Programmatic Environmental Assessment for Funding Aquaculture Research and Development Projects

TITLE:	Programmatic Environmental Assessment for Funding Aquaculture Research and Development Projects
LEAD AGENCY:	National Sea Grant Office Office of Oceanic and Atmospheric Research (OAR) National Oceanic and Atmospheric Administration (NOAA) U.S. Department of Commerce
COOPERATING AGENCY:	Office of Aquaculture (OAQ) National Marine Fisheries Service (NMFS), NOAA
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ABSTRACT: This Programmatic Environmental Assessment (PEA) serves as a framework to analyze the potential impacts on the natural and human (social and economic) environment from aquaculture research and development projects funded by federal financial assistance award programs in the Office of Oceanic and Atmospheric Research (OAR) and the National Marine Fisheries Service (NMFS) and includes anticipated environmental impacts of current and future related initiatives and decisions. This PEA is a planning tool to support tiered, site-specific analyses by narrowing the spectrum of environmental impacts to focus on project-level reviews as needed. Projects will vary in terms of project or activity size, complexity, geographic location and timing. Therefore, this PEA provides a programmatic-level analysis of environmental impacts associated with the proposed action and alternatives. In addition, NOAA intends to rely on this document to assess site-specific or project-level/specific actions that are determined to be within the range of alternatives and scope of potential environmental effects, and do not have significant impacts on social and economic factors of the human environment.

DATE: April 24, 2023

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List of Acronyms

ADCP	Acoustic Doppler Current Profiler
AGO	Acquisition and Grants Office
AOA	Aquaculture Opportunity Areas
ASV	Autonomous Surface Vehicle
AUV	Autonomous Underwater Vehicle
BMP	Best Management Practice
CE	Categorical Exclusion
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CM	Companion Manual
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
DLNR	Department of Land and Natural Resources
DO	Dissolved Oxygen
DOC	Department of Commerce
EA	Environmental Assessment
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
EO	Executive Order
EPA	Environmental Protection Agency
ESA	Endangered Species Act
FLUPSY	Floating Upweller System
FONSI	Finding of No Significant Impact
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIS	Geographic Information System
GLERL	Great Lakes Environmental Research Laboratory
GMD	Grants Management Division
HAB	Harmful Algal Bloom
HAPC	Habitat Area of Particular Concern
IMTA	Integrated Multi-Trophic Aquaculture
IWG-A	Interagency Working Group on Aquaculture
NHPA	National Historic Preservation Act
MMPA	Marine Mammal Protection Act
MSA	Magnuson-Stevens Fishery Conservation and Management Act
NAGPRA	Native American Graves Protection and Repatriation Act
NAO	NOAA Administrative Order
NCCOS	National Centers for Coastal Ocean Science
NEPA	National Environmental Policy Act
NGO	Non-governmental Organization
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration

NOS	National Ocean Service
NPDES	National Pollution Discharge Elimination System
NSGO	National Sea Grant Office
NRHP	National Registry for Historic Places
OAQ	Office of Aquaculture
OAR	Office of Oceanic and Atmospheric Research
OCM	Office for Coastal Management
OMB	Office of Management and Budget
ORF	Operations, Research, and Faculties
OSF	Office of Sustainable Fisheries
OSHA	Occupational Health and Safety Administration
PEA	Programmatic Environmental Assessment
PIT	Passive Integrated Transponders
RAS	Recirculating Aquaculture System
RFP	Request for Proposal
ROD	Record of Decision
ROV	Remotely Operated Vehicles
SAV	Submerged Aquatic Vegetation
SBIR	Small Business Innovation Research
SCA	Subcommittee on Aquaculture
SCUBA	Self-contained Underwater Breathing Apparatus
SK	Saltonstall-Kennedy
SL	Standard length
SONAR	Sound Navigation and Ranging
SPDES	State Pollution Discharge Elimination System
TEK	Traditional Ecological Knowledge
US	United States
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
USC	United States Code
USDA	United States Department of Agriculture

Glossary of Terms

Algae: General term for a large and diverse group of photosynthetic, mainly aquatic, organisms, including unicellular microalgae and multicellular macroalgae such as various seaweeds.

Aquaculture: The propagation and rearing of aquatic organisms for any commercial, recreational, or public purpose" in controlled or selected environments. This definition covers all production of finfish, shellfish, plants, algae, and other marine organisms for: 1) food and other commercial products; 2) wild stock replenishment for commercial and recreational fisheries; 3) rebuilding populations of threatened or endangered species under species recovery and conservation plans; and 4) restoration and conservation of marine and Great Lakes habitat (NOAA, 2011).

Benthos: The community of organisms that live on, in, or near the bottom of a water body such as a sea, river, lake, or stream, also known as the benthic zone.

Broodstock: Mature individuals of a given aquatic species used in aquaculture for breeding purposes.

Coastal waters: The Coastal Zone Management Act (CZMA) of 1972 defines coastal waters as: (a) waters in the Great Lakes area, the waters within the territorial jurisdiction of the United States consisting of the Great Lakes, their connecting waters, harbors, roadsteads, and estuary-type areas such as bays, shallows, and marshes and (b) in other areas, those waters, adjacent to the shorelines, which contain a measurable quantity or percentage of sea water, including, but not limited to, sounds, bays, lagoons, bayous, ponds, and estuaries."

Coastal watershed counties: Counties where either: 1) at a minimum, 15% of the county's total land area is located within a coastal watershed, or 2) a portion of or the entire county accounts for at least 15% of a coastal USGS 8-digit cataloging unit (a geographic area representing part of all of a surface drainage basin, a combination of drainage basins, or a distinct hydrologic feature).

Coastal shoreline counties: Counties that: 1) have a coastline bordering the open ocean or Great Lakes coasts (or associated sheltered water bodies), or 2) contain velocity zones (V-zones) or coastal high hazard areas. V-zones are areas where wave heights more than 3 feet and/or high velocity water can cause structural damage in a 100-year flood; a flood with a 1-percent chance of occurring or being exceeded in a given year.

Diversity: The full representation of and collaboration between people with different identities, knowledge sets, experiences, and perspectives.

Ecosystem services: Outputs, conditions, or processes provided by certain aquacultured species that benefit natural systems. Examples of ecosystem services include improving water quality and provision of habitat for other species.

Environmental justice*: The fair treatment and meaningful involvement of all people, regardless of race, color, gender, sexual orientation, national origin, religion, disability, or income during development, implementation, and enforcement of environmental laws, regulations, and policies, including but not limited to:

- Equitable protection from environmental and health hazards;
- Equitable access to decision-making processes; and
- Equitable opportunity for underserved communities that have been marginalized.

*Adapted from the Environmental Protection Agency definition.

Equity: The consistent and systematic fair, just, and impartial treatment of all individuals, including individuals who belong to underserved communities that have been denied such treatment (as defined by Executive Order 13985)

Exclusive Economic Zone (EEZ) of the United States: A zone contiguous to the territorial sea, including zones contiguous to the territorial sea of the United States, the Commonwealth of Puerto Rico, the Commonwealth of the Northern Mariana Islands (to the extent consistent with the Covenant and the United Nations Trusteeship Agreement), and United States overseas territories and possessions. The Exclusive Economic Zone extends to a distance 200 nautical miles from the baseline from which the breadth of the territorial sea is measured. In cases where the maritime boundary with a neighboring State remains to be determined, the boundary of the Exclusive Economic Zone shall be determined by the United States and other State concerned in accordance with equitable principles. (FR48 10605)

Farm site: The location of an aquaculture operation.

Feed conversion rate: In aquacultured species requiring feed, feed conversion rate or FCR is the weight of feed administered over the production cycle of an animal divided by weight gained.

Focal species: Species that have not had much research done on their life history or market viability but have the potential to become commercially viable aquaculture products. Focal species include shellfish (clams, oysters, mussels, scallops), finfish (marine pelagic, marine ornamentals), and seaweeds, as well as copepods (for feed), shrimp, sea cucumber, seahorses, and sea urchins. Research may include the development of techniques (broodstock conditioning and cryogenic preservation of gametes and larvae) that enable seed or fingerling production throughout the year.

Genetic pollution: Potential undesirable gene flow resulting from escape or release of aquaculture species into wild populations.

Harmful algal bloom: Occur when colonies of algae (simple plants that live in the sea and freshwater) grow out of control and produce toxic or harmful effects on people, fish, shellfish, marine mammals and birds.

Hatchery: An aquaculture facility in which reproduction and culture of early life stages of an aquatic species occurs.

Integrated multi-trophic aquaculture: The rearing of a fed aquatic species—which could be a finfish species such as salmon, for example—in association with species that occupy other trophic levels, making use of the waste products of the fed organisms. Typically, this association involves species such as seaweeds or plants to assimilate dissolved nutrients, filter-feeders such as mollusks to use suspended organic materials, and deposit-feeders to use settleable solids. However, there are various approaches to achieving the basic goals of IMTA that span freshwater and marine aquaculture (Barrington, et al, 2009)

Inclusion: The creation of an open and welcoming environment that recognizes and affirms the value and dignity of all people.

Molluscan shellfish: Invertebrate species of the phylum Mollusca such as oysters, clams, mussels, and scallops.

Nursery: An aquaculture facility or operation in which juvenile life stages of aquatic species are produced for subsequent transfer to grow out operations for the production of market ready organisms.

Outplanting: Transfer of aquacultured species, typically their juvenile life stages such as shellfish seed, to farm or restoration sites.

Pelagic: An aquatic species native to the open ocean.

Pond aquaculture: Production method in which water is maintained in an enclosed area by artificially constructed ponds where aquatic species are reared. In watershed ponds, water required to fill and maintain the pond is entirely sourced from the watershed runoff and may be supplemented by ground or surface water. The most common type of aquaculture pond are levee ponds which are created in flat land areas. Groundwater is typically used to fill and maintain levee ponds.

Raceways: Constructed, typically flow-through, channels used in aquaculture to culture aquatic species.

Recirculating aquaculture system (RAS): Aquaculture production technology in which water (typically in tanks) is recycled and reused after mechanical and biological filtration and removal of suspended matter and metabolites, coupled with water sterilization and degassing. RAS are used for high-density culture of various aquatic species, utilizing minimum land area and water, and affords the ability to control water parameters such as temperature and salinity.

Seafood: Any form of aquatic life regarded as food by humans, prominently including fish and shellfish. Shellfish include various species of mollusks (e.g., bivalve mollusks such as clams, oysters and mussels, and cephalopods such as octopus and squid), crustaceans (e.g., shrimp, crabs, and lobster), and echinoderms (e.g., sea cucumbers and sea urchins). Edible sea plants such as some seaweeds and microalgae may also be considered seafood. Note that the term seafood currently applies not only to marine aquatic species, but freshwater species as well.

Seed: A term primarily referring to juvenile molluscan shellfish past the larval stage, but with shell formation. The term seed is dependent on the species. For example, seed oysters have shell lengths less than approx. 30-mm.

Sustainable aquaculture: aquaculture developed within the context of the DOC goals of encouraging economic growth and employment opportunities as well as in the context of NOAA goals of integrating environmental, social and economic considerations in management decisions concerning aquaculture (NOAA, 2011).

Therapeutants: Drugs, biologics, and other chemical substances used on aquaculture operations when necessary to keep aquatic species healthy during their production cycle.

Underserved communities: Populations sharing a particular characteristic, as well as geographic communities, that have been systematically denied a full opportunity to participate in aspects of economic, social, and civic life, such as Black, Latino, and Indigenous and Native American persons, Asian Americans and Pacific Islanders and other persons of color; members of religious minorities; lesbian, gay, bisexual, transgender, questioning/queer and related identities (LGBTQ+) persons; persons with disabilities; persons who live in rural areas; and persons otherwise adversely affected by persistent poverty or inequality.

Variant: A pathogen such as a virus, that has been genetically altered or mutated.

Executive Summary

This Programmatic Environmental Assessment (PEA) serves as a framework to analyze the potential impacts on the natural and human (social and economic) environment from aquaculture research and development projects funded by federal financial assistance award programs in the Office of Oceanic and Atmospheric Research (OAR) and the National Marine Fisheries Service (NMFS) and includes anticipated environmental impacts of current and future related initiatives and decisions. This PEA is a planning tool to support tiered, site-specific analyses by narrowing the spectrum of environmental impacts to focus on project-level reviews as needed. NOAA determined a programmatic approach was appropriate for this analysis because the proposal to continue to issue aquaculture research and development awards is a broad and diverse action that is implemented nationwide. NOAA intends for this PEA to create efficiencies by establishing a framework that can be used for "tiering" when appropriately applied to future aquaculture research and development awards. As financial assistance awards are proposed, to the extent additional NEPA analysis is required, environmental review will rely on the analysis set forth in this PEA (40 C.F.R. § 1508.28,1502.20 (1978)).

The overall goal of NOAA's aquaculture research and development federal financial assistance award programs is to provide opportunities to public and private entities to create scientific knowledge that will inform state and Federal entities, stakeholders, and NOAA's regulatory and resource management decisions, in addition to fostering innovative and sustainable approaches to aquaculture that will benefit NOAA's trust resources, the aquaculture industry, and the American public. The purpose of the Proposed Action is to further these efforts in domestic marine and freshwater aquaculture research and development in accordance with the statutory authorities described in Chapter 1.2.1 and 1.2.2 of this PEA. Existing federal financial assistance award programs for aquaculture research and development projects that are discussed in this PEA include: the National Sea Grant College Program (Sea Grant), the Small Business Innovation Research Program (SBIR) and the Office of Aquaculture (OAQ).

Aquaculture research and development federal financial awards are needed to gain scientific knowledge and develop a trained workforce to address critical issues, including: supporting a healthy coastal economy; addressing the demand for domestic seafood products; and enhancing wild stock populations. The federal financial assistance award programs described in Chapter 1 provide a unique opportunity within NOAA to partner with external scientists and institutions, engage in private sector and public collaborations, and facilitate aquaculture research and development to meet the needs for a sustainable aquaculture industry.

This document has been prepared in compliance with the National Environmental Policy Act of 1969 (NEPA), the 1978 Council on Environmental Quality (CEQ) Regulations (40 Code of Federal Regulations [CFR] 1500–1508), and NOAA policy and procedures (NOAA Administrative Order 216-6A (NAO 216-6A and its Companion Manual (CM)).

Projects analyzed as part of this PEA are broadly described as falling under one of the following five main research and development categories:

- Outreach, Education, and Planning
- Data Analysis and Social Science Research
- Laboratory and Rearing Science and Research on Finfish and Shellfish
- Field Research and Assessments
- Shellfish Aquaculture Restoration

As aquaculture research and development projects are being proposed for federal financial assistance awards, the activities and techniques for each project and its impacts are reviewed and evaluated by NOAA to determine whether the activities fall within the scope of this PEA. If after analysis of the proposed award, there are no potential negative impacts identified, then no further NEPA analysis is necessary. An inclusion analysis document (identifies any steps needed for ensuring compliance) will serve as the NEPA documentation for this determination. If a proposed activity is not within the scope of the PEA or the activity is within the scope but requires additional review because expected impacts are greater than those analyzed by the PEA, then additional NEPA analysis will be performed.

Chapter Outline and Summary

Chapter 1 Overview. This chapter discusses how NOAA supports innovative aquaculture research projects through collaboration with academic and private sector partners through the NOAA competitive award programs for marine and Great Lakes aquaculture. NOAA's aquaculture-related authorities and policies and how NOAA ensures that U.S. aquaculture develops sustainably, in concert with healthy, productive, resilient coastal ecosystems and strategic plans are also discussed here.

Chapter 2 Alternatives. This chapter discusses the five main research and development categories: (1) Outreach, Education, and Planning, (2) Data Analysis and Social Science Research, (3) Laboratory and Rearing Science and Research on Finfish and Shellfish, (4) Field Research and Assessments, and (5) Shellfish Aquaculture Restoration with respect to the two Alternatives: the Proposed Action (Preferred Alternative) and the No Action Alternative. The Preferred Alternative is for NOAA to issue federal financial assistance awards to applicants for aquaculture research and development projects through programs administered by Sea Grant, SBIR, and NMFS OAQ. The Preferred Alternative would allow eligible applicants to carry out work that addresses one or more of the five main research and development categories and provide the ability to adapt to any future changes in agency and program priorities. The PEA also evaluates the impact of the No Action alternative in which NOAA would not provide federal financial assistance awards for aquaculture research and development. This alternative serves as a baseline for comparing the Proposed Action with the No Action alternative.

Chapter 3 Affected Environments. This Chapter discusses potential impacts of the alternatives on the affected environments, such as land-based, coastal and ocean, and freshwater (including the Great Lakes) in which aquaculture research and development actions may occur. Due to the programmatic nature of the actions being evaluated, specific details about each affected environment relative to site-specific or project-level/specific actions are not fully analyzed in this PEA. This analysis will occur on a project-specific basis as projects are submitted for review under NOAA's competitive award programs.

Chapter 4 Environmental Effects. This chapter discusses the effects or impacts from the proposed action or alternatives that are reasonably foreseeable that cause changes to the human environment. Effects include ecological (such as the effects on natural resources and on the components, structures, and functioning of affected ecosystems), aesthetic, historic, cultural, economic, social, or health, whether direct, indirect, or cumulative. Effects may also include those resulting from actions which may have both beneficial and detrimental effects, even if on balance NOAA believes that the effects will be beneficial.

Based on the assessment of the Proposed Action alternative for NOAA to issue federal financial assistance awards, it was determined that none of the project types have the potential for significant physical, biological, or socioeconomic impacts. Though all activities discussed have the potential to contribute to cumulative impacts, they are considered negligible.
Analysis of the No Action alternative revealed the potential for minor to moderate long-term adverse impacts on all resources because the lack of funding aquaculture research and

development projects, would prevent gains in scientific knowledge used to develop sustainable aquaculture.

Chapter 5 Relevant Environmental Laws, Regulations, and Executive Orders. Some of the most common statutes that are applicable to aquaculture research and development activities are listed in this Chapter. Each proposal for financial assistance of an aquaculture research and development project submitted to NOAA, undergoes an environmental review for compliance with environmental laws and executive orders. Compliance with relevant environmental laws and executive orders will occur at the project specific level.

Chapter 6 List of Preparers. A list of individuals who participated in the preparation of the PEA.

Chapter 7 List of People Consulted. A list of all individuals based on their area of expertise and knowledge of aquaculture.

Chapter 8 References Cited. A list of all the literature and references cited in the PEA.

Chapter 1 Overview

1.1 Introduction

The National Oceanic and Atmospheric Administration's (NOAA's) policy defines aquaculture as "the propagation and rearing of aquatic organisms for any commercial, recreational, or public purpose" in controlled or selected environments. This definition covers all production of finfish, shellfish, plants, algae, and other marine organisms for 1) food and other commercial products; 2) wild stock replenishment for commercial and recreational fisheries; 3) rebuilding populations of threatened or endangered species under species recovery and conservation plans; and 4) restoration and conservation of marine and Great Lakes habitat (NOAA, 2011).

Growing demand for aquaculture products and an interest in providing food security and new jobs provide the basis for promoting domestic aquaculture development. The United States (U.S.) is a major consumer of aquaculture products. Roughly 70 to 85 percent of the seafood consumed in the U. S. is imported and about half of this is produced by aquaculture. Domestic aquaculture supplies only about 7 percent of the entire U.S. seafood supply and has a landed (or total value once it arrives in the United States) value of $1.5 billion. The predominant farmed aquatic organisms include channel catfish, rainbow trout, crawfish, baitfish and ornamental fish, salmon, oysters, clams, mussels, and aquatic plants (USDA NASS 2019; NMFS 2021).

NOAA supports innovative aquaculture research through collaboration with academic and private sector partners, including international and bilateral research initiatives with foreign scientists, and through NOAA's competitive award programs for coastal, marine, and Great Lakes aquaculture. As an example, NOAA established the National Shellfish Initiative and assisted in the establishment of nine state/regional Shellfish Initiatives, in partnership with shellfish farmers and shellfish restoration organizations with the goal to increase populations of bivalve shellfish in our nation's coastal waters—including oysters, clams, and mussels—through both sustainable commercial production and restoration activities. Additional areas of emphasis include research on environmental effects, aquatic health, nutrition, early life history culture techniques, aquatic species restoration, stock enhancement, ecosystem management, social issues, and aquaculture economics and markets. Current research initiatives focus on 1) strengthening aquaculture research capabilities at the agency's regional NOAA Fisheries Science Centers; 2) in-house research focused on genetics, alternative feeds for marine fish, restoration of threatened and endangered species, and stock enhancement; and 3) research and development supported by the programs described in this Programmatic Environmental Assessment (PEA).

1.2 Regulatory Framework

NOAA has jurisdiction over ocean, coastal and Great Lake resources and habitats, and NOAA has a multi-faceted role in aquaculture development in the United States, from supporting scientific research, education and engagement to federal policy-making and regulation. NOAA is charged with ensuring that U.S. aquaculture develops sustainably, in concert with healthy, productive, and resilient coastal ecosystems. The agency's aquaculture mission is implemented consistent with NOAA strategies and policies identified in various planning documents (described in Section 1.2.2) and advanced by several established federal financial assistance award programs that support associated aquaculture priorities. The federal mandates and agency strategies inform the purpose and need for the proposed action analyzed in this PEA and are described more in this Chapter.

1.2.1 NOAA Federal Financial Assistance Award Programs for Aquaculture

NOAA administers funding approved by Congress that provide resources for aquaculture research and development to public and private external entities. This is done through a federal financial awards process, which is described more in the Guide to Federal Aquaculture Grants and Financial Assistance that was published by NOAA, through the Joint Subcommittee on Aquaculture (SCA): https://www.fisheries.noaa.gov/resource/document/guide-federal-aquaculture-grant-and-financial-assistance-services-2021.

The authorities and the associated NOAA line offices that distribute federal funds for aquaculture are the subject of this PEA as discussed below.

- The National Sea Grant College Program (Sea Grant) Act of 1966 identifies NOAA as the "most suitable locus and means for" promoting activities "that will result in greater understanding, assessment, development, management, utilization, and conservation of ocean, coastal, and Great Lakes resources. The most cost-effective way to promote such activities is through continued and increased Federal support of the establishment, development, and operation of programs and projects by Sea Grant colleges, Sea Grant institutes, and other institutions, including strong collaborations between Administration scientists and research and outreach personnel at academic institutions." 33 U.S.C. § 1121(a)(5). The National Sea Grant Office (NSGO), within the Office of Oceanic and Atmospheric Research (OAR), administers federal financial assistance awards to the Sea Grant programs throughout the nation and oversees several national funding competitions. The majority of funding is through institutional cooperative agreements, released through a multi-year "omnibus" award that supports each Sea Grant program's core research, extension, education, outreach, and communications activities. Additional competitive opportunities are offered each fiscal year to address national strategic priorities, such as aquaculture. Occasionally, non-competitive awards are made to Sea Grant programs in compliance with DOC directives for such awards. In each instance, the individual Sea Grant programs apply to the NSGO for funds, and all applications for federal funds are subject to review and approval by the NSGO and the Grants Management Division (GMD) of NOAA's Acquisition and Grants Office (AGO).

- Small Business Innovation Development Act of 1982 (P.L. 97-219) (and its multiple reauthorizations and extensions) encourages the effective use of small business in meeting federal research and development objectives. The Small Business Innovative Research (SBIR) Program, administered by OAR, provides competitive research awards and enables small businesses to explore their technological potential. Aquaculture funding awarded through the SBIR Program is directed at development and commercialization of new tools and technology to help growers, resource managers, and scientists. The potential exists for awardees to partner with growers for in-situ testing of their products as they move from proof of concept towards commercialization.

- The National Marine Fisheries Service (NMFS) has administered grant programs that fund aquaculture research, on a competitive basis, through the Office of Aquaculture (OAQ) and Office of Sustainable Fisheries (OSF). For example, OAQ has been directed by Congress to work with the three U.S. interstate fisheries commissions (i.e., Atlantic, Gulf, and Pacific States Marine Fisheries Commissions) to distribute congressionally-appropriated funds in the form of grants for regional pilot and other programs. These and similar programs aim to form partnerships between the seafood industry, universities, and communities to develop, validate, and deploy economically and environmentally sustainable aquatic farming techniques and regional business practices to grow domestic seafood production and have generally focused on promising, less commercially developed technologies.

1.2.2 NOAA's Aquaculture-related Authorities and Policies

The National Aquaculture Act of 1980 ("the Act"), 16 United States Code [U.S.C.] 2801, *et seq*., establishes aquaculture as a national policy priority for the United States. The Act, in recognizing that the wild harvest of fish and shellfish can exceed levels of optimum sustainable yield, and that the rehabilitation and enhancement of fish and shellfish resources are important, calls for the Secretary of Agriculture, the Secretary of Commerce, and the Secretary of the Interior to develop a National Aquaculture Development Plan. The Plan must, among other things, identify aquatic species that the Secretaries determine to have significant potential for culturing on a commercial or other basis and recommend actions to be taken by the public and private sectors (which may include, but are not limited to, research and development, technical assistance, demonstration, extension, education, and training activities) that are necessary to achieve such potential (16 U.S.C. 2803(b)). In implementing the Plan, the Secretaries are required to "encourage the implementation of aquacultural technology in the rehabilitation and enhancement of publicly owned fish and shellfish stocks and in the development of private commercial aquacultural enterprises." (16 U.S.C. 2804(a)).

The Act also established the SCA. NOAA is a member of the SCA and has participated in developing strategic plans for federal aquaculture research, including the most recent *National Strategic Plan for Federal Aquaculture Research 2021-2025*. The plan outlines Federal priorities for research, science, and technology development that will facilitate expansion of domestic aquaculture. In 2020, E.O. 13921, *Promoting American Seafood Competitiveness and Economic Growth*, further established NOAA as a primary authority in aquaculture development.

The Department of Commerce (DOC) developed an *Aquaculture Policy*, consistent with the National Aquaculture Act of 1980, to advance scientific knowledge and public understanding, and encourage and foster the development of sustainable aquaculture (DOC, 2011). To implement this policy, DOC and its bureaus will, among other things, "work in partnership with other federal agencies, Congress, state, local, and tribal governments, industry, academia, non-governmental organizations, and other constituents at the national, regional, and local levels to: … [a]ccelerate the implementation of sustainable aquaculture production methods by developing pilot, demonstration, and technology transfer projects with seafood and related industries, nongovernmental organizations, state and local governments, federal agencies, and other partners[,]" and "[e]nhance the capabilities of federal research laboratories and participating research partners to provide the necessary ecological, technological, economic, and social data and analysis to effectively and sustainably develop, support, manage, and regulate private and public sector aquaculture." (DOC, 2011).

NOAA's *Marine Aquaculture Policy* aligns with DOC's *Aquaculture Policy* and proposes to enable the development of sustainable marine aquaculture within the context of NOAA's multiple stewardship missions and broader social and economic goals (NOAA, 2011). This agency-wide aquaculture policy forms the basis from which NOAA offices have further developed strategic plans and guidance documents to meet agency goals which are discussed below.

A number of strategic plans demonstrate NOAA's commitment to aquaculture development. DOC's current, department-wide strategic plan, *U.S. Department of Commerce Strategic Plan 2022-2026* emphasizes advancing research in marine aquaculture to promote the blue economy (DOC, 2022). The NOAA Aquaculture Strategic Plan (2023–2028), National Marine Fisheries Service (NMFS) Strategic Plan 2022-2025, and National Sea Grant College Program (Sea Grant) Strategic Plan 2018-2023 aim to foster a sustainable aquaculture industry,

1.3 NEPA Compliance

The National Environmental Policy Act (NEPA), as amended (42 U.S.C. §§ 4321, et seq.), was enacted in 1969 to establish a national policy for the protection of the environment. It applies to federal agency actions that have the potential to affect the quality of the human environment. It requires federal agency decision-makers to conduct a review process to ensure consideration of potential environmental impacts through a systematic and interdisciplinary approach, including consideration of the natural and social sciences in planning, evaluation, and decision-making. Federal agencies are obligated to comply with NEPA regulations adopted by the Council on Environmental Quality (CEQ) (40 Code of Federal Regulations [C.F.R.] Parts 1500-1508). This document has been prepared in compliance with the NEPA, the 1978 CEQ Regulations, NOAA Administrative Order (NAO) 216-6A and its Companion Manual (CM). NOAA's NAO 216-6A describes NOAA's policies, requirements, and procedures for complying with NEPA and its implementing regulations. The CM contains a list of actions, referred to as Categorical Exclusions (CEs), that typically do not individually or cumulatively have significant impacts on the human environment. An action that would normally qualify for a CE may have extraordinary circumstances that may disqualify it from being categorically excluded without further environmental analysis. Actions that are not covered by a CE or actions covered by a CE that have unresolved extraordinary circumstances, require the preparation of an Environmental Assessment (EA) under NEPA to determine the nature and extent of impacts of the action and determine whether the action has significant impacts on the quality of the human environment. If none are anticipated, this is documented in a Finding of No Significant Impact. An action that is expected to have significant impacts requires the preparation of an Environmental Impact Statement (EIS) and Record of Decision (ROD).

1.3.1 Public Involvement

The NEPA process is intended to assist NOAA in making informed decisions considering the potential environmental effects of proposed actions and their alternatives. Public involvement is an essential part of this process under NEPA, which facilitates the development of a NEPA analysis and informs the scope of issues to be addressed in the analysis, as well as identifies additional alternatives and potential mitigation measures. Although NOAA policy and procedures do not require publication of a PEA in the *Federal Register* prior to finalizing the analysis, NOAA's draft PEA was published in the *Federal Register* (87 FR 68441) for a 30 day comment period, from November 15 to December 15, 2022, to solicit relevant environmental information and provide the public an opportunity to submit comments. All 18 comments received within the 30-day period and responses are summarized in Appendix A.

1.4 Purpose of Using a PEA

The CEQ regulations encourage the development and use of programmatic NEPA documents and tiering to eliminate discussion of repetitive issues (40 CFR § 1501.11 and 1502.4). Programmatic NEPA reviews add value and efficiency to the decision-making process when they inform the scope of decisions and subsequent tiered NEPA reviews. This PEA analyzes the potential direct, indirect, and cumulative impacts to the human environment associated with the proposal to continue awarding federal financial assistance to public and private entities for aquaculture research and development projects using existing federal financial assistance award programs in OAR (Sea Grant, SBIR) and NMFS (OAQ). A programmatic approach may be used when initiating or reevaluating a federal program for compliance with NEPA. NOAA determined this was appropriate for this analysis because the proposal to continue to issue aquaculture research and development awards is a broad and diverse action implemented nationwide. NOAA recognizes that environmental effects are caused by site-specific, project-level activities. Therefore, this PEA is a planning tool to support tiered, site-specific analyses by narrowing the spectrum of environmental impacts to focus on project-level reviews as needed. NOAA intends to use this document to approve future project-specific actions, as long as the activity being proposed is within the range of activities being considered and the scope of potential environmental effects have been analyzed herein. As financial assistance awards are proposed, environmental review will use the analysis set forth in this PEA (40 C.F.R. §1508.28, 1502.20 (1978)). Any future project-specific activities proposed by NOAA that are not within the scope of alternatives or environmental effects considered in this document, will require additional analysis under NEPA but may rely on, as appropriate, analyses and information included in this document.

The programmatic approach for assessing impacts related to the federal financial assistance award program is being undertaken due to the uncertainty regarding the timing and implementation of individual aquaculture research and development projects and activities.

Details, such as specific location and site conditions, are not known until NOAA receives proposals for review during the financial assistance award process.

Because of this inherent uncertainty, the PEA uses past and predicted funding requests and proposals to develop a broad and general examination of typical issues and alternatives to develop a baseline for future funding actions which may or may not require additional environmental analysis. Funded projects will vary in terms of size, scale, scope, complexity, and geographic location.

1.4.1 How to Use this PEA

Each federal financial award proposal that is included under this PEA, will be evaluated for NEPA compliance using an inclusion analysis document (e.g., memo, form, or checklist). This inclusion document serves as the NEPA analysis documentation for the administrative record as applied to specific projects. For example, the following scenarios describe the possible applications of the PEA to a site-specific or project-level/specific action, identifying when additional environmental review under NEPA is required:

1. All activities of the proposed action are described in the PEA (or the activities are similar enough to the activities analyzed in the PEA to support a conclusion that their impacts will not be different from those described in the PEA). Impacts are below the thresholds provided in (Chapter 4). No additional NEPA review required;
2. All activities of the proposed action are described in the PEA (or the activities are similar enough to the activities analyzed in the PEA to support a conclusion that their impacts will not be different from those described in the PEA). Impacts are greater than the thresholds provided in (Chapter 4). Additional NEPA review required;
3. An activity (or activities) of the proposed action is within the scope of the PEA and others are not. Additional NEPA review required; and
4. None of the activities of the proposed action are within the scope of the PEA. Additional NEPA review required.

In addition to NEPA, each proposed award needs to comply with all other applicable environmental statutes, including, but not limited to, the Endangered Species Act (ESA), Marine Mammal Protection Act (MMPA), Clean Water Act (CWA), Coastal Zone Management Act (CZMA), and Magnuson-Stevens Fishery Conservation and Management Act (MSA). The inclusion analysis document will also contain information to identify when any of these statutes are triggered by the proposed action and additional environmental review (analysis and/or consultation) is required. If further analysis under these other statutes is required, this PEA may be used to support those analyses or consultations, as appropriate.

1.5 Summary of the Proposed Action

NOAA proposes to issue federal financial assistance awards through existing programs within the OAR (Sea Grant, SBIR) and NMFS (OAQ) for aquaculture research and development projects involving farmed and wild populations of aquatic organisms (defined for this PEA as crustaceans, molluscan shellfish, echinoderms, algae and aquatic plants, and finfish). The potential "action area" of NOAA-funded aquaculture research and development projects evaluated in this PEA includes permitted aquaculture facilities and sites, research laboratories (compliant with the Occupational Safety and Health Administration (OSHA)), the Great Lakes and associated freshwater areas, and ocean and coastal environments within the Exclusive Economic Zone (EEZ) of the United States and its territories. The content of this PEA is considered for future projects awarded under existing programs. Program staff will periodically review the PEA and relevant environmental concerns to determine whether its scope and analysis remain applicable to the federal financial assistance award programs.

The agency decision to award federal financial assistance under the proposed action is triggered by the receipt of requests for such action during the pre-award phase of the federal financial assistance award process. In this pre-award phase, NOAA plans and develops a funding program based on its authorities and mission, goals of the Administration, and congressional mandates and initiatives, as described in this chapter. Next, NOAA formally announces a funding opportunity, advertising it to applicant communities and inviting proposals tailored to address the program mission. When an application has been submitted, NOAA reviews the applications that have met minimum requirements per the funding opportunity announcement, and then conducts merit or competitive review to determine which applications should be proposed for funding. The applications proposed for funding then undergo programmatic review by NOAA and assessment for environmental compliance, including compliance with NEPA. Once environmental compliance review is complete, proposals are submitted to NOAA AGO for the final funding award decision.

1.6 Purpose and Need

The overall goal of NOAA's aquaculture research and development federal financial assistance awards is to provide opportunities to public and private entities to obtain scientific knowledge that will inform NOAA's regulatory and resource management decisions and foster innovative and sustainable approaches to aquaculture. The purpose of the Proposed Action is to further these efforts in domestic marine and freshwater aquaculture research and development in accordance with the statutory authorities described in Chapter 1.2.1 and 1.2.2 of this PEA. Existing federal financial assistance award programs for aquaculture research and development projects that are discussed in this PEA include: Sea Grant, SBIR and programs administered by the OAQ. NOAA is charged with ensuring that U.S. aquaculture develops sustainably, in concert with healthy, productive, and resilient coastal, Great Lakes, and marine ecosystems through multiple mandates including, but not limited to, legislative mandates, Executive Orders, agency aquaculture strategies and policies, and NOAA's mission and priorities.

Aquaculture research and development federal financial assistance awards are needed to gain scientific knowledge and develop a trained workforce to address critical issues including: supporting a healthy coastal economy; addressing the demand for domestic seafood products; and enhancing wild stock populations (for commercial purposes). Each of these issues is explained in greater detail below.

- Support a Healthy Coastal Economy. The "Blue Economy" is a term used to describe a sustainable ocean and coastal economy which emerges when economic activity is in balance with the long-term capacity of ocean and coastal ecosystems. The U.S. is an ocean nation with a growing Blue Economy. In 2018, the American Blue Economy, including goods and services, contributed about $373 billion to the nation's gross domestic product, supporting 2.3 million jobs and grew faster than the nation's economy in its entirety (NOAA, 2021). Marine aquaculture supports establishing a Blue Economy by creating jobs throughout the seafood supply chain, supporting resilient working waterfronts and coastal communities, and providing new international trade opportunities. As aquaculture has grown to complement our wild fisheries, current and former fishermen are using aquaculture to supplement and support fishing livelihoods. Farmed seafood products already make up half of the world's seafood supply, but U.S. production lags behind much of the world, leading to a $14 billion seafood deficit in the United States in 2016. In 2019, estimated freshwater plus marine U.S. aquaculture production was approx. 300 million kg with a value of $1.5 billion. This reflects a decrease of 10.2 million kg (3.3 percent) from 2018. Freshwater aquaculture production decreased 7.1 million kg (2.7 percent) from 2018. In 2019, marine aquaculture production decreased by 3.1 million kg (7.0 percent) to 41.0 million kg (NMFS, 2020).

- Address the Demand for Seafood Products Domestically. In 2020, U.S. per capita consumption of seafood products declined to 19.0 pounds from 19.3 pounds in 2019. Although there was increased consumption of shrimp, canned tuna, and canned sardine, this was offset by declines in consumption of fresh and frozen finfish, and by the lower canned salmon production due to the biennial (taking place every other year) pink salmon run. Currently, the majority of seafood products consumed in the U.S. are imported. In 2020, the estimated percentage of consumption coming from imports was 79 percent (NMFS, 2020). Global and domestic demand for seafood is poised to grow. In per capita terms, food fish consumption rose from 9.0 kg (live weight equivalent) in 1961 to 20.3 kg in 2017, at an average rate of about 1.5 percent per year (FAO, 2020). The expansion in consumption has been driven not only by increases in production, but also by a combination of many other factors. These include: technological developments in processing, cold chain (refrigerant technologies), shipping and distribution; rising incomes worldwide, which strongly correlate with increased demand for fish and fish products; reductions in loss and waste; and increased awareness of the health benefits of fish among consumers (FAO, 2020). Even as we maintain and rebuild our wild harvest fisheries, we cannot meet increasing domestic demand for seafood solely through wild-caught fisheries. Aquaculture provides a domestic source of economically and environmentally sustainable seafood that complements and supports domestic wild fisheries production.

- Enhance Wild Stock Populations. (For commercial and recreational purposes) Enhancement of wild stock populations is a form of aquaculture in which farmed fish, shellfish, and plants are released into the wild to rebuild wild populations or restore coastal habitats. Stock enhancement can be used as a management tool to help rebuild populations depleted due to overfishing, habitat loss, or other factors (NMFS website *Marine Aquaculture and the Environment*). As described in section 3.3.4, if a site-specific or project-level/specific action area overlaps in time or space with any protected species and or habitat, using the best available scientific and commercial information, project staff will determine whether preparation of additional NEPA documents are necessary, or initiation of a consultation is required.

Developing and sustaining robust aquacultural solutions to address these challenges is inherently dependent upon the obtainment, understanding and application of scientific knowledge of aquaculture, as well as strong public-private collaborative partnerships. The federal financial assistance award programs described in Chapter 1 provide a unique opportunity within NOAA to partner with external researchers and institutions, engage in private sector and public collaborations, and facilitate aquaculture research and development to meet these needs.

1.7 Scope of the PEA

The scope includes an analysis of aquaculture research and development projects that NOAA proposes to award across a broad range of environmental locations where this work may occur (land-based, ocean and coastal, and freshwater environments) and their potential for impacts on the human environment. Certain types of aquaculture research and development projects may have significant environmental effects, and thereby, require a more rigorous review through additional NEPA analysis. For the purposes of this PEA, the following offshore finfish aquaculture installation and operations are considered outside the scope of this PEA:

- Offshore finfish grow out and stocking;
- Construction, installation or operation of new shellfish, seaweed, and finfish culture facilities such as hatcheries and laboratories;
- Offshore testing of new gear types; and
- Wild stock enhancement and restoration of finfish populations for non-commercial purposes, such as restoration of federally listed species.

Chapter 2 Description of the Alternatives

In accordance with NEPA and the CEQ regulations, NOAA is required to evaluate all reasonable alternatives, or those that substantially meet the agency's purpose and need. Reasonable alternatives include those that are practical and feasible from a technical and economic standpoint (40 C.F.R 1508.1).

2.1 Alternative 1 No Action

The No Action alternative serves as a baseline with which the impacts of the Proposed Action are compared and contrasted. For analysis purposes, NOAA has defined the No Action alternative as the decision by OAR and/or NMFS not to issue financial assistance awards for aquaculture research and development under the following existing programs and offices: Sea Grant, SBIR Program, and OAQ.

2.2 Alternative 2 Proposed Action

Alternative 2 is the preferred alternative and takes the most comprehensive approach to achieving NOAA's mandates and mission by continuing to fund a wide range of projects for aquaculture research and development involving farmed and wild populations of aquatic organisms including crustaceans, molluscan shellfish, echinoderms, algae and aquatic plants, and finfish in both onshore, inshore, offshore environments. For the purposes of this PEA, finfish activities are limited to land-based and coastal near-shore research activities. Excluded activities are discussed in Chapter 1.7. Under this alternative, NOAA would issue federal financial assistance awards under existing aquaculture-focused programs administered by Sea Grant, SBIR, and OAQ (discussed in Chapter 1) to eligible public and private entities. These include: researchers at U.S. academic institutions and private research laboratories; for-profit and nonprofit companies/firms, and state, local, and tribal agencies.

Activities that are funded by NOAA's federal financial assistance award programs for aquaculture research and development would allow eligible applicants to carry out work that addresses one or more of five main research and development categories (detailed below and summarized in Table 2.1) and allow the flexibility to adapt to any future changes in agency and program priorities. This PEA does not include an exhaustive list of activities but provides examples of the types of activities under the five categories that may be funded. Site- and project-specific details may be described in subsequent NEPA compliance determinations or in future NEPA documents for each proposal funded, as described in Chapter 1.6.3. These categories described in Table 2.1 were chosen based on the *National Sea Grant College Program 2018-2023 Strategic Plan* focus areas and *NMFS Marine Aquaculture Strategic Plan 2016-2020* goals.

Table 2.1. Summary of Aquaculture Research and Development Project Categories

Project Category	Chapter Section	Examples of Activities in this Category
Outreach, Education, and Planning • Routine Administrative • Educational, informational, advisory, or consultative	2.2.1	• Convene meetings, workshops, conferences, trainings • Develop and deliver presentations and briefings • Develop permanent and semi-permanent learning displays and exhibits • Engage in strategic planning • Written materials, brochures, 1-pagers, educational and outreach materials • Develop websites, digital media and content • Develop social media • Develop multi-media products, videos
Data Analysis and Social Science Research • Assembling, analyzing, and presenting of data • Information collection for studies	2.2.2	• Conduct social science surveys, interviews, legal and policy research • Manage, analyze, and synthesize data • Computer modeling • Computer-based tool development
Laboratory and Rearing Research • Research, development, testing, and evaluation studies • Laboratory research in aquaculture facilities	2.2.3	• Research, development, testing, and evaluation studies • Genetics • Rearing trials • Disease prevention/mitigation • Novel technologies and methodologies
Field Research and Assessments	2.2.4	• Field testing of novel technologies and methodologies • Field surveys and monitoring • Mapping • Broodstock and specimen collection • Marking and/or tagging • Shellfish outplanting
Shellfish Aquaculture Restoration • Restoration • Rehabilitation	2.2.5	• Placement or modification of substrate • Re-introduction of shellfish seed stock

2.2.1 Outreach, Education, and Planning

An important part of NOAA's overall mission is to foster and enhance public knowledge and stewardship of coastal, Great Lakes, and marine ecosystems. Constituent engagement, education and planning projects engage the public by improving access to accurate information about the state of marine and freshwater aquaculture research and management and raising awareness of NOAA's key aquaculture initiatives and its partners. Activities under this category include routine administrative actions and activities that are educational, informational, advisory, or consultative to other agencies, public and private entities, visitors, individuals, or the general public, including training exercises and simulations.

Examples of routine administrative activities are described below and include:

- Supporting project operational costs and administration including personnel management, salary/fringe, overhead, budgeting, planning, and program evaluation.
- Providing support to establish cooperative endeavors, such as consortia, networks, business incubators, and/or inter-agency agreements or to apply for an environmental permit.

Examples of educational, informational, advisory, or consultative activities are described below and include:

- Supporting fellowship programs related to Sea Grant's mission and activities.
- Creating, revising, and distributing written (*e.g.*, brochures, factsheets, handbooks magazines, printed newsletters, press releases, peer-reviewed articles, and signage), digital (*e.g.*, websites, social media, e-newsletters, on-line manuals), and multimedia (*e.g.*, videos, photos, audio, webinars, podcasts, story maps) materials to educate stakeholders or communicate the results of research projects.
- Developing educational materials aimed at constituents (tribes, coastal residents and business owners, fishermen, tourists, agency staff, and other members of the public) including educational displays and exhibits, curriculum, and outreach activities.
- Developing and executing training, technical assistance, and workforce program opportunities that provide in person, peer-to-peer (*e.g.*, grower to grower), internship, and virtual professional, workforce, and technical-knowledge development.
- Convening workshops and supporting conference attendance in an effort to facilitate dialogue and conflict resolution among constituents, map ocean uses, and discuss ideas, strategies, work plans, regulations, and permitting.
- Disseminating aquaculture information and NOAA research at public meetings and conferences, through the Sea Grant extension networks, and through the web and social media.

2.2.2 Data Analysis and Social Science Research

NOAA uses data analysis and social science research to assess necessary scientific information, allowing for the development of tools aquaculture managers need to make critical permitting and management decisions. NOAA also conducts data analysis to support technology development and provide science services in support of industry needs and the broader aquaculture community, frequently in partnership with researchers in universities, industry, non-governmental organizations (NGOs), states, and tribal groups to leverage resources, expertise, and capabilities. The activities in this category include projects involving assembling, analyzing, and presenting data that has already been collected and translating data into maps, models, or summaries. Activities also include social science projects and programs, including education, economic, political science, human geography, demography, and sociology studies, including information collection activities in support of these studies.

Examples of data analysis and social science research activities are described below and include:

- Developing and using databases to organize and analyze field or laboratory data.

- Simulating and modeling the impacts of an in-water activity (*e.g.*, aquaculture) on biological, chemical, and physical environmental parameters.
- Applying Geographic Information Systems (GIS) to map, screen, and/or site potential aquaculture facilities or other ocean or coastal uses.
- Producing computer-based or written data tools (*e.g.*, field data collection sheets) to assist in data collection and analysis of field and laboratory data.
- Examining video or camera remote monitoring data.
- Conducting economics research, which include developing and administering surveys, polls, questionnaires, focus groups, interviews, as well as market research, and the analysis of the collected data.
- Conducting legal, policy, and permitting research and analysis, excluding the creation of new policies and procedures as a result of this research and excluding final permit preparation or submission to state or Federal agencies.
- Conducting social science research to better understand the public's understanding and perceptions of aquaculture, as well as consumer purchasing preferences of all types and sources of seafood.

2.2.3 Laboratory and Rearing Research

Laboratory and rearing research projects develop, evaluate, and refine procedures for the culture of finfish and shellfish encompassing all life stages from the hatchery to harvest. This category focuses on various aspects of laboratory and rearing research involving the culture of animals, the environment they are exposed to, and the culture system they are reared in. Research can be conducted in the laboratory or at inshore or land-based sites, including those involving recirculating aquaculture systems (RAS).

Examples of routine laboratory analysis activities include:

- Research, development, testing, and evaluation studies.
    - Analyzing previously collected water samples to assess water quality or other characteristics.
    - Studying previously collected benthic samples for biological, chemical, or geological characteristics.
    - Analyzing seafood samples obtained from legal commercial and/or recreational harvest.
    - Developing analytical laboratory assays (*e.g.*, for disease detection).
    - Conducting molecular genetics research on previously collected samples.
    - Testing prototypes within a controlled laboratory environment.

Examples of laboratory research in aquaculture facilities include activities such as:

- Genetics (conducted in laboratory facilities only). Genetics research includes selective breeding experiments such as breeding organisms of different strains to improve culture performance of offspring, as well as research focused on the production of hybrid organisms or triploid organisms. Genetics research also involves studying molecular genetic mechanisms that convey disease or environmental resistance associated with optimal traits.

- Rearing trials. Rearing trials focus on the growth and production of juvenile and adult animals under conditions and protocols in use commercially. Increasingly, the use of selective breeding techniques for traits that enable organisms to withstand environmental change and/or be cultivated in a broad range of conditions and to breed lines adapted for maximum production in the natural environment are being employed as part of rearing trials. This research includes subjecting organisms to varying laboratory representations of ocean warming and/or acidification regimes and selectively breeding well-performing animals. Broodstock collected from wild population range extremes are also cultivated from individuals to investigate possible physiological and genetic differences and selectively cultivate new variants (*e.g.*, variants with different thermal or salinity tolerance). This research is most commonly focused on shellfish but may include other commercially important species or candidate species that have potential for commercial use in the future.

  Rearing trials may also focus on ecological interactions and ecosystem services, integrated multi-trophic aquaculture (IMTA), predator control trials, and algae bioremediation, which are often housed in land-based recirculating aquaculture systems (RAS) and flow-through facilities.

  Finally, rearing trial projects are used to test new feeds to understand the dietary requirements of different life stages of various species. Past funded projects have included experimentation with feeds incorporating soy, seafood processing byproducts, and copepods. For example, a research project employed genetics in rearing trials to develop rapid genotyping of genetic markers in an effort to select broodstock that can be fed plant-based feeds rather than feeds derived from animal proteins. Trials also incorporate the use of enzymes to improve nutrient absorption, immune-stimulating compounds for disease resistance, and probiotics for overall improved health.

- Disease prevention/mitigation. Funding for research activities on diseases and toxins may include, but are not limited to, White Spot Syndrome virus (*Litopenaeus vannamei*) in shrimp, parasitic (e.g., Dermo (*Perkinsus marinus*)) infections, MSX disease (*Haplosporidium nelson*), and Vibrio sp., norovirus, bacterial fecal coliform contamination in shellfish, sea lice infestations in finfish, and harmful algal blooms (HABs). Research into aquaculture diseases has focused on the development of rapid and inexpensive means to detect diseases or toxins (e.g., in the laboratory, commercial setting, in-situ at a farm), development and testing therapeutants, antiviral and vaccine treatments, and investigating the physiological impacts of the infection. Research activities regarding this topical area must, as appropriate, biosecurity measures to prevent exposure of wild populations to the pathogen or toxin being studied.

- Novel Technologies and Methodologies. This aspect of research focuses on testing new technologies, approaches, modified gear, or the evaluation of candidate culture species. Testing can take place in a laboratory setting or in a field setting (as discussed in the next section Field Research and Assessments). Examples include testing self-cleaning culture tanks as well as the efficacy of different settlement substrate materials (e.g., ropes and "spat tape") in hatcheries. Equipment configuration trials for seaweed culture, Floating

Upweller System (FLUPSY) modification trials, or new IMTA configurations are also part of funded research. This research category may also include post-harvest treatments and processing of farmed products (e.g., drying, blanching, freezing; treating to remove bacterial contaminants) to study the quality, safety, and consumer acceptability of different post-harvest processing.

2.2.4 Field Research and Assessments

Field research and assessment encompasses field surveys and monitoring, broodstock and specimen collection, mapping areas for siting purposes, marking and/or tagging, and shellfish outplanting with the goal of evaluating performance of farmed species, as well as determining environmental impacts and effects. The location of these activities varies but occurs primarily at permitted aquaculture sites., landowners, etc., for the described activities.

Examples of small-scale field research and assessment activities are described below and include:

- Field testing of novel technologies and methodologies. This aspect of research focuses on testing new technologies, or approaches, or modified gear in the field, such as freshwater and ocean and coastal environments.

- Field surveys and monitoring are used to determine impacts of aquaculture on bottom habitats and biogeochemical processes on farm and non-farm sites using benthic field surveys, including small-scale sediment grab sampling, to examine sediment properties (physical, geological, chemical) or study in-situ fauna assemblages. Other useful techniques include field surveys and monitoring of the water column to characterize water quality, quantify organism abundance in or around farm sites, determine ecosystem services (e.g., water filtration), and monitor farm performance, security, or interaction with protected species. Technologies utilized may include Go-Pro and other camera systems, self-contained underwater breathing apparatus (SCUBA), and moored or unmoored instruments (such as, water quality probes, underwater cameras, etc.) deployed for short time periods, as well as collecting information from existing oceanic and coastal instrumentation (e.g., buoys, weather stations). The measurement of water quality parameters, including: temperature, salinity, chlorophyll, nitrogen, phosphorus, dissolved oxygen, turbidity, etc. or the concentration of toxins or pollutants may be performed. Abundance surveys of organisms in the water column, on farm equipment, or on benthic substrates are considered non-invasive and observational rather than manipulative.

- Mapping includes operating a variety of equipment and technologies to gather accurate and timely data on the nature and condition of the marine and coastal environment and to survey and monitor the effectiveness of remote monitoring of gear security, protected resource interactions, water quality, and organism growth on existing farms. The types of equipment and technologies used may include the operation of remotely operated vehicles (ROVs), autonomous surface vehicles (ASVs), autonomous underwater vehicles (AUVs), echosounders, and acoustic doppler current profilers (ADCPs). ROVs are controlled remotely at all times by a human operator and are often tethered to a crewed vessel. Autonomous vehicles operate with various levels of autonomy and use a variety of propulsion sources, including diesel, diesel/electric, battery, solar, buoyancy driven, and wave-gliding propulsion systems. Echo sounders transmit a repeated series of short sound signals (on the order of milliseconds) into the water column. These signals continue until they reach the seafloor and reflect back to the echo sounder's receiver. By measuring the amount of time for the sound to return from the seafloor or object, the depth of the water can be determined. Echo sounders used for mapping can generally be divided into three categories: single beam systems, multibeam systems, and side-scan sonars. ADCPs are active, stationary acoustic systems used to measure the velocity of water by measuring the relative shifts in sound frequency associated with relative motion. These profilers provide detailed and important data on oceanographic conditions, including current patterns, waves, and turbulence. ADCPs are often operated from tethered systems, buoys, or fixed moorings. Mobile ADCPs are hull mounted (NOS, 2021).

- Broodstock and specimen collection includes collecting a limited number of organisms (e.g., finfish, seaweeds, invertebrates) from wild populations and habitats by permit, if required, and uses established methods for broodstock cultivation, nutrient uptake studies, disease monitoring, population biology and structure investigations, tagging, or other topics. This group of techniques may also include collecting fin clip samples for genetic or other laboratory analyses.

- Marking and/or tagging includes marking or otherwise tagging finfish or invertebrates from wild populations and habitats using standard procedures and safeguards to study growth, movement, mortality, and other parameters.

- Shellfish outplanting includes outplanting (the placement of farmed cultivated organisms into the environment, for restoration or later harvest) native or naturalized shellfish on permitted established farms or lease sites to evaluate growth, survival, and performance characteristics under commercial conditions.

2.2.5 Shellfish Aquaculture Restoration

NOAA supports many kinds of bivalve shellfish restoration activities. These activities primarily benefit native oysters (e.g., *Crassostrea virginica*, *Ostrea lurida*, *O. conchaphila*), but may also restore other shellfish species (e.g., hard clams, abalone, mussels, and scallops) or finfish species that use reef structures for forage or shelter through their various life stages (NMFS, 2015a).

Small-scale (i.e., limited in time, space) restoration activities in land-based, ocean and coastal environments can be grouped into two types: placement or modification of substrate and re-introduction of shellfish. One or the other of these types may be used, or both together at the same restoration site, depending on the species or the needs of the locality.

- Placement or modification of substrate. Both natural and artificial oyster reefs play an important role in aquatic ecosystems. Oyster reefs can be enhanced or created as components of open water reefs or living shoreline projects as natural shoreline protective structures to dissipate wave energy, decrease coastal erosion, increase habitat for fish and invertebrate species, improve water quality, and provide protection for newly planted marsh grasses and submerged aquatic vegetation (SAV). Substrate may be used to encourage recruitment of fish or oyster larvae recruitment in tidal environments. Mollusks are ecosystem engineers and their shells form complex and heterogeneous habitats in benthic environments that affect processes on population, community, and ecosystem levels.

- Natural substrate, such as oyster or clam shells, and rocks have been used more widely for restoration, but their supply is limited mostly because oyster shells have historically been sent for land-based uses such as gravel, and soil amendments for gardening, etc. There is high demand for natural substrate from the restoration and aquaculture sectors. Shell substrate is preferred by oyster larvae; however, it is not always available. As such, some states have partnered with nonprofit organizations and local businesses to develop oyster shell recycling programs. For example, the Oyster Recovery Partnership annually collects 36,000 bushels of shell from approximately 200 restaurants and 70 public drop sites in the mid-Atlantic region. (Oyster Recovery Partnership website). There are also some state regulations that encourage recycling of shells in exchange for state income tax credits. For example, MD Code, Tax - General, § 10-724.1 allows for a credit against the State income tax in an amount equal to $5 for each bushel of oyster shells recycled during the taxable year.
- Artificial substrate such as limestone marl, granite, or crushed concrete (sometimes in combination with shells) may also be used when there is not enough shell substrate available, or in high-energy areas where substrate would otherwise be unstable and may require a more stable or higher reef structure. Other commonly used artificial substrates for shellfish reef restoration include wire mesh cages, racks, steel rebar structures, or weighted plastic mats containing natural or artificial substrate. Such solutions are effective, but naturally occurring materials are often preferred for restoration.

Most substrate is deployed from a boat or barge when the restoration site is far from shore. At nearshore, shallow-water project sites, restoration practitioners and community volunteers may carry substrate to the reef location (when manageable, such as oyster shell bags). Large volumes of loose shells can be sprayed off barges with high-pressure hoses or placed with large equipment such as a backhoe or with specialized hopper-conveyer belt systems built into the deployment vessel. Heavy substrates such as concrete or limestone are typically placed using heavy equipment located either onshore or loaded onto a barge. Oyster reefs are typically constructed or replenished immediately prior to times of high spat set (larval settling).

- Re-introduction of shellfish. In addition to reef/substrate construction, shellfish restoration efforts also include placing native shellfish in the restoration area if the local population is not large enough to produce viable larvae or has been fully extirpated from the area. Shellfish for restoration purposes may be obtained from natural beds, purchased from commercial harvesters or producers, or reared in land-based or nearshore aquaculture facilities. Non-reef-forming bivalves such as scallops, abalone, or clams may be deposited as single individuals. Similarly, because reef-forming oysters attach to hard substrates and each other, they may be distributed as individuals, or as multiple juveniles already attached to substrate. Shellfish may also be placed in cages in spawner sanctuaries to reduce predation or poaching and to facilitate research efforts. The preliminary step in planting live shellfish may include use of a shellfish rearing facility, which is occasionally an aspect of shellfish restoration. These facilities usually consist of land-based tanks or floating cages. Even when wild stocks of bivalves are used, hatcheries may be used to augment the bivalve supply and to ensure that stocks are disease-free before being placed in their new environment (NMFS, 2015a).

This chapter has outlined the No Action and Proposed Action alternatives covered by this PEA. The next chapter will describe the potential environments that will be affected by the Proposed Action.

Chapter 3 Affected Environments

3.1 Introduction

The affected environments and potential impacts of the alternatives considered in this PEA are discussed in this Chapter. Due to the programmatic nature of the Proposed Action, it is not feasible to include specific details about each project area in the affected environment. This will occur on a project-specific basis. However, general descriptions of the common environments in which aquaculture research and development actions occur are described and categorized as physical, biological, or socioeconomic. Additionally, to understand these affected environments, it is helpful to also understand common aquaculture terminology. Therefore, the common types of aquaculture systems, infrastructure and gear that are referred to throughout this PEA are included.

Table 3.1. Common Aquaculture Systems, Species Group Farmed, and Farmed Areas as organized in the Affected Environment of this Chapter.

Common Aquaculture Systems	Farmed Aquatic Organisms Type	Land Bas	Ocean and Coastal	Fresh Water
1. Ponds	Finfish, Crustaceans (shrimp, crawfish)	✔	✔	✔
2. Flow-Through or Single-Pass Systems	Finfish, Molluscan shellfish, Macroalgae	✔	✔	✔
3. Cages and Net Pens	Finfish, Echinoderms (sea cucumbers, sea urchins)		✔	✔
4. Recirculating Systems (RAS)	Finfish, Macroalgae, Molluscan shellfish, Crustaceans, Plants	✔		
5. On Bottom Culture	Molluscan shellfish		✔	
6. Near Bottom Culture	Molluscan shellfish		✔	
7. Water Column Culture	Molluscan shellfish, Macroalgae		✔	✔

3.1.1 Common Aquaculture Systems, Infrastructure and Gear

There are a variety of aquaculture systems (summarized in Table 3.1) used for finfish, molluscan shellfish, crustacean, and macroalgae aquaculture in various physical environments (land based, ocean and coastal, and freshwater). Common types of aquaculture systems and examples of gear utilized in selected systems are described below.

1. Ponds. Aquaculture ponds are water impoundments, usually constructed containing embankments or levees. Today, most commercial finfish such as catfish and crawfish production in the U.S. is conducted in freshwater ponds. Ponds have also been used for culturing shrimp as well as marine finfish. The majority of growers using ponds provide some form of management and supplemental energy input, such as aeration. In some areas, coastal or ocean water may be used, but regulations and water quality must be considered. Most aquaculture ponds are less than 20 acres in size and have a depth of 3 to 5 feet; they are not usually larger than 5 acres with smaller ponds more the norm.

2. Flow-Through or Single-Pass Systems**.** Raceways and tanks with water flowing through them have been used to rear finfish, such as rainbow trout, for over a century. High quality water continuously flows into these culture units and passes through the raceways, which hold the culture animals. Each raceway has one or more feeding stations. Cultured species waste is discharged from the downstream end of the system. Federal, state, and local laws (National Pollution Discharge Elimination System, NPDES; State Pollution Discharge Elimination System, SPDES) require that the effluent above approved discharge thresholds from these operations meet quality standards before being returned to public waters.

3. Cages and Net Pens. Many engineered as well as natural bodies of water including the open ocean can be unsuitable for aquaculture because they are too deep, too large, or have irregular bottoms or obstructions that impede culture operations, such as harvesting. However, some of these bodies of water may be used to culture aquatic species such as finfish confined to cages or net pens. Cages are relatively small mesh enclosures usually between 1-20 cubic yards. Net pens used in coastal and marine environments are large mesh enclosures ranging in size from 60 to over 100 hundred cubic yards. Both cages and net pens consist of a floating or submersible circular or square frame. Juvenile, farmed-raised culture animals are placed in the cages or pens and feed is distributed by hand or mechanically. Animals are harvested when they attain a desired market size. Both cages and net pens are secured or anchored in an area where water flow and depth are sufficient to provide sufficient flow to ensure optimal water quality and removal of wastes.

4. Recirculating Aquaculture Systems (RAS). These systems support the culture of a variety of aquatic species including finfish, molluscan shellfish, crustaceans, and macroalgae in a temperature and salinity-controlled environment. These systems are most commonly land-based and culture species are raised in tanks. Although design varies among RAS installations, RAS typically involves mechanical and biological filtration, coupled with gas removal and water sterilization. Mechanical filtration is employed to remove particulate wastes; biological filtration involves the use of detoxifying bacteria that convert toxic ammonia (NH_3) and nitrite (NO_2^-) to nitrate (NO_3^-), which is non-toxic to most aquatic species at concentrations of several hundred parts per million. Some RAS are also equipped with denitrification processes, which reduce nitrate and nitrite to gaseous forms of nitrogen, principally nitrous oxide (N_2O) and nitrogen (N_2). RAS

systems also typically employ a de-gassing component, primarily for the removal of CO_2, which is followed by oxygen injection or supplementation, and water sterilization via UV or ozone before the treated water is returned to the culture tanks. In RAS, since most water is "recirculated," with the only losses due to evaporation and waste removal, systems require relatively small additions of new water (typically 10-20% of the total system volume daily). RAS requires continuous aeration or oxygenation of both the culture tanks and biological filter to function properly. Water quality must be monitored closely and carefully managed and emergency back-up systems are essential.

5. On Bottom Culture. Molluscan shellfish such as oysters and clams are commonly reared by planting seed directly on suitable coastal bottom sites. In a traditional method, oyster shells seeded with larvae ('spat') can be placed directly on the bottom and cultured. Clam seed can also be planted or placed directly on the bottom and subsequently covered with plastic mesh panels to help prevent predation or seed is placed in mesh bags on the bottom. Planting sites are inspected periodically as shellfish grow and market size animals are harvested by dredging or mechanical harvesters.

6. Near Bottom Culture. Molluscan shellfish, most commonly oysters, are also cultured using cages placed on the bottom or in plastic mesh bags placed on racks just off the bottom. Seed is stocked in cages or bags and as the oysters grow, they are transferred at appropriate densities to cages or bags with increasingly larger mesh size to ensure water and food flow until oysters reach market size.

7. Water Column Culture. Molluscan shellfish and macroalgae can be reared in the water column using suspended as well as floating culture gear. In the case of shellfish, oysters are commonly cultured using plastic mesh floating bags or cages near the surface of the water, while mussel seed is commonly stocked in lantern nets, which are cylindrical containers made of nylon netting divided into sections and suspended in the water column or seed is affixed to roped hung from rafts floating on the surface. As with near bottom culture, animal densities and gear are managed as animals grow to market size. Regarding macroalgae, species such as kelp are reared in the water column by seeding culture ropes that are strung between buoys. At harvest, ropes are retrieved, along with the full-size blades of kelp attached. Another application of water column culture for rearing shellfish seed is the use of floating upweller systems or FLUPSYs, which are in-water powered (electrical or tidal) nursery systems used to grow shellfish seed before transferring to sites for final grow out. FLUPSYs can consist of large floating boxes or units concealed in a floating dock. Both configurations are designed to move large quantities of water thus increasing growth rates by increasing the available supply of phytoplankton to the growing shellfish seed.

3.2 Physical Environment

The physical environments in which the Proposed Action may take place include: land-based, ocean and coastal, and freshwater environments. These environments are further characterized to include: reefs (i.e., oyster and coral), wetlands, estuaries, pelagic environment, ponds and lakes (including the Great Lakes), stream and river channels, and riparian areas. Projects that take place in ocean and coastal environments can occur nearshore (defined as the part of the sea that is close to the shore) and offshore (defined as starting nearshore and extending 200 nautical miles (nm) to the EEZ). Additionally, aquaculture research and development activities may occur in areas of special importance, including those under NOAA jurisdiction, such as National Marine Sanctuaries, Endangered Species Act (ESA) designated critical habitat, or essential fish habitat (EFH) as mandated by the Magnuson-Stevens Fishery Conservation and Management Act (MSA). Permits and/or agency consultations may be required for proposed aquaculture activities (NMFS, 2022b).

3.2.1 Land Based Environments

There are a variety of environments on land where the proposed action may occur. These include: office, classroom and community settings (both indoors and outdoors) following all local, state, and federal guidelines for COVID-19; OSHA compliant laboratories and indoor aquaculture facilities that follow standard approved permits and protocols; and outdoor aquaculture facilities, such as flow-through raceways, recirculating system-based tanks, outdoor tanks, and ponds, that follow state and local guidelines and approved methods in permitted locations. Land-based aquaculture facilities are used to culture various stages of shellfish, finfish, macroalgae, and miscellaneous invertebrates such as shrimp; and educate the public. Hatcheries focused on the production of early stages of various aquatic organisms are land-based and typically consist of flow-through or recirculating systems.

3.2.2 Ocean and Coastal Environments

The action area for some of the funded activities includes ocean and coastal environments. Coastal environments, also known as nearshore, extend from the low tide mark of the shore line to the end of the continental shelf (about 200 feet). Ocean environments, also known as open ocean, encompass the area beyond the continental shelf. These environments are defined by their unique biotic (living) and abiotic (nonliving) factors. Biotic factors include plants, animals, and microbes; important abiotic factors include the amount of sunlight in the ecosystem, the amount of oxygen and nutrients dissolved in the water, proximity to land, depth, temperature, and salinity. (NMFS website. *Marine Aquaculture and the Environment*). The types of marine ecosystems are discussed below.

3.2.2.1 Coastal/Tidal Wetlands. Coastal (or tidal) wetlands are wetlands located in coastal watersheds. Tidal wetlands include salt, brackish, and fresh tidal marshes that are transitional habitats between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is covered by shallow water tidally or seasonally. (Thayer et al., 2003). Coastal wetlands are found along the Atlantic, Pacific, Alaskan and Gulf of Mexico coasts. Coastal wetlands are among the most productive ecosystems in the world, supporting thousands of species of plants, animals, shellfish, finfish, birds, invertebrates, and microbes (NMFS 2011). Approximately 85 percent of commercially harvested fish depend on estuaries and near coastal waters at some stage in their life cycles. (National Research Council, 1997). Adult stocks of commercially harvested shrimp, blue crabs, oysters, and other species throughout the United States are dependent on wetland quality and quantity (Turner and Boesch, 1988).

3.2.2.2 Estuaries. Estuaries, and their surrounding wetlands, are bodies of water usually found where rivers meet the ocean. An estuary is most frequently a partially enclosed body of water formed where freshwater from rivers and streams flows into the salty seawater (brackish) harboring unique plant and animal communities. These areas of transition between the land and the sea are tidally driven, but, like rivers, they are sheltered from the full force of ocean wind and waves. Estuaries are generally enclosed in part by the coastline, marshes, and wetlands; the seaward border may be barrier islands, reefs, and sand flats or mud flats. These estuaries are home to unique plant and animal communities that have adapted to brackish water. However, there are also several types of entirely freshwater ecosystems that have many similar characteristics to the traditional brackish estuaries. For example, along the Great Lakes, river water with very different chemical and physical characteristics mixes with lake water in coastal wetlands that are affected by tides and storms similar to estuaries along the oceanic coasts.

Estuaries are found throughout every region of the United States and vary in character in and along different coastlines. Estuaries are some of the most productive ecosystems in the world directly supporting thousands of species of plants, animals, birds, and fish as well as sequestering and storing substantial amounts of carbon from the atmosphere, particularly in their vegetated coastal wetlands. Bodies of water that may be estuaries include sloughs, bays, harbors, sounds, inlets, and bayous. Some familiar examples of estuaries are Chesapeake Bay, San Francisco Bay, Boston Harbor, Tampa Bay, and Puget Sound. Many animal species rely on estuaries for food and as places to nest and breed. Human communities also rely on estuaries for food, recreation, and jobs.

3.2.2.3 Pelagic and Benthic Environments. The open ocean, or pelagic zone, is the area of the water outside of coastal areas. This zone includes the entire water column and is the world's largest habitat. Depending on depth, the pelagic zone varies widely in the amount of sunlight, temperature, pressure, and dissolved oxygen. Pelagic life is found throughout the water column, although the numbers of individuals and species decrease with increasing depth. Species range from small zooplankton which forms the base of the pelagic food web, to large marine mammals. The abundance of pelagic life, including fish species, has led to harvesting of fish stocks for commercial value. The benthic environment is considered separate from the pelagic environment. This area is the region near or at the bottom of a pond, lake, or ocean where substrates are usually rocky or sandy. Benthic biomass is largely controlled by water column productivity and is therefore linked to the pelagic zone. Like the pelagic zone, benthic organism diversity is dependent on overlying water factors including depth, nutrient availability, dissolved oxygen, temperature, salinity, and pressure.

3.2.2.3.1 Geology and Soils. Marine ecosystems across the U.S. include a variety of geologic structures of underwater canyons, rocky shorelines, sandy and pebble beaches, estuarine systems with composite sandy/loamy/silty soils, and volcanic island systems and archipelagos. Geology and soil resources potentially impacted by NOAA funded projects vary greatly, and may include sandy beach, barrier island, rocky coastline, mud bottom, and many other types of substrate and source material. Geologic features and soils generally depend on location, local physical geography, climate, geologic activity level, and a number of other attributes. This PEA does not include an exhaustive list or describe all of the specific types and features of the geology and soil present in the ocean and coastal environment but provides a general description of the characteristics, materials, unique features, and areas of concern for soils and geologic formations that comprise some key habitat types that may be affected by NOAA funded activities:

- Sandy beaches: the interface between land and ocean, these areas are naturally unstable due to constant action of waves, currents, and winds; including: sandy bluffs, embayments, barrier islands, and dunes. Materials are fine to coarse (diameters from 0.5mm to 2mm) and may contain substantial amounts of shell fragments.
- Rocky coastlines and intertidal zones: Areas composed of rock with low to high energy depending on slope, tidal range, currents, waves, etc. Include solid rock formations as well as gravel, cobble, or boulders that are often consolidated but can be moved.
- Mud flats: Low-energy areas influenced by flooding or tides that consist primarily of unconsolidated silts and clays.
- Sand flats: Low-energy areas influenced by flooding or tides that consist mostly of unconsolidated sands.
- Shell flats: Low-energy intertidal habitats that consist predominantly of unconsolidated shell fragments.
- Peatlands: Submerged or former tidal marsh plains that are predominated by peat.
- Other soils and materials present in non-tidal areas, which can be hydric (either occasionally, frequently, or permanently wet in wetland areas), or dry upland materials, which can be highly variable in the organic and inorganic composition.

In addition, NOAA funded activities may potentially affect the following sediment and rock types:

- Clay-silts: Often found in estuaries, marshes, slow-moving rivers and streams, pools, and deltas.
- Limestone: Calcium carbonate substrate, commonly associated with coral reefs, occurs along coasts of Florida and the Gulf of Mexico.
- Sand: Forms when rocks, such as quartz, breakdown from weathering and eroding over time.
- Gravel: A loose aggregation of rock fragments. Gravel occurs naturally throughout the world as a result of sedimentary and erosive geologic processes; it is also produced in large quantities commercially as crushed stone.

3.2.3 Freshwater Environments

Unlike ocean and coastal environments, freshwater environments contain water sources that have low salinity. The types of freshwater ecosystems are discussed below.

3.2.3.1 Stream/River Channels and Riparian Zones. A river is a natural flow of running water that follows a well-defined, permanent path, usually within a valley. A stream (also called a brook, creek, or bayou) is a natural flow of water that follows a more temporary path that is usually not in a valley. Many rivers and streams along the coast are tidal, with the effects of ocean tides extending upstream. The channel of a stream or river is the portion of the cross section that is usually submerged and totally aquatic (EPA Office of Water, 2004). Channel substrates may be composed of various materials, including cobbles, boulders, sand, clay, and silt. Tidal portions of a river channel often contain biological elements such as oyster reefs or SAV beds that help shape or define the channel. The riparian zone is the land immediately adjacent to a stream or river. Riparian environments are maintained by high water tables and experience seasonal or periodic flooding. Riparian zones contain or adjoin riverine wetlands and share many functions including water storage, sediment retention, nutrient and contaminant removal as well as habitat functions. The integrity of stream and river channels is important to the viability of not only the streams and rivers themselves, but also to the estuaries, oceans, marshes, and wetlands connected to them. Stream and river channels are also critical to the viability of living coastal and marine resources. In addition to providing fresh water, rivers and streams transport nutrients and provide habitat for thousands of aquatic and terrestrial species, including birds, shellfish, finfish, amphibians, reptiles, mammals, plants, and invertebrates.

3.2.3.2 Inland/Non-Tidal Wetlands. Inland (or Non-tidal) wetlands occur inland and are not subject to tidal influences. They account for 94% of all the wetlands in the United States and are found throughout the country. (Natural Resources Conservation Service, n.d.) Inland wetlands are most common on floodplains along rivers and streams (riparian wetlands), in isolated depressions surrounded by dry land (for example, playas, basins and "potholes"), along the margins of lakes and ponds, and in other low-lying areas where the groundwater intercepts the soil surface or where precipitation sufficiently saturates the soil (vernal pools and bogs). Inland wetlands include marshes and wet meadows dominated by herbaceous plants, swamps dominated by shrubs, and wooded swamps dominated by trees. Certain types of inland wetlands are common to particular regions of the country. For more information, see the EPA’s website at: https://www.epa.gov for a full list.

Many of these wetlands are seasonal (they are dry one or more seasons every year), and, particularly in the arid and semiarid West, may be wet only periodically. The quantity of water present and the timing of its presence in part determine the functions of a wetland and its role in the environment. Even wetlands that appear dry at times for significant parts of the year, such as vernal pools, often provide important habitat for wildlife adapted to breeding exclusively in these areas.

3.2.3.3 Ponds and Lakes. Ponds and lakes are freshwater habitats located in topographic depressions where water is naturally or artificially impounded and stored for extended periods of time. Ponds and lakes are located throughout the United States, occurring in every state and region. Ponds and lakes are critical ecological resources with respect to the proposed action. Similar to the freshwater wetlands, with which they are often intricately associated, ponds and lakes provide habitat for species such as waterfowl that also use coastal resources. In addition, many lakes and ponds are hydrologically connected with coastal or marine resources through processes such as surface water flow and groundwater recharge. They provide nutrients, sediment and pollution filtration, and water storage, among many other functions.

Of notable interest is the Great Lakes ecosystem which is the largest freshwater system in the world supporting commercial and recreational fishing, tourism, shipping, and other industries and the only lake system managed by NOAA. It holds roughly 21 percent of the world’s supply of fresh water and 84 percent of North America’s freshwater; covers 95,000 square miles with 9,000 miles of shoreline; and includes 5,000 tributaries (to include neighboring streams, river channels, riparian zones, and inland/nontidal wetlands) (www.epa.gov). Lake and pond ecosystems support complex and important food web interactions and provide habitat for wildlife and supply people with drinking water, food, and medicine. NOAA's Great Lakes Environmental Research Laboratory (GLERL) conducts research in this region to provide information for resource use and management decisions that lead to safe and sustainable ecosystems, ecosystem services, and human communities.

3.2.4 Environmental Quality

3.2.4.1 Water Quality. One critical factor to each environment described in this chapter, which in turn affects the success of aquaculture, is water quality. Water quality is a generic term used to represent the general "cleanliness" of the water of a certain resource. It is based on the relationship between the concentrations of various chemical and physical contaminants or pollutants and the ability of the water resource to support its ecosystem adequately. Although water quality is a function of many factors, five primary indicators are often used to assess the quality of surface water in an estuary or freshwater body to include: nitrogen, phosphorus, chlorophyll a, dissolved oxygen (DO) content, and water clarity. Light penetration into estuarine waters is important for submerged aquatic vegetation (SAV), which serves as food and habitat for the resident biota. Some nutrient inputs to coastal waters (e.g., nitrogen and phosphorus) are necessary for a healthy, functioning estuarine ecosystem. But when nutrients from various sources, such as sewage and fertilizers, are introduced into an estuary, the concentration of available nutrients can increase beyond natural background levels, resulting in eutrophication. Excess nutrients can lead to excess plant production and thus to increased chlorophyll, which can decrease water clarity and lower concentrations of dissolved oxygen. (EPA 2006). Several regulatory statutes protect beaches, coasts, and the marine environment from pollution and development. Permitting requirements of Section 404 of the Clean Water Act (CWA) are discussed in Chapter 6, and many other regulations have been established by agencies such as the Environmental Protection Agency (EPA), NOAA, U.S. Fish and Wildlife Service (USFWS), and U.S. Army Corps of Engineers (USACE) for the protection of water resources. For example, in 2000, EPA was ordered under E.O. 13158 to "expeditiously propose new science-based regulations, as necessary, to ensure appropriate levels of protection for the marine environment. Such regulations may include the identification of areas that warrant additional pollution protections and the enhancement of marine water quality standards."

Marine offshore waters are threatened in the United States and elsewhere by changes in water quality. Contamination of the marine environment from point and nonpoint source pollution and climate change has caused alteration or loss of habitat; reductions in numbers of species and individuals that live in these waters; reductions in seawater pH levels (ocean acidification); increases in floating trash and debris, and advisories concerning fish consumption and swimming; and the loss of recreational and commercial opportunities. (EPA 2004). For marine aquaculture, the affected environment consists of aquatic ecosystems, including marine and estuarine ecosystems in the United States. Due to the large geographic scale of the affected environment (i.e., the entire United States and its territories), as well as the many past and present human activities that have shaped the affected environment, the impacts of the activities and techniques of the proposed action are described more broadly in Chapter 4.

3.2.4.2 Climate Change. According to the Intergovernmental Panel on Climate Change (IPCC), climate change refers to a change of climate which is attributed directly or indirectly to human population and activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods. In addition to changing temperatures that can negatively impact aquatic species, ocean acidification is strongly correlated with climate change with respect to fisheries and aquaculture. The ocean absorbs about 30 percent of the CO_2 that is released in the atmosphere, and as levels of atmospheric CO_2 increase, so do the levels in the ocean. When CO_2 is absorbed by seawater, a series of chemical reactions occur resulting in the increased concentration of hydrogen ions. This increase causes the seawater to become more acidic and causes carbonate ions to be relatively less abundant. Carbonate ions are an important building block of structures such as seashells and coral skeletons and serve as buffers against wide swings in pH. Decreases in carbonate ions can make building and maintaining shells and other calcium carbonate structures difficult for calcifying organisms such as oysters, clams, sea urchins, shallow water corals, deep sea corals, and calcareous plankton. These changes in ocean chemistry can affect the behavior of non-calcifying organisms as well. Certain fish's ability to detect predators is decreased in more acidic waters. When these organisms are at risk, the entire food web may also be at risk. Ocean acidification is affecting the entire world's oceans, including coastal estuaries and waterways. Many economies are dependent on fish and shellfish and people worldwide rely on food from the ocean as their primary source of protein. (NOS website. *What is Ocean Acidification?*).

3.3 Biological Environment

The biological environment includes all the organisms that will be affected by the activities or techniques of the Proposed Action, including the farmed aquatic organisms themselves. Other considerations include species protected under federal regulations such as the Endangered Species Act (ESA), the Marine Mammal Protection Act (MMPA), and the Magnuson-Stevens Fishery Conservation and Management Act (MSA). This section describes these general categories of organisms that together comprise the biological environment. There is some overlap between the physical and biological environments regarding the types of biological organisms that will be affected and their role as a living habitat for other species such as mangroves, SAV and algae, shellfish reefs, estuaries, and wetlands.

3.3.1 Mangrove Forests

The term 'mangrove' is used to refer to a group of trees and shrubs that inhabit the coastal intertidal zone (the areas where the ocean meets the land between high and low tides). There are about 80 different species of mangrove trees. All of these trees grow in areas with low-oxygen soil, where slow-moving waters allow fine sediments to accumulate. Mangrove forests only grow at tropical and subtropical latitudes near the equator because they cannot withstand freezing temperatures. (NOS website. *What is a Mangrove Forest?*). Mangrove trees have developed special adaptations to survive the variable flooding and salinity conditions imposed by the coastal environment. They act as a buffer between the land and sea, trapping much of the soil and nutrients that runoff from land. Mangrove communities, like salt marshes, facilitate much nutrient cycling, trapping nutrient-rich sediments and maintaining high rates of organic matter fixation (Cintron-Molero,1992). Mangroves also provide important shelter for larval fish and crustaceans and contribute detritus and dissolved organic carbon to estuarine food webs (Heald, 1969; Odum 1971; Twilley, 1982). Mangrove ecosystems are often coupled to other systems such as seagrass beds and coral reefs, supporting migratory species of fish, shrimp, and birds. Both mangroves and seagrass play an important role in holding down the ground. The roots of mangroves help absorb the action from waves and help prevent shoreline erosion. Mangrove communities may also support large resident and migratory populations of mammals, reptiles, and other animals (Cintron-Molero, 1992). Mangroves maintain nearshore fisheries and are an important area for fish and shellfish production in the sea. By trapping nutrients and sediments from drainage, mangroves protect coral reefs, seagrass meadows and coastal waters in general. Mangrove forests trap sediment and prevent silt from damaging associated coral reefs and seagrass beds (NOS, 2013).

3.3.2 Submerged Aquatic Vegetation and Marine Algae

Submerged aquatic vegetation (SAV) differs from most other wetland plants in that it is almost exclusively subtidal, resides mainly in marine salinities, and uses the water column for support. Seagrasses occur across a wide depth range, from rocky intertidal habitats to depths of 40 meters, and, for some species, across broad latitudinal ranges. Distribution patterns are influenced by physical (waves, currents, tides), geological (sediment grain size) and geochemical factors. Seagrasses supply many habitat functions, including: (1) support of large numbers of epiphytic organisms; (2) damping of waves and slowing of currents, which enhances sediment stability and increases the accumulation of organic and inorganic material; (3) binding by roots of sediments, thus reducing erosion and preserving sediment microflora; and (4) roots and leaves provide horizontal and vertical complexity to habitat, which, together with abundant and varied food sources, support densities of fauna generally exceeding those in un-vegetated habitats (Wood et al. 1969; Thayer et. al. 1984). As with salt marshes, seagrasses are very productive ecosystems that also store and sequester substantial amounts of carbon below ground in soils at very high rates, commonly known as ‘blue carbon’. This ability to sequester and store carbon at high rates makes these ecosystems approximately equivalent to terrestrial forests in their ability to serve as carbon sinks, despite having a much smaller geographic footprint. Commercially and recreationally important, federally managed fisheries and many other species are dependent upon SAV for all or part of their life history. Additionally, SAV has been identified and described as EFH for select species or groups of fish and some Fishery Management Councils have identified seagrass as a Habitat Area of Particular Concern (HAPC) (NOS., 2013).

Marine macroalgae (i.e., kelp forests and other seaweeds including brown, green, and red macroalgae) are important structural components of the nearshore marine environment that provide nursery and feeding grounds for marine species. They are also instrumental in the carbon sequestration process, which is important to maintaining healthy carbon dioxide levels in the environment. Marine algae do not have the vascular system (internal transport system) of plants and do not have roots, stems, leaves and flowers or cones. Like plants they use the pigment chlorophyll for photosynthesis but also contain other pigments which may be colored red, blue, brown or gold. Some subtidal marine communities are dominated by large brown algae (kelps) that form floating canopies on the surface of the sea. Kelp forest communities are found from sea level to as deep as 60 meters, depending on light penetration. The combination of nutrients, warm temperatures and other macrophytes (macrophytes are aquatic plants growing in or near water; they may be either emergent, submerged or floating) determine the distribution of kelp forest at low latitudes, while kelp forest distribution is dependent on light at high latitudes. The major species that form floating surface canopies along the West Coast are *Macrocystis pyrifera* and *Nereocystis luetkeana*, off California, and *Alaria fistulosa* in Alaska. Kelps with floating canopies grow along rocky coastlines and do not occur along the East Coast, although plants can obtain heights of over 6 meters above the bottom. Four national marine sanctuaries harbor kelp forests. Giant kelp inhabits the Channel Islands National Marine Sanctuary as well as the Monterey Bay National Marine Sanctuary, where giant kelp and bull kelp coexist. In the more northern Greater Farallones and Olympic Coast National Marine Sanctuaries, kelp forests are predominantly bull kelp (*Nereocystis luetkeana)*. Kelp forests are highly productive and create a three-dimensional aspect to the nearshore environment, providing habitat and food for hundreds of other species of plants (algae) and animals (NOS, 2013).

3.3.3 Reefs

Oyster reefs may be found in intertidal (the area where the ocean meets land between high and low tides) and subtidal areas (the area below the intertidal zone and is continuously covered by water), where suitable substrate and adequate larval supply exist, along with appropriate salinity levels and water circulation. Oyster reefs are naturally built by the cementing together of oyster shells, with additional hard substrate provided by other bivalves, barnacles, and calcareous tube builders such as some polychaetes. Oyster reefs create important habitat for hundreds of other marine species and filter and clean the surrounding water. Species like mussels, barnacles, and sea anemones settle on them, creating abundant food sources for commercially valuable fish species. Oyster reefs provide habitat to forage fish, invertebrates, and other shellfish. They also provide a safe nursery for commercially valuable species. Oyster reefs provide shoreline protection (hard substrate) from wave action, remove nutrients, provide habitat for other invertebrates, and serve as an important food source for humans. Oysters are a crucial component of global ocean health, providing food, jobs, and habitat (NOS, 2013).

Coral reefs are fragile, highly complex communities which have great biological and habitat diversity. Coral reefs are some of the most biologically rich and economically valuable ecosystems on Earth. They provide food, jobs, income, and protection to billions of people worldwide. NOAA is leading U.S. efforts to study and conserve these precious resources for future generations. Together, with seagrass beds, mangrove forests, and their physical and chemical environments, comprise the coral reef ecosystems which support well over a million species. Coral reefs grow upward from the seafloor as the polyps of new corals cement themselves to the skeletons of those below and in turn provide support for algae and other organisms whose calcium carbonate secretions serve to bind the skeletons together (NOS, 2020). Most stony corals are within the group “scleractinians" and are primarily responsible for laying the foundations of, and building up, reef structures (notable exceptions of stony corals outside this scleractinian order include: Fire corals, which fall under the Hydrozoan, and Blue and Organ Pipe corals, which are Octocoral) (NOAA, 2013). Some coral reefs and species of coral are afforded special protection under various federal laws including the ESA, MSA, E.O. 13178 Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve, and E.O. 13158 Marine Protected Areas. When they occur within the boundaries of National Marine Sanctuaries, they are further protected by measures in sanctuary management plans. Shallow-water, reef-building (hermatypic) corals typically are found in tropical waters above 70-meter depth and at temperatures between 23° and 29° C. Other important organisms contributing sediments to reef structure include mollusks, foraminiferans, and echinoderms (NOAA 2005). Coral reef systems provide food, shelter, breeding, and nursery areas for many reef and non-reef organisms. Coral reefs are also linked to mangroves and seagrasses where these systems occur in close proximity to one another (Maragos, 1992).

3.3.4 Threatened, Endangered and Protected Species and Habitat

This PEA does not contain an exhaustive list of threatened and endangered species and/or critical habitat (protected under the ESA), essential fish habitat (protected under MSA), or marine mammals (protected under the MMPA) or birds (protected under the MBTA) within the environments described in Chapter 3.2 (see Chapter 5 for description of relevant laws, regulations, and E.O.). Nor does it provide details on status, trends in abundance and distribution, threats, etc. The aquaculture research and development activities described in the PEA are not generally expected to result in "take" of protected species, or otherwise adversely affect them. Whether a protected species would be affected by the Proposed Action is dependent on many variables, starting with whether a site-specific or project-level/specific action area would overlap in time or space with any protected species. Prior to funding a site-specific or project-level/specific action, project staff would review the lists of protected species to determine whether any occur within the project area, and initiate consultations with NMFS or FWS if the action "may affect" such species or their habitat. Prior to undertaking funding for a site-specific or project-level/specific action, using the best available scientific and commercial information, project staff will determine whether preparation of additional NEPA documents are necessary, or initiation of a consultation is required.

3.3.5 Other Biological Species

In addition to the species that may already be present in the ocean, coastal or freshwater environment of the project area, there may be additional species (farmed aquatic species) affected that are the focus of the Proposed Action. These species will spend all or part of their life cycle in a land-based, ocean or coastal, and or freshwater environment and are summarized in Table 3.2.

Table 3.2. Common Farmed Aquatic Species that may be included as part of the Proposed Action

Group	Species Type
Crustaceans	Shrimp, Crab, Lobsters, Crawfish
Molluscan shellfish	Oysters, Mussels, Clams, Scallops, Abalone, Conch
Echinoderms	Sea Cucumbers, Sea Urchins
Macroalgae	Brown algae, Red algae, Green algae

Microalgae	Unicellular, multiple species
Finfish	Food fish species including those for enhancement/restoration/recreational purposes, Ornamental species, Laboratory model species, Baitfish species

3.4 Socioeconomic Environment

For the purposes of this PEA, the socioeconomic environment considers the existing coastal communities (including environmental justice communities), businesses (both commercial and recreational), and cultural and historical resources as they relate to aquaculture research and development.

3.4.1 Existing Coastal Communities

3.4.1.1 Coastal Demographics. NOAA describes the nation's coastal demographics under two major categories: *coastal watershed counties* and *coastal shoreline counties*. Coastal watershed counties are defined as those counties where a substantial portion of their land area intersect coastal watersheds, and consequently represent where land use changes and water quality impacts most directly impact coastal ecosystems. The Coastal Shoreline Counties, a subset of Coastal Watershed Counties, are those counties directly adjacent to the open ocean, major estuaries, and the Great Lakes. The Coastal Shoreline Counties, due to their proximity to these waters, bear the most direct effects of coastal hazards and host the majority of economic production associated with coastal and ocean resources (NOAA, 2013a).

3.4.1.1.1 Workforce Development. Federal financial assistance awards for aquaculture research and development prepares the communities discussed in the previous section to address risks from events such as drought, flooding, hurricanes and declines in fisheries by developing a skilled workforce that is engaged and enabled to address critical local, regional, and national needs. To achieve this goal, NOAA's federal financial assistance award programs aim to expand awareness among the nation's diverse population of career paths that support the needs of the nation's coastal communities; increase opportunities for vocational students, undergraduate and graduate students, and post-graduates to gain knowledge and experience in the science and management of watershed, coastal and marine resources; and prepare a responsive and diverse workforce to advance and benefit from sectors (discussed in the next section) that support the needs of the nation's coastal communities and ecosystems (e.g. industry, research, government), and to adapt and thrive in changing conditions.

3.4.1.2 Environmental Justice. NOAA plays an active and fundamental role in carrying out the Environmental Justice laws, regulations, and EO's (see description in Chapter 5) to integrate economic prosperity and environmental quality through public engagement using a variety of different tools such as federal financial assistance awards (including grants and cooperative agreements) with educational and research institutions. The aquaculture research and development activities included in the Proposed Action are conducted as part of federal financial assistance award programs. These programs distribute funds almost entirely through a competitive award process; a process in which NOAA cannot discriminately select projects with potential to impact (either adverse or beneficial) minority or low-income populations. Additionally, NOAA recognizes the need to increase social diversity in the seafood and aquaculture community. For example, non-profit organizations, such as *Minorities in Aquaculture*, collaborate with NOAA's Community of Practice for Aquaculture Literacy, allowing them to connect to aquaculture researchers, federal agency staff, farmers, and marine educators to collectively increase diversity and accessibility of aquaculture in the United States. Such organizations lead efforts such as increasing access to communities interested in aquaculture, career development opportunities, mentorship, and other ways to collaborate.

3.4.2 Businesses

The U.S. marine economy (defined as those businesses whose existence depends on the oceans or Great Lakes) includes six business sectors marine construction; living resources; offshore mineral extraction (including oil and gas); ship and boat building; tourism and recreation; and marine transportation. In 2018, the marine economy's 162,000 business establishments employed about 3.4 million people, paid $140 billion in wages, and produced $346 billion in goods and services, or gross domestic product (GDP). This accounted for about 2.3 percent of the nation's employment and 1.7 percent of its GDP (NOAA, 2019a).

3.4.2.1 Marine Economy Sectors Relevant to Aquaculture Research and Development. While each of these sectors has an intersection with aquaculture research and development, living resources (which includes commercial fishing, aquaculture, and seafood processing and markets), and tourism and recreation are the sectors that would most likely be affected by the Proposed Action. As such, these business sectors will be discussed in more detail below and in Chapter 4.

3.4.2.1.1 Living Resources**.** This sector includes commercial fishing, fish hatcheries and aquaculture, seafood processing, and wholesale and retail markets, accounting for 2.5 percent of the employment and 3.3 percent of the gross domestic product of the U.S. marine economy. This sector had the second lowest average wage of all the marine sectors (NOAA, 2019a).

- <u>Commercial Fisheries.</u> Commercial fishing refers to the harvest of fish and other seafood and resources from oceans, rivers, and lakes for the purpose of marketing them. Nationally, species groups with the highest landings value were crabs ($584 million), lobsters ($563 million), scallops ($488 million), salmon ($478 million), and shrimp ($435 million). (NMFS, 2022). Commercial landings (edible and industrial) by U.S. fishermen at ports in the 50 states were 8.4 billion pounds (3.8 million metric tons) valued at $4.8 billion in 2020.
- <u>Aquaculture</u>. The propagation and rearing of aquatic organisms for any commercial, recreational, or public purpose" in controlled or selected environments. Thriving shellfish industries can be found in all coastal regions of the United States, however the Atlantic and Pacific Coast states produce more oysters, clams, and mussels by value ($134.1 and $131.0 million, respectively), while the Gulf states produce more by volume (24.3 million pounds). Freshwater production is primarily composed of catfish (361.9 million pounds), crawfish (223.6 million pounds), and trout (66.3 million pounds). While

aquaculture only accounts for 7 percent of total domestic seafood production, the focus on high value products means that 24 percent of the value of seafood products comes from aquaculture (NMFS, 2022).

- Processed Fishery Products. The estimated value of the 2020 domestic production of edible and non-edible processed fishery products was $11.2 billion. The value of edible products was $10.3 billion. The value of industrial products was $822 million in 2020.The value of canned fishery products in the 50 states, American Samoa, and Puerto Rico was 846.6 million pounds valued at $1.5 billion. The 2020 pack included 545.4 million pounds with a value of $1.3 billion for human consumption and 301.2 million pounds valued at $235.9 million for bait and animal food (NMFS, 2022).

  The value of the domestic production of industrial fishery products was $575.4 million. The Atlantic Coast accounted for the majority of marine recreational trips (68 percent) and catch (68 percent). The Gulf Coast accounted for 29 percent of trips and 30 percent of catch. The remaining regions (Alaska, Hawaii, and the Pacific Coast) collectively accounted for 3 percent of trips and 2 percent of catch (NMFS, 2022).

3.4.2.1.2 Tourism and Recreation. This sector has more business establishments and employs more people than all of the other five sectors combined. In 2019, it was also the largest sector measured in terms of gross domestic product, accounting for about 42.9 percent of the total marine economy. This sector includes a wide range of businesses that attract or support marine-based tourism and recreation, such as, eating and drinking establishments, fee-fishing businesses, hotels and lodging, scenic water tours, aquariums, parks, marinas, boat dealers, recreational vehicle parks and campsites, and associated sporting goods manufacturing. Since many of the activities associated with this sector, such as hotels and restaurants, are not always directly marine dependent, only businesses located in shore-adjacent zip codes are considered marine dependent. Many of the coastal and marine amenities that attract visitors are free, generating no direct employment, wages, or gross domestic product, yet these “non-market” features are usually key drivers for market-based activities. The majority of the jobs in this sector are in hotels and restaurants in nearshore areas where many of the tourist attractions are located. These two industries accounted for 93.7 percent of the employment and 92 percent of the gross domestic product in this sector in 2019. California and Florida are the two largest contributors to this sector, together accounting for more than one-third of the sector’s total employment and gross domestic product in 2019 (NOAA, 2019a).

- Recreational Fisheries. While recreational fishing and angler landings have remained fairly consistent over the last 3 years. In 2020, recreational anglers took nearly 200 million saltwater fishing trips in the continental United States and Hawaii. Anglers caught an estimated 1 billion fish, of which 65 percent were released alive. Anglers harvested (kept or released dead) an estimated 344 million fish with a combined weight of more than 353 million pounds. The Atlantic Coast accounted for the majority of marine recreational trips (68 percent) and catch (68 percent). The Gulf Coast accounted for 29 percent of trips and 30 percent of catch. The remaining regions (Alaska, Hawaii, and the Pacific Coast) collectively accounted for 3 percent of trips and 2 percent of catch. Florida and North Carolina rank first and second for total fish caught and number of trips taken in 2020: Anglers in Florida caught about 461 million fish and took about 83 million trips, while anglers in North Carolina caught about 72 million fish and took about 16 million trips. Together, marine recreational anglers in Florida and North Carolina caught more fish in total than the rest of the country combined (NMFS, 2022).

3.4.3 Cultural and Historic Resources

Cultural and historic resources include a variety of physical resources protected by Federal statute and Executive Orders such as historic properties (buildings, sites and structures, including archeological sites) that are listed or eligible for listing under the National Historic Preservation Act (NHPA); archeological resources; and resources of traditional, cultural, and religious importance to federally recognized tribes and Native Hawaiian Organizations. Although a complete inventory of potentially impacted cultural and historic resources is not possible given the programmatic scope of this analysis, NOAA recognizes that aquaculture research and development projects may have an inherent nexus with cultural and historic resources.

Activities covered by this PEA will comply with applicable statutes, Executive orders, and NOAA policies addressing cultural resources as those activities are proposed, planned and implemented. Analysis of the specific details will be conducted on a project specific basis to determine if additional analysis, such as an NHPA Section 106 consultation, would be needed. The proposed action analyzed in this PEA is programmatic in nature and does not trigger any specific NHPA Section 106 compliance requirements. NOAA will also work to ensure that project specific analyses respect the Indian tribes in their role as managers and stewards of tribal trust resources for cultural, spiritual, economic, subsistence, and recreational purposes.

Chapter 4 Environmental Effects

In accordance with NAO 216-6A, "when considering the proposed action of issuing a financial assistance award under NEPA, the decision maker must consider the impacts of the activities to be funded by the award." This chapter evaluates the environmental effects on the physical, biological, and socioeconomic resources that result from the proposed action and no action alternatives described in Chapter 2.

4.1 Impacts Assessment Methodology

The evaluation criteria used to determine potential impacts to resources from the alternatives include the *type*, *duration,* and *intensity* of the impact.

Type (direct, indirect, and cumulative) of effect, analyzes the timing and proximity of potential impacts and is defined by the CEQ regulations (40 C.F.R. 1508.7, 1508.8) as follows:

- <u>Direct</u> - A known or potential effect caused by the action that occurs at the same time and place as the action.
- <u>Indirect</u> - A known or potential effect caused by the action that occurs later in time or is farther removed in distance but is still reasonably foreseeable.
- <u>Cumulative</u> - A known or potential effect resulting from the incremental effect of the action added to other past, present, or reasonably foreseeable future actions.

This PEA also analyzes significance of an impact in terms of duration (short-term, long-term). While duration is not specifically defined by the CEQ regulations, short-term and long-term are considered "relevant" under 40 C.F.R. 1508.27(a) (1978) but does not specify an associated timeframe. For the purposes of this PEA, the characteristics of duration are defined as follows:

- <u>Short-Term</u> - Occurs while the activity is underway and does not persist once the activity ends.
- <u>Long-Term</u> - Continues for a period of time after the activity has ceased.

Significance also includes intensity which refers to the severity of the impact. Intensity is also described in terms of whether an impact would be beneficial or adverse. An adverse impact is one having unfavorable or undesirable outcomes for the environment (NOS, 2020). The levels of magnitude are identified based on differing levels of impact on resources as negligible, minor, moderate, and major and are defined below:

- <u>Negligible</u> -No detectable or measurable change to the structure or function of a resource
- <u>Minor</u> - A slightly detectable change with an effect that is localized and of little consequence to the resource.
- <u>Moderate</u> - A readily detectable change with a small effect to the resource.
- <u>Major</u> - A readily detectable change with substantial effect to the resource over a large area.

In addition to the evaluation criteria, the alternatives also discuss impacts based on sustainability. NEPA commits the United States to sustainability by declaring it a national policy, "...to create and maintain the conditions under which humans and nature can exist in productive harmony to support present and future generations…" (40 C.F.R. 1500-1508). Sustainable aquaculture is the cultivation of aquatic species by means that have a minimal impact on the environmental quality, and that contribute to social and economic development.

4.2 Activities (or Actions) Eliminated from Further Analysis

Resources where environmental impacts are not anticipated or are considered negligible were not brought forward for further analysis and are discussed below.

4.2.1 Negligible Impacts Anticipated

Resources were eliminated from further analysis if they were expected to have negligible impacts. A negligible impact is defined as impacts on habitat that "would be limited to temporary (lasting up to several hours) changes to habitat characteristics of space; nutritional or physiological requirements; cover or shelter; or sites for breeding, reproduction, or rearing (or development) of offspring found within the project area. Impacts on habitat would not cause lasting damage or alteration." (NOS, 2021). These resources include:

- Air Quality and Climate Change. Implementing activities outlined in this PEA would involve only small quantities of fuel for equipment and boating operations mostly during field surveys and assessment activities, as well as emissions produced as a result of electricity use in land-based facilities. Negligible impacts to air quality and climate are anticipated for the proposed action, thus impacts to climate were eliminated from further analysis. Subsequent environmental reviews for aquaculture research and development projects tiered from this PEA will include an appropriate level of analysis of GHG emissions and assess any project for site-specific or project-level/specific considerations related to climate change. Activities and techniques from the proposed action may produce emissions as a result of electricity use in land-based facilities and from the operation of vessels or other gas or electricity powered technologies but are considered minor and short in duration.

4.2.2 Evaluation of Activities with No Significant Impacts

The following three activities are eliminated from further analysis because they have already been determined to not result in significant impacts, either individually or cumulatively. (NOAA, 2016). Though the procedures and analyses for applying CEs to proposed actions are different, Sea Grant's past practice with CE application and analysis of past actions helps inform the scope of and analysis in this PEA. These activities continue to facilitate a more comprehensive approach to enhancing a sustainable aquaculture industry while minimizing impacts from aquaculture on the environment.

- Outreach, Education, and Planning. NOAA funded projects that engage the public with accurate information about the state of marine and freshwater aquaculture research and management and key initiatives by NOAA and its partners would have indirect, long-term, minor to moderate beneficial impacts to all resources. The beneficial impacts of these activities include: 1) continually educating the industry and the public about sustainable aquaculture practices that minimize harm to resources; 2) supporting science based planning for aquaculture siting and operation that includes consideration of best practices for minimizing impacts and; 3) educating the public on the numerous benefits of seafood consumption of sustainable aquaculture products and providing protection and reduction of non-sustainable sources of seafood. These activities will typically occur in office or other built or previously disturbed (e.g., public parkland) environments in which the work is conducted in compliance with OSHA standards.

- <u>Data Analysis and Social Science Research.</u> NOAA funded projects that allow for the development of tools, including development and use of mathematical models and computer simulations, allowing aquaculture managers to make critical and expedient permitting and management decisions would have indirect, long-term, minor to moderate beneficial impacts to all resources. The beneficial impacts are varied, but in general data analysis supports the development of science-based decision-making tools for social, economic, and environmental purposes such as providing the aquaculture industry with siting and operations guidance based on sound science for reducing biological impacts. In addition, data analysis can form the basis for enhanced farm monitoring techniques and improved technologies for aquaculture practices. Social science research activities are valuable in improving siting techniques to minimize social conflicts, understand markets and the public perception of aquaculture, and ensure that the best available science is used in aquaculture operations. These projects utilize existing data and occur in a virtual, computer-based environment. The office environment within which the work is conducted follows OSHA standards.
- <u>Laboratory and Rearing Research.</u> *Research, development, testing, and evaluation studies* NOAA funded laboratory research projects that utilize existing samples and employ routine techniques. These activities, which occur in a laboratory environment with no direct environmental interaction outside of the built environment, would have indirect, long-term, minor to moderate beneficial impacts to all resources. Laboratory research is conducted in compliance with OSHA standards and research practices and safeguards are in place to prevent environmental impacts from any laboratory practices. Research involving noxious weeds or nonnative invasive species also have specific regulatory safeguards in place to prevent introduction, continued existence, or spread.

4.2.3 Evaluation of Activities (or Actions) with Potential Impacts

The remaining resources under the physical, biological, and socioeconomic environments are being brought forward for further discussion in this chapter. Potential impacts to the physical, biological, and socioeconomic environments are analyzed based on the categories of activities listed below (Chapter 2):

- Laboratory and Rearing Research (excluding *Research, development, testing, and evaluation studies*)
- Field Research and Assessments
- Shellfish Aquaculture Restoration

4.3 No Action Alternative

As described in Chapter 2.1, the No Action alternative serves as a baseline with which the impacts of the Proposed Action are compared and contrasted. For analysis purposes, NOAA has defined the No Action alternative as the decision by OAR and/or NMFS to not issue financial assistance awards for aquaculture research and development under the following existing grant programs and offices: Sea Grant, SBIR, OAF, and OAQ. The consequence of the No Action alternative would limit advancing knowledge in aquaculture fields, and deny the financial, scientific, and technical resources needed to foster the expansion of sustainable U.S. aquaculture. For example:

- Physical environment. The No Action alternative may impact environmental services from aquaculture, such as water quality improvements generated by the presence of farmed shellfish.
- Biological environment. The No Action alternative may diminish future research into improved strains of species, identifying alternative diets, induced reproduction and evaluating improved methods of aquaculture. These research areas are important towards improving production time to market, lessening reliance on wild fisheries for feed ingredients, and minimizing the collection of wild broodstock. The No Action alternative has limited benefits relative to local recreationally and commercially important species, reef structure, and subsequent shelter and feeding grounds these organisms create. Additionally, less research effort will reduce the quantity and quality of baseline information provided by field surveys and assessments to understand of potential impacts of increased aquaculture activity; and limit placing of native shellfish species in areas where local populations are not large enough to produce viable larvae or where species have been fully extirpated from the area.
- Socioeconomic environment: The No Action alternative may limit knowledge transfer to assist communities to understand the challenges and opportunities of seafood farming, develop trust in scientists and the process of science, build confidence in the credibility of the sources providing public audiences with information and limit significant economic value to regional coastal communities that shellfish cultivation and harvest provide.

The potential environmental impacts of the No Action alternative are similar for all three environments (physical, biological, and socioeconomic). Therefore, overall impacts from the no action alternative are **indirect, adverse, long-term** and **minor** to **moderate**. There are no known beneficial impacts from the No Action alternative.

4.4 Proposed Action Alternative

As described in Chapter 2.2, NOAA would issue federal financial assistance awards on an annual basis under the following existing aquaculture-focused programs and offices: Sea Grant, SBIR, and OAQ for aquaculture research and development projects involving farmed and wild populations of aquatic organisms including crustaceans, molluscan shellfish, echinoderms, algae and aquatic plants, and finfish in both onshore and offshore (limited, see Chapter 1.7) environments for the next 10 years. The sections below look at each of the environments described in Chapter 3, as well as the individual activities described in Chapter 2 and assess adverse impacts followed by beneficial impacts for each action.

4.4.1 Physical Environment

The physical environment, as described in Chapter 3.2, for which the Proposed Action may take place, includes land-based, ocean and coastal, and freshwater environments. The sections that follow describe the adverse and beneficial impacts from laboratory and rearing research, field surveys and assessments and shellfish restoration activities on the physical environment and any applicable BMP's (Table 4.1).

4.4.1.1 Laboratory and Rearing Research. Laboratory and rearing research activities (as described in Chapter 2.2.3) include biological, chemical, food production, ecological, or toxicological research conducted in land-based laboratories or closed or partially-closed system aquaculture facilities. Research is conducted according to recommended protocols providing containment and disposal of waste, chemicals, toxins, non-native species, etc., in compliance with established Federal and state regulatory guidelines, and best management practices.

Adverse Impacts. Adverse impacts in the physical environment can include water quality and quantity (usage). Activities that will occur in a minimal discharge system mesocosm (or conducted entirely within an aquaculture facility accepting discharge through municipal sewage systems) have no potential for interaction with anything outside of the system. For example, recirculating aquaculture systems (RAS) require relatively small additions of new water (typically approx. 5% to 15% of the total culture volume daily). During maintenance for removal of settled solids, water may be discharged to municipal wastewater facilities, agricultural fields, retention ponds, sludge collection systems, septic systems, or by other approved discharge methods. Some culture activities may occur in partially closed systems that involve pumping water from the physical environment through tank systems in the facility and then pumping the water directly back out to the physical environment. For example, raceways (an artificial channel consisting of rectangular basins or canals constructed of concrete and equipped with an inlet and outlet) have been used to rear finfish and shellfish seed for over a century. Water continuously flows into these culture units and passes through the stocked raceways, which hold the animals. These activities have minimal potential for direct environmental interaction due to higher flow rates, and shorter water retention times than other land-based aquaculture systems (Fornshell et al, 2012). However, in the case of ponds, adverse effects from water being discharged are limited. For example, catfish ponds are commonly only drained approximately every 10 years to allow repair of pond levees. As such, ponds act as a mostly enclosed system with no regular direct impact to the natural environment outside of discharge during long-term maintenance activities (Tucker and Hargreaves 2012). In all cases, discharge activities are conducted in compliance with federal, state and local laws (NPDES, SPDES) and with best practices and safeguards in place to prevent environmental impacts through any facility practices (e.g., appropriate facility design, optimization of efficient feed formulations).

Therefore, **direct adverse impacts** to freshwater and coastal resources, within the physical environments for laboratory rearing and research activities are anticipated to be **negligible** and **short-term**.

Beneficial Impacts. Laboratory and rearing research activities seek to optimize animal growth and survival by refining culture methods, improving feed conversion ratios, and producing less waste (Hardy et al. 2021). These research activities also target ways to improve the sustainability and efficiency of aquaculture operations. For example, rearing trials and genetic selection can be used to develop stocks that reach market size more quickly. This will reduce potential negative impacts caused by current farming practices by reducing the time and exposure to the environment for rearing. Conducting some of these untested concepts in laboratory settings will remove the risk of negative physical impacts to the environment by confining those activities to strictly controlled facilities where each stage can be closely managed and monitored.

Therefore, laboratory and rearing research activities would have **indirect, long-term** and **minor to moderate beneficial impacts** on the physical environment.

4.4.1.2 Field Surveys and Assessments. Field Surveys and Assessments (as described in Chapter 2.2.4) include field testing of novel technologies and methodologies, field surveys and monitoring, mapping, broodstock and specimen collection, marking and tagging, and shellfish outplanting. The activities in this project category typically take place in coastal and ocean environments on a small-scale in terms of area (e.g., for benthic or water sampling) or organism collection (i.e., number collected relative to the overall source population). The activities in this category vary widely but include: collecting aquatic and terrestrial data in a non-destructive manner; remotely surveying or observing living resources in the field using non-invasive techniques, which have little to no potential to adversely affect the environment or interfere with organisms or habitat; and, using invasive techniques or methods that are conducted for scientific purposes in accordance with all applicable provisions of the Endangered Species Act, Marine Mammal Protection Act, Migratory Bird Treaty Act, and Magnuson-Stevens Fishery Conservation and Management Act. Such activities will be limited to impacting living resources on a small-scale relative to the size of the populations, and limited to methodologies and locations to ensure that there are no long-term adverse impacts to ecosystems. In assessing whether a proposed action is small-scale, in addition to the actual magnitude (minor, moderate, or major) of the proposal, NOAA considers factors such as industry norms and the relationship of the proposed action to similar types of development or activity in the vicinity of the proposed action.

4.4.1.2.1 Field Surveys and Monitoring. Field surveys and monitoring activities (as described in Chapter 2.2.4) are used to observe the natural environment, as well as assess the impact of aquaculture activities in a given location throughout the duration of the study. This work includes examining baseline information of the environment outside of the direct aquaculture farming techniques, such as collecting and analyzing water column and benthic samples to characterize water quality and determine ecosystem services (e.g., water filtration), coupled with monitoring of farm performance and biosecurity, to assess whether or not farming activities create impacts outside the boundaries of that farm site. Technologies utilized include camera mounted systems, SCUBA, and moored or unmoored instruments (such as water quality probes, underwater cameras, etc.), as well as existing oceanic and coastal instrumentation such as buoys and weather stations.

Adverse Impacts. Impacts can result from interaction of equipment and humans with the physical environment while performing activities, including sampling, gear and infrastructure deployment and maintenance, and harvesting when moving through the physical environment. Impact from human presence can include increases in boat traffic and sound, or direct disturbance of the water column or benthos when deploying and/or recovering gear. Collection of bottom grab samples or soils and marine sediments, with or without the use of SCUBA operations, temporarily impact bottom substrate in marine, freshwater, and estuarine areas. Bottom grab samples inherently damage substrate and potentially reduce or damage naturally existing underwater structures or habitat (i.e., reefs, seagrass beds, etc.) or disturb the benthos leading to resuspension of sediments and increased turbidity. Deployment of bottom gear or anchoring equipment may also impact the benthic environment. In any instances where instrumentation is deployed, experimental gear and associated infrastructure would be removed at the conclusion of the research activities, thus these impacts would be localized to the site where activities are occurring and only be short-term in duration. Some of the best management practices that will be used for these activities include: using existing oceanic and coastal instrumentation buoys and weather stations to gather data where applicable, mounting instrumentation to existing structures or surfaces (such piers, buoys, or docks), and minimizing physical presence in the environment by using ships of opportunity (boats/ships that will already be in the area for alternative use/needs). All activities have short-term impacts, because the funded activities have a finite start and end date and will not become permanent. Equipment used for survey and monitoring activities is only present in the environment long enough to use technologies to examine the natural environment, as well as impacts of aquaculture operations on habitats within permitted or approved operation sites and adjacent areas which include all land based, ocean and coastal, and freshwater environments as described in Chapter 3.

Therefore, any **adverse impacts** resulting from field surveys and monitoring activities using various technologies are considered **direct, short-term,** and **minor**.

Beneficial Impacts. There is the potential for beneficial impacts to resources in the coastal, ocean and freshwater environments where these activities occur. The data provided by field surveys and monitoring can help identify optimal areas to site or locate operations and research activities based on factors such as tidal flow, wave energy, phytoplankton abundance, and salinity. As a result, research plans can be altered to prevent unnecessary harm or damage from operations and collection activities and increase the understanding of wild populations and their interaction with aquaculture related activities.

While beneficial impacts would extend to environments adjacent to and beyond the site, activities have the potential to provide **indirect, long-term, minor to moderate beneficial impacts** on the physical environment as well.

4.4.1.2.2 Mapping. Mapping activities (as described in Chapter 2.2.4) are used to gather physical or biological data to inform permitting and planning for aquaculture activities on proposed or existing aquaculture sites and ocean, coastal, and freshwater environments. A variety of equipment and technologies are used in mapping activities, such as remotely operated vehicles (ROVs, ASVs or AUVs) with cameras or sensors, ADCPs, and other equipment.

Adverse Impacts. When conducting mapping activities using remotely operated technologies, as well as when using crewed vessel operations, the potential exists for a vehicle to be lost or to inadvertently collide with structures on the seafloor. This can cause direct damage to structures or habitat. Additionally, these types of events may cause chemical or physical alterations to the water column. Damage to the vehicle may disturb the benthos enough to result in suspension of sediments and increase turbidity temporarily or more directly by negative effects from fuel or battery leakage resulting from impact. However, any leakage from hazardous substances would be small and quickly dispersed. Mapping activities are used as a finite planning tool in the ocean, coastal and freshwater environments, and as such will have limited, short-term impact to these environments. Activities will only occur throughout the start and end date of the funded action (or study) and occur over a small area of seafloor being mapped relative to the overall ecosystem. As a best management practice, funded activities avoid damage to sensitive habitat areas (e.g., coral reefs, seagrass beds, and hard bottom areas). The physical disturbance of sea floor within aquatic habitat areas associated with mapping and surveying activities is expected to be minor and not outside the range of natural variability (NOS, 2021).

Therefore, any **adverse impacts** would result in **direct, short-term,** and **minor** impacts to ocean, coastal, and freshwater environments.

<u>Beneficial Impacts</u>. The beneficial impacts of mapping activities are similar to those described above in Chapter 4.4.1.2.1 Field Surveys and Monitoring. Mapping activities are critical to gathering information that may affect where proposed research and aquaculture activities are conducted to prevent unnecessary harm or damage to the environmental resources from operations and collection activities.

As such, these activities have the potential to provide **indirect, long-term, minor to moderate beneficial impacts** on the physical environment.

4.4.1.2.3 Broodstock and specimen collection. Collecting (as described in Chapter 2.2.4) a limited number of organisms (e.g., finfish, seaweeds, invertebrates) from wild populations and habitats provides for broodstock establishment, nutrient uptake studies, disease monitoring, improved understanding of population structure and biology, and allows for organisms to be subjected to tagging (discussed in the *Marking or Tagging* section).

<u>Adverse Impacts</u>. As part of collecting broodstock and specimens, there is the physical presence of human activity and use of scientific equipment in the ocean, coastal and freshwater environments. Collection is done through hand sampling, SCUBA diving, fishing and trapping. During human presence in the environment, there is the potential for direct interaction with the physical environment which may disturb the water column or benthos, increase turbidity, or cause damage to substrate or habitat. The impacts are similar to those described for *Field Surveys and Monitoring*, which utilizes the same direct sampling techniques. All activities are short-term, as the activities have a finite start and end date.

The **adverse impacts** of broodstock and specimen collection activities on the physical environment can be considered **direct, short-term,** and **minor**.

<u>Beneficial Impacts</u>. There are no known beneficial impacts to the physical environment from broodstock and specimen collection activities.

4.4.1.2.4 Marking or Tagging. Marking or tagging (as described in Chapter 2.2.4) aquatic organisms allows scientists to study growth, movement, mortality, and other parameters such as survival and can occur in ocean, coastal and freshwater environments.

Adverse Impacts. When accessing organisms to mark or tag in nearshore environments, such as shellfish, the physical presence of human activity and/or use of scientific equipment in the physical environment and subsequent impacts would be the same as the impacts described above in *Field Surveys and Monitoring* which utilizes the same direct sampling techniques. Projects would not include marking or tagging of any federally protected species without a permit issued under applicable laws, such as ESA or MMPA.

The **adverse impacts** of marking and tagging activities on the physical environment can be considered **direct, short-term,** and **minor**.

Beneficial Impacts. There are no known beneficial impacts to the physical environment from marking or tagging activities.

4.4.1.2.5 Shellfish Outplanting. Outplanting (as described in Chapter 2.2.4) of native or naturalized shellfish in ocean, coastal, or freshwater environments provides opportunities to evaluate growth, survival, and performance of organisms and the effect of these activities in the environment. Outplanting activities occur within farmed or leased sites approved for this type of activity.

Adverse Impacts. Outplanting cultivated organisms is achieved by seeding or placing seed in culture gear (floating or suspended bags or cages) through the use of boats or by directly walking to the outplanting site. For example, juvenile clams are commonly distributed on the bottom of a lease site, then covered with plastic mesh panels (Castagna, M. 2001). Walking to the sites during seeding and sampling can disturb the benthic environment by creating depressions on the bottom, disrupting SAV, and increasing turbidity of the water column by disturbing bottom sediments. These activities have the potential to be disruptive to the benthos and water column, with the same impacts as described in *Field Surveys and Monitoring*, which utilizes the same direct sampling techniques. To minimize impacts, activities are limited to locations that have been previously disturbed or sites that are permitted or authorized for these types of ongoing activities.

Thus, the adverse impacts from shellfish outplanting activity are limited to farm research or lease sites and may result in **direct, short-term, minor adverse impacts** to the physical environment.

Beneficial Impacts. Shellfish outplanting activities improve water quality in the immediate project area as a result of increased shellfish filtering capacity over the long term, specifically resulting in removal of excess nutrients such as nitrogen (Van der Schatte and Olivier et al. 2018). By outplanting cultivated organisms with increased growth, survival, and performance, the beneficial impact provided by these organisms is extended over the longer lifespan of these organisms. These beneficial impacts would also extend to environments adjacent to and beyond the site as water flows in and out of the shellfish beds.

Therefore, these activities result in **direct, long-term, minor, beneficial impacts**.

4.4.1.3 Shellfish Aquaculture Restoration. Shellfish aquaculture restoration (as described in Chapter 2.2.5) includes the placement or modification of substrate and/or re-introduction of shellfish in nearshore environments. Restoration activities can also involve rehabilitation and recovery of shellfish habitat so that it is conducive for restoration.

Adverse Impacts. These activities typically take place in nearshore environments and within areas of previously disturbed habitats or existing restoration efforts. The activities that potentially impact the physical environment are the same as those described above in *Field Surveys and Monitoring*. Short term impacts, such as increased turbidity, can occur as a result of access via boats or by walking directly to the restoration site and placing cultivated organisms or restoration substrate (such as oyster shells or concrete) to build reefs in the environment. In addition to the physical presence in the environment for these activities, this work has the potential to alter water column chemistry (Ahmed and Solomon, 2016). No long-term impacts to the aquatic environment or marine species from the water discharge are anticipated; unlike some forms of aquaculture, shellfish culture does not create high nutrient discharge because shellfish often feed on phytoplankton in seawater, rather than needing nutrient-rich feed (Mugg et al. 2000). As shellfish filter phytoplankton from the water, much of the nitrogen removed from the water column is transferred to sediments through their excreted psuedofeces (Pietros et al. 2003). Ammonia produced by shellfish is taken up by phytoplankton (Clark and Wikfors 1998). These ecological interactions lead to low impacts on the surrounding area, provided that native species are grown in historically documented concentrations (NMFS, 2015a)

Therefore, these activities result in **direct, short-term, minor adverse impacts**.

Beneficial Impacts. As with shellfish outplanting described above in Chapter 4.5.2.2.6*,* shellfish restoration activities improve water quality in the immediate project area and adjacent areas as a result of increased shellfish filtering capacity (Dvarskas et al. 2020). Shellfish reefs also increase shoreline stabilization, by providing protection from storms. Shellfish reefs serve as barriers to storms and tides, absorbing that energy and preventing erosion and protecting productive estuarine habitats. Restoration activities enhance or improve already established shellfish beds that have continued, long-term benefits to the physical environment.

Therefore, these activities result in **direct, long-term, minor, beneficial impacts**.

4.4.2 Biological

The biological environment, as described in Chapter 4.3 for which the Proposed Action may take place, includes mangrove forests, SAV and algae, reefs, protected species and farmed aquatic organisms. The sections that follow describe the adverse and beneficial impacts from laboratory and rearing research, field surveys and assessments and shellfish restoration activities on the biological environment and any applicable BMP's (Table 4.1).

4.4.2.1 Laboratory and Rearing Research. Laboratory and rearing research activities (as described in Chapter 2.2.3) includes genetics and culturing or selectively breeding organisms, including disease research, to improve overall health of aquaculture species.

Adverse impacts. Most of this work is completed in land-based or recirculating aquaculture facilities with no potential for release or exposure to the natural biological environment.

However, some novel technologies and methodologies may also be used, which include partially closed systems. Partially closed systems are connected to the natural environment and, therefore, unintended release of organisms can occur in the biological environment (mangrove forests, SAV and algae, reefs,). This may result in potential adverse impacts by affecting the long-term genetic structure of wild populations. However, the potential for this impact is minor with the implementation of mitigation measures to prevent unintended release of organisms or waste to the environment as required by the laboratory and aquaculture facility permits issued by regulatory agencies. For example, routine inspection of gear can ensure prevention of unintended release and research focused on hybridization (crossing two different species) and ploidy manipulation (production of triploid organisms) which only uses sterile organisms to ensure that if unintended release does occur, results in fewer impacts from interbreeding with wild populations.

As with genetic and rearing research, most research on diseased farmed animals is also typically conducted in land-based recirculating and partially closed aquaculture systems. This research includes laboratory-based studies to evaluate the effects of exposure of culture animals to various disease pathogens and evaluating the efficacy of disease treatments and vaccines. Disease research may adversely affect wild organisms through unintended release of therapeutants (disease treatment agents) and disease pathogens into the environment. However, the potential of this impact is minor due to proper protocols and facility mitigation measures, which include use of approved treatment concentrations and management of effluent to control any release of disease treatment agents and pathogens. Impacts associated with the evaluation of focal species are minor, as research is limited to the use of native or naturalized species which are present in the wild environment of the area that research is being conducted.

Therefore, these activities can have **indirect, long-term and minor to moderate adverse impacts** on the biological environment.

Beneficial impacts. Laboratory and rearing research activities can provide direct, beneficial impacts to the biological environment, particularly to the farmed aquatic organisms themselves, through improved sustainability of aquaculture operations that ensure that farmed aquatic organisms can thrive in various changing environmental conditions. Identification and development of improved broodstock variants produce progeny (offspring) that have better survival rates, feed conversion rates, and growth rates. In other words, genetically improved organisms are more resistant to adverse environmental conditions and require less input of feed to reach marketable sizes; this can improve long-term production efficiencies, overall farm output, and the ability to consistently supply market demand. Disease prevention and mitigation techniques that detect pathogens or toxins, develop therapeutants, antiviral and vaccine treatments, and investigate physiological impacts of infection can improve disease resistance of species.

There is also the potential for significant indirect beneficial long-term impacts, as these activities also have the potential to improve existing practices and create more sustainable aquaculture operations. However, this impact analysis is limited to the laboratory and research activities described in this PEA. Collection of broodstock and specimens can enhance research to improve husbandry and performance of farmed aquatic organisms, resulting in reducing the time needed to reach harvestable size (and spending less time in the water) for a given species (Gjedrem 2012). This in turn indirectly results in improved production and output for future aquaculture operations when adopted by industry practices. These research activities will permanently improve production, by reducing loss of animals from disease, or poor performance of animals stressed by disease agents. In addition, laboratory and rearing research produces broodstock that are hybrid and/or sterile, leading to fewer future impacts from interbreeding with wild populations, and contributing to increased production through improved growth rates. Novel technologies and methodologies increase research and aquaculture production efficiencies, reduce labor, and increase overall farm output. In addition, improved production efficiencies prevent unnecessary harm or damage to the biological environment by reducing the time necessary for operations in the environment to produce marketable organisms. This reduces the overall indirect impact aquaculture practices have on the natural biological environment (mangrove forests, SAV and algae, reefs, and protected species).

Therefore, the activities described above have **direct** and **indirect, long-term and minor to moderate beneficial impacts** on the biological environment.

4.4.2.2 Field Surveys and Assessments. Field Surveys and Assessments (as described in Chapter 2.2.4) evaluate the performance of farmed aquatic organisms and identify and monitor impacts to wild populations. The activities in this project category typically take place in coastal and ocean environments on a small-scale in terms of area (e.g., for benthic or water sampling) or organism collection (i.e., number collected relative to the overall source population). Given that these activities span all physical environments (coastal and ocean), there is potential impact for all biological environments described in Chapter 4.3, including mangrove forests, SAV and algae, reefs, protected species and farmed aquatic organisms.

4.4.2.2.1 Field Testing of Novel Technologies and Methodologies. Testing of novel technologies and methodologies (as described in Chapter 2.2.3) can include evaluation of aquaculture gear and infrastructure as well as husbandry protocols such as stocking density, which has the potential need to place organisms into novel gear in the physical environment for testing.

Adverse Impacts. In any instance where species are placed in the physical environment, there is the potential for unintended release to the coastal, ocean, and freshwater environments resulting in potential indirect, long-term impacts to wild populations of organisms. However, the potential for this impact is minor given the routine mitigation measures required as part of the permitting necessary to conduct these operations, which include routine inspection of gear to ensure prevention of unintended release of farmed aquatic organisms.

Additionally, placement of gear and infrastructure, as well as the activities necessary to access testing sites, can result in direct unintended disturbance or damage to the biological environment. For example, walking to sites or infrastructure, placement of anchors and structures on the seafloor (bottom), can result in direct, short-term disturbance of mangrove forests, SAV and algae, reefs, and associated benthic animals and plants.

Therefore, activities result in **direct** and **indirect, long-** and **short-term, minor adverse impacts** to benthic and water-column plants and organisms.

Beneficial Impacts. There is a wide array of culture technologies and protocols currently in use with existing aquaculture operations. Novel technologies and methodologies can create improved gear, infrastructure, and culture protocols that have less invasive environmental impact and reduce impact on benthic ecosystems and habitats, such as SAV, mangrove forests and coral reefs. There is the potential for significant indirect beneficial impacts of testing novel technologies and methodologies long-term, as these novel technologies have the potential to replace existing practices and create more sustainable aquaculture operations. However, the activities described and reviewed are limited to the testing of novel technologies and methodologies, not the commercialization of these practices. Thus, the direct beneficial impact that occurs during field testing is minor, as testing practices are of short duration and limited in scale while conducting proof of concept experiments. For example, novel technologies that improve infrastructure installation and enhance gear design can increase the longevity and lifespan of gear, thus reducing the time needed to access sites for management purposes and preventing the indirect impacts to related biological environments. Additionally, new and improved installation methods, such as minimizing anchor points or reducing bottom footprint of gear, will reduce direct impact to the biological environments. Improved designs can also include the development of gear that does not quickly degrade or leach harmful substances, which can indirectly impact biological species health. Activities can also include work to develop improved technology to prevent predators from entering gear as well as escapement of culture animals and the development of best practices for maintaining gear and ensuring unintentional negative interactions do not occur.

These beneficial impacts are considered **indirect** and **direct, short-** and **long-term,** and **minor to moderate**.

4.4.2.2.2 Field Surveys and Monitoring. When conducting biological surveys and monitoring in the field (as described in Chapter 2.2.4), valuable scientific information is provided on wild and farmed aquatic species populations and habitats. These activities are used to quantify organism abundance in or around existing and potential farm sites, as well as provide knowledge on interactions with protected species. Activities may occur in the coastal environment and include surveys of the water surface, water column, and benthos. The methods used for surveys of organisms are non-invasive and observational rather than manipulative, and there is no need to directly interact with species for these activities.

Adverse Impacts. Field surveys and monitoring require interaction with the environment to gather scientific data and information about target species, habitats and the surrounding environment. These activities may result in the temporary disturbance of the benthos and biological environments of mangroves, SAV and corals, as well as the potential to startle and displace biological species, or the unintentional capture of organisms. The effects of such disturbances would be temporary and short in duration. For example, when conducting visual surveys, researchers may access the environment via boat or SCUBA to take video images with cameras which are later used to quantify species presence and abundance. During these activities there is the potential to inadvertently create minor damage or fragmentation to coral reefs through direct interaction. However, all precautions are taken, including advanced scientific collection SCUBA training, to prevent such impacts. All projects that have the potential to impact federally protected species will be assessed individually for compliance with associated regulatory laws.

Therefore, there is the potential for **indirect, short-term,** and **minor adverse impacts.**

Beneficial impacts. Beneficial impacts of field surveys are realized by developing a more complete understanding of the proposed environments for future/potential long-term aquaculture operations in order to ensure that those activities do not adversely impact biological habitats or protected species. For example, a field survey exercise may identify a critically important habitat that would automatically exclude that area as a suitable site for an aquaculture operation. Similarly, the presence of a protected species in a specific area would likely result in the elimination of that site for consideration for aquaculture (NOAA 2019).

Therefore, while there are no known direct beneficial impacts from this activity, there is the potential for significant **indirect, long-term,** and **minor to moderate beneficial impacts**.

4.4.2.2.3 Mapping. Mapping technologies (as described in Chapter 2.2.4) allow for optimal siting of aquaculture operations as well as for biomass estimation on existing and potential future farm sites. In addition, mapping activities can remotely ascertain gear and infrastructure viability.

Adverse Impacts. Activities such as crewed vessel operations, ROV, AUVs and ASVs, and use of underwater acoustic equipment, such as SONAR (echo sounders) and ADCPs, increase the ambient sound level of affected aquatic habitats through the production of underwater sound. Underwater sound will adversely affect aquatic taxa variably, with effects differing considerably based on the frequency and intensity of the sound and the hearing sensitivity of the affected organism. Crewed vessel, ROV, and autonomous vehicle operations themselves may also generate sounds whose frequencies are in the mid- and low-level range which correlates with the hearing range of most prey species, but would be infrequent, geographically widely distributed, and likely to elicit a minimal or temporary response. The majority of these systems (crewed and uncrewed vessel operations, and underwater acoustic equipment) operate at high frequency (75-1,200 kHz) and are moderate in terms of source levels (< 160-180 dB re: 1 µPa m) (NOS, 2021). Use of active underwater acoustic sources would involve directional, and short duration, repeated signals which increase the ambient sound environment of aquatic habitat areas. A majority of the sounds generated by underwater acoustic sources are well above the hearing frequencies of most prey species, thus, unlikely to cause behavioral disturbance and hearing impairment. Projects involving acoustic technology (such as sonar) will be individually assessed to ensure that frequency, magnitude and duration will have minor or negligible temporal and spatial impacts based on the hearing ranges of sensitive species within a given project location (NOS, 2021).

Therefore, the use of these technologies has the potential for **direct, short-term,** and **minor adverse impacts** on marine organisms in coastal and pelagic environments.

Beneficial impacts. Mapping provides information needed for optimal siting of operations to reduce impacts to the environment and by developing a more complete understanding of the proposed environments for future/potential long-term aquaculture operations. This ensures that those activities do not adversely impact biological habitats or protected species. For example, improved mapping of an area may identify a critically important habitat that would automatically exclude that area as a suitable site for an aquaculture operation. For example, if a mapping exercise identifies bottom types or benthic structures that are likely locations for breeding activities of a protected species known to exist in that area, that area would be eliminated from consideration for aquaculture activities. In addition, mapping can remotely ascertain the viability of gear and infrastructure and provide a means to ensure that gear is not damaged, thereby reducing unintended introduction of farmed aquatic organisms.

Therefore, while there are no known direct beneficial impacts from this activity, there is the potential for **indirect, long-term, minor to moderate beneficial impacts.**

4.4.2.2.4 Broodstock and Specimen Collection. Collection (as described in 2.2.4) is vital for work in genetics and evaluation of focal species. Broodstock are typically collected as adult sexually mature organisms or juvenile animals which are subsequently reared in captivity until reaching sexual maturity. Research focused on focal species can involve collection of a given organism during all life stages. Collection of wild organisms of various life stages is also conducted to assess the physiology, age, and growth of a given species under natural conditions.

Adverse Impacts. As with *Field Surveys and Monitoring*, collection includes the direct interaction with wild populations in pelagic and coastal waters**.** Collection and removal methods can range from the use of standard, well-established fishing practices to more targeted collection of specific individuals by hand. Alternatively, in some circumstances there is a need for researchers to collect wild specimens for blood/tissue/gamete etc. samples in order to conduct experiments. These specimens would be returned to the wild, when possible. Collection and/or sampling of organisms from the wild for research purposes is limited relative to the overall wild population of a given organism. Activities that include the direct handling or interaction with federally protected species will be reviewed under the appropriate applicable federal laws such as MMPA, ESA, etc.

Therefore, these activities have the potential for **direct, short-term,** and **minor adverse impacts.**

Beneficial impacts. Collection of broodstock and specimens can enhance research to improve husbandry and performance of farmed aquatic organisms, resulting in reducing the time needed to reach harvestable size (and spending less time in the water) for a given species, and in turn the time an aquaculture operation is active in the environment (Gjedrem 2012). Improvements to broodstock include disease resistance, improved feed conversion ratios, and a better understanding of the genetic makeup of both wild and captive populations of a particular species. In addition to reducing the time to market for these cohorts, these benefits can indirectly protect nearby wild populations by reducing the risk of disease exposure or potential genetic alteration of wild populations related to escape events (Atalah and Sanchez-Jerez 2020).

Therefore, these activities have the potential for **indirect, long-term, minor to moderate beneficial impacts.**

4.4.2.2.5 Marking and Tagging. Marking or tagging (as described in 2.2.4) aquatic species allows for long term monitoring and an enhanced understanding of the species being studied. The types of marking/tagging differ depending on species and can range from Passive Integrated Transponders (PIT) tagging, elastomer marking, attached tags, fin clipping, etc.

Adverse Impacts. The act of marking/tagging specimens in the wild has the potential for direct effects in the form of an injury to the animal that may result in death if not performed correctly. All marking and tagging activities would be conducted primarily in the coastal and pelagic environment by trained individuals in accordance with standard protocols (Axelsson et al. 2020). In addition, impacts to the biological environment are small in scale relative to the size of the populations, and limited to methodologies and locations to ensure that there are no long-term, adverse impacts to ecosystems. Activities involving the use of these techniques or methods on federally protected species will be conducted in accordance with all applicable laws.

Therefore, these activities have **direct, short-term, and minor adverse impacts**.

Beneficial impacts. As with collection of broodstock, marking and tagging activities allow better understanding of a given species, which can result in increased production efficiencies of aquaculture operations. Using data from marking and tagging studies, researchers can learn more about which habitats a particular species of fish may occupy at different (potentially sensitive) life stages, and help regulatory agencies avoid siting aquaculture operations in essential fish habitat, for example.

Therefore, these activities have the potential for **indirect, long-term, minor to moderate beneficial impacts.**

4.4.2.2.6 Shellfish Outplanting. Outplanting (as described in 2.2.4) of native or naturalized (non-native organisms that have been formerly introduced to an environment and have become established) shellfish in ocean, coastal, or freshwater environments provides opportunities to evaluate growth, survival, and performance of organisms and evaluation of outplanting activities on the environment. Outplanting activities occur within farmed or leased sites approved for this type of activity.

Adverse Impacts. Adverse impacts may occur if outplanted shellfish compete with other biological resources in space and time, attract predators, or serve as a source or habitat for deleterious organisms. For example, boring sponges can become established on restoration reefs which in turn will negatively affect the reef and adjacent reefs (Dunn et al., 2014). Typically, the projects that would be funded under the proposed action would take place in previously disturbed areas within established farm sites, thereby, limiting these potential adverse impacts. The proposed projects would also include measures, such as the use of disease-free stocks and disease screening of transferred stocks, to reduce disease introduction. Outplanting locally sourced or sterile shellfish would also be used to reduce impacts to the existing population structure. The number of animals outplanted would be very small compared to the total size of the natural population, minimizing the risk of competition with wild stocks.

Therefore, shellfish outplanting has the potential to cause **direct, short-term, and minor adverse impacts.**

Beneficial Impacts Shellfish outplanting can provide ecosystem services, including enhancement of water filtration and removal of nitrogen from the water column. Shellfish outplanting activities can also result in attracting various life stages of aquatic organisms to outplanting sites, thereby serving as artificial reefs and providing protection for early life stages of a variety of other organisms (Theuerkauf et al., 2021).

Therefore, these activities have the potential to provide **indirect, long-term, minor to moderate beneficial impacts**.

4.4.2.3 Shellfish Aquaculture Restoration. Shellfish aquaculture restoration (as described in 2.2.5) increases populations of bivalve shellfish in coastal waters (such as oysters, clams, and mussels) and provides habitat for other marine animals and plants. Substrate may be used to encourage recruitment of fish or shellfish larvae recruitment in tidal environments. In addition to reef/substrate construction, shellfish restoration efforts also include placing native shellfish in the restoration area if the local population is not large enough to produce viable larvae or no longer present in the area.

Adverse Impacts. Restoration and reintroduction of shellfish seed stock activities may cause adverse impacts by displacing organisms occurring in/near shallow or intertidal habitat through the increased activity associated with restoration project implementation. Terrestrial vegetation may be disturbed if shellfish restoration sites are accessed from land instead of by boat. These impacts are likely to be minimal and short in duration given the scale of restoration activities funded under the proposed action. As with shellfish outplanting, adverse impacts may also occur if shellfish restoration activities result in competition with other biological resources in space and time, attract predators, or serve as a source or habitat sink for deleterious organisms (e.g., boring sponge). Funded projects would take place in previously disturbed areas limiting these potential impacts.

Therefore, these activities may cause **direct, adverse, short-term,** and **minor** impacts.

Beneficial Impacts. The beneficial impact of these activities includes improved water quality due to filtration and nutrient sequestration provided by shellfish, and increased productivity of both shellfish and other species that use the improved shellfish habitat. The structure that shellfish reefs create provide refuge from predators and habitat for other biological resources. Direct, long-term, moderate to major beneficial impacts are likely to affect living coastal and marine resources and essential fish habitat as a result of increased fish productivity within species that use the improved oyster habitat, as well as the productivity of the oysters themselves (Wong et al., 2011). Threatened and endangered species may generally experience indirect, long-term, minor beneficial impacts as a result of the improved habitat and shoreline protection values oyster reefs provide. For example, Atlantic sturgeon (*Acipenser oxyrinchus*) use oyster reefs as forage and refuge habitat (NMFS, 2015a).

Therefore, these activities would be **direct and indirect, beneficial, long-term** and **minor to major.**

4.4.3 Socioeconomic

The socioeconomic environment, as described in Chapter 3.4, includes existing coastal communities (e.g. fishing and indigenous communities), workforce development, environmental justice, cultural and historical resources, and the U.S. marine economy business sectors related to aquaculture research and development (Living Resources and Tourism and Recreation). Both adverse and beneficial impacts from laboratory and rearing research, field surveys and assessments, and shellfish restoration activities on existing coastal communities and businesses are described below.

Adverse Impacts. Adverse socio-economic impacts from laboratory and rearing research, field surveys and assessments, and shellfish restoration activities exist but are limited. With limited funds available, awards directed towards these topics would potentially be unavailable for more direct studies or projects focused on strengthening the socio-economic benefits of aquaculture. Study areas used for the activities funded by this work may be closed to other uses, thereby reducing the benefits that may have been provided by fishing, workforce development, and recreation and tourism in those areas. Of particular concern, areas selected for research or restoration may adversely impact or interfere with traditional uses of the associated resource. For example, research and restoration activities may, directly and in the short-term, impede recreational boating and commercial fishing activities. Indirectly, areas that have experienced successful shellfish restoration have often seen increasing property values which have, in some cases, led to changes in the demographics and socioeconomic status of who can afford to live in those areas (Mann, 2000; Howie and Bishop, 2021).

Surveys and assessments may reveal that a particular resource or habitat is threatened, leading to closures or restricted uses that would result in an adverse economic impact. For example, if a resource or habitat in an area that was previously used by the recreational or commercial fishery industry is deemed threatened from factors such as pollution, that area may then be closed off to those economic sectors.

There has been a historically held view that the aquaculture industry could have adverse impacts on the commercial fishing industry by competing for consumers, ocean space and resources required to produce commercial fish feed (Anderson, 1985). However, the most recent data makes it clear that both forms of seafood production will be needed to meet U.S. seafood demand (both for processing and consumption), and that a sustainably managed domestic aquaculture industry does not necessarily cause a negative impact on a sustainably managed commercial fishing industry (Froehlich, 2021).

The specific research activities described in this PEA have no known direct negative impact on communities or businesses. However, research activities may have indirect adverse socioeconomic impacts to communities and groups. For example, research activities using floating gear may cause impediments to recreational or commercial boating and fishing, and may also alter the viewshed of a given coastal location.

Therefore, the potential **adverse** impacts from all categories of activities would be **direct**, **indirect, short-term, long-term,** and **minor to moderate**.

Beneficial Impacts to Coastal Communities. The aquaculture industry requires a reliable and trained workforce, and many of the skills and capabilities needed exist within the workforce of fishing communities. Communities and individuals affected or displaced by a subsiding fishing industry can often find alternative careers within the businesses supported by these research activities. However, there is a need to expand efforts with respect to workforce development to support the growing aquaculture industry. Notably, some community colleges offer aquaculture training programs, and recently NOAA Sea Grant provided funding for projects to support initial efforts geared toward the Young Fishermen's Development Act, which will support not only workforce development of the commercial fishing industry, but also aquaculture (https://seagrant.noaa.gov/YoungFishermen).

There has also been a significant need, and value added, by including traditional and local knowledge to support aquaculture research. Aquaculture activities described in this PEA identify and support indigenous and local communities in their efforts to make sure their own knowledge is recognized, understood, and valued in relevant research, outreach, and education programs.

Indigenous communities, and to an extent other groups of people whose livelihoods depend on natural resources such as fishing communities, have unique perspectives about human-ecological relationships that come from years, or millennia, of living in a place and depending on a place for their survival, identity, culture, and sustenance. Traditional aquaculture practices have also been in place and used by cultures across the globe for millennia. Learning from these historical practices can have lasting impacts on decisions made to address pressing resource management needs, as well as societal needs today. Similarly, investing in research and activities that integrate more modern techniques into these traditional methods can further enhance the benefits that these practices provide to their communities (e.g. disease monitoring, ecological forecasting, workforce development, etc.…). An example of a longstanding aquaculture practice includes shellfish culture as practiced by certain Native American tribes. For example, clams are an important traditional food and a cultural keystone species for the Swinomish Indian Tribal Community in Washington state, who have a tradition of creating clam gardens: moving and clearing rocks, and building small rock walls to create terraces in tidal flats to enhance clam habitat and support the overall integrity of the surrounding marine environment. In partnership with Washington Sea Grant, the Swinomish Indian Tribal Community, is incorporating indigenous knowledge and a participatory approach to design and plan a clam garden, which will be the first known reintroduction of a functioning clam garden in the United States.

NOAA is committed to building inclusive aquaculture research programs that serve people with unique backgrounds, circumstances, needs, perspectives, and ways of thinking. Each federal financial assistance award announcement encourages applicants of all ages, races, ethnicities, national origins, gender identities, sexual orientations, disabilities, cultures, religions, citizenship types, marital statuses, education levels, job classifications, veteran status types, income, and socioeconomic status types to apply (E.O 13985).

Beneficial Impacts to Businesses. Aquaculture supports the U.S. Blue Economy and successful aquaculture businesses can provide a comprehensive or an alternative source of income for fishers, their families and their communities, and more opportunities for economic development and growth. According to the World Bank, the blue economy is the "sustainable use of ocean resources for economic growth, improved livelihoods, and jobs while preserving the health of the ocean ecosystem." (World Bank 2017). In 2018, the U.S. Blue Economy, including goods and services, contributed about $373 billion to the nation's gross domestic product, supporting 2.3 million jobs and grew faster than the nation's economy in its entirety (NOAA, 2021). Statistics released by the U.S. Bureau of Economic Analysis (BEA) showed the marine economy accounted for 1.7 percent or $361.4 billion of current-dollar U.S. gross domestic product (GDP) in 2020. In January 2021, NOAA released its Blue Economy Strategic Plan for 2021-2025 (https://aambpublicoceanservice.blob.core.windows.net/oceanserviceprod/economy/Blue-Economy%20Strategic-Plan.pdf), laying out a roadmap for new ways to advance the US Blue Economy and enhance the global ocean economy (NMFS, 2020).

Below describes how NOAA funded aquaculture research and development projects, under this PEA, benefit the U.S. Blue Economy.

- Laboratory and Rearing Research. Providing support to local business and growers through improved tools and technologies for aquaculture services can increase production output and have a cascade of indirect positive impacts over the long term to businesses and coastal communities. For example, improving production methods for farmed oysters can result in increased availability of product and as a result, beneficial impacts to community seafood restaurants and markets, as well as aquaculture support industries such as gear manufacturing and boating industries. Thriving local businesses, supported by these activities, are essential to supporting positive socioeconomics of the tourism and recreation sector. Laboratory and rearing research can also help boost economic benefits by making improvements to farmed species resulting in improved genetics, increased growth rates, resistance to disease and parasites, and the potential to adapt to a changing climate. In addition, development of culture methods for new species can result in crop diversification and increased product availability of aquaculture businesses. These impacts can directly benefit aquaculture businesses and processed seafood production by improving the production and supply of marketable organisms. For example, establishment of a hard clam aquaculture industry in Cedar Key, Florida during the 1990s in response to increased fishery regulations such as oyster closures and net bans created an economic opportunity for the affected fishing community (Colson and Sturmer, 2000). Today, clam farming adds an estimated $45 million a year into the area's economy and supports over 500 jobs (University of Florida, 2022). However, changes to industry practices that stem from laboratory and rearing research activities are incremental, and slowly adopted by industry. No single study or project would produce more than a minor impact on its own. Disease prevention and mitigation is one category of laboratory research that may be more quickly transferred to industry because growers can discern a likely reduction in risk, but it is still a stepwise process and not all growers will be equally willing to adopt new techniques and technologies.

Rearing research will improve farmed protocols and methods which indirectly support commercial and recreational fisheries. Stock enhancement refers to the release of organisms to the natural environment to restore overfished stocks and/or enhance catch rates in wild commercial and recreational fisheries. Direct stocking of finfish is outside of the scope of this PEA, however, rearing research conducted within the laboratory environment indirectly benefits stocking activities by improving production and the availability of larvae and/or juveniles used for stocking. For example, funding for research projects has supported marine finfish stock enhancement programs and activities in Texas and South Carolina, which have benefited recreational and commercial fisheries in each state.

Direct and short-term benefits of these activities to local business also include instances where researchers directly purchase spat, seed, adult organisms, etc., from farms and hatcheries to perform research studies. For example, researchers commonly rely on commercial operations to supply organisms to be used in research activities.

In conclusion, the potential **beneficial** impacts on the socioeconomic environment from laboratory and rearing research would be **direct, indirect, short-term, long-term** and **minor to moderate**.

- <u>Field Surveys and Assessments.</u> Field testing of novel technologies and methodologies leads to improved gear, equipment, and culture methods that can be adopted by the aquaculture industry. By optimizing practices and technologies, increasing automation, and reducing the need to visit sites during operations, industry efficiencies increase which results in increased production. Thus, these activities provide the same indirect, long-term beneficial socioeconomic benefits as those provided by laboratory and rearing research because these activities also aim to improve and support a thriving local and sustainable aquaculture industry. However, as described above, industry changes resulting from these activities are incremental, and slowly adopted by industry. No single study or project would produce more than a minor impact on its own.

  Field surveys and assessments also allow for proper siting of potential future long-term operations to ensure that they minimize user conflicts and lead to more profitable sustainable farming operations by selecting operation sites with optimal biological and physical conditions for aquaculture production, as well as limiting potential conflicts with other potential users of the site or adjacent to the site. Minimizing user conflicts such as reducing interactions with boating and fishing activities, as well as concerns with the coastal viewshed, results in an indirect benefit to coastal communities and the tourism industry. For example, NOAA's National Ocean Service, National Centers for Coastal Ocean Science (NCCOS), through its Coastal Aquaculture Siting and Sustainability is actively involved in providing siting and planning tools for coastal and marine aquaculture, such as development of atlases for AOAs in the Gulf of Mexico and Southern California (Morris et al. 2021; Riley et al. 2021).

  Therefore, the potential **beneficial** impacts on the socioeconomic environment from laboratory and rearing research would be **indirect, long-term** and **minor to moderate**.

- Shellfish Aquaculture Restoration. The beneficial impact of these activities includes improved seafood productivity and provision of ecosystem services, particularly restored habitats that provide protection from coastal erosion and storm events, shelter and habitat for other organisms, and improved water filtration. Each of these benefits indirectly improves the ability of these areas to be used for tourism by allowing for cleaner, more stable, and more productive habitats that provide services that are most desirable for visitors. Restoration can also allow fishing areas that had been previously closed to re-open for commercial and recreational use. Reduced coastal erosion and reduced effects from storms protects property owned by residents and businesses, and therefore property values can also benefit from shellfish restoration. Enhanced water filtration associated with shellfish restoration improves overall water quality and can allow for the return of species associated with those habitats including sea grasses, juvenile fish, and crustaceans that use shellfish reef structures as shelter (Gilby et al. 2018). The naturally occurring processes of carbon storage and sequestration will also return to areas and habitats that have been restored.

  Successful shellfish restoration projects are outstanding tools for education and workforce development. Bringing groups to these sites and teaching them about the entire process, including all of the described benefits, not only increases support for such projects in communities that may not be directly impacted, but it can increase the likelihood that participants will pursue additional education (and potentially employment opportunities) in related fields.

  There have also been recent efforts to use shellfish restoration projects as a form of economic relief from impacts caused by the COVID-19 pandemic (e.g., https://seagrant.noaa.gov/News/Article/ArtMID/1660/ArticleID/2828/Relief-that-Restores-Shellfish-Aquaculture). In those cases, shellfish that were unable to be sold when markets shut down were instead purchased and donated to nearby restoration projects. This directly lowered the operating costs for those programs, provided critical income to the growers, and allowed growers to make room on their farms for the next season's crop.

  Therefore, the potential **beneficial** impacts on the socioeconomic environment would be **indirect, direct, long-term** and **minor to moderate**.

4.5 Cumulative Effects

In accordance with NEPA, this PEA considers the incremental effects of the Proposed Action alternative when added to other past, present, and reasonably foreseeable future actions, regardless of what agency (federal or non-federal) undertakes such other actions. Cumulative effects can result from individually minor, but collectively significant impacts from actions taking place over time. 40 C.F.R. Part 1508.7. Cumulative effects are an important consideration for programmatic analysis because of the potential for additive effects from individual projects that may result in cumulative effects to a resource in a project area. However, analyzing cumulative effects at a programmatic level is more challenging, primarily because of the large geographic extent of NOAA's aquaculture research and development projects and the limited time frames. Additionally, when applying the concept of cumulative impacts to a programmatic analysis, consideration must also be given to the uncertainty associated with the selection of future projects.

The Proposed Action described in this PEA may have minor to moderate impacts, at the programmatic level on all resources based on the impact significance methodology in Chapter 4.1 and the environmental effects analysis presented in this chapter. Other ongoing past, present, and reasonably foreseeable future actions (other than the proposed action) that contribute to the cumulative impacts in the environments described in Chapter 3 can include (but are not limited to) other NOAA projects outside the scope of this PEA (both funded or unfunded), impacts from other sectors of the marine economy (such as marine construction), commercial and recreational boating activities impacts, and impacts from tourism and recreation. The minor to moderate impacts to the environment from the proposed action are expected to result in short-term, indirect cumulative effects. As an example, when testing new gear in a coastal environment, there may be short-term cumulative impacts, such as increased turbidity from deployment and retrieval of that gear as well as from site access for maintaining any existing gear at the location. Similarly, restoration and reintroduction of shellfish seed stock activities may displace organisms occurring in/near shallow or intertidal habitat due to the increased activity and noise associated with restoration project implementation. Once the project has ended, it is anticipated that restoration can promote recovery of endangered coastal foundation species, reclaim lost ecological interactions, and help reverse decades of degradation over a period of time resulting in beneficial effects (Smith et al. 2022).

4.5.1 Climate Change

Another important component of the cumulative impacts analysis is climate change and ocean acidification. The presence of climate change is well established and supported by the scientific community around the world. Global temperatures have risen about 1.98°F (1.1°C) from 1901 to 2020. By reinstating EO 13653, President Biden is elevating climate resilience and adaptation as priorities for his administration. The order makes it clear that all federal agencies have a role in preparing the nation for the impacts of climate change.

Just as fisheries and agriculture are vulnerable to the impacts of climate change, so is aquaculture. Projections for how aquaculture will respond to climate change vary. In some regions, warming waters may result in increased occurrences of harmful algal blooms (HABs) and pathogens, and these events can be particularly detrimental for cultivation of shellfish such as oysters, mussels, and clams. However, in tropical and subtropical regions, projections indicate that ocean water temperature will remain within the optimal range for most farmed species. In these regions, warming may result in faster growth and increased regional production of farmed stocks.

Ocean acidification poses a risk to shellfish aquaculture, as young shellfish are less able to grow shells as the pH of their environment decreases. The impact of ocean acidification is already being felt in shellfish hatcheries in the Pacific Northwest. Hatcheries are responding to reduce their vulnerability through smart site selection, improved animal health programs, species selection, selective breeding, advanced animal nutrition, and other husbandry approaches.

Aquaculture has the potential to play a beneficial role in reducing global climate change and its impacts. In a process referred to as bioextraction, seaweeds and filter-feeding shellfish take up carbon dioxide and nutrients from their environment, improving water quality as they grow by removing dissolved acid, nitrogen, and phosphorus. In Puget Sound, a collaborative group has undertaken an effort to farm seaweed to help mitigate ocean acidification. Seaweeds also give off oxygen, which can improve water quality in low-oxygen dead zones. As ocean conditions continue to change, aquaculture has an increasingly important role in maintaining the production and availability of seafood for the world's growing population (De Silva, 2009).

4.6 Summary of Environmental Impacts for the Alternatives

Using the evaluation criteria described in Chapter 4.1, a summary of potential impacts from each category of activities to the physical, biological and socioeconomic environments is provided in Table 4.4 below. Similar impacts may overlap with more than one category and or environment. Because of the programmatic nature of this PEA, environmental effects are evaluated based on the broader categories of activities, rather than project-specific actions.

Table 4.2. Summary of Environmental Impacts

Aquaculture Research and Development project categories		**Alternative 1-No Action**			**Alternative 2-Proposed Action (Preferred Alternative)**		
		Physical	Biological	Socioeconomic	Physical	Biological	Socioeconomic
Laboratory and Rearing Research	*Genetics*	Indirect, adverse, long-term, minor to moderate	Indirect, adverse, long-term, minor to moderate	Indirect, adverse, long-term, minor to moderate	Direct, adverse, short-term, negligible Indirect, beneficial, long-term, minor to moderate	Indirect, adverse, long-term, minor to moderate Indirect and direct, beneficial, long-term, minor to moderate	Indirect, adverse, long-term, minor to moderate Indirect and direct, beneficial, short-term and long-term, minor to moderate
	Rearing trials	Indirect, adverse, long-term, minor to moderate	Indirect, adverse, long-term, minor to moderate	Indirect, adverse, long-term, minor to moderate	Direct, adverse, short-term, negligible Indirect, beneficial, long-term,	Indirect, adverse, long-term, minor to moderate Indirect and direct, beneficial,	Indirect, adverse, long-term, minor to moderate Indirect and direct, beneficial, short-term and long-term,

					minor to moderate	long-term, minor to moderate	minor to moderate
	Disease prevention/mitigation	Indirect, adverse, long-term, minor to moderate	Indirect, adverse, long-term, minor to moderate	Indirect, adverse, long-term, minor to moderate	Direct, adverse, short-term, negligible Indirect, beneficial, long-term, minor to moderate	Indirect, adverse, long-term, minor to moderate Indirect and direct, beneficial, long-term, minor to moderate	Indirect, adverse, long-term, minor to moderate Indirect and direct, beneficial, short-term and long-term, minor to moderate
	Novel technologies and methodologies (excluding field tested)	Indirect, adverse, long-term, minor to moderate	Indirect, adverse, long-term, minor to moderate	Indirect, adverse, long-term, minor to moderate	Direct, adverse, short-term, negligible Indirect, beneficial, long-term, minor to moderate	Indirect, adverse, long-term, minor to moderate Indirect and direct, beneficial, long-term, minor to moderate	Indirect, adverse, long-term, minor to moderate Indirect and direct, beneficial, short-term and long-term, minor to moderate
Field surveys and assessments	*Field Tested novel technologies and methodologies*				Indirect, adverse, short-term, minor Indirect, beneficial, long-term, minor to moderate	Direct and indirect, adverse, long- and short-term, minor Direct and indirect, beneficial, long- and short-term, minor	Indirect, adverse, long-term, minor to moderate Indirect, beneficial, long-term, minor to moderate
	Field surveys and monitoring	Indirect, adverse, long-term,	Indirect, adverse, long-term,	Indirect, adverse, long-term, minor	Direct, adverse, short-	Indirect, adverse, short-	Indirect, adverse, long-term, minor to moderate

		minor to moderate	minor to moderate		term, minor Indirect, beneficial, long-term, minor to moderate	term, minor Indirect, beneficial, long-term, minor to moderate	Indirect, beneficial, long-term, minor to moderate
	Mapping	Indirect, adverse, long-term, minor to moderate	Indirect, adverse, long-term, minor to moderate	Indirect, adverse, long-term, minor	Direct, adverse, short-term, minor Indirect, beneficial, long-term, minor to moderate	Direct, adverse, short-term, minor Indirect, beneficial, long-term, minor to moderate	Indirect, adverse, long-term, minor to moderate Indirect, beneficial, long-term, minor to moderate
	Broodstock and specimen collection	Indirect, adverse, long-term, minor to moderate	Indirect, adverse, long-term, minor to moderate	Indirect, adverse, long-term, minor	Direct, adverse, short-term, minor	Direct, adverse, short-term, minor Indirect, beneficial, long-term, minor to moderate	Indirect, adverse, long-term, minor to moderate Indirect, beneficial, long-term, minor to moderate
	Marking and/or tagging	Indirect, adverse, long-term, minor to moderate	Indirect, adverse, long-term, minor to moderate	Indirect, adverse, long-term, minor	Direct, adverse, short-term, minor	Direct, adverse, short-term, minor Indirect, beneficial, long-term, minor to moderate	Indirect, adverse, long-term, minor to moderate Indirect, beneficial, long-term, minor to moderate
	Shellfish Outplanting	Indirect, adverse, long-term, minor to moderate	Indirect, adverse, long-term, minor to moderate	Indirect, adverse, long-term, minor	Direct, adverse, short-term, minor Direct, beneficial, long-term, minor	Direct, adverse, short-term, minor Indirect, beneficial, long-term, minor to moderate	Indirect, adverse, long-term, minor to moderate Indirect, beneficial, long-term, minor to moderate

Shellfish aquaculture Restoration	*Placement or modification of substrate*	Indirect, adverse, long-term, moderate	Indirect, adverse, long-term, moderate	Indirect, adverse, long-term, moderate	Direct, adverse, short-term, minor Direct, beneficial, long-term, minor	Direct, adverse, short-term, minor Direct, Indirect, beneficial, long-term, minor to major	Direct, Indirect, adverse, short-term, long-term, minor to moderate Indirect and Direct, beneficial, long-term, minor to moderate
	Re-introduction of shellfish seed stock	Indirect, adverse, long-term, moderate	Indirect, adverse, long-term, moderate	Indirect, adverse, long-term, moderate	Direct, adverse, short-term, minor Direct, beneficial, long-term, minor	Direct, adverse, short-term, minor Direct, Indirect, beneficial, long-term, minor to major	Direct, Indirect, adverse, short-term, long-term, minor to moderate Indirect and Direct, beneficial, long-term, minor to moderate

4.7 Mitigation Measures and Aquaculture Best Management Practices

4.7.1 Mitigation Measures

As outlined in the NAO 216-123 *NOAA Mitigation Policy for Trust Resources*, mitigation is an important component of accomplishing NOAA's mission. The definition of mitigation is derived from the CEQ NEPA regulations and falls into three general categories: avoidance, minimization, and compensation.

- Avoid: avoid the impact altogether by not taking a certain action or parts of an action or by modifying the action to avert impacts.
- Minimize: minimize the impact by limiting the degree or magnitude of the impact, action, or its implementation.
- Compensate: offset or compensate for the impact by replacing or providing equivalent substitute resources or environments (40 CFR 1508.1(s)).

Mitigation measures may be incorporated into site-specific projects as required by the terms of any consultation, permit, or authorization necessary to implement the project.

4.7.2 Best Management Practices

The best management practices (BMPs) described below are generally used to ensure that activities described in the Proposed Action comply with applicable laws for environmental protection and minimization or avoidance of potential impacts on environmental resources. As part of reducing or avoiding impacts and avoiding the need for potential mitigation efforts, implementation of best management practices may also enhance performance efficiency (water use, feed conversion, disease prevention, prevention of unintentional introductions of farm raised organisms into wild populations) and reduce waste (physical waste and operation inefficiency). The best practices summarized in Table 4.2, do not reflect an exhaustive list of best practices used in all aquaculture research and development projects funded by NOAA's federal financial assistance awards, but are practices considered in the analysis of environmental effects.

Table 4.3. Aquaculture Best Management Practices

Areas of Best Practices	Examples of Best Practices	Related Project Categories	Types of Impacts Minimized or Avoided
Effluent management	• Appropriate facility design. • Minimize nutrient, phosphorus, nitrogen and solids discharge through optimization of efficient feed formulations. • Operate feed storage, handling, and delivery methods to minimize waste and the creation of fine particles of feed. • Prevent overfeeding.	• Laboratory and Rearing Research • Outreach, Education, and Planning	• Water quality degradation
Drug and chemical handling	• Follow all product label directions for use, storage and disposal. • Consult an aquatic organism health specialist or veterinarian prior to use of drugs.	• Laboratory and Rearing Research • Outreach, Education, and Planning • Field Research and Assessments	• Pollution, Human health impacts
Human health and product quality	• Ensure all employees are properly trained in culture procedures • Obtain all required permits for the sale of farmed aquatic organisms including shellfish for human consumption • Follow all requirements for the handling and sale of farmed aquatic organisms including shellfish for human consumption • Shellfish to be marketed whole, in-the-shell, should be clean, with the shell free of excessive mud or other fouling organisms	• Laboratory and Rearing Research • Outreach, Education, and Planning • Data Analysis and Social Science Research	• Human health impacts • Economic impacts

Predator control	• Regular inspection of gear and equipment • Design facility to prevent or minimize predator access	• Laboratory and Rearing Research • Field Research and Assessments • Shellfish Aquaculture Restoration • Outreach, Education, and Planning	• Unintended introductions of farmed aquatic organism • Animal entanglements • Economic impacts
Disease prevention and management	• Ensure proper stocking densities • Prepare and implement an Aquatic Organism Health Management Plan • Where any lot of aquatic animals is shown to be infected with one or more of the diseases of concern listed in the Aquatic Organism Health Management Plan, all aquatic organisms on the premises must be quarantined or depopulated/destroyed • Follow all regulatory requirements for the importation of shellfish seed including a disease-free certification • To prevent spread of disease, any farmed aquatic organism transported across state lines must be certified disease free and inspected for potential invasive species.	• Laboratory and Rearing Research • Outreach, Education, and Planning • Field Research and Assessments	• Farmed aquatic organisms' mortality • Market sale disruption • Disease transfer to wild populations
Animal health and welfare	• Ensure proper stocking densities, husbandry protocols, harvest or euthanasia procedures	• Laboratory and Rearing Research • Shellfish Aquaculture Restoration • Outreach, Education, and Planning • Field Research and Assessments	• Farmed aquatic organisms' mortality • Economic impacts
Shipping, transportation, and sale	• Any shipments from out of the State must conform to the regulations for importation of aquafarmed products.	• Laboratory and Rearing Research • Data Analysis and Social Science Research • Shellfish Aquaculture Restoration	• Unintentional introductions of farmed aquatic organisms • Product loss/confiscation

		• Outreach, Education, and Planning	
Containment	• All holding, transport, and culture systems at land-based facilities must be designed, operated and maintained to prevent the escape of farmed aquatic species into waters of the state. Any method of containment that will effectively prevent release or escape may be utilized. • All holding, transport, and culture systems must be designed, operated and maintained to prevent the escape of all life stages of nonnative aquatic species into waters of the state.	• Laboratory and Rearing Research • Shellfish Aquaculture Restoration • Outreach, Education, and Planning • Field Research and Assessments	• Unintentional introductions of farmed aquatic organisms
Biosecurity	• Identify any areas within your operation that are not secure and may be vulnerable to product adulteration/tampering. • Immediately investigate any reports of suspicious activity and alert local law enforcement officials • Conduct daily security checks for signs of tampering or unusual situations	• Laboratory and Rearing Research • Shellfish Aquaculture Restoration • Outreach, Education, and Planning • Field Research and Assessments	• Disease outbreaks of farmed stocks • Disease transfer to wild populations
Farm operations and production systems	• Shell or other substance used for substrate enhancement would be procured from clean sources that do not deplete the existing supply of shell bottom. Shells should be left on dry land for a minimum of six months (up to a year or more) before placement in the aquatic environment. Shells from the local area would be used whenever possible.	• Laboratory and Rearing Research • Shellfish Aquaculture Restoration • Outreach, Education, and Planning • Field Research and Assessments	• Negative impacts to natural environments and habitats • Escapement of farmed aquatic animals to the wild/unintended introductions • Disease transfer to wild populations

4.8 Conclusion

This chapter analyzed the potential direct, indirect and cumulative environmental impacts of the Proposed Action and No Action alternatives associated with aquaculture research and development activities funded through Sea Grant, the SBIR program, and NMFS OAQ. This PEA does not predict the impacts of specific projects. Each financial award proposal would be evaluated using this PEA on a project-specific basis to determine if it falls within its scope of analysis and impacts. If the project does not fall within the scope of this PEA, a separate NEPA review will be conducted.

Examination of the Proposed Action alternative revealed that none of the project types have the potential for significant impacts. As summarized in Table 4.3, 100% of the activities in land based, freshwater, and ocean and coastal environments have the potential for adverse, short-term, negligible to minor impacts. In the biological environment, to include mangrove forests, SAV and algae, reefs, protected species and farmed aquatic organisms, 38% of the activities had the potential for long-term, minor to moderate adverse impacts; 54% had the potential for short-term minor impacts; and 8% had the potential for both short- and long-term minor impacts. The variation in the impacts is related to the type of activities. For example, partially closed systems are often used in land-based aquaculture facilities that are connected to the natural environment where unintended release of organisms can occur. This may result in potential adverse impacts by affecting the long-term genetic structure of wild populations. However, the potential for this impact is minor with the implementation of mitigation measures to prevent unintended release of organisms or waste to the environment as required by the laboratory and aquaculture facility permits issued by regulatory agencies. When testing new gear or infrastructure in the field, walking to sites or infrastructure, or placement of anchors and structures on the seafloor (bottom) can result in short-term, minor disturbance of mangrove forests, SAV and algae, reefs, and associated benthic animals and plants that return to their original condition once human presence is removed. At the same time, if this activity also includes farmed aquatic organisms, there is the potential for unintended release to the coastal, ocean, and freshwater environments resulting in long-term, minor impacts to wild populations of organisms. As mentioned above, the potential for this impact is minor with the implementation of mitigation measures to prevent unintended release of organisms to the environment as required by the laboratory and aquaculture facility permits issued by regulatory agencies. The specific research activities described in this PEA have no known direct adverse impact on existing coastal communities or marine business sectors. However, all of these research activities indirectly lead to a better-established aquaculture industry, which can result in perceived or actual long-term, minor to moderate, adverse impacts to communities and groups where industry practices are established. For example, establishment of shellfish aquaculture farms using floating gear may cause impediments to recreational or commercial boating and fishing and may also alter the viewshed of a given coastal location. Though all activities discussed have the potential to contribute to cumulative impacts, they are considered minor and short-term.

The No Action alternative serves as a baseline for analysis for comparison with the Proposed Action. However, analysis of the No Action alternative revealed the potential for minor to moderate long-term adverse impacts on all resources because the lack of funding aquaculture research and development projects, would prevent gains in scientific knowledge used to expand sustainable aquaculture.

Chapter 5 Relevant Environmental Laws

NOAA is responsible for ensuring that NOAA-funded projects comply with all relevant environmental authorities. Each proposal for financial assistance of an aquaculture research and development project submitted to NOAA, undergoes an environmental review which includes compliance with other environmental laws and executive orders. Compliance with relevant environmental authorities other than NEPA will occur at the project-specific level. An inclusion analysis document will identify any steps needed for ensuring compliance with these other requirements. Some of the most common statutes triggered by aquaculture research and development activities are summarized below.

The Anadromous Fish Conservation Act (16 U.S.C. §757a-f) authorizes the Secretaries of Commerce and/or Interior to enter into cooperative agreements with the states for the conservation, development, and enhancement of the Nation's anadromous fishery resources. Pursuant to such agreements, the federal government may undertake studies and activities to restore, enhance, or manage anadromous fish, fish habitat, and passages. The Act authorizes federal financial assistance awards to the states or other non-Federal entities to improve spawning areas, install fishways, construct fish protection devices and hatcheries, conduct research to improve management, and otherwise increase anadromous fish resources.

The Clean Water Act (CWA) (33 U.S.C. §1251) establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters. Under Section 404 of the CWA, a permit is required from the U.S. Army Corps of Engineers before filling, constructing on, or altering a jurisdictional water or wetland (see 33 U.S.C. 1344). Under Section 402 of the CWA, permits are required from the U.S. Environmental Protection Agency or states with approved programs for discharges of pollutants other than discharges of dredged or fill material into waters of the United States. Discharges of stormwater into the waters of the U.S. from municipal or industrial facilities require Section 402 permits (see 33 U.S.C. 1342(p)).

The Coastal Zone Management Act (CZMA) (16 U.S.C. §1456 and 15 C.F.R. part 930) provides for the management of the nation's coastal resources, including the Great Lakes. The goal of the Act is to "preserve, protect, develop, and where possible, to restore or enhance the resources of the nation's coastal zone." The CZMA requires that federal actions which have reasonably foreseeable effects on any coastal use (land or water) or natural resource of the coastal zone be consistent with the enforceable policies of a state's federally approved coastal management program. In addition, the CZMA requires non-federal applicants for federal authorizations and funding to be consistent with enforceable policies of state coastal management programs.

The Endangered Species Act (ESA) (16 U.S.C. §1532) protects and recovers imperiled species and the ecosystems upon which they depend. Under the ESA, species may be listed as either endangered or threatened. "Endangered" refers to a species that is in danger of extinction throughout all or a significant portion of its range. "Threatened" refers to a species that is likely to become endangered within the foreseeable future. The ESA also provides for the designation and protection of critical habitat, specific geographic area(s) that contains those physical or biological features (I) essential to the conservation of a threatened or endangered species, and (II) which may require special management considerations or protection. Section 7(a)(2) of the ESA requires Federal agencies, in consultation with the U.S. Fish and Wildlife Service or the NMFS, to ensure that any action authorized, funded, or carried out by the agency is not likely to jeopardize the continued existence of listed species or destroy or adversely modify their critical habitat.

The Interjurisdictional Fisheries Act of 1986 (16 U.S.C. §1801) provides for grants by the Secretary of Commerce to States for management of interjurisdictional commercial fishery resources. The Interjurisdictional Fisheries Act ("Act") is federal legislation that promotes and encourages state activities in support of the management of interjurisdictional fishery resources. Pursuant to 16 USCS § 4102, the term interjurisdictional fishery resource means:

1. A fishery resource for which a fishery occurs in waters under the jurisdiction of one or more states and the exclusive economic zone;
2. A fishery resource for which there exists an interstate fishery management plan; or
3. A fishery resource which migrates between the waters under the jurisdiction of two or more States bordering on the Great Lakes.

The Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 U.S.C. § 1801) is the primary law governing marine fisheries management in U.S. federal waters. First passed in 1976, the MSA fosters long-term biological and economic sustainability of our nation's marine fisheries in the U. S. Exclusive Economic Zone. Key objectives of the MSA are to 1) prevent overfishing; 2) rebuild overfished stocks; 3) increase long-term economic and social benefits; 4) use reliable data and sound science; 5) conserve EFH (as added by the 1996 Sustainable Fisheries Act), and 6) ensure a safe and sustainable supply of seafood. The MSA includes provisions concerning the identification and conservation of EFH, which is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." Federal agencies that authorize, fund, or undertake actions that may adversely affect EFH must consult with NMFS, and NMFS must provide conservation recommendations to federal and state agencies regarding actions that would adversely affect EFH.

The Marine Mammal Protection Act (MMPA) (16 U.S.C. §1362) protects all marine mammals, including cetaceans (i.e., whales, dolphins, and porpoises), pinnipeds (i.e., seals, walrus, and sea lions), sirenians (i.e., manatees and dugongs), sea otters, and polar bears within waters under the jurisdiction of the U.S. The MMPA provides for an incidental take authorization to be obtained for the unintentional "take" of marine mammal's incidental to otherwise lawful activities. The term "take" means to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal.

The Migratory Bird Treaty Act (MBTA) (16 U.S.C. §703-712) protects over 800 species of migratory bird species from any attempt at hunting, pursuing, wounding, killing, possessing, or transporting any migratory bird, nest, egg, or part thereof, unless permitted by regulations (i.e., for hunting and subsistence activities).

The National Aquaculture Act of 1980 (16 U.S.C. §2901) promotes aquaculture in the United States by, among other things, "encouraging aquaculture activities and programs in both the public and private sectors of the economy that will result in increased aquaculture production, the coordination of domestic aquaculture efforts, the conservation and enhancement of aquatic resources, the creation of new industries and job opportunities, and other national benefits."

The National Historic Preservation Act (NHPA) of 1966 (54 U.S.C. §300101), amended in 1992, requires that responsible agencies taking action that may potentially affect any property with historic, architectural, archeological, or cultural value that is listed on or eligible for listing on the National Register of Historic Places (NRHP) comply with the procedures for consultation and comment issued by the Advisory Council on Historic Preservation. The responsible agency also must identify properties affected by the action that are listed on or potentially eligible for listing on the NRHP, usually through consultation with the state historic preservation officer. Under the provisions of Section 106 of the NHPA, the Secretary of the Interior has compiled a national register of sites and buildings of significant importance to United States history.

The National Marine Sanctuaries Act (NMSA) (16 U.S.C. §1431 et seq.) authorizes the Secretary of Commerce to designate and manage areas of the marine environment with special national significance due to their conservation, recreational, ecological, historical, scientific, cultural, archeological, educational, or esthetic qualities as National Marine Sanctuaries. The NMSA provides the NOAA Office of National Marine Sanctuaries (ONMS) with authority to comprehensively manage uses of the National Marine Sanctuary System and protect its resources through regulations, permitting, enforcement, research, monitoring, education and outreach. Section 304(d) requires interagency consultation between NOAA and federal agencies that are "likely to destroy, cause the loss of, or injure" any sanctuary resource. ONMS has the authority to issue permits for any activity conducted in a National Marine Sanctuary that is otherwise prohibited by sanctuary regulations.

The National Sea Grant College Program Amendment Act of 2019 (33 U.S.C. §1123) reauthorizes through FY2024 and revises the National Sea Grant College Program, through which NOAA supports university-based programs that focus on studying, conserving, and effectively using U.S. coastal resources. The bill authorizes federal financial assistance awards for (1) priority issues identified in the National Sea Grant Program's strategic plan, and (2) university research on sustainable aquaculture techniques and technologies. 1121(b) Objective: "The objective of this subchapter is to increase the understanding, assessment, development, management, utilization, and conservation of the Nation's ocean, coastal, and Great Lakes resources by providing assistance to promote a strong educational base, responsive research and training activities, broad and prompt dissemination of knowledge and techniques, and multidisciplinary approaches to environmental problems." Additionally, 1131. (a)(2)(E) states "University research and extension on sustainable aquaculture techniques and technologies."

The Uniform Administrative Requirements for Grants and Cooperative Agreements with Institutions of Higher Education, Hospitals, other Non-Profit and Commercial Organizations (15 C.F.R. Part 14) establishes uniform administrative requirements for Department of Commerce (DOC) grants and agreements awarded to institutions of higher education, hospitals, other non-profit, and commercial organizations.

Chapter 6 List of Preparers

This document was prepared by an interdisciplinary NOAA team including staff from the Office of Oceanic and Atmospheric Research (OAR) and the National Marine Fisheries Service (NMFS).

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Appendix A Draft PEA Notice of Availability for Public Comments and Responses

The following table contains the comments received during the 30-day Notice of Availability (November 15 - December 15, 2022) for Public Comments (87 FR 68441) of the National Sea Grant Office and NOAA Sea Grant/OAQ's response to those comments.

Comment Number	Section	Submitter	Comment	NOAA Sea Grant/OAQ Response
1	General	Robert M. Griffin, Ph.D. SMAST UMass Dartmouth	Comments not specific to the PEA	Rejected. Comments not applicable to the scope of the PEA.
2	4.5.1.2.2. Mapping	Ventura Port District	he PEA states: "As a best management practice, funded activities avoid sensitive habitat areas (e.g., coral reefs, seagrass beds, and hard bottom areas), and the physical disturbance of sea floor within aquatic habitat areas associated with mapping and surveying activities is expected to be minor and not outside the range of natural variability. (NOS, 2021)." This seems to imply that mapping avoids sensitive habitat areas as a BMP. However, some of the most important mapping is the mapping of those sensitive habitat areas so that they can be avoided by aquaculture projects. This benefit is noted elsewhere in the PEA, where it notes that "improved mapping of an area may identify a critically important habitat that would automatically exclude that area as a suitable site for an aquaculture operation." . Critical research also takes place in sensitive habitats like eelgrass and other seagrasses to evaluate the effects of aquaculture	Accepted. Added language for clarity to state that we do work in sensitive habitat areas for beneficial actions as described.

			projects on those resources. Therefore, we recommend deletion of the recommended BMP, at least in regards to research projects that involve evaluation of those sensitive habitat areas	
3	4.5.2.3. Shellfish Aquaculture Restoration	Ventura Port District	The PEA states that "Funded projects would take place in previously disturbed areas within established farm sites, thereby, limiting these potential impacts." This is not always the case and should not disqualify shellfish restoration projects in areas that were not previously farmed. For example, there may be areas appropriate for shellfish restoration where there were historical wild populations that need additional efforts to rebound to historic levels. We recommend deletion of this sentence.	Accepted. Modified language for clarity.
4	4.5.3. Socioeconomic	Ventura Port District	The PEA states "For example, establishment of shellfish aquaculture farms using floating gear may cause impediments to recreational or commercial boating and fishing, and may also alter the viewshed of a given coastal location." We recommend deletion of this comment. The PEA does not evaluate the establishment of shellfish aquaculture farms that use floating gear. The research of such farms (the activity associated with the PEA) is unlikely to affect these resources and may actually provide the research necessary to minimize these effects. This non sequitur claim is better suited for a project-specific analysis of any proposed shellfish aquaculture farm that proposes to utilize floating gear. In our experience working with NOAA, there are significant opportunities based upon research, spatial planning, and site location, to minimize or eliminate impacts to recreational	Accepted. Modified language for clarity on indirect adverse impacts of described activities on socio economic environment.

			or commercial boating or fishing and eliminate aesthetic or view impacts.	
5	4.3.2, Best Management Practices, Table 4.3	Ventura Port District	Under Disease Prevention and Management, it states “Molluscan shellfish would be species native to the project area.” We recommend that this be revised to state “Molluscan shellfish would be species native or naturalized to the project area.” First, it is unclear how this BMP is associated with disease prevention and management, as there are a variety of non-native (naturalized) species that have the same disease profile as native shellfish species. Depending on the species and disease, they can be more or less susceptible to certain diseases. Regardless, the importation of any shellfish species is regulated by both state health authorities and, frequently, state fish and wildlife agencies, who can identify species that are appropriate to prohibit importation. Second, eliminating non-native, naturalized species from research projects would eliminate most of the species that are commercially grown on the West coast. The species most commercially cultivated, by far, on the West coast is the Pacific oyster (*Crassostrea gigas*) which is non-native but naturalized in most West coast estuaries.	Accepted. Modified language for clarity.
6	General	Siesta Key Association	Comments not specific to the PEA.	Rejected. Comments not applicable to the scope of the PEA.
7	General	Taylor Shellfish Company	Did we include NOAA’s National Shellfish Initiative?	Accepted. Modified language for clarity.
8	General	Don’t Cage Our Oceans	NOAA’s lack of legal authority to regulate aquaculture in U.S. federal waters: “NOAA repeatedly asserts authority in setting up and permitting an unprecedented	Comment noted. Thank you for your comment and participation in the NEPA process. No specific changes were requested,

			nation-wide system of commercial industrial-scale offshore aquaculture installations across all U.S. waters, even though Congress has never passed any legislation granting the agency authority to do so. Furthermore, the courts have affirmed this lack of authority to oversee aquaculture activities in federal waters: in 2020 the Fifth Circuit held that NOAA indeed lacks any statutory authority to regulate aquaculture.”	and none have been made in response.
9	General, 1.2	Don't Cage Our Oceans	NOAA's lack of legal authority to regulate aquaculture in U.S. federal waters, specifically: “In PEA 1.2, NOAA boldly claims that the agency “has a multi-faceted role in aquaculture development in the United States, from supporting science and research to federal policymaking and regulation. Multiple mandates including, but not limited to, statutes and Executive Orders (EOs), charge NOAA with ensuring that U.S. aquaculture develops sustainably, in concert with healthy, productive, and resilient coastal ecosystems.” This is a gross exaggeration of authority, and redirects attention from the only statute that could potentially grant such authority to NOAA - the Magnuson-Stevens Fishery Conservation and Management Act (MSA).”	No specific changes were requested, but additional language has been added to Chapter 1 and text has been reordered to offer greater clarity on NSGO's authority to fund research actions covered by this PEA. NSGO will fund projects per the Sea Grant Authorization priority activities, which include: *“University research and extension on sustainable aquaculture techniques and technologies.”* **33 USC Ch. 22 §1131.**
10	General	Don't Cage Our Oceans	NOAA Fisheries has gone rogue in its relentless promotion of offshore fish farming: “Privatizing public resources for the benefit of large corporations, especially those not from the U.S., is inherently un-American. Through the Aquaculture Opportunity Area (AOA) designation process, NOAA is proposing to carve up and hand out control of our federal ocean	This comment is outside the scope of this analysis. Without agreeing, disagreeing, or otherwise addressing the assertions made within the comment, NOAA reiterates that the scope of this document does not cover commercial fin fish production.

			spaces – a public resource that should be managed for the benefit of all – to private corporations and foreign interests. In rushing through permitting for marine finfish aquaculture, NOAA is actively harming fishing families and the many small businesses in coastal communities that support them. NOAA should instead focus on assisting independent fishermen and co-ops, and other community-based, sustainable seafood producers, as their small businesses continue to recover from the ongoing COVID pandemic. Investing the money to support fishing families and other community-based seafood producers would not only be the right thing to do, but is actually an area already within NOAA's legal purview, under MSA."	
11	ES, Chapter 1 and 5.13	Don't Cage Our Oceans	"As described in PEA 1.2.2 and PEA 5.13, the National Sea Grant College Program Act of 1996 ("Sea Grant") "identifies NOAA as the 'most suitable locus and means for' promoting activities 'that will result in greater understanding, assessment, development, management, utilization, and conservation of the ocean, coastal, and Great Lakes resources." Our members agree that when used thoughtfully, the Sea Grant program is a valuable source of much needed funding in an area that might otherwise be overlooked. For example, Sea Grant has been instrumental in providing research in very complex and dynamic subject areas (further complicated by climate change), launching and sustaining the careers of marine scientists and policymakers, and providing fishing and aquaculture communities with the tools and support they need	Comment noted. No changes requested.

			to stay afloat in difficult economic times. Of course, all of this is outside of the scope of this PEA, which “serves as a framework to analyze the potential impacts on the natural and human environment from aquaculture research and development projects” undertaken by OAR and NMFS. (PEA, Executive Summary, emphasis added.) Congressional enthusiasm for NOAA’s role in tackling broad-based oceanic research and conservation initiatives are reflected in the National Sea Grant College Program Amendment Act of 2019 (33 U.S.C. 1123), as noted in PEA 5.13. This reauthorizes through FY 2024 and revises the National Sea Grant College Program, “through which NOAA supports university-based programs that focus on studying, conserving, and effectively using U.S. coastal resources. The bill authorizes federal financial assistance awards for (1) priority issues identified in the National Sea Grant Program's strategic plan, and (2) university research on sustainable aquaculture techniques and technologies.” (Emphasis added.)”	
12	General	Don’t Cage Our Oceans	Summary of concerns over “factory fish farming” under the heading “NOAA Sea Grant’s National Strategic Plan and how NOAA defines sustainability”...“This abbreviated summary is just the beginning of the list of harms; our members encourage the agency to reach out should it be interested in learning more about economic, social, and environmental harms caused by factory finfish farming.”	Thank you for the comment. Open water, commercial finfish farming is outside the scope of this document. No changes were requested, and no changes were made in response.

13	General	Don't Cage Our Oceans	Problematic funding in the NOAA Sea Grant program: "It is urgent that the agency reflect on its true mission and remember that it serves the U.S. public, not the unwanted and unneeded big corporate development of seafood production."	Comment noted. No changes were requested, and none were made in response.
14	General	Don't Cage Our Oceans	Problematic funding in the NMFS Saltonstall-Kennedy ("S-K") Grant program	This comment is outside the scope of this PEA.
15	General	Don't Cage Our Oceans	Problematic funding in the SBIR program	Thank you for your comment. No changes were requested, and none were made in response.
16	General	Don't Cage Our Oceans	NOAA fails to properly evaluate environmental impacts and cumulative effects: When considering that NOAA has consistently advocated for funding offshore fish aquaculture for decades, and that the assessment of physical, biological, and socioeconomic impacts – as well as cumulative impacts/effects – is so poorly done, we can come to no other conclusion than that the assessment intentionally obscures true concerns.	Comment noted.
17	4.6	Don't Cage Our Oceans	It is one thing for university awardees to conduct a distinct and time-bound experiment, where there are indeed minimal long-term impacts once the experiment is completed, and the area is restored. But, when we consider that many of these grants assist in disseminating corporate propaganda or directly aid these factory fish farms in getting a foot-hold in pubic waters (e.g., through permitting assistance or money to conduct more broodstock research), it is foolish to assume that the benefits derived by these companies simply end at the conclusion of the funding cycle. Indeed, "in accordance with	Comment noted. NSGO will fund projects per the Sea Grant Authorization priority activities, which include: *"University research and extension on sustainable aquaculture techniques and technologies."* **33 USC Ch. 22 §1131.**

			NEPA," this PEA should "consider the incremental effects of the Proposed Action alternative when added to other past, present, and reasonably foreseeable future actions." (PEA 4.6) Funding factory farms in the ocean through these grants means that the agency should understand that it is directly responsible for actualizing these companies' publicly stated plans to scale up pilot projects by ten-fold or more.	
18	General	Don't Cage Our Oceans	Our members support Alternative 1, the No Action Alternative, and urge that NOAA overhaul how it makes determinations on its aquaculture funding decision-making. Contrary to the agency's assertion of alleged benefits and harms of various awards, our members maintain that every grant made to a company or academic institution that furthers the goals of the offshore fish farming industry is a grant against the public interest. Great harm has arisen from the $36.3 million that was awarded to projects from 2017-2022 that benefitted (and continue to aid) the offshore fish farming industry. Our members object to the factory farming of our oceans, and instead support fishing and aquaculture that operates within our values of community-driven, community-supported, and responsibly-managed. Indeed, these values-based forms of aquaculture warrant the agency's serious consideration when it comes to aquaculture programs that deserve funding.	Thank you for your comment and input.