Recommendations for Supporting Shellfish Aquaculture

Preliminary Report to the
Washington State Conservation Commission's
Sustainable Farms & Fields Program

June 2025

PACIFIC CONSERVATION DISTRICT

MASON CONSERVATION DISTRICT EST. 1956

Whatcom CONSERVATION DISTRICT

SAN JUAN ISLANDS CONSERVATION DISTRICT

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Recommendations for Supporting Shellfish Aquaculture

Preliminary Report to the Washington State Conservation Commission's Sustainable Farms & Fields Program[1]

Missed connections: Conservation programs and shellfish aquaculture

The Washington State Conservation Commission (SCC) works to conserve natural resources in Washington state through voluntary funding and technical assistance programs, in collaboration with local Conservation Districts (CDs), the USDA Natural Resources Conservation Service (NRCS), and other partners.

As the nation's lead producer of farmed clams, oysters, and geoducks, Washington State's economy, culture, and ecosystems are directly linked to shellfish aquaculture. A limited number of existing SCC- and NRCS-supported practices are applicable to aquaculture, though they largely do not address producers' priorities and - with a few exceptions - there is limited SCC, CD, and NRCS engagement with shellfish aquaculture and related issues. In order to address this gap, Pacific, Mason, Whatcom, and San Juan Islands CDs conducted outreach to shellfish producers and technical assistance providers; analyzed resulting insights, existing practices, and programs; and made recommendations for SCC, CDs, and NRCS to better support shellfish aquaculture through specific practices, program development and adjustments, and increased staff capacity and awareness.

The report focuses on SCC's Sustainable Farms and Fields (SFF) program's support for climate-smart carbon sequestration and greenhouse gas reduction practices. Recommendations also identify broader ways to support aquaculture. SCC, CDs, and NRCS are in an opportune position to develop strategic aquaculture support through development of specific practices alongside building programmatic and staff capacity.

Key ways to support aquaculture through programs and staffing capacity

A. **Adapt existing SCC or NRCS practices for aquaculture**

B. **Provide cost-share and grant funding opportunities for practices not currently linked to an existing SCC- or NRCS-approved practice**

C. **Address discrepancies between NRCS "umbrella" practices and SCC funding availability**

D. **Build SCC and CDs' aquaculture awareness and involvement, develop aquaculture-focused funding and technical assistance programs, and influence NRCS' aquaculture capacity**

E. **Assist aquaculture producers with strategic economic planning, market development, environmental stewardship, and policy development**

F. **Support aquaculture-related outreach and education**

G. **Support assessments and monitoring**

H. **Support flexible timelines (e.g. phased implementation projects) through SCC grant programs**

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New recommended practices related to SFF program priorities[2]

Modifying existing aquaculture activities to support carbon sequestration

1. Minimize sediment disturbance ⭐
2. Increase in-water oyster shell volumes and shellfish production
3. Multitrophic or diversified aquaculture
4. Wild harvest

Improving carbon sequestration in the aquaculture ecosystem

5. Modify light penetration of overwater structures
6. Stewardship of seagrasses and seaweeds ⭐
7. Coordination with other local restoration and stewardship activities ⭐

Materials management to reduce GHG consumption

8. Plastics recycling ⭐
9. Reduction in plastics use and use of alternative packaging ⭐

Energy sourcing and use

10. Electrification, equipment upgrades, and reductions in fossil fuel use ⭐
11. Energy production and storage
12. Local market access or development

Assessment, planning, and policy for carbon sequestration and/or GHG reduction

13. Credit banking and easements for aquatic lands ⭐
14. Carbon sequestration farm planning and assessment ⭐
15. GHG reduction farm planning and assessment ⭐

New recommended practices beyond SFF program priorities

Farm planning and organizational assistance

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17. Economic, market, and policy strategy/assistance

Water quality and ecological conditions

18. Improve survivability during temperature extremes
19. Invasive/nuisance species management
20. Repair or removal of derelict structures
21. Water quality monitoring and assessment of water quality impairments
22. Water quality improvement
23. Litter removal

Equipment and methods improvements

24. Aquaculture processing infrastructure improvements
25. Alternative gear purchase

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[2] SFF-related practices with stars ("⭐") were prioritized by shellfish aquaculture producers.

I. Introduction

Washington's Conservation Commission and Conservation Districts

The Washington State Conservation Commission[3] (SCC) works to conserve natural resources on lands in Washington state, through voluntary and incentive-based programs, in collaboration with conservation districts and other partners.

SCC is the coordinating state agency for all 45 conservation districts (CDs) in Washington State. Together, the SCC and CDs provide voluntary, incentive-based programs that empower people to practice conservation and ensure healthy natural resources and agriculture for all.

The SCC provides financial and operational support and oversight to our state's 45 conservation districts, designs policy and program structures that can be customized to address site-specific natural resource conditions and landowner needs, and facilitates collaborative solutions that meet state natural resource priorities and work on the ground.

Conservation districts — sometimes referred to as "CDs"— engage people with voluntary actions that keep our air, water, soil, habitats, and farmland healthy for all. CDs are community-based hubs of natural resource expertise and funding. They're staffed and led by locals who understand the needs of landscapes and fellow community-members that they serve. Each of Washington's 39 counties is represented by at least one CD. CDs provide:

- Non-regulatory services that are tailored to meet the needs of local people, local properties, and natural resources.
- Site-specific plans for your property designed to help you achieve your land use and conservation goals.
- Grant funding and free or low-cost services that make it more affordable for you to take actions that make our water, soil, air, landscapes, and habitats healthier for all.
- Technical expertise for project planning, permitting, and construction.

Through CDs, the SCC provides grants and cost-share funding programs such as:

- *Sustainable Farms & Fields (SFF)*, which makes it easier and more affordable for farmers and ranchers to implement climate-smart practices and projects that increase carbon sequestration and reduce greenhouse gas emissions.
- *Shellfish Program*, which invests in projects voluntarily installed by conservation districts and landowners that build cumulative results for shellfish recovery and water quality improvement.
- *Natural Resource Investments (NRI)*, which provides incentives to landowners to voluntarily install best management practices (BMPs) which advance progress toward resource objectives, such as improved water quality and habitat, and are farm-friendly.
- *Riparian Grant Program (RGP)*, which funds projects to restore and protect riparian habitat.

[3] https://www.scc.wa.gov/

- *Disaster Assistance Program (DAP)*, a short-term disaster recovery financial assistance program for farmers and ranchers sustaining physical damage or incurring expenses as a result of a natural disaster.
- *Voluntary Stewardship Program (VSP)*, which provides an alternative approach for counties to meet Growth Management Act requirements through a watershed-focused, incentive-based, voluntary collaboration to protect critical areas of conservation, to promote agriculture, and to bring together diverse stakeholders.
- *Office of Farmland Preservation*, which works to address the loss of agricultural land in Washington state through agricultural conservation easements and related technical assistance.
- *Coordinated Resource Management (CRM)*, which empowers local people to resolve land use and natural resource issues using collaborative problem solving.

Aquaculture in Washington State

"Washington is the nation's lead producer of farmed clams, oysters, and geoducks, with an estimated annual harvest worth more than $107 million. Nowhere else in the country can you find the abundance and variety of shellfish that we enjoy." [4]

Washington State shellfish aquaculture production centers on mussels, geoduck clams, Manila clams, Pacific oysters, and softshell clams, though other species are also harvested for market. Figure 1 compares the 2013 weight and value of harvested shellfish in Washington - the last time this data was aggregated.[5]

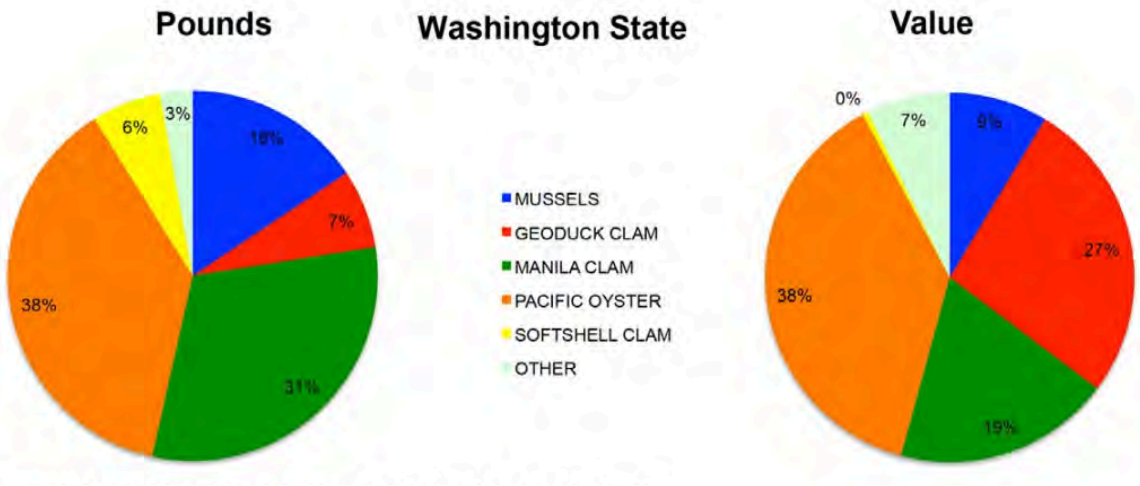

Figure 1. Harvested weight (left) and value (right) of primary shellfish species harvested in Washington. (Image via Washington Sea Grant)

Shellfish production is primarily centered in the South Puget Sound and Willapa Bay (37% and 25% of weight harvested, and 58% and 17% of value, respectively), though the Hood Canal and North Puget Sound account for a sizable portion of shellfish production (17% and 15% of harvested weight, respectively).[6] WIllapa Bay

[4] https://wsg.washington.edu/our-northwest/shellfish/
[5] Washington Sea Grant (2015). *Shellfish aquaculture in Washington State: Final report to the Washington State Legislature.* 84 pp. Available: https://wsg.washington.edu/shellfish-aquaculture
[6] Washington Sea Grant, ibid.

produces the state's largest amount of Pacific oysters, while South Puget Sound produces the largest amount of Manila clams and most of the state's geoduck clams (Figure 2).

Figure 2. Primary bivalve shellfish species produced in Washington, with circles around highest-valued species according to Figure 1. (Images via WA Sea Grant, WA Department of Fish and Wildlife, and WA Department of Health)

Just as each region produces their own assortment of species, each shellfish species requires different growing, harvest, and processing methods. These activities are undertaken by farms of various sizes - from small start-up operations to multigenerational small farms to global corporations - adding to the complexity of the industry and its needs. Furthermore, some species are produced through multiple cultivation types. For example, Pacific oysters are farmed through on-bottom as well as off-bottom (suspended) culture, often resulting in different products destined for different markets.

In Washington State, the shellfish industry has no agricultural commodity commission to research, market, and otherwise improve the economic well-being of the industry.[7] To assist shellfish producers with their variety of needs, various organizations provide assistance. Some - but not all - of these organizations include:

- *Pacific Coast Shellfish Growers Association (PCSGA):* Representing growers across all five states along the Pacific Ocean, PCSGA "works … on a broad spectrum of issues, including environmental protection, shellfish safety, regulations, technology and marketing." Based in Olympia, WA.
- *Pacific Shellfish Institute (PSI):* Collaborative research and educational activities in support of sustainable shellfish production and healthy marine environments. Based in Olympia, WA.
- *University of Washington (UW):* Research-based support through a network of professors, post-doctoral students, and programs such as the Department of Biology and the School of Oceanography.
- *United States Department of Agriculture Agricultural Research Service (USDA-ARS) Pacific Shellfish Research Unit:* Research and technical assistance to develop improved stocks and enhance production of shellfish along the US Pacific coast while ensuring that culture practices are sustainable and environmentally acceptable. Based in Newport, OR.
- *USDA Farm Service Agency:* Direct financial assistance to shellfish producers, including through their Emergency Assistance for Livestock, Honeybees, and Farm-Raised Fish (ELAP) program.
- *USDA Natural Resources Conservation Service (NRCS):* Limited technical and financial assistance, though NRCS has not historically serviced shellfish producers in Washington.
- *Washington Department of Health (WA DOH)*: Shellfish and water testing for consumer safety; licensing and inspection.

[7] https://agr.wa.gov/washington-agriculture/commissions

- *Washington Sea Grant (WSG):* Coastal- and marine-focused extension services including applied research, water quality monitoring, public outreach, prospective farmworker training, working group facilitation, and more. Based out of the UW College of the Environment in Seattle, WA.
- *Washington State University Extension (WSU Extension):* Agriculture-focused research and extension services, including but not limited to grower-informed workshops and assistance with invasive species management. Extension staff live and work locally in counties across Washington State.
- *Willapa-Grays Harbor Oyster Growers Association (WGHOGA):* Upholding the legacy of environmental stewardship and water quality through sustainable shellfish farming in Willapa Bay and Grays Harbor.

This report identifies specific steps to insert the SCC and CDs into this list of technical assistance providers. As this report is focused on shellfish aquaculture, "aquaculture" herein refers to shellfish aquaculture specifically.

Project goals and methods

The SCC's Sustainable Farms and Fields program (SFF) supports CDs to implement climate-smart practices and projects that increase carbon sequestration and reduce greenhouse gas emissions. While SFF funds apply to aquaculture,[8] established best management practices target terrestrial locations. Based on the previous experiences of Pacific CD, Mason CD, Whatcom CD, and San Juan Islands CD, a collaboration was formed to better understand the service gaps and needs for aquaculturists in Washington State.

This report specifically addresses shellfish aquaculture since no growers or technical service providers responded to outreach with information related to seaweed farming.

This project was completed in multiple steps. The first step was to understand how Conservation Districts are currently supporting aquaculturists and what barriers exist to providing ongoing support. This was completed by sending an electronic survey to all Washington State CDs, with focused outreach to the fifteen coastal CDs.

The second step was to send a survey and engage with shellfish farmers to understand what existing or emerging Best Management Practices ("practices," related to SFF priorities or beyond) they were implementing, which practices they were interested in, their existing and desired relationships with CDs regarding technical assistance and funding, and how they would like to be involved in the remainder of this project. Surveys were distributed electronically, by mail, and in person at outreach events.[9]

An additional survey was sent to organizations who provide technical assistance to aquaculture producers.

Following this information-gathering, the project team evaluated SCC's and USDA's existing practices with regard to aquaculture applications, conducted a literature review to identify potential activities that meet the needs of SFF and aquaculture producers, and engaged shellfish farmers in co-development of potential practices for potential inclusion in future SFF grant rounds. Practices identified through this process were assessed based on producer interest, the availability of methods to quantify carbon sequestration and/or greenhouse gas reductions, hurdles or opportunities related to the practice, SCC and NRCS criteria, and other criteria which emerged through this work.

[8] See RCW 89.08.615: https://app.leg.wa.gov/RCW/default.aspx?cite=89.08.615
[9] E-mail and mailing addresses were acquired for all licensed aquaculture producers in the state via Washington State Department of Health. In-person outreach included Washington Sea Grant's Annual Shellfish Growers Conference, quarterly meetings of the Willapa-Grays Harbor Estuary Collaborative, discussions with existing contacts, and more.

II. Existing support for aquaculture

Conservation Districts' existing support for aquaculture

A survey was sent out to all Washington State coastal and non-coastal Conservation Districts to better understand how districts are supporting aquaculture at present and what challenges and barriers exist for districts to provide ongoing support.

Twelve districts responded to the survey. Of the twelve, six CDs had a shellfish farmer or tribal representative onboard. However, we see a different picture regarding the work being done by CDs. While four districts work directly with aquaculture producers, only two are directly involved with on-farm shellfish farming or harvesting activities (in addition to indirect support): Whatcom CD has conducted shellfish bed restoration, while Pacific CD has been involved in multiple shellfish-focused projects including development of new harvesting and processing techniques. An additional seven of these twelve districts indirectly support aquaculture through off-farm habitat restoration, working with upland producers on terrestrial practices linked to water quality, public education and outreach, or invasive species removal (Figure 3).

Direct support of aquaculture operations includes ongoing demonstration projects, research projects, working groups, farm plans and other technical assistance, restoration projects, and education.

Three existing NRCS practices have been used by districts to directly support aquaculture. These are:

- Bivalve Aquaculture Gear and Biofouling Control (NRCS 400)
- Herbaceous Weed Treatment (NRCS 315)
- Integrated Pest Management Plan (NRCS 114)

Several other practices were implemented by districts to indirectly support aquaculture by means of increasing water quality in upland areas in shellfish growing area watersheds. For a full list of these practices, see *Appendix B: Conservation Districts survey results*.

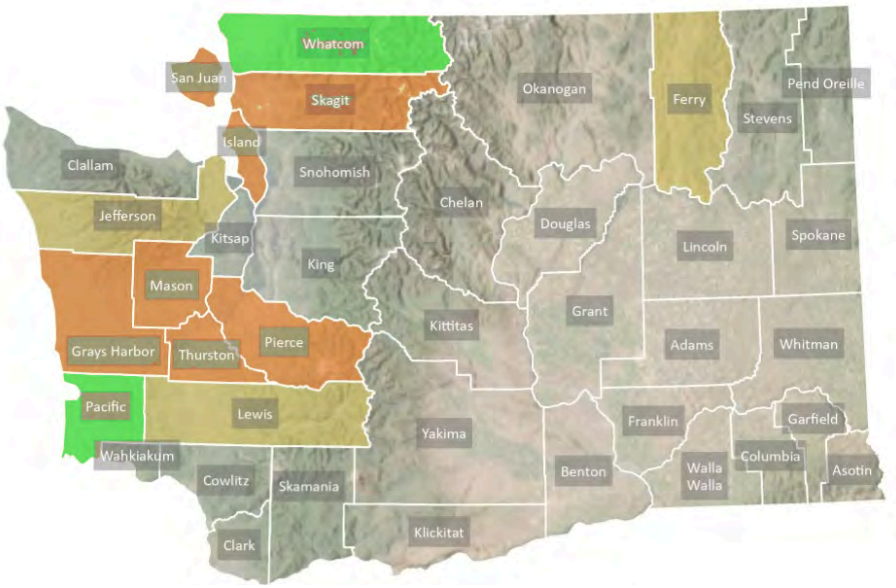

Figure 3. CDs directly involved with on-farm shellfish farming or harvesting activities (green, 2); CDs involved indirectly via water quality, public education, off-farm habitat restoration, or invasive species removal (orange, 7); and CDs who responded to the survey but are not involved in aquaculture (yellow, 3).

Existing SCC and NRCS practices supporting aquaculture

Best Management Practices (practices or BMPs) are a known and uniform way to treat an identified problem, gap or issue in a farm system to improve environmental outcomes, operational efficiency and long-term viability. NRCS and SCC have developed nationwide and statewide practices that address specific concerns by outlining standards and implementation requirements that can be adapted to fit specific situations. Every NRCS practice has been rated for its environmental and economic effects on each resource concern in the Conservation Practice Physical Effects matrix.[10] Since NRCS and SCC practices have been evaluated based on their benefits and ability to address specific natural resources issues, they can be eligible for cost-share funding programs and grants for which they satisfy eligibility criteria.

SCC's Sustainable Farms and Fields (SFF) program provides a list of climate-smart practices that are eligible for SFF funding.[11] Of those 37 existing practices, the following practices could likely be adapted for an aquaculture context through the examples noted or otherwise:

1. Alley Cropping (NRCS 311) - re: eelgrass
2. Conservation Cover (NRCS 327) - re: eelgrass
3. Conservation Crop Rotation (NRCS 328) - re: eelgrass
4. Residue and Tillage Management – No-Till/Strip-Till/Direct Seed (NRCS 329) - re: precision harvest
5. Contour Buffer Strips (NRCS 332) - re: eelgrass vegetated strips
6. Cover Crop (NRCS 340) - re: eelgrass
7. Windbreak/Shelterbelt Establishment and Renovation (NRCS 380) - re: eelgrass
8. Field Border (NRCS 386) - re: eelgrass
9. Hedgerow Planting (NRCS 422) - re: eelgrass
10. Strip cropping (NRCS 585) - re: general habitat provision
11. Vegetative Barriers (NRCS 601) - re: eelgrass
12. Herbaceous Wind Barriers (NRCS 603) - re: eelgrass

The following existing NRCS and SCC practices are not currently eligible for SFF funds, were identified as relevant for aquaculture, and are expanded upon in *Appendix D: Existing NRCS or SCC Best Management Practices (BMPs) relevant to aquaculture*:

Upland practices indirectly related to aquaculture

1. Waste Storage Facility (NRCS 313)
2. Energy Efficient Agricultural Operation (NRCS 374)
3. Riparian Forest Buffer (NRCS 391)
4. Access Control (NRCS 472)
5. Heavy Use Area Protection (NRCS 561)
6. Energy Efficient Lighting System (NRCS 670)
7. Dynamic Revetment and Erosion Reduction (SCC46)

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10 https://www.nrcs.usda.gov/resources/guides-and-instructions/conservation-practice-physical-effects&sa=D&source=docs&ust=1750786547659595&usg=AOvVaw2mKgFc7ooZl3v1GMrd74t8

11 *Sustainable Farms and Fields Grant Programmatic Guidelines, Effective July 1, 2023.* https://cdn.prod.website-files.com/5faf8a950cdaa224e61edad9/64a780d711fec18f82547bd7_SFF%20Programmatic%20Guidelines_July2023.pdf

Marine practices and assistance directly related to aquaculture

8. Herbaceous Weed Treatment (NRCS 315)
9. Combustion System Improvement (NRCS 372)
10. Bivalve Aquaculture Gear and Biofouling Control (NRCS 400)
11. Integrated Pest Management Plan, Pest Management Conservation System (NRCS 114, 595)
12. Restoration of Rare or Declining Natural Communities (NRCS 643)
13. Wetland Wildlife Habitat Management (NRCS 644)
14. Structures for Wildlife (NRCS 649)
15. Precision On-Bottom Shellfish Harvest (SFF Demonstration Practice)
16. Shellfish Farm Planning/Carbon Planning
17. Coastal Zone Soil Survey (CZSS)
18. Conservation Easements

The review of these practices concluded that some NRCS BMPs are already relevant to shellfish aquaculture. Though many of these practices could already meet the needs of aquaculture growers, others may face limitations in practice scope and fundability to reduce their current usability. If tailored to better address aquaculture's site-specific and ecosystem-level challenges, these practices could be leveraged to assist aquaculture growers.

NRCS is well-positioned to play a crucial role in supporting sustainable aquaculture. The agency's expertise in conservation planning, habitat restoration, and technical assistance informs practices that are developed with ecological, economic, and cultural values in mind. This allows these practices to be funded through SCC programs, allowing CDs to advance this work and for aquaculture producers to more easily engage in these beneficial practices.

Challenges for supporting aquaculture via SCC and NRCS programs

SCC and NRCS offer multiple funding programs for private and public entities, and shellfish aquaculture is a key industry for Washington State. However, most SCC and NRCS programs - and the specific practices supported through these programs - have traditionally centered terrestrial farms and lack the nuances relevant to shellfish aquaculture.

Challenges reported by CDs

Districts reported several difficulties in working to directly support aquaculture. Regulatory backstops was noted as the largest limiting factor to engaging with conservation on aquaculture operations. Hurdles such as lengthy and costly permitting processes and punitive regulatory measures against growers not only restrict the type of work that can occur, but also create an environment of distrust between growers and government agencies.

For cooperators who do make aquaculture requests of districts, CDs were consistently unable to meet requests due to lack of program infrastructure and staff capacity, lack of available BMPs and funding (including misalignment between funding programs and aquaculture considerations), scale of funding needed to address concerns, and regulatory hurdles.

It is clear from surveying districts that more CDs would like to better serve aquaculture producers. Engaging in this work in the future will require increased scaffolding from NRCS and SCC in defining the ways CDs can support aquaculture operations, alongside proactive program- and project-development by CDs themselves.

Challenges to applying existing NRCS and SCC practices

Existing aquaculture-relevant NRCS and SCC practices are described in *Appendix D*. While this review did not specifically focus on the challenges associated with these practices, several challenges were evident in analysing response data:

- Limited payment scenarios compensating landowners for ecosystem services provided;
- Limited producer outreach or knowledge of eligibility through NRCS and SCC programs;
- Limited SCC, CD, and NRCS staff knowledge and understanding of aquaculture and associated practices, along with limited historic services provided to aquaculture producers in this region;
- Multiple practices utilized by CDs and funded by other agencies but not currently supported by SCC or NRCS funding programs or not included on their respective practice lists; and
- Limited funding programs for which aquaculture is eligible.

NRCS staff noted that “NRCS really hasn't plugged into the shellfish industry yet here in Washington State.” However, USDA-ARS Pacific Shellfish Research Unit (based out of Newport, OR) has regular involvement with shellfish aquaculture and related ecosystems in Washington.

Challenges reported by aquaculture producers

In this project’s outreach, aquaculture producers were not prompted to describe challenges working with SCC and NRCS. However, responses to surveys and supplemental outreach (described further in *Appendix E: Outreach to Aquaculture Producers*) indicate that:

- Only a small proportion of aquaculture producers have engaged with SCC, CDs, or NRCS;
- Many aquaculture producers would be interested to work with SCC, CDs, or NRCS, though some do not know what these organizations offer;
- There are misalignments between producers’ priority needs and the funding or services provided by SCC, CDs, and NRCS. Some of the priorities are complex issues depending on large systems, such as inequities between farms of different sizes, labor supply, and regulations.

Additional challenges and related details are described in the following section.

III. Recommendations to support aquaculture

The following recommendations to SCC are sourced primarily from aquaculture producers' input, with additional input from Conservation Districts and technical service providers (*Appendix E* and *Appendix B*, respectively). Specific recommendations are grouped in the following sections:

- New recommended practices to support aquaculture related to SFF program priorities
- Detailed descriptions of recommended SFF practices
- New recommended practices to support aquaculture beyond SFF program priorities
- Key ways to better support aquaculture, beyond specific practices

SFF-related practices prioritized by aquaculture producers are denoted with a star (⭐).[12]

New recommended practices related to SFF program priorities[13]

Modifying existing aquaculture activities to support carbon sequestration

1. Minimize sediment disturbance ⭐
2. Increase in-water oyster shell volumes and shellfish production[14]
3. Multitrophic or diversified aquaculture
4. Wild harvest

Improving carbon sequestration in the aquaculture ecosystem

5. Modify light penetration of overwater structures
6. Stewardship of seagrasses and seaweeds ⭐
7. Coordination with other local restoration and stewardship activities ⭐

Materials management to reduce GHG consumption

8. Plastics recycling ⭐
9. Reduction in plastics use and use of alternative packaging ⭐

Energy sourcing and use

10. Electrification, equipment upgrades, and reductions in fossil fuel use ⭐
11. Energy production and storage
12. Local market access or development

Assessment, planning, and policy for carbon sequestration and/or GHG reduction

13. Credit banking and easements for aquatic lands ⭐
14. Carbon sequestration farm planning and assessment ⭐
15. GHG reduction farm planning and assessment ⭐

[12] "Prioritized" practices are those that received a "very interested" ranking in the final survey's responses or were repeatedly mentioned on surveys.
[13] Some of these may also offer other benefits, e.g. improved water quality. These are all new practices, and differ from the existing practices described in *Appendix D*.
[14] Including but not limited to oyster bed restoration, distributing shell on tidelands, and hatchery support

Detailed descriptions of recommended SFF practices

This section describes the previous section's practices in more detail. The following practice descriptions are based on work done through this project, and are intended to provide an introductory description of each recommended practice. For more information, see *Appendix F: Matrix of recommended practices*.

Most categories describing each practice are based on criteria needed by SCC to uptake practices into the Conservation Practice Data System (CPDS). More investigation should be done to fully assess certain categories.

The "Natural resource concerns" category descriptions are based on USDA NRCS' SWAPA+HE framework (Figure 4). For more detail on "Supporting literature," see *Appendix C: Literature review results*.

Figure 4. Icons used below to represent NRCS' SWAPA+HE framework. which represents Soil, Water, Animals, Plants, Air, Humans, and Energy.

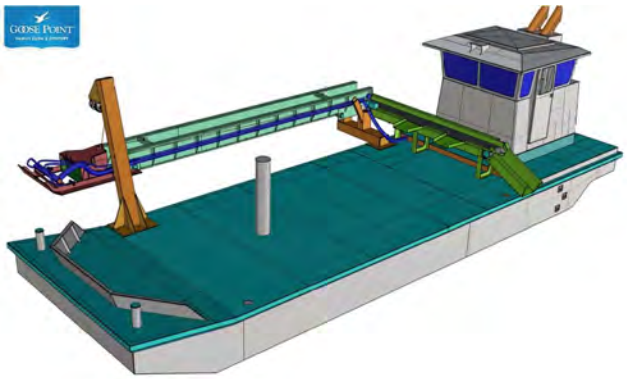
Recommended carbon sequestration-focused practices (#1-7) are in alignment with USDA's Principles to Improve Soil Health:[15] minimize disturbance, maximize soil cover, maximize biodiversity, and maximize presence of living roots - also referred to as Regenerative Agriculture Principles. While these principles directly align with SFF program priorities, they may also align with other funding programs and technical assistance resources through SCC and NRCS. This general opportunity for advancing recommendations #1-7 is not listed below in the respective tables' "Hurdles or opportunities for implementation" category, as it is not specific to any one recommendation.

AREA INTENTIONALLY LEFT BLANK

[15] https://www.farmers.gov/conservation/soil-health

1. Minimize sediment disturbance ⭐	
Description	To reduce benthic disturbance during shellfish transplant, harvest, and/or other aquaculture activities. Ancillary benefits include lessened impact on protected species, e.g. native eelgrass *(Zostera marina)*. This practice could cover multiple specific actions, which would differ based on shellfish species and culture type.
Units of measure	Acres of area where practice is applied.
Other measurements	Turbidity before, during, and after implementation.
Engineering required?	Not for practice itself, but potentially for design or installation of equipment.
Practice lifespan	Not assessed. Consider shellfish species and transplant/harvest timeline.
Natural resource concerns	
Potential negative impacts	Not assessed; varies based on the specific environment, species of shellfish farmed, specific method of minimizing sediment disturbance, and more. Overall, this practice is intended to reduce impacts on natural resources.
Hurdles or opportunities for implementation	Disturbance-reducing equipment and associated upgrades may pose a financial and practical hurdle to some producers. Disturbance-reducing practices may align with permitting requirements.
Supporting literature	1) Valentine, K., Hotard, A., & Elsey-Quirk, T. (2022). *Benthic biofilm potential for organic carbon accumulation in restored and created marshes*.[16] 2) Lutz, M. (2018). *A Search for Blue Carbon in Central Salish Sea Eelgrass Meadows A Search for Blue Carbon in Central Salish Sea Eelgrass Meadows*.[17] 3) Jansen, H., & van den Brink, L. (2020). *Blue carbon by marine bivalves*.[18]
Case study	Pacific Conservation District received a 2024-25 Type B Demonstration Project grant from SFF to advance this practice, with Goose Point Oysters, Willapa-Grays Harbor Oyster Growers Association, University of Washington School of Oceanography, and Oregon State University Hatfield Marine Sciences Center. The goal of this in-progress project is to advance precision harvest technology for on-bottom Pacific oyster harvest and transplant, by: 1) refining design of the existing precision harvest prototype (Figure 5); 2) identifying a boat attachment that is transferable to other boat types in

[16] https://scholarworks.wm.edu/cgi/viewcontent.cgi?article=3260&context=vimsarticles
[17] https://cedar.wwu.edu/wwuet/757
[18] https://edepot.wur.nl/537188

1. Minimize sediment disturbance ⭐	
	the region (via conveyor belt or otherwise, Figure 6); and 3) conducting a study of carbon sequestration in the benthos.  *Figure 5. Prototype precision harvest head, which uses water jets to float oysters onto a conveyor belt (image via Goose Point Oysters).*  *Figure 6. Rendering of precision harvest head and conveyor belt attachment to boat (image via Goose Point Oysters).*

2. Increase in-water oyster shell volumes and shellfish production	
Description	To increase carbon sequestration and water quality (e.g. nutrient reductions, localized buffers to ocean acidification) through the increase of oyster shell and living shellfish in the water. This could include but is not limited to restoration of shellfish growing areas, via substrate restoration, seeding, and otherwise. Higher-density clam seeding could also allow the removal of clam protection netting, reducing greenhouse gases via the amount of plastic used by aquaculture.
Units of measure	Volume of shell placed, or number of seeds planted or set (bushels or dozens).
Other measurements	Acres of area where practice is applied.
Engineering required?	No.
Practice lifespan	Not assessed. Consider shellfish species and transplant/harvest timeline.
Natural resource concerns	
Potential negative impacts	Not assessed; varies depending on variables such as the specific environment, species of shellfish farmed, specific method of increasing shell volumes or shellfish production, and more. Overall, this practice is intended to reduce impacts on natural resources.
Hurdles or opportunities for implementation	Growers mentioned regulatory, financial, and labor force hurdles. Viability of increasing in-water shell volumes depends on availability of shellstock providers. Higher shell density may serve as a buffer against ocean acidification. Increased shell density may improve water quality, improve commercial revenues, and have cultural benefits via traditional activities such as clam gardens. Increased shell density may also slow or reduce establishment of pest species, such as burrowing shrimp.
Supporting literature	1) U.S. EPA. (2017). *The blue carbon reservoirs from Maine to Long Island Sound*.[19] 2) University of North Carolina. (2021). *How Carolina is reducing its carbon footprint with oysters*.[20] 3) Baker, P., & Baker, S. (2010). *Carbon fixation by Florida cultured clam.* University of Florida: Shellfish Aquaculture Research and Extension.[21]
Case study	Whatcom Conservation District is collaborating with the Lummi Nation to support resilience in the Tribe's subsistence shellfish growing and harvest capacity, which has been reduced in part due to seasonal shellfish growing area closures.

[19] https://drive.google.com/file/d/1WSwbvvyuELtfbI8QXAvPMkfE0WATc5bi/view?usp=sharing
[20] https://www.unc.edu/discover/how-carolina-is-reducing-its-carbon-footprint-with-oyster-shells-and-marsh-grass/
[21] https://shellfish.ifas.ufl.edu/projects/shellfish-farm-environment/carbon-fixation/

2. Increase in-water oyster shell volumes and shellfish production	
	Collaboration in recent years has focused on increasing shellfish production by establishing and maintaining additional acreage of nearshore shellfish beds in areas not impacted by seasonal closures, and seeding that acreage with spat from the Tribe's shellfish nursery. A significant barrier to this work is the SCC "umbrella practice" issue. An earlier phase of collaboration between the CD and the Tribe utilized SCC's Shellfish Program funding and match to acquire equipment for substrate placement and seeding, and seeding 25 acres of nearshore shellfish growing habitat in Lummi Bay. The current phase of collaboration is focused on securing permits and funding to seed and manage an additional 24 acres of shellfish growing habitat in Lummi Bay.

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3. Multitrophic or diversified aquaculture	
Description	To improve carbon sequestration and habitat functions by farming multiple species in the same environment, resulting in improved carbon-sequestering ecological functions such as primary production.
Units of measure	Acres of area where practice is applied.
Other measurements	Number or types of species involved in this practice.
Engineering required?	No.
Practice lifespan	Not assessed. Consider shellfish species and transplant/harvest timeline.
Natural resource concerns	
Potential negative impacts	Not assessed; varies depending on variables such as the specific environment, species farmed or restored, and more. Overall, this practice is intended to reduce impacts on natural resources and improve ecological functions.
Hurdles or opportunities for implementation	This practice may not provide as much revenue per unit area or per unit of effort, as compared to single-species aquaculture. Other general hurdles include potential lack of aquaculture producer interest, lack of knowledge and/or technical assistance, regulatory issues, and limited practicality of the activity. Specific species mentioned by growers for production and/or harvest include razor clams, basket cockles, butter clams, native oysters, native eelgrass, seaweed (kelp and potentially other species), salmon, and regularly-farmed shellfish (e.g. Pacific oyster, geoduck, Manila clams, mussels). This practice may have ecological benefits related to *4. Wild Harvest*, or *7. Coordination or collaboration with other local restoration and stewardship activities.*
Supporting literature	1) Lai, Q., Ma, J., He, F., Zhang, A., & Wang, Y. (2022). *Current and future potential of shellfish and seaweed aquaculture*.[22] 2) U.S. EPA. (2017). *The blue carbon reservoirs from Maine to Long Island Sound*.[23]
Case study	Mason Conservation District has partnered with the Squaxin Island Tribe to support the Kamilche (“Peaceful”) Valley agroforestry project, which features forested wetlands lined with native plants, an abundant orchard, a small berry field and a thriving vegetable garden.[24] While this project is upland, it involves Conservation Districts, CD-related funding sources, and other methods that may be applicable to multitrophic or diversified aquaculture.

[22] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9308103/
[23] https://drive.google.com/file/d/1WSwbvvyuELtfbl8QXAvPMkfE0WATc5bi/view?usp=sharing
[24] https://www.masoncd.org/salish-roots-agroforestry.html

3. Multitrophic or diversified aquaculture	
	Another effort, the Indigenous Aquaculture Collaborative, is a "network of Pacific-region Sea Grant offices; Northwest Tribes and First Nations, Native Hawaiian and Indigenous communities; and organizations and universities working as a community of practice to advance Indigenous Aquaculture."[25] The Collaborative advances the creation and stewardship of clam gardens and fishponds, two forms of multitrophic aquaculture. Multiple partners in the Collaborative are based in Washington.

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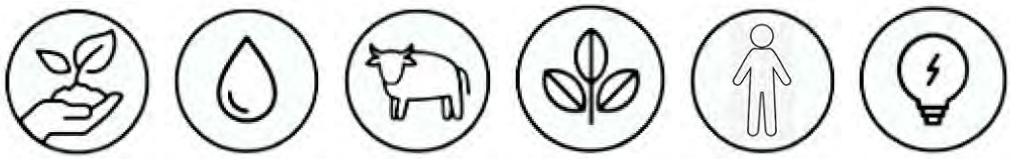
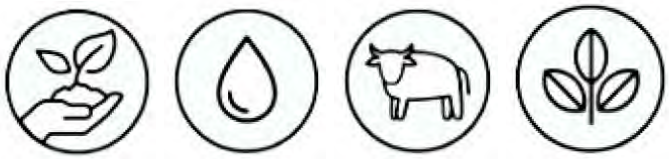
[25] https://indigenousaquaculture.org/

4. Wild harvest	
Description	To harvest wild stock shellfish species, or farm in a way that resembles wild cultivation, resulting in improved carbon-sequestering ecological functions such as primary production.
Units of measure	Acres of area where practice is applied.
Other measurements	N/a
Engineering required?	No.
Practice lifespan	Not assessed. Consider shellfish species and harvest timeline.
Natural resource concerns	
Potential negative impacts	Not assessed; varies depending on the specific environment, species of shellfish farmed, and specific method of increasing shell volumes or shellfish production. Overall, this practice is intended to reduce impacts on natural resources.
Hurdles or opportunities for implementation	Growing shellfish seed without grow-out bags or other protection can lead to predation on seed. Other potential hurdles include regulatory and financial issues. Specific species mentioned by growers for production and/or harvest include razor clams, basket cockles, butter clams, native oysters, and regularly-farmed shellfish (e.g. Pacific oyster, geoduck, Manila clams, mussels). This practice may have ecological benefits related to *3. Multitrophic or diversified aquaculture*, or *7. Coordination or collaboration with other local restoration and stewardship activities.*
Supporting literature	1) University of North Carolina. (2021). *How Carolina is reducing its carbon footprint with oysters*.[26] 2) Lai, Q., Ma, J., He, F., Zhang, A., & Wang, Y. (2022). *Current and future potential of shellfish and seaweed aquaculture.* [27]
Case study	See above case studies for *3. Multitrophic or diversified aquaculture.* One survey respondent described wild stock clam harvesting with tribal partners. The Squaxin Island Tribe in Mason County collaborated with local water quality-focused agencies to recycle grey water from corrections centers and municipalities in Shelton, with a realized goal of improving water quality conditions which reopened traditional wild harvest areas for the tribe.

[26] https://www.unc.edu/discover/how-carolina-is-reducing-its-carbon-footprint-with-oyster-shells-and-marsh-grass/
[27] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9308103/

5. Modify light penetration of overwater structures	
Description	To allow increased light penetration through overwater structures, increasing carbon sequestration via primary production in the water column and substrates below these structures.
Units of measure	Square feet of area where practice is applied.
Other measurements	N/a
Engineering required?	Potentially, based on the degree of alterations involved to the existing structure.
Practice lifespan	In perpetuity, for the lifetime of the overwater structure.
Natural resource concerns	
Potential negative impacts	Not assessed.
Hurdles or opportunities for implementation	Potential hurdles include financial hurdles. This action may be viewed positively from a regulatory perspective, as it can promote eelgrass growth via improved light penetration and reduce fish predation by removing areas for predators to hide. Potential negative impacts were not assessed. This practice may assist viability of species described in *3. Multitrophic or diversified aquaculture, 4. Wild harvest*, *6. Stewardship of seagrasses and seaweeds*, or *7. Coordination with other local restoration and stewardship activities*. This practice may align with the existing practice, *Structures for Wildlife (NRCS 649)*: “To provide structures, in proper amounts, locations, and seasons to enhance or sustain non-domesticated wildlife, or modify existing structures that pose a hazard to wildlife.”
Supporting literature	While not assessed through this project’s literature review, multiple studies have highlighted the use of dappled light by juvenile salmonids in nearshore environments. Additionally, increased light availability enables primary production by species such as plants and algae, which can increase the potential for carbon sequestration in the environment.
Case study	Not assessed.

6. Stewardship of seagrasses and seaweeds ⭐	
Description	To enhance survival and ecological functions of native seagrasses and/or seaweeds. Activities could include active restoration (e.g. planting of seagrasses and seaweeds), passive restoration (e.g. allowing establishment of these species on beds or portions of beds), or modification of existing farm practices to support viability of eelgrass on beds (e.g. precision on-bottom harvest, described above).
Units of measure	Acres of area where practice is applied.
Other measurements	Shoot density or other species-relevant density metric.
Engineering required?	No.
Practice lifespan	Not assessed. Consider 3-5 years for native eelgrass to establish and grow out in alignment with shellfish harvest cycle, or otherwise depending on shellfish and seagrass/seaweed species.
Natural resource concerns	
Potential negative impacts	Not assessed; varies depending on variables such as the specific environment, species of shellfish farmed, specific method of increasing shell volumes or shellfish production, and more. Overall, this practice is intended to reduce impacts on natural resources.
Hurdles or opportunities for implementation	Shellfish farmers are unlikely to be able to participate in the active planting of seagrasses and seaweeds, due to limited farm capacity. However, partnerships with Conservation Districts or other organizations may overcome this hurdle. Shellfish farmers need a longer commitment than the 1-year SFF timeline to pursue this practice (e.g. 3-5 years for eelgrass to establish and grow out). Additional potential hurdles include regulatory issues, technical issues (eelgrass seed source), or limited effectiveness or practicality of the practice. An aquaculture stewardship- and restoration-focused network could help overcome these hurdles and advance this practice throughout the region, however this group is currently nonexistent (though it was suggested in the survey responses). While the regulatory environment surrounding native eelgrass (a protected species) presents a challenge, native eelgrass meadows and shellfish aquaculture are not incompatible. Shellfish farmers have mentioned the value of eelgrass on their beds, as eelgrass can help protect shellfish such as oysters from strong winds and currents, burrowing shrimp, and sedimentation, and also prevent the loss of fine sediment (Figure 7).

6. Stewardship of seagrasses and seaweeds ⭐	
	This practice has relevance to NRCS' existing Conservation Reserve Program, and recommended practice *13. Credit banking and easements for aquatic lands.* This practice also aligns with Washington's Statewide Kelp and Eelgrass Health and Conservation Plan (via the Department of Natural Resources).[28]  *Figure 7. Overlapping eelgrass meadow and on-bottom oyster bed, Willapa Bay.*
Supporting literature	1) Multiple studies by the Ruesink Lab at the University of Washington have investigated eelgrass dynamics, and could apply to specific activities under this proposed practice. 2) Oka, N., Oishi, T., Takada, Y., Tsukamoto, K., Matsuyama, M., & Koike, H. (2021). *Oyster aquaculture using seagrass beds as a climate-change countermeasure*. Archimer – IFREMER.[29] 3) Tallis, H. M., Ruesink, J. L., Dumbauld, B., Hacker, S., & Wisehart, L. M. (2009). Oysters and aquaculture practices affect eelgrass density and productivity in a Pacific Northwest estuary. *Journal of Shellfish Research*, *28*(2), 251-261.[30]
Case study	Multiple partners - including Pacific Conservation District, University of Washington's Ruesink Lab, Willapa-Grays Harbor Oyster Growers Association and multiple growers, Pacific Shellfish Institute, Washington Sea Grant, and Washington State Department of Natural Resources - have submitted grant proposals to advance this practice (currently under review). The proposed project would "empower coastal shellfish farmers towards recognition – financial and social – of their contributions to persistent submerged aquatic vegetation along the rural Washington State coast where healthy coastal

[28] https://dnr.wa.gov/aquatics/aquatic-science/nearshore-habitat-program/statewide-kelp-and-eelgrass-health-and-conservation-plan
[29] https://drive.google.com/file/d/1rcl29A1TbbYloreR6dzaQSgTaRygN77X/view?usp=sharing
[30] https://bioone.org/journals/journal-of-shellfish-research/volume-28/issue-2/035.028.0207/Oysters-and-Aquaculture-Practices-Affect-Eelgrass-Density-and-Productivity-in/10.2983/035.028.0207.full

6. Stewardship of seagrasses and seaweeds ⭐	
	ecosystems include resilient seagrass and farms. [This work] seeks co-creation of field projects with shellfish farmers to test “vegetated strips” – a common technique in terrestrial agriculture – and other cost-effective techniques that enhance native eelgrass resilience and cover. Vegetated strips could alter hydrodynamics and sediment transport in ways that reduce the need for bed maintenance and increase Blue Carbon. Vegetated strips could also reduce the cumulative effects of spatial crowding (multiple adjacent beds), which could otherwise restrict individual permit applications.” Additionally, Taylor Shellfish has created a Habitat Management Plan for floating oyster culture in Oakland Bay, sourced through a third-party study. Spacing of structures, materials utilized, impacts to submerged aquatic vegetation, and impacts to wildlife were included in the study, leading to permits from local and state agencies, ensuring no net loss of ecological functions from the proposed aquaculture expansion. Other shellfish farms have expressed interest in developing similar habitat management plans, which could include stewardship of seagrasses and seaweeds. A Habitat Management Plan could also be developed for specific growing areas encompassing multiple companies.

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7. Coordination with other local restoration and stewardship activities ⭐	
Description	To advance restoration and stewardship activities that indirectly support aquaculture, through activities involving aquaculture farms or related entities. By restoring or stewarding local habitats, ecological disturbance is minimized and carbon sequestration is increased. As coastal issues are not confined to parcel boundaries, there is value in involving aquaculture interests in large-scale restoration and stewardship of aquatic and intertidal ecosystems. Potential activities include, but are not limited to, wetland and tidal restoration, removal of salmon spawning barriers, assisting water quality efforts, restoration of specific species (e.g. native shellfish, sunflower star, kelp, urchins, and abalone), and riparian restoration.
Units of measure	Acres of restored habitat
Other measurements	Varies per specific restoration action or type of habitat restored.
Engineering required?	No.
Practice lifespan	Not assessed.
Natural resource concerns	
Potential negative impacts	Not assessed. Overall, this practice is intended to reduce impacts on natural resources.
Hurdles or opportunities for implementation	The ability for producers to engage in restoration efforts will vary, based on farm siting, local restoration priorities, organizational capacity, and other considerations. Potential partners suggested by survey respondents include land trusts and other local restoration project proponents. Multiple survey respondents mentioned growing Olympia oysters for hobby and restoration purposes. As such, shellfish producers could be partners - compensated or otherwise - for growing this species for restoration activities. These activities could relate to other recommended practices: *6. Stewardship of seagrasses and seaweeds*, *21. Water quality monitoring*, or *22. Water quality improvement*. Depending on the type of project, this may overlap with existing practices and programs supported by SCC, e.g. the Riparian Grant Program.[31]
Supporting literature	Not assessed.
Case study	SCC's Shellfish Program supports water quality improvement, and increased involvement from aquaculture interests could improve intended aquaculture benefits. WDOH Pollution Identification and Correction (PIC) program is an

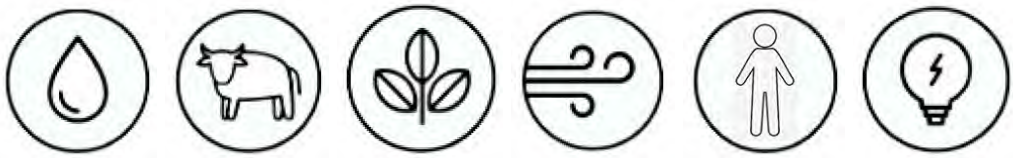
[31] https://www.scc.wa.gov/programs/riparian-grant-program

7. Coordination with other local restoration and stewardship activities ⭐	
	example of landscape-scale multi-agency coordination involving aquaculture.[32] The San Juan Islands Conservation District was recently awarded a grant from the SeaDoc Society to advance eelgrass restoration through an innovative method that integrates aquaculture byproducts. This project will test the effectiveness of Bivalve-Facilitated Seeding, in which eelgrass (*Zostera marina*) seeds are attached to live basket cockles (*Clinocardium nuttallii*)**.** As the cockles burrow, they naturally deposit the seeds into the sediment. This process not only buries seeds at an ideal depth but also improves sediment quality by aerating it and reducing sulfide concentrations, which are harmful to eelgrass. The cockles used in this project will be sourced from local geoduck aquaculture operations, where they are typically considered a nuisance species found inside culture tubes. By repurposing these cockles for ecological restoration, the project links aquaculture with conservation to support eelgrass recovery at three sites in the San Juan Islands.

[32] https://doh.wa.gov/community-and-environment/shellfish/epa-grants/pathogens-grant/pic

8. Plastics recycling ⭐	
Description	To recycle, improve existing recycling methods for, or reuse plastics used in aquaculture-related processes (e.g. oyster bags, clam netting). Reduction in use of new plastics could reduce reliance on greenhouse gas-producing processes.
Units of measure	Pounds/tons of material recycled or reused.
Other measurements	N/a
Engineering required?	No, though engineers would be involved in the creation and maintenance of plastics recycling facilities and design of reusable plastic equipment.
Practice lifespan	Not assessed.
Natural resource concerns	
Potential negative impacts	Recycling of plastics through typical methods has potential negative environmental impacts due to the energy consumed during this process.
Hurdles or opportunities for implementation	This practice can have a positive impact on the industry's public perception. Hurdles include finding local markets for recycled plastic and ensuring economic viability of the process. Availability and cost-effectiveness of this practice need to be improved before it is practical for some producers. *Bivalve Aquaculture Gear and Biofouling Control (NRCS 400)* is already being used by some aquaculture producers, and assists reuse of plastic equipment. This suggested practice is connected to *9. Reduction in on-farm plastics use and use of plastic alternatives for packaging* and *23. Litter removal.*
Supporting literature	1) Collins, H., & Shumway, S. E. (2024). *Emerging research on shellfish, aquaculture, and marine plastics*. Department of Marine Sciences, University of Connecticut.[33] 2) Lopes, C., Gago, J., Álvarez, P., & Pedrotti, M. L. (2020). Plastic pollution pathways from marine aquaculture practices and potential solutions for the North-East Atlantic region. *Marine Pollution Bulletin, 150*, 110739.[34]
Case study	Pacific oyster farmers utilizing longline culture have explored viability of recycling polypropylene rope used during this process. Further details were not assessed. Shellfish farmers in Willapa Bay received grant funds to develop a pilot program to recycle plastic mesh seed bags. The program will deploy a bailing system to better contain bags, making transport more economical. Farmers hope to work with a manufacturer who can use the plastic to create new aquaculture gear, eventually creating a circular system.

[33] https://seagrant.media.uconn.edu/wp-content/uploads/sites/1985/2024/08/Shellfish-Plastic-Fact-Sheet-8.13.24-final.pd
[34] https://doi.org/10.1016/j.marpolbul.2020.110739

9. Reduction in plastics use and use of alternative packaging ⭐	
Description	To reduce use of plastics and therefore reduce reliance on greenhouse gas-producing processes.
Units of measure	Pounds of plastics avoided.
Other measurements	N/A.
Engineering required?	No.
Practice lifespan	Not assessed.
Natural resource concerns	
Potential negative impacts	Not assessed; none known.
Hurdles or opportunities for implementation	Shellfish farmers and technical assistance providers noted that much effort has already gone into researching plastic alternatives for on-farm equipment in the marine environment, with limited success. Specific activities with potential to reduce reliance on plastics include: ● Use of a Floating Upweller Systems ("FLUPSY") to reduce reliance on plastic grow bags and lead to direct planting of oysters[35] ● Utilizing UV stable plastics to decrease plastic release ● Heavier seeding of clams to reduce the need for plastic protective netting ● Reducing reliance on single-use plastics (e.g. grow bags, ropes, or nets) ● Use of biodegradable harvest bags (if feasible)
Supporting literature	Not assessed.
Case study	Hama Hama Oysters and Taylor Shellfish were referenced as producers who have innovated with reduction of plastics for on-farm and packaging uses. Pacific Seafood, in coordination with Pacific CD and funds from SCC, has developed the "Cluster Buster," a shared piece of equipment which removes additional rope from the shell it was once attached to during longline oyster culture. By removing the rope from the shell, Pacific Seafood can recycle them and use them as a hard surface for future oysters (see *2. Increase in-water oyster shell volumes and shellfish production*)

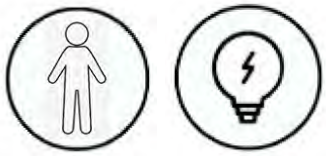
[35] While flupsy systems may reduce plastics use during the early stages of the oyster lifecycle, growers may continue to need plastic grow bags or other similar equipment once the shellfish grow too large to remain in the flupsy.

10. Electrification, equipment upgrades, and reduction in fossil fuel use ⭐	
Description	To reduce fossil fuel use and ensuing greenhouse gas emissions through electrification or efficiency upgrades of equipment. Specific potential activities include, but are not limited to, electrification or efficiency improvements for boat motors, vehicles, pumps, and refrigeration.
Units of measure	Carbon dioxide equivalent impact benefits (greenhouse gas reduction) as compared to previous energy use(s).
Other measurements	Kilowatt hours (kWh) reduced or otherwise per specific application.
Engineering required?	No.
Practice lifespan	Not assessed.
Natural resource concerns	
Potential negative impacts	Not assessed.
Hurdles or opportunities for implementation	General hurdles noted include regulatory issues and financial issues. Some related activities, such as purchasing electric vehicles/motors at a large scale, may involve coordination with distributors. A grant or other program to help in updating propulsion equipment with more fuel efficient systems (or other activities) could help expedite the decarbonization of the aquaculture industry.
Supporting literature	Not assessed.
Case study	Survey respondents stated, “We farm geographical properties with large plots that minimize travel of cars and equipment” and “We minimize deliveries to keep the trucks off the road as much as possible.” “Rural Energy Development for Washington” is a statewide program that helps implement renewable energy and energy efficiency projects on farms and rural small businesses by providing education about energy conservation options and incentives, technical assistance and assessment of site feasibility for clean energy projects, and grant writing for state and federal grant and loan programs. All services are provided free of charge.[36]

[36] https://piercecd.org/485/Renewable-Energy-and-Energy-Efficiency

11. Energy production and storage	
Description	To produce, store, and/or distribute energy which provides an alternative to fossil fuels or reduces greenhouse gas emissions. Suggested activities include enhancement of aquaculture farms' capacity for storing electricity (e.g. acquisition of batteries and associated infrastructure for marine or upland applications), and small hydropower or tidal energy for aquaculture facilities.
Units of measure	Carbon dioxide equivalent impact benefits (greenhouse gas reduction) as compared to previous energy source(s).
Other measurements	Kilowatt hours (kWh) produced or otherwise per specific application.
Engineering required?	Yes.
Practice lifespan	Not assessed.
Natural resource concerns	
Potential negative impacts	Not assessed. Energy production infrastructure is likely to have impacts on natural resources, particularly in aquatic environments.
Hurdles or opportunities for implementation	Potential hurdles noted by aquaculture producers include financial issues, lack of landowner interest, and limited effectiveness or practicality of the activity. Regulatory hurdles also exist for in-water energy production. Energy production may be a desirable activity for marginal lands owned by farms, whether upland or in-water. Funding and technical assistance opportunities may come through Washington's Clean Energy Transformation Act (CETA)[37] and associated implementation plans, managed through the Washington Department of Commerce. Additional support may come through the statewide "Rural Energy Development for Washington" program,[38] which helps implement renewable energy and energy efficiency projects on farms and rural small businesses by providing education about energy conservation options and incentives, technical assistance and assessment of site feasibility for clean energy projects, and grant writing for state and federal grant and loan programs. All services are provided free of charge.
Supporting literature	Not assessed.
Case study	Not collected, but energy production and storage for aquaculture applications may have been funded through CETA or the Rural Energy Development for Washington program.

[37] https://www.commerce.wa.gov/energy-policy/electricity-policy/ceta/
[38] https://piercecd.org/485/Renewable-Energy-and-Energy-Efficiency

12. Local market access or development	
Description	To connect to existing local markets or incubate new local markets for shellfish aquaculture products, reducing carbon-intensive shipping activities. This could also include event production/involvement, delivery, or direct to consumer (DTC) activities - via in-person or online sales.
Units of measure	Carbon dioxide equivalent impact benefits (greenhouse gas reduction) due to change to local markets.
Other measurements	Weight or value of product sold locally instead of non-locally.
Engineering required?	No.
Practice lifespan	Not assessed.
Natural resource concerns	
Potential negative impacts	Not assessed, but not anticipated.
Hurdles or opportunities for implementation	Potential hurdles noted by aquaculture producers include technical or knowledge-based issues, limited effectiveness or practicality of the activity, and financial issues. This practice may bring increased revenue to shellfish producers, which could be a higher priority to growers than focusing on carbon sequestration and greenhouse gas reduction alone. This practice may be fundable via Washington State Department of Agriculture's Resilient Food Systems Infrastructure Program,[39] and is connected to farm planning practices and *17. Economic, market, and policy strategy/assistance*.
Supporting literature	Not assessed.
Case study	While there are many more potential methods to improve local market access, existing activities by shellfish farms in Washington include: ● Direct on-farm sales, offering ecotourism opportunities: see Goose Point Oysters' Oystery in Bay Center, the Hama Hama Oyster Saloon in Lilliwaup, and Taylor Shellfish's Samish Oyster Bar in Bow; ● Tribal food distribution programs; ● Direct seafood sales events and coordinated local food strategies;[40] and ● Sales via local restaurants, seafood markets, and farmers markets. and direct seafood sales events.

[39] https://agr.wa.gov/services/grant-opportunities/resilient-food-system-infrastructure
[40] See https://www.bellinghamseafeast.org/dockside-market and https://www.experiencewestport.com/fresh-catch

13. Credit banking and easements for aquatic lands ⭐	
Description	To provide financial compensation for shellfish aquaculture producers for the ecological services provided by their farms or farmlands, potentially including but not limited to carbon sequestration and habitat provision. Suggested activities include placing nearshore mudflats in conservation banks, in exchange for expanded farm boundaries or financial compensation. Such a conservation easement program could be adapted for marine use similar to the terrestrial farming sector where growers can participate in temporarily setting aside areas for conservation in exchange for entering into a lease based on production value of the land. Financial compensation could be through a public program, or through private financing similar to carbon or mitigation credits.
Units of measure	Acres of habitat conserved, or carbon dioxide equivalent impact benefits (carbon sequestered)
Other measurements	Varies based on goals of TBD program.
Engineering required?	No.
Practice lifespan	Not assessed. Consider 10-15 years.
Natural resource concerns	
Potential negative impacts	Not assessed, but not anticipated.
Hurdles or opportunities for implementation	This practice was repeatedly mentioned as a priority by shellfish producers - regardless of its potential to sequester carbon. While a well-planned credit banking or easement program may be well-received by aquaculture producers, it also may require significant efforts to develop this program and associated financial frameworks (e.g. coordination with carbon credit banks). Modification of or collaboration with existing programs - such as SCC's Office of Farmland Preservation,[41] FSA's Conservation Reserve Program (technical assistance provided through NRCS),[42] or Washington's Statewide Kelp and Eelgrass Health and Conservation Plan[43] - may provide an opportunity to advance this practice without building a program from the ground up. In doing so, the primary goal of the practice may be related to overall habitat and natural resource conservation, and carbon sequestration may be a secondary goal - potentially avoiding the need to engage with the financial complexities of carbon markets. However, modifying these existing programs will require continued outreach, advocacy, and additional state legislative appropriations.

[41] https://www.scc.wa.gov/ofp
[42] https://www.nrcs.usda.gov/programs-initiatives/crp-conservation-reserve-program
[43] https://dnr.wa.gov/aquatics/aquatic-science/nearshore-habitat-program/statewide-kelp-and-eelgrass-health-and-conservation-plan

13. Credit banking and easements for aquatic lands ⭐	
	General hurdles noted include regulatory issues, financial issues, and technical or knowledge-based issues (specifically regarding carbon markets). This practice may relate to *1. Minimize sediment disturbance*, *6. Stewardship of seagrasses and seaweeds*, *7. Coordination with other local restoration and stewardship activities*, *14. Carbon sequestration farm planning and assessment*, *15. Greenhouse gas reduction farm planning and assessment*, *16. Farm planning*, and *19. Invasive/nuisance species management*.
Supporting literature	1) National Oceanic and Atmospheric Administration, Office for Coastal Management. (2025). *Final findings: Rhode Island Coastal Resources Management Program (September 2019–October 2024)*[44]
Case study	Puget Sound Partnership offers a Nearshore Conservation Credit Program, which provides funds to slow the loss of nearshore habitat in Puget Sound.[45] As described in *6. Stewardship of seagrasses and seaweeds*, multiple partners (CD, academic, private, and state) have submitted grant proposals to investigate cost-effective techniques that enhance native eelgrass resilience and cover - including financial compensation of shellfish aquaculture producers for on-farm conservation practices. Funding for this work is currently under review. In 2019, the Rhode Island Coastal Resources Management Council, in collaboration with The Nature Conservancy and other partners, initiated a conservation easement program in Narragansett Bay to protect working waterfronts and support shellfish aquaculture. Funded in part by NOAA and the National Fish and Wildlife Foundation, the project placed legal protections on waterfront properties to prevent future residential or commercial development while affirming aquaculture, fishing, and public access as compatible, protected uses. In addition to safeguarding access and water quality, the easements helped buffer shorelines against erosion and served as a model for integrating legal conservation tools with ecological resilience strategies. This hybrid approach demonstrates how estuarine systems like Willapa Bay could benefit from conservation easements that sustain both ecological functions and local aquaculture economies.

[44] https://www.crmc.ri.gov/aboutcrmc/2025_NOAA312_Findings.pdf
[45] https://psp.wa.gov/pspnc-suggest-conservation-projects.php

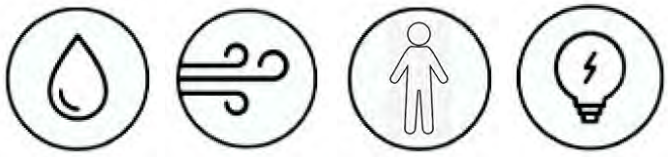
14. Carbon sequestration farm planning and assessment ⭐[46]	
Description	To quantify the amount of carbon sequestration in current aquaculture activities - including but not limited to other activities in this report, and the amount of carbon sequestered for each shellfish species farmed - and develop a plan to maximize the amount of carbon sequestered by the farm while meeting other farm goals.
Units of measure	Carbon dioxide equivalent impact benefits (carbon sequestered)
Other measurements	Varies based on additional goals of plan.
Engineering required?	No.
Practice lifespan	Not assessed.
Natural resource concerns	
Potential negative impacts	Not assessed, but not anticipated.
Hurdles or opportunities for implementation	Potential hurdles noted include lack of landowner/grower interest, technical or knowledge-based issues, and limited effectiveness or practicality of activity. Financial issues may be a hurdle for implementation of planned activities, though these may be addressed if funding is made available for other carbon-sequestering practices recommended herein.
Supporting literature	1) U.S. EPA. (2017). *The blue carbon reservoirs from Maine to Long Island Sound*.[47] 2) University of North Carolina. (2021). *How Carolina is reducing its carbon footprint with oysters*.[48] 3) Lutz, M. (2018). *A Search for Blue Carbon in Central Salish Sea Eelgrass Meadows A Search for Blue Carbon in Central Salish Sea Eelgrass Meadows*.[49]
Case study	SCC has supported work to develop a carbon farm plan template, which is based in an upland agricultural context and cou-ld be adapted for aquaculture.

[46] This practice was noted as a priority activity in the final survey to shellfish producers. However, due to the wording in the survey, respondents may have been unclear about the distinction between this practice and *15. GHG reduction farm planning and assessment*. As such, this practice may have been interpreted to include greenhouse gas reductions, rather than solely carbon sequestration. In order to accommodate this discrepancy, both practices (#14 and 15) are listed as priorities in this report.

[47] https://drive.google.com/file/d/1WSwbvvyuELtfbI8QXAvPMkfE0WATc5bi/view?usp=sharing

[48] https://www.unc.edu/discover/how-carolina-is-reducing-its-carbon-footprint-with-oyster-shells-and-marsh-grass/

[49] https://cedar.wwu.edu/wwuet/757

15. GHG reduction farm planning and assessment ⭐[50]	
Description	To conduct a greenhouse gas emissions inventory for current aquaculture activities, and develop a plan to maximize greenhouse gas reductions by the farm while meeting other farm goals. Specific activities could include, but are not limited to: energy audits for upland and in-water activities; strategizing which areas to farm, minimizing travel for employees, equipment, and shellfish; and other recommendations to reduce aquaculture operations' greenhouse gas footprint.
Units of measure	Carbon dioxide equivalent impact benefits (greenhouse gas reduction)
Other measurements	Varies based on additional goals of plan.
Engineering required?	No.
Practice lifespan	Not assessed.
Natural resource concerns	
Potential negative impacts	Not assessed, but not anticipated.
Hurdles or opportunities for implementation	Potential hurdles noted include lack of landowner/grower interest, technical or knowledge-based issues, and limited effectiveness or practicality of activity. Financial issues may be a hurdle for implementation of planned activities, though these may be addressed if funding is available for other GHG-reducing practices.
Supporting literature	1) Lutz, M. (2018). *A Search for Blue Carbon in Central Salish Sea Eelgrass Meadows A Search for Blue Carbon in Central Salish Sea Eelgrass Meadows*.[51] 2) Jansen, H., & van den Brink, L. (2020). *Blue carbon by marine bivalves*.[52] 3) U.S. EPA. (2017). *The blue carbon reservoirs from Maine to Long Island Sound*.[53] 4) University of North Carolina. (2021). *How Carolina is reducing its carbon footprint with oysters*.[54]

[50] This practice was not noted as a priority activity in the final survey to shellfish producers. However, due to the wording in the survey, respondents may have been unclear about the distinction between this practice and *14. Carbon sequestration farm planning and assessment*, which was noted as a priority. As such, practice #14 may have been interpreted to include greenhouse gas reductions, rather than solely carbon sequestration. In order to accommodate this discrepancy, both practices (#14 and 15) are listed as priorities in this report.

[51] https://cedar.wwu.edu/wwuet/757

[52] https://edepot.wur.nl/537188

[53] https://drive.google.com/file/d/1WSwbvvyuELtfbl8QXAvPMkfE0WATc5bi/view?usp=sharing

[54] https://www.unc.edu/discover/how-carolina-is-reducing-its-carbon-footprint-with-oyster-shells-and-marsh-grass/

15. GHG reduction farm planning and assessment ⭐[50]	
	5) Baker, P., & Baker, S. (2010). *Carbon fixation by Florida cultured clam.*[55] University of Florida: Shellfish Aquaculture Research and Extension.[56]
Case study	The Jamestown S'Klallam Tribe has a Carbon Neutral Plan,[57] which aims to achieve net zero emissions by 2032. Through this plan, the tribal government has made steps toward reducing GHG emissions (e.g. electric vehicle purchases, building efficiency), which underpins much of tribal aquaculture work directly or indirectly. However, tribal aquaculture operations have thus far not been as involved in direct decarbonizing activities due to separation between tribal businesses and tribal government operations. The tribe is currently in preliminary stages of working with Pacific Northwest National Labs (PNNL) to explore using marine energy sources to power aquaculture facilities.

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[55] https://shellfish.ifas.ufl.edu/projects/shellfish-farm-environment/carbon-fixation/
[56] https://shellfish.ifas.ufl.edu/projects/shellfish-farm-environment/carbon-fixation/
[57] https://jamestowntribe.org/wp-content/uploads/2023/02/Carbon-Neutral-Plan_v4.pdf

New recommended practices beyond SFF program priorities

The following practices were identified by shellfish aquaculture producers but did not clearly match SFF's funding criteria (carbon sequestration and greenhouse gas reduction), though further assessment may show links between these practices and SFF funding criteria. Some of these practices may be prioritized by aquaculture producers over carbon sequestration and greenhouse gas reduction practices. Therefore, these practices may provide opportunities for SCC, CDs, and NRCS to meet shellfish aquaculture needs in ways that are most relevant to producers. For more information, see *Appendix F*.

Farm planning and organizational assistance

16. Aquaculture farm planning[58]
17. Economic, market, and policy strategy/assistance[59]

Water quality and ecological conditions

18. Improve survivability during temperature extremes
19. Invasive/nuisance species management[60]
20. Repair or removal of derelict structures[61]
21. Water quality monitoring and assessment of water quality impairments[62]
22. Water quality improvement[63]
23. Litter removal

Equipment and methods improvements

24. Aquaculture processing infrastructure improvements
25. Alternative gear purchase[64]

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[58] Including but not limited to assisting producers to implement SCC- or NRCS-supported practices, other ecological stewardship activities or innovations, and overall farm resilience to changing social, economic, or environmental conditions. As such, this practice could advance recommended practices for SFF, e.g. *14. Carbon sequestration farm planning and assessment, 15. Greenhouse gas reduction farm planning and assessment*, and various others.

[59] Including but not limited to exploring new ways to grow, process, and market shellfish; assisting labor force; improving prices paid to farmers relative to expenditures; supporting small growers; promoting the aquaculture industry; expanding programs common in the terrestrial agriculture sector; and assisting with permitting (streamlining, navigating, or otherwise), licensing, and/or associated fees.

[60] Inclusive of Integrated Pest Management, which has associated NRCS practices. Specific species mentioned by survey respondents include European green crab, burrowing shrimp, oyster drills, and sea lions. This could also relate to Harmful Algal Blooms (HABs), and practices *21. Water quality monitoring and assessment of water quality impairments* and *22. Water quality improvement.*

[61] Including but not limited to the renovation of derelict structures for local market access, and removal of redundant pilings. The repair of derelict structures could reduce GHG emissions by relying on existing materials rather than relying on new materials. However, only one survey respondent mentioned *repair* of derelict structures while multiple respondents suggested the *removal* of derelict structures, leading this to be listed as a practice beyond SFF priorities.

[62] Monitoring activities may be fundable via the Voluntary Stewardship Program (VSP). For example, Pacific County's VSP recognizes commercial shellfish beds as a critical area (due to water quality filtration functions) and recognizes commercial shellfish as an agricultural activity. VSPs - in current or updated forms - may be a key tool to leverage here.

[63] Including but not limited to oxygenation and mitigation of eutrophication, mitigating acidification, erosion mitigation, water filtration assistance, land use modifications and restoration, and repair or upgrade of failing septic systems. This covers upland, in-water, or infrastructural activities. These activities could relate to the previous recommended practice, *21. Water quality monitoring and assessment of water quality impairments.* While SCC's Shellfish Program focuses on water quality, survey responses indicate a mismatch between the program and shellfish producers' needs, described further in the next section.

[64] E.g. floating bag purchase. This practice may have environmental benefits related to carbon sequestration, depending on the specific culture type being replaced. However, this practice is not contingent on replacing an existing culture type. Further research would also be needed to compare the relative carbon sequestration across multiple culture types.

Key ways to support aquaculture, beyond specific practices

A. Adapt existing SCC or NRCS practices for aquaculture

Adapt existing practices that have previously benefited natural resources related to aquaculture. These practices may be quickly incorporated within SCC databases such as CPDS to be eligible for ranking and funding. Specific examples of potential activities include *649 - Structures for Wildlife*, which could assist Conservation Districts in oyster reef restoration through the deposition of relic shell material, recycled from aquaculture producers.

As described in the "Existing SCC and NRCS practices supporting aquaculture" section above, there are a few clear examples in which NRCS BMPs could be applied to aquaculture if modifications to the existing practice occur. While aquaculture-specific practices and programs are necessary to meet the nuanced needs of aquaculture, existing pilot activities such as incentivizing "vegetated strips" of eelgrass provide an opportunity to expand terrestrial agriculture-focused practices into coastal and marine environments.[65]

When practices cannot be modified to better serve aquaculture, consider pathways for creating new practices, as described in item B below.

B. Provide cost-share and grant funding opportunities for practices not currently linked to an existing SCC- or NRCS-approved practice

Develop ways to fund new practices to support aquaculture. This supports further assessment and development of practices that can support aquaculture in alignment with SCC and NRCS programs, as described in this report.

Allow space for planners and engineers to explain how the proposed practice meets the objectives of relevant SCC grant programs and how the practice would still meet lifespan or operational requirements in line with SCC policies. Update grant program language to support pilot practices similar to the Sustainable Farms and Fields' Demonstration Projects (Type A and B).

Continue conversations between the project team and NRCS to focus on feasibility of specific practices and targeted research (via the USDA-ARS station in Newport, Oregon, or otherwise).

C. Address discrepancies between NRCS "umbrella" practices and SCC funding availability

Address the "umbrella" practice issue where multiple aquaculture-relevant NRCS practices are currently not included on SCC's list of eligible practices because the SCC considers them "umbrella" practices (e.g. NRCS 643 - *Restoration of Rare or Declining Natural Communities*, NRCS 644 - *Wetland Wildlife Habitat Management*). One approach would be to identify and/or develop a list of eligible NRCS "supporting" practices to accompany the use of "umbrella" NRCS practice standards in a SCC funding situation. Another solution could be the adoption of a stand-alone SCC-approved practice that mirrors these NRCS's practice standards.

D. Build SCC and CDs' aquaculture awareness and involvement, develop aquaculture-focused funding and technical assistance programs, and influence NRCS' aquaculture capacity

Involve SCC and CDs in development of SCC aquaculture programs to ensure awareness, knowledge, and skill in aquaculture-related topics and serving these interests. This includes awareness of

[65] For example, see the case study for recommendation *#6. Stewardship of seagrasses and seaweeds*.

permitting processes and requirements, existing and emerging policy, and stewardship practices for aquaculture producers. Engaging with producers could advance potential collaborations, expose growers to new stewardship practices, provide technical assistance, and improve overall SCC/CD support for aquaculture.

While long-term programs are being developed, a critical near-term action is for SCC and CD staff to simply begin to engage with aquaculture producers. This can build relationships, trust, and general awareness of issues and opportunities for collaboration.

Program-level discussions should also be developed with NRCS, as NRCS funding provides an opportunity for larger and longer-term funding,[66] though this would require additional effort beyond the Washington State-focused scope of this project. Advancement of aquaculture-supporting programs could allow for a holistic approach to addressing the needs of aquaculture, rather than the current piecemeal approach. In doing so, SCC, CDs, and NRCS will be better situated to address complex or foundational issues for aquaculture producers, maintain relationships and trust, leverage emerging opportunities, and engage in incremental long-term efforts.

Among local, state, and federal agencies SCC, CDs, and NRCS have a unique ability to assist private landowners with cost-share funds, grants, and technical assistance. In a multi-year study and report published in 2022,[67] Washington Sea Grant and the Washington State Department of Ecology found that CDs are a key organization to involve in rural community-driven coastal hazards resilience efforts and the local capacity building necessary to advance resilience - due to CDs' ability to assist private landowners, but also due to the place-based methods and trust that CDs employ. Just as the state has recognized CD's value in building resilience to hazards (leading to ongoing partnerships and funding between coastal CDs, academia, and state agencies), CDs are positioned in a unique opportunistic position to meet shellfish aquaculture needs in alignment with WA State priorities and build local or programmatic capacity to do so, whether these activities relate to SFF funding criteria or otherwise.

E. Assist aquaculture producers with strategic economic planning, market development, environmental stewardship, and policy development

Provide strategic assistance to aquaculture producers, including but not limited to the following topics:[68]

- Financial issues, including increasing farmers' revenues;
- Supporting and maintaining the shellfish aquaculture labor force;
- Navigating regulations and streamlining permitting, including permitting assistance;
- Local, state, and federal policy development;[69]
- Balancing the needs of small and large producers, ensuring equitable support for small growers;
- Exploring new ways to grow, process, and market shellfish;
- Knowledge-sharing regarding environmentally-friendly practices and BMPs; and
- Aquaculture advocacy and promotions.

While these issues vary, they all are generally beyond the scale of specific practices that CDs typically engage with, and may be best addressed in a coordinated manner. This project's outreach highlighted

[66] See recommendation *H. Support flexible timelines (e.g. phased implementation projects) through SCC grant programs*.
[67] https://wacoastalnetwork.com/resilience-action-demonstration-project/
[68] This recommendation is similar to recommended practice #17. Economic, market, and policy strategy/assistance. Practice #17 refers to support for individual aquaculture producers, while recommendation E refers to broader support.
[69] One specific suggestion was to provide a well-researched template for local jurisdictions to adapt/adopt aquaculture-relevant policies when updating their Shoreline Master Programs

multiple ways that support for these issues could come about, potentially convened by SCC and CDs, potentially with support from SCC's Coordinated Resource Management program:[70]

- Strategy development could involve focused engagement with individual farmers or local farming organizations (e.g. the Willapa-Grays Harbor Oyster Growers Association), in the landowner-based partnership structure that Conservation Districts typically employ.

- Strategy development could also involve a larger working group of organizations, reflective of the scale of issues that shellfish farmers have identified. As the shellfish industry has no agricultural commodity commission to research, market, and otherwise improve the economic well-being of the industry, this working group may address a crucial need, especially for small farms with limited capacity. The following specific organizations or groups were mentioned by producers as collaborators on economic, environmental, and/or policy topics, and may be useful participants in such a working group:[71] [72]

    - Shellfish farms (small and large-sized companies, alongside new and old companies)
    - Shellfish industry workers and/or representative organizations
    - Aquaculture-focused organizations (e.g. Pacific Shellfish Institute, Pacific Coast Shellfish Growers Association, Willapa-Grays Harbor Oyster Growers Association)
    - Hobby growers and recreational harvesters
    - Washington State Department of Natural Resources (and other public tideland owners)
    - Tribes
    - Local jurisdictions
    - Regulatory agencies
    - State and federal agencies providing grants or other assistance
    - Innovators within the industry
    - Educational organizations
    - SCC, CDs, and NRCS staff
    - Marine Resources Committees
    - Researchers (e.g. University of Washington, Friday Harbor Labs, Pacific Northwest National Labs)
    - Restoration-focused groups (e.g. Puget Sound Restoration Fund)
    - Consumers and the general public, or representative perspectives

F. <u>Support aquaculture-related outreach and education</u>

Engage youth and the general public in educational programming. This could increase sustainability of aquaculture operations by supporting innovative future aquaculture leaders and social license for aquaculture, respectively. Outreach and education could be active (e.g. classes, jobs training, workshops, field visits) or passive (e.g. interpretive signage).

Support "Demonstration gardens" which are a grower-recommended activity to showcase stewardship practices for aquaculture in an educational manner that informs technical and non-technical audiences, including producers, technical assistance providers, youth, and the general public.

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[70] This would involve the previous recommendation, *D. Build SCC and CDs' aquaculture capacity and involvement*
[71] Note that this group may refer primarily to organizations currently involved in shellfish aquaculture, and could be expanded in order to embrace new opportunities.
[72] See the *Willapa-Grays Harbor Estuary Collaborative* for a regional example of this type of working group, though largely focused on interactions between shellfish aquaculture, burrowing shrimp, and eelgrass species: www.wghec.org

G. Support assessments and monitoring

Advance emerging efforts to develop practices in tidal waters, where existing SCC or NRCS practices or funding programs do not currently apply. SFF's "Demonstration Project" category has succeeded in supporting emerging aquaculture practices, and could be applied to other SCC programs. Monitoring can help determine the efficacy of demonstration projects or other in-development practices.

SCC can further benefit aquaculture by ensuring funding programs and other forms of support are applicable to monitoring programs that are not tied directly to specific practices, such as water quality monitoring. Monitoring environmental parameters is relevant to aquaculture success and its environmental stewardship, but funding is limited for this work. In Spring 2025, the Willapa-Grays Harbor Estuary Collaborative identified environmental monitoring and equipment sharing as a key priority. As SCC and NRCS are two of the only public entities which provide funds to private aquaculture landowners, SCC will fill a significant funding gap by providing funding explicitly for monitoring activities. This may align with Voluntary Stewardship Program activities,[73] which could be expanded to have more focus on aquaculture.

H. Support flexible timelines (e.g. phased implementation projects) through SCC grant programs

Ensure alignment between existing SCC funding programs and marine project permitting timelines. Projects along marine shorelines - e.g. erosion reduction and restoration efforts - are likely to involve permits that require federal review by the US Army Corps of Engineers, NOAA Fisheries, and the US Fish and Wildlife Service. This permitting can regularly take 18 months, and recent federal staffing cuts have extended some wait times at NOAA.

SFF funds are regularly granted on a one-year timeline, based on the Washington State fiscal year. SCC's Shellfish Program requires that projects be implemented within the biennium they are funded. Due to permitting timelines, this means that funds meant to support aquaculture may not actually be able to fund work along marine shores that can directly benefit aquaculture. By allowing phased projects to be funded via these grant program, marine projects (and resulting benefits to shellfish aquaculture) are more likely to be advanced by SCC's Shellfish Program.

Related, the Washington fiscal year timeline (July 1-June 30) does not align with the growing season for eelgrass (April-September). This also applies to other intertidal species, including marsh vegetation, as peak growing season and biomass presence is typically July. This issue presents another hurdle for SCC funds being applicable to aquaculture projects. This could be addressed through longer-term funding or more flexibility around when the 1-year funding timeline starts and ends. This is especially important for demonstration projects that rely on data collection.

[73] https://www.vsp.wa.gov/

IV. Conclusion and next steps

There is a significant opportunity for SCC, CDs, and NRCS to further engage with the aquaculture industry on shared goals such as environmental stewardship, ecological restoration, and sustaining the economic vitality of these industries and their associated communities. Increased SCC, CDs, and NRCS programmatic engagement with the shellfish aquaculture industry can fill gaps in the current organizational services and frameworks available to the shellfish aquaculture industry. SFF's carbon sequestration and greenhouse gas reduction priorities provide opportunities to address these gaps and build greater capacity to serve the shellfish aquaculture industry. Aquaculture engagement - through the SFF program or otherwise - will increase SCC's, CDs, and NRCS' understanding of the gaps for supporting aquaculture and related ecological functions, build relationships, and result in technical assistance opportunities. For this to happen, however, CD staff will need continued support from SCC and NRCS to develop awareness, build trust, provide technical assistance and funding, and produce tangible results in collaboration with the aquaculture community.

To advance the practices recommended in this report, further study is needed on their viability and nuances - potentially as Type B Demonstration Projects via future SFF funding rounds, via further exploration of conservation easements through the SCC's Office of Farmland Preservation, and otherwise. Several specific practices and broader recommendations may involve securing additional state funding though Washington State legislative appropriations, both through existing SCC program budgets or new programs. Given current state budget constraints, this may be a longer-term strategy. Engagement with Washington Association of Conservation Districts may also advance these recommendations. There is also a need to assess opportunities to work further with NRCS on supporting aquaculture and building NRCS programs' and staff capacity to do so, via regional Local Work Groups, the State Technical Advisory Committee, or otherwise. While SFF provides a useful starting point to support aquaculture, there is a need to expand aquaculture services in a manner that is more broadly beneficial to producers, recognizing the lack of a shellfish aquaculture commodity commission.

Of the 15 SFF-aligned practices recommended in this report, the following practices are most relevant for shellfish aquaculture producers:

- Minimizing sediment disturbance
- Stewardship of seagrasses and seaweeds
- Coordination with other local restoration and stewardship activities
- Plastics recycling
- Reduction in on-farm plastics use and use of plastic alternatives for packaging
- Electrification, equipment upgrades, and reductions in fossil fuel use
- Credit banking and easements for aquatic lands
- Carbon sequestration and GHG reduction farm planning and assessment

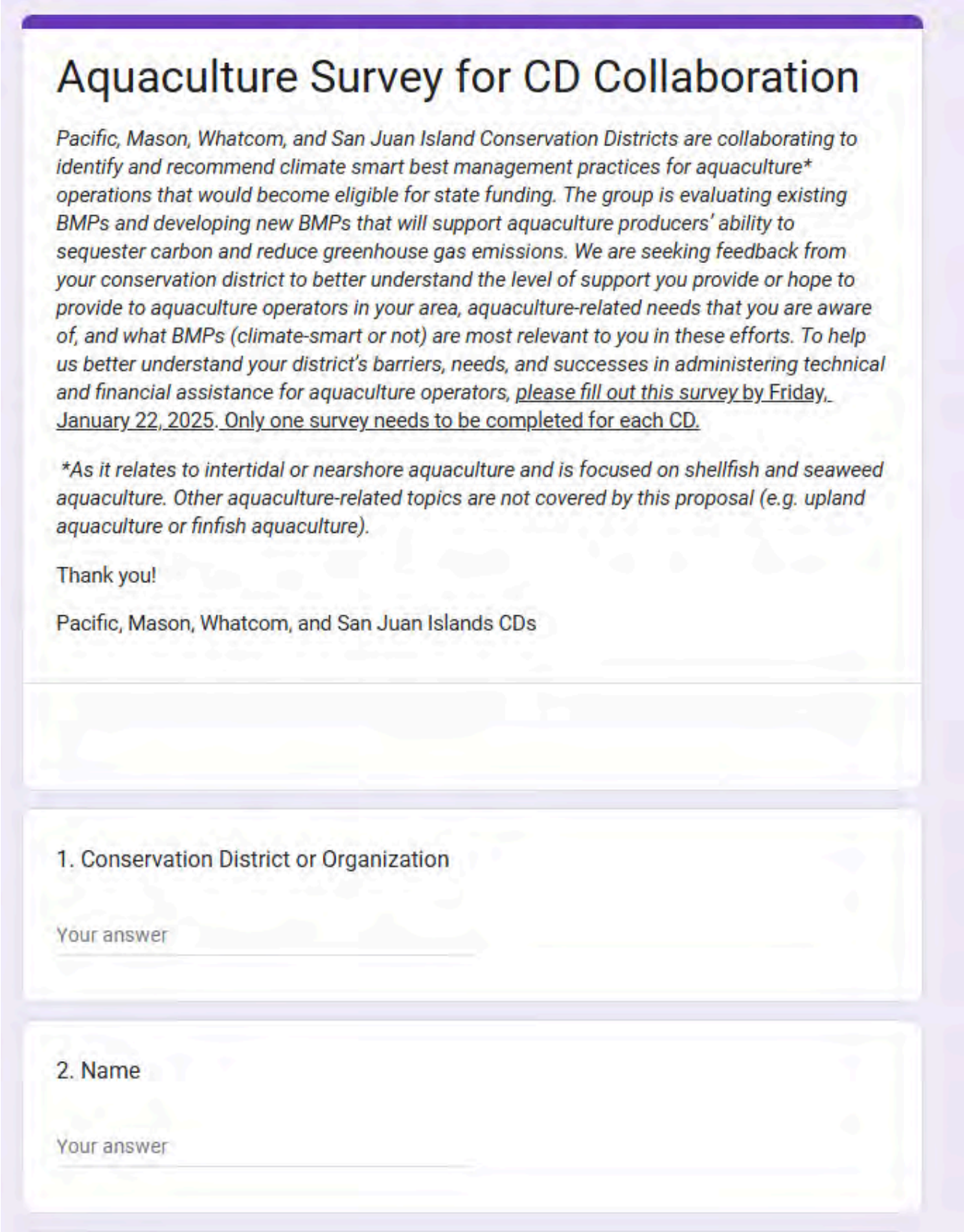
If these or other practices are done in a manner that advances the recommendations outlined in the section titled "Key ways to support aquaculture, beyond specific practices," then SCC, CDs, and NRCS will be able to build the trust, cultivate relationships, and develop programs and projects that address foundational environmental and economic issues for aquaculture producers, their associated communities, and the ecosystems they rely upon. Doing so initially requires program development and policy adjustments internal to SCC and NRCS, along with increased engagement and collaboration with shellfish aquaculture interests. As one shellfish farmer stated:

"Just being involved in the aquaculture community is very important to keep apprised of the variety of issues."

Appendix A: Outreach materials

Appendix A: Outreach materials contains all outreach materials used during the project:

- Figures A-1 through A-5: Survey to Conservation Districts, SCC staff, and NRCS staff (digital)
- Figures A-6 through A-12: Initial survey to aquaculture producers (physical & digital)
- Figures A-13 through A-18: Materials used with in-person outreach (physical)
- Figures A-19 through A-22: Survey to technical assistance providers and researchers (digital)
- Figures A-23 through A-26: Survey to producers to review recommended practices (physical & digital)



Aquaculture Survey for CD Collaboration

Pacific, Mason, Whatcom, and San Juan Island Conservation Districts are collaborating to identify and recommend climate smart best management practices for aquaculture operations that would become eligible for state funding. The group is evaluating existing BMPs and developing new BMPs that will support aquaculture producers' ability to sequester carbon and reduce greenhouse gas emissions. We are seeking feedback from your conservation district to better understand the level of support you provide or hope to provide to aquaculture operators in your area, aquaculture-related needs that you are aware of, and what BMPs (climate-smart or not) are most relevant to you in these efforts. To help us better understand your district's barriers, needs, and successes in administering technical and financial assistance for aquaculture operators, please fill out this survey by Friday, January 22, 2025. Only one survey needs to be completed for each CD.*

**As it relates to intertidal or nearshore aquaculture and is focused on shellfish and seaweed aquaculture. Other aquaculture-related topics are not covered by this proposal (e.g. upland aquaculture or finfish aquaculture).*

Thank you!

Pacific, Mason, Whatcom, and San Juan Islands CDs

1. Conservation District or Organization

Your answer

2. Name

Your answer

Figure A-1. Survey (page #1 of 4) sent virtually to Washington's Coastal Conservation Districts

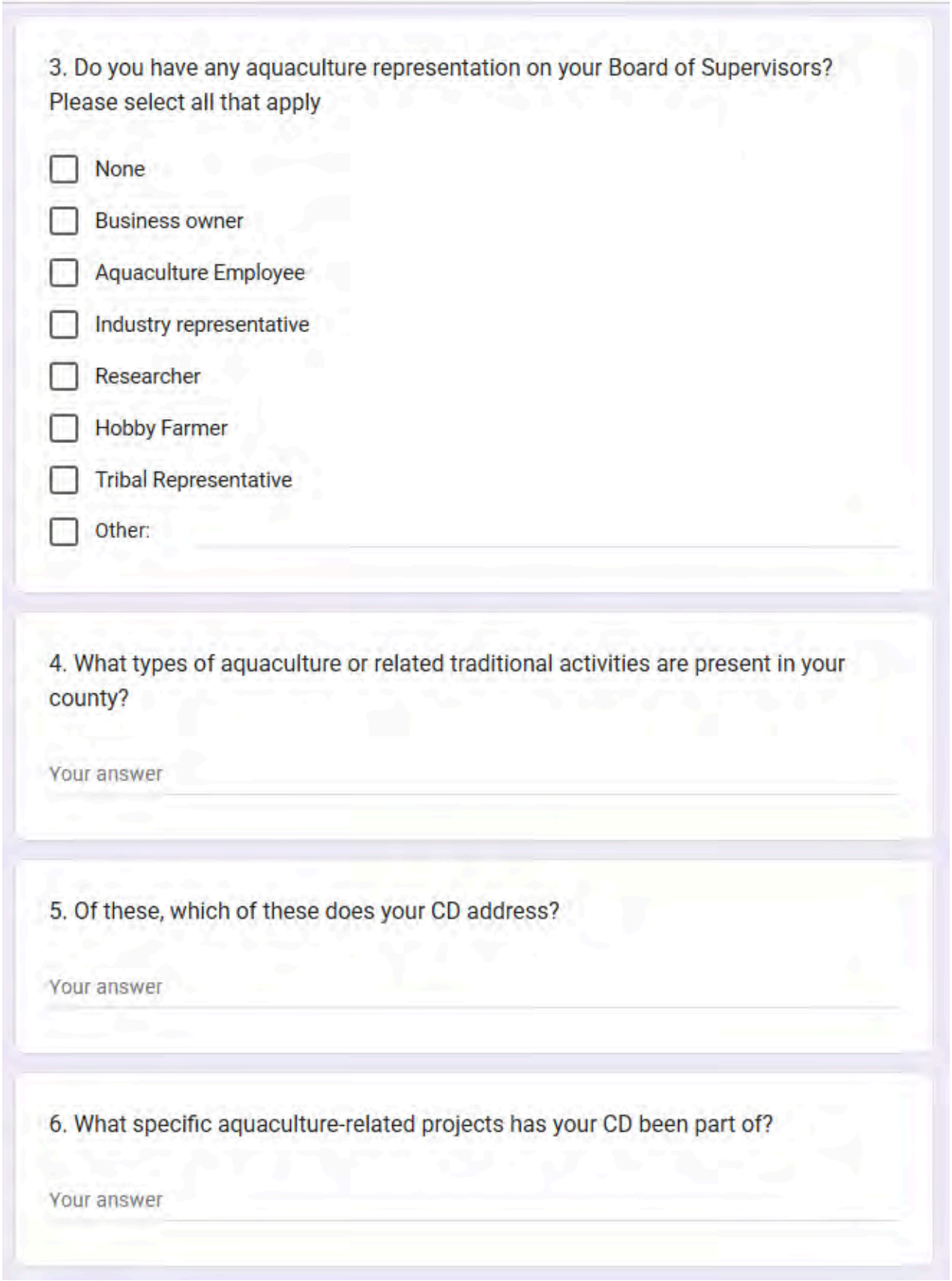


Figure A-2. Survey (page #2 of 5) sent virtually to Washington's Coastal Conservation Districts

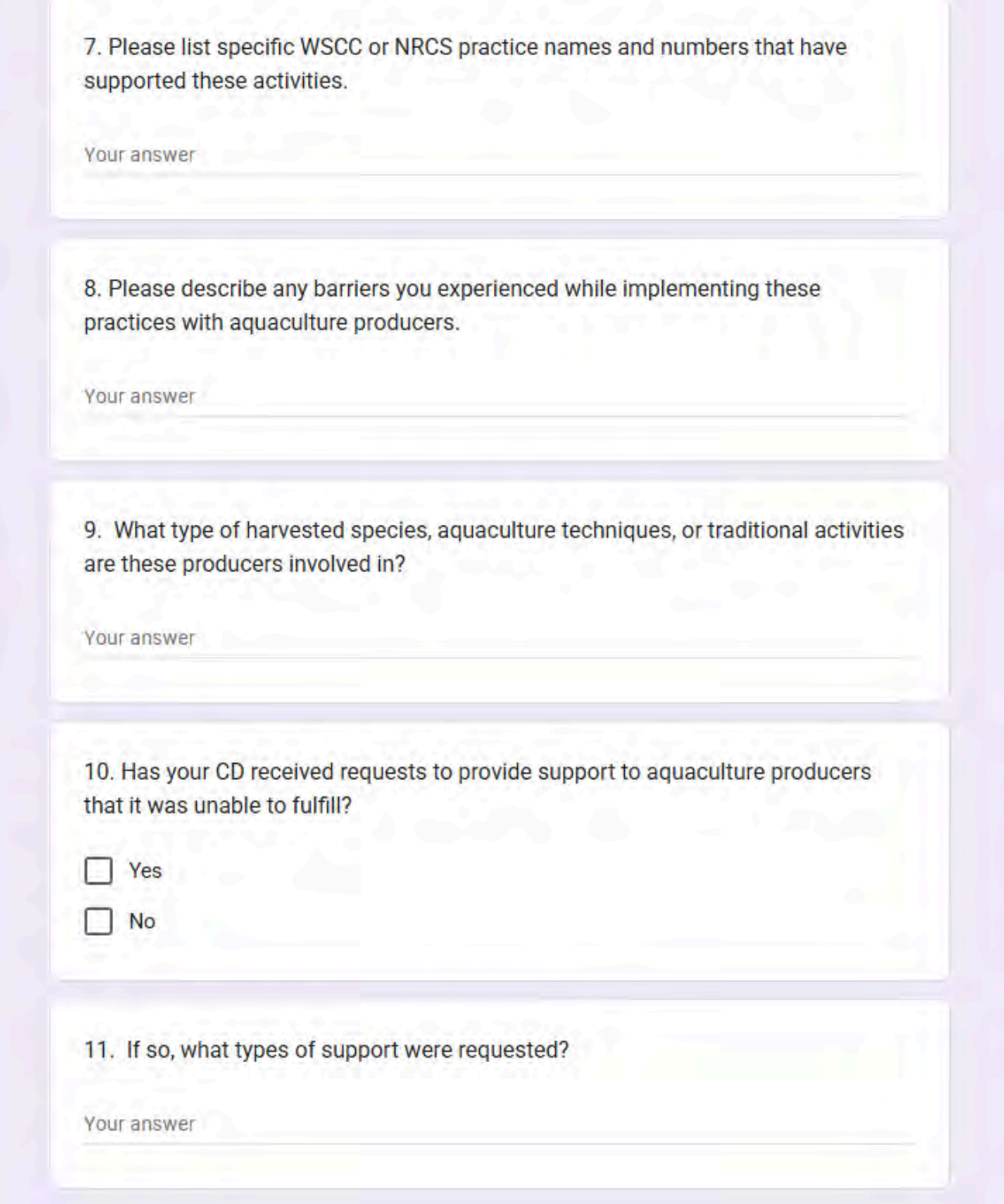


Figure A-3. Survey (page #3 of 5) sent virtually to Washington's Coastal Conservation Districts

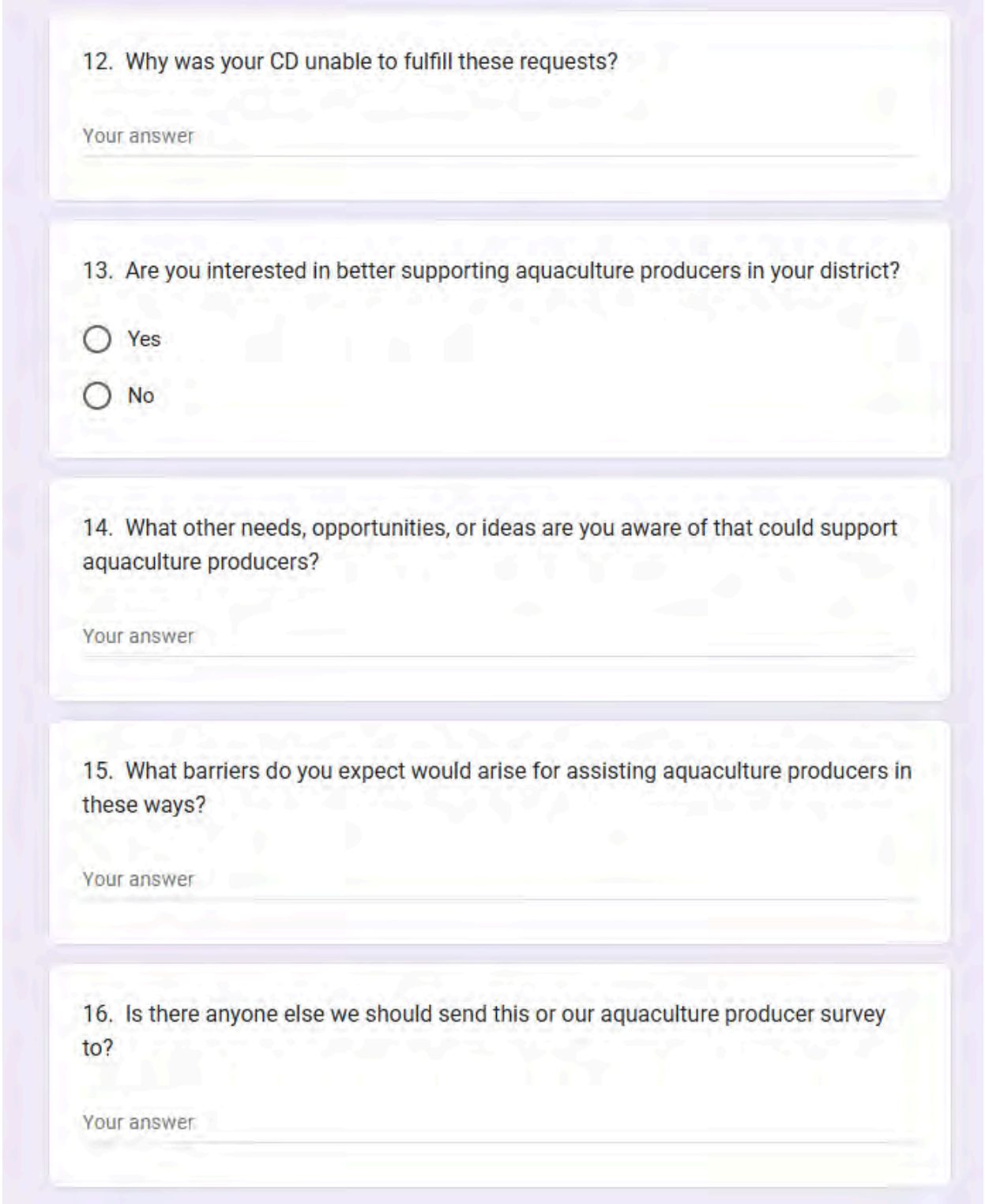


Figure A-4. Survey (page #4 of 5) sent virtually to Washington's Coastal Conservation Districts

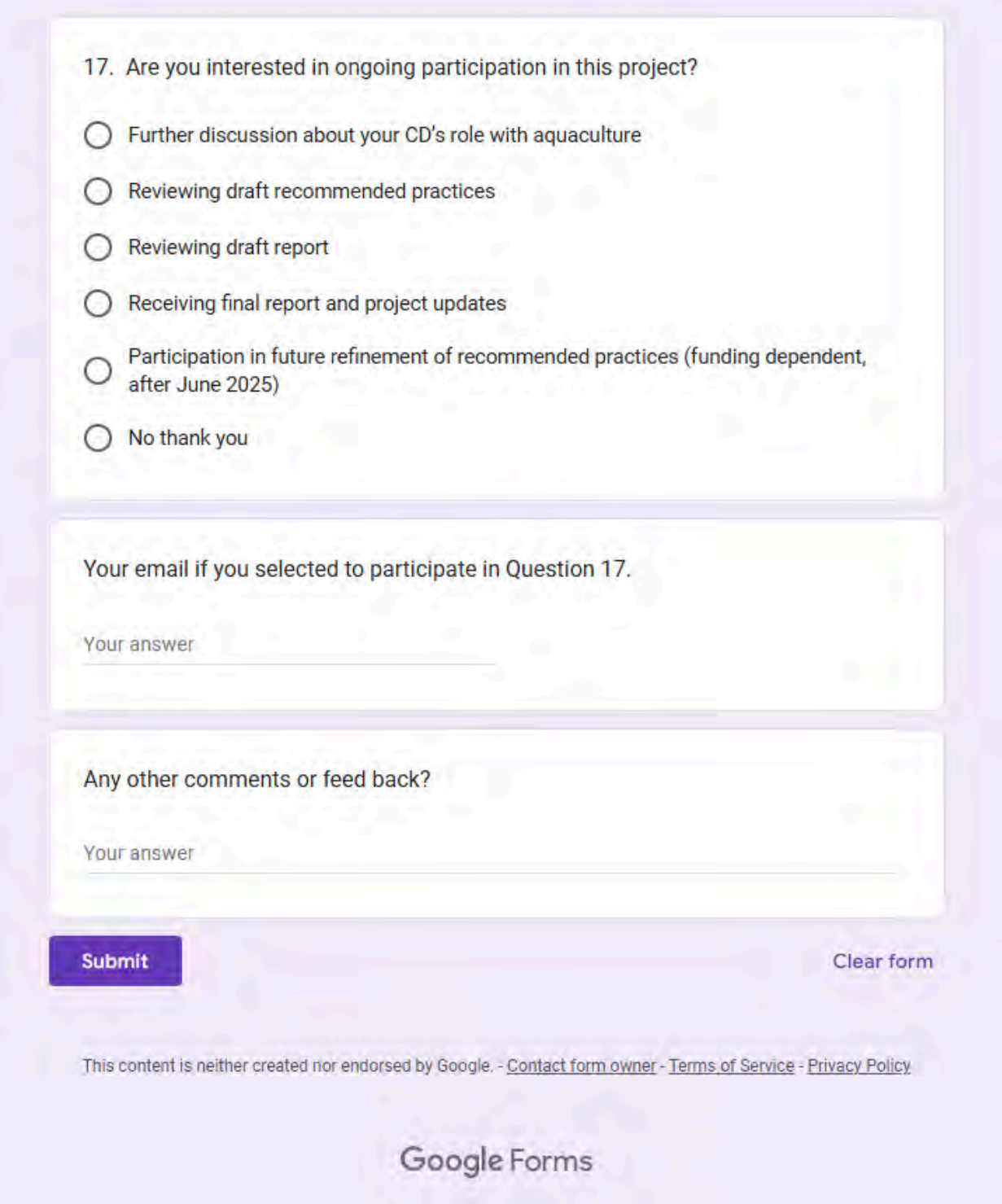
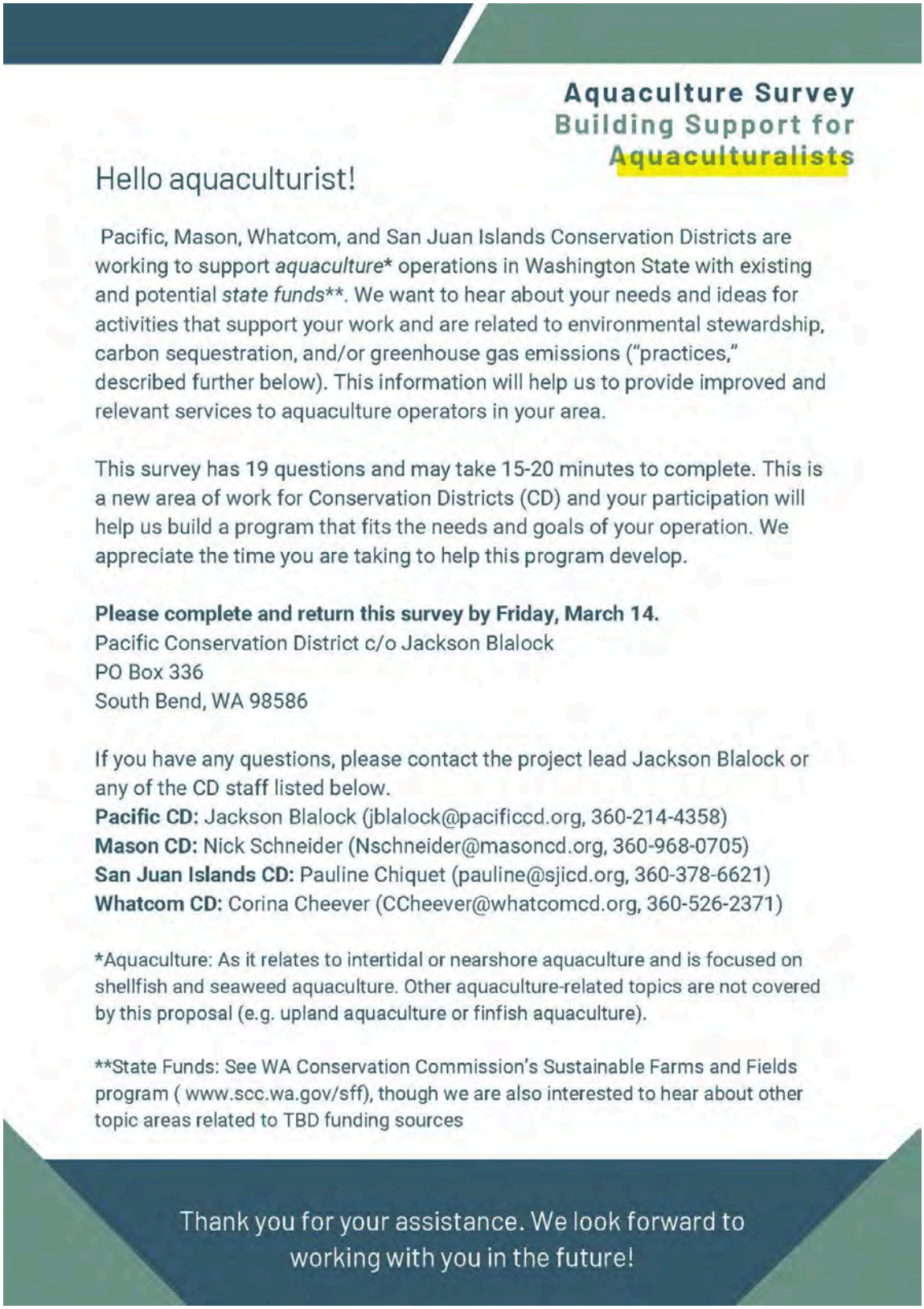


Figure A-5. Survey (page #5 of 5) sent virtually to Washington's Coastal Conservation Districts



Aquaculture Survey
Building Support for Aquaculturalists

Hello aquaculturist!

Pacific, Mason, Whatcom, and San Juan Islands Conservation Districts are working to support *aquaculture** operations in Washington State with existing and potential *state funds***. We want to hear about your needs and ideas for activities that support your work and are related to environmental stewardship, carbon sequestration, and/or greenhouse gas emissions ("practices," described further below). This information will help us to provide improved and relevant services to aquaculture operators in your area.

This survey has 19 questions and may take 15-20 minutes to complete. This is a new area of work for Conservation Districts (CD) and your participation will help us build a program that fits the needs and goals of your operation. We appreciate the time you are taking to help this program develop.

Please complete and return this survey by Friday, March 14.
Pacific Conservation District c/o Jackson Blalock
PO Box 336
South Bend, WA 98586

If you have any questions, please contact the project lead Jackson Blalock or any of the CD staff listed below.
Pacific CD: Jackson Blalock (jblalock@pacificcd.org, 360-214-4358)
Mason CD: Nick Schneider (Nschneider@masoncd.org, 360-968-0705)
San Juan Islands CD: Pauline Chiquet (pauline@sjicd.org, 360-378-6621)
Whatcom CD: Corina Cheever (CCheever@whatcomcd.org, 360-526-2371)

*Aquaculture: As it relates to intertidal or nearshore aquaculture and is focused on shellfish and seaweed aquaculture. Other aquaculture-related topics are not covered by this proposal (e.g. upland aquaculture or finfish aquaculture).

**State Funds: See WA Conservation Commission's Sustainable Farms and Fields program (www.scc.wa.gov/sff), though we are also interested to hear about other topic areas related to TBD funding sources

Thank you for your assistance. We look forward to working with you in the future!

Figure A-6. Survey (page #1 of 7) mailed to all aquaculture operations licensed by Washington State Department of Health.

Practices that assist aquaculture and carbon sequestration

Many conventional agricultural practices release CO2 (carbon dioxide) into the atmosphere. Carbon farming includes a suite of farming practices that do the reverse—they capture CO2 out of the atmosphere and store it as organic matter or biomass in soils, plants, algae, and shellfish. This process of capturing and storing CO2, often referred to as carbon sequestration, is one method of reducing the amount of CO2 in the atmosphere with the goal of reducing global climate change. Practices that sequester carbon can receive funding through WA State Conservation Commission. Example activities could include:

- Minimizing impacts to benthic substrates and biofilms
- Minimizing impacts to eelgrass (and in turn, assisting with permitting)
- Conservation easements and conservation buffers

1. If carbon-sequestering activities could bring funds/assistance to your organization or farm, would you be interested? Select only one.

☐ Yes ☐ No ☐ Other: _____

2. How does carbon sequestration relate to your work or the environment you work in?

_____

_____

_____

_____

_____

3. What carbon sequestration-related activities could be useful for your organization or farm? Please include any ideas, whether mentioned above or not, even if they are not tested out yet.

_____

_____

_____

_____

_____

4. What barriers do you expect to arise for assisting aquaculture producers in these ways? Select all that apply.

☐ regulatory issues ☐ financial issues

☐ lack of landowner/grower interest ☐ technical or knowledge-based issues

☐ limited effectiveness or practicality of activity

☐ Other: _____

Figure A-7. Survey (page #2 of 7) mailed to all aquaculture operations licensed by Washington State Department of Health.

Practices that support aquaculture and greenhouse gas reduction

Carbon farming also encompasses practices that reduce fossil fuel use and associated greenhouse gas emissions. The main greenhouse gases of concern within agriculture are carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O).
Example activities could include:

- Energy audits and upgrades (for example, boat engines or water heaters)
- GPS guidance systems
- Plastic recycling or waste-reduction

5. If greenhouse gas-reducing activities could bring funds/assistance to your organization or farm, would you be interested? Select only one.

☐ Yes ☐ No ☐ Other: _____

6. How does greenhouse gas reduction relate to your work or the equipment you work with?

_____

_____

_____

_____

_____

7. What greenhouse gas reduction-related activities could be useful for your organization or farm? Please include any ideas, whether mentioned above or not, even if they are not tested out yet.

_____

_____

_____

_____

_____

8. What barriers do you expect to arise for assisting aquaculture producers in these ways? Select all that apply.

☐ regulatory issues ☐ financial issues
☐ lack of landowner/grower interest ☐ technical or knowledge-based issues
☐ limited effectiveness or practicality of activity
☐ Other: _____

Figure A-8. Survey (page #3 of 7) mailed to all aquaculture operations licensed by Washington State Department of Health.

What did we miss?

9. What are some of your organization/farm's priority issues related to environmental stewardship or infrastructure? Please list your top 3, but feel free to share more if you'd like.

_____

_____

_____

_____

_____

10. What activities have you tried to implement but have been unsuccessful?

_____

_____

_____

_____

_____

11. What barriers do you expect to arise for assisting aquaculture producers in these ways? Select all that apply.

- ☐ regulatory issues
- ☐ financial issues
- ☐ lack of landowner/grower interest
- ☐ technical or knowledge-based issues
- ☐ limited effectiveness or practicality of activity
- ☐ Other: _____

12. Have you worked with...?

	Yes	No	I would like to work with in the future.
Local Conservation Districts (CD's)	☐	☐	☐
WA State Conservation Commission (WSCC)	☐	☐	☐
Natural Resources Conservation Service (NRCS)	☐	☐	☐

Figure A-9. Survey (page #4 of 7) mailed to all aquaculture operations licensed by Washington State Department of Health.

13. In general, how would you like CDs, WSCC, or NRCS to support your organization or farm?

Next Steps

14. Is there anyone else we should send this survey to?

15. Are you interested in ongoing participation in this project, which runs through June 2025? Select all that apply. IF you select A-D, please also write your email below.

- ☐ Reviewing draft recommended practices
- ☐ Reviewing draft report
- ☐ Receiving fnal report and project updates
- ☐ Participation in future use or refinement of practices identified by this survey
  (funding dependent, after June 2025)
  limited effectiveness or practicality of activity
- ☐ Not Interested

Email: _____

16. Any other comments or feedback?

Figure A-10. Survey (page #5 of 7) mailed to all aquaculture operations licensed by Washington State Department of Health.

Overview of your farm/organization's activities

17. Where is your organization/farm located? Select only one.

- ☐ North Puget Sound
- ☐ Central Puget Sound
- ☐ South Puget Sound
- ☐ Hood Canal
- ☐ Willapa Bay
- ☐ Grays Harbor
- ☐ Outside of Washington State

18. How big is your production area? Select only one.

- ☐ Small (less than 500 acres)
- ☐ Medium (500-1500 acres)
- ☐ Large (1500+ acres)
- ☐ Other: _____

19. What types of aquaculture or related traditional activities is your organization/farm involved in? Please fill out all that apply in the questions below. For other types of aquaculture operations please use the "Other" section on the next page.

What types of commercial shellfish? (Please specify species and culture type)

_____

_____

_____

What types of hobby shellfish? (Please specify species and culture type)

_____

_____

_____

What types of commercial seaweed/algae? (Please specify species and culture type)

_____

_____

_____

What types of hobby seaweed/algae? (Please specify species and culture type)

_____

_____

_____

Figure A-11. Survey (page #6 of 7) mailed to all aquaculture operations licensed by Washington State Department of Health.

If your farm or organization is not involved in commercial or hobby seaweed/algae or shellfish operations please use the lines below to describe your operations. (Please specify species and culture type)

_____

_____

_____

_____

_____

We appreciate your responses!

Thank you for taking the time to fill out this survey. Come find our information table at the Washington Sea Grant Annual Shellfish Growers Conference and say hi.

If you have any questions, please contact the project lead Jackson Blalock or any of the CD staff listed below.

Pacific CD: Jackson Blalock (jblalock@pacificcd.org, 360-214-4358)

Mason CD: Nick Schneider (Nschneider@masoncd.org, 360-968-0705)

San Juan Islands CD: Pauline Chiquet (pauline@sjicd.org, 360-378-6621)

Whatcom CD: Corina Cheever (CCheever@whatcomcd.org, 360-526-2371)

Figure A-12. Survey (page #7 of 7) mailed to all aquaculture operations licensed by Washington State Department of Health.

Figure A-13. Front of postcard used during outreach (e.g. while tabling at Washington Sea Grant's 2025 Conference for Shellfish Growers) to solicit grower input (side #1 of 2).

Figure A-14. Back of postcard used during outreach (e.g. while tabling at Washington Sea Grant's 2025 Conference for Shellfish Growers) to solicit grower input (side #2 of 2).

Figure A-15. Trifold brochure (panel #1 of 4) used during outreach (e.g. while tabling at Washington Sea Grant's 2025 Conference for Shellfish Growers) to solicit grower input.

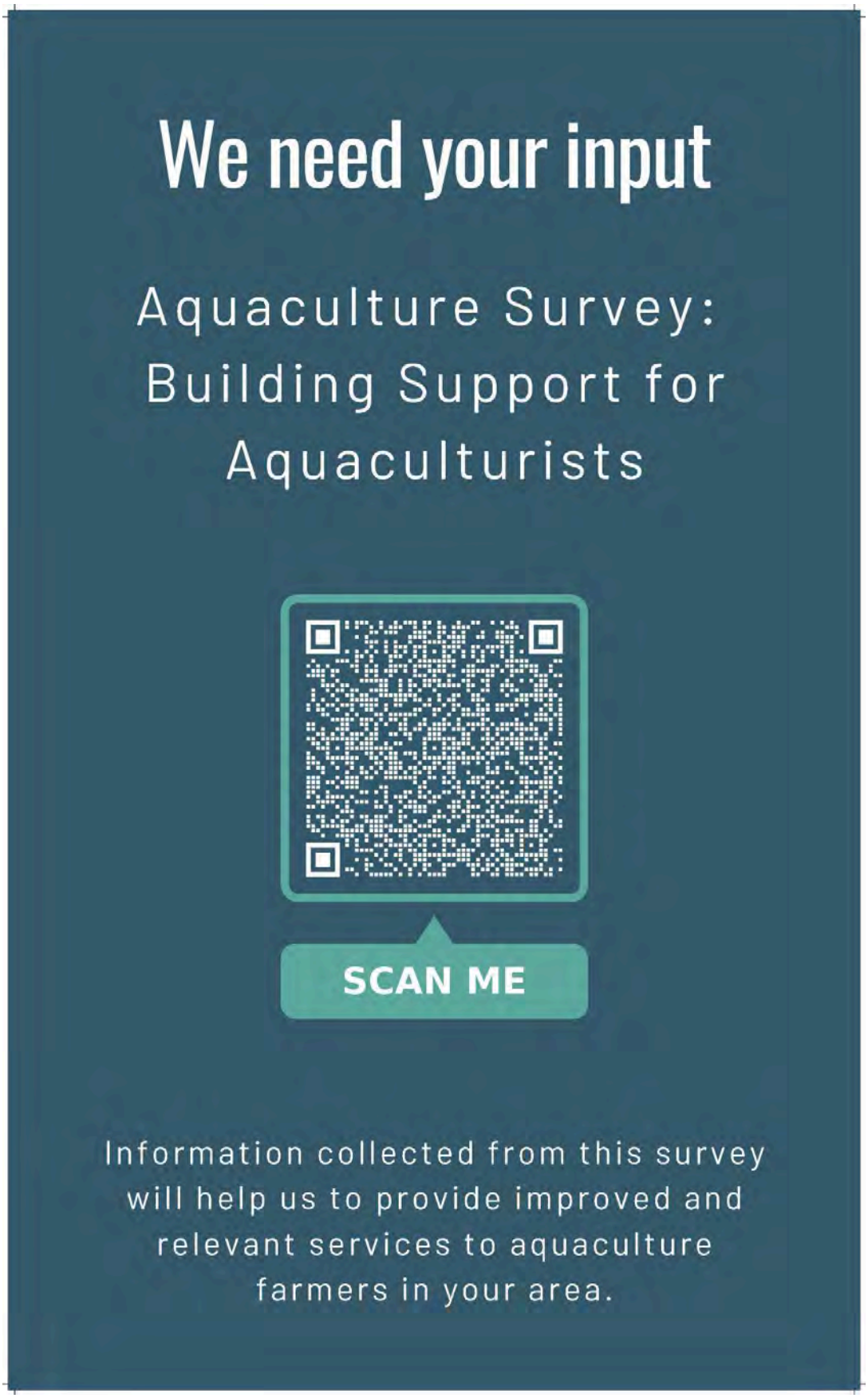
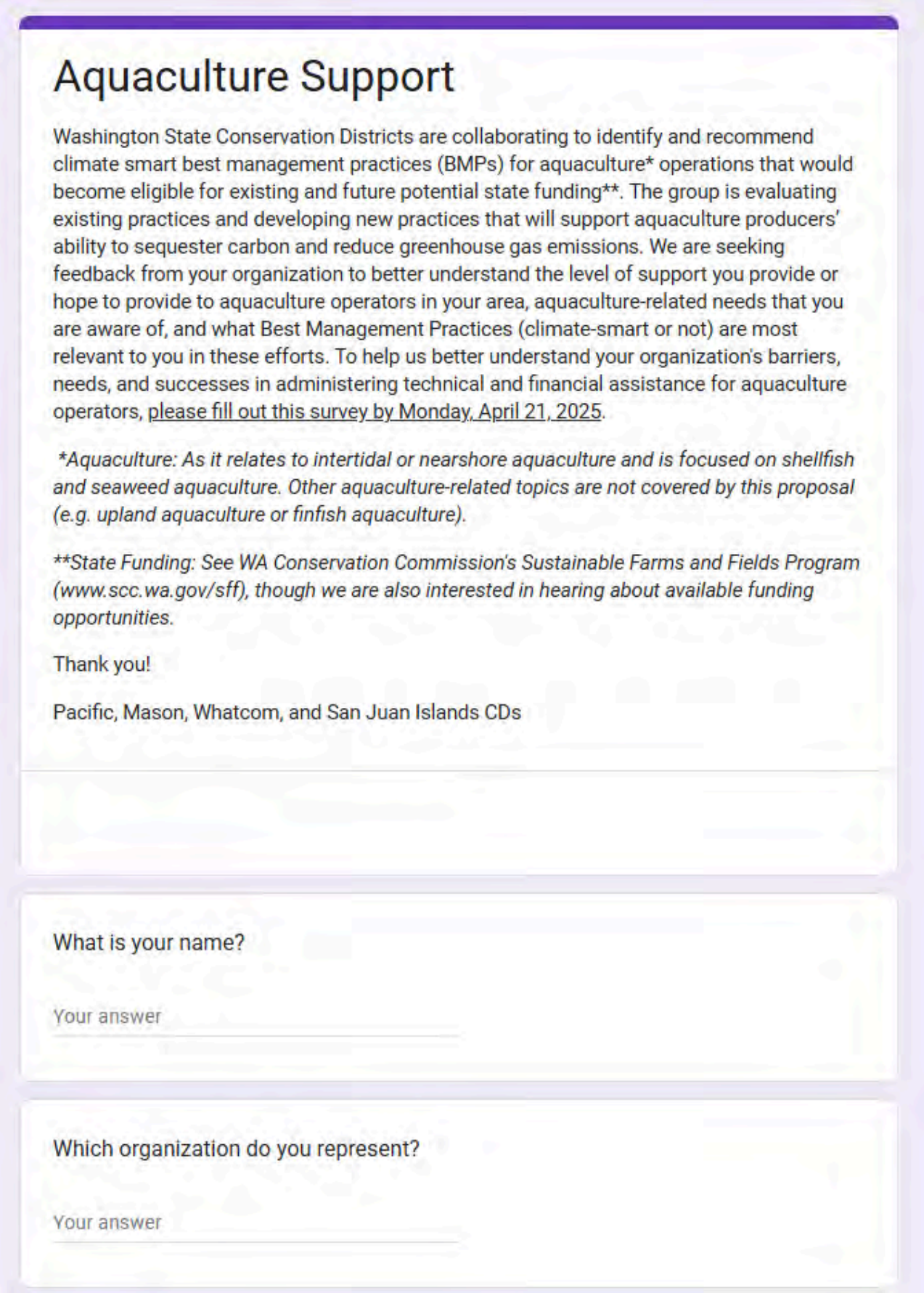


Figure A-16. Trifold brochure (panel #2 of 4) used during outreach (e.g. while tabling at Washington Sea Grant's 2025 Conference for Shellfish Growers) to solicit grower input.

Figure A-17. Trifold brochure (panel #3 of 4) used during outreach (e.g. while tabling at Washington Sea Grant's 2025 Conference for Shellfish Growers) to solicit grower input.

Figure A-18. Trifold brochure (Image #4 of 4) used during outreach (e.g. while tabling at Washington Sea Grant's 2025 Conference for Shellfish Growers) to solicit grower input.



Aquaculture Support

Washington State Conservation Districts are collaborating to identify and recommend climate smart best management practices (BMPs) for aquaculture* operations that would become eligible for existing and future potential state funding**. The group is evaluating existing practices and developing new practices that will support aquaculture producers' ability to sequester carbon and reduce greenhouse gas emissions. We are seeking feedback from your organization to better understand the level of support you provide or hope to provide to aquaculture operators in your area, aquaculture-related needs that you are aware of, and what Best Management Practices (climate-smart or not) are most relevant to you in these efforts. To help us better understand your organization's barriers, needs, and successes in administering technical and financial assistance for aquaculture operators, please fill out this survey by Monday, April 21, 2025.

**Aquaculture: As it relates to intertidal or nearshore aquaculture and is focused on shellfish and seaweed aquaculture. Other aquaculture-related topics are not covered by this proposal (e.g. upland aquaculture or finfish aquaculture).*

***State Funding: See WA Conservation Commission's Sustainable Farms and Fields Program (www.scc.wa.gov/sff), though we are also interested in hearing about available funding opportunities.*

Thank you!

Pacific, Mason, Whatcom, and San Juan Islands CDs

What is your name?

Your answer

Which organization do you represent?

Your answer

Figure A-19. Survey (page #1 of 4) to technical assistance providers and researchers.

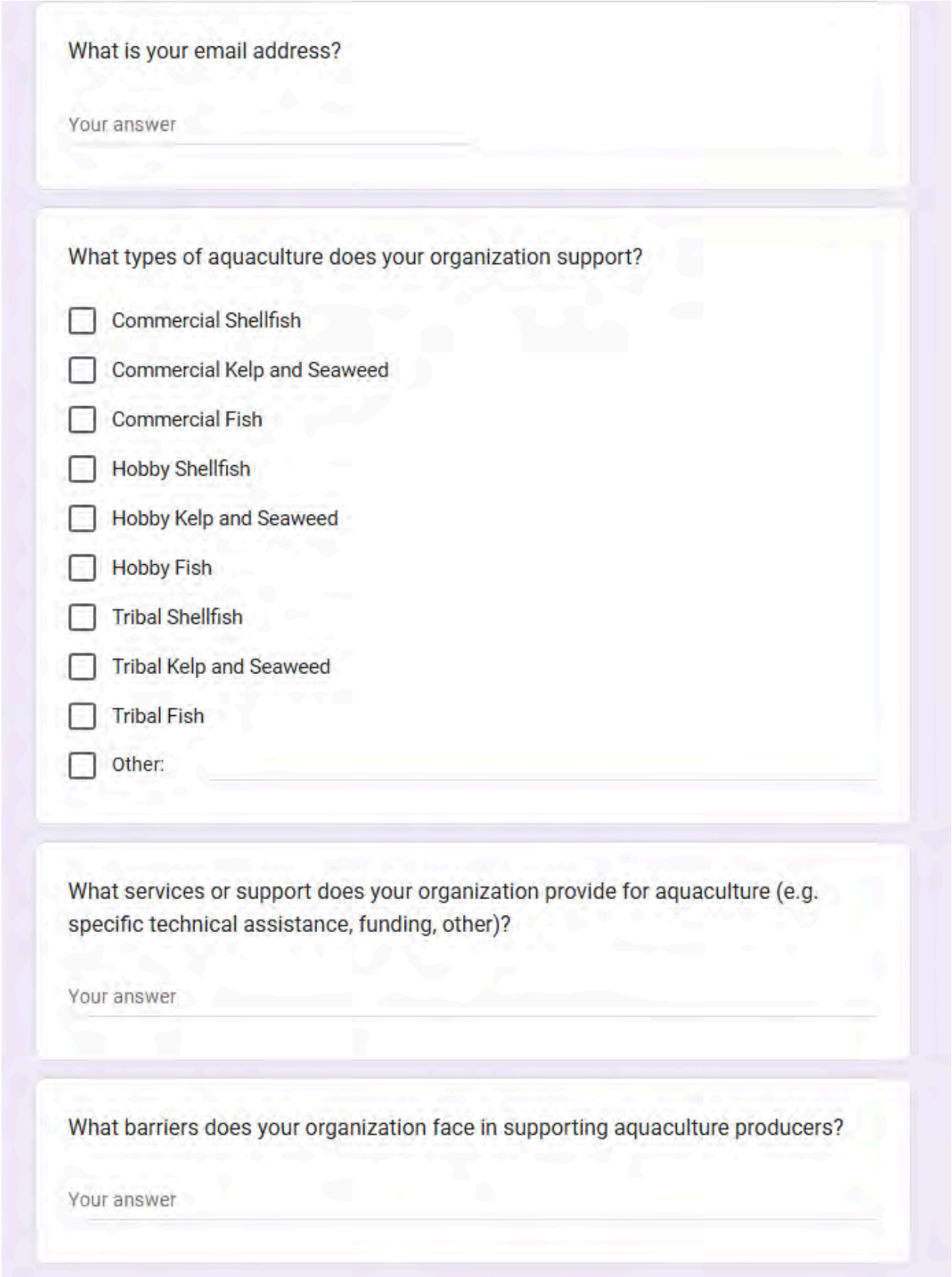


Figure A-20. Survey (page #2 of 4) to technical assistance providers and researchers.

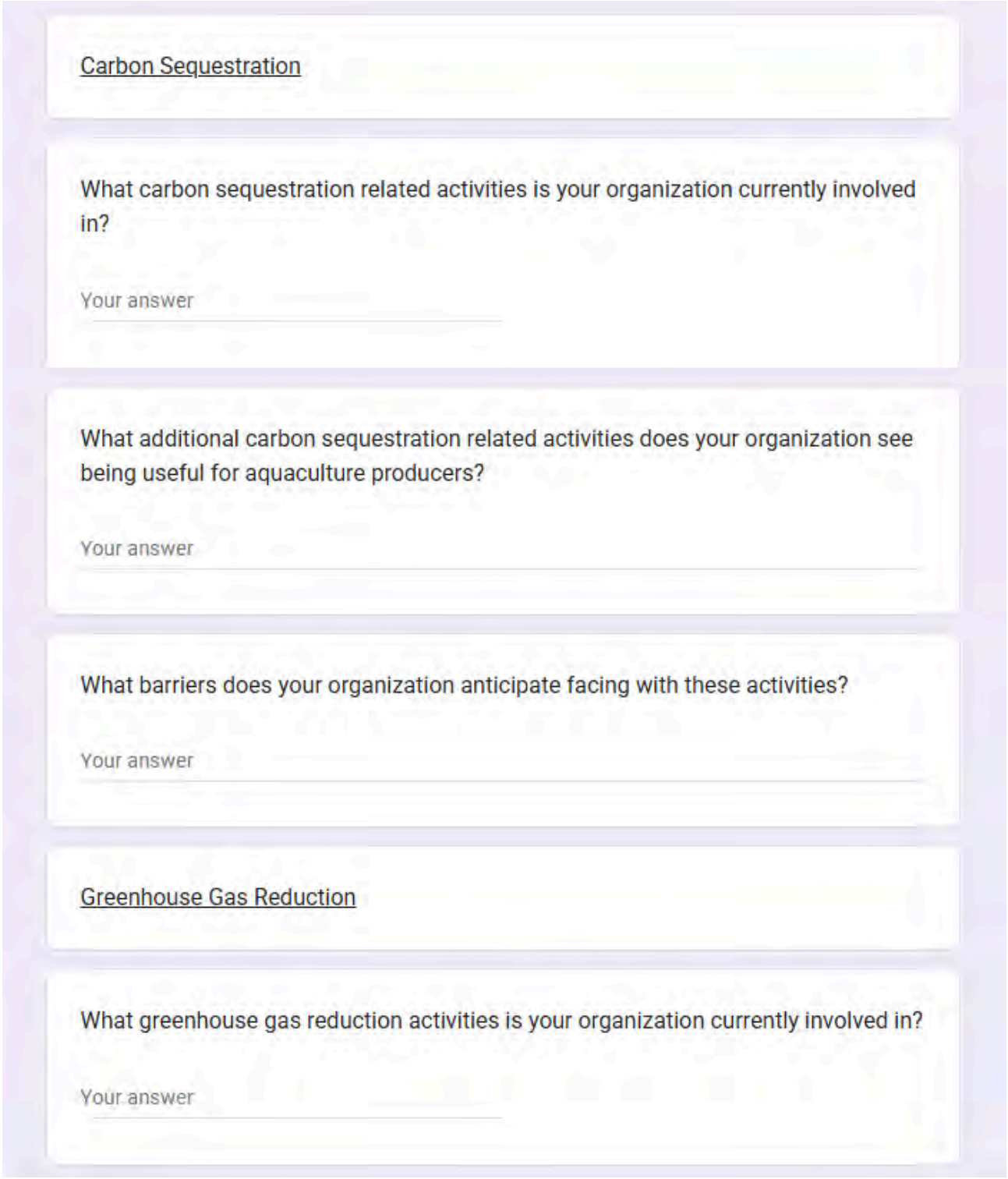


Figure A-21. Survey (page #3 of 4) to technical assistance providers and researchers.

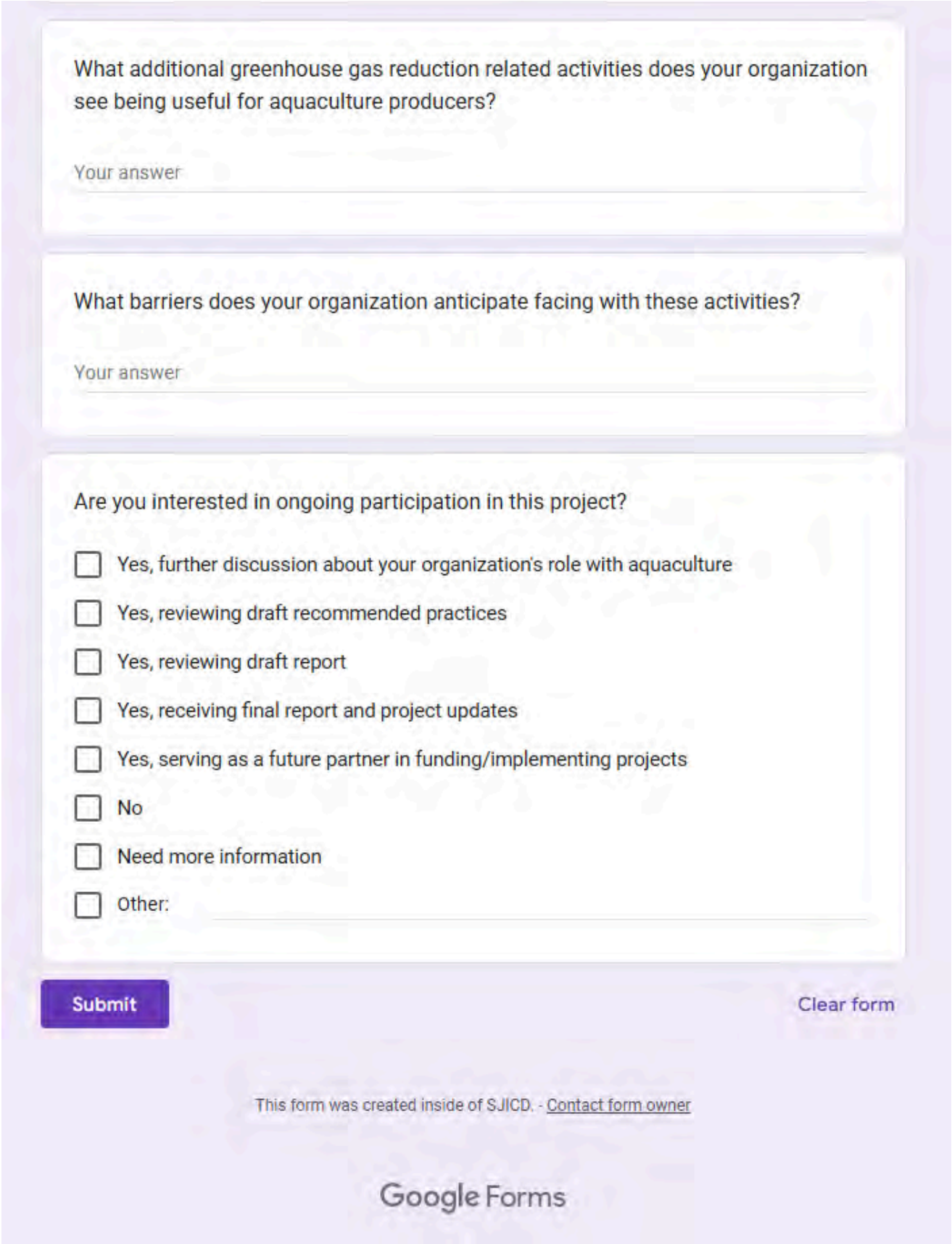
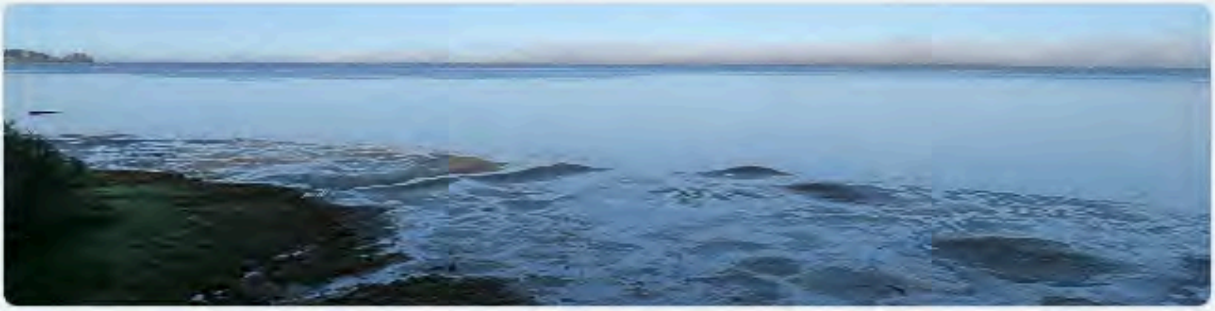


Figure A-22. Survey (page #4 of 4) to technical assistance providers and researchers.



Aquaculture + Conservation Districts: survey

Washington State Conservation Districts are collaborating to recommend climate smart practices for shellfish and/or seaweed aquaculture, which could become eligible for funding via Washington State Conservation Commission. The below survey describes draft practices from our outreach to-date. Please share your perspective so Conservation Districts can better support aquaculture.

Responses to this survey will be accepted until Monday, June 9. If you are viewing on a cell phone, the survey will be more readable if you hold the phone in landscape orientation.

Thank you very much!
Pacific, Mason, Whatcom, and San Juan Islands CDs

Name

Your answer

Email

Your answer

Figure A-23. Survey (page #1 of 4) to interested growers to review recommended practices.

Organization

Your answer

Please prioritize each practice for your organization, if funding were available

	Unsure what this is	Not interested	Interested	Very interested
1. Minimizing sediment/benthic disturbance	○	○	○	○
2. Increase in-water oyster shell volumes and shellfish production	○	○	○	○
3. Multitrophic or diversified aquaculture	○	○	○	○
4. Wild harvest	○	○	○	○
5. Modify light penetration of overwater structures	○	○	○	○
6. Stewardship of seagrasses and seaweeds	○	○	○	○
7. Coordination or collaboration with other local restoration and stewardship activities	○	○	○	○

Figure A-24. Survey (page #2 of 4) to interested growers to review recommended practices.

8. Plastics recycling	○	○	○	○
9. Reduction in plastics use and use of environmentally friendly plastics	○	○	○	○
10. Electrification, equipment upgrades, and reductions in fossil fuel use	○	○	○	○
11. Energy production and storage	○	○	○	○
12. Local market access or development	○	○	○	○
13. Credit banking and easements for aquatic lands	○	○	○	○
14. Carbon farm planning and assessment	○	○	○	○
15. Greenhouse Gas farm planning and assessment	○	○	○	○

5. Please share more about your #1 priority practice: How would you do this? How could we overcome obstacles? Who is already doing this?

Your answer

Figure A-25. Survey (page #3 of 4) to interested growers to review recommended practices.

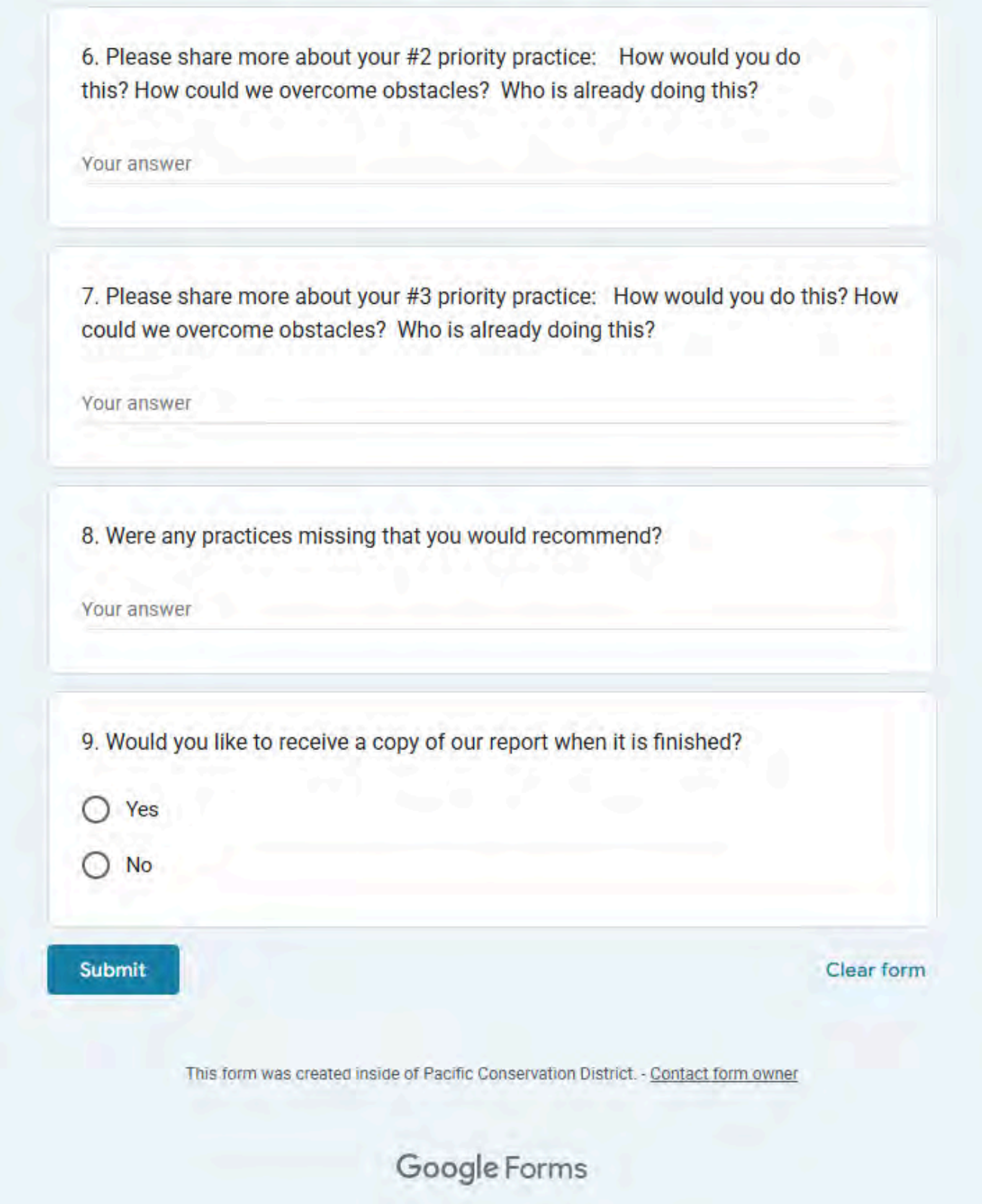


Figure A-26. Survey (page #4 of 4) to interested growers to review recommended practices.

Appendix B: Conservation Districts survey results

A. District Respondent Demographic

This survey was sent out to all Washington State Conservation Districts (CDs), both coastal and non-coastal. Twelve Washington State conservation districts replied to the Aquaculture Survey for Conservation Districts (Figure B-1). The Districts represented by this survey are:

- San Juan Islands CD
- Whidbey Island CD
- Pacific CD
- Skagit CD
- Ferry CD
- Thurston CD
- Grays Harbor CD
- Lewis CD
- Whatcom CD
- Pierce CD
- Jefferson CD
- Mason CD

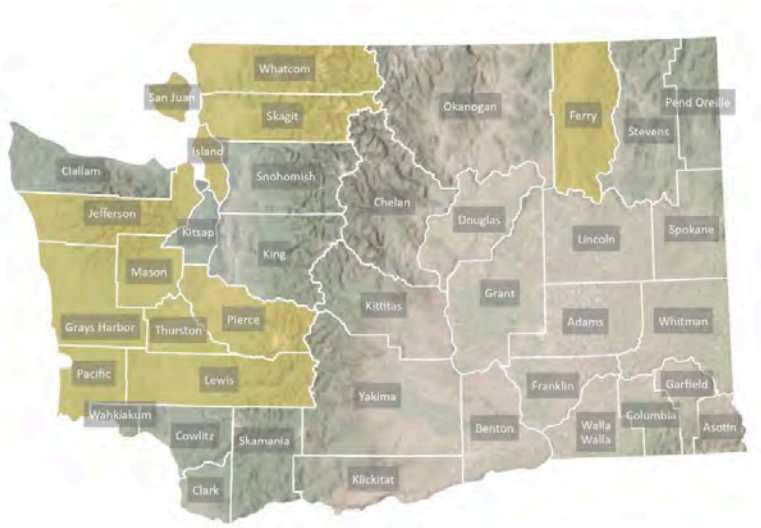


Figure B-1. Location of the 12 CDs that responded to the aquaculture survey.

In these counties, marine aquaculture activities include shellfish farming (mussels, oysters, Manila clams, razor clams, basket cockles, butter clams, geoduck), crabbing, seaweed farming, kelp restoration, eelgrass restoration, hatcheries, and private fish farming. These activities are represented by commercial operations, recreational harvests, tribes, and hatcheries/nurseries.

Of these twelve CDs, six had a shellfish farmer or tribal representative on their board.

B. District Involvement in Aquaculture

Of the twelve respondent counties, only two (Whatcom and Pacific CDs) are directly involved in shellfish farming or harvesting activities. Seven other CDs are indirectly involved in aquaculture through work with water quality, public education and outreach, off-farm habitat restoration, or invasive species removal (Figure B-2). Two of these seven are currently working directly with aquaculture producers on activities indirectly related to aquaculture.

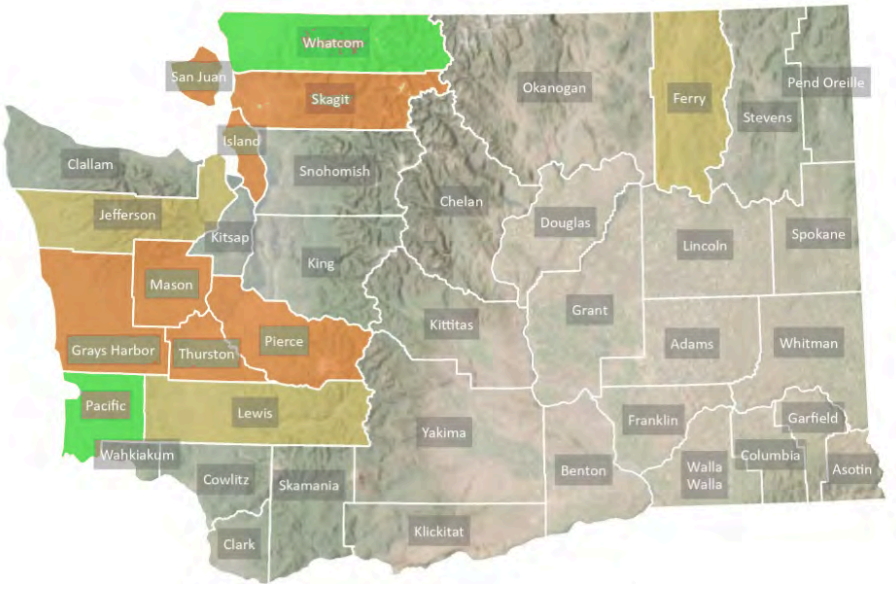


Figure B-2. CDs directly involved with on-farm shellfish farming or harvesting activities (green, 2); CDs involved indirectly via water quality, public education, off-farm habitat restoration, or invasive species removal (orange, 7); and CDs who responded to the survey but are not involved in aquaculture (yellow, 3).

Of the CDs directly working in aquaculture, the following are examples of current projects underway:

Demonstration Projects	
• Precision oyster harvest	• Demonstration oyster gardens
• Oyster and geoduck farm tour	
Research Projects	
• Sediment dynamics	
Working Groups	
Farm Plan Development	
Technical Assistance	
• Ongoing research	• Policy and planning impacts
• Best management practice advising	• Invasive species removal
Restoration Projects	
• Oyster bed restoration	• Site incubators
Education	

• Youth engagement	

Other indirect work includes:

- Marine Restoration
    - Eelgrass restoration
- Upland Conservation
    - Shoreline and salt marsh restoration
    - Farm planning, technical assistance, and financial assistance for upland agriculture operations
    - Fecal coliform monitoring

C. Existing Aquaculture Practices

Only one district reported successfully using SCC or NRCS practices to directly support aquaculture operations. These practices include:

- Bivalve Aquaculture Gear and Biofouling Control (NRCS 400)
- Herbaceous Weed Treatment (NRCS 315)
- Integrated Pest Management Plan (NRCS 114)

Many other practices have been utilized in upland areas for water quality enhancement. Among these are:

- Waste Storage Facility (NRCS 313)
- Heavy Use Area Protection (NRCS 561)
- Livestock Exclusion Fence (NRCS 382)
- Riparian Forest Buffer (NRCS 391)
- Diversion (NRCS 362)
- Roof Runoff Structures (NRCS 558)
- Waste Transfer (NRCS 634)
- Dynamic Revetment (SCC 46)

D. Barriers to Directly Supporting Aquaculture Producers

CDs have reported on different barriers to supporting aquaculture producers. Regulatory backstops are one of the biggest limiting factors for engaging with conservation on aquaculture farms. One of the regulatory difficulties CDs navigate when working with aquaculture producers is the stringent regulations on eelgrass disturbance which creates an environment of distrust for producers who work in eelgrass areas for fear of recrimination and for the barriers it causes on expansion. Another difficulty in regulation is permitting. Permits are both difficult for aquaculture producers to acquire and often not geared towards the nuances of aquatic dynamics.

The second biggest barrier to supporting aquaculture producers is a lack of applicable practices and available funding directly available for aquaculture producers. There is a demonstrable need for ongoing funding to support marine and shoreline restoration. Because much of this work is still in development and under research, there is often not a shovel-ready solution to resource concerns in the same way that there are for upland agriculture operations

In addition to these difficulties, there is no state agency taking the lead on aquaculture, and permitting for management of invasive and/or nuisance species, for example, is much more challenging than in terrestrial environments.

Because of the difficulty of navigating regulatory uncertainties, aquaculture producers are hesitant to seek conservation assistance for fear and mistrust of the additional permits this might generate.

E. Requests from Producers

Approximately half of CDs reported receiving requests they could not field, although most CDs would be interested in better supporting aquaculture producers. Of those who did receive requests, requests included the following:

- Conservation easement assistance
- Cost share for practices not linked to a BMP (i.e., processing and floating bag purchases)
- Harvest closure support
- Upland erosion mitigation
- Invasive species removal (burrowing shrimp and European green crab)
- Repair of failing septic systems
- Support for artificial reef installation
- Water filtration assistance
- Energy audits

CDs were unable to meet these requests due to a lack of program infrastructure, lack of available BMPs and funding, scale of funding needed to address concerns, regulatory hurdles, limited staff capacity, and inexperience of funders with aquaculture practices.

F. Future Potential Support of Aquaculture Producers

When asked where CDs envisioned providing future support of aquaculture producers, they replied by listing the following areas of need and desired future involvement:

- Land-lease agreements for marine carbon credits
- Clear guidelines from NRCS and SCC on how to address aquaculture
- Fuel efficiency
- Infrastructure improvements
- Hatchery support
- Permitting hurdles
- Supply chain disruptions
- Small farm resilience
- Waste reduction
- Joint habitat restoration projects in aquaculture growing areas
- Minimizing sediment disturbance
- Reduced GHG emissions and increased carbon sequestration
- Invasive species removal

Engaging in these areas of need will require increased scaffolding from NRCS and SCC in defining the ways CDs can support aquaculture operations. Likely resource concerns and best management practices will need to be developed specifically with these producers in mind.

Once scaffolding and funding is in place, CDs will need to conduct outreach and education to bring growers on board to participate in program offerings. CDs will need to leverage messaging in support of a non-regulatory, voluntary, and incentive-based landscape under which we operate. The hope is that aquaculture producers can be supported just as terrestrial based producers are supported today, which will take time and resources.

Appendix C: Literature review results

1. Abt Associates Inc. (2008). *Ecological and economic impacts and invasion management strategies for the European Green Crab.* https://www.epa.gov/sites/default/files/2017-12/documents/ee-0513-01.pdf

   Topic(s): Oysters
   The 2008 report provides an examination of the invasive European green crab (Carcinus maenas), highlighting its significant ecological and economic impacts. Ecologically, green crabs are aggressive and adaptable predators that disrupt native food webs by consuming a wide variety of prey including clams, mussels, and juvenile fish. Their foraging and burrowing behavior also contributes to the degradation of eelgrass beds—critical nursery habitat for many marine species—thereby compounding their ecological harm. Their tolerance to a broad range of environmental conditions has allowed them to rapidly spread across U.S. coastlines, with especially pronounced effects in estuarine environments.
   Economically, green crabs have caused major losses to the commercial shellfish industry, with annual damages estimated at over $44 million, including $22.6 million to shellfisheries alone. In response, the report outlines several key management strategies aimed at mitigating these impacts. These include early detection and rapid response protocols to contain new invasions, coordinated monitoring programs, public education initiatives, and targeted removal efforts in high-priority areas. It also recommends integrating ecological and economic modeling to inform cost-effective decision-making and resource allocation. Overall, the report underscores the urgent need for proactive, science-based management to limit the spread and reduce the long-term consequences of green crab invasions on coastal ecosystems and economies.

2. Alleway, H., Jones, A., Jones, R., McAfee, D., Reis-Santos, P., & Theuerkauf, S. (2022). *Climate-friendly seafood: the potential for emissions reduction and carbon capture in marine aquaculture.* Oxford Academic Journals: Bioscience. https://doi.org/10.1093/biosci/biab126

   Topic(s): Shellfish, Carbon, Eelgrass
   This publication focuses on potential ways to make bivalve aquaculture more carbon friendly. The researchers suggest supporting seagrasses and provide citations of projects that demonstrate how oysters can help seagrasses. Another big focus in this publication is on the secondary use of oyster shells, and their potential for carbon sequestration. The researchers highlighted floating bivalve aquaculture as a way to give space for seagrasses and explored the potential of co-cultivation of seagrasses with seaweed.

3. Apostolaki, G, Fourqurean, J., Duarte, C., Kennedy, H., Marbà, N., Holmer, M., Mateo, M., Kendrick, G., Krause-Jensen, D., McGlathery, K., & Serrano, O. (2012). *Seagrass ecosystems as a globally significant carbon stock. Nature* Geoscience (5, 505–509). https://doi.org/10.1038/ngeo1477

   Topic(s): Seagrass
   When discussing carbon storage many people are inclined to think about the importance of protecting forests as a way to increase stored carbon and mitigate climate change. In this publication, researchers shine a light on the “blue carbon” storage potential in coastal ecosystems. The methods conducted in this project evaluated “measurements of the organic carbon content of living seagrass biomass and underlying soils in 946 distinct seagrass

meadows across the globe". The researchers estimate that "globally, seagrass ecosystems could store as much as 19.9 Pg organic carbon; according to a more conservative approach, in which we incorporate more data from surface soils and depth-dependent declines in soil carbon stock, we estimate that the seagrass carbon pool lies between 4.2 and 8.4 Pg carbon. We estimate that present rates of seagrass loss could result in the release of up to 299 Tg carbon per year, assuming that all of the organic carbon in seagrass biomass and the top metre of soils is remineralized."

4. Apostolaki, E., Reid, G., Howarth, L., Lewis-McCrea, L., & Kellogg, L. (2022). *Aquaculture and eelgrass Zostera marina interaction in temperate ecosystems.* Aquaculture Environment Interactions (14, 15-34). https://doi.org/10.3354/aei00426

   Topic(s): Shellfish, Eelgrass
   This paper examines the effects of shellfish and finfish aquaculture on eelgrass (Zostera marina), a widely distributed seagrass in the northern hemisphere. Shellfish aquaculture shows a range of impacts on eelgrass, from beneficial—such as improving water clarity and providing nutrients through bivalve filtering and bio deposits—to detrimental, primarily due to shading and sedimentation, which are most severe close to the farms. In contrast, the impacts of finfish aquaculture are less understood, with limited and inconclusive research from temperate regions, although negative effects are well-documented in Mediterranean seagrasses due to nutrient build-up and other factors.

5. Baker, P., & Baker, S. (2010). *Carbon fixation by Florida cultured clam.* University of Florida: Shellfish Aquaculture Research and Extension.
   https://shellfish.ifas.ufl.edu/projects/shellfish-farm-environment/carbon-fixation/

   Topic(s): Clams
   A study by the University of Florida's IFAS Shellfish Aquaculture Research & Extension Program found that hard clam aquaculture in Florida sequesters significant amounts of carbon. Each harvested clam contributes approximately 2.93 grams of carbon fixed in its shell, resulting in an estimated 536 metric tons of carbon sequestered by the industry in 2007.

6. Bauman, J., Carlon, D., Charles, E., DuBois, K., & Ralph, F. (2024). *Shifting seagrass-oyster interaction alter species response to ocean warming and acidification.* British Ecological Society Journal of Ecology. https://doi.org/10.1111/1365-2745.14406

   Topic(s): Oysters, Eelgrass
   This study explores how rising ocean temperatures and increasing acidity impact the relationship between oysters and eelgrass. Normally, oysters help eelgrass grow better, but eelgrass can make it harder for oysters to thrive by shifting their energy use from body growth to shell development, especially under environmental stress. When exposed to warmer waters and more acidic conditions, these interactions shift dramatically, affecting the growth and health of both species. Under the stress of warmer waters and increased acidity, the beneficial relationship between eastern oysters and eelgrass changes significantly. These environmental changes cause complex shifts in their interactions, affecting each species' growth and energy allocation differently.

7. Belknap, D. *Maine Sea Grant: DV-13-14 Invasive Green Crab Impacts on Salt Marshes.* The University of Maine Research and Development Projects. https://seagrant.umaine.edu/research/projects/dv-13-14-invasive-green-crab-impacts-on-salt-marshes/

   Topic(s): European Green Crab
   This resource explores the connections between increased populations of invasive green crab and “the widespread destruction of juvenile clams, eelgrass beds, and possible impacts on mussels and lobsters in Maine.”

8. Brown, K. (2022). *Effects of Green Crab (Carcinus maenas) across variable densities of Eelgrass (Zostera marina).* Dissertation and Theses, 5895). https://doi.org/10.15760/etd.7766

   Topic(s): European Green Crab, Eelgrass
   This master's thesis examines how invasive European green crabs impact eelgrass beds in Netarts Bay, Oregon. The study found that eelgrass beds with lower shoot densities were more vulnerable to degradation, regardless of crab presence, while plots with green crabs experienced greater overall eelgrass loss. Interestingly, the combined effects of low eelgrass density and green crab presence were not statistically significant, suggesting their impacts may be independent rather than synergistic. For restoration, the findings emphasize the importance of planting eelgrass at higher densities to improve resilience and recommend continued removal efforts to manage green crab populations and protect eelgrass habitats.

9. Bucci, J., Burge, C., Cox, R., Friedman, C., Groner, M., Staudigel, P., Van Alstyne, K., Wyllie-Echeverria, S., & Rivlin, N. (2018). *Oysters and eelgrass: potential partners in a high pCO2 ocean*. The Wiley and Ecological Society of America. http://dx.doi.org/10.1002/ecy.2393

   Topic(s): Oysters, Eelgrass
   This study investigates the interactions between Pacific oysters and eelgrass under varying levels of ocean acidification (OA). While OA poses a threat to calcifying organisms like oysters, eelgrass can utilize increased carbon from lower pH levels to enhance photosynthesis and create localized refuges of higher pH. The research shows that co-culturing eelgrass with oysters can reduce the severity of eelgrass wasting disease, although it does not significantly mitigate the negative effects of high pCO2 on oyster mass. Further studies are suggested to better understand the benefits of such co-cultures and to examine these interactions more broadly in natural settings.

10. Buhle, E., Margolis, M., & Ruesink, J. (2005). *Bang for buck: cost-effective control of invasive species with different life histories.* Department of Biology, University of Washington. https://depts.washington.edu/jlrlab/PDF/2005_EcoEcon.pdf

    Topic(s): Economics, Invasives
    This publication reviews biological and economic data on control cost options to removal of invasive species.

11. Carlton, J., Everett, R., & Ruiz, G. (1995). *Effect of oyster mariculture on submerged aquatic vegetation: an experimental test in a Pacific Northwest estuary.* Marine Ecology Progress Series (125:205-217). https://doi.org/10.3354/meps125205

    Topic(s): Oysters, Eelgrass

The authors in this publication review stake and rack methods of oysters reduced eelgrass abundance. The use of racks seemed to cause greater issues for growers. The study also found greater sediment erosion with racks, and greater deposition with stakes. Mud and C increased with stakes, but decreased with racks. Issues with stakes include; too much sediment and physical disturbance when placing stakes, and racks lead to too much erosion and potential for shading problems.

12. Casco Bay Estuary Partnership (2015). *Eelgrass beds decline as Green Crab numbers explode.* State of the Bay Publication. https://www.cascobayestuary.org/wp-content/uploads/2015/10/Indicator_Eelgrass.pdf

    Topic(s): European Green Crab, Eelgrass
    The 2015 Casco Bay Estuary Partnership report documents a 55% decline in eelgrass beds between 2001 and 2013, largely attributed to a surge in invasive European green crab populations. In response, a pilot restoration project was launched to test transplant methods, identify suitable sites, and assess whether crab control is needed for eelgrass recovery.

13. Caughill, P. (2017). *Two new Department of Energy projects want to fuel cars with seaweed.* Futurism. https://futurism.com/two-new-department-of-energy-projects-want-to-fuel-cars-with-seaweed

    Topic(s): Seaweed
    Researchers at the University of the West Indies in Barbados have developed a process that converts invasive sargassum seaweed into biogas capable of powering converted combustion-engine cars. By combining sargassum with rum distillery wastewater in bioreactors, the team successfully produced enough biogas to fuel vehicles, with the conversion kit costing around $2,500. This approach not only addresses the environmental problems caused by smelly, decomposing seaweed bathing Caribbean beaches but also creates a potential renewable energy source, showcasing a creative solution that tackles both pollution cleanup and energy innovation simultaneously.

14. Cerro, C. (2014). *Calculation of oyster benefits with a bioenergetics model of the Virginia oyster.* US Army Corps of Engineers: Engineer Research and Development Center. https://erdc-library.erdc.dren.mil/jspui/bitstream/11681/7129/1

    Topic(s): European Green Crab
    The 2014 report “Calculation of Oyster Benefits with a Bioenergetics Model of the Virginia Oyster” by Carl F. Cerco demonstrates the ecological value of eastern oysters (Crassostrea virginica) through a detailed energy-based modeling approach in the Great Wicomico River, Virginia. The model found that oysters significantly enhance water quality by filtering 164 metric tons of carbon annually, with substantial sequestration in sediments and shell material. It also estimated nitrogen removal at 28 metric tons per year, including 6.2 tons permanently eliminated via burial and denitrification—key processes in mitigating eutrophication. These findings reinforce oysters’ role as critical nutrient cyclers and support targeted restoration strategies that maximize filtration and nutrient removal. The report emphasizes the need for accurate data on oyster growth, mortality, and recruitment to fully capture and scale the ecological benefits of restoration projects.

15. Christie, M., Jone, L., Le Vay, L., Malham, S., Oliver, A., & Wilson, J. (2018). *A global review of the ecosystem services provided by bivalve aquaculture.* Wiley Reviews in Aquaculture (12:1, 3-25). https://doi.org/10.1111/raq.12301

    Topic(s): Bivalves, Seagrass
    The 2018 study offers a comprehensive assessment of the diverse benefits that bivalve farming—encompassing oysters, mussels, and clams—delivers beyond mere food production. Utilizing the Common International Classification of Ecosystem Services (CICES) framework, the authors categorize these benefits into provisioning, regulating, and cultural services. Provisioning services include the direct harvest of bivalve meat, valued at approximately $23.9 billion globally, along with by-products such as shells used in construction and poultry grit, with oyster shells alone estimated at a potential $5.2 billion market value. Regulating services are notably significant; bivalve aquaculture contributes to nutrient remediation by removing an estimated 49,000 tonnes of nitrogen and 6,000 tonnes of phosphorus annually, equating to a potential economic value of $1.2 billion. Cultural services, while acknowledged as broad-ranging and impactful, remain challenging to quantify due to limited data. Overall, the study estimates that non-food ecosystem services from bivalve aquaculture are worth approximately $6.47 billion per year, though this figure likely underrepresents the true value due to existing knowledge gaps. The authors advocate for the integration of these ecosystem services into environmental policy and coastal management strategies, emphasizing the role of bivalve aquaculture in promoting sustainable marine ecosystems.

16. Collins, H., & Shumway, S. E. (2024). *Emerging research on shellfish, aquaculture, and marine plastics*. Department of Marine Sciences, University of Connecticut. https://seagrant.media.uconn.edu/wp-content/uploads/sites/1985/2024/08/Shellfish-Plastic-Fact-Sheet-8.13.24-final.pdf

    Topic(s): Marine plastics, shellfish aquaculture, environmental impacts
    Reviews emerging research on the interactions between shellfish aquaculture and marine plastics, including ingestion by shellfish, gear-related pollution, and regulatory approaches. Emphasizes knowledge gaps and research priorities.

17. Correia-Martins, A., Derolex, V., Hamaguchi, M., Hori, M., Lagarde, F., Richard, M., Sato, M., & Tremblay, R. (2021). *Oyster aquaculture using seagrass beds as a climate change countermeasure.* Bulletin of Japan Fisheries Research and Education Agency. https://drive.google.com/file/d/1rcl29A1TbbYloreR6dzaQSgTaRygN77X/view

    Topic(s): Shellfish, Seagrass
    This experiment revealed that spat recruitment was significantly higher in areas without eelgrass distribution, while spat growth and survival rate after the settlement were significantly higher in eelgrass beds even when anoxic events occurred in the study areas. Therefore, results indicate a possibility that seagrass vegetation contributes to sustainability of oyster aquaculture by mitigating environmental degradation during cultivation.

18. Creese, R., & Forrest, B. (2006). *Benthic impacts of intertidal oyster culture, with consideration of taxonomic sufficiency.* Environmental Monitoring and Assessment (112, 159-176). https://link.springer.com/article/10.1007/s10661-006-0359-3

    Topic(s): Shellfish, Sediments

Within farms (using racks), there were higher amounts of fine sediment and organic and lower soil strength. 35 m from the farm, there were no measurable impacts on macrofauna. Sediment strength was the biggest variable affected by farming. Sedimentation patterns around the racks indicated hydrodynamic controls -- seabed elevation was lower under racks compared to between racks. Soil strength is reduced beneath racks.

19. Chen H., Hua Y., Gu R., Liu T., Tang J., Zhang W., Ge Z. (2023). *Contribution of microphytobenthos to the carbon sink in brackish and freshwater tidal flats of the Yangtze Estuary.* Marine Ecology Progress Series (720, 25-37). https://doi.org/10.3354/meps14405

    Topic(s):
    Biofilms are a net sink of co2, in salt and fresh flats. High salinity water reduced respiration, increasing storage (winter), and freshwater flats had higher storage in summer. Salt fluctuations are also an important consideration.

20. Dawkins, P.D., Fiorenza, E.A., Gaeckle, J.L. *et al* (2024). *Seagrass ecosystems as green urban infrastructure to mediate human pathogens in seafood.* Nature Sustain (7, 1247–1250). https://doi.org/10.1038/s41893-024-01408-5

    Topic(s): Bivalve, Seagrass

    Urban greening offers an opportunity to reinforce food security and safety. Seagrass ecosystems can reduce human bacterial pathogens from coastal sources, but it remains unknown whether this service is conferred to associated food fish. We find a 65% reduction in human bacterial pathogens from marine bivalves experimentally deployed across coastal urban locations with seagrass present compared with locations with seagrass absent. Our model estimates that 1.1 billion people reside in urban areas within 50 km of a seagrass ecosystem. These results highlight the global opportunity to support human health and biodiversity sustainability targets.

21. Dewy, B. *Impact of ocean acidification on the shellfish industry.* Taylor Shellfish Farms. https://drive.google.com/file/d/1zK_bMHMLLfd9dnokFAo6vv-j2YwKcuTX/view

    Topic(s): Shellfish, Industry
    This powerpoint reviews the following topics: impacts of acidification to growers, negative impact mitigation, expanded industry collaboration, ramped up monitoring/research, evaluating breeding as potential adaptation tool, increased seed production capacity in Hawaii, increased capacity at local hatcheries, treating hatchery water intake, expanded outreach and education.

22. Dumbauld, B., Hacker, S., Ruesink, J., Tallis, H., & Wisehart, L. (2009). *Oysters and aquaculture practices affect eelgrass density and productivity in a Pacific Northwest estuary.* Journal of Shellfish Research. https://doi.org/10.2983/035.028.0207

    Topic(s): Eelgrass, shellfish
    This study found that oyster density leads to decreased eelgrass density, but did not affect eelgrass growth rate, plant size, or production. Other observations of this study include long line harvesting leads to healthy eelgrass, and oysters in dredged/hand picked lead to increased eelgrass growth rates, but decreases in density, size, and production. This study revealed the

need for identifying exact metrics of eelgrass for maximizing carbon storage because in this paper, methods of harvest impacted different eelgrass metrics.

23. Elsey-Quirk, T., Mariotti, G., Valentine, K., & Hotard, A. (2021). *Benthic biofilm potential for organic carbon accumulation in salt marsh sediments.* Retrieved from William and Mary ScholarWorks: https://scholarworks.wm.edu/server/api/core/bitstreams/889eb04b-d1ee-4a2f-a151-bb9af92f1e0e/content

    Topic(s): Benthic Biofilm, Marshes
    This is a study on marshes that is transferable to benthic biofilms of intertidal shellfish growing areas. The lead author is interested in collaboration (currently at UW, currently researching in Willapa). Biofilms can sequester carbon, but rates are highest in high-deposition environments. For Willapa, this may be most applicable near the mouth and south bay.

24. Environmental Protection Agency, Region 1 (2023, March). *The blue carbon reservoirs from Maine to Long Island, NY. https://drive.google.com/file/d/1WSwbvvyuELtfbl8QXAvPMkfE0WATc5bi/view*

    Topic(s): Seagrasses, Marshes, Mapping
    This resource maps areas likely for carbon sequestration - focusing on marshes and eelgrass.

25. Fei, H., Lai, Q., Ma, J., Pei, D., Yu, M., & Zhang, A. (2022). Current and future potential of shellfish and algae mariculture carbon sinks in China*. International Journal of Environmental Research and Public Health, 19(14).* https://doi.org/10.3390/ijerph19148873

    Topic(s): Bivalves, Algae
    This study used the material quality assessment method to estimate the carbon sink capacity of shellfish and algae. Product value, carbon storage value, and oxygen release value were used to calculate the economic value of shellfish and algae carbon sequestration. The results showed that the annual average shellfish and algae carbon sink in China was 1.10 million tons from 2003 to 2019, of which shellfish accounted for 91.63%, wherein Crassostrea gigas, Ruditapes philippinarum, and Chlamys farreri were the main contributors.

26. Feng, J., Sun, L., & Yan. J, (2023). *Carbon sequestration via shellfish farming: a potential negative emissions technology.* Renewable and Sustainable Energy Reviews (171). https://doi.org/10.1016/j.rser.2022.113018

    Topic(s): Shellfish
    They claim the aquaculture is a net sink of carbon based on looking at the entire lifecycle, claiming that fecal pellets lead to long term carbon storage, as well as the soft oyster tissue (that is transferred to the terrestrial system). I am skeptical, but like the concept they describe here. They also strongly talk about how aquaculture is much more sustainable compared to beef, eggs, etc

27. Fisheries Research and Development Corporation (2021). *Carbon neutral certification for oyster farmers.* FRDC Project 2021-032. https://www.nswoysters.com.au/uploads/5/7/9/9/57997149/carbon_neutral_certification_for_oyster_farmers.pdf

    Topic(s): Shellfish

The goal of this project was to find ways to measure the carbon sequestration in shellfish operations, and suggest or discuss potential incentives to growers to increase the carbon sequestration of their operations. Though the results were interesting, there was not a conclusive recommendation.

28. Fodrie, J., Gittman, R., Grabowski, J., Lindquist, N., Peterson, C., Piehler, M., Ridge, J., & Rodriguez, A. (2017). *Oyster reefs as carbon sources and sinks.* Royal Society Publishing. https://doi.org/10.1098/rspb.2017.0891

    Topic(s): Oysters
    "While CO release is a by-product of carbonate shell production (then burial), shellfish also facilitate atmospheric-CO drawdown via filtration and rapid biodeposition of carbon-fixing primary producers." This publication explains the complexity of shellfish carbon sequestration. Also, explained in this publication is the need for protecting existing reefs, as a means to mitigate climate change.

29. Furman, B., Hoellein, T., Peterson, B., & Zarnoch, C. (2017). *Eelgrass meadows, Zostera marina (L), facilitate the ecosystem service of nitrogen removal during simulated nutrient pulses in Shinnecock Bay, New York, USA.* Marine Pollution Bulletin (124:1, 376-387). https://doi.org/10.1016/j.marpolbul.2017.07.061

    Topic(s): Eelgrass
    This study looks at how eelgrass (Zostera marina) meadows and nearby sandy areas in Shinnecock Bay handle nitrogen, a nutrient that can impact water quality. Normally, both the eelgrass and the sand areas don't add much nitrogen to the environment. However, when extra nitrogen is present, the eelgrass is much better at removing it than the sandy areas, thanks to its ability to break down nitrogen using the organic material in its sediment. This suggests that eelgrass meadows are especially good at cleaning up excess nitrogen, which can come from things like runoff from rainstorms or groundwater.

30. Gagnon, K., Christie, H., Didderen, K., Fagerli, C.W., Govers, L.L., Gräfnings, M.L.E., Heusinkveld, J.H.T., Kaljurand, K., Lengkeek, W., Martin, G., Meysick, L., Pajusalu, L., Rinde, E., van der Heide, T. and Boström, C. (2021). *Incorporating facilitative interactions into small-scale eelgrass restoration—challenges and opportunities.* Restoration Ecology, (29:5). https://doi.org/10.1111/rec.13398

    Topic(s): Bivalves, Seagrass
    Marine ecosystem engineers like seagrasses and bivalves create vital coastal habitats that support high biodiversity and provide essential ecosystem services. However, restoring these habitats is challenging because feedback mechanisms often require large-scale efforts for success. Small-scale restoration could be more feasible and effective by incorporating facilitative interactions, which would reduce the strain on donor sites, lower costs, and save time.
    This study tested two methods for enhancing small-scale eelgrass (Zostera marina) restoration in northern Europe: 1, Co-restoration with blue mussels (Mytilus edulis, M. trossulus). 2, Using biodegradable establishment structures (BESEs).
    In aquaria experiments, co-restoration with mussels showed promise, with eelgrass growth nearly doubling in treatments with medium and high mussel densities compared to those without mussels. However, field experiments did not show improved shoot length or density due to

hydrodynamic exposure, which reduced survival for both eelgrass and mussels, particularly in highly exposed sites.The use of BESEs showed more potential. BESEs enhanced eelgrass survival, reduced mussel loss, and supported mussel recruitment at one site. However, eelgrass survival was lower in BESE plots with mussels compared to BESE plots without mussels. Overall, while co-restoration with mussels was not effective at small scales, BESE structures improved early eelgrass survival and showed promise for small-scale eelgrass and bivalve restoration.

31. Jansen, H., & van den Bogaart, L. (2020). *Blue carbon by marine bivalves* (report C116/20) Wageningen University & Research. https://edepot.wur.nl/537188

    Topic(s): Bivalves
    The current report is centred around the following case studies:
    Case study I. mussel aquaculture: with the aim to quantify C-fixation dynamics for mussel aquaculture at the scale of one cultivation plot, and at the scale of the entire industry
    Case study II. wild bivalve stocks: with the aim to quantify the carbon stored in wild populations

32. Klohmann, C (2022). *The environmental microbial composition and pathogen reduction capability of temperate seagrass beds.* University of Washington School of Aquatic and Fishery Sciences thesis submission. https://digital.lib.washington.edu/researchworks/bitstreams/75dc76ac-28c4-4396-9da4-29422fb87e49/download

    Topic(s): Shellfish, eelgrass
    This is a graduate thesis, written by an individual with extensive background on the topic. This publication reviews the interactions between seagrass beds and shellfish aquaculture and related diseases.

33. Lopes, C., Gago, J., Álvarez, P., & Pedrotti, M. L. (2020). Plastic pollution pathways from marine aquaculture practices and potential solutions for the North-East Atlantic region. *Marine Pollution Bulletin, 150*, 110739. https://doi.org/10.1016/j.marpolbul.2020.110739

    Topic(s): Aquaculture gear, marine debris, plastics mitigation
    Reviews sources and fate of plastic waste from aquaculture (e.g., nets, ropes, buoys), and provides mitigation strategies such as material innovation and policy recommendations. Focus is on North-East Atlantic but applicable elsewhere.

34. Lutz, M.D. (2018). *A search for blue carbon in Central Salish Sea eelgrass meadows.* Western Washington University Graduate School Collection. 757. https://cedar.wwu.edu/wwuet/757

    Topic(s):Seagrass
    Confirms note on #4 that CO2 sequestration is higher in high-depositional environments. Found lower carbon sequestration rates than reported on seagrasses worldwide, likely due to eelgrass not thriving in areas more conducive to high carbon sequestration. Recommends further regional and site-specific studies.

35. Maps, L. (2024). Researchers discover eelgrass superpower in Washington's Puget Sound. The Seattle Times. https://www.chronline.com/stories/researchers-discover-eelgrass-superpower-in-washingtons-puget-sound,360062

Topic(s): Eelgrass
In this paper, published in various Washington State publications, the author explains the "superpowers" of eelgrass. "Already highly valued as nurseries for sea life, researchers have discovered a new eelgrass superpower, as living urban systems that reduce human pathogens in seafood by as much as 65%."

36. Mistri, M., Munari, C., & Rossetti, E. (2013). Shell formation in cultivated bivalves cannot be part of carbon trading systems: a study case with Mytilus galloprovincialis. Journal for Marine Environmental Research. https://doi.org/10.1016/j.marenvres.2013.10.006

    Topic(s): Shellfish
    Respiration and co2 released from shell formation outweigh carbon storage in mussels and are a net source of carbon, not a sink. Shell formation shouldn't be part of C trading.

37. Mitchell, I. (2006). *In situ biodeposition rates of Pacific oysters (Crassostrea gigas) on a marine farm in Southern Tasmania (Australia).* Science Direct Journal of Aquaculture (257,1-4). https://doi.org/10.1016/j.aquaculture.2005.02.061

    Topic(s): Oysters
    Biosediments did not accumulate under cultivated oyster racks, but instead were transported away from the farmed areas. There was, however, a lot of bio sediment created, so knowing the fate of these is important

38. Naar, N., Stote, A., & Vadopalas, B. (2023). *Ecological interactions between shellfish aquaculture, eelgrass and burrowing shrimp in Willapa Bay and Grays Harbor.* Washington Sea Grant. https://wghec.org/wp-content/uploads/2024/02/WGHEC.EI_.pdf

    Topic(s): Shellfish, Eelgrass
    This publication discusses the dynamics of shellfish aquaculture management in Washington's Willapa Bay and Grays Harbor, areas vital for the nation's oyster production. The interaction between cultivated shellfish, eelgrass, and burrowing shrimp plays a central role in these ecosystems, influencing various ecological processes and management practices. Shellfish benefit eelgrass by enhancing light availability and nutrient concentrations, but certain aquaculture methods can harm it. Eelgrass can affect shellfish yields by modifying water conditions, while burrowing shrimp, though sometimes detrimental to shellfish by destabilizing sediments, are important in nutrient cycling and providing food for predators. The report underscores the necessity of an ecosystem-based management (EBM) approach that incorporates ongoing scientific research and monitoring to understand the interactions and trade-offs among these key species.

39. Newcomb, L. (2017). *New tool helps oyster growers prepare for changing ocean chemistry.* NOAA Ocean Acidification Program Publication. https://oceanacidification.noaa.gov/new-tool-helps-oyster-growers-prepare-for-changing-ocean-chemistry/

    Topic(s): Bivalves, Seagrass
    This study reviews ocean acidification monitoring, socio-economic impacts, and potential adaptation strategies. The publication also expands on tools for capturing carbonate chemistry data.

40. NOAA Fisheries. *Aquaculture funding opportunities and grants.* https://www.fisheries.noaa.gov/national/aquaculture/aquaculture-funding-opportunities-and-grants

    Topic(s): Bivalves, Seagrass, Funding
    This webpage lists various funding sources that are available to shellfish growers and aquaculturists.

41. National Oceanic and Atmospheric Administration (NOAA) Office for Coastal Management. (2025). *Final findings: Rhode Island Coastal Resources Management Program (September 2019–October 2024)* [PDF]. https://www.crmc.ri.gov/aboutcrmc/2025_NOAA312_Findings.pdf

    Topic(s): Conservation easements, aquaculture policy, shoreline resilience, working waterfronts
    Includes a detailed case study of a 2019 conservation easement initiative that protected aquaculture sites and public access in Narragansett Bay. The project used legal tools to prevent development, support shoreline resilience, and sustain working waterfronts. Offers a replicable model for integrating ecological and legal strategies to support aquaculture.

42. Oregon Conservation Partnership (2024). *Carbon sequestration and soil health guidebook.* https://www.oacd.org/carbon-sequestration-and-soil-health-guidebook

    Topic(s): Carbon Farming, Working Lands
    This guidebook outlines carbon farming and soil health practices suitable for Pacific Northwest producers. It details co-benefits like improved water retention and nutrient cycling, and explains how practices like cover cropping, reduced tillage, composting, and hedgerow planting contribute to carbon sequestration.

43. Poppe, K, & Rybczyk, J. (2018). *Carbon sequestration in Pacific Northwest eelgrass (zostera marina) meadow*. Western Washington University, Environmental Sciences Faculty and Staff Publications 55. https://cedar.wwu.edu/esci_facpubs/55

    Topic(s): Eelgrass
    This study evaluates the carbon sequestration capabilities of eelgrass (Zostera marina) in Padilla Bay, Washington. Eelgrass is typically understudied in terms of its ability to bury carbon compared to tropical seagrasses like Posidonia oceanica. The findings from Padilla Bay show low carbon sequestration rates, averaging between 9 to 11 g C m-2 yr-1, which are attributed to the area's minimal sediment organic content and slow accretion rates. ***Note this "low" rate of sequestration is still higher than almost all terrestrial ecosystems.** This study suggests that such low rates might be characteristic of healthy eelgrass meadows, potentially due to the species' low tolerance for conditions that reduce light penetration and increase toxic sulfide levels. Further research is recommended to investigate carbon sequestration in other eelgrass meadows with potentially higher rate.

44. Poppe, K., & Rybczyk, J. (2016). *Eelgrass (zostera marina) meadows provide many ecosystem goods and services, but high rates of carbon sequestration may not be one of them.* Salish Sea Ecosystem Conference. https://cedar.wwu.edu/ssec/2016ssec/habitat/12/

    Topic(s): Seagrasses

This study looks at the benefits of eelgrass on the health of marine and intertidal ecosystems, however the research was unable to confirm that carbon sequestration was one of the benefits.

45. Ralph, F. (2022). *Mitigation of negative effects of ocean change on oysters by eelgrass and its implications for aquaculture in Midcoast Maine.* Bowdoin Library Honors Projects. https://digitalcollections.bowdoin.edu/view/4889/

    Topic(s):Oysters, Eelgrass
    This study (Graduate Thesis) explores how the interaction between eelgrass and eastern oysters might help mitigate the adverse effects of ocean acidification on oyster farming in Midcoast Maine. It finds that eelgrass can potentially enhance oyster shell growth and overall condition by locally increasing pH levels through photosynthesis, suggesting that eelgrass could be a valuable ally for oyster farmers facing the challenges of more acidic ocean conditions.

46. Ruesink, J., Lenihan, H., Trimble, A., Heiman, K., Micheli, F., Byers, J., & Kay, M. (2005). *Introduction of non-native oysters: ecosystem effects and restoration implications.* University of Washington Health Services Libraries (36, 643-89). doi: 10.1146/annurev.ecolsys.36.102003.152638

    Topic(s): Non-Native Oysters
    This publication is a review of literature studying the implications of oyster introductions of 18 non-native oyster species in 73 countries and the effects to ecosystem functions.

47. Save the Sound (2023). Video: a new method for eelgrass restoration-short version. https://youtu.be/kA-cMtAtwDk?si=NUM6uCY3oo_ctn1g

    Topic(s): Shellfish, Eelgrass
    This video shows how eelgrass seeds can be planted by gluing seeds to clams and then distributing.

48. University of North Carolina Institute for Marine Sciences (2021). *How Carolina is reducing its carbon footprint with oyster shells and marsh grass.* https://www.unc.edu/discover/how-carolina-is-reducing-its-carbon-footprint-with-oyster-shells-and-marsh-grass/

    Topic(s): Oyster Shells, Marshes
    The University of North Carolina at Chapel Hill is advancing its carbon neutrality goals through a coastal restoration project led by the Institute for Marine Sciences. By constructing a saltmarsh fortified with oyster reefs in Morehead City, the initiative captures and stores atmospheric carbon in sediment, serving as a natural carbon offset while also enhancing shoreline resilience and marine biodiversity.

49. Washington Sea Grant (2019). Webinar series: Seaweed farming in Washington State. https://wsg.washington.edu/community-outreach/kelp-aquaculture/seaweed-farming-training/seaweed-farming-agenda-nov-20-2019/

    Topic(s): Bivalves, Seagrass
    National Seaweed Hub in development; recordings from a WA-specific seaweed conference, including navigating regulatory climate; found here: https://wsg.washington.edu/research/aquaculture/

50. Washington Sea Grant (2020). *Annotated bibliography: Shellfish aquaculture interactions with eelgrass with an emphasis on Washington coastal estuaries and the Pacific Northwest.* Shellfish-Aq-Eelgrass-Interactions_Annotated-Biblio_11-11-2020.docx

    Topic(s): Shellfish, Eelgrass
    This publication is a collection of 56 resources with annotations all on Shellfish Aquaculture Interactions with Eelgrass. Link leads to the annotated bibliography.

51. Wilson, R. *Notes on carbon sequestration and shellfish role in global warming: for review.* Bay Center Mariculture. https://drive.google.com/file/d/1ht8cGB9msMJNhoAn_ses59fu5rDf7hTJ/view

    Topic(s): Shellfish
    Carbon sequestration calculations for shellfish in Willapa Bay (not peer reviewed)

52. Wilson, R. (2023). *Sequestration capture and hold via shellfish.* Bay Center Mariculture. https://drive.google.com/file/d/1hn2VaG5ywiWJOC89l_IhAiL4NJ3BIwiI/view

    Topic(s):Shellfish
    Email response in response to David Beugli's (WGHOGA) question: "How does burial of these shells change the baseline rate of carbon
    sequestration?"

Appendix D: Existing NRCS or SCC Best Management Practices (BMPs) Relevant for Shellfish Aquaculture

Overview

Shellfish aquaculture is a critical component of sustainable seafood production and coastal ecosystem health. Shellfish such as oysters, clams, and mussels provide essential ecosystem services, including water filtration, shoreline stabilization, carbon sequestration, and habitat creation.

The USDA Natural Resources Conservation Service (NRCS) offers a suite of Best Management Practices (BMPs), technical support, and financial assistance to help aquaculture producers improve environmental outcomes, operational efficiency, and long-term viability. The Washington State Conservation Commission (SCC) offers similar services, alongside additional state-accepted BMPs. This report compiles applicable existing BMPs, relevant NRCS and SCC practice standards, and real-world examples of implementation across the U.S., including the Pacific Coast.

SCC's Sustainable Farms and Fields program (SFF) provides a list of climate-smart practices that are eligible for SFF funding.[1] Of those 37 existing practices, the following practices could likely be adapted for an aquaculture context:

1. Alley Cropping (NRCS 311) - re: eelgrass
2. Conservation Cover (NRCS 327) - re: eelgrass
3. Conservation Crop Rotation (NRCS 328) - re: eelgrass
4. Residue and Tillage Management – No-Till/Strip-Till/Direct Seed (NRCS 329) - re: precision harvest
5. Contour Buffer Strips (NRCS 332) - re: eelgrass vegetated strips
6. Cover Crop (NRCS 340) - re: eelgrass
7. Windbreak/Shelterbelt Establishment and Renovation (NRCS 380) - re: eelgrass
8. Field Border (NRCS 386) - re: eelgrass
9. Hedgerow Planting (NRCS 422) - re: eelgrass
10. Strip cropping (NRCS 585) - re: general habitat provision
11. Vegetative Barriers (NRCS 601) - re: eelgrass
12. Herbaceous Wind Barriers (NRCS 603) - re: eelgrass

Specific existing practices that are not eligible for SFF funds but are relevant for aquaculture are described further in the following section, and include:

<u>Upland practices indirectly related to aquaculture</u>

1. Waste Storage Facility (NRCS 313)
2. Energy Efficient Agricultural Operation (NRCS 374)
3. Riparian Forest Buffer (NRCS 391)
4. Access Control (NRCS 472)

[1] *Sustainable Farms and Fields Grant Programmatic Guidelines, Effective July 1, 2023.* https://cdn.prod.website-files.com/5faf8a950cdaa224e61edad9/64a780d711fec18f82547bd7_SFF%20Programmatic%20Guidelines_July2023.pdf

5. Heavy Use Area Protection (NRCS 561)
6. Energy Efficient Lighting System (NRCS 670)
7. Dynamic Revetment and Erosion Reduction (SCC46)

Marine practices directly related to aquaculture

8. Herbaceous Weed Treatment (NRCS 315)
9. Combustion System Improvement (NRCS 372)
10. Bivalve Aquaculture Gear and Biofouling Control (NRCS 400)
11. Integrated Pest Management Plan, Pest Management Conservation System (NRCS 114, 595)
12. Restoration of Rare or Declining Natural Communities (NRCS 643)
13. Wetland Wildlife Habitat Management (NRCS 644)
14. Structures for Wildlife (NRCS 649)
15. Precision On-Bottom Shellfish Harvest (SFF Demonstration Practice)
16. Shellfish Farm Planning/Carbon Planning
17. Coastal Zone Soil Survey (CZSS)
18. Conservation Easements

Applicable BMPs not eligible for SFF funds

Upland practices indirectly related to aquaculture

1. **Waste Storage Facility (NRCS 313)**
   - *Purpose:* To minimize or eliminate the impacts on surface water, and/or minimize or eliminate the impacts on groundwater resources, and/or minimize emissions such as greenhouse gases to improve air quality
   - *Shellfish Aquaculture Use:* Mitigates impacts of manure and potential harvest closures due to fecal pollution. Future potential for direct aquaculture for storage of waste or mortality post-harvest.
   - *Practice Barriers:* Limited funding through SCC.
   - *Case Study:* Not identified.
2. **Energy Efficient Agricultural Operation (NRCS 374)**
   - *Purpose*: To improve energy efficiency for facilities, equipment, and/or processes.
   - *Shellfish Aquaculture Use*: Supports improved energy usage across operations and associated cost savings through energy audits and upgrades in facilities such as hatcheries and processing areas. Improvements may include efficient pumps, solar panels, or insulation to reduce heating/cooling demands. This practice applies to nonresidential structures, equipment, and other energy-using systems that support agricultural production and related enterprises except where another NRCS Conservation Practice Standard (CPS) is more appropriate.
   - *Practice Barriers:* Not identified.
   - *Case Study:* Not identified.
3. **Riparian Forest Buffer (NRCS 391)**

- *Purpose:* To reduce transport of sediment to surface water, and reduce transport of pathogens, chemicals, pesticides, and nutrients to surface and groundwater; and/or improve the quantity and quality of terrestrial and aquatic habitat for wildlife, invertebrate species, fish, and other organisms; and/or maintain or increase total carbon stored in soils and/or perennial biomass to reduce atmospheric concentrations of greenhouse gasses; and/or lower elevated stream water temperatures; and/or restore diversity, structure, and composition of riparian plant communities.
- *Shellfish Aquaculture Use:* Upland mitigation
- *Practice Barriers:* Not identified

4. **Access Control (NRCS 472)**
   - *Purpose:* To achieve and maintain desired resource conditions by monitoring and managing the intensity of use by animals, people, vehicles, and equipment in coordination with the application schedule of practices, measures, and activities specified in the conservation plan.
   - *Shellfish Aquaculture Use:* Upland pollution mitigation
   - *Practice Barriers:* Not identified

Heavy Use Area Protection (NRCS 561)

- *Purpose:* To reduce soil erosion; provide a stable, non-eroding surface for areas frequently used by animals, people, or vehicles; protect or improve water quality
- *Shellfish Aquaculture Use:* Upland mitigation
- *Practice Barriers:* Not identified

5. **Energy Efficient Lighting System (NRCS 670)**
   - *Purpose*: To improve energy efficiency of an agricultural facility lighting system.
   - *Shellfish Aquaculture Use*: Reduce electricity consumption through lighting upgrades. Used in indoor hatchery operations or processing buildings. Replacing fluorescent or halogen bulbs with LEDs reduces costs and heat output, improving worker safety and facility efficiency.
   - *Practice Barriers:* Not eligible for funding through SCC sources.
   - *Case Study:* Energy audits and upgrades are considered low-cost yet effective strategies to engage producers in implementing practices to reduce energy consumption.

6. **Dynamic Revetment and Erosion Reduction (SCC46)**
   - *Purpose*: To stabilize shorelines using small rocks (12”-) or cobbles, in order to absorb wave energy. This causes suspended sediment to drop from the water column, building elevation of the beach or shore. Often used in conjunction with native plantings and large woody debris.
   - *Shellfish Aquaculture Use*: Reduce water quality impacts to shellfish farms via preventing marine debris and contaminant inputs to aquaculture-supporting waterbodies. Can also protect farm infrastructure and nursery habitats from erosion. Often paired with native planting and mitigation of hazards’ ecological stresses to support broader habitat goals, indirectly benefiting aquaculture.

- *Practice Barriers:* Permitting.
- *Case Study:* Pacific Conservation District has utilized this practice at the mouth of Willapa Bay to reduce erosion and rebuild the shoreline. This work protects adjacent commercial, recreational, and traditional shellfish beds from marine debris associated with erosion of "Washaway Beach", and potential water quality issues which would occur if the Grayland drainage ditch were to be breached.

Marine practices directly related to aquaculture

7. **Herbaceous Weed Treatment (NRCS 315)**
   - *Purpose*: To enhance accessibility, quantity, and/or quality of forage and/or browse; and/or restore or release native or desired plant communities for wildlife habitat; and/or protect soils and control erosion; and/or reduce fine fuel loads and wildfire hazard; and/or control pervasive plant species to a desired level of treatment.
   - *Shellfish Aquaculture Use*: Applied to eradicate, suppress, or reduce invasive or nuisance aquatic vegetation in coastal zones, such as *Spartina alterniflora, Zostera japonica,* or macroalgae, improving sunlight penetration and water circulation for shellfish beds. Treatment may include mechanical removal or selective herbicide application with ecological safeguards.
   - *Practice Barriers:* Not identified.
   - Case Study: Not identified.
8. **Combustion System Improvement (NRCS 372)**
   - *Purpose*: To improve air quality by reducing emissions of oxides of nitrogen (NOx); and/or improve air quality by reducing emissions of particulate matter (PM); and/or reduce energy use by increasing the efficiency of the combustion system.
   - *Shellfish Aquaculture Use*: Replace, repower, or retrofit a combustion system and related components or devices. Rebates on combustion system improvements have assisted producers on reducing emissions by replacing and upgrading inefficient, outdated, or substandard diesel engines in the marine production areas,
   - *Practice Barriers*: Not currently funded through SCC programs, popular amongst partner agencies such as WDFW and ECY
   - *Case Study*: This practice has been used successfully to upgrade older marine diesel engines to lower or zero emissions, using funds from the US Environmental Protection Agency, Washington Department of Ecology, and other agencies.[2]
9. **Bivalve Aquaculture Gear and Biofouling Control (NRCS 400)**
   - *Purpose*: To reduce adverse impacts of shellfish aquaculture operations and gear on water, plant, animal, and human resources; and/or improve dependable water quantity and quality to support shellfish production; and/or improve adequate food quantity and quality to support shellfish production.

[2] https://www.epa.gov/newsreleases/epa-announces-28m-washington-upgrade-older-diesel-engines-cleaner-zero-emission

- *Shellfish Aquaculture Use*: Minimizes impacts to aquaculture gear through biofouling management and sustainable maintenance. Growers apply this practice by cleaning gear on land, rotating gear to prevent buildup, and using materials that deter fouling organisms. This helps reduce environmental impact and enhances water flow and growth rates.

- *Practice Barriers:* Not identified.

- *Case Study:* Survey respondents identified use of this practice via pressure washing fouled oyster tumble baskets. It was not clear whether this activity was funded by SCC or NRCS, or involved CDs.

10. Integrated Pest Management Plan, Pest Management Conservation System (NRCS 114, 595)

- *Purpose*: NRCS 114 is described as "a conservation activity plan documenting decisions by producer/growers who agree to implement an ecosystem-based strategy that is a sustainable approach to manage pests using a combination of conservation practices and IPM techniques that are characterized as chemical applications, biological control, and habitat manipulation, modification of cultural practices and use of resistant varieties.Methods of chemical applications are selected in a manner that minimizes risks to human health, beneficial and non-target organisms, and the environment..

  NRCS 595 is described as "A system that combines an integrated pest management (IPM) decision-making process with natural resource conservation to address pest and environmental impacts."

  As these two practices are strongly linked, they are categorized together. NRCS 114 refers to planning activities, while NRCS 595 refers to the implementation of said plan.

- *Shellfish Aquaculture Use*: Helps manage marine pest populations such as invasive tunicates, oyster drills, and predatory crabs through biological, physical, and chemical tools. Implementation includes trapping, rotation of grow-out areas, and careful selection of approved treatments to minimize environmental harm.

- *Practice Barriers*: Limited payment scenario, little producer outreach or knowledge of eligibility through NRCS. Limited knowledge and understanding of practice conditions for Puget Sound CD Planners.

- *Case Study*: NRCS 114 has been implemented to assist shellfish farmers to develop IPM plans in Pacific County. Implementation of those plans has been funded through other sources.

11. Restoration of Rare or Declining Natural Communities (NRCS 643)

- *Purpose*: To restore the physical conditions and/or unique plant community on sites that partially support, or once supported, a rare or declining natural community. Application of this practice addresses resource concerns of a degraded plant condition and/or inadequate wildlife habitat.

- *Shellfish Aquaculture Use*: Reestablish and manage habitats like oyster reefs and submerged aquatic vegetation to enhance biodiversity and ecosystem services. Restoration projects often serve dual purposes—supporting aquaculture and rebuilding natural populations. Activities include deploying clutches, seeding native oysters, restoring aquatic bed/substrate, and removing invasive species.

- *Practice Barriers:* 1) NRCS limits the use of this practice to the restoration of habitat for native shellfish species only. This practice or a similar one would be useful for shellfish growing area

habitat restoration without specifying shellfish species. 2) Not currently funded through SCC grant programs. See “Other Considerations” for details.

- *Case Study:* Utilized by NRCS in Hood Canal Olympia Oyster Restoration, done in collaboration with Skokomish Indian Tribe. Reports have indicated successful re-establishment.

- *Other Considerations:* Practice Code 643 Restoration of Rate and Declining Natural Communities is currently not included on the SCC’s list of eligible practices because the SCC considers it an “umbrella” practice. At first glance, one might suggest the solution is to fund all “supporting” NRCS practices standards that are applicable to shellfish and aquaculture project scenarios. However, the criteria for “supporting” NRCS practice standards may not apply to shellfish and aquaculture project scenarios. This conundrum points to the need to address the “umbrella” practice issue within the SCC’s eligible practices framework. One solution could be to identify and/or develop a list of eligible NRCS “supporting” practices to accompany the use of NRCS practice standard 643 in a SCC funding situation. Another solution could be the adoption of a stand-alone SCC-approved practice that mirrors NRCS’s practice standard 643.

Wetland Wildlife Habitat Management (NRCS 644)

- *Purpose*: To maintain, develop, or improve wetland habitat for waterfowl, shorebirds, fur-bearers, or other wetland-dependent or associated flora and fauna.

- *Shellfish Aquaculture Use*: As shellfish aquaculture lands are often classified as wetlands, this practice has the potential to be applied in situations where aquaculture would benefit from wetland wildlife management.

- *Practice Barriers:* Not currently funded through SCC grant programs. See “Other Considerations” for details.

- *Case Study:* Not identified.

- *Other Considerations:* Practice Code 644 Wetland Wildlife Habitat Management is currently not included on the SCC’s list of eligible practices because the SCC considers it an “umbrella” practice. At first glance, one might suggest the solution is to fund all “supporting” NRCS practices standards that are applicable to shellfish and aquaculture project scenarios. However, the criteria for “supporting” NRCS practice standards may not be applicable to shellfish and aquaculture project scenarios. This conundrum points to the need to address the “umbrella” practice issue within the SCC’s eligible practices framework. One solution could be to identify and/or develop a list of eligible NRCS “supporting” practices to accompany the use of NRCS practice standard 644 in a SCC funding situation. Another solution could be the adoption of a stand-alone SCC-approved practice that mirrors NRCS’s practice standard 644.

12. Structures for Wildlife (NRCS 649)

- *Purpose:* To provide structures, in proper amounts, locations, and seasons to enhance or sustain non-domesticated wildlife, or modify existing structures that pose a hazard to wildlife.

- *Shellfish Aquaculture Use:* Potential for habitat restoration for oyster reef and other marine invertebrate habitat. Includes the intended use for nesting or roosting habitat, which in the context of marine invertebrates can extend towards natural set.

- *Practice Barriers:* Permitting, limited context and eligibility through potential funding sources such as Sustainable Farms and Fields

- *Case Study:* Skagit CD assisted a restoration practitioner to explore viability of artificial reef structures made with rebar and hooked up to a weak electrical current ("seacrete"). The project proponent sought to counteract ocean acidification while helping improve shellfish spawning success. The structures were also intended to improve habitat for juvenile fish. CD staff met with the practitioner and NRCS to discuss how to support Olympia oysters through this approach, but the project has not advanced further.

  Structures for Wildlife has been utilized in Hood Canal as part of a larger inter-agency partnership that included the Skokomish Indian Tribe to restore degrading oyster reef habitat. Relic shell material was distributed at low tide and by barge to facilitate natural set over time.

13. Precision On-Bottom Shellfish Harvest (SFF Demonstration Practice)

- *Purpose*: Reduce benthic disturbance from shellfish harvest and transplant activities, improving carbon sequestration.

- *Shellfish Aquaculture Use*: This practice has application to multiple species and culture types, by modifying harvest or transplant methods.

- *Practice Barriers:* Not assessed.

- *Case Study:* Pacific Conservation District received a 2024-25 Type B Demonstration Project grant from SFF to advance this practice, with Goose Point Oysters, Willapa- Grays Harbor Oyster Growers Association, University of Washington School of Oceanography, and Oregon State University Hatfield Marine Sciences Center.

  The goal of this in-progress project is to advance precision harvest technology for on-bottom Pacific oyster harvest and transplant, by:

  1) refining design of the existing precision harvest prototype;
  2) identifying a boat attachment that is transferable to other boat types in the region (via conveyor belt or otherwise; and
  3) conducting a study of carbon sequestration in the benthos.

14. Shellfish Farm Planning/Carbon Planning

- *Purpose*: To create holistic plans covering site selection, crop scheduling, nutrient management, and emergency protocols. Provide an update of current resources, resource conditions, and future management needs. Outline management options & opportunities to help meet identified goals & objectives. Serve as a mechanism for information sharing for managers and staff as well as with consultants, contractors, or anyone performing work on owned farmlands. Educate and inform readers on shellfish management issues and opportunities, operation and maintenance procedures, and best management practices.

- *Shellfish Aquaculture Use*: Ensures compliance with local regulations and sustainability certifications. Incorporates monitoring, recordkeeping, and adaptive strategies.

- *Practice Barriers:* Dynamic growing environment with varied land use by year. No clear ranking of conservation values by cultivation type.

- *Case Study:* Not identified.

15. Coastal Zone Soil Survey (CZSS)

- *Purpose*: A Coastal Zone Soil Survey is a SSURGO (Order 2 soil survey map and data) product that focuses the soil survey maps and data in the coastal zone which includes the dunes, marshes, beaches, anthropogenic coastal areas and the shallow-subtidal subaqueous soils (submerged lands) where submerged aquatic vegetation (SAV) is either growing or has the potential to grow. Once completed, a coastal zone soil survey provides detailed (1:12,000 scale) spatial soil maps (points, lines, and polygons), a rich database of soil chemical and physical properties, site data, and interpretations for coastal applications (beach replenishment, aquaculture, coastal blue carbon, restoration, etc.).

- *Shellfish Aquaculture Use*: This collaborative, goal-oriented mapping project will not only address the soil data needs of conservation planners and engineers but also confront emerging issues such as climate change, coastal resiliency, estuary restoration, small- and large-scale watershed use planning, and environmental literacy. Coastal zone soil survey data already guides protecting, conserving, and managing our nearshore coastal waters and natural resources in other areas of the United States. The CZSS has been successfully used to map large-scale geographies (e.g., Long Island Sound, NY), and is appropriate for mapping Washington estuaries used for aquaculture.

- *Practice Barriers:* Cost; need to transport equipment across the country; multi-year timeline required to initiate data collection, process data, and create data products.

- *Case Study:* Coastal zone soil surveys have been conducted across the Atlantic coast, but have not been conducted in Washington State.[3] The Willapa-Grays Harbor Estuary Collaborative has initiated conversations with CZSS staff in anticipation of conducting a survey of Willapa Bay.[4]

16. Conservation Easements

- *Purpose:* Conservation easements are voluntary legal agreements that permanently limit certain types of uses or prevent development on a property to protect its ecological value. These tools can play a critical role in securing the long-term protection of key coastal habitats, estuarine ecosystems, and working waterfronts. Easements are tailored to meet conservation objectives while allowing landowners to retain ownership and continue compatible uses, such as shellfish aquaculture, habitat restoration, or low-impact recreation. Multiple public and private organizations provide conservation easements in coastal Washington State (Figure D-1).

- *Shellfish Aquaculture Use:* Conservation easements may support long-term shellfish aquaculture viability by allowing farmers to be compensated for conservation activities and/or marginal tidelands. By buffering farms from the impacts of urban runoff and coastal development, easements can also help preserve water quality and reduce pathogen and nutrient loading that threaten shellfish viability. Additionally, they can provide legal protections for traditional working waterfronts, helping to ensure the continuity of shellfish operations in the face of changing land use and ownership patterns. This use aligns with broader goals of supporting sustainable seafood production and rural coastal economies.

- *Practice Barriers:* Despite their potential, several barriers limit the implementation of conservation easements in the region:

[3] https://www.nrcs.usda.gov/conservation-basics/natural-resource-concerns/soil/coastal-zone-soil-survey
[4] www.wghec.org, which involves Pacific and Grays Harbor Conservation Districts

- Lack of Local Precedent: Few examples of conservation easements tailored to estuarine or aquaculture contexts exist in southwest Washington, creating uncertainty around terms, monitoring, and stewardship.
- Landowner Concerns: Some landowners are hesitant to place long-term restrictions on their property due to concerns about future flexibility, perceived regulatory burdens, or impacts on land value. Shellfish farmers have placed emphasis on temporary easements (e.g. 20-year easements similar to those through SCC's Office of Farmland Preservation).
- Funding and Capacity: Securing funding for easement purchase, appraisal, and long-term stewardship is a major challenge, particularly in areas with low land values or limited conservation infrastructure.
- Interagency Coordination: Overlapping jurisdiction among state, Tribal, and federal entities can complicate easement design, especially when protecting both ecological function and working waterfront access

- *Case Study 1:* In 2019, the Rhode Island Coastal Resources Management Council (CRMC), in partnership with The Nature Conservancy, Rhode Island Sea Grant, and the City of East Providence, launched a conservation easement initiative to protect working waterfronts and enhance shoreline resilience in Narragansett Bay. Funded in part through NOAA's National Coastal Resilience Fund and supported by the National Fish and Wildlife Foundation, the effort focused on securing long-term protections for properties supporting shellfish aquaculture, fishing access, and small-scale maritime infrastructure.

  These easements placed legal restrictions on future conversion of these sites to residential or commercial development, while affirming aquaculture and public access as compatible, protected uses. The project addressed increasing development pressure, helped buffer shorelines against erosion, and aimed to preserve water quality in the Bay's shellfish beds. It also served as a model for hybrid shoreline protection strategies, combining legal land protection tools with ecological design and stakeholder engagement.

  This approach highlights how conservation easements can be adapted to support both ecological integrity and the sustainability of working waterfronts—an approach that holds clear relevance for estuarine systems like Willapa Bay.

  Case Study 2: Currently, marine construction projects that impact subtidal lands in the San Juan Islands require the purchase of mitigation credits (Eelgrass Credits, Forage Fish Habitat Credits, and/or Subtidal Habitat Credits). Their are only two existing options for compensatory mitigation:

  1. Project proponents can implement their own mitigation project (on-site or off-site), which is not always an option available to landowners, or
  2. Project proponents can purchase credits from approved third-party mitigation programs instead of building and maintaining their own mitigation sites. Currently, there are no locally managed conservation banks in the San Juan Islands that sell nearshore mitigation credits within their marine service area (North Puget Sound). There is one Advanced Mitigation site in the north Puget Sound service area, the Port of Anacortes – Fidalgo Bay Eelgrass Site; however, these credits are typically only available to the Port of Anacortes.

This lack of viable mitigation options led the Port of Friday Harbor (POFH) to approach San Juan Islands Conservation District (SJICD) to identify ways to allow for more local control of mitigation credits purchased in the San Juan Islands, ensuring that these mitigation credits are applied to conservation practices within the San Juan Islands. This would be beneficial to the ecosystem as mitigation would be more closely localized to any damage of concern and under the discretion of stakeholders and conservation managers within the impacted community.

POFH proposed the formation of a mitigation credit bank. This bank would perform habitat restoration in nearshore habitats, on subtidal lands leased from WDNR. SJICD would implement habitat restoration projects on these leased lands, while POFH would manage the selling of mitigation credits to organizations and individuals in need of purchasing credits. To ensure that this would not allow for increased in-water construction, these credits were planned to be only sold for efforts on repairing/maintaining existing structures.

The cost of leasing this WDNR-provided land was not feasible for two reasons: first, subtidal easements from WDNR are not permanent, instead preferring shorter-term lease arrangements and where WDNR maintains ownership of the lands, making investment by leaseholders more risky; second, the cost of leasing subtidal lands can be substantial, making the cost of implementing restoration higher than the expected income from selling the earned credits.

Initially, POFH and SJICD pursued a partnership with WDNR to remedy this discrepancy and create a conservation easement on WDNR-owned land. POFH and SJICD failed to establish contact with anyone at WDNR to begin negotiating such an arrangement.

Next, POFH and SJICD approached Friday Harbor Laboratories (FHL) as another partner. FHL manages several marine preserves owned by University of Washington (UW) under the management of UW FHL - specifically False Bay and Argyle Lagoon located on San Juan Island, and Parks Bay on Shaw Island. However, UW owns only the tidelands of these reserves. FHL only stewards the subtidal lands of these reserves, as that land is still under WDNR ownership. This means FHL's preserves could only be used for mitigation implementation in the intertidal zone, and subtidal credits could not be awarded using FHL's preserves as the mitigation site. FHL's preserves could potentially be used as eelgrass mitigation sites, except there is no available mitigation to be done via the removal of docks or creosote. While habitat restoration could be a feasible way to do mitigation in these sites for eelgrass credits (most of these sites have seen loss of eelgrass habitat in the intertidal zone), eelgrass restoration is not yet dependably successful enough to responsibly sell mitigation credits solely based on this method of mitigation.

A final effort was made by POFH, SJICD, and FHL to establish a San Juan Islands-based In-Lieu Fee program (ILF).[5] This would be possible since government agencies or non-profit organizations with expertise in marine resource management are involved, and an ILF would be less risky than setting up a conservation bank since fees can be collected prior to implementing the mitigation practice in an ILF program. However, the same subtidal land ownership issues arise with WDNR when considering an ILF program for a conservation bank.

[5] https://psp.wa.gov/pspnc-in-lieu-fee-program.php

#	Program name	Location	Program Home	Land Use Type	Use Criteria	Duration of Easement	Requirements for Payment	Amount of Payment to	Size Criteria	Ecological Criteria	Easements in WA	Examples	Relevance/Gaps for Aquaculture
1	Office of Farmland Preservation (OFP)	Washington State	Washington State Conservation Commission (WSCC)	Agricultural lands (with potential aquaculture integration)	Commercial agricultural lands; potential for aquaculture if integrated within agricultural use	Perpetual	Voluntary sale of development rights; land must remain in agricultural or compatible use	Varies by appraisal of development rights; tax benefits possible	Assessed based on agricultural viability and strategic value	Preserves farmland, supports water quality and wildlife habitat	Yes; statewide	Preserved farmland in multiple WA counties; limited direct aquaculture examples	Supports open space and land conservation that can benefit aquaculture; may require case-by-case review
2	Conservation Reserve Enhancement Program (CREP)	National	USDA, NRCS; in WA: WSCC and FSA	Agricultural lands near streams/riparian zones	Environmentally sensitive lands, especially near water bodies; voluntary enrollment by landowners; eligibility based on potential ecological benefit.	Typically 10–15 years; some may be permanent depending on agreement.	Implementation and maintenance of approved conservation practices such as planting buffers, fencing, etc.	Annual rental payments, cost-share (up to 50–100%) for practices, plus bonuses/incentives in some cases.	No strict minimum; land must contribute meaningfully to conservation objectives.	Enhances water quality, fish/wildlife habitat, stabilizes streambanks, reduces runoff and sediment.	Yes; focused on salmon-bearing streams for riparian restoration.	Riparian tree planting, livestock exclusion fencing, habitat restoration for salmonids.	Indirect benefit through improved water quality and habitat, but not targeted toward aquaculture.
3	ACEP (Agricultural Conservation Easement Program)	National (implemented in WA)	USDA NRCS	Agricultural lands, croplands, grasslands, wetlands	Agricultural lands at risk of conversion; must have agricultural and conservation value.	Perpetual or term (e.g., 30 years)	Maintain conservation practices that preserve agricultural use and ecological value.	Up to 50% of land value (ag use), up to 100% (wetlands)	No strict minimum; based on conservation benefit	Improves water quality, wildlife habitat, protects working lands.	Yes; active in southwest WA	Farmland and wetland easements in Clark County	Improves watershed health; indirect benefits to aquaculture
4	Columbia Land Trust	Southwest WA and Northwest OR	Columbia Land Trust	Natural areas, forests, working lands	Lands with habitat, scenic, or ecosystem value	Perpetual	Voluntary agreement to conserve land; site-specific requirements	Negotiated case-by-case	Flexible	Focus on habitat, water quality, biodiversity	Yes; numerous in Clark County and surrounds	East Fork Lewis and Washougal River projects	Watershed benefits support aquatic systems
5	Capitol Land Trust	South Puget Sound, Chehalis Basin	Capitol Land Trust	Natural areas and working lands	Ecologically or agriculturally significant lands	Perpetual	Voluntary; tailored to site	Based on appraisal and conservation value	Flexible	Wildlife habitat, water protection, riparian zones	Yes; Grays Harbor, Lewis, Thurston counties	Twin Rivers Ranch, Stillman Creek Preserve	Water quality improvements benefit aquatic systems
6	Forterra	Statewide (WA)	Forterra	Forests, farms, green spaces, natural areas	Lands with social, economic, or environmental importance	Perpetual	Varies by project	Negotiated	Flexible; strategic value prioritized	Focus on climate resilience, biodiversity, water/forest protection	Yes; statewide presence	Port Gamble shoreline, urban greenbelts	Watershed-level effects; not directly targeted
7	Cascade Forest Conservancy	Southwest Washington (Gifford Pinchot region)	Cascade Forest Conservancy	Forests, streams, and wildlife habitat	Lands with ecological significance including watersheds and biodiversity hotspots	Not specified; primary focus is conservation, restoration, and advocacy	Not applicable; focuses on partnerships and projects rather than direct payments	Not applicable; does not typically purchase easements	Flexible; from localized projects to landscape-level conservation	Forest and watershed protection, climate resilience, wildlife habitat	Yes; active in the Gifford Pinchot National Forest area	Habitat restoration, species monitoring, mining opposition near Mt. St. Helens	Watershed protection supports healthier aquatic ecosystems; indirect benefits
8	Virginia Eastern Shore Land Trust (VESLT)	Virginia, Eastern Shore	Virginia Eastern Shore Land Trust	Working lands including aquaculture, agriculture, forestry	Land must support traditional land uses; conservation easements protect from development	Perpetual	Land must remain in traditional uses such as aquaculture, agriculture, or forestry	Varies; often donated easements with tax benefits, some potential for purchase	Flexible; based on conservation and use value	Protects working waterfronts, preserves coastal ecosystems, limits incompatible development	No; East Coast (Virginia)	Easements protecting shellfish farms and waterfront access	Directly supports aquaculture by preserving access and limiting development
9	Lower Shore Land Trust	Maryland, Eastern Shore	Lower Shore Land Trust	Farms, forests, wetlands, potential aquaculture areas	Conservation of working lands including lands supporting aquaculture	Perpetual	Lands must be maintained under conservation-compatible uses	Can be donated or funded easements; varies by agreement	No strict minimum; case-by-case basis	Preserves habitat, water quality, and sustainable land use practices	No; East Coast (Maryland)	Farm and wetland easements; potential for aquaculture support	Supports sustainable land uses; compatible with aquaculture conservation
10	ACEP (East Coast Use for Aquaculture)	National (used on East Coast)	USDA NRCS	Agricultural lands, including aquaculture in some cases	Lands must have conservation and agricultural value; applicable to aquaculture areas in some regions	Perpetual or term	Must implement conservation practices in line with program goals	Up to 50% of appraised value; cost-share for conservation practices	Flexible; evaluated on conservation value	Improves land and water conservation, supports sustainable agricultural use	Yes, but aquaculture use more common on East Coast	Working farm easements including aquaculture-compatible operations	Supports sustainable aquaculture when aligned with conservation goals
11	McKenzie River Trust (MRT)	Western Oregon	McKenzie River Trust	Rivers, streams, wetlands, riparian areas	Lands with conservation value—habitat, water quality, biodiversity; indirect support for aquaculture	Perpetual	Voluntary easement donation to protect ecological values; terms tailored to landowner goals	Typically donated; potential tax benefits	Flexible; based on conservation importance	Habitat preservation, water quality improvement, ecosystem resilience	No; Oregon-based	Easements on riparian and floodplain areas supporting aquatic ecosystems	Indirectly supports aquaculture by improving aquatic ecosystem health

Figure D-1. Table of existing conservation easement programs in western Washington State.

Additional NRCS Implementation Examples

East Coast & Gulf States

- **Virginia (Chesapeake Bay)**: NRCS provided $776,284 through the Regional Conservation Partnership Program (RCPP) to fund 40 oyster restoration contracts. These included deploying natural substrate, placing spat-on-shell, and establishing oyster beds under Code 643. These efforts improved water filtration and created habitats for fish and crabs.
- **New Jersey**: Under the NJ COASTAL Project, NRCS partnered with the Ocean County Soil Conservation District to enhance aquatic habitat quality. Projects involved reducing nutrient runoff, improving water clarity, and supporting gear innovations that minimize seabed disturbance.
- **Rhode Island**: Through EQIP, NRCS supported reef development via spat-on-shell production and the strategic deployment of cultch materials. The Bivalve Aquaculture Gear and Biofouling Control practice helped growers reduce gear impacts while maintaining productivity.
- **Florida**: After hurricanes Debby, Helene, and Milton, NRCS provided approximately $1 million in emergency assistance. Support focused on gear management, debris cleanup, and equipment replacement to ensure environmental compliance and allow quick recovery.

Washington

- **Hood Canal**: NRCS collaborated with Puget Sound Restoration Fund and the Skokomish Indian Tribe to restore 15 acres of native Olympia oyster habitat. Clean oyster shells were spread using tugboats and water cannons to promote natural settlement. This project contributed to tribal heritage and water quality improvement. *643 - Restoration of Rare and Declining Communities* was the applied BMP.
- **Willapa Bay & Grays Harbor**: Through participation in the Washington Coast Shellfish Aquaculture Study led by Washington Sea Grant, USDA-ARS Pacific Shellfish Research Unit (Newport, OR) supported research into sediment dynamics, eelgrass interactions, and shrimp control. The project promotes adaptive, ecosystem-based management approaches.

Conclusion

NRCS BMPs are highly relevant to shellfish aquaculture and can be tailored to address site-specific and ecosystem-level challenges. By leveraging its expertise in conservation planning, habitat restoration, and technical assistance, NRCS plays a crucial role in supporting sustainable aquaculture. The agency's collaboration with industry stakeholders, research institutions, and tribal governments ensures practices align with ecological, economic, and cultural values.

Shellfish growers are encouraged to consult their local NRCS office and Conservation District to explore available practices and funding opportunities. The integration of conservation and aquaculture strengthens both coastal economies and environmental health.

Appendix E: Outreach to aquaculture producers

A. Methods

Building from the initial survey to Conservation Districts (CDs), described in *Appendix B: Conservation District Survey Results*, the project team developed a survey focused on aquaculture producers, with support from Willapa-Grays Harbor Oyster Growers Association (WGHOGA). This survey was shared in both print (mailed) and digital (emailed) formats to the entire 320 licensed shellfish growers in Washington State. This list was provided by the Washington State Department of Health. For specific survey questions and related information shared to growers, see *Appendix A: Outreach Materials*. Physical surveys included a self-addressed stamped envelope in order for respondents to mail their responses to Pacific Conservation District staff. Upon receipt of the 28 completed surveys, print and digital results were consolidated into a single spreadsheet for processing. More detailed survey results than are described herein are available upon request.

Additional in-person outreach supplemented the surveys. The resulting conversations provided additional insights that were analyzed alongside the survey responses. In-person outreach included:

- Participation in the 2025 Annual Conference for Shellfish Growers, hosted by Washington Sea Grant in Union, WA.[1] The project team provided a brief presentation and set up a table with outreach materials and surveys.
- Participation in the Willapa-Grays Harbor Estuary Collaborative's Fall 2025 and Spring 2025 quarterly meetings.[2] At these meetings, the project team heard insights related to the overall project goals and received feedback on emerging recommendations, respectively.
- Targeted communications to shellfish farmers who had expressed interest in follow-up conversations in their survey responses, who did not respond to the surveys but were known for their innovative efforts, and/or who already known to the project team, assisted by WGHOGA.

Based on the survey and outreach results, recommended practices were developed by:

1. Grouping specific respondent-recommended practices related to carbon or greenhouse gases, based on their topic area (eelgrass and ecology; shellfish lifecycle; ocean acidification and water quality; regulations, mitigation, or easements; materials and methods; equipment, fuels, and energy use; other; and multiple). Hurdles, related organizations, real-world examples, and related ecological components were also tracked according to these specific practices.
2. Grouping specific respondent-recommended practices that were not related to carbon or greenhouse gases, based on these same topic areas, alongside related hurdles, organizations, real-world examples, and ecological components.
3. Grouping respondent-recommended ways for CDs to support aquaculture.
4. Based on the resulting topic areas, the project team standardized language for each emerging practice.
5. All related hurdles, organizations, real-world examples, and ecological components were grouped based on emerging practices, in order to inform descriptions in the report.
6. Emerging practice recommendations were revised by the project team.
7. A survey was made to receive feedback on emerging practice recommendations, with a tool for ranking practices based on grower interest. This survey was shared with the survey respondents who

[1] https://wsg.washington.edu/event/2025-conference-for-shellfish-growers/
[2] https://wghec.org/ : The Willapa-Grays Harbor Estuary Collaborative is a group of local, tribal, state, federal, industry, and environmental organizations committed to increasing the resilience of communities and ecosystems on the southwest Washington coast while building trust and common understandings.

expressed interested in reviewing recommendations, Willapa-Grays Harbor Estuary Collaborative members, and other shellfish farming contacts.

8. Practice recommendations were refined and compiled in the full report, incorporating all relevant data and categories obtained via surveys and supplementary outreach.

In parallel to outreach to shellfish growers, a similar survey was sent to "boundary organizations" that provide technical support for shellfish growers in order to better understand the existing services provided, gaps in services, and related. hurdles or opportunities. The results from boundary organizations' survey responses informed the full report but are not described further in this appendix.

B. Survey Respondent Demographics

Survey respondents represented North Puget Sound and Straits (4), South Puget Sound (13), Hood Canal (6), Grays Harbor (3), and Willapa Bay (2). Supplemental in-person outreach was largely focused on Willapa Bay and Grays Harbor.

One survey respondent had a "large (1500+ acres)" production area, representing South Puget Sound. Two respondents had "medium (500-1500 acres)" production area, representing South Puget Sound and Willapa Bay. Twenty four respondents had "small (less than 500 acres)" production area.

Commercial shellfish grower were primarily Pacific oysters (*Magallana gigas*, formerly *Crassostrea gigas*), though other shellfish included clams (Manila clam, *Ruditapes philippinarum*, and other unspecified clam species), Kumamoto oyster (*Magallana sikamea*, formerly *Crassostrea sikamea*), mussels (unspecified species), Pacific geoduck (*Panopea generosa*), Olympia oyster (*Ostrea lurida*, both for commercial and restoration purposes). Species listed only once include red sea urchin (*Mesocentrotus franciscanus*).

No survey respondents commercially grew seaweed or algae, though one grew seaweed/algae for hobby purposes while another was considering this activity in the future. Another respondent mentioned growing algae to feed larval shellfish and seed, which we believe is a more widespread practice than survey results show. One respondent mentioned producing experimental sea cucumber and sablefish that are not for market.

Of the 28 respondents, 5 said they have worked with CDs, and 9 said they would like to work with CDs in the future.

Of the 28 respondents, 3 said they have worked with the Washington State Conservation Commission (SCC) and 8 said they would like to work with SCC in the future.

Of the 28 respondents, 3 said they have worked with the USDA NRCS and 8 said they would like to work with USDA NRCS in the future.

C. Survey results: Overall reception

Most survey responses were informational and encouraging of the project team's work. Several responses highlighted the shellfish aquaculture producers' unfamiliarity with terminology such as "carbon sequestration," though this also may be due to wording that was confusing. Two others respondents stated that carbon sequestration is "nonsense" or "does not apply to our work." Overall, respondents were generally able to respond to all survey questions with detailed responses.

Many responses focused on topics unrelated (or indirectly related) to carbon sequestration and greenhouse gas reduction. While the survey intentionally sought responses that would provide an understanding of aquaculture producers' priorities beyond these two SFF-supported topics, multiple responses interjected these issues into responses to questions intended to be focused on SFF-supported topics.

D. Survey results: Suggested practices to support aquaculture:

Survey respondents and ensuing outreach respondents identified the following carbon sequestration and greenhouse gas-reducing activities, described further in the full report. Items with a star (⭐) by them were prioritized in the final survey about emerging recommended practices:

Modifying existing aquaculture activities to support carbon sequestration

1. Minimize sediment disturbance ⭐
2. Increase in-water oyster shell volumes and shellfish production
3. Multitrophic or diversified aquaculture
4. Wild harvest

Improving carbon sequestration in the aquaculture ecosystem

5. Modify light penetration of overwater structures
6. Stewardship of seagrasses and seaweeds ⭐
7. Coordination with other local restoration and stewardship activities ⭐

Materials management to reduce GHG consumption

8. Plastics recycling ⭐
9. Reduction in plastics use and use of alternative packaging ⭐

Energy sourcing and use

10. Electrification, equipment upgrades, and reductions in fossil fuel use ⭐
11. Energy production and storage
12. Local market access or development

Assessment, planning, and policy for carbon sequestration and/or GHG reduction

13. Credit banking and easements for aquatic lands ⭐
14. Carbon sequestration farm planning and assessment ⭐
15. GHG reduction farm planning and assessment ⭐

The following activities were also recommended, though they do not clearly align with SFF priorities. These are also described further in the full report:

Farm planning and organizational assistance

16. Farm planning
17. Economic, market, and policy strategy/assistance

Water quality and ecological conditions

18. Improve survivability during temperature extremes
19. Invasive/nuisance species management
20. Repair or removal of derelict structures
21. Water quality monitoring and assessment of water quality impairments
22. Water quality improvement

23. Litter removal

Equipment and methods improvements

24. Aquaculture processing infrastructure improvements
25. Alternative gear (e.g. floating bag) purchase

Survey and supplemental outreach also informed *Additional ways for SCC/CDs to better support aquaculture*, described further in the full report.

Appendix F: Matrix of recommended practices

#	Recommended practice	relevant WSCC programs								scale of action				type of action				status****			
		Sustainable Farms & Fields*	Shellfish Program**	Natural Resource Investments	Riparian Grant Program	Disaster Assistance Program	Voluntary Stewardship Program	Office of Farmland Preservation	Coordinated Resource Management	parcel or farm	shore, embayment, or watershed	regional	state or national	assessment + monitoring	planning + capacity building***	physical implementation	education, outreach, + policy	assess + monitor*****	planning + cap building	implementation	edu, outreach
	Modifying existing aquaculture practices to support carbon sequestration																				
1	Minimize sediment disturbance	x	x	x						x					x	x			x		
2	Increase in-water oyster shell volumes and shellfish production	x		x						x						x		x			
3	Multitrophic or diversified aquaculture	x		x						x				x	x	x		x			
4	Wild harvest	x								x				x	x	x			x		
	Improving carbon sequestration in the aquaculture ecosystem																				
5	Modify light penetration of overwater structures	x		x						x						x			x		
6	Stewardship of seagrasses and seaweeds	x	x	x					x	x					x	x			x		
7	Coordination/collaboration with other local restoration and stewardship activities	x	x	x	x		x				x				x	x			x		
	Materials management to reduce GHG consumption																				
8	Plastics recycling	x	x	x					x	x		x	x		x	x			x	x	
9	Reduction in plastics use and use of environmentally friendly plastics	x	x	x					x	x		x	x			x		x	x	x	
	Energy sourcing and use																				
10	Electrification, equipment upgrades, and reductions in fossil fuel use	x		x						x						x		x		x	
11	Energy production and storage	x		x						x	x	x				x		x	x	x	
12	Local market access or development	x		x					x	x		x			x		x	x	x	x	x
	Assessment, planning, and policy for carbon sequestration and/or GHG reduction:																				
13	Credit banking and easements for aquatic lands	x					x	x		x			x			x	x	x			x
14	Carbon farm planning and assessment	x				x				x				x	x				x	x	
15	GHG farm planning and assessment	x				x				x				x	x			x	x		
	Other practices beyond SFF priorities																				
16	Farm planning					x				x				x	x			x	x		
17	Economic, market, and policy strategy/assistance								x	x		x	x	x	x			x	x		
18	Improve survivability during temperature extremes			x		x			x	x	x		x	x		x		x	x	x	
19	Invasive/nuisance species management			x					x	x	x	x	x	x	x	x	x	x	x	x	x
20	Repair or removal of derelict structures		x	x						x	x					x				x	
21	Water quality monitoring and assessment of water quality impairments		x			x			x	x	x	x		x					x	x	
22	Water quality improvement		x	x	x				x	x	x	x		x	x	x				x	
23	Litter removal		x	x					x	x	x	x				x					
24	Aquaculture processing infrastructure improvements			x						x						x					
25	Floating bag purchase			x						x						x					

*practices are marked that could be eligible as SFF demonstration projects

**the Shellfish Program only funds implementation, but this report recommends an update to this policy. Therefore some practices here may be eligible that are not currently, and are marked accordingly

***many of these practices involve - or could be preceded by - this phase in order to be done successfully

****this group describes the action needed to the advance practice

*****many of these practices could benefit from assessment of cumulative environmental impacts or relationship to ecological carrying capacity