Full-Time Status

Wild harvester participant representation is shown by length of time in industry (left) and full-time status (right) [N = 5].

In total, 25 of 32 participants involved in shellfish **industry support** completed the Q sort as such, and these participants were connected to shellfisheries in integrated and varied ways. A large number of participants were involved in research; these included students, scientists, and professors. Extension specialists involved in research and education also participated. Some participants worked in research hatcheries or were involved in shellfish propagation that benefits a public resource. A number were involved on the regulatory side of shellfisheries and included shellfish constables, regulators, management officials, and others connected to government relations and shellfish food safety. Others were tied to the development of the industry as gear manufacturers, suppliers, wholesalers, as well as industry association and non-profit leaders.

Q Sort Survey

Data collected in three regions and detailed in Chapter 4 and Appendix 1 were used to create and administer an online Q sort survey. The initial list of services discussed in interviews spanned all 4 types of ecosystem services (cultural, provisioning, regulating, and supporting) and, as outlined previously, included 9 benefit categories with 46 unique but related subcategories of services and benefits (Chapter 4; Appendix 1). These 46 sub-categories were summaries of themes that, in some cases, were quite complex. Their detailed form (Appendix 1) represents the overall concourse related to the topic, however it was essential to distill this concourse into a suitable number of statements for the Q set. Statements were created using participant language to represent this complete list, with awareness and caution to avoid participant exhaustion and survey withdrawal with too long of a Q set. Statements were worded as simply as possible, with room for individual interpretation (Coogan & Herrington, 2011). In total, 49 statements comprised the Q set, which is within recommended range for a reasonable and effective Q sort (Table 14; Brown, 1993; van Exel & de Graaf, 2005; Watts & Stenner, 2005). Some statements reflected benefits for more than one service type (e.g., statements 46 and 49). One benefit, overall "job satisfaction," was not included as a unique statement with the assumption, based on interviews, that all listed benefits contribute to job satisfaction. Q set statements were preliminarily piloted with a subset of participants who took part in initial interviews.

Table 14. Q Set of Statements

The 49 statements participants sorted are listed with corresponding ecosystem service (ES) categories – cultural ecosystem service (CES); provisioning ecosystem service (PES); regulating and supporting ecosystem services (RSES). ES subcategories (Detail 1) and benefits (Detail 2) are also included. Refer to Appendix 1 for complete descriptions.

Q Set Statement	ES Category	ES Detail 1	ES Detail 2
1. My job continues local traditions of work related to shellfish.	CES	Identities	Cultural Heritage
2. My family members are/were involved in similar work.	CES	Identities	Family Heritage
3. My job is unique.	CES	Identities	Novel Occupation
4. My work has its own associated identity. (Ex: fisherman, oyster farmer)	CES	Identities	Occupation
5. My work helps to ensure that future generations have the same opportunity to interact with the environment.	CES	Identities	Responsibility of Care - Environment
6. My job produces a reliable product.	CES	Experiences	Security and Reliability
7. My work helps create or maintain jobs in my community.	CES	Identities	Contribution to Community
8. I am responsible for the care, growth, and/or success of an animal.	CES	Identities	Responsibility of Care - Husbandry
9. Because of my work, I am part of a larger community or industry with similar interests and goals.	CES	Identities	Sense of Belonging
10. This job is what I was meant to do.	CES	Identities	Sense of Purpose
11. My work instills a sense of responsibility to take care of the environment, water, or worksite.	CES	Identities	Responsibility of Care - Environment
12. Through my work, I am contributing to a greater good.	CES	Identities	Sense of Purpose
13. My work contributes to shoreline protection.	RSES	Reef Formation	Shoreline Protection
14. My job provides a sense of adventure or thrill.	CES	Experiences	Adventure
15. I enjoy the beautiful things I see at work. (Ex: sunrise/sunset, animals, etc.)	CES	Experiences	Aesthetic Appreciation
16. My job provides challenges that I must overcome or solve.	CES	Experiences	Challenge
17. My job offers freedom and flexibility.	CES	Experiences	Independence
18. My work creates habitat for other species.	RSES	Reef Formation	Supports Other Species & Fisheries
19. I have a good amount of control in my job.	CES	Experiences	Independence
20. My job allows me to be creative or innovative.	CES	Experiences	Innovation
21. The overall lifestyle associated with my work is appealing. (Ex: outdoors, on the water, hands-on.)	CES	Experiences	Lifestyle
22. I am proud of the work that I do or the product I create.	CES	Experiences	Pride

Q Set Statement	ES Category	ES Detail 1	ES Detail 2
23. I enjoy hearing positive feedback or recognition from others because of my work.	CES	Experiences	Pride
24. My job provides a spiritual connection or experience.	CES	Experiences	Spiritualism
25. My job enables a relationship with or an awareness of nature.	CES	Experiences	Relationship with Nature
26. My job provides a relatively high level of safety at work.	CES	Experiences	Safety
27. My job provides a stable income.	CES	Experiences	Security and Reliability
28. I produce a sustainable food item.	PES	Food Production	Sustainable Product
29. My job helps reduce stress and/or provides a sense of relief and calm.	CES	Experiences	Therapy
30. My work contributes to improved water quality.	RSES	Filter Feeding	Improved Water Quality
31. I feel a special connection or attachment to the location where I work.	CES	Identities	Sense of Place
32. My job has created or strengthened connections with other people (within and/or outside of the industry).	CES	Experiences	Shared Experiences/ Social Capital
33. My job contributes to good or improved mental health.	CES	Capabilities	Mental Health
34. My job lets me gain new skills, apply prior skills, and/or teach skills to others.	CES	Capabilities	Skills
35. My job lets me gain knowledge, apply prior knowledge, and/or teach others.	CES	Capabilities	Knowledge
36. My job enabled a positive change in my life.	CES	Experiences	Transformation
37. There is variety in my daily activities and tasks at work.	CES	Experiences	Variety
38. My job provides a better income than other jobs.	CES	Capabilities	Income
39. My work has no negative environmental impact, or is environmentally positive.	RSES	General	Environmentally Positive
40. I produce a local food item.	PES	Food Production	Local Product
41. My job is physically demanding and helps me stay in shape.	CES	Capabilities	Physical Health
42. I help wild shellfish populations through my work.	RSES	Spawning	Contributes to Wild Shellfish Population
43. I produce a high quality food item.	PES	Food Production	High Quality Product
44. I create a food product through my work.	PES	Food Production	Food (General)
45. I create a healthy source of protein for people to eat.	PES	Food Production	Healthy Product
46. I produce a safe food item.	CES & PES	Experiences & Food Production	Safety and Safe Product
47. I produce shells that can be used for jewelry, decorative, or collector's purposes.	PES	Shell Production	Decorative & Hobby
48. My work enhances the populations of other (non-shellfish) species.	RSES	Reef Formation & Spawning	Supports other Species & Fisheries
49. I create a food product that people enjoy.	CES & PES	Experiences and Food Production	Shared Experiences & Food (general)

This Q set was entered into an online survey tool, QMethodSoftware (Lutfallah & Buchanan, 2018, 2019). After testing multiple online Q methodology options, this platform was chosen primarily for its ease of use for participants during the sorting activity. Though still time-consuming, the ability to click and drag cards, similar to an in-person sort, was presumed to be easier than other online formats. The survey was limited to computers rather than smartphones because of this feature. The size of the sorting grid would also have rendered smartphones an unsuitable platform.

In addition to sorting the Q set, participants were asked to complete a corresponding questionnaire that occurred as related surveys within the same online session. The length of the questionnaire paired with a hard-copy Q sort made participation via postal mail unlikely. Thus, while recognizing that this would exclude some participants from taking part (37 participants involved in initial interviews had requested future correspondence via postal mail relative to 181 participants requesting via email), the decision was made to administer the Q sort survey online only. Though participation was anonymous, several of the ‘postal-mail’ participants notified the researcher that they completed the online survey. Many researchers prefer to administer Q sort surveys in person, but others have shown that mail and computer-based surveys are equally reliable (van Exel & de Graaf, 2005; van Tubergen & Olins, 1979). Online administration, however, limits the ability for the researcher to conduct interviews in tandem with the sort (van Exel & de Graaf, 2005). To address this potential issue, follow-up questions gave participants the option to expand on each section. Participants were also encouraged to contact the researcher if they had questions or additional thoughts, and many did.

The first survey targeted general demographic data as well as information about each participant's role in the shellfish industry. Participants were asked: the zip codes of their place of work and residence, year of birth, gender, race, and ethnicity. They had the option to not disclose for each of these questions. Participants were asked if they worked as a commercial shellfish grower, wild harvester, and/or shellfish industry support. Shellfish growers were asked the species grown, length of time in the industry, and annual production. Wild harvesters were asked the type of catch/fishery, length of time in the industry, and whether they were full or part-time wild harvesters. Industry support were provided with an open-ended question to generally detail the type of work that they did. At the end of this first survey, participants were asked to select one shellfish-related role (shellfish grower, wild harvester, or industry support) and answer the remaining questions with only that role in mind. This was critical to clarify, as many participants had worked with shellfish in multiple capacities.

The second activity asked participants to read each Q set statement and indicate whether it was something very important, somewhat important, or not important to them about their job. This preliminary sort was intended to organize statements to make the final sort slightly easier. Next, participants were presented with the complete list of statements and asked to identify those statements that they felt were not relevant to their work. This additional survey was used because statements were created via separate interviews with participants in seven different states. It was possible that a statement was strongly linked to one person's job with shellfish, but not with someone else's job in a different state or working with shellfish in a different way. This survey option allowed for better understanding of whether something was unimportant or simply not relevant to a participant.

Next, participants were asked to conduct the 'final sort'. In this activity, participants were presented with a screen that had three stacks of cards at the top, divided according to their earlier designation of: very important, somewhat important, or not important. They were directed to move each card to its appropriate spot (per their opinion) on a gridded pyramid (Figure 39). Cards placed at the far left were least important and increased in importance to the far right, where they were most important. Vertical placement in the pyramid made no difference, only where they were placed left to right. It was in this activity that participants had the most problems or questions. Multiple participants emailed or called for clarification of the instructions or assistance with the program. Some had attempted to complete the survey on a smartphone, and could not complete the sort. Others were not comfortable with the idea of placing statements that were important to them, as one example, in the half of the grid that was colored as unimportant, as they had already filled the right side of the grid. Explanation that the color of the cells and numbers at the bottom did not matter, as sorting was all relative, helped to alleviate concerns in that case. As additional incentive, participants were given the opportunity to provide contact information at the end of the survey to be entered to randomly win one of multiple $50 gift cards.

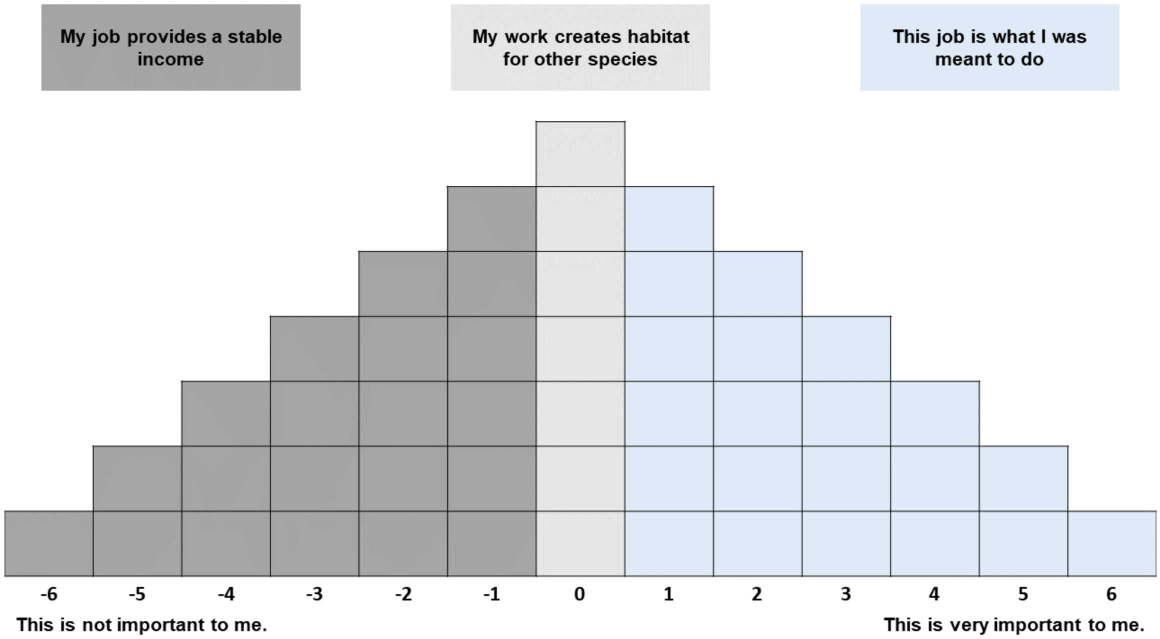


Figure 39. Q Sort Participant Display

For the final sort, participants were asked to move statement cards from their pre-sorted piles into the appropriate location within the grid, based on their own assessment of the statements.

Because the structure of the full online survey tool involved four individual steps: 1) demographic information survey, 2) pre-sort, 3) relevance survey, and 4) final sort, it is possible to see where participants stopped in the process. A total of 152 people opened the initial survey link and began to answer questions in the demographic survey. Ninety-nine people, comprised of 54 shellfish growers, 10 wild harvesters, and 35 industry support, completed the pre-sort. Seventy-four people completed the final sort and did so as 44 shellfish growers, 5 wild harvesters, and 25 industry support.

Data Analysis

QMethod Software analyzed data to create an output report that included: 1) original participant sort data, 2) Q sort factor loadings, 3) flagged Q sorts, 4) statement z-scores, 5) statement factor scores, 6) general factor characteristics, 7) correlation between factor z-scores, 8) standard error of differences between factors, and 9) distinguishing and consensus statements. Outputs could be generated for between two and seven factors, a reasonable range for Q projects (Brown, 1993). Though the software completed the correlation and factor analysis, steps are detailed here.

An initial correlation matrix organized the relationship of each participant Q sort configuration with every other Q sort configuration (Watts & Stenner, 2005). The matrix was factor analyzed using a principal components analysis (PCA) with varimax rotation to identify the number of natural groupings of Q sorts based on similarity to one another (van Exel & de Graaf, 2005). These natural grouping resulted in a series of factors. Though some argue that centroid analysis with hand rotation is the preferred method, as it allows the researcher greater subjectivity with an infinite number of rotated solutions (Newman & Ramlo, 2010; Watts & Stenner, 2005), PCA with varimax rotation is commonly used and yields equally appropriate and rigorous results (Moree, 2017; Zabala et al., 2018; Watts & Stenner, 2005).

Each factor was a representation of an average sort of individual viewpoints for that factor, structured using statement factor scores, which are the average of individual statement scores for all sorts associated with that factor (Brown, 1993; Newman & Ramlo, 2010). Resulting factors represented a group of highly correlated individual viewpoints that were uncorrelated with other factors and likewise uncorrelated with the viewpoints that loaded onto other factors (van Exel & de Graaf, 2005). Factor loadings expressed the extent to which each participant sort was associated with each factor and were used as one means to identify the most appropriate number of factors for the research topic. Significant loading correlations between each participant sort and factors were flagged within each factor and were identified as 'loading' on a particular factor if significant at $P < 0.05$ and the loading score was higher than other factors for that same participant sort (Table 16 in Results). Flagged loadings indicated a meaningful relationship between the Q sort and factor type (Zabala & Pascual, 2016).

Factor analysis produced six potential factor output options, ranging from possibilities of two through seven factors. In other words, the researcher needed to determine which factor output model best represented the data, one comprised of only two factors, three factors, etc. These factor outputs were evaluated for best fit and appropriateness based on number of loading sorts and eigenvalues (Coogan & Herrington, 2011). All eigenvalues were greater than one, thus none were immediately discarded, however the three-factor output had a greater number of sorts that loaded upon it than all other factor outputs (Coogan & Herrington, 2011; Watts & Stenner, 2005). Explanation of variance was also examined within each factor output. This value was slightly higher for outputs with a greater number of factors, but none had as many loaded sorts as the three-factor output. The three-factor output was determined to be the most appropriate representation of the data.

The factors were qualitatively analyzed to better understand the underlying viewpoints. This included looking at consensus and distinguishing statements among the three factors, identified by comparing z-scores among factors for each statement (van Exel & de Graaf, 2005). Distinguishing statements were identified at $P<0.05$, $P<0.01$, $P<0.001$, and $P<0.0001$ (Table 18). Only those distinguishing at $P<0.0001$ were used to understand factors.

Beyond distinguishing and consensus statements, each factor was examined to understand which benefits were ranked highest, lowest, and in between. This included considering the individual values or views that led to each sort ranking and how they differed between factor groups. The presence of non-relevant statements was also examined to determine how appropriate the Q set was for participants in each factor group and how non-relevance may have influenced rankings. Within each factor, participant attributes were inspected to identify possible similarities among those who loaded on the same factors.

Additional comparative data analyses occurred to extend understanding of ranking patterns. All factor outputs (2 through 7) were examined for their placement of wild harvester participants in order to identify if one factor output was better than others at capturing the perspectives of the limited number of wild harvesters. The relationship between frequencies of mention of benefits in Chapter 4 was compared to the value of benefits per rankings. The 15 most frequently mentioned benefits in Chapter 4 were examined relative to how each factor ranked their corresponding benefit statements. Statements ranked especially high or low were noted and overall trends discussed. Finally, the overall value of benefits was inspected by comparing statements ranked high (1-15), moderately (16-34), and low (35-49) among factors. Statements with similar rankings among all three groups were flagged and discussed.

Results

Factor Analysis

Three factors were selected as the best representation of the Q sort dataset. This selection occurred independently of participant attribute data, and, as outlined in the methods, was based on the number of loading sorts and eigenvalues relative to other factors (Table 15). In total, 63 of the 74 sorts loaded on to these three factors; their loading scores are shown in red in Table 16.

Table 15. Factor Characteristics

Statistics characterizing each factor and used to help select the appropriate number of factors are shown.

	Factor A	Factor B	Factor C
Average Reliability Coefficient	0.8	0.8	0.8
Number of loading Q Sorts: 63	23	26	14
Eigenvalues	10.0773	8.6573	6.0226
Total Explained Variance	13.6	11.7	8.1
Composite Reliability	0.9892	0.9905	0.9825
Standard Error of Factor Scores	0.1037	0.0976	0.1325

Table 16. Participant Loading Scores

Participant loading scores are shown for each factor. Scores in red indicate those 'flagged' as significantly loading on a particular factor (P < 0.05).

Participant	Factor A	Factor B	Factor C
Grower 1	0.2318	0.5956	0.0972
Grower 2	0.0112	0.1901	0.2181
Grower 3	0.243	0.4434	-0.1992
Grower 4	0.0335	0.466	-0.2652
Grower 5	0.1748	0.4759	0.1509
Grower 6	-0.1441	0.7305	-0.3116
Grower 7	0.1443	0.5148	-0.1504
Grower 8	0.234	0.5864	0.0785
Grower 9	0.1842	-0.0496	-0.0119
Grower 10	0.2547	0.5249	0.4052
Grower 11	0.0579	-0.0014	0.0828
Grower 12	-0.0436	0.0718	-0.1144
Grower 13	0.0497	-0.0782	0.0325
Grower 14	0.1434	0.2942	0.3234
Grower 15	0.0324	0.4135	0.2782
Grower 16	-0.0584	0.6673	-0.052
Grower 17	0.4313	-0.2467	0.0551
Grower 18	0.1175	0.2851	0.1873
Grower 19	-0.034	-0.1673	-0.0432
Grower 20	0.0976	0.1796	0.182
Grower 21	0.0517	0.4337	-0.0846
Grower 22	-0.0718	0.4005	0.1162
Grower 23	0.1791	0.1767	0.0198
Grower 24	0.2	-0.0676	0.3573

Participant	Factor A	Factor B	Factor C
Grower 25	-0.2159	0.4054	0.2174
Grower 26	0.2892	-0.2621	0.4109
Grower 27	-0.0655	0.6597	0.0742
Grower 28	0.1946	0.4986	0.4062
Grower 29	0.3352	0.7143	0.0029
Grower 30	0.1671	0.2187	0.5418
Grower 31	0.2691	0.2114	0.1194
Grower 32	-0.1515	0.3872	0.4269
Grower 33	-0.0895	0.5894	0.2999
Grower 34	0.2019	0.5176	0.2459
Grower 35	0.0763	0.029	0.506
Grower 36	-0.0269	-0.1439	0.6599
Grower 37	-0.2563	0.1153	0.4742
Grower 38	0.3508	0.2955	0.0017
Grower 39	0.0778	0.5694	-0.0449
Grower 40	-0.0272	0.0226	-0.4563
Grower 41	0.3677	0.4041	0.132
Grower 42	-0.0691	0.0718	0.2982
Grower 43	0.0789	-0.0434	0.7369
Grower 44	-0.0098	0.5735	-0.1966
Wild 1	-0.1968	0.119	0.5015
Wild 2	-0.3739	0.6128	0.3086
Wild 3	-0.1327	0.3039	-0.1339
Wild 4	0.5656	-0.1722	0.2394
Wild 5	0.429	0.0755	0.4368
Support 1	0.4696	0.1757	0.4111
Support 2	0.2991	0.1243	0.2502
Support 3	0.3214	0.2802	0.0495
Support 4	0.1275	0.3184	0.2095
Support 5	0.6683	-0.0281	-0.1164
Support 6	0.4339	0.0901	0.0401
Support 7	0.4727	-0.0504	0.317
Support 8	0.461	-0.1472	0.5537
Support 9	0.6139	0.0024	-0.0476
Support 10	0.7929	-0.0193	0.1985
Support 11	0.6872	0.0905	0.2155
Support 12	0.6664	0.2962	0.1656
Support 13	0.5195	0.2623	0.2954
Support 14	0.6741	0.1522	-0.0501
Support 15	0.4871	-0.0142	-0.1585
Support 16	-0.0548	0.3623	0.1858
Support 17	0.6451	0.2683	0.0338
Support 18	0.2584	0.3903	0.3713

Participant	Factor A	Factor B	Factor C
Support 19	0.7711	0.0303	0.0283
Support 20	0.8099	-0.0379	0.1232
Support 21	0.6651	0.3291	-0.0272
Support 22	0.6519	0.0142	0.1512
Support 23	0.2256	0.0877	0.6272
Support 24	0.6241	0.4809	-0.1128
Support 25	0.6939	0.0575	0.3327

Factor scores, the composite or average statement sort score for each factor (Table 17), were used to create representative sort diagrams for each factor (Figure 40). The diagrams depict where each statement was located in the sort structure, as indicated by the number in each cell. They are color-coded to illustrate each statement's corresponding ecosystem service category with cultural ecosystem services (CES) in gray, provisioning ecosystem services (PES) in light blue, and the combined category of regulating and supporting ecosystem services (RSES) in dark blue.

Table 17. Factor Scores

Each statement is listed with the corresponding factor scores, representative of average scores for each factor group. Scores range from -6 (not important) to 6 (very important) as with the Q sort and indicate the relative importance of statements as sorted by participants.

Q Set Statements	A	B	C
1. My job continues local traditions of work related to shellfish.	-1	-1	-1
2. My family members are/were involved in similar work.	-5	-5	0
3. My job is unique.	0	-2	4
4. My work has its own associated identity. (Ex: fisherman, oyster farmer)	-1	-3	2
5. My work helps to ensure that future generations have the same opportunity to interact with the environment.	3	1	-3
6. My job produces a reliable product.	-2	2	-2
7. My work helps create or maintain jobs in my community.	0	1	1
8. I am responsible for the care, growth, and/or success of an animal.	0	1	-2
9. Because of my work, I am part of a larger community or industry with similar interests and goals.	3	0	-1
10. This job is what I was meant to do.	0	-3	4
11. My work instills a sense of responsibility to take care of the environment, water, or worksite.	3	5	-1
12. Through my work, I am contributing to a greater good.	4	0	-2
13. My work contributes to shoreline protection.	-2	-2	-5

Q Set Statements	A	B	C
14. My job provides a sense of adventure or thrill.	-2	-3	2
15. I enjoy the beautiful things I see at work. (Ex: sunrise/sunset, animals, etc.)	1	2	1
16. My job provides challenges that I must overcome or solve.	6	-1	3
17. My job offers freedom and flexibility.	2	-1	5
18. My work creates habitat for other species.	0	4	-4
19. I have a good amount of control in my job.	2	-4	4
20. My job allows me to be creative or innovative.	5	0	3
21. The overall lifestyle associated with my work is appealing. (Ex: outdoors, on the water, hands-on.)	1	3	5
22. I am proud of the work that I do or the product I create.	3	3	6
23. I enjoy hearing positive feedback or recognition from others because of my work.	4	1	0
24. My job provides a spiritual connection or experience.	-3	-3	-5
25. My job enables a relationship with or an awareness of nature.	2	4	-2
26. My job provides a relatively high level of safety at work.	-1	-4	-4
27. My job provides a stable income.	2	-4	2
28. I produce a sustainable food item.	-3	2	0
29. My job helps reduce stress and/or provides a sense of relief and calm.	-2	-2	-4
30. My work contributes to improved water quality.	0	6	-3
31. I feel a special connection or attachment to the location where I work.	-1	3	0
32. My job has created or strengthened connections with other people (within and/or outside of the industry).	1	0	-1
33. My job contributes to good or improved mental health.	-2	-1	-3
34. My job lets me gain new skills, apply prior skills, and/or teach skills to others.	4	0	2
35. My job lets me gain knowledge, apply prior knowledge, and/or teach others.	5	0	1
36. My job enabled a positive change in my life.	1	-1	0
37. There is variety in my daily activities and tasks at work.	2	-2	1
38. My job provides a better income than other jobs.	-1	-5	-1
39. My work has no negative environmental impact, or is environmentally positive.	1	4	0
40. I produce a local food item.	-4	1	1
41. My job is physically demanding and helps me stay in shape.	-1	-2	-1
42. I help wild shellfish populations through my work.	0	0	-3
43. I produce a high quality food item.	-4	5	3
44. I create a food product through my work.	-4	-1	1
45. I create a healthy source of protein for people to eat.	-3	1	0
46. I produce a safe food item.	-3	2	2
47. I produce shells that can be used for jewelry, decorative, or collector’s purposes.	-6	-6	-6
48. My work enhances the populations of other (non-shellfish) species.	1	2	-2
49. I create a food product that people enjoy.	-5	3	3

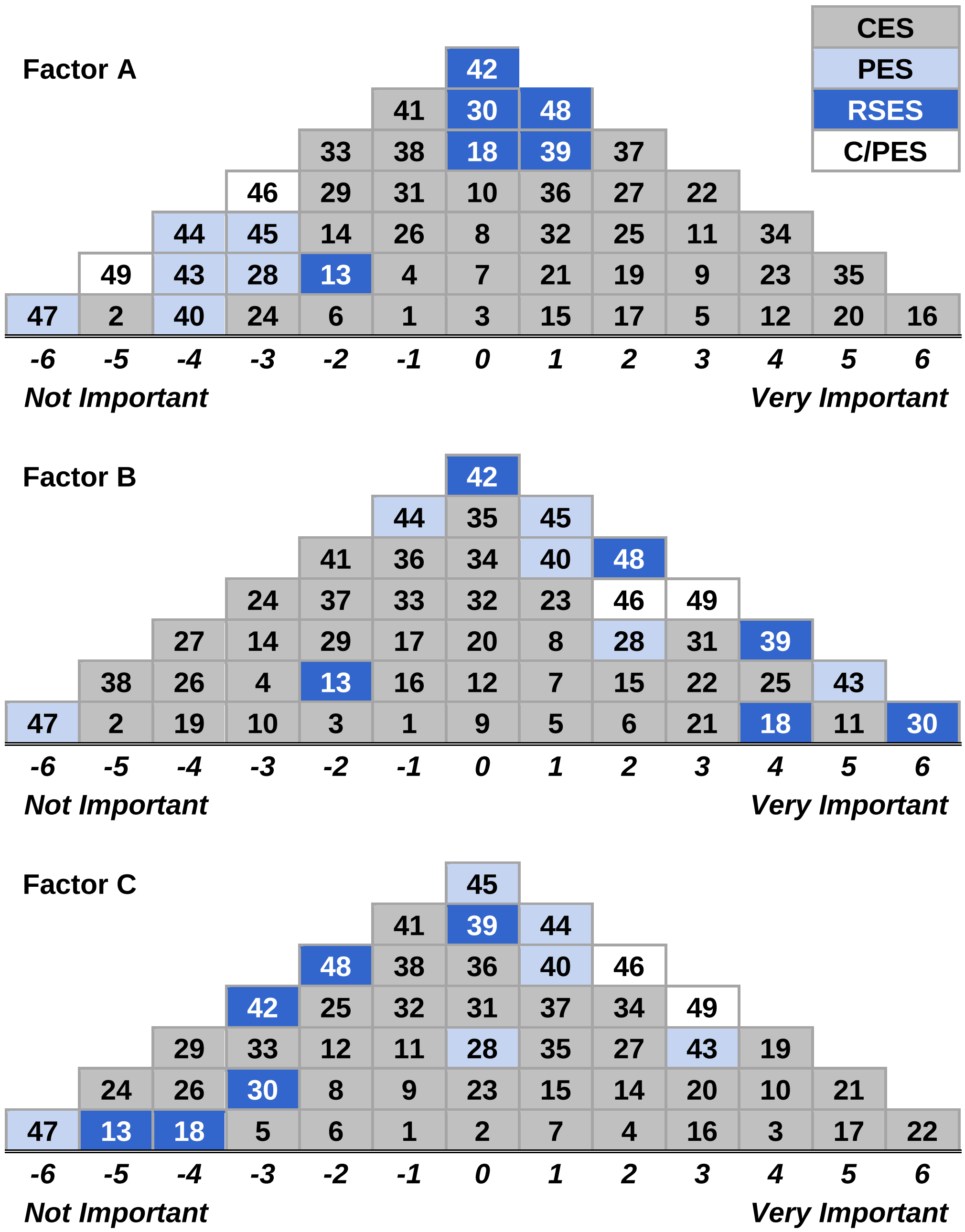


Figure 40. Representative Sort of Each Factor

Each factor is shown as its composite sort. Cell numbers indicate statements corresponding to placement. Statements have increasing importance from left to right. Cells are color-coded according to ecosystem service (ES) categories and include cultural services (CES, gray), provisioning services (PES, light blue), regulating and supporting services (RSES, dark blue), and statements that represented both cultural and provisioning services (C/PES, white).

Differences among z-scores were used to identify distinguishing and consensus statements (Table 18). The number of distinguishing statements at P < 0.05 were so numerous that those discussed in subsequent factor descriptions include only those significant at P < 0.0001 and total 41 statements. Some statements were distinguishing for all factors, others only distinguished one factor from one other factor. There were three consensus statements among factors (also in Table 18).

Table 18. Distinguishing and Consensus Statements

Differences (diff.) in z-scores between factors are shown for each statement. Significant (sign.) differences are indicated at P < 0.05 (*), P < 0.01 (**), P < 0.001 (***), and P < 0.0001 (****). For factor discussion, only distinguishing statements significant at P < 0.0001 were examined. Consensus statements, those statements whose z-scores were not significantly different among all three factors, are also noted.

Statement	Distinguishing at P<0.0001	Diff. A-B	Sign. A-B	Diff. A-C	Sign. A-C	Diff. B-C	Sign. B-C
1	**Consensus**	-0.0882		-0.144		-0.055	
2	C	0.1726		-1.557	****	-1.73	****
3	All	0.9112	****	-1.493	****	-2.404	****
4	C	0.5579	***	-1.213	****	-1.771	****
5	C	0.4205	**	1.957	****	1.537	****
6	B	-1.5476	****	-0.208		1.339	****
7	**Consensus**	-0.2319		-0.305		-0.073	
8	B and C	-0.3657	*	0.58	***	0.946	****
9	A	0.8218	****	1.426	****	0.605	***
10	All	1.2938	****	-1.244	****	-2.538	****
11	C	-0.383	**	1.292	****	1.675	****
12	All	1.1568	****	2.04	****	0.883	****
13	C	0.2002		1.127	****	0.927	****
14	C	0.0586		-1.543	****	-1.602	****
15		-0.1031		0.306		0.409	*
16	B	1.8018	****	0.633	***	-1.169	****
17	B	1.3985	****	-0.761	***	-2.16	****
18	All	-1.0279	****	1.237	****	2.265	****
19	B	1.9259	****	-0.621	***	-2.547	****
20	B	1.5602	****	0.524	**	-1.036	****
21	A and C	-0.4604	**	-1.19	****	-0.73	***
22	B and C	0.0376		-0.77	***	-0.807	****
23	A	0.7746	****	1.042	****	0.267	

Statement	Distinguishing at P<0.0001	Diff. A-B	Sign. A-B	Diff. A-C	Sign. A-C	Diff. B-C	Sign. B-C
24		-0.0012		0.664	***	0.665	***
25	C	-0.3397	*	1.54	****	1.879	****
26	A and B	1.1556	****	0.574	***	-0.582	***
27	B	2.3087	****	0.227		-2.082	****
28	A	-1.9293	****	-1.283	****	0.646	***
29	C	-0.0713		0.862	****	0.934	****
30	All	-1.6928	****	1.114	****	2.807	****
31	B	-1.2724	****	-0.121		1.152	****
32	A and C	0.4518	**	0.869	****	0.418	*
33		-0.6745	***	0.097		0.772	***
34	A and B	1.2966	****	0.546	**	-0.751	***
35	A	1.3338	****	1.206	****	-0.128	
36		0.466	**	0.28		-0.186	
37	B	1.4708	****	0.45	**	-1.02	****
38	B	1.5031	****	-0.097		-1.6	****
39	B	-0.7161	****	0.627	***	1.343	****
40	A	-1.9782	****	-1.765	****	0.213	
41	**Consensus**	0.2427		0.223		-0.02	
42	C	0.2934	*	1.16	****	0.867	****
43	A	-2.9662	****	-2.4	****	0.566	***
44	A	-1.0061	****	-1.784	****	-0.778	***
45	A	-1.7917	****	-1.023	****	0.768	***
46	A	-1.9127	****	-1.998	****	-0.085	
47		0.28	*	0.464	**	0.184	
48	C	-0.5505	***	1.102	****	1.652	****
49	A	-2.7839	****	-2.649	****	0.135	

Tables 19 through 21 provide the ranked statements in order of decreasing z-score for each factor. Statements at the top of each list, with the highest z-scores, represent the statements ranked highest by participants (furthest right on the sorting grid). As in Table 14, statements are listed with the corresponding ecosystem service categorization and are color-coded as in Figure 40; CES are highlighted in gray, PES in light blue, and RSES in dark blue. Additionally, distinguishing statements are identified with bold-type font as well as an asterisk (*).

Table 19. Factor A

Statements are presented in order of composite rankings (by z-score) for factor A. Also listed are corresponding ecosystem service (ES) categories: cultural ecosystem services (CES; gray), provisioning ecosystem services (PES; light blue), and regulating/supporting services (RSES, dark blue). Statements that correspond to more than one ES category are indicated with a white ES fill. Distinguishing statements are identified in bold font and with an asterisk (*).

#	Statement: Factor A Rankings	ES	ES Detail 1	ES Detail 2	Z-Score
16	My job provides challenges that I must overcome or solve.	CES	Experiences	Challenge	1.592
35	**My job lets me gain knowledge, apply prior knowledge, and/or teach others.***	CES	Capabilities	Knowledge	1.568
20	My job allows me to be creative or innovative.	CES	Experiences	Innovation	1.432
34	**My job lets me gain new skills, apply prior skills, and/or teach skills to others.***	CES	Capabilities	Skills	1.276
12	**Through my work, I am contributing to a greater good.***	CES	Identities	Sense of Purpose	1.268
23	**I enjoy hearing positive feedback or recognition from others because of my work.***	CES	Experiences	Pride	1.118
22	I am proud of the work that I do or the product I create.	CES	Experiences	Pride	1.103
11	My work instills a sense of responsibility to take care of the environment, water, or worksite.	CES	Identities	Responsibility of Care - Environment	1.074
9	**Because of my work, I am part of a larger community or industry with similar interests and goals.***	CES	Identities	Sense of Belonging	1.007
5	My work helps to ensure that future generations have the same opportunity to interact with the environment.	CES	Identities	Responsibility of Care - Environment	0.987
17	My job offers freedom and flexibility.	CES	Experiences	Independence	0.961
27	My job provides a stable income.	CES	Experiences	Security and Reliability	0.898
37	There is variety in my daily activities and tasks at work.	CES	Experiences	Variety	0.879
25	My job enables a relationship with or an awareness of nature.	CES	Experiences	Relationship with Nature	0.866
19	I have a good amount of control in my job.	CES	Experiences	Independence	0.762
15	I enjoy the beautiful things I see at work. (Ex: sunrise/sunset, animals, etc.)	CES	Experiences	Aesthetic Appreciation	0.737
32	**My job has created or strengthened connections with other people (within or outside of the industry).***	CES	Experiences	Shared Experiences/Social Capital	0.653
21	**The overall lifestyle associated with my work is appealing. (Ex: outdoors, on the water, hands-on.)***	CES	Experiences	Lifestyle	0.543
39	My work has no negative environmental impact, or is environmentally positive.	RSES	General	Environmentally Positive	0.471

#	Statement: Factor A Rankings	ES	ES Detail 1	ES Detail 2	Z-Score
36	My job enabled a positive change in my life.	CES	Experiences	Transformation	0.33
48	My work enhances the populations of other (non-shellfish) species.	RSES	Reef Formation/ Spawning	Supports other Species and Fisheries	0.293
42	I help wild shellfish populations through my work.	RSES	Spawning	Contributes to Wild Shellfish Population	0.278
30	**My work contributes to improved water quality.***	RSES	Filter Feeding	Improved Water Quality	0.255
10	**This job is what I was meant to do.***	CES	Identities	Sense of Purpose	0.187
7	My work helps create or maintain jobs in my community.	CES	Identities	Contribution to Community	0.151
18	**My work creates habitat for other species.***	RSES	Reef Formation	Supports other Species and Fisheries	0.131
3	**My job is unique.***	CES	Identities	Novel Occupation	0.056
8	I am responsible for the care, growth, and/or success of an animal.	CES	Identities	Responsibility of Care - Husbandry	-0.104
31	I feel a special connection or attachment to the location where I work.	CES	Identities	Sense of Place	-0.171
41	My job is physically demanding and helps me stay in shape.	CES	Capabilities	Physical Health	-0.298
1	My job continues local traditions of work related to shellfish.	CES	Identities	Cultural Heritage	-0.375
38	My job provides a better income than other jobs.	CES	Capabilities	Income	-0.461
4	My work has its own associated identity. (Ex: fisherman, oyster farmer)	CES	Identities	Occupation	-0.496
26	**My job provides a relatively high level of safety at work.***	CES	Experiences	Safety	-0.534
13	My work contributes to shoreline protection.	RSES	Reef Formation	Shoreline Protection	-0.541
29	My job helps reduce stress and/or provides a sense of relief and calm.	CES	Experiences	Therapy	-0.76
14	My job provides a sense of adventure or thrill.	CES	Experiences	Adventure	-0.828
6	My job produces a reliable product	CES	Experiences	Security and Reliability	-0.926
33	My job contributes to good or improved mental health.	CES	Capabilities	Mental Health	-0.936
24	My job provides a spiritual connection or experience.	CES	Experiences	Spiritualism	-0.975
28	**I produce a sustainable food item.***	PES	Food Production	Sustainable Product	-1.065
45	**I create a healthy source of protein for people to eat.***	PES	Food Production	Healthy Product	-1.202
46	**I produce a safe food item.***	C/PES	Experiences/ Food Production	Safety/Safe Product	-1.293
44	**I create a food product through my work.***	PES	Food Production	Food (General)	-1.461
43	**I produce a high quality food item.***	PES	Food Production	High Quality Product	-1.487
40	**I produce a local food item.***	PES	Food Production	Local Product	-1.495

#	Statement: Factor A Rankings	ES	ES Detail 1	ES Detail 2	Z-Score
2	My family members are/were involved in similar work.	CES	Identities	Family Heritage	-1.549
49	**I create a food product that people enjoy.***	C/PES	Experiences/ Food Production	Shared Experiences/Food (general)	-1.633
47	I produce shells that can be used for jewelry, decorative, or collector's purposes.	PES	Shell Production	Decorative and Hobby	-2.285

Table 20. Factor B

Statements are presented in order of composite rankings (by z-score) for factor B. Also listed are corresponding ecosystem service (ES) categories: cultural ecosystem services (CES; gray), provisioning ecosystem services (PES; light blue), and regulating/supporting services (RSES, dark blue). Statements that correspond to more than one ES category are indicated with a white ES fill. Distinguishing statements are identified in bold font and with an asterisk (*).

#	Statement: Factor B Rankings	ES	ES Detail 1	ES Detail 2	Z-Score
30	**My work contributes to improved water quality.***	RSES	Filter Feeding	Improved Water Quality	1.948
43	I produce a high quality food item.	PES	Food Production	High Quality Product	1.479
11	My work instills a sense of responsibility to take care of the environment, water, or worksite.	CES	Identities	Responsibility of Care - Environment	1.457
25	My job enables a relationship with or an awareness of nature.	CES	Experiences	Relationship with Nature	1.206
39	**My work has no negative environmental impact, or is environmentally positive.***	RSES	General	Environmentally Positive	1.187
18	**My work creates habitat for other species.***	RSES	Reef Formation	Supports other Species and Fisheries	1.159
49	I create a food product that people enjoy.	C/PES	Experiences/ Food Production	Shared Experiences/ Food (general)	1.151
31	**I feel a special connection or attachment to the location where I work.***	CES	Identities	Sense of Place	1.101
22	I am proud of the work that I do or the product I create.	CES	Experiences	Pride	1.066
21	The overall lifestyle associated with my work is appealing. (Ex: outdoors, on the water, hands-on.)	CES	Experiences	Lifestyle	1.003
28	**I produce a sustainable food item.***	PES	Food Production	Sustainable Product	0.864
48	My work enhances the populations of other (non-shellfish) species.	RSES	Reef Formation/ Spawning	Supports other Species and Fisheries	0.843
15	I enjoy the beautiful things I see at work. (Ex: sunrise/sunset, animals, etc.)	CES	Experiences	Aesthetic Appreciation	0.84
6	**My job produces a reliable product.***	CES	Experiences	Security and Reliability	0.621
46	I produce a safe food item.	C/PES	Experiences/ Food Production	Safety/ Safe Product	0.62
45	I create a healthy source of protein for people to eat.	PES	Food Production	Healthy Product	0.59
5	My work helps to ensure that future generations have the same opportunity to interact with the environment.	CES	Identities	Responsibility of Care - Environment	0.566
40	I produce a local food item.	PES	Food Production	Local Product	0.483
7	My work helps create or maintain jobs in my community.	CES	Identities	Contribution to Community	0.383

#	Statement: Factor B Rankings	ES	ES Detail 1	ES Detail 2	Z-Score
23	I enjoy hearing positive feedback or recognition from others because of my work.	CES	Experiences	Pride	0.344
8	**I am responsible for the care, growth, and/or success of an animal.***	CES	Identities	Responsibility of Care - Husbandry	0.262
35	My job lets me gain knowledge, apply prior knowledge, and/or teach others.	CES	Capabilities	Knowledge	0.235
32	My job has created or strengthened connections with other people (within or outside of the industry).	CES	Experiences	Shared Experiences/Social Capital	0.201
9	Because of my work, I am part of a larger community or industry with similar interests and goals.	CES	Identities	Sense of Belonging	0.185
12	**Through my work, I am contributing to a greater good.***	CES	Identities	Sense of Purpose	0.112
42	I help wild shellfish populations through my work.	RSES	Spawning	Contributes to Wild Shellfish Population	-0.016
34	**My job lets me gain new skills, apply prior skills, and/or teach skills to others.***	CES	Capabilities	Skills	-0.02
20	**My job allows me to be creative or innovative.***	CES	Experiences	Innovation	-0.128
36	My job enabled a positive change in my life.	CES	Experiences	Transformation	-0.136
16	**My job provides challenges that I must overcome or solve.***	CES	Experiences	Challenge	-0.21
33	My job contributes to good or improved mental health.	CES	Capabilities	Mental Health	-0.262
1	My job continues local traditions of work related to shellfish.	CES	Identities	Cultural Heritage	-0.287
17	**My job offers freedom and flexibility.***	CES	Experiences	Independence	-0.438
44	I create a food product through my work.	PES	Food Production	Food (General)	-0.455
41	My job is physically demanding and helps me stay in shape.	CES	Capabilities	Physical Health	-0.54
37	**There is variety in my daily activities and tasks at work.***	CES	Experiences	Variety	-0.592
29	My job helps reduce stress and/or provides a sense of relief and calm.	CES	Experiences	Therapy	-0.688
13	My work contributes to shoreline protection.	RSES	Reef Formation	Shoreline Protection	-0.741
3	**My job is unique.***	CES	Identities	Novel Occupation	-0.855
14	My job provides a sense of adventure or thrill.	CES	Experiences	Adventure	-0.887
24	My job provides a spiritual connection or experience.	CES	Experiences	Spiritualism	-0.974
4	My work has its own associated identity. (Ex: fisherman, oyster farmer)	CES	Identities	Occupation	-1.054
10	**This job is what I was meant to do.***	CES	Identities	Sense of Purpose	-1.107
19	**I have a good amount of control in my job.***	CES	Experiences	Independence	-1.164
27	**My job provides a stable income.***	CES	Experiences	Security and Reliability	-1.411

#	Statement: Factor B Rankings	ES	ES Detail 1	ES Detail 2	Z-Score
26	**My job provides a relatively high level of safety at work.***	CES	Experiences	Safety	-1.689
2	My family members are/were involved in similar work.	CES	Identities	Family Heritage	-1.722
38	**My job provides a better income than other jobs.***	CES	Capabilities	Income	-1.964
47	I produce shells that can be used for jewelry, decorative, or collector's purposes.	PES	Shell Production	Decorative and Hobby	-2.566

Table 21. Factor C

Statements are presented in order of composite rankings (by z-score) for factor C. Also listed are corresponding ecosystem service (ES) categories: cultural ecosystem services (CES; gray), provisioning ecosystem services (PES; light blue), and regulating/supporting services (RSES; dark blue). Statements that correspond to more than one ES category are indicated with a white ES fill. Distinguishing statements are identified in bold font and with an asterisk (*).

#	Statement: Factor C Rankings	ES	ES Detail 1	ES Detail 2	Z-Score
22	**I am proud of the work that I do or the product I create.***	CES	Experiences	Pride	1.8729
21	**The overall lifestyle associated with my work is appealing. (Ex: outdoors, on the water, hands-on.)***	CES	Experiences	Lifestyle	1.7328
17	My job offers freedom and flexibility.	CES	Experiences	Independence	1.7217
3	**My job is unique.***	CES	Identities	Novel Occupation	1.5491
10	**This job is what I was meant to do.***	CES	Identities	Sense of Purpose	1.431
19	I have a good amount of control in my job.	CES	Experiences	Independence	1.3833
49	I create a food product that people enjoy.	C/PES	Experiences/ Food Production	Shared Experiences/ Food (general)	1.0152
16	My job provides challenges that I must overcome or solve.	CES	Experiences	Challenge	0.9589
43	I produce a high quality food item.	PES	Food Production	High Quality Product	0.9134
20	My job allows me to be creative or innovative.	CES	Experiences	Innovation	0.9083
34	My job lets me gain new skills, apply prior skills, and/or teach skills to others.	CES	Capabilities	Skills	0.7304
4	**My work has its own associated identity. (Ex: fisherman, oyster farmer)***	CES	Identities	Occupation	0.7166
14	**My job provides a sense of adventure or thrill.***	CES	Experiences	Adventure	0.7149
46	I produce a safe food item.	C/PES	Experiences/ Food Production	Safety/ Safe Product	0.705
27	My job provides a stable income.	CES	Experiences	Security and Reliability	0.6713
7	My work helps create or maintain jobs in my community.	CES	Identities	Contribution to Community	0.4563
15	I enjoy the beautiful things I see at work. (Ex: sunrise/sunset, animals, etc.)	CES	Experiences	Aesthetic Appreciation	0.4313
37	There is variety in my daily activities and tasks at work.	CES	Experiences	Variety	0.4283
35	My job lets me gain knowledge, apply prior knowledge, and/or teach others.	CES	Capabilities	Knowledge	0.3622
44	I create a food product through my work.	PES	Food Production	Food (General)	0.3228

#	Statement: Factor C Rankings	ES	ES Detail 1	ES Detail 2	Z-Score
40	I produce a local food item.	PES	Food Production	Local Product	0.2702
28	**I produce a sustainable food item.***	PES	Food Production	Sustainable Product	0.218
23	I enjoy hearing positive feedback or recognition from others because of my work.	CES	Experiences	Pride	0.0764
36	My job enabled a positive change in my life.	CES	Experiences	Transformation	0.0497
2	**My family members are/were involved in similar work.***	CES	Identities	Family Heritage	0.0077
31	I feel a special connection or attachment to the location where I work.	CES	Identities	Sense of Place	-0.0507
39	My work has no negative environmental impact, or is environmentally positive.	RSES	General	Environmentally Positive	-0.1555
45	I create a healthy source of protein for people to eat.	PES	Food Production	Healthy Product	-0.1784
32	**My job has created or strengthened connections with other people (within or outside of the industry).***	CES	Experiences	Shared Experiences/Social Capital	-0.2163
11	**My work instills a sense of responsibility to take care of the environment, water, or worksite.***	CES	Identities	Responsibility of Care - Environment	-0.2182
1	My job continues local traditions of work related to shellfish.	CES	Identities	Cultural Heritage	-0.2312
38	My job provides a better income than other jobs.	CES	Capabilities	Income	-0.3634
9	Because of my work, I am part of a larger community or industry with similar interests and goals.	CES	Identities	Sense of Belonging	-0.4198
41	My job is physically demanding and helps me stay in shape.	CES	Capabilities	Physical Health	-0.5203
25	**My job enables a relationship with or an awareness of nature.***	CES	Experiences	Relationship with Nature	-0.6731
8	**I am responsible for the care, growth, and/or success of an animal.***	CES	Identities	Responsibility of Care - Husbandry	-0.6843
6	My job produces a reliable product.	CES	Experiences	Security and Reliability	-0.718
12	**Through my work, I am contributing to a greater good.***	CES	Identities	Sense of Purpose	-0.7717
48	**My work enhances the populations of other (non-shellfish) species.***	RSES	Reef Formation/ Spawning	Supports other Species and Fisheries	-0.809
30	**My work contributes to improved water quality.***	RSES	Filter Feeding	Improved Water Quality	-0.8594
42	**I help wild shellfish populations through my work.***	RSES	Spawning	Contributes to Wild Shellfish Population	-0.8825
5	**My work helps to ensure that future generations have the same opportunity to interact with the environment.***	CES	Identities	Responsibility of Care - Environment	-0.9705
33	My job contributes to good or improved mental health.	CES	Capabilities	Mental Health	-1.0333
18	**My work creates habitat for other species.***	RSES	Reef Formation	Supports other Species and Fisheries	-1.1064
26	My job provides a relatively high level of safety at work.	CES	Experiences	Safety	-1.1075

#	Statement: Factor C Rankings	ES	ES Detail 1	ES Detail 2	Z-Score
29	**My job helps reduce stress and/or provides a sense of relief and calm.***	CES	Experiences	Therapy	-1.622
24	My job provides a spiritual connection or experience.	CES	Experiences	Spiritualism	-1.639
13	**My work contributes to shoreline protection.***	RSES	Reef Formation	Shoreline Protection	-1.6681
47	I produce shells that can be used for jewelry, decorative, or collector's purposes.	PES	Shell Production	Decorative and Hobby	-2.7491

Participant Description within Factors

Participant attributes by factor are presented in this section with the intent to provide a qualitative understanding of participant characteristics in each group. The nature of Q methodology is to understand typologies or views shaping sorts primarily, and explore within factor groups for other attributes secondarily. Thus, statistical analyses were not run on these data, and in most cases such tests would not be statistically sound or theoretically practical. Instead, participant attributes were summarized to enhance understanding and examination of factors. Additionally, though individuals whose sorts did not load on a factor do not represent a group with a shared viewpoint, their characteristics are mentioned below as they relate to each attribute detailed.

In terms of participant role, differences were visibly apparent among the three factors (Figure 41). The majority of participants who sorted as industry support loaded on factor A, and the majority of sorts within factor A are from industry support. Factor B contained mostly shellfish growers, as did factor C, but factor B had more loaded sorts overall. Those whose sorts did not load on a factor included ten shellfish growers and one industry support.

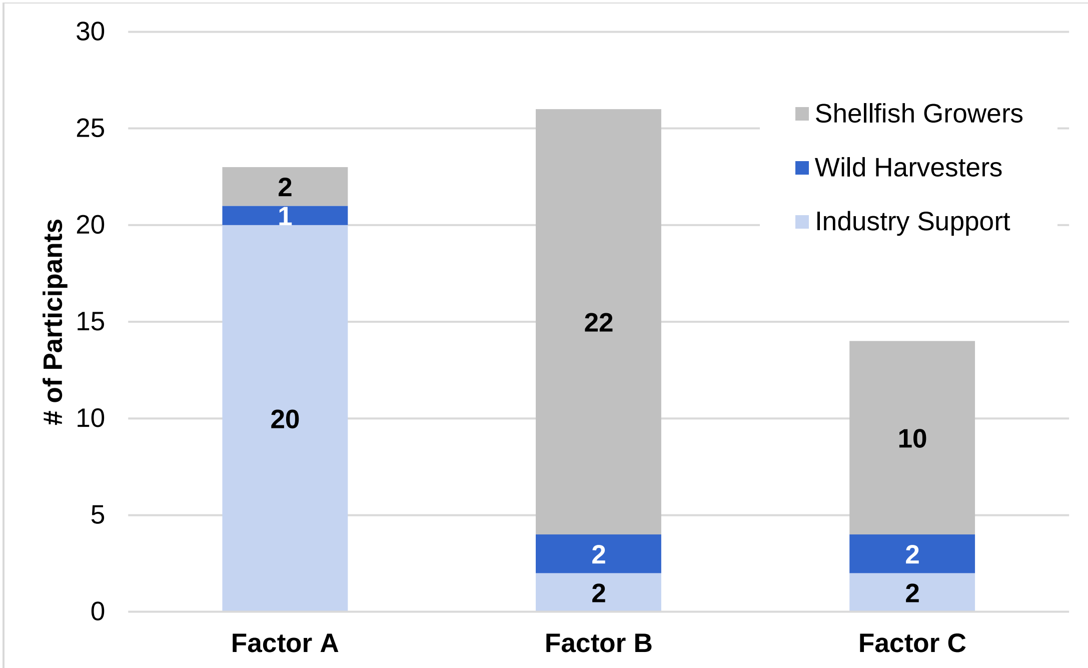


Figure 41. Participant Role within Each Factor

The number and type of participants (shellfish growers, wild harvesters, and industry support) represented in each factor are shown.

Regional representation was similar across all three factors. Each geographic region was represented in all three factors with exception for the southeast, which only had two participants overall (Figure 42). Those participants whose sorts did not load on any factor also included multiple regions, mirroring the other factors to a certain degree. One potential distinction, however, is that participants from New York did not load on any factor.

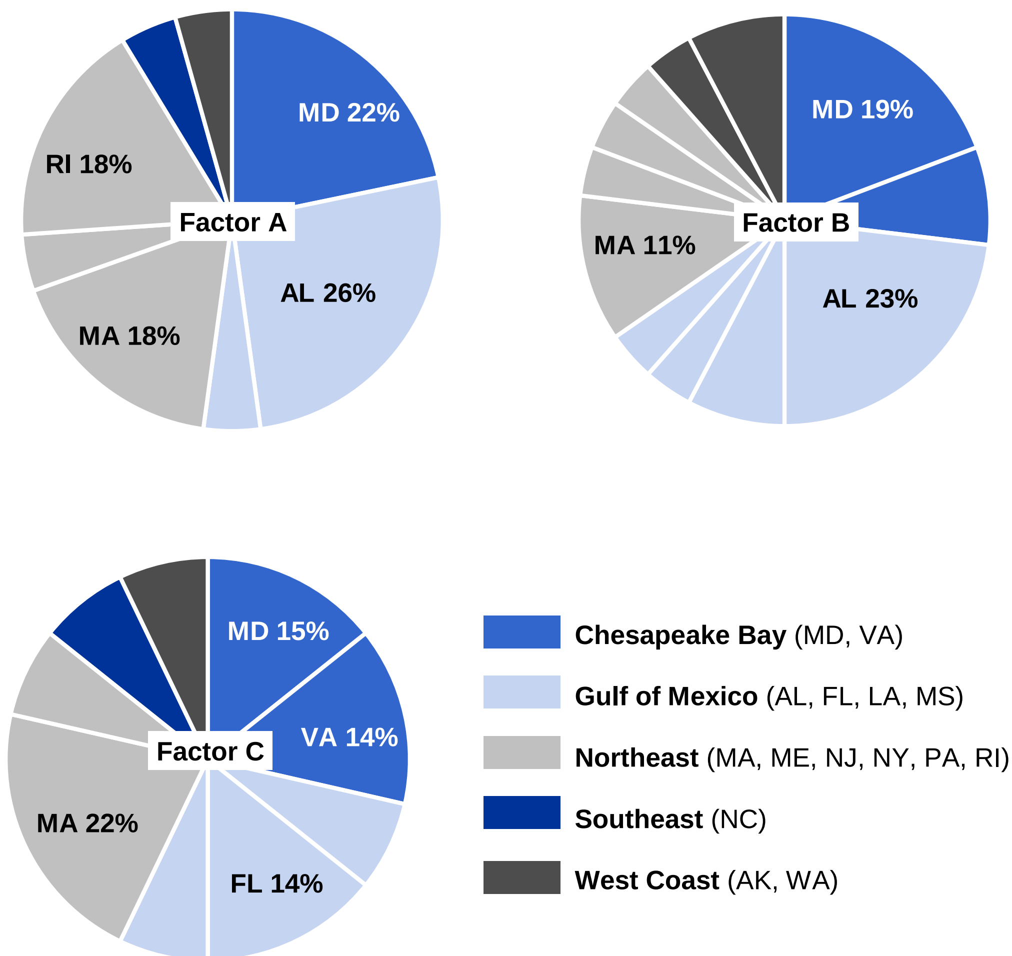


Figure 42. Geographic Participant Distribution by Factor

Participant regional representation is shown for factors A (N = 23), B (N = 26), and C (N = 14). States with greater representation within a factor are identified with state abbreviations and percentages. There were no participants from: VA, LA, MS, NJ, PA, and AK within factor A, NY and PA within factor B, and MS, ME, NJ, NY, RI, and AK within factor C. All other states are presented clockwise in alphabetical order by region.

No stark contrasts were apparent in participant age among factor groups, though factor A did contain a larger proportion of participants between the ages of 18 and 30, while factor C had a larger proportion of participants between the ages of 61 and 70 than other factors (Figure 43). Those whose sorts did not load on any factor represented all five age groups.

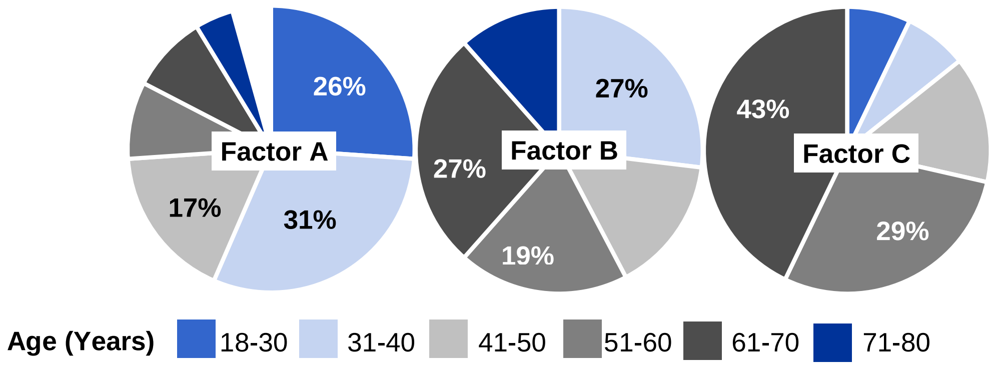


Figure 43. Participant Age Distribution by Factor

Participant age representation is shown for factors A (N = 23), B (N = 26), and C (N = 14). The white section within factor A represents participants who did not disclose their age. Percentages are shown for groups with greater representation within each factor.

Comparing gender representation among factors, factor A was unique in that it was over 50% female (Figure 44). Both other factors and those who did not load on a factor were majority male.

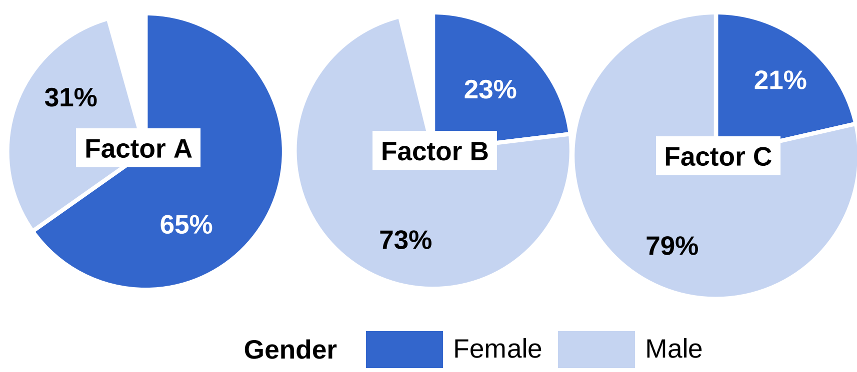


Figure 44. Participant Gender Distribution by Factor

Participant gender representation is shown for factors A (N = 23), B (N = 26), and C (N = 14). The white section within each factor represents participants who did not disclose their age.

For shellfish growers who sorted as growers, when examining length of time in the industry factor A stood out from the other two, however it represented only two growers (Figure 45). This distinction is more likely an effect of the number of growers who loaded on that factor than patterns related to time in the industry, as both sorts B and C also contained growers within the range of 6 to 10 years. In addition to those who sorted as growers, one participant in factor A and one in factor C were also involved in shellfish aquaculture. Those who did not load on a factor represented all time distributions, but had proportionally and actually a greater number of participants who had been in the industry for over 30 years than other groups.

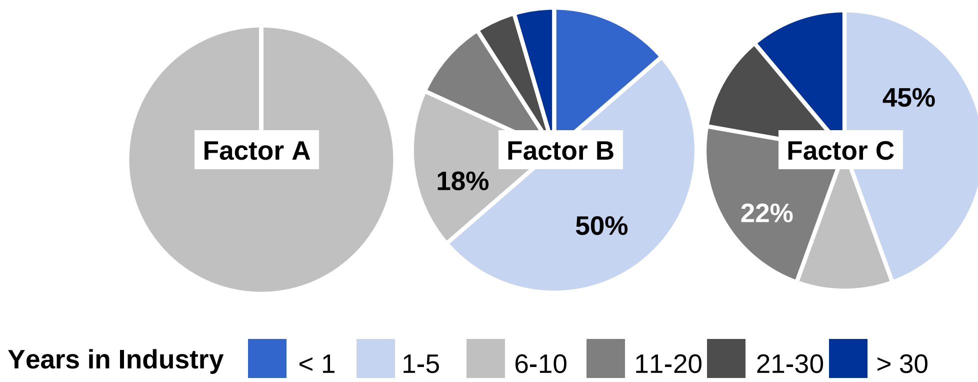


Figure 45. Shellfish Grower Time in Industry Distribution by Factor

Shellfish grower representation of time in industry (in years) is shown for factors A (N = 2), B (N = 22), and C (N = 10). Percentages are shown for groups with greater representation within each factor.

Variation in annual production by shellfish growers across factors was more likely an effect of participant sample numbers than viewpoint-related attributes, however the majority of those growing over 1 million animals were in factor C, and proportionally they are the most represented within that factor (Figure 46). Both participants who grow shellfish but sorted in another role grew between 100,000 and 500,000 animals per year (in factors A and C). Those who sorted as growers but did not load on any factor represented all five production categories.

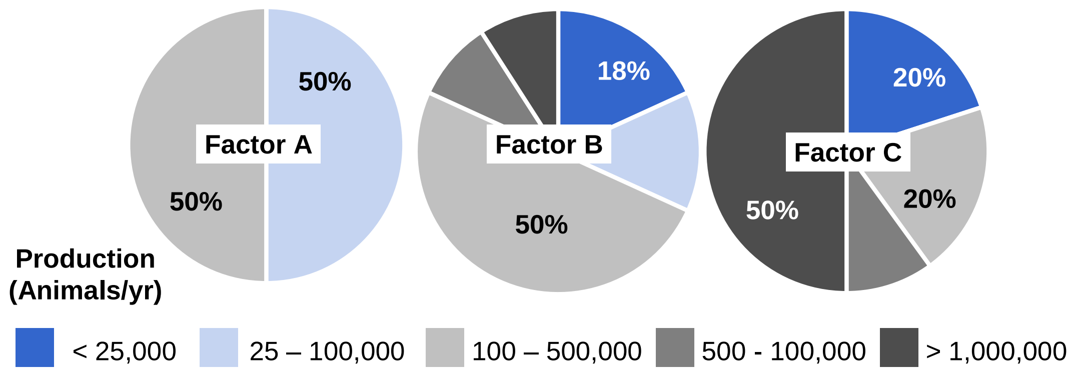


Figure 46. Shellfish Grower Annual Production by Factor

Shellfish grower representation of annual production (in animals per year) is shown for factors A (N = 2), B (N = 22), and C (N = 10). Percentages are shown for groups with greater representation within each factor.

Because of the small sample size, it is not practical to speak to any patterns regarding wild harvester time in industry or full-time status by factor. All who sorted as wild harvesters loaded on a factor, thus there were no wild harvesters in the group of 5 who did not load. For those participants who sorted as another role, but were also wild harvesters, three had spent 1 – 5 years in the industry (factors A, B, and C), one had spent 6 – 10 years (factor B), four had spent 11 – 20 years (factor A [N = 1], factor B [N = 3], and no-factor [1]), and eight had worked as wild harvesters for more than 30 years (factors B [N = 1], factor C [N = 5], and no factor [N = 2]). Again, it is not prudent to deduce patterns for full-time status because of sample size, but three who sorted were full-time and two were part-time. Wild harvesters who sorted as other roles included 11 full-time and 5 part-time; factor A contained two full-time wild harvesters who did not sort as wild harvesters and all others were distributed fairly evenly across the other two factors and the no factor group. Those wild harvesters who identified as full-time were likely wild harvesters in the past but have now transitioned into shellfish growing or industry support.

The exact representation of industry support roles was too integrated to cleanly present as figures, and 20 of 24 participants who sorted as industry support loaded on factor A. Industry support participants who loaded on factors B and C did not represent roles different from those also represented in factor A, nor did the individual industry support participant who did not load on any factor.

Statement Relevance

As mentioned above, the study approach meant that not all statements would necessarily be relevant to every participant. Participants were asked to indicate which statements were not relevant to their work. Summaries of overall non-relevance are detailed by factor (Table 22). Factor A participants had the highest average of non-relevant responses, with over 50% of participants identifying 13 statements as non-relevant; this higher proportion was associated with industry support and the single wild harvester in this group (Table 23). Overall, however, only one statement (47) was identified as non-relevant by over 50% of participants. Within factor A, all participants indicated at least 1 statement as non-relevant and 10 total statements were not identified as non-relevant by any participant. Within factor B, all but 1 participant had at least 1 non-relevant statement and 10 total statements were not identified as non-relevant by any participant. Finally, within factor C, all participants indicated at least 1 non relevant statement, but contrary to the other groups, 17 statements were not identified as non-relevant by any participant. Relative to those who loaded on factors, participants who did not load on factors did not identify any notably different non-relevance patterns. The number of statements identified as non-relevant among this non-group ranged from 1 to 14, with an average of 6.5 +/-4.38.

Table 22. Summary of Non-Relevant Statements by Factor

Summary statistics of non-relevant statements are given as the total number of non-relevant statements by factor and participant role within each factor.

	Participant Group	Total Non-Relevant Statements		
		Range	Mean	Std. Dev.
Factor A	Growers (N=2)	1 - 2	1.5	0.5
	Wild (N=1)	12	12	0
	Support (N=20)	2 - 27	14.75	7.48
	Overall (N=23)	**1 - 27**	**13.48**	**7.92**
Factor B	Growers (N=22)	0 - 28	8.545	5.75
	Wild (N=2)	1 - 3	2	1
	Support (N=2)	4 - 7	5.5	1.5
	Overall (N=26)	**0 - 28**	**7.81**	**5.63**
Factor C	Growers (N=10)	2 - 22	8	5.66
	Wild (N=2)	1 - 7	4	3
	Support (N=2)	5 - 14	9.5	4.5
	Overall (N=14)	**1 - 22**	**7.64**	**5.43**

Table 23. Proportion of Non-Relevance by Statement

The percentage of participants who identified each statement as non-relevant to their work are listed. Values over 50% are shown in red.

Statement	% of Participants who said Statement not Relevant			
	Factor A	Factor B	Factor C	Overall
1	39%	38%	0%	26%
2	61%	58%	43%	47%
3	13%	8%	0%	7%
4	26%	4%	0%	9%
5	4%	8%	14%	7%
6	52%	8%	21%	23%
7	22%	15%	14%	15%
8	26%	4%	7%	11%
9	0%	4%	14%	4%
10	30%	35%	36%	28%
11	4%	0%	0%	1%
12	0%	8%	14%	5%
13	52%	50%	50%	43%
14	30%	31%	21%	24%

Statement	% of Participants who said Statement not Relevant			
	Factor A	Factor B	Factor C	Overall
15	13%	4%	7%	7%
16	0%	0%	0%	0%
17	26%	8%	14%	14%
18	30%	0%	29%	15%
19	17%	12%	7%	11%
20	0%	8%	0%	3%
21	13%	4%	0%	5%
22	0%	0%	7%	1%
23	0%	19%	7%	8%
24	57%	35%	36%	36%
25	4%	4%	7%	4%
26	30%	50%	43%	35%
27	17%	50%	36%	30%
28	52%	0%	7%	18%
29	74%	31%	57%	45%
30	4%	0%	14%	4%
31	26%	4%	0%	9%
32	0%	0%	7%	1%
33	57%	35%	29%	35%
34	0%	4%	0%	1%
35	0%	4%	0%	1%
36	22%	12%	21%	15%
37	0%	12%	0%	4%
38	48%	81%	29%	49%
39	13%	4%	0%	5%
40	52%	4%	0%	18%
41	30%	12%	21%	18%
42	30%	35%	43%	30%
43	61%	0%	0%	19%
44	57%	0%	0%	18%
45	57%	4%	0%	19%
46	43%	4%	0%	15%
47	78%	65%	71%	61%
48	17%	12%	29%	15%
49	57%	0%	7%	19%
Total >50%	*13*	*6*	*3*	*1*

Frequency and Importance

Data from Chapter 4 were used to compare frequently mentioned benefits in Chapter 4 interviews to factor scores. The 15 most frequently cited benefits are listed with factor scores from this study (Table 24). Few frequently mentioned benefits were also high-ranking.

Table 24. Frequently Mentioned Benefits and Rankings

The 15 most frequently mentioned benefits in Chapter 4 interviews are listed in order of descending frequency with their corresponding Q factor scores. High-value benefit scores (>2) are shown in green while low-value benefit scores (<-2) are shown in red.

Benefit	Q Statements	Factor A	Factor B	Factor C
Social Capital	32	1	0	-1
Lifestyle	21	1	3	5
Independence	17	2	1	-5
	19	2	-4	-4
Knowledge	35	5	0	1
Security	27	2	-4	2
Contribution to Community	7	0	1	1
Environmentally Positive	39	1	4	0
Income	38	-1	5	-1
	27 CES	2	-4	2
Variety	37	2	-2	1
Food General	44	-4	-1	1
Sense of Place	31	-1	3	0
Family Heritage	2	-5	-5	0
Novel Occupation	3	0	-2	4
Challenge	16	6	-1	3
Aesthetic Appreciation	15	1	2	1

Discussion

Overall Representation

Overall, the Q survey captured data from a broad and diverse group. This included participants from 5 coastal regions and 15 states, with greater representation from states where initial interviews occurred. Relative to factors however, no regional patterns surfaced. Though participants did not reflect all marine shellfish-producing states, participant solicitation was successful in attracting a diversity of states whose rankings do not appear to be driven by state or region-related characteristics. This does not suggest that all shellfishing communities are created equal; instead, that geographic location is not the largest factor shaping individual viewpoints related to these benefits. The inclusion of data from additional states would help to affirm this idea, however, as noted, a well-designed Q survey should identify all viewpoints within the population if the population is represented in the sample, even at low numbers (van Exel & de Graaf, 2005). In this case, the population was US shellfisheries broadly and there was representation from a wide-ranging geographic sample. The data suggest that regional and state-level characteristics were not driving ranking patterns within this population.

Relative to industry role, the survey also captured a regionally expansive group of shellfish growers and industry support, though wild harvester distribution was more limited for those who completed the sort as wild harvesters. Again with the target population of US shellfisheries, focusing on participants working in three roles (shellfish growers, wild harvesters, and industry support) this sample size is not necessarily a problem. Delving deeper into participant attributes within the group of wild harvesters may be less reasonable, but framing their viewpoints within the context of a factor is not. Additionally, many wild harvesters took part in the study but sorted as other roles, adding another layer of consideration for how wild harvesters perceive these benefits.

Age and gender were also generally distributed across the overall participant group. The male majority is typical within fisheries, and in fact, females may be overrepresented in this sample if compared to fisheries overall (FAO, 2013; Posadas, 2018). Data were not available on gender specific to US shellfisheries, but in other areas both wild and farmed shellfisheries are typified by higher participation by women than in other types of fisheries (e.g., Bose et al., 2013; Frangoudes et al., 2008; Meltzoff, 1995; Siar, 1995; Szuster et al., 2008). As noted in the results, in terms of race and ethnicity, the sample was fairly homogenous. This may not reflect the industry overall, particularly in certain sectors and regions, but rendered these attributes to be unlikely drivers of factor patterns (e.g., Posadas, 2018).

Participants reflected the suite of bivalve shellfish being cultured commercially in the US; not represented were individuals growing mussels. The majority of shellfish-growing participants have been in the industry for less than 10 years, which replicates more recent development of aquaculture industries in several of the states more largely represented (see Chapter 4). Similarly, a broad range of production was captured with no sizeable patterns observed among factors.

Wild harvester participants represented numerous fisheries, both shellfish and finfish, and reflected East, West, and Gulf Coast catch. As noted, though only five sorted as wild harvesters, this is not a problematic sample size for Q methodology. Additional data, however, could be illustrative to see whether other wild harvesters distributed similarly across all three factors, in a 1:2:2 ratio as in these data, or if they loaded disproportionately on one factor. Examination of factor typologies suggests that perhaps the ratio would shift to more wild harvesters loading on factor 3, however this cannot be certain without additional surveys. Wild harvesters represented the full range of time in the industry, trending toward longer than shellfish grower participants. The majority of wild harvester participants were full-time wild harvesters and had worked in the industry for over 20 years.

The survey captured a diverse representation of industry support, spanning research, education, regulation, wholesale, infrastructure, and promotion. As expected, and the basis for categorizing with such a broad designation as ‘industry support’, there were too many roles to attempt to quantitatively compare representation for this participant group. This underscores the far reach that shellfisheries have in terms of livelihood benefits, well beyond those commercially harvesting and growing.

Though drastically increased participant numbers may have complicated analyses, there are several gaps in representation. Regionally, additional participants from the southeast would be beneficial in attempts to discuss regional patterns even if it is unlikely that regional attributes are driving factor groupings. Demographically, representation of more diversity in terms of race and ethnicity is needed to understand how values may differ according to ethnic background in this population (Cuni-Sanchez et al., 2016). As mentioned, additional sorts by wild harvesters as wild harvesters would be helpful in affirming possible trends in ranking.

Factor Consensus

As illustrated in Figure 40, three factor groupings revealed quantitatively and qualitatively different ranking patterns. While the factors had many distinguishing statements, which will be addressed within each factor description below, only three consensus statements were present:

1. My job continues local traditions of work related to shellfish.
7. My work helps create or maintain jobs in my community.
41. My job is physically demanding and helps me stay in shape.

The significance of consensus statements is not only their content, but also their placement. All three statements were ranked of moderate importance. Statement 1 places moderate value on the idea of continuing local traditions of work related to shellfish. This placement, ranked at -1 across all three factors, was interesting considering the participant role representation of each factor group. In other words, industry support (factor A) and shellfish growers (factors B and C) valued this benefit similarly even though they work with shellfish in different ways that specifically may not be the 'local tradition' of work. One might have thought that wild harvesters would place greater value on this statement, since in many locations, wild harvest is the traditional shellfishery. Examination into individual data showed that wild harvesters ranked statement 1 at: 0, 1, 2, 3, and 3. They did not rank this benefit as the most important, but their collective scores were slightly higher than the group average for each factor. Inspecting the responses of the sample population overall showed variability in ranking on this statement across the group. Separating rankings into low (-6 to -2), moderate (-1 to 1) and high (2 to 6) showed that 29 participants ranked this benefit as low-importance, 24 as moderate, and 21 as high. It is possible that the variability in response weakened any distinction on this statement.

Statement 7 focused on jobs in the community. It was also ranked moderately, but slightly higher than statement 1 by all groups (0, 1, and 1 for A, B, and C respectively). Its placement was interesting because, in Chapter 4 interviews, this benefit (contribution to community) was one of the more frequently mentioned benefits. It often tied to community heritage and shellfish-based local economies (Appendix 1). Though frequently mentioned, this benefit was not highly valued in the Q survey.

Statement 41 had a different emphasis, and its placement as a consensus statement may reflect its dual nature as both a service and disservice acquired through work. Participants discussed physical labor associated with work as a benefit in interviews, but as a benefit that potentially became a detriment, particularly for older participants who detailed the various ailments, injuries, and surgeries they endured because of their work.

They discussed how, over time, the physical labor can take a toll on one's body; this could underlie its ranking for all three groups.

In the sections that follow, individual factors are examined to create factor profiles or typologies for those participants who loaded on each. These include discussion of overall patterns related to ecosystem services (ES) and ES details, as well as consideration for distinguishing statements and relevance of statements to each participant group. Overall, statements were largely relevant to participants, even though not all participants were involved in their creation. Among the entire participant group, statement 47 was the only benefit identified as non-relevant by more than 50% of participants. This statement, focusing on shell production for decorative purposes, was also the lowest-valued benefit on all factor composite sorts. As is standard in Q methodology, every single ranking of every statement may not be noteworthy, but the typologies presented aimed to detail themes shaping each factor viewpoint.

Factor A: Improvers of Self, Society, and (Eco)System

Within factor A, though CES were placed across the grid, ranging from -5 to 6 in terms of relative importance, it was the placement of other ES types that highlights the value of CES in comparison (Figure 40). Regulating and supporting services (RSES) were all ranked moderately between -2 and 1, while provisioning services (PES) were ranked of little importance (-3 and lower). The two statements that represented dual ES categories, CES and PES, were also ranked of little importance, suggesting that these participants might have perceived statements 46 and 49 in terms of the food production and PES component rather than their CES connection.

High-Value Benefits

For the purposes of this discussion, rankings are grouped as high-value (top 15 statements), moderate-value (middle 19 statements), and low-value (bottom 15 statements). Statements are referred to by their initial survey number (Table 15) rather than ranked placement.

It is clear that CES were valued highly by individuals whose sorts loaded on factor A and inspecting the additional ES details with distinguishing statements can illuminate why, or what opinions might be driving these rankings. In total, 19 statements were identified as distinguishing for factor A (at $P < 0.0001$). Of these, 5 were ranked as high importance and were ranked higher for factor A than for factors B and C.

In factor A the 15 high-value benefits were CES, as were the top 3 moderate-value benefits. These high-value benefits contributed to experiences, identities, and capabilities. The highest four connected to personal development or self-improvement: gaining, applying, and sharing knowledge and skills (statements 16 and 35); facing and solving challenges (20); and opportunities for creativity and innovation (34). Within these, statements 34 and 35 were also distinguishing for this factor; both focused on capabilities enabled by work with shellfish. Ranked not far from these four, statement 23 was distinguishing and emphasized recognition or feedback, potentially because of one's knowledge, skills, and the ability to apply or transfer them. Paired with the first four benefits, this suggests that factor A participants valued their ability, through developed skills and knowledge, to accomplish their work and were proud of their successes.

Other high-value rankings revealed a combination of pride in the work (23 and 22) and how it contributed to environmental stewardship and a relationship with nature (11, 5, and 25), along with a sense of a common goal (9) or greater purpose (12).

Statements 12 and 9 were distinguishing for this factor; they contributed to identities in linked benefit categories: sense of purpose and sense of belonging. These benefits tied to being part of something bigger, in one sense, a larger cause, and in another, an abstract community working toward a cause. A related sense of purpose benefit, as the statement, “this job is what I was meant to do” (10) was ranked lower by factor A participants. They ranked two examples of responsibility of care for the environment (11 and 5) high, and showed that this particular form of environmental relationship as stewardship was important to them, possibly strengthening their overall relationship with nature (25) compared to other environmental benefits ranked lower. This ranking relationship to less valued RSES suggests that factor A participants potentially considered themselves contributing more to the large cause of environmental protection rather than directly involved in specific ecosystem functions, or they at least valued the former role more. This second theme of high-value rankings suggests that factor A participants valued their role in contributing to environmental improvement through their work, and also valued the fact that they were part of a larger community or network working to achieve this.

Toward the bottom of these high-value benefits were experiences that relate to workplace characteristics such as income security (27), daily variety (37), and independence or control in one’s job (17, 19). These benefits did not fit into the prior themes as easily, but variety of day to day activities could be related to knowledge and skills development also.

Low-Value Benefits

The lowest ranked benefits for factor A were dominated by statements related to food production (statements 28, 45, 46, 44, 43, 40, and 49), along with the other PES, shell production (47). All but 47 were distinguishing statements. Factor A was unique for having ranked them lower than any other factor group. Considering that many in industry support were not directly producing a food item, it is logical that these would be ranked lower. All of these statements, except 46, also had high incidence of non-relevance. Security and reliability (6), categorized as a CES, was also low-valued. This statement mentioned a reliable product and its wording, specifically the use of the word ‘product,’ likely contributed to its low ranking in this group. Factor A participants may have perceived it specifically as a food product rather than any type of output. More than 50% of participants indicated this statement as non-relevant.

Just above low-value PES were benefits related to stress relief (29), mental health (33), and spiritualism (24). Though spiritualism and mental health are not necessarily related benefits, all three of these statements reflect a way that work may be calming. Non-relevant results, discussed below, indicated that these statements were not necessarily low-valued, but instead not relevant to the majority of factor A participants.

The other two statements ranked low were 14, which emphasized thrill or adventure associated with work, and 2, which stated that family members do similar work. This experience and identity were not part of larger patterns and may simply reflect benefits that participants did not associate with their work, which was confirmed by relevance data for statement 2.

Moderate-Value Benefits

Moderately important benefits most notably included all RSES except one (13), ranked highest out of the bottom 15. Shoreline protection may have been ranked lower than other RSES because participants in Factor A, largely as industry support, may work to promote shellfisheries but not necessarily restoration, which is typically more associated with shoreline protection (though shellfish farms can provide similar benefits, as cited in Chapter 2). Statement 13 was also indicated as non-relevant by more than half of the group. Factor A participants appeared to place moderate value on RSES in general, and several of these statements were distinguishing for this factor. Distinguishing statements featured improved water quality (30) and habitat provision (19). In both cases, factor A participants valued them more than factor C, but less than B.

Moderately valued CES benefits for factor A represented a combination of experiences, identities, and capabilities. Within this group, themes were not as easily recognized, however one broad theme that connected seven statements was the value associated with place-based occupational identities and what they mean for a community. This was expressed as work-related identities (10, 3, and 4) that can form a large part of the character of a location or community (7 and 1), and because of this afford a certain way of life (21) and place-based connections (31). Within this theme, three statements were distinguishing. Factor A participants ranked sense of purpose (10) and novel occupation (3) higher than factor B but lower than factor C. Without understanding factors B and C, this distinction is not clear, but as will be detailed below, factor C participants placed high value on their occupational identity. Factor B, however, valued occupational identity and related benefits less, and did not share the feeling that they "were meant to do this" with factor C participants. The general lifestyle (21) associated with the job was ranked lower by factor A than other factors. The wording of this statement may have influenced this. In order to clarify that this did not mean a certain "way of life" financially, examples were provided based on participant interviews (e.g., outdoors, on the water, hands-on). Overall this theme was interesting for a group largely comprised of industry support, as it suggests that they valued how their work contributes to maintaining communities characterized by shellfisheries; even as a non-harvester or non-grower, they valued community and place-associated benefits.

Other moderately valued benefits include aesthetic appreciation (15), transformation (36), strengthened connections with people (32), responsibility of care in the form of husbandry (8), physical health (41), better income (38), and safety (26). These CES benefits were not as clearly linked. Safety at work (26) was distinguishing and ranked higher than other factors. Given that the majority of participants in factor A were industry support and may not spend as much time on or in the water as other participants, it is not surprising that they ranked this higher; their jobs possibly are safer or less risky than shellfish growers and wild harvesters. Connections to others within and outside of the industry (32) was also distinguishing and ranked higher than factor C.

Non-Relevance Summary

Participants in factor A indicated more non-relevant statements than any other factor group (mean 13.48 +/- 7.92). This was largely driven by industry support participants who dominated the group numbers-wise and identified an average of 14.75 +/- 7.48 statements as non-relevant. The one wild harvester in this group also identified a large number of statements as non-relevant (12), including nearly all food production benefits. It is possible this harvester is typically not fishing for human food directly, and instead catches for fish meal, bait, etc. Or perhaps the wording of statements did not resonate as expected with this participant. The two growers in this group identified very few statements as non-relevant (1 and 2). The maximum number of statements identified as non-relevant was 27, by someone in industry support.

Statements that more than 50% of participants in factor A identified as non-relevant represent 13 of the lowest 15 rankings, which means that for many participants in factor A, these benefits were not simply unimportant, they were not relevant. Two benefits in the bottom ranking that were not identified by more than 50% of people as non-relevant were numbers 46 and 14. Statement 46 related to a food product, but specifically a safe food item. This statement may not have been identified as non-relevant because a number of industry support participants noted that their work is connected to food safety, even if they are not selling food items directly. Statement 14 related to adventure or thrill, and this relevance may be dependent upon personal interpretation. In interviews, several industry support participants discussed thrills associated with their work, such as an exciting research finding, which might differ from adventure or risk associated with a wild fishery, for example.

Benefits ranked in positions 1 through 7 were relevant to 100% of those in factor A. This, paired with the higher frequency of non-relevance in low-ranking statements, suggests that participants took time to sort appropriately, placing non-relevant benefits in the lowest-ranking positions. This is important to note, as some participant sorts, particularly in this factor, were completed very quickly according to the overall survey time.

Participants

Factor A was comprised largely of industry support (N = 20 out of 23 total in A) and included most of the industry support participants in the survey. Thus, factor A's viewpoint appears to be strongly associated with industry support roles. Industry support roles were varied and included: research, hatchery and propagation, regulatory/enforcement, extension, non-profit, wholesale, industry association. Many participants were involved in more than one aspect of industry support.

Factor A represented all five regions, with greater participation from Maryland, Alabama, and Massachusetts, as in all factors. There were no obvious patterns in participant age within this group, however relative to other groups factor A participants were slightly younger, with more participants between 18 and 30 than other factors. The presence of graduate researchers in factor A contributed to this distinction. Factor A was also largely female, which is unique among the three factors and may reflect shifting gender demographics within common industry support roles (e.g., academia, research, and regulation, but particularly graduate research) relative to the industry itself (Arismendi et al., 2013). It is possible that age and gender-associated differences are driving rankings within this factor, however factor examination and comparison among factors suggest that industry role was the more likely influence. The proportional differences among factors by industry role were larger than by gender or age (Figures 34 and 35). Shellfish grower representation in factor A was minimal and thus no strong links can be deduced between years in industry or annual production and this factor, aside from emphasizing the low number of shellfish growers loading on factor A compared to other factors. This is also true of wild harvesters in this group; three participants had worked as a wild harvester at some point, but only one sorted as such.

Factor A: Improvers of Self, Society, and (Eco)System
Participants value personal development and self-improvement, evidenced through knowledge and skill acquisition, transfer, and application. They are proud of their successes, which have been made possible through their own capabilities but also because of their role as part of a larger network working toward common goals. One such goal is environmental improvement, and they value that they are able to contribute toward this goal through their work. Even though they may not be involved in the commercial production of shellfish, a secondary goal is to help maintain shellfishing communities. *Individuals working in areas that support shellfisheries (industry support) are likely to share this view.*

Factor B: Sustainable Providers

Participants within factor B placed higher value on both RSES and PES than factors A and C. With a wider spread, PES were ranked at -1 or greater, with exception again for statement 47 (ranked at -6). All RSES were ranked at -2 or higher, with the majority at 2 or higher. As with factor A, participants in factor B ranked dual category CES/PES benefits (46 and 49) similarly to PES benefits.

High-Value Benefits

Participants whose sorts loaded on factor B revealed three integrated high-value benefit themes. They included all types of ES, but can be framed as: 1) ways participant's work positively influences the local environment (Statements 30, 11, 39, 18, 28, and 48 in descending order), 2) closely related benefits tied to nature and participant interaction with nature (11, 25, 31, 21, 15), and 3) various aspects of producing a high-quality product, including associated pride (43, 49, 22, 28, 6, 46). RSES benefits related to water quality (30), environmental impact (39), and habitat (18) were distinguishing statements and were ranked higher than in factors A or C. As with all RSES, statements were worded to reflect the participant's role in generating these benefits through their work. Sense of place (31) was also a distinguishing statement that factor B participants ranked higher than participants in the other factors. Like factor A, factor B participants ranked pride in their work or product relatively high (22), but unlike A, they ranked a reliable product (6) higher; both statements 22 and 6 were distinguishing. In these high rankings it was seen that factor B participants valued the ability to produce a superior food product, while at the same time helping their local environment and enhancing their own outdoor experiences. It may be the interaction of these aspects of their work that brings most value or satisfaction.

Low-Value Benefits

The lower rankings of factor B were less cohesive. Toward the top of the lower tier were benefits that include physical health (41) and therapy or stress relief (29); they were not ranked far from mental health (33), which fell in to the middle group of rankings for this factor. Participants within factor B seemed to place low value on health-related benefits associated with their work.

Producing shells ranked lowest and was identified as largely non-relevant, but also near the bottom were income-related benefits (27 and 38). Factor B, composed mainly of shellfish growers, exemplified the initial, half-joking response from many interviewees when asked why they started to grow oysters – "It sure ain't the money." Statement 38, emphasizing a better income than other jobs, was distinguishing for this factor, but was also identified as non-relevant by more than 50% of participants. Based on interviews, many participants who grow shellfish left other careers to do so, and previous careers were not always wild harvest. In many cases, they experienced a pay cut in doing so, but other aspects of the work brought more job satisfaction. Closer examination of the age of growers in this factor paired with time in industry suggests that growing shellfish was not their first career. Likewise, a stable income (27) was distinguishing as it was ranked lower for factor B than C. This may also be driven by participants who have entered aquaculture from either another industry where the pay was more stable or they have acquired enough funds that instability in their shellfish farm was less of an obstacle. To summarize this theme, income-related benefits were least important for factor B participants.

There were several identity-related benefits within this lower ranking for factor B, including novel occupation (3), occupational identity in general (4), and sense of purpose via the statement “this is what I was meant to do” (10). Statements 3 and 10 were distinguishing in that they were ranked at such low importance relative to other factors (factor scores of -2 and -3). This suggests that for this group it was not about simply “being” a shellfish farmer. Somewhat similarly, family heritage-based identity (2) did not rank high within factor B, and was identified as non-relevant by more than 50% of participants.

Aspects of the work itself that ranked low for factor B include variety (37), independence discussed as control (19), and safety (26). Of these, only statement 26 was non-relevant to the majority of participants but all three were distinguishing. Factor B participants valued variety and control less than both other factors. Statement 26’s non-relevance may be another effect of factor B participants working in a different, relatively safer, position before entering the industry. Additional statements were low-ranked but do not fit easily into the observed themes. Shoreline protection (13) was ranked low and non-relevant. Adventure (14) and spiritualism (24) were also low-valued benefits in factor B.

Moderate-Value Benefits

Factor B's moderate rankings included one RSES, two PES, and all others were CES. Their arrangement inspired different interpretation for some of the benefits compared to factor A and C but yielded three themes of how these middle benefits might be perceived and valued. The PES statements emphasized food production overall (44), and that it was local (40), healthy (45), and participants received positive feedback on it (23, also CES). Thus, food production benefits were valued fairly high overall when paired with high-value benefits, but factor B participants may place more value on the sustainable aspect of their product.

A second grouping featured benefits valued highly by factor A. Factor B participants placed self-improvement and personal development at moderate value compared to other benefits, ranking knowledge (35), skills (34), ability to innovate (20), transformation (36), and challenge (16) in the middle. Distinguishing statements here included the benefits tied to skills (34), challenge (16), and innovation (20), which were ranked highly for factor A, but moderately for B. Statements 16 and 20 were also distinguishing in that they were ranked lower than factor C.

The last theme within factor B's moderate-value benefits included a combination that emphasized community in various ways. This included responsibility of care or the legacy of environment left to future generations (5), which can be considered as providing for the local community in one sense. It entails creating local jobs (7), continuing local traditions of work (1), strengthening social bonds (32), and becoming part of a larger community (9) all working toward a common goal or greater good (9 and

12). In this way, factor B participants valued their role in helping to sustain strong communities surrounding shellfisheries, but not as much as the higher value benefits. Within this theme, only the contribution to a greater good (12) was a distinguishing statement because of its low rank relative to factor A and high rank relative to C.

Also ranked moderately, but outside of these three themes, were responsibility of care associated with animal husbandry (8) and helping wild shellfish populations (42). These two benefits, though a CES and RSES, were related in that both involve a role in 'caring' for shellfish. Of these, only 8 was a distinguishing statement. Toward the lower end of moderately-valued benefits were mental health (33) and freedom or flexibility (17), which were similar to the low-valued benefits sorted just below them as other aspects of the work and overall health. Statement 17 was distinguishing for factor B because it was lower than both A and C.

Non-Relevance Summary

Those who loaded on factor B had overall higher statement relevance than factor A, but lower than C. The average number of non-relevant statements was 7.81 +/- 5.63. In this group, industry support had a narrower range than growers. One grower indicated that 28 statements were not relevant, more than any other participant in the project. Like the wild harvester in factor A, all PES were not relevant to this participant. Unlike the harvester, this participant was growing shellfish based on survey responses. Perhaps they grow only for restoration purposes, or perhaps this was one case where interpretation of the statements as non-relevant versus unimportant blurred.

The top-ranked statements for this group were largely relevant. The top 11 statements were deemed non-relevant by 0 or 4% of participants (often the 4% was the participant with 28 non-relevant statements). Only 6 statements were non-relevant to 50% or more participants.

Participants

Factor B participants were mostly growers and represented four of five regions. No participants from the southeast were in this group, but overall a small number of participants existed from the southeast. The Gulf Coast was slightly more represented, with Alabama driving this trend. Compared to factors A and C, more states were represented in this factor. This group was slightly older than Group A, with participants between 31 and 80 years old.

Twenty-two participants in factor B grew shellfish and all sorted as growers. Shellfish growers had been in the industry across the range of years, but the most commonly represented was 1-5 years, similar to factor C. Half of the growers in this group were growing 100,000 to 500,000 shellfish per year. All were growing oysters; some also grew clams and scallops. As with factor A, the small sample size made it difficult to draw any conclusions related to wild harvester time in industry. Both wild harvesters in this group were full-time. Of all participants in factor B, nine are or were wild harvesters, but only two sorted as such. Within factor B, six participants were involved in industry supportive roles, but only two sorted as industry support. Roles included: regulatory/enforcement, extension, research, wholesale, gear manufacture, liaison, and industry association.

Factor B: Sustainable Providers
Participants pride themselves in their ability to produce a superior food product and do so in a way that is helpful rather than harmful for the environment. At the same time, they value that they can enhance their own experiences with nature through their work. Their role in producing a food item is important broadly, but doing so sustainably is most important. *Shellfish growers who previously worked other jobs, particularly those outside of fisheries, are likely to share this view.*

Factor C: Shellfisherfolk

Participants who loaded on factor C ranked CES in general higher than other ES, but again what was more illustrative was the placement of other types of ES and the detail of the highly-ranked CES. In factor C, PES were ranked moderately, between 0 and 3 with exception of statement 47 at -6. Again, statements 46 and 49 (CES/PES) were ranked near PES. All RSES were distributed between -5 and 0, suggesting that this group places less value on RSES than other types of ES.

High-Value Benefits

Factor C's highest rankings reflected multiple interweaving themes. As highlighted by four distinguishing statements, this group valued their occupation for the identity it contributes to, in the sense of a general identity as a shellfish grower or wild harvester (4), the fact that it is a unique identity (3), and one that brings them pride (22) as well as the feeling that it is what they were meant to do (10). Features of the day-to-day of the job were also important to this group, including the overall lifestyle (21), associated independence (17 and 19), and the sense of adventure (14). That both statements related to independence and the statement related to adventure were cited here suggest that this category, though dominated by shellfish growers, was also shaped by those with wild harvester backgrounds. In interviews, both independence and adventure were mentioned by shellfish growers and wild harvesters, but were more frequently mentioned by wild harvesters. Adventure, in particular, was discussed as something former wild harvesters miss about their work in a wild fishery. Statement 14 was distinguishing as it was ranked higher for factor C than other factors. The collection of high-value benefits suggested that factor C participants, contrary to factor B, valued "being" a shellfish grower, wild harvester, or their role in industry support. There is something special about their occupation that was of particular value, and it is with this in mind that factor C was named.

Also highly ranked by this group were several of the 'self-development' benefits that were ranked highly by factor A. Challenge (16), innovation (20), and skills (34) were ranked high. Relative to factor A, this group placed higher value on the abilities to develop and apply skills to creatively problem-solve than self-development broadly. Another high-ranking item was food production, as a product people enjoy (49), which was both high quality (43), and safe (46). These benefits did not emphasize the green or sustainable side of their work, suggesting that environmental impacts associated with their work were not high-value, but not unimportant.

This group was the only group to highly rank an income benefit, and valued that income was stable (27). This may also be reflective of wild harvester connections. Though this group has more shellfish growers represented, many have worked in wild fisheries. In numerous interviews with wild harvesters now growing shellfish, although shellfish farmers can also have a bad season or year, many noted that it was a more stable income for them than wild harvest was, for a variety of reasons. This group had the most diversity in its high value benefits.

Low-Value Benefits

RSES benefits (13, 18, 42, 30, and 48) were distinguishing and ranked in the lowest section of the sort, except the benefit of one's work being generally environmentally positive (39), which was non-distinguishing and moderately ranked. As with factor A, factor C participants may have perceived the general environmental positivity or neutrality as valuable and specific RSES as less valuable, though largely still relevant. In addition, CES benefits associated with a relationship or caretaker role with the environment, wildlife, and nature were also distinguishingly low-ranked (25, 8, and 5). These low-ranking benefits suggest that factor C participants do not place environmental improvement or protection high in importance in terms of the benefits they receive. It should be emphasized, that they did not identify these benefits as non-relevant or unimportant, just less important than other benefits.

Factor C sorts also ranked several of the more abstract benefits, like sense of purpose associated with contributing to a greater good (12) and a spiritual experience (24) low. Statement 12 was distinguishing as it was ranked lower than factor B, but on its own was challenging to draw any value-patterns from. Mental health (33) and stress relief (29) were ranked low by factor C participants, but only stress relief (29) was distinguishing and also non-relevant to over 50% of participants. Strangely, 29 was ranked higher than 24 (spiritual connection), but only 36% of participants identified 24 as non-relevant. As with factor A, this combination of low-value benefits were linked in that they may all connect to emotional calm or ease.

Additional benefits that did not fit prior themes but were low ranked include producing a reliable product (6), high level of safety (26), and shell production (47). Shell production was non-relevant to over 50% of participants, while safety was close at 43%.

Moderate-Value Benefits

For participants in factor C, moderately-ranked statements represented an assortment of themes, with a few benefits tied to each theme rather than several broad themes. Food production ranked high within this category as PES, suggesting that they were not the most valued benefits, but still important. Moderately ranked food benefits included food in general (44), local product (40), sustainable product (28), and healthy product (45).

This group had several statements ranked of moderate importance that focused on location: contribution to community via jobs (7), aesthetic appreciation of the things seen at work (15), connection or attachment to the work site (31), sense of responsibility to take care of site (11), and local traditions of work (1). Only statement 11 in this group was distinguishing. These place-based benefits represent more than solely sense of place, and showcase the variety of benefits and opportunities afforded by working with shellfish in traditional fishing communities.

Two moderate-value statements emphasized self-development related to knowledge (35) and a positive change in life (36). Three statements connected to human relationships, specific and abstract: family members in similar work (2), strengthened connections (32), and being part of a larger community (9). Additional statements valued moderately include benefits tied to variety (37), pride (23), a better income (38), and physical health (41). Of these, statement 2 on family heritage was distinguishing. This is notable because this group ranked it higher than both factors A and B; even though it was not highly ranked, family connections to the industry may be more important to those in factor C than in other factors. Statement 32 on strengthened social bonds was also distinguishing and ranked lower than factor A.

Non-Relevance Summary

Participants who loaded on factor C had the fewest number of non-relevant statements (mean 7.64 +/- 5.43). By industry role, wild harvesters had the least, followed by growers, then industry support. High-ranking statements had lower incidence of non-relevance, though not as cleanly as factors A and C. Within the top 31 ranked statements, 17 had no participants identify them as non-relevant and 7 had only 1 participant.

Participants

A smaller number of participants loaded on to Factor C, but the majority were growers (N = 10), with two wild harvesters, and two industry support. Regionally, there were low numbers across all regions with no region overrepresented. There were no obvious patterns with age and more male respondents than female.

Within factor C, there were 11 shellfish growers total, though only 10 sorted as a grower. The majority grew oysters, and three also grew clams. Proportionally and relative to the other groups, this group had a large number of participants who were growing more than 1,000,000 animals per year. These large growers were growing oysters and clams; no attribute patterns existed among them, other than that they were all men between 44 and 61 years old. It possible that there was a connection between high production and this factor, but not possible to conclude given these data. There were nine wild harvesters in this group, but only two sorted as wild. This total was similar to factor B, however, proportionally there was more wild harvester experience in factor C, with all but one having worked as a current or former full-time wild harvester. Factor C had four total industry support participants, but only two sorted as such. Their roles included: liaison, research, wholesale, education.

Factor C: Shellfisherfolk
Participants place high value on their occupational identity and what it means to be a: shellfisherman, waterman, shellfish farmer, etc. The lifestyle, day-to-day activities, and all that the work requires represent something strongly associated with their community (sense of place) and personal identity. They value their role in providing a seafood product, and continuing this local way of life. *Shellfish growers who previously worked or continue to work in wild fisheries, and possibly wild harvesters, are likely to share this view.*

Taken together, the factor profiles provided illustrated three nuanced positions from which individuals with shellfish-based livelihoods engage with, perceive, and value ecosystem services and related benefits from their work. These value typologies appear to be influenced by the way that individuals are working with shellfish, as shellfish growers, wild harvesters, and industry support. In other words, individuals involved in similar shellfish-work perceive and value benefits of their work similarly, but variety in viewpoints still exists within roles demonstrating nuanced perceptions of benefits. Within the sample of shellfish growers, different viewpoints existed. In the case of the typologies detailed, factors B and C both were linked to shellfish growers, but may be distinguished by individual connections to wild harvest. Wild harvesters loaded on all three factors, with slightly more representation on factors B and C. This suggests that wild harvesters not only perceived the same types of benefits from their work as those in shellfish aquaculture, but also shared similar understandings of their value or importance.

Additional Considerations

In addition to the description of factor viewpoints as a means to understand the opinions shaping value patterns, several complementary comparisons were examined.

Below, further discussion is provided on wild harvester representation, frequency comparisons to Chapter 4, and the overall value of benefits.

Wild Harvesters and Additional Factor Outputs

Because there were fewer participants who sorted as wild harvesters, an additional examination of all factor outputs was conducted to inspect for the possibility that wild harvesters all loaded on the same factor in another output scenario. If present, that may have suggested that the three factor output did not adequately distinguish wild harvester viewpoints. With the research objectives in mind, it was especially important to understand and appropriately capture their perspectives. No other factor analysis captured all five wild harvester sorts loaded onto a single factor. In fact, the three-factor product analyzed in this chapter was the only one to include all five wild harvesters. As such, the presented output was the best depiction of wild harvester views in this survey.

Relationship Between Frequency and Value

Interview data detailed in Chapter 4 were not intended for rigorous quantitative analysis, but as presented, did provide a means to understand how often each benefit type was mentioned in interviews. Frequency data, however, did not correspond to value in this survey. Focusing on the 15 benefits most frequently mentioned in interviews, Table 24 details where each of these benefits ranked by factor groups. Only seven benefits were ranked of high-importance at a score of 3 or more, and even those were not highly valued across all factors. Five frequently mentioned benefits were ranked at the opposite value; six statements corresponding to these five benefits received rankings of -4 or lower. Similarly, focusing on benefits frequently mentioned in Chapter 4 photovoice interviews (21, 32, 25, 41), high-frequency did not appear to correlate to high-value. Though this was not an intricate analysis, it illustrated that frequently mentioned benefits were not necessarily the most important benefits.

Overall Value of Benefits

One objective of this project was to understand if certain types of shellfisheries-related benefits were valued more than others, overall. To answer this question, benefit rankings were compared among all three factors to identify if there was any consistency to ranking at least some benefits. This was done for high, moderate, and low-value rankings. In total, only nine statements were ranked in similar value categories across all three groups, and of these, only one was a high value statement (22). It would appear that the viewpoints shaping these factors did not agree on what benefits are most important, though pride in one's work was high for all groups. Four statements were moderately ranked by all three factor groups. This was true for low-value rankings also. In this situation the moderately-valued benefits were less telling without considering the suite of benefits they were ranked relative to, but common low-value benefits included: shoreline protection, spiritualism, therapy or relief, and the production of shells for decorative or hobby purposes. Thus, only a small number of benefits were consistent as low-value benefits across the sample population and even fewer were consistently recognized as high-value.

Summary of Findings

Results indicated that the benefits obtained through work with shellfish were not perceived or valued according to an industry-wide sense of importance. Very few benefits were valued overall similarly across participants. Instead, benefits were perceived and valued according to three different viewpoints, which, in addition to having unique value perspectives shaping them, were also strongly connected to industry roles. Data suggested that individuals working in industry support tended to think about benefits from their work similarly and rank their importance accordingly. They were represented best by factor A, “Improvers of Self, Society, and (Eco)System”. This group placed high-value on personal capabilities developed through their work, such as knowledge and skills, and how they could be applied innovatively to problem-solve. Also important for this group was the idea of being part of a larger community whose work shares a common goal.

It is reasonable to expect that those working in similar jobs might receive like benefits from their work and place comparable levels of importance on these benefits. Here, however, factor analysis revealed that within the same type of work – shellfish aquaculture – different perspectives and value-systems existed. Shellfish growers were represented by two factor groups. Factor B, the “Sustainable Providers,” placed high-value on the quality of food product they provided, and the fact that it was done in an environmentally-friendly manner. An enhanced relationship to the environment was also important to this group. Other shellfish growers were represented by factor C, “Shellfisherfolk”. For this group, identity was everything. Though they did not dismiss the environmental benefits, they placed greater value on the identity their work gave them, as shellfishermen or shellfish growers. This was tied into not only to what that identity translated to as their day-to-day activities and way of life, but also how it contributed to the character of their local community.

Between these two groups of largely shellfish growers, it seems that the “Sustainable Providers” were more likely to have entered aquaculture from a career outside of fisheries, while the “Shellfisherfolk” had more experience in wild harvest or wild capture fisheries. The number of participants who sorted as wild harvesters was low, but it is expected that wild harvesters would be more represented by factor C. Even so, the fact that the wild harvesters who sorted as such in this study were distributed across all three factors, paired with relatively low non-relevance metrics among shellfish growers and wild harvesters, suggests that wild harvesters and shellfish growers perceived similar benefits.

The finding that industry role appears to be the biggest attribute shaping these factor perspectives is a different outcome relative to a small number of similar studies. MacDonald et al. (2015) also utilized Q methodology to understand values related to fisheries. Their study featured values related to the experience of the ocean versus its utility, and results showed that rankings were not correlated by role in the seafood subsector (MacDonald et al., 2015). A different study that employed Q methodology to examine stakeholder perceptions of marine fish farming also showed that stakeholders from the same sector did not necessarily share the same perceptions (Bacher et al., 2013). Though these are only two examples, the results of this research when paired with these cases underscore the importance of conducting these types of studies rather than make assumptions on the values shaping stakeholder perspectives. Viewpoints can vary in potentially surprising ways and it is important to put forth the effort to solicit and understand these perspectives for more effective fisheries management as well as seafood industry promotion and support.

Conclusion

This study aimed to understand the benefits obtained through work with shellfish by targeting three broad themes as presented in the chapter introduction: 1) the overall benefits obtained through work with shellfish, 2) the perception of benefits according to industry role, and 3) the perception of benefits based on other industry attributes. Results showed that there were no industry-wide patterns to perceived importance of benefits, but different perspectives were present. Three viewpoints, strongly influenced by participant role in the shellfish industry, were identified and represented three different sets of values shaping the perception of benefits related to shellfish-based livelihoods. This study was the first to evaluate these types of services related to shellfish. Results from this study contribute theoretically and methodologically to ongoing discussions of ecosystem services, in addition to having fisheries management and shellfish aquaculture development applications.

Applied Implications

Even though smaller-scale participant attributes could not be rigorously analyzed in this study, results suggest that participant role within the industry was the strongest driver behind these different viewpoints. The results speak to how individuals in these groups, representing US shellfisheries as a whole, value different types of ecosystem services. With cultural ecosystem services (CES) spread across all rankings for all groups, it is evident that these benefits as a whole are not unimportant. In terms of relevance, CES-related statements were infrequently identified as non-relevant. These CES are benefits that participants largely recognized as part of their work, though they may experience and value them to varying degrees. Regulating and supporting services (RSES) were ranked differently by all three factor groups, suggesting that their value is most variable within the industry. This is important to recognize, particularly when considering the promotion of shellfish aquaculture development. The RSES provided by shellfish receive the most attention but may not be the most important benefit associated with shellfish for many people. Emphasizing other aspects, like the suite of CES, could be a more effective promotional tool, both to encourage new shellfish growers to enter the industry and to potentially change the opinions of stakeholders who are not supportive of aquaculture. Provisioning services (PES) were ranked moderate to high for those actually involved in providing a food product. This suggests that shellfish growers and harvesters value their participation in food systems and continuing to emphasize their critical role is also important.

With its emphasis on benefits, this study presents a useful dataset for shellfisheries marketing and promotional material at large, but the nuances associated with these different factor perspectives enable a more refined promotional opportunity as well. US aquaculture continues to expand, providing jobs in a wide range of roles as detailed here. These factor typologies might assist with targeted recruitment, if individuals can see themselves in a certain profile, for example. Different approaches to market the benefits enabled through work with shellfish may attract different shellfish growers. The data also show that there is opportunity for different personalities within the industry. In many of the earlier interviews, shellfish growers noted the jobs aquaculture provided but also spoke to challenges of finding reliable labor. It is possible that these factors, as employee profiles, might help to identify suitable employees for the work.

Beyond industry promotion, the results of this study have implications for wild and aquaculture fisheries management. Prior anthropological work emphasizes the importance of accounting for a variety of perspectives in resource management decisions. In a study cited in Chapter 4, Paolisso & Dery (2010) used cultural models to illustrate how implicit and shared understandings shape different viewpoints related to oyster restoration and their relevance to management. This built upon prior work that showcased how cultural models contributed to different forms of environmentalism among Chesapeake Bay stakeholders (Paolisso, 2006; Paolisso, 2007). The three factors presented in this study, similar to cultural models, illustrate viewpoints on shellfisheries that vary based on implicit understandings. Awareness of these different models or views by resource managers can contribute to more equitable fisheries management that better satisfies the needs of stakeholders. The consideration of value systems underlying these factors can help managers better predict possible social-ecological responses to management decisions and enhance more collaborative management opportunities.

Ecosystem Services Implications

This study speaks to two specific areas in need of further research that were introduced in Chapter 2. First, focusing on linked ecosystem services, if factors in this study were conceptualized as linked services, the data suggest that linked ecosystem services are even more complex. Participants, consciously or unconsciously, may view equally ranked benefits as related to one another, similarly to how the factors were described. With this understanding, the results here suggest that linkages also vary according to participant perspective. This observation on its own may be expected, but the variability and distinction between these three factors showcase how wide the perception of linkages can be.

This study also utilized pluralistic valuation, as called for in Chapter 2. Values discussed here are pluralistic from a stakeholder perspective as well as a disciplinary perspective. Grounded in the ecosystem services framework, this study implemented a mixed methods approach and drew from both natural and social sciences. Values represented were created by participants involved in various aspects of shellfisheries and the resulting factors illustrate the different value systems at work. The results, however, show that evaluating multiple values in this scenario did entail some obstacles. For example, many benefits were not relevant to participants who sorted as industry support. It may have been better for those participants to have a unique set of benefits to sort, based on their own interview data. Although this revised approach may have provided a richer understanding of industry support benefits and values, it would have not been as readily comparable to shellfish grower and wild harvester data. Thus outcomes must be carefully considered when deciding the most suitable approach. In this study, it was important that all participants were ranking the same set of benefits to allow for comparison across the group of participants.

Additional Recommendations

Through the online survey, a large participant sample for a Q project was obtained. This group represented a broad sample within the population of US shellfisheries, focusing on growers, harvesters, and industry support. It was lacking, however, in representation of certain states and much of the racial and ethnic diversity that exists within the industry, even if such diversification is limited to certain sectors. Looking within participant attributes, sample size also became too small to draw any conclusions relative to ranking patterns for most attributes. There are several recommendations to improve upon methods for future work, with regional or local efforts as one means to achieve better representation of additional participant groups.

First, this approach may provide richer detail at a smaller scale, regionally, or even locally. It was evident that participants who the researcher interviewed were more likely to complete the survey, and this even extended to new participants from those same states (indicated by industry support roles that were not identified in original interviews). Second, additional incentives to complete the survey could have enhanced participation. Participants had the opportunity to enter a lottery to randomly win one of multiple $50 gift cards (allotted using the remaining participant incentive funding from Chapter 4 interviews). Approximately 60% of participants entered; added incentives may not be a factor for all, but a guaranteed incentive could attract more participants. Finally, streamlining the survey tool for ease of use could have reduced withdrawals before the final sort. Many participants would have liked to complete the survey on their phone. As stated, even if the software worked on a smartphone, visualizing the sort on the small screen would have been a challenge. Still, the ability to do so might be a means to gain more representation.

As a final thought on this study, the data suggest that individuals working in wild and aquaculture shellfisheries perceive and receive similar benefits. As discussed throughout this dissertation, wild fisheries are associated with high levels of job satisfaction because of the associated sociocultural benefits. The assumption here is that due to the presence of similar benefits in shellfish aquaculture and wild fisheries, the two ways of working with shellfish yield similar job satisfaction. Continued work to investigate this relationship could provide an interesting extension of this project; a possible next step would be to evaluate whether the individuals represented by these three different viewpoints or perspectives perceive similar levels of job satisfaction.

Overall, this study represented a sizeable effort to evaluate ecosystem services and benefits associated with shellfisheries. Even with several areas identified for possible improvement, it helps to move cultural services discussions forward and provide a level of detail on wild and farmed shellfisheries that did not exist prior to the project.

Chapter 6: Conclusion

The expanding industry of shellfish aquaculture within the United States (US) provided an ideal topic with which to investigate and contribute to ongoing evaluation of the ecosystem services framework. This project emphasized the academically and politically underappreciated cultural ecosystem services. In doing so, it allowed for relevant consideration of ecosystem services application and how this academic undertaking was also useful for the communities in focus. With this in mind, this dissertation was developed to answer four guiding questions:

1. Are cultural ecosystem services important to individuals working with shellfish?
2. What are the cultural ecosystem services obtained through work in shellfish aquaculture?
3. Are some services and benefits more important or valuable than others, and what drives these perceived values?
4. Can shellfish aquaculture provide the same types of cultural ecosystem services as wild fisheries in similar systems?

Through a series of three studies, these questions were answered and provided the foundation necessary for continued research and extension. In the first study to investigate motivation to participate in oyster aquaculture (Chapter 3), results illustrated that among ecosystem services, cultural services were central to individual decision-making. The study provided data necessary to define the need to better understand the cultural ecosystem services associated with shellfish. It showed that this type of research was relevant not only because cultural ecosystem services data are lacking, but because cultural ecosystem services are important.

The next study (Chapter 4) was inspired by these findings and resulted in a comprehensive list of the cultural ecosystem services associated with shellfisheries. This study was conducted at a large, multiregional scale in order to thoroughly understand and detail the many benefits associated with shellfisheries-based work, particularly shellfish aquaculture. Results and comments from the subsequent Q sort survey (Chapter 5) suggested that this list was representative of benefits across the US shellfish aquaculture industry.

Chapter 4 showed that, overall, benefits received through work in shellfish aquaculture are comparable to the benefits received through work in wild fisheries, with a few exceptions. Most notably, the experience-related benefit of ‘adventure’ was more strongly associated with wild fisheries. This benefit may be more difficult to match within aquaculture, but wild harvester participants who transitioned into aquaculture found ways to adapt. Many former wild harvester participants indicated that they retained their commercial permits (where the fisheries persisted, this was not the case in all communities), as both a safety net for income and just in case they “got the itch” to go wild harvest or catch for a day.

The final study (Chapter 5) investigated further into cultural services and other ecosystem services enabled through work with shellfish in order to understand how individuals who work with shellfish perceive benefits from their work. Results suggested that few benefits were valued similarly across the industry at large, but three groupings emerged, presenting three different viewpoints and value systems that shaped how individuals perceived benefits from their work. The viewpoints were strongly associated with industry role and showed, most notably, how those involved in industry support valued work-related benefits differently from shellfish growers. Within the group of shellfish growers, however, two perspectives were present, with one potentially linked to backgrounds in wild harvest. Regional patterns did not influence benefit perception and ranking, but this does not mean that all shellfish communities are the same. This study was not intended to and does not claim that every shellfishing community is identical. Site characterizations affirmed that is not the case (Chapter 4). Instead, this study suggested that individuals received similar benefits from their work across US shellfisheries, with exception for those benefits related to food production for participants involved in industry support. The manner in which participants worked with shellfish, both at the time of the survey and in the past, was more influential to their benefit-related values than geography. Additionally, results from Chapter 5 indicated that the cultural ecosystem services detailed in Chapter 4 were more relevant to participants, regardless of industry role, than other types of ecosystem services.

Contributions to Ecosystem Services

This research contributed to advancement and refinement of ecosystem services conceptualization and application in several ways. First, this project provided another example of the elevated role that cultural services have as they are perceived relative to other services by many people (Chapter 3; Daniel et al., 2012; Gould et al., 2015; Milcu et al., 2013). Cultural services were shown to be more influential in livelihood-related decision-making than other services, even with a livelihood that is strongly associated with provisioning, regulating, and supporting service creation. In addition to emphasizing their importance, this research compared methods of eliciting cultural services. Semi-structured interviews allowed for a broader discussion of services, as a larger diversity of benefits were detailed in semi-structured interviews, but photovoice interviews were more engaging and appreciated by most participants who took part in both interview types. The combined interview approach was an effective means of both enhancing the participatory nature of cultural services research and achieving a holistic comprehension of cultural services.

Additional knowledge on the topic of linked services was generated through this project as shellfish-based livelihoods provided an ideal situation to better depict linkages. Many shellfish-based systems have been thoroughly studied with regard to regulating and supporting services (e.g., Alleway et al., 2018; Carranza et al., 2009; Castilla et al., 2007; Coen et al., 2007; Dumbauld et al., 2009; Gentry et al., 2019; Higgins et al., 2001; Humphries et al., 2016; Plew et al., 2005; Rose et al., 2014; Tallman & Forrester, 2007; Tang et al., 2011; van der Schaate et al., 2018). As such, knowledge of these systems may be *closer* to complete than other systems; it can never be truly complete with dynamic social-ecological systems. This heightened knowledge enabled better understanding of possible service connections and the data presented in Chapter 4 illustrated how intricately connected all of these services were (Also see Appendix 1). It points to the idea that it is largely impossible to conceive of ecosystem services in a clean, 'accounting' way, and attempts at valuation must consider how to appropriately address these links (Costanza et al., 2017). Chapter 5 took the idea of linkages one step further. If one assumes that factor typologies indicated connected services, then they also demonstrated that linkages were not consistent. The perception of linkages varied according to individual perspectives and value systems. From an anthropological standpoint, this is perhaps unsurprising. For the ecosystem services framework, however, it further complicates comprehensive classification of these linked services.

Chapter 5 also added support to the relevance of and need for pluralistic valuation (Diaz et al., 2015; Raymond et al., 2014; Small et al., 2017). The three factor typologies illustrated that participants in this setting value ecosystem services differently, at least as these services related to their work. This finding emphasized the utility of a pluralistic value approach, because ultimately ecosystem services as a concept are based on their connection to people. The incorporation and application of ecosystem services into decision-making, likewise, should be based on the values driven by people. These values are varied, even within a topic area as targeted as the benefits enabled through work with shellfish.

In Chapter 4, the idea that ecosystem service delivery may change with a transition from wild shellfisheries to shellfish aquaculture was explored. Results showed that the perception of whether this transition was associated with enhancement or diminishment of services was strongly dependent upon individual perspectives. For cultural services in particular, participants noted opposing perceptions of change. Thus, it is not a simple task to identify how cultural ecosystem service delivery is affected by a changing social-ecological system. Researchers must be explicit in framing from whose perspective these services are being affected.

As it relates to the overall structure and language of the ecosystem services framework, the methods were carried out to allow for flexibility rather than rigid structure. It was more important to consider the final outcomes and how best to achieve them, rather than be limited by a framework ill-equipped to account for the variability and context of this research setting (Costanza et al., 2017; Lélé et al., 2013). In this case, the MEA (2005) framework did not meet the needs of this project to detail cultural ecosystem services, but the conceptual framework by Fish et al. (2016) did. The Fish et al. (2016) adaptation was tailored to fit the benefits and services discussed by participants. Attempts were made to categorize all benefits similarly to previous literature and with categories that were applicable at broader scales, but some benefits may be unique to shellfish-based livelihoods. Using this approach, it is possible that the list of ecosystem services overall, not strictly with shellfish, will expand with continued research and not every service will be relevant to every ecosystem. Trying to create a framework that restricts services and benefits to only those relevant to all applications, however, would greatly limit the ability to characterize ecosystem services for any particular social-ecological system.

In response to those who have called for the removal of cultural services from the ecosystem services framework (Fisher et al., 2009), eliminating cultural services should then, in principle, result in complete disassembly of the framework. It is true that cultural services are different from other types of ecosystem services, and their perception is linked to the delivery of other services. The same can be said, however, of *all* other types of ecosystem services. Cultural services are as distinct as other types of ecosystem services, and their targeting for separation from the framework is more related to disciplinary walls rather than service definitions. Based on the experience with this dissertation research, each type of ecosystem service may be best approached and understood through individual sub-frameworks that allow for thoughtful consideration and understanding of services. The ecosystem services framework at large, then, can be thought of as the umbrella concept that allows for specialization and appropriate characterization of the four service types within it. Means of understanding ecosystem services and benefits should be relevant to the social-ecological system of study, and also relatable. Attempting to simplify framework language would be useful for broader conceptual understanding. Though 'cultural ecosystem services' and other categories are still a mouthful, the adapted frameworks used to present each type of ecosystem service and related benefits in this project were an attempt to clarify benefits and the processes that enable them.

Chapter 4 introduced a variety of approaches to understanding the sociocultural benefits obtained through work in fisheries. Though this dissertation employed a cultural ecosystem services approach, that does not mean is it the best or most appropriate means to address these types of benefits. Detailing sociocultural benefits as cultural ecosystem services, however, did allow for a more complete understanding of the suite of benefits connected to a social-ecological system and moves one step further to better integrate sociocultural benefits and values into resource management discussions that center on ecosystem services. As suggested by others, transitioning this 'ecosystem services' approach to a 'social-ecological services' approach would be a better means of understanding human-nature relationships and might also help to resolve some of the disciplinary divides that hinder recognition of cultural ecosystem services as ecosystem services (Reyers et al., 2013; Wainger et al., 2017).

Contribution to Industry and Management Applications

Through the generation of a list of benefits enabled through work with shellfish, this project provides material that can benefit shellfisheries, both wild and farmed. It illustrates the value of shellfisheries overall to people and communities, from the perspectives of those in the industry and those who support it through their work. Highlighting these overall benefits can contribute to greater social acceptance, potentially introducing those who might be unfamiliar with wild and farmed shellfisheries to their broader influence. Though it is certainly not a guarantee that oppositional minds will change, data generated through this project as rich details, engaging quotes, and photos created by participants might contribute to a better understanding of shellfisheries for the general public (e.g., ElShafie et al., 2018; Moezzi et al., 2017; Moloney & Unger, 2014).

Similarly, the methods utilized along with the data produced in this project can be used to facilitate consensus building in communities struggling with expanding shellfish aquaculture and use conflicts. In addition to sharing the visual outcomes of this project as photos accompanied by poignant quotes, additional research can supplement the data here and be used to mediate conflict. The perception of diminished and enhanced services associated with a shift from wild fisheries to aquaculture was variable depending on participant. This project included participants from shellfish aquaculture, wild fisheries, and shellfish industry support in all of its forms. It did not include, however, upland property owners, recreational fishers, or other groups who have voiced opposition to shellfish aquaculture in various communities. Extending this project to gain the perspective of those outside the industry could help to identify what opponents worry is at risk with aquaculture expansion, as well as identify what they see as potentially enhanced benefits. Ultimately, approaching these conversations appropriately can contribute to shellfish industry longevity and success.

Also on the theme of possible transitions from wild shellfisheries to aquaculture, results from this project showcased the extent that benefits provided by aquaculture are similar to a wild fishery. In areas where wild harvesters are considering entry into aquaculture, or where resource managers would like them to, prospective shellfish growers can have a more realistic expectation of the sociocultural implications of a livelihood transition into aquaculture. An interesting component of this project that could be expanded with continued research is to evaluate whether the different perspectives on benefits enabled through work in shellfisheries (Chapter 5) translate to different perceived levels of job satisfaction. Shellfish growers valued benefits in two very different ways, grouped as factors B and C; do different values shaping perception of benefits also yield different perceived levels of job satisfaction? This continuation of research within this project theme would also be illustrative and relevant to those considering aquaculture as a career.

Overall, the data from this project are useful for the integration of cultural services and social values into resource management and related decision-making. Failure to incorporate these concepts will result in an incomplete understanding of the role that wild and farmed shellfisheries play in a community and hinder resource management and community planning. Similarly, resource managers, community planners, and other leaders must determine whose social values shape management decisions. Integrating more perspectives, particularly from those working directly with the resource, can yield better management outcomes and a reduced gap between policy and people (Krause et al., 2015, 2019).

Final Summary

This project filled a noted absence in ecosystem services literature related to shellfish and contributed to greater understanding of cultural ecosystem services in general. As recently as 2019, Gentry et al. called for the identification of the social values connected to aquaculture and cited a deep knowledge gap. This research made a large step forward to address this need, but it is only the beginning. It provided much needed foundation for continued work emphasizing the sociocultural benefits and values surrounding shellfisheries.

Appendix

Appendix 1: Ecosystem Services Enabled Through Work with Shellfish

In this section, the ecosystem services mentioned in interviews with participants (as introduced and summarized in Chapter 4) are detailed. The majority of services discussed are classified as cultural ecosystem services (CES), defined here using cultural ecosystem benefits as: the contributions ecosystems make to human well-being in terms of the identities they help frame, the experiences they help enable, and the capabilities they help equip (Fish et al., 2016).

Additional services mentioned in interviews are also included. Whereas cultural services were broadly targeted during interviews and the resulting list is likely a fairly complete representation of the cultural services enabled through work with shellfish, other service types – provisioning (PES), regulating and supporting (RSES) – were not specifically targeted and those included here are not meant to represent an exhaustive list of these services. Instead, the provisioning, regulating, and supporting services detailed in this section represent those services that are important perceived benefits to participants interviewed in seven study states for this project. Each category is framed with an example quote from interviews with wild harvesters, commercial fishermen, shellfish growers, and others in roles supportive to shellfisheries. To preserve anonymity, quotes from participants whose role might make them identifiable, such as a state aquaculture extension specialist, aquaculture coordinator, research scientist, or gear manufacturer are linked to the general role of "shellfish industry support".

Each service or benefit is summarized and subsequently detailed based on participant discussions during interviews. Linked services are also included, but likely do not account for all potential linked services. The number of linkages, however, illustrates the complexity of tracking ecosystem services and how very few are perceived or received as standalone benefits.

Because this study focused on systems at various stages of potential transition into aquaculture, the effects of these changes are included here as enhanced or diminished benefits as they relate to such a transition. In other words, benefits are considered as they may change with transition from a wild shellfishery into shellfish aquaculture. As with benefits overall, enhanced and diminished benefits detailed include only those discussed by participants.

To illustrate the relative frequency of mention for each benefit, the number of participants who discussed each type of benefit are noted out of the total sample of 218 participants interviewed. With the exception of several categories infrequently mentioned (CES: mental health; PES: healthy product, shell production for decorative purposes and hobby; RSES: shoreline protection, spawning supports other species), benefits mentioned did not qualitatively vary by region. Nearly all benefits were discussed in all three study regions (Chesapeake Bay, Gulf of Mexico, and New England).

Finally, within each service or benefit category, the related Q sort statement from the administered survey (Chapter 5) is included. To reduce risk of participant burn-out, benefits were consolidated where possible. Thus, some benefits were targeted via shared Q sort statements. Other benefits were represented by multiple statements as relevant.

Cultural Ecosystem Services (CES)

Cultural ecosystem services presented below are organized according to three subcategories: 1) identities framed by work with shellfish, 2) experiences enabled by work with shellfish, and 3) capabilities equipped by work with shellfish.

Identities Framed by Work with Shellfish:

1. Contribution to Community

> *"The hatchery provides jobs and larvae. Farmers get seed and they get trained workers. That extends to wholesalers [and] the shops that farmers stop at on their way to work. There's a constant chain of jobs and increased labor opportunities.*
>
> *- Shellfish Hatchery Employee*

Summary. Identity is shaped by the ability to contribute to local jobs and market chains through work with shellfish. This includes: providing stable, accessible employment; helping to maintain working waterfronts; reducing the need for out-migration.

Discussion. Participants indicated that their work with shellfish contributes to the local community in terms of job provision and economic input, and this helped to frame a component of their identity. Both for wild and farmed shellfisheries, participants contribute to local economic growth in ways that help to maintain working waterfront communities and their associated community identities. As such, "contribution to community" was linked to sense of place and cultural heritage for many participants. Participants recognized their contribution to economic growth through the associated businesses that benefit from shellfisheries – gear manufacturers, boat repair, hatcheries, etc. Through their work, they saw themselves in a role where they were helping not only their local community but also the industry overall. In addition, the tendency of shellfisheries to involve small businesses rather than large corporations was cited as a related benefit.

It was important to participants that they were not only contributing to economic growth via market supply chains, but were doing so in a way that allowed for stability, local employment options, and continued work on the water or in the seafood industry. Jobs in both wild and farmed shellfisheries were valued because of their accessibility; specific backgrounds and skill levels were not essential to entry. Several participants also acknowledged their role in assisting others with entry into both types of shellfishery (wild and farmed).

Enhanced or Diminished Benefits. Participants described this benefit as both enhanced and diminished considering a transition from wild fisheries into aquaculture. Both types of shellfishery were claimed to provide more jobs throughout the community than the other. Similarly, different participants saw both fisheries as more accessible forms of employment than the other – wild fisheries for potentially lower upfront costs, aquaculture because it was easier to learn for those with no experience on the water.

Linked Services. CES: cultural heritage, sense of place, security and reliability, social capital.

Frequency of Mention. 96 participants.

Related Q Sort Statement. My work helps create or maintain jobs in my community.

2. Cultural Heritage

> *"I love the cultural heritage of commercial fisheries. They are huge part of the Chesapeake Bay. I've lived within a block of a creek or river my whole life. I would miss that part if it were gone. But we, as aquaculture people, are developing our own heritage. Massachusetts and Rhode Island are ahead of us, but we've been going here in Virginia 20 years. It's going to be a different kind of cultural heritage but… for example in France, they probably don't even remember a wild oyster fishery. I would like to see a public oyster fishery, but it's more and more difficult to sustain."*
>
> *- Shellfish Farmer*

Summary. Identity is shaped by local or regional tradition of working the water (fisheries). Work with shellfish allows for continued presence of working waterfronts and contributes to local identity and community pride.

Discussion. Participants described how local heritage and shellfisheries were intertwined, contributing to place and occupation-based identities. Many discussed how wild shellfisheries were just "what you do here" and how fisheries contributed to community identity. Wild harvesters recognized their role in helping to maintain local cultural heritage through work in a shellfishery.

Participants involved in shellfish aquaculture shared identities shaped by this contribution to local cultural heritage. In some cases, communities had long-standing histories of aquaculture, as well as wild fisheries, and the line between the two was blurred – they were simply shellfisheries. In other communities, wild shellfisheries were in decline or restricted, and participants saw their involvement in the developing aquaculture industry as a way to continue this identity founded in local shellfisheries.

Likewise, some participants discussed how aquaculture might contribute to a new cultural heritage, one where the community is shaped by its farmed shellfish industry.

Enhanced or Diminished Benefits. Participants in several regions shared concerns that large-scale industrial expansion of shellfish aquaculture may negatively affect cultural heritage. In these cases, participants emphasized that absence of a wild fishery could change cultural heritage in an unwelcome way, even with aquaculture in its place. Similarly, some participants voiced concern that a transition from small to large-scale aquaculture could diminish associated cultural heritage. An active wild fishery, on the other hand, was associated by some with preserving a tradition and way of life.

Other participants, particularly in locations where the wild shellfishery was effectively non-existent, indicated that aquaculture could complement or enhance cultural heritage. They saw aquaculture as helping to continue a tradition of working the water that was no longer possible or reliable with the wild fishery.

Linked Services. CES: contribution to community, lifestyle, occupation, pride, sense of place; PES: food (general).

Frequency of Mention. 50 participants.

Related Q Sort Statement. My job continues local traditions of work related to shellfish.

3. Family Heritage

> *"I'm doing what we've done for 5 to 6 generations. Working on the water, being outside, and making a living. I don't know what else you could [adapt]. [Aquaculture's] not exactly what we've done. But it's the same place."*
>
> *- Shellfish Farmer, Former Net-Fisherman*

Summary. Family identity and traditions are shaped and strengthened through work with shellfish.

Discussion. Participants discussed how their work with shellfish allows them to connect to family members who are or were active in commercial fisheries. They continue a generational livelihood or have entered the shellfish industry with the hope that it becomes a livelihood tradition for their own children.

In some cases, participants emphasized connection to family locations or sites, integrating sense of place into this perceived benefit. Additionally, some participants felt that their work with shellfish connected them to past family activities, traditions, or events. Existing family connections were strengthened through work with shellfish, allowing family members to work together, to be closer to home, and to be present for more family activities. For some, connections were felt in a more spiritual way, connecting individuals to their ancestors.

Enhanced or Diminished Benefits. For several participants who viewed aquaculture as drastically different from wild fisheries, a family heritage identity may be perceived as weakened by a transition into aquaculture. Others noted that they were continuing the work of their predecessors, but in a method that could be unrecognizable to their grandfathers, etc. For this latter subset of participants, aquaculture did not diminish this identity, but perhaps altered it. Participants also shared a third view of this benefit, suggesting that aquaculture enhanced family heritage as it provided a business or career that they felt more comfortable passing down to their children, relative to a less predictable wild fishery.

Linked Services. CES: cultural heritage, occupation, sense of place, social capital, spiritualism.

Frequency of Mention. 67 participants.

Related Q Sort Statement. My family members also are/were involved in similar work.

4. Novel Occupation

"We're also bringing a product to market that Mississippi chefs can have. Who else is doing that? This is the first opportunity to do that. We're breaking new ground. We're pioneers. I never would have thought that."

- Shellfish Farmer

Summary. Beyond an occupational identity, the uniqueness or newness of the job (and/or industry) involves many benefits that contribute to an identity described as: interesting, exciting, mysterious, etc.

Discussion. Participants discussed how the novelty, uniqueness, or newness of their occupation contributes to a variety of benefits, many stemming from social interactions and relationships with other people. Work with shellfisheries is a different way to make a living, which leads to interest from others as well as a perceived celebrity status for some when asked about their work. Some participants noted that their children were more interested in this work than other jobs they (participants) had in the past.

The job is also unique in that it forces many connections related to shellfish: wild fisheries, aquaculture, restoration, science, etc. Because of this, participants are part of a network of people that not all jobs would enable and they emphasized this distinctive characteristic. Likewise, work in shellfisheries is novel because of its integration of entrepreneurship, outdoor activity, environmental benefits, and food production.

For participants working in areas where shellfish aquaculture is a more recent industry, they cited the excitement associated with being “pioneers” on the “frontier” of a new industry. This was complemented by opportunity for innovation and growth. For many, their job is unique in terms of numbers as well – the industry is not large relative to other fields, which affords some notoriety or novelty when one says they are part of it. Participants also discussed how they do for work what most people do for fun. For both wild and farmed shellfisheries, there is a noted romanticism or mystique, and participants differed in their opinions of which type of fishery held greater claim to that aspect.

Where aquaculture had a slight advantage in terms of benefits discussed within this category was through name recognition and farmer stories connected to their shellfish product. Aquaculture may entail slightly more ability to connect an individual or a story to a product, and many participants active in aquaculture discussed this benefit.

Enhanced or Diminished Benefits. Though novelty was cited as a benefit, novelty and newness of industry may correlate with increased development challenges. This was discussed as it relates to conflict over lease area as well as food safety concerns. In addition, several participants noted that the novelty-associated draw of the aquaculture industry perhaps created an initial boom of many industry entrants, with fewer who persisted beyond a few years. Some participants shared concern that the "romantic" allure of the business could result in flooded markets and struggles related to sales. Even so, this benefit was more frequently associated with aquaculture rather than wild harvest, and as such can be considered enhanced with aquaculture.

Linked Services. CES: challenge, innovation, occupation, sense of belonging, sense of place, shared experiences, social capital; PES: local product, safe product.

Frequency of Mention. 66 participants.

Related Q Sort Statement. My job is unique.

5. Occupation

> *"There's no way I could put a dollar value on the amount of friends and people I've met from one end of the bay to another. It's like one big family - watermen. Sometimes we bicker, but we all stick together."*
>
> *- Wild Harvester/Commercial Fisherman*

Summary. Identity is associated with type of work or livelihood activity. This identity is not necessarily connected to a family/cultural tradition, but is an important means of self-identification.

Discussion. From the general sense of working on the water or being part of the seafood industry, participants linked their identities to their occupation overall. In some cases, this occupational identity was also part of their family or cultural heritage. It also connected to sense of belonging as this identity incorporated those working with shellfish into part of a much larger community.

For those participants transitioning from wild harvest into aquaculture, many recognized that their occupation was shifting somewhat, but still maintained an identity of working on the water. It was also a way to apply previously acquired knowledge and skills on the water to a new method or technique of working it.

Enhanced or Diminished Benefits. Some participants discussed people involved in wild fisheries as being one of the last of a certain group, with concern that the wild fisheries and fishermen would disappear. This occupational identity may thus be diminished by the transition into aquaculture. As with cultural heritage, however, other participants offered aquaculture as an opportunity to continue an occupational identity working the water, in a slightly different way.

Linked Services. CES: cultural heritage, family heritage, knowledge, sense of belonging, sense of place, skills; PES: food production.

Frequency of Mention. 52 participants.

Related Q Sort Statement. My work has its own associated identity. (Ex: fisherman, oyster farmer).

6. Responsibility of Care – Environment

> *"Leave it better than you found it. Whether my kids decide to do it or not, knowing what I did with my father…the thought that they might not have that option tears me up. Any man should have that option."*
>
> *- Shellfish Farmer*

Summary. Work with shellfish contributes to an identity based on an active role in and the desire to positively affect the water or environment so that future generations may have the same opportunity to experience it. This identity is linked to a general feeling of responsibility to be a good steward of the environment.

Discussion. Participants discussed this form of identity as it related to environmental stewardship or bequest in several ways. They discussed a sense of responsibility to their farm site, their body of water, or the environment in general, that has been strengthened because of their work with shellfish. Some specifically emphasized their practices of returning oyster shell (from harvested animals) to the water as a way to make the fishery more sustainable.

Many participants discussed not only how they passed on lessons in environmental responsibility to their children, but that part of the motivation for their work was so that their children could experience this environment in a similar way. Several saw that as their mission or legacy.

Enhanced or Diminished Benefits. Many participants perceived this benefit as enhanced with work in aquaculture. They noted that caring for their site or farm inspired larger obligations to promote environmental protection in other aspects of their lives.

Linked Services. RSES: all; CES: family heritage, relationship with nature, sense of place.

Frequency of Mention. 23 participants.

Related Q Sort Statements. My work helps to ensure that future generations have the same opportunity to interact with the environment. My work instills a sense of responsibility to take care of the environment, water, or worksite.

7. Responsibility of Care – Husbandry

> *"I think that's the most fun part for me about this job - it's a challenge and I look forward to coming in every morning and being able to see the differences between the previous day and the next day. To see if those larvae have progressed a little bit more. It takes usually about two and half weeks to get through that larvae stage, so anything that I can be doing to help them get to that stage… and there's a lot of different variables that go into growing these guys. Some variables we control and some variables we can't control. But, that's kind of the job and that's what I like most about it."*
>
> *- Shellfish Hatchery Employee*

Summary. Identity is shaped by a perceived responsibility for the care, growth, and success of another animal (in this case, oysters, clams, or other bivalves). Inherent to this identity is the knowledge and ability to understand another animal's needs in order to identify best cultivation practices.

Discussion. Discussion of this identity as a caretaker was more common from participants involved in shellfish aquaculture. Many cited the reward and benefit associated with the responsibility of care involved in raising an oyster or clam from larvae, in some cases, all the way to market size. A noted sense of accomplishment was obtained through successful rearing of their shellfish, and many were proud of the resulting product.

Participants also took pride in their husbandry role, facilitating and assisting with cultivation, understanding a species and its needs, and being able to problem solve accordingly if growth or survival was hindered. Many enjoyed the experience of seeing their product grow and observing its metamorphoses as well as more general changes. Some felt that they were more than mere observers and had a key role in the grow-out process. Often, participants discussed this identity as similar to a parent-child relationship with their shellfish.

Enhanced or Diminished Benefits. Typically, this identity was not associated with wild harvest and thus was enhanced with aquaculture. Shellfish growers were involved in cultivating a product and caring for that animal, in some cases from spawn to market.

Linked Services. CES: challenge, knowledge, pride, shared experiences, skills; PES: food (general).

Frequency of Mention. 62 participants.

Related Q Sort Statement. I am responsible for the care, growth, and/or success of an animal.

8. Sense of Belonging

> *"It's the people connected with shellfish that I enjoy. Here's your focal point – [the oyster]. It's like any food item that people are passionate about. Our common currency is that we all speak oyster. [Our organization] could have been anywhere. And there are people on diametrically opposite sides, but everybody is here because of oysters. I get so jazzed on the people. No matter how they're involved. It connects people. We all think about how we can do the most good for oysters. It [creates] the opportunity to move forward."*
>
> *- Shellfish Industry Support*

Summary. Identity is shaped by being part of a larger, potentially abstract, community with similar interests and goals.

Discussion. In some cases, participants discussed an identity based on belonging in a way similar to occupational identity, but it was more than simply "being" a fisherman or oyster farmer. Occupational identity was linked to a sense of belonging, but many participants discussed how their work made them feel like they were part of a much larger community, which extended beyond basic occupation. They belonged to a larger entity with a shared interest – shellfish, or the success of shellfisheries. A sense of belonging was enhanced through shared goals, passions, and the associated camaraderie or altruism. Many described this group as similar to a family.

Enhanced or Diminished Benefits. In some cases, where the perceived line between farmed and wild shellfisheries was more distinct, wild harvesters discussed what may be the opposite of a sense of belonging. Most notably in Maryland and Cedar Key (FL), wild oyster harvesters shared concerns that shellfish aquaculture was being promoted and given attention over wild fisheries. This perception contributed to feelings of exclusion rather than belonging as farmed shellfisheries continue to grow.

Some participants suggested instead that aquaculture enhanced sense of belonging. They perceived the shellfish aquaculture industry as more unified that wild shellfisheries and appreciated that their work made them part of that group.

Linked Services. CES: novel occupation, occupation, sense of purpose, shared experiences, social capital; PES: food production (general), high quality food, local food.

Frequency of Mention. 50 participants.

Related Q Sort Statement. Because of my work, I am part of a larger community or industry with similar interests and goals.

9. Sense of Place

> *"If shellfish aquaculture had not come to Cedar Key with the net ban, it would be a pseudo-quaint fishing village, filled with condos. Shellfish aquaculture allowed it to remain a fishing, working waterfront community…Cedar Key is unique. The wild fishery is another sector of the community that makes it what it is. It's part of the community. If it's not there, does it matter? Yes."*
>
> *- Shellfish Industry Support*

Summary. Identity is shaped by strong connection to location based on familiarity, history, and/or emotion. In this case, connections are created because of shellfisheries.

Discussion. Participants discussed how their identity was influenced by sense of place at multiple scales, ranging from the region (e.g., Chesapeake Bay) to the specific one-acre plot that their shellfish farm occupies. Many participants emphasized their familiarity with a site, its challenges, and its nuances, and how that translated to a perceived connection or relationship with the area based on enhanced knowledge of the location. Some cited a sense of communal or individual ownership over an area; as an example, one participant referred to the bay where he worked as "[his] playground".

Many participants held high regard for the place in which they worked with shellfish, and this translated to a sense of responsibility of care both for its environmental condition as well as maintaining the character that contributed to its sense of place. For some, their family history or "roots" were connected to a particular place. This in turn yielded emotional connections and related identities. Sense of place was enhanced through shellfish-related festivals, events, and activities that serve to promote local cultural heritage and emphasize unique local character based on shellfish livelihoods as well as place-based identities.

Several participants discussed ways that oyster and clam fisheries contribute to sense of place. Through place-name association of shellfish products, sense of place is strengthened. This is an output of both wild and farmed shellfisheries, even if shellfish farmers are more likely to put forth effort toward product name and brand recognition.

Enhanced or Diminished Benefits. Participants discussed subtleties between a shared resource or commons (as with a wild shellfishery) and a private or leased area (as with aquaculture). It is possible that participants in each type of fishery experience slightly different identities related to sense of place. This does not necessarily suggest diminished or enhanced services, but instead different constructions of place-based identities. Those in aquaculture appreciate having their farm, lease, or site to return to each day. Wild harvesters did not detail exactly what the distinction was, but suggested they have a different relationship with and perception of the water than what a shellfish grower might have.

Linked Services. CES: aesthetic appreciation, challenge, cultural heritage, family heritage, knowledge, pride, relationship with nature, responsibility of care – environment; PES: local food product.

Frequency of Mention. 69 participants.

Related Q Sort Statement. I feel a special connection or attachment to the location where I work.

10. Sense of Purpose

> *"I know this sounds crazy, but I was meant to do the job. My grandfather was a waterman. I grew up around him. Working the water was something I always wanted to do. In school they told you that 'you can't do that'. I was determined to make it work. I saw it as a challenge."*
>
> *- Wild Harvester*

Summary. Work with shellfish shapes an identity that is based on the sense that you are part of something larger than yourself and/or contributing to a greater good because of your involvement.

Discussion. For some participants, sense of purpose was gained through a perception that working with shellfish – or fisheries in general – was simply what you were meant to do, for sometimes inexplicable reasons. In some cases, this identity tied to a sense of belonging, sense of place, as well as family and cultural heritage.

For other participants, their work with shellfish fulfilled a role that enabled them to "give back" or work toward a common goal. For some, this identity feature was recognized at the individual level, for others it made them part of a movement or larger community. The job contributed to a feeling of giving back to the environment or industry and allowed people to feel satisfied that they were doing something meaningful through their work.

Enhanced or Diminished Benefits. Participants did not specifically state that features connected to sense of purpose were enhanced or diminished with aquaculture. The dual conceptions of purpose associated with this benefit, however, were each strongly linked to one type of fishery. Wild harvesters were much more likely to describe their job as what they were meant to do. Shellfish growers were more likely to acknowledge their desire to “give back” as part of their work.

Linked Services. CES: challenge, cultural heritage, family heritage, sense of belonging, sense of place; RSES: environmentally positive.

Frequency of Mention. 32 participants.

Related Q Sort Statements. 1) This job is what I was meant to do. 2) Through my work, I am contributing to a greater good.

Experiences Enabled Through Work with Shellfish:

1. Adventure

> *“That’s what I miss [about wild harvest] – the agony of defeat, the sweetness of victory. Some days you make $500-600, some days nothing.”*
>
> *- Shellfish Farmer*

Summary. Work with shellfish provides a sense of thrill, adventure, and/or risk-taking.

Discussion. Often, participants described the “thrill of the hunt” obtained through their work, particularly in wild fisheries. They detailed the sweetness of victory associated with a good day or big haul and its counterpoint, the agony of defeat that comes with a bad day or low harvest. Inherent to these extremes was the risk or excitement associated with the unpredictability of what the day may bring. Some participants in wild fisheries described the related thrill as something of an addiction.

Linked to this sense of adventure was the pride and recognition associated with out-fishing or out-harvesting someone.

This exact type of thrill does not exist for aquaculture, but multiple participants who transitioned to aquaculture from wild fisheries discussed the challenges and problem-solving associated with their new work in aquaculture as providing a similar, albeit different, sensation.

Enhanced or Diminished Benefits. There is likely a diminished "thrill of the hunt" with aquaculture, however this is typically linked to an enhanced experience of security and reliability. One participant described his time in wild fisheries as "always hunting and gathering" compared to his current work in aquaculture, where he is "always gathering".

Linked Services. CES: challenge, income, pride, security and reliability (-), skills, variety.

Frequency of Mention. 26 participants.

Related Q Sort Statement. My job provides a sense of adventure or thrill.

2. Aesthetic Appreciation

> *"The overall peace and the beauty. I still, even after all these years, am thankful we get to work in this beautiful setting. It's a privilege that we get to use state waters to do this."*
>
> *- Shellfish Farmer*

Summary. Work enables the opportunity to enjoy viewing nature/weather/wildlife/scenery.

Discussion. Participants talked about the many aesthetically pleasing experiences that were a regular part of their work. Most often these involved discussions of sunrise, sunset, and moonrise as well as the overall beautiful setting in which they work. A number of participants shared an appreciation for witnessing seasonal and weather pattern changes as well as weather events. Some described this as observing the power of Mother Nature. A smaller number of participants voiced aesthetic appreciation for the animals they produce.

Enhanced or Diminished Benefits. For both aquaculture and wild fisheries, poorly tended gear could lead to diminished aesthetic appreciation (for both those in the industry and outside of it). In areas where floating aquaculture gear is not seen favorably, participants noted that a wild fishery may provide others (outside of the industry) with a clearer viewshed.

Linked Services. CES: lifestyle, novel occupation; relationship with nature.

Frequency of Mention. 66 participants.

Related Q Sort Statement. I enjoy the beautiful things I see at work. (Ex: sunrise/sunset, animals, etc.)

3. Challenge

> *"I like when no one thinks you can get a load of clams because it's blowing with a Nor'easter and I come in with a load of clams. I love going out on a morning tide when no one thinks you can go. When it's impossible and you do it anyway. "*
>
> *- Wild Harvester*

Summary. Work provides an array of challenges and/or continues to be challenging and stimulating. This may include novel, site-specific, or unpredictable problems. Satisfaction is found in responding to and conquering challenges.

Discussion. Participants discussed the pleasure and satisfaction gained through being faced with a diversity of challenges and having the ability to solve them. This included the fact that they were regularly confronted with unpredictable and dynamic problems, having the ability to apply previous knowledge and skills in order to solve them, as well as the opportunity to think of creative solutions. Challenges could be mechanical issues, cultivation and care issues, or industry-level problems. The idea that each site or business experienced its own unique challenges, but continued to share knowledge on the chance it could be helpful, was also discussed as a benefit. The enhanced unpredictability and suite of difficulties associated with working outside were regularly mentioned related to daily and seasonal challenges.

In addition, both wild harvesters and shellfish farmers commented that at certain points they had been told by others, for various reasons, that they (the participants) cannot or would not be able to accomplish their goals related to shellfish work. Participants used this challenge for motivation to succeed.

Enhanced or Diminished Benefits. Some participants described how farmed shellfishery-associated challenges might be too prohibitive and inhibit the possibility of a sustainable, lasting aquaculture business for some. This often related to the initial financial input and delayed reward associated with aquaculture relative to a wild fishery.

Another view was that aquaculture is not as challenging or stimulating as trying to succeed in a wild fishery. In this way, aquaculture does not provide the level of challenge desired. Some shellfish growers disagreed, contending that with aquaculture, they are continuously challenged as they try to make their business bigger and better.

Linked Services. CES: adventure, innovation, knowledge, novel occupation, skills, shared experiences, social capital, variety.

Frequency of Mention. 66 participants.

Related Q Sort Statement. My job provides challenges that I must overcome or solve.

4. Independence

> *"The best thing I guess is the freedom. I have the ability to work at my own pace. I can do what I want to do – it's not like I'm dedicated to a 9 to 5. I work when I want to work. Sure, if I don't go out, I don't make money. [But ultimately, I'm in control]."*
>
> *- Wild Harvester*

Summary. This type of work offers a sense of personal control over one's own schedule, effort, practices, etc., that is not available at every job. This enables individuals to experience a sense of independence, freedom, or flexibility because they have a relatively high degree of control.

Discussion. Participants discussed perceived independence through their work in multiple ways. Often being self-employed was first mentioned, along with its associated benefit of not having a boss over your shoulder. Participants appreciated that they did not have to rely on someone else for a job. These discussions were similar for both wild and farmed shellfisheries and represent one of the more commonly cited benefits overall.

Self-employment in turn afforded more personal control over gear choices, harvest and cultivation practices, general effort, and scheduling.

Flexibility related to schedule was frequently mentioned, with slight differences based on the type of fishery. For example, aquaculture enabled some former offshore fishermen to return home at night, which they viewed as a benefit. This benefit was paired, however, with a need to regularly tend their new shellfish crop, which could be perceived as restricted independence. Others cited aquaculture-associated flexibility because, although the work must be done, they could arrange work schedules around other activities.

Independence associated with wild fisheries was perceived as greater than with aquaculture for some because of the ability to travel to different sites, or to switch target catch when desired. In aquaculture however, participants felt they may have slightly more control over their product and the price they can get for it, which translated to another form of independence.

Enhanced or Diminished Benefits. Wild harvesters noted perceived diminished independence in aquaculture relative to a wild fishery whereas aquaculturists differed, citing greater freedom via control of their own destiny. Some wild harvesters also involved in aquaculture noted greater independence in terms of the aquaculture regulatory environment, suggesting that states were more supportive of aquaculture relative to wild harvest.

Linked Services. CES: adventure, income, innovation, lifestyle, safety.

Frequency of Mention. 102 participants.

Related Q Sort Statements. 1) My job offers freedom and flexibility. 2) I have a good amount of control in my job.

5. Innovation

> *"It's exciting to try and figure this out. I wouldn't mind if it already existed. But I'm energized by the challenges of making a better oyster. I'm dreaming of a system that doesn't exist. "*
>
> *- Shellfish Farmer*

Summary. Work provides the opportunity to regularly create/design/innovate better ways of doing things or solutions in response to challenges.

Discussion. Participants discussed innovation both as an opportunity and a requirement of their work. In some cases, the newness of the industry (as with aquaculture) was linked to an open landscape of opportunity to develop new practices, marketing strategies, and other aspects of the industry. In wild shellfisheries, work still provided chances to streamline practices or improve efficiency.

Participants mentioned different approaches to harvest as well as cultivation that they were able to create or refine. Many participants mentioned invention as a necessity of their work, particularly because each site provides unique challenges and there is no one-size-fits-all solution.

Participants also emphasized the role of knowledge exchange with other harvesters and farmers, and how this contributed to ongoing innovation within the industry. For participants transitioning from other types of employment, work in aquaculture, or shellfisheries more generally, helped them to utilize creative skills that may or may not have been part of their previous work.

Enhanced or Diminished Benefits. This benefit was not regularly cited as varying between wild and aquaculture shellfisheries, with exception for one participant who appreciated the artistry involved in crafting a farmed oyster. He did not believe that wild fisheries allowed for that same experience.

Linked Services. CES: challenges, independence, knowledge, novel occupation, skills, pride, shared experiences, social capital.

Frequency of Mention. 55 participants.

Related Q Sort Statement. My job allows me to be creative or innovative.

6. Job Satisfaction

> *"Job satisfaction. You gotta love it. If you don't love this job, you will grow to hate it. For those of us who love being outside and working hard, it's the best job in the world."*
>
> *- Shellfish Farmer*

Summary. The job contributes to a general feeling of satisfaction and fulfillment. Typically, this experience is shaped or influenced by other services.

Discussion. Participants shared feelings of job satisfaction, often directly stating high levels of job satisfaction and fulfillment. Overall, all cultural services contribute to job satisfaction, however examples coded under this category include mentions of less specific benefits such as descriptions of work as: fun, enjoyable, cool, gratifying, satisfying, and rewarding. Often these characteristics were discussed relative to other jobs, suggesting that shellfisheries provide greater levels of each quality. The nature of the work itself was mentioned routinely as it relates to job satisfaction and included features such as being: project-oriented, hands-on, outdoors.

Enhanced or Diminished Benefits. Some participants felt that wild fisheries might provide higher levels of job satisfaction, largely connected to feelings of accomplishment after a large haul. Those not involved in wild harvest, however, also noted high levels of satisfaction.

Linked Services. All CES.

Frequency of Mention. 55 participants.

Related Q Sort Statement. All statements contribute to job satisfaction.

7. Lifestyle

> *"I get paid to go out on a boat. I get paid to go swim in the ocean. It's fun. It's a fun job to have. I couldn't think of a better way to make a living."*
>
> *- Shellfish Farmer*

Summary. Job provides a welcome associated lifestyle in terms of practices and environment (rather than income-related lifestyle). For example, work is: on the water, outdoors, laid back, manual labor.

Discussion. The lifestyle associated with work was mentioned in a number of ways. Examples within this category do not represent an income-based type of lifestyle (i.e., the ways that a participant is able to live and purchase because of their work in shellfish), but instead were coded to indicate aspects of the work that are simply part of the job. Nearly all participants valued the ability to be outdoors and on the water, rather than in an office environment at a desk. Some discussed the pleasure they received from working the tides and having their day dependent on natural cycles.

Certain aspects of the work connected to its flexibility were discussed, including scheduling, dress code, and the ability to recreationally fish while at work. Participants joked that their work is like some folks' vacations or weekend activities. Others valued the physical nature of the work. Work in shellfisheries is hard, dirty, and involves manual labor; while participants noted that it was not for everyone, they appreciated that aspect of the job.

Enhanced or Diminished Benefits. Some participants saw the requirements associated with containerized aquaculture gear as different from traditional water work, and thought that there were fewer lifestyle-related benefits with aquaculture. For example, containerized gear may need to be handled more frequently or consistently, which limits perceived flexibility of scheduling.

Others noted that work in aquaculture was less physically demanding and involved shorter days than their previous work in wild fisheries. They appreciated this shift in lifestyle and thus viewed it as enhanced relative to wild fisheries. This perception, however, may change according to how shellfish are being grown in aquaculture.

Linked Services. CES: independence, physical health, pride, relationship with nature, social capital.

Frequency of Mention. 165 participants.

Related Q Sort Statement. The overall lifestyle associated with my work is appealing. (Ex: outdoors, on the water, hands-on.)

8. Pride

> *"This first photo shows our distributor picking up the very first harvest from us. And we were so proud that we had grown those babies from tiny little seeds up to three inch oysters and made it on time and got out there to the truck, and everything had worked perfectly. We were very, very proud."*
>
> *- Shellfish Farmer*

Summary. Job enables a sense of pride based on role in providing a seafood product, including the work that went into its creation or harvest and the recognition of its quality.

Discussion. Participants discussed work-associated pride associated with their practices and product. Many were proud of their final product and described their shellfish as superior, world-class, or high quality. This pride stemmed from the effort put forth to reach that marketable product and was affirmed through consumer feedback as well as name recognition. Participants were also proud of specific skills or talents possessed that contributed to the quality of the final product.

In addition, participants were proud of their role in contributing to the industry overall – for some, this was associated with the production of seed that directly assisted farmers with product. Some mentioned how their work with shellfish enhanced community pride, and gave local areas a product to celebrate.

Enhanced or Diminished Benefits. Shellfish growers suggested that this benefit may be enhanced via aquaculture because there is pride in serving an oyster or clam that *you* created. The hands-on aspect throughout the life of the animal as it is cultivated to reach market size may inspire a strengthened sense of pride in the final product.

Linked Services. PES: high quality product, food product (general); CES: cultural heritage, contribution to community, family heritage, independence, innovation, knowledge, novel occupation, responsibility of care – husbandry, sense of purpose, skills.

Frequency of Mention. 49 participants.

Related Q Sort Statements. 1) I am proud of the work that I do or the product I create. 2) I enjoy hearing positive feedback or recognition from others because of my work.

9. Relationship with Nature

> *"There are a few things that I like but they all connect to being on the water every day. I'm at the same place every day throughout the seasons. I'm intimately connected to the cycles [of this spot]. It's all the little things that nobody else gets to see. Like when the jellies show up, or when the bullfish show up."*
>
> *- Shellfish Farmer*

Summary. Job allows for an enhanced or unique interaction with and understanding of nature.

Discussion. Participants discussed how working with shellfish enables a relationship with nature that other jobs, particularly jobs outside of fisheries, do not share. Within these relationships, participants cite greater understanding of natural or environmental cycles and overall knowledge of the environment. They are able to recognize slight changes that others would not. They also mentioned a greater appreciation for their local environment and how this relationship translated to a responsibility of care or stewardship for the area.

Within this benefit category, participants shared that they enjoyed interacting with animals at their sites and had a greater understanding of local species' behavior and ecology because of their work. Much of this knowledge, both of species and the overall environment, was also put into practice in order to respond to changing environmental or weather-related conditions at their site. Some participants cited a connection to the body of water where they worked and discussed this as their own relationship with that site.

Enhanced or Diminished Benefits. Similar to sense of place, wild harvesters did not detail exactly how this benefit differed with a wild fishery, but suggested that they had a different experience with nature than shellfish growers.

Linked Services. CES: aesthetic appreciation, challenge, knowledge, responsibility of care – environment, sense of place, spiritualism.

Frequency of Mention. 62 participants.

Related Q Sort Statement. My job enables a relationship with or an awareness of nature.

10. Safety

> *"The advantage over offshore fishermen is that I get to sleep in my bed. I don't worry about losing my life in a perfect storm. If a hurricane comes, I go home."*
>
> *- Shellfish Farmer*

Summary. Work provides a sense of safety for myself, employees, and my customers relative to other jobs.

Discussion. Particularly with aquaculture relative to wild fisheries, participants discussed how the ability to control their own schedule allowed for safer working conditions. Generally, shellfishers can choose to avoid foul weather, but wild harvesters may be more financially impacted by a day off the water than aquaculturists. The inshore nature of many shellfisheries also allows participants a certain degree of safety and the opportunity to return home each night, which offshore fisheries may not.

Participants also discussed safety as it relates to the consumer, suggesting that regulations and practices for farmed shellfish are linked to increased traceability and decreased risk of handling-related illness.

Enhanced or Diminished Benefits. Typically safety was associated with aquaculture over wild fisheries, thus aquaculture enhanced this benefit.

Linked Services. CES: independence; PES: high quality product, safe product.

Frequency of Mention. 12 participants.

Related Q Sort Statements. 1) My job provides a relatively high level of safety at work. 2) I produce a safe food item.

11. Security and Reliability

> *"Shellfish aquaculture can be organized to get a fresher product to market. It doesn't have to get harvested then sold, you can plan based on sales when and what to harvest."*
>
> *- Shellfish Farmer/Former Wild Harvester*

Summary. Work provides stability both in terms of income, even if supplemental, as well as ability to send product to market, relative to similar jobs in area.

Discussion. Participants discussed associated security and reliability with shellfisheries mainly, but not exclusively, as they relate to aquaculture. Shellfish farmers saw themselves as having a more stable market, and with more control over that market, than wild harvesters. They also thought they were able to more consistently bring product to market than with the uncertainty typically associated with wild shellfisheries, and this coincided with a more stable customer base as well. Stability translated to predictable profit and sales. According to participants, shellfish growers can more predictably control how much seed goes in the water, how much effort is put toward working it, and, barring disease or disaster, how much gets to market and when. Aquaculture was also discussed as more reliable due to its year-round availability, providing stable year-round employment.

On the other hand, some participants saw the wild fishery as a form of security, using it as a back-up or "insurance policy" if their aquaculture yield failed. With this mindset, many former wild harvesters retained their wild harvest permits, in case they opted to use it in the future.

Enhanced or Diminished Benefits. Wild harvesters cited the risk associated with failure in aquaculture as a larger liability than with the wild fishery because of greater initial investment. This could be perceived as diminished security associated with aquaculture, however, for the most part aquaculture was viewed to enhance this benefit.

Linked Services. CES: contribution to community, independence; PES: safe product.

Frequency of Mention. 98 participants.

Related Q Sort Statements. 1) My job provides a stable income. 2) My job produces a reliable product.

12. Shared Experiences

"We do tours quite frequently here. Planned and unplanned. So we've got a lot of people [who] come through... And I think what's really cool about this part is that we're all just buried in our work every single day, whether it's me with larvae, or somebody else in broodstock, our algae person who's working hard in algae. And it's nice to be able to step back and be able to talk to people about what we do. And share our passion and share our knowledge with the public. I think that's probably what I like most about this job – being able to communicate with the public and just seeing the curiosity and the wonder on their faces when they come here. Most people know what an adult oyster looks like but not many people know what a larval oyster looks like. Or what algae looks like under the microscope. And people seeing that for the first time, I think it kind of opens up their eyes a little bit."

- Shellfish Hatchery Employee

Summary. Work enables shared experiences with others.

Discussion. Participants discussed the pleasure of sharing shellfish-related experiences through situations like serving their shellfish to others at shucking tables, events, and festivals. They acknowledged that sharing something you grew, harvested, or produced entailed a special benefit. Eating oysters as an activity itself was discussed as a unique shared experience, more so than other jobs or even foods can provide.

Participants also described shared experiences through teaching. Their examples included teaching customers, employees, coworkers, and others. They detailed the camaraderie and shared experiences, even if unpleasant, with coworkers and industry members. They highlighted both successes and failures endured with their coworkers and saw benefit to both types of shared experiences.

Enhanced or Diminished Benefits. Aquaculture may enhance this experience because of the greater likelihood of working as part of a team and having a product that was tended from seed to market.

Linked Services. CES: knowledge, responsibility of care – husbandry, skills, social capital; PES: food (general).

Frequency of Mention. 50 participants.

Related Q Sort Statements. 1) My job has created or strengthened connections with other people (within and/or outside of the industry). 2) I create a food product that people enjoy**.**

13. Social Capital

> *"The most gratifying part is the camaraderie. The band of brothers. The shared hardship. I can trust these guys with my life. It's that shared experience of hardships. Figuring out your limits and pushing through them."*
>
> *- Shellfish Farmer*

Summary. The job has strengthened or created connections to or relationships with other people. This includes: related camaraderie, teamwork, and connections to people both in and outside of industry.

Discussion. Work with shellfish strengthens social bonds or capital in a number of ways. Camaraderie among coworkers or the industry overall was regularly mentioned by participants, as was the idea of the industry as a family or community with shared interests and aims. This camaraderie was associated with shared experiences of both success and failure. Social capital can be enhanced by sharing knowledge or skills with others, both inside and outside of the industry. Participants also highlighted new social connections created because of their work with shellfish.

Enhanced or Diminished Benefits. For some participants who transitioned from wild harvest to aquaculture, prior relationships (with other wild harvesters) were negatively impacted, but new relationships have formed in their place. Some participants suggested that as an industry, shellfish growers operated more collectively and were more united than how they perceived most wild harvesters to be. Thus, they saw this benefit as enhanced via aquaculture.

Linked Services. CES: challenge, knowledge, sense of belonging, shared experiences, skills.

Frequency of Mention. 165 participants.

Related Q Sort Statement. My job has created or strengthened connections with other people (within and/or outside of the industry).

14. Spiritualism

> *"The nonverbal stuff is very large with oysters. There's a deep connectivity to everybody and everything before us. When you handle something associated with them, that ain't of this time. There was a time when mostly everybody of the world was eating oysters. The spiritual presence. It's there."*
>
> *- Shellfish Farmer*

Summary. Job provides the opportunity for a spiritual connection or experience related to shellfish and/or work.

Discussion. Though infrequently mentioned, some participants referenced how their work helps connect them to early inhabitants or native groups because of a history of shellfish consumption. More often, spirituality was discussed as it relates to meditative or "Zen" moments while at work. Some described their own connection to the site or shellfish, and how that connection transcends the everyday experience.

Enhanced or Diminished Benefits. None mentioned.

Linked Services. CES: mental health, relationship with nature, therapy.

Frequency of Mention. 4 participants.

Related Q Sort Statement. My job provides a spiritual connection or experience.

15. Therapy

> *"No oysterman has ever needed a therapist. Especially when you're out by yourself, you have all the time in the world to think about whatever is on your mind."*
>
> *- Wild Harvester*

Summary. Work creates a sense of escape, relief, or peace that is calming.

Discussion. Often connected with being in the outdoors, participants discussed ways that their work provided a therapeutic benefit, describing feelings of escape, relief, or peace. Some saw it as a break from their other routine or job. Others found certain aspects of the work, such as being in the water, or even shucking oysters, as meditative. Some likened their work with shellfisheries to their salvation. For many, though work at times could be a stress builder, work with shellfish helped reduce overall stress in their life. Participants also discussed the peace associated with solitude at work, and the ability to appreciate the calm and quiet if they chose.

Enhanced or Diminished Benefits. In some cases, ownership of a small business such as a shellfish farm could be more stressful than working as a wild harvester – though some participants argued the opposite because of increased stability with aquaculture.

Linked Services. CES: mental health, relationship with nature, transformation.

Frequency of Mention. 28 participants.

Related Q Sort Statement. My job helps reduce stress and/or provides a sense of relief and calm.

16. Transformation

> *"[This] was my hometown. It was weird coming back. Life was not good. But the flats saved me. I met [my wife]. She brought me to the river and I started oystering. I carried a clam hoe with me still, it was like a pacifier. And underneath the oyster beds, it was quahog central. I demolished the quahogs. I got 5 bushels a tide because there was nobody digging them. Within 5 years, I'd cleaned up."*
>
> *- Wild Harvester*

Summary. Job enabled a positive transformation in life. It is more fulfilling than prior work, provides new opportunities, and/or enabled a positive change.

Discussion. Numerous participants were seeking a change in life when they entered the shellfish industry. Working with shellfish, wild or farmed, provided a more fulfilling job or a job that they were more passionate about. Several described how work with shellfish drastically and positively transformed their lives, not in a financial sense, but in terms of overall health and well-being. Work in aquaculture also provided new opportunities for some participants, leading to positive interactions with other people who influenced their lives. Several participants mentioned how their work with shellfish inspired new perspectives on the environment or the area.

Enhanced or Diminished Benefits. None mentioned.

Linked Services. CES: mental health, therapy, relationship with nature, social capital.

Frequency of Mention. 21 participants.

Related Q Sort Statement. My job enabled a positive change in my life.

17. Variety

> *"There's a lot of diversity in what you do day to day. I get to wear a lot of hats, without it getting too complicated."*
>
> *- Shellfish Farmer*

Summary. Duties of the job are diverse and dynamic. This variety and variability keeps work interesting.

Discussion. Both in wild and farmed shellfisheries, participants discussed the variety of activities and variability from day to day as benefits of their work. In the wild fishery, participants can vary target species using different gear throughout the year, as well as potentially travel to new sites. In aquaculture, participants appreciated the multiple roles they were required to fill.

Both types of fisheries are required to respond to changing weather and seasonal conditions, which enhances experiences of variety. In addition, sites differ from one another and the same site may differ from year to year, thus conditions are regularly changing and participants must adapt or respond.

A smaller number of participants discussed the variety in the product created (e.g., each oyster is different) as well as diversity in the people involved in the industry.

Enhanced or Diminished Benefits. Some participants mentioned aquaculture as lacking variety or more monotonous than a wild fishery, but this benefit was mentioned frequently as it relates to both wild and farmed shellfisheries.

Linked Services. CES: challenge, knowledge, relationship with nature, skills, social capital.

Frequency of Mention. 76 participants.

Related Q Sort Statement. There is variety in my daily activities and tasks at work.

Capabilities Equipped Through Work with Shellfish:

1. Income

> *"It's good money and I don't have to go out of town to make it. I don't have to leave my kids."*
>
> *- Shellfish Farmer*

Summary. Job provides a source of income that exceeds other job opportunities in some way.

Discussion. For many participants, income was discussed relative to other jobs in the area and was not necessarily a higher income, but had other associated benefits. The income was stable, year-round, or supplemental. It was sufficient to live comfortably, or even more than comfortably for the area. It was an income earned while positively affecting the environment, working outside, working on boats, and other lifestyle features associated with an occupation in shellfisheries.

Related to identities based in contribution to community, shellfisheries represented accessible income, in that anyone can do it without a specialized background. Participants also discussed the direct relationship between effort put in and income received as a benefit that one did not find in every occupation.

Enhanced or Diminished Benefits. Overall, participants suggested that one could make more money in another job, but be less satisfied. Comparing aquaculture and wild fisheries, both have income-related aspects that participants viewed as favorable and unfavorable.

Linked Services. CES: aesthetic appreciation, contribution to community, lifestyle, relationship with nature, security and reliability. Paired with many other CES, work in shellfisheries is a way to make money that enables another benefit. RSES: sustainable product.

Frequency of Mention. 86 participants.

Related Q Sort Statement. My job provides a better income than other jobs.

2. Knowledge

> *"It's been really interesting to learn about the benefits of raising oysters this way and helping the state to increase production of oysters. I've been preaching oyster farming to everyone we know and meet. I get excited and want to learn more. I enjoy telling our story. It's the lagniappe. The lagniappe is that I'm excited about growing oysters, and making money, and eating them."*
>
> *- Shellfish Farmer*

Summary. Work involves hands-on and continuous learning, innovation, and discovery. It allows the application of previous knowledge. Work may also involve knowledge-sharing with others (customers, coworkers, scientists, etc.).

Discussion. Participants shared multiple ways they acquired, applied, and transferred knowledge through their work and discussed all of these aspects as benefits. With both wild and farmed shellfisheries, participants acknowledged their ability to apply previously acquired knowledge, however those involved in aquaculture described how a broader or more diverse type of knowledge became relevant in their work with shellfish. For example, shellfish farmers had more utility for backgrounds in graphic design and marketing than most wild shellfisheries may require.

Overall, participants discussed the diversity in knowledge gained and applied, noting that they experienced continual learning through the work. Site-specificity and dynamic systems contributed to this perception on ongoing knowledge development. Many found their work intellectually stimulating, though some questioned whether it would always be that way.

Participants were able to contribute to the creation of new knowledge and play a primary role in sharing it, both informally on farms and boats as well as formally in research settings. Many described mentor and training relationships formed as well as an associated pride in the success of trainees.

Enhanced or Diminished Benefits. Both types of fisheries foster opportunities to develop and transfer knowledge. Some participants noted that a greater number of formal education opportunities exist related to aquaculture.

Linked Services. CES: challenge, contribution to community, innovation, relationship with nature, shared experience, skills, social bonds, variety.

Frequency of Mention. 100 participants.

Related Q Sort Statement. My job lets me gain knowledge, apply prior knowledge, and/or teach others.

3. Mental Health

> *"And emotional [benefits] too. It saves me. Every day. I don't know that I'd be alive without it."*
>
> *- Wild Harvester*

Summary. Work provides an opportunity to reduce stress and anxiety, contributing to overall mental health.

Discussion. Participants discussed how work with shellfish contributed to improved mental health overall as it led to decreased stress and anxiety. In particular, it allowed for less stress than other jobs might create. Some participants described their work as meditative, or providing "saltwater therapy". In addition, participants described a number of emotional benefits associated with their work.

Enhanced or Diminished Benefits. None mentioned.

Linked Services. CES: spiritualism, therapy, transformation.

Frequency of Mention. 9 participants.

Related Q Sort Statement. My job contributes to good or improved mental health.

4. Physical Health

> *"Mental [and physical] health. I'm someone that gets particularly stressed and anxious without full understanding and control of each day. Being out here knocks off a lot of the essentials I need to be happy. Like being physically active. My heart is always racing. My body is always pushing. I really feel like I'm working physically."*
>
> *- Shellfish Farmer*

Summary. Shellfish work is an active job that is physically demanding. It contributes to overall physical health and ability, as well as providing an associated satisfaction in the hard work completed.

Discussion. Work with shellfish is both physically demanding and stimulating. Participants discussed the benefits of associated physical labor as a means of getting exercise or staying in shape. With limited down time, the daily activities of the work lead to improved physical health and make a gym membership unnecessary, according to participants. Participants also highlighted related feelings of accomplishment and satisfaction, knowing they put in a full day of hard work, and resting easily because of it (both mentally and physically). A smaller number of participants discussed health benefits associated with eating oysters.

Enhanced or Diminished Benefits. In both wild and farmed shellfisheries, the physical labor may take an eventual toll on physical health. One participant stated that what was good exercise becomes bad exercise over time. Others proactively try to make tasks more efficient and less strenuous to prevent future ailments and injuries.

Linked Services. CES: job satisfaction, lifestyle, mental health; PES: healthy product.

Frequency of Mention. 37 participants.

Related Q Sort Statement. My job is physically demanding and helps me stay in shape.

5. Skills

"The ability to be creative is a big thing. And this job combines so much of my background – business, fishing, boat-building. It allows for a little bit of everything. Not many people get to do that and combine their life experiences to do something that they are perfectly suited for."

- Shellfish Farmer

Summary. Work involves constant acquisition of new skills, as well as the ability to apply previously gained skills. Work overall contributes to a diverse skill set.

Discussion. Participants discussed the variety of skills required for the work as well as how they apply previously acquired skills to their current work in shellfisheries. The need to develop new skills keeps work interesting and enables a continuously growing and diverse skillset that participants are proud of. Participants also discussed the opportunity to teach skills to others as a benefit of the work.

Skills mentioned include those related to: boat-handling, marketing and promotion, work ethic in general, shucking, species cultivation, and catching an animal.

Enhanced or Diminished Benefits. Participants discussed skills as a capability enhanced with aquaculture. Overall, many participants saw aquaculture as an opportunity to develop and apply a broader skillset. According to some wild harvesters, aquaculture did not match the skills necessary to be a good or successful wild harvester.

Linked Services. CES: innovation, job satisfaction, knowledge, pride, shared experiences, social capital, variety.

Frequency of Mention. 63 participants.

Related Q Sort Statement. My job lets me gain new skills, apply prior skills, and/or teach skills to others.

Provisioning Ecosystem Services (PES)

Food Production:

1. Food (General)

> *1: "Having something you know you grew. There's something cool about eating your oysters or clams."*
>
> *2: "And sharing that with other people. Like a pie that you made or a cookie. Sharing your work with them, you know it's important."*
>
> *1: "I think you nailed it. Giving someone something [you produced] carries more weight."*
>
> *- Shellfish Farmers*

Summary. Work entails producing a food item for self or others to consume.

Discussion. Participants described something special about growing a food item, which they recognized as a benefit of the work. They discussed how being part of the food production process was something they prized. Sharing their product with others, and being praised, was also a benefit. Additionally, some participants viewed the fact that they get to eat their own product as a benefit.

Enhanced or Diminished Benefits. None mentioned.

Linked Services. CES: pride, shared experiences, social capital.

Frequency of Mention. 75 participants.

Related Q Sort Statements. 1) I create a food product through my work. 2) I create a food product that people enjoy.

2. Healthy Product

"And at the end of the day, you are what you eat. What about what you're eating is eating? [Farmed shellfish are] good for you compared to steroid-Monsanto chicken and beef."

- Shellfish Hatchery Employee

Summary. Work entails producing a food item that is a healthy source of protein.

Discussion. Shellfish are good sources of protein for human consumption, particularly when compared to other protein sources. They are healthy, safe, and nutritious. Participants valued that they had a role in providing this type of protein to people.

Enhanced or Diminished Benefits. None mentioned.

Linked Services. CES: contribution to community, sense of purpose; PES: food (general).

Frequency of Mention. 8 participants.

Related Q Sort Statement. I create a healthy source of protein for people to eat.

3. High Quality Product

> *"That's what it's all about. This is a picture of a shucked several dozen of our oysters. This is at [a] restaurant in [Alabama]. And it's really what we look for. They're firm, full meats, a lot of glycogen. You can see by how thick the meats are. The shells are very white, which indicates very low incidence of mud worms. That's really the target product that we shoot for. Clean oysters, no blemishes on the shell, so it's a nice, white shell when people eat it; it looks clean."*
>
> *- Shellfish Farmer*

Summary. Work involves producing a high quality food item.

Discussion. Shellfish produced are tasty, high-end, hand-selected, superior, consistent in quality, and overall high quality. For aquaculture, the product is available year-round. Participants also discussed the ability to cultivate unique shellfish with distinguishing qualities, contributing to a sense of artistry. Satisfaction and pride in the positive feedback from consumers on the quality of shellfish were also mentioned.

Enhanced or Diminished Benefits. Participants involved in both wild fisheries and aquaculture viewed their products as high quality relative to others.

Linked Services. CES: responsibility of care – husbandry, pride, shared experiences, social capital; PES: food (general).

Frequency of Mention. 57 participants.

Related Q Sort Statement. I produce a high quality food item.

4. Local Product

> *"One of the best things I anticipate is being able to provide Mississippi oysters to Mississippi chefs. I like working with chefs... I'm excited to see what they can do with our oysters. I see how fast the market can grow when we send a Mississippi-produced farmed oyster."*
>
> *- Shellfish Farmer*

Summary. Work involves producing a local food item.

Discussion. Multiple participants valued their role in providing a local shellfish product. Production of a local food item enables a farm-to-table experience and highlights the community and region. The ability to connect product to farmer or harvester is both important to consumers and fosters potential for unique product branding. In addition, local businesses are supported.

Enhanced or Diminished Benefits. This benefit may be enhanced with aquaculture as branding as a local or named product may be more challenging for wild shellfish, though some localities do have notoriety for their wild shellfish.

Linked Services. CES: cultural heritage, contribution to community, sense of place, shared experiences; PES: Food (general).

Frequency of Mention. 34 participants.

Related Q Sort Statement. I produce a local food item.

5. Safe Product

"Oysters are great sources of protein. And it allows for a unique opportunity to help with seafood safety. Growers can prepare oysters ahead of time for harvest, so that they can get them in refrigeration within the allotted time."

- Shellfish Industry Support

Summary. Work involves producing a fresh and safe food item.

Discussion. Work involves production of a food item that is both good for your health and has a decreased risk of hazards because of associated regulation. Harvesters and shellfish farmers have a better peace of mind that the consumers eating their product will not be harmed by it. In most settings, shellfish are also fresh and traceable.

Enhanced or Diminished Benefits. Many shellfish growers saw the planning and predictability associated with their harvest as safer in terms of *Vibrio spp.* management relative to the wild fishery.

Linked Services. CES: safety; PES: food (general), healthy product.

Frequency of Mention. 11 participants.

Related Q Sort Statement. I produce a safe food item.

6. Sustainable Product

"Knowing that you're providing something good for the environment and the world. It's a good product for people to enjoy and to eat."

- Shellfish Farmer

Summary. Work involves producing a food item in a sustainable manner.

Discussion. Discussed more frequently with aquaculture, shellfish are produced efficiently and sustainably, with little to no environmental input and a reduced carbon footprint relative to other industries.

Enhanced or Diminished Benefits. Aquaculture was viewed to be more sustainable in most cases, and thus associated with enhancement of this benefit.

Linked Services. CES: responsibility of care – environment; PES: food (general), local product.

Frequency of Mention. 64 participants.

Related Q Sort Statement. I produce a sustainable food item.

Shell Production:

1. For Decorative Purposes

> *"Because we own shells, we can use the shells for anything. Like jewelry. There's a variety of shells. And I haven't done anything with them."*
>
> *- Shellfish Farmer*

Summary. Work involves producing shell that can be used to make jewelry and other decorative items.

Discussion. Shells can be used to create jewelry or other decorative items.

Enhanced or Diminished Benefits. None mentioned.

Linked Services. CES: aesthetic appreciation.

Frequency of Mention. 2 participants.

Related Q Sort Statement. I produce shells that can be used for jewelry, decorative, or collector's purposes.

2. For Hobby Trade

"This is when we first got our very first batch of babies, 10 thousand. They were about the size of my little finger nail and we were just amazed at how they looked, even how they felt. And I was amazed that they were sea shells, because you know, I'm a sea shell fanatic. And they were little tiny, baby sea shells, and they were beautiful."

- Shellfish Farmer

Summary. Work involves producing shells that can be collected as a hobby.

Discussion. Some collect shells as a hobby and both wild and farmed shellfisheries can provide these shells.

Enhanced or Diminished Benefits. None mentioned.

Linked Services. CES: aesthetic appreciation.

Frequency of Mention. 2 participants.

Related Q Sort Statement. I produce shells that can be used for jewelry, decorative, or collector's purposes.

Regulating and Supporting Ecosystem Services (RSES)
General:

1. Environmentally Positive

"Environmentally, it's doing everything we would want for this river and more. It's a way to give back."

- Shellfish Farmer

Summary. Work is part of an industry that benefits the environment rather than negatively impact it.

Discussion. Participants discussed generally how their work with shellfish benefits the environment. This included references to cleaning the environment, helping the bay, improving bay health, providing environmental benefits, and adding an ecosystem engineer to the water. Participants also discussed their work as a green or sustainable business, with a decreased carbon footprint.

Enhanced or Diminished Benefits. Aquaculture was viewed to enhance this benefit relative to a wild fishery.

Linked Services. CES: responsibility of care – environment; PES: sustainable product.

Frequency of Mention. 87 participants.

Related Q Sort Statement. My work has no negative environmental impact, or is environmentally positive.

Filter Feeding:

1. **Improved Water Quality**

> *"And as a side-benefit, we're saving the bay. In that sense, it's honest work and we're helping the bay. We all generally care about water quality. We take our kids out to the sandbar. We want the bay to be clean."*
>
> *- Shellfish Farmer*

Summary. Generally, work with shellfish, through the presence of filtering bivalves, contributes to better water quality and overall waterbody health. Specifically, work with shellfish reduces excess nutrients, algae blooms, and toxins while enhancing submerged aquatic vegetation and human health. Participants valued this aspect of their work.

Discussion. Participants discussed the importance of good water quality for overall watershed health and how their work contributed to improved water quality. They cited how an increased number of filtering bivalves in the water impacted water quality for wild oysters, other larval species, as well as human health by contributing to decreased algae blooms, decreased excess nutrients, decreased toxins, and increased submerged aquatic vegetation.

Enhanced or Diminished Benefits. Benefit was more often associated with aquaculture rather than wild fisheries, thus aquaculture may be considered to enhance this service.

Linked Services. CES: pride, responsibility of care - environment, sense of purpose; PES: sustainable product; RSES: environmentally positive.

Frequency of Mention. 52 participants.

Related Q Sort Statement. My work contributes to improved water quality.

Reef Formation:

1. Shoreline Protection

> *"For both of us, we'd been looking for some sort of business [to start] and found one that was a good fit. As we looked at solutions for erosion control [at our family property], we learned about oyster aquaculture."*
>
> *- Shellfish Farmer*

Summary. My work contributes to shoreline protection by helping to create living shorelines to buffer storm surge and reduce erosion.

Discussion. Addition of shellfish to the water, in containers or directly on bottom, helps to prevent or reduce erosion. Work with shellfish helps create living shorelines and natural breakwaters to help buffer storm surge.

Enhanced or Diminished Benefits. Aquaculture may more directly contribute to shoreline protection than a wild fishery, depending on the specific wild shellfishery's role in creating reefs.

Linked Services. CES: pride, responsibility of care, sense of purpose; PES: sustainable product; RSES: environmentally positive.

Frequency of Mention. 7 participants.

Related Q Sort Statement. My work contributes to shoreline protection.

2. Supports Other Species and Fisheries

"I never thought [the farm] would become an artificial reef. I've got the best diving in the state. There's double the biodiversity on and in my cages compared to in the nearby eelgrass. That's an absolutely unexpected side benefit. Seeing that diversity. Now I take my kids fishing by the lease."

- Shellfish Farmer

Summary. Work with shellfish provides habitat/refuge for other species (and substrate for spat), often in previously barren areas. It also enhances the abundance and diversity of reef species - including commercial and recreational fishery catch.

Discussion. Participants discussed how they have witnessed increases in the abundance of fish and other organisms within their sites, acknowledging that, through their work, they have helped to provide habitat and shelter as well as a food source for other species. Shellfish farms and wild reefs serve as nursery grounds for other species, provide substrate for oyster spat and other encrusting organisms, and serve as an overall attractor for other species. Biodiversity is increased relative to what the area contained prior to a shellfish farm, and a farm provides continuous habitat as shellfish are constantly added and gear worked – cited as different from a reef that is worked and not re-planted.

Species mentioned: sea horses, mullet, speckled trout, sheepshead, grouper, grunts, catfish, shiners, stone crab, blue crab, mussels, terrapin, and eels.

Enhanced or Diminished Benefits. Some participants noted that while container gear provides habitat, it is possibly difficult to fish near or over, thus commercial and recreational fisheries may not benefit via increased catch. Still, shellfish growers suggested that they are actively creating habitat whereas a wild fishery may not be contributing in a similar way. For the most part, aquaculture was perceived to enhance this benefit.

Linked Services. CES: pride, responsibility of care - environment, sense of purpose; PES: sustainable product; RSES: environmentally positive.

Frequency of Mention. 51 participants.

Related Q Sort Statement. 1) My work creates habitat for other species. 2) My work enhances the populations of other (non-shellfish) species.

Spawning:

1. Contributes to Wild Shellfish Population

> *"Aquaculture has redeeming qualities. It doesn't impact the wild fishery, and in fact complements it."*
>
> *- Shellfish Farmer*

Summary. Specific to oysters, work enhances number of diploid oysters, which spawn and add both numbers and genetic diversity to wild oyster population.

Discussion. In settings where diploid shellfish are added to the water (via aquaculture or wild reef seeding), shellfish spawn and contribute to the wild population. A spawn can help create new reef habitat and help reduce wild harvest pressure through a larger shellfish population.

Enhanced or Diminished Benefits. Many shellfish growers are using triploid oysters that do not spawn, but those using diploid enhance this benefit for the most part.

In some areas, diploid aquaculture sets were discussed as prohibitive to gear handling and led to increased effort to remove overset gear and animals.

Linked Services. CES: pride, responsibility of care – environment, sense of purpose; PES: sustainable product; RSES: environmentally positive.

Frequency of Mention. 36 participants.

Related Q Sort Statement. I help wild shellfish populations through my work.

2. Supports other Species and Fisheries

> *"It's all about habitat, cover, and food. One oyster produces 50 million larvae. Other animals eat it. Everything is growing quick. There are gigantic schools of drum. Recreational fishermen are all around because it's great around all oyster aquaculture."*
>
> *- Shellfish Farmer*

Summary. Larvae, spat, and adult oysters resulting from work are a food source for other species, including some commercial and recreational fish and crab species.

Discussion. Addition of shellfish to the water creates a new or additional food source for other animals via spawning.

Enhanced or Diminished Benefits. None mentioned.

Linked Services. CES: pride, responsibility of care - environment, sense of purpose; PES: sustainable product; RSES: environmentally positive.

Frequency of Mention. 3 participants.

Related Q Sort Statement. My work enhances the populations of other (non-shellfish) species.

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