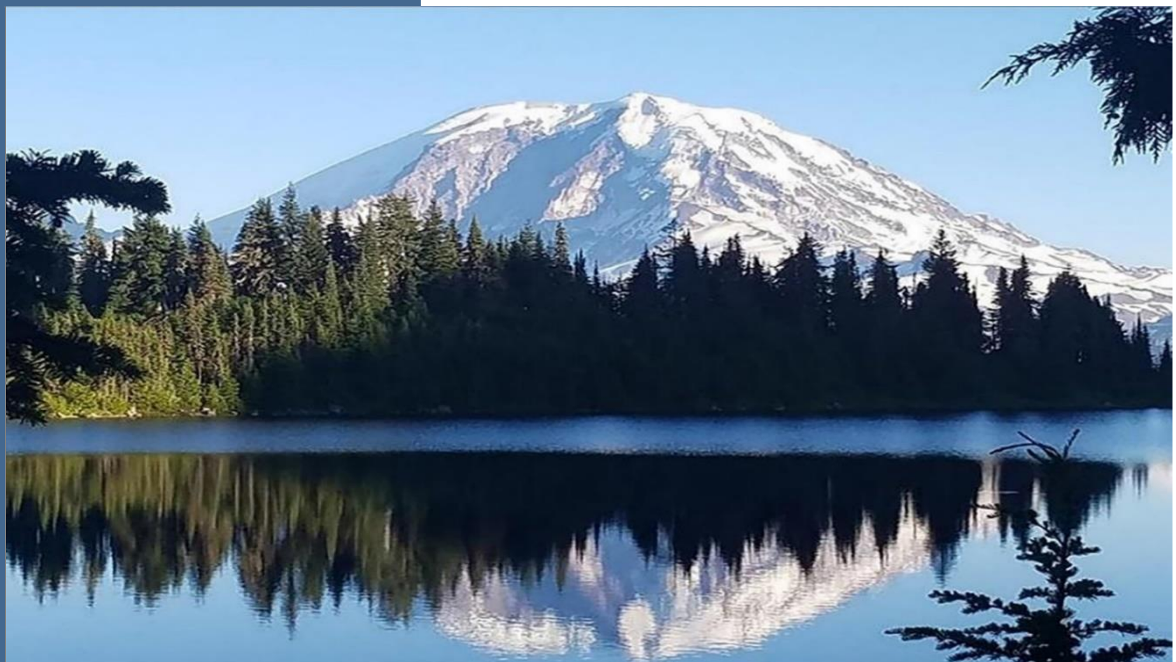

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Guidance for Marine Net Pen Aquaculture in Washington State

Regulations, Risk, and Management

Washington State Department of Agriculture

Washington State Department of Ecology

Washington State Department of Fish and Wildlife

Washington State Department of Natural Resources

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Contact Information

XXXXXX Program

P.O. Box 47600
Olympia, WA 98504-7600
Phone: XXX-XXX-XXXX
Website[1]: Washington State Department of Ecology

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WASHINGTON STATE DEPT OF NATURAL RESOURCES

Washington Department of FISH and WILDLIFE

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Contributors

The authors of this report thank the following people for their contribution to this guidance document:

- To be developed when document is finalized.

Executive Summary

To be developed when document is finalized.

About the Guidance

The guidance examines the regulatory protections of the environment, identifies additional environmental risks, and provides further mitigation and best management actions to reduce these risks. This document is a tool for local and state governments and the marine net pen aquaculture industry when assessing new or existing net pen operations.

Organization

This guidance contains a short introduction about marine net pen aquaculture and three major resource sections of which:

- The first walks you through the **legal framework** that is in place – the laws and rules, the authorizations, leases, licenses, and permits, and the authorizing agencies responsible for each.
- The second looks at **aspects of the natural environment to be considered** and associated risks, and provides recommendations for best practices to reduce negative impacts.
- The third identifies **recommendations for additional legislative oversight and support** to ensure net pen operations in Washington are appropriately sited and effectively managed.

Throughout the document, potential risks and best practices reflect current science and are approached through the lens of site, structure, and maintenance and operations. You'll find that monitoring, inspection, and response are common themes, and that planning is a common link between permits and practices. There are also two appendices included. Appendix A: Guidance on Local Shoreline Permitting summarizes the permitting process and summarizes the best practices for use by local governments that are implementing Shoreline Master Plans. Appendix B: Fish Health Glossary provides definitions for technical terminology used in this document.

Limitations

The guidance in this document is intended to reduce or minimize negative impacts to Washington's natural resources by greatly reducing the risk of those impacts occurring. However, it is important to remember all risk cannot be eliminated even if following every best practice in this guidance. Some events, such as natural disasters, criminal activity, and navigational accidents, may pose risks beyond the control and management capability of net pen authorities, proponents, and operators. Additionally, there are some potential impacts associated with net pen operations that may require further scientific research to fully understand. The final section of this document lists recommendations about additional oversight and research needs to address these data gaps.

It is also important to remember this guidance:

- Considers only marine finfish net pens in Puget Sound and Strait of Juan de Fuca.
- Is not law or regulation, nor is it designed to be adopted into state regulations. It recommends a direction; it doesn't require you to conform.
- Is not a substitute for law or rules. Make sure you are familiar with the real thing.
- Is not a checklist. It is a starting point, not a one-size-fits-all plan. Each project is unique, and some may need to consider factors not featured in this guidance.
- Does not describe every aspect of net pen projects. For instance, it does not describe risks or mitigation of the aesthetic impacts or navigation conflicts, but we identify they are considered during the siting process and respective authorizations during the appropriate regulatory steps.
- Does not assess or address potential impacts to tribal treaty rights. Tribal treaty rights must be evaluated on a case-by-case basis by each permitting or authorizing agency.
- Is not a definitive. Laws, regulations, and best management practices will evolve as technology advances and scientific understanding improve.

Introduction

Commercial marine finfish net pens are part of Washington's aquaculture industry. This guidance is intended to help project proponents and permitting authorities understand some key management issues of which to be aware and consider when making decisions about net pen projects.

The guidance focuses on reducing negative impacts to Washington's natural resources by appropriately siting net pens and safely and effectively managing these open in-water fish[2] farms. It includes requirements and best practices for permitting, planning, and operations. This guidance provides information about authorities, regulations, site conditions, concerns, and choices. It also contains recommendations and best management practices for net pen operations.

This guidance reflects:

- **The inherent link between marine net pens and Washington's natural resources.** The same saltwater environment upon which marine finfish net pens rely is also home to a myriad of native species, including some considered at-risk. The marine environment also supports recreation, fishing and shellfish harvesting, shipping, and other commercial interests. There are many regulations in place to protect such public interests and resources that apply to net pen projects.

- **The complexity of net pen projects.** These projects connect to multiple resources and regulatory jurisdictions. Coordination in authorizing approvals, leases, licenses and permits, inspections, and enforcement is important. It is also critically important for project proponents to share and communicate the scope of their projects including all the environmental components. By understanding the causes of and potential for negative impacts, proponents and authorities can work to reduce them.

- **The current science about potential impacts of net pens on the natural environment.** Paying attention to what the science tells us and using it as a foundation for decisions provides authorities with a basis for determining the conditions that must be met to issue a permit or authorization. It also provides proponents with tools to meet requirements and operate safely. It takes away guesswork and assumptions, and establishes a consistent approach for proponents and the public.

- **The potential for change.** Net pen environments are dynamic. They are subject to tidal forces, weather, natural disasters, human-caused accidents, and simply the passage of time. Even the fish they contain change, growing from smolts to harvestable size. Also,

[2] Unless otherwise indicated all mention of "fish" refers to "finfish" only

new technologies, knowledge, and conditions can lead to new aquaculture techniques, processes, regulations, and recommendations.

About marine net pen aquaculture

When considering a marine net pen project or operation in Washington, it can help to start with a basic understanding of what net pens are and why site selection, structure design and construction, and operations and maintenance practices matter.

Net Pens

A net pen is basically a cage in the open water, into which young finfish (as opposed to shellfish) are placed, allowed to grow, and then taken out for harvest. Multiple pens together make up an array. Net pens, as well as arrays, may be in a variety of shapes.

A typical net pen array in Puget Sound is built with the net pens attached to floating walkways. Each pen is constructed using a net to prevent fish from escaping, and the pens are encased with a single, stronger net secured to the array's perimeter to keep out predators. The overwater structure usually includes a place for service boats to tie up to and barges for staff to operate from to tend the fish—feed them, check their health and growth, and harvest them. Different projects may use different configurations and materials for the pens, anchors, floats, lines, walkways, and barges. Often times, there is an adjacent land-based dock and office that supports net pen operations.

Although marine net pen operations may differ in design and in the fish they raise, they share four basic characteristics:

- They require saltwater deep enough so even extreme low tides do not cause the net pen to touch the sediment bottom.
- They require good water quality that ensures fish health all year long.
- They must be secured so they don't float away or break apart.
- They are built to concentrate a greater number of fish in one area than naturally would occur.

These characteristics are at the root of the environmental concerns addressed in this guidance. They drive the required permits and authorizations, and they shape decisions about site selection, structure, and operations and maintenance.

Site Selection

Where a net pen project is located is vitally important to reduce environmental impacts as well as use conflicts. Different sites have different environmental influences and limitations, from bathymetric limits, tidal forces, existing water quality to nearby native fish runs. Deliberate, well-informed site selection for marine finfish net pen facilities is crucial for reducing the various impacts to natural resources. Careful site analysis and selection can significantly reduce negative effects on water quality, sensitive habitats and native species, and other uses.

Finding sites suitable for finfish aquaculture is primarily the responsibility of the project proponent, and their proposed location will face significant scrutiny by permitting and leasing authorities to ensure the chosen site and nature of their operations will avoid potential negative impacts.

Structure Design and Construction

How a net pen array is built is important for safe operations—the configuration, the material of it is made, and how it is engineered and constructed. These things affect the integrity of the structure, whether it will hold together and how long it will last. Some materials are not suited for saltwater. They may break down or be toxic to aquatic species. Some designs may be more vulnerable to external forces—physical or biological. Design determines if an array can be functional. Even the size of the net mesh needs to be appropriate for containing the fish being raised, ensuring sufficient water flow for fish health, and maintaining the integrity of the net pen array. And whatever the design and materials, care must be taken to prevent negative impacts during the construction process.

Ensuring appropriate design and construction is primarily the responsibility of the project proponent. It needs to be compatible with the specific site selected and intended use. And like the site, it will be scrutinized by permitting and leasing authorities.

Operation and Maintenance Practices

How a net pen facility and the fish reared are managed is important for fish and environmental health. Even an ideal site and structure cannot prevent negative impacts caused by poor practices. Plans for how operations and maintenance will be conducted can prescribe best practices, but follow-through is needed too. Paying attention, monitoring conditions, inspecting key elements, and responding to problems in an appropriate and timely manner can prevent a variety of negative impacts.

Ensuring appropriate operation and maintenance practices are followed is primarily the responsibility of the project proponent. Plans and implementation of such practices will be scrutinized by permitting and leasing authorities, and inspections may be conducted to verify compliance.

Legal Framework

The legal framework for marine finfish net pen facilities in Washington reflects the complexity of net pen projects and natural resources. The framework includes local, state, and federal agencies. It includes regulations, policies, permits, leases, and licenses that address potential risks such as pollution, pathogens, and escapes. These are the primary regulatory tools for preventing adverse environmental impacts.

Project proponents and operators need to be familiar with the legal requirements. Permitting authorities do, too. Although different authorities regulate different aspects of net pen facilities, those aspects connect, and impacts can cross jurisdictions. All parties should be aware of potential conflicts and concerns when making decisions. Proponents should contact agencies directly to discuss proposals and issues.

This chapter provides an overview of the legal framework by focusing on:

- Roles and responsibilities
- Laws and permits
- Interagency coordination

It is important to remember that the information in this chapter is not a substitute for the regulations to which it refers. Also, this chapter is limited. It describes portions of the legal framework that address aquaculture or environmental concerns. Other authorizations may be necessary to site, build, or operate a net pen facility. In addition, this chapter does not address on-shore support facilities.

Roles and responsibilities

Understanding who does what makes it easier to navigate the legal requirements and processes involved. This section provides basic information about the roles of:

- Project proponents and operators
- Tribes
- Local governments
- State agencies
- Federal agencies

Project proponents and operators

These entities are directly responsible for the net pen facility, its operations, and its impact on the environment.

Proponents propose a project and its location, and must obtain the proper permits, leases and other approvals required by law. To do so, they must plan the facility and its operations, and provide the information required to receive approval from authorities. They complete and submit the State Environmental Policy Act (SEPA) checklist and applications for permits and other authorizations.

If a project is approved, proponents are responsible for the construction, installation and operation of the facility in the manner consistent with their lease and permits. Throughout operations, they must comply with various regulations and the conditions of their lease and permits, including notifying the proper authorities of disease outbreaks, fish escapes, and events that could lead to structural instability. They also must make their facility available for inspection by authorities.

Tribal governments

Tribes have specific rights and interests in resources that can be impacted by net pen facilities.

Tribal governments of Washington are sovereign nations recognized by the United States. Each tribal reservation constitutes a neighboring jurisdiction to Washington, subject to tribal and federal laws, such as U.S. Environmental Protection Agency-approved Clean Water Act water quality standards. Tribes have authority to ensure that cultural and natural resources are protected and treaty rights upheld.

The Treaty Tribes of Washington are co-managers of fisheries resources, including salmon, groundfish, and shellfish. They possess treaty-reserved rights to take fish and shellfish at all their usual and accustomed places for commercial, ceremonial, and subsistence purposes.

These rights have been upheld in court. For example, in 1996 a federal district court upheld the U.S. Army Corps of Engineers denial of a Section 10 permit for proposed salmon fish farm net pens on the basis of Corps' determination that the project would interfere with the right of Lummi Nation fishers to access one of their usual and accustomed fishing areas[3].

Tribes have the right to review and comment on federal permits, and Washington State agencies are obligated and committed to consulting with affected tribes and may place conditions on state permits to address tribal concerns.

Local governments

Cities and counties have a critical role in authorizing commercial net pen facilities located within their shoreline jurisdictions.

They review project proposals for compliance with their land use ordinances and shoreline master programs, as well as other local environmental regulations, zoning, and other codes. Local governments typically conduct their reviews prior to state and federal agencies, including environmental assessments under the SEPA. They consider whether a proposed net pen operation and its impacts are compatible with existing uses and whether there would be significant adverse environmental impacts needing to be offset or mitigated. Some cities and counties require a visual impacts assessment as part of the application process.

[3] See NW Sea Farms, Inc. v. United States Army Corps of Engineers, 931 F. Supp. 1515 (W.D.Wash. 1996).

State agencies

There are four Washington state agencies that have key roles and responsibilities related to net pen projects: the departments of Agriculture, Ecology, Fish and Wildlife, and Natural Resources. Not all the roles are regulatory.

Washington State Department of Agriculture (WSDA)

WSDA has both regulatory and non-regulatory roles related to net pen operations and their products.

WSDA fosters the state's aquaculture industry, provides market assistance, and regulates labeling of aquaculture products, including those from fish farmed in net pens.

WSDA's Animal Health program supports the Washington Department of Fish and Wildlife (WDFW) in the monitoring of aquaculture diseases. If a reportable disease is detected in a net pen WDFW notifies the State Veterinarian at WSDA, who reports it to the U.S. Department of Agriculture, who reports it to the World Organisation for Animal Health (OIE). If it is an actionable reportable disease, WDFW has jurisdiction over what happens to the fish in which the pathogen was detected.

WSDA's Animal Feed Program regulates commercial feed, including fish feed and its ingredients. The program inspects feed facilities for compliance with regulations related to, labeling, current Good Manufacturing Practices (Title 21 CFR Part 225 and Part 507), Hazard Analysis, and Risk-Based Preventive Controls, compliance with Veterinary Feed Directives (VFDs). The program also samples commercial feed to test for compliance with guaranteed analyses and for the presence of pathogens, chemical contaminants and other adulterants. The program can help net pen operators address issues about feed or feed ingredients they have received. A net pen operation can mix its own feed, but it will need a commercial feed license from WSDA's Animal Feed Program to distribute feed to others.

WSDA's food safety program educates and regulates the food industry regarding hazard assessment and control. To ensure farmed fish used for food or feed meet standards for safe consumption, net pen operators need to be aware of any likely food or feed safety hazards related to farm practices.

Washington State Department of Ecology (Ecology)

Ecology is the primary state agency responsible for protecting water quality, sediment quality, and for managing and protecting marine and freshwater shorelines.

Ecology administers and enforces state and federal environmental laws, such as water quality regulations. It has authority from the U.S. Environmental Protection Agency (EPA) to administer National Pollutant Discharge Elimination System (NPDES) permits to protect water quality on non-tribal lands.

Ecology also administers the state Shoreline Management Act (SMA), providing guidance, reviews, and approvals for local government shoreline master programs and for some shoreline management permits. There are three basic SMA policy areas: Shoreline use, environmental protection, and public access. As much as possible, shorelines should be reserved for "water-oriented" uses, including those that are "water-dependent," "water-related," and for "water-enjoyment." The SMA is intended to protect shoreline natural resources including the land, vegetation, wildlife, and aquatic habitats against adverse environmental effects. The SMA also promotes public access to publicly-owned areas and encourages the preservation and enlargement of recreational opportunities.

Washington State Department of Fish and Wildlife (WDFW)

WDFW regulates finfish aquaculture—including net pen operations—through licensing, permits, and fish health and infrastructure inspection programs.

These regulatory actions are part of WDFW's primary responsibility to preserve, protect, perpetuate, and manage fish and wildlife species of the state, including those that are at-risk and protected (federal Endangered Species Act (ESA), Washington state listed species, or species of concern).

WDFW works to protect native species from a wide range of threats, such as disease, invasive species, and habitat loss—all of which are possible impacts from finfish net pen facilities and operations. Impacts can be either direct (e.g., genetic, ecological, disease transmission) or indirect (e.g., through effects to prey or habitat).

WDFW issues marine finfish aquaculture permits, and authorizes live finfish transport permits, and registers aquatic farms. WDFW requires operations plans, escape prevention plans, and receives quarterly reports on the species cultured, quantity harvested for sale, and unit value.

WDFW'S regulatory authority for marine aquaculture is designed to prevent the introduction of specific pathogens. Fish, gametes, and embryos must be tested at their source and may not be transported to a new location if they test positive for specific pathogens. In addition, WDFW requires that the live fish or the brood stock that produced the gametes or embryos test negative for specific pathogens before a transport permit will be issued for their offspring.

WDFW also inspects marine net pens facilities for the presence of disease, requires diseases be reported, and takes action as necessary to protect native stocks from disease that will cause severe mortality. Finally, WDFW requires that net pen infrastructure is in good working order as a precaution to reduce the chance of structural failure and escaped fish. WDFW may deny a permit if the infrastructure is at risk of structural failure.

WDFW regulatory authority under RCW 77.55 to require a Hydraulic Project Approval (HPA) permit does not apply to the installation or maintenance of tideland and floating private sector commercial fish and shellfish culture facilities (RCW 77.12.047). However, an HPA is required to construct accessory hydraulic structures, such as bulkheads or boat ramps. The department recommends that producers utilize the process authorized by RCW 77.55.400 and described under WAC 220-660-050(18) if there is any question about the need for an HPA prior to construction.

Washington State Department of Natural Resources (DNR)

DNR manages state-owned aquatic lands, and it leases aquatic lands for a variety of uses, including net pen facilities.

To ensure they are in deep enough water, marine net pen facilities in Washington typically need to be located over state-owned aquatic lands managed by DNR. This means projects need a use authorization (lease) from DNR, which acts as the landlord on behalf of the state.

As steward of the state's aquatic lands, DNR is responsible for ensuring protection of habitat and fostering public access and water-dependent activities. DNR manages state-owned aquatic lands for the public benefits for all residents, including future generations. Generating revenue in a manner consistent with these goals is a public benefit, and DNR must charge rent for the private use of public land.

Federal agencies

U.S. Environmental Protection Agency (EPA)

EPA administers the Clean Water Act to protect the overall water quality of the nation.

Through the National Pollutant Discharge Elimination System (NPDES), Section 402 of the Clean Water Act addresses water pollution by regulating point sources that discharge pollutants to waters of the United States. Net pen facilities are considered to be point sources (40 CFR 122.24 and appendix C of 40 CFR part 122). EPA also produced effluent guidelines for the industry in 40 CFR Part 451.

EPA has authorized Ecology to administer the NPDES program for Washington State. EPA is the federal Clean Water Act Section 402 permit authority in Indian Country and in Washington, and retains Section 402 permit authority for federal facilities.

U.S. Coast Guard (Coast Guard)

The Coast Guard administers the Private Aids to Navigation (PATON) permit for marking a structure/object/hazard and ensuring the safety of the boating public.

If unseen, net pen facilities can be a hazard to boaters. Marking a structure can make facilities more visible, preventing collisions and resulting damage to boats, boaters, and the facility. Permission to install Private aids to Navigation can be obtained by submitting an application. The U.S. Army Corps of Engineers (USACE), DNR, and local jurisdictions are involved with Private Aids to Navigation or PATON permit issuance.[4]

U.S. Army Corps of Engineers (USACE)

The USACE regulates discharges of dredged or fill material into waters of the United States, and structures or work in navigable waters of the United States.

A proposed project's impacts to these areas will determine what permit type is required under Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act.

The USACE is required to consult with other federal agencies prior to issuing a permit. The agencies must review the project and, if needed, recommend mitigation measures to protect the environment or wildlife.

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[4] ORIA. Private Aids to Navigations. https://apps.oria.wa.gov/permithandbook/permitdetail/98 Accessed 18 September 2020

Tribal governments also have the opportunity to comment on federal permits. Tribes may comment on proposals regarding habitat and treaty-reserved Usual and Accustomed (U&A) areas and provide information on potential effects to historic properties.

The USACE must address comments prior to issuing a permit. Absent tribal consent, the USACE is not authorized to permit a project that would qualify or limit the tribes' ability to access one of their usual and accustomed fishing sites or grounds for a purpose other than conservation of salmon. This applies to commercial marine salmon net pens.

Regulations

Most regulations that apply to net pens come from state and federal law. However, local regulations also play a critical role. Two key state laws link local authorities to statewide concerns: the State Environmental Policy Act and the Shoreline Management Act. Together these statutes create a foundation for permits and the interagency process needed for new or expanded net pen facilities in Washington's marine waters.

Other regulations apply to specific aspects of net pen projects, including operations and the environment in which they occur, such as regulations protecting water quality and fish health.

State Environmental Policy Act (SEPA) – Chapter 43.21C RCW

SEPA is meant to ensure that environmental amenities and values, along with economic and technical considerations, are given appropriate attention during governmental decision making.

SEPA requires a comprehensive review of a proposed project to identify and analyze the environmental impacts associated with governmental decisions. While most regulations focus on particular aspects of a proposal, SEPA requires that probable impacts on all elements of the environment be identified and evaluated, including mitigation options.

Proponents submit an environmental checklist when seeking a permit or other authorization. An environmental impact statement may be required if there are probable significant environmental impacts. Cities and counties where a new net pen facility is proposed typically lead the SEPA process on behalf of all agencies with jurisdiction over the proposal.

SEPA requires all state agencies and local governments to "use a systematic, interdisciplinary approach through the integration of natural and social sciences and environmental design in planning and decision making on environmental impacts" (RCW 43.21C.030).

State and local agencies can condition or deny a proposal based on their SEPA authority. SEPA gives agencies tools to consider and mitigate environmental impacts of a proposal. SEPA also integrates public notice and reviews, tribal consultation, and state and local agency review prior to any final decision.

Shoreline Management Act (SMA) – Chapter 90.58 RCW

The overarching goal of the Shoreline Management Act is "to prevent the inherent harm in an uncoordinated and piecemeal development of the state's shorelines."

The SMA provides a broad policy framework for fostering reasonable and appropriate water-oriented uses, promoting public access, and protecting the natural resources and ecology of Washington's shorelines. It promotes three main policies: Environmental protection, shoreline uses, and public access. The SMA requires all 39 counties, as well as towns and cities with shorelines of the state, to develop and implement a locally-tailored Shoreline Master Program (SMP). More than 260 cities and counties have developed these important tools.

- "Shorelines of the state" include all marine waters and their associated upland areas.
- Shoreline master programs are local land-use policies and regulations that guide use of Washington's shorelines. They protect natural resources for future generations, provide for public access to public waters and shorelines, and plan for water-dependent uses.

The SMA establishes the concept of preferred shoreline uses. These uses are consistent with controlling pollution, preventing damage to the natural environment, or are unique to or dependent upon use of Washington's shorelines. As much as possible, shorelines should be reserved for preferred "water-oriented" uses, including those that are "water-dependent," "water-related," and for "water-enjoyment." Finfish aquaculture qualifies as a "water dependent" use under the SMA.

The SMA states that the interest of all the people "shall be paramount in the management of shorelines of statewide significance (SSWS)." These shorelines include the Pacific Coast, Hood Canal, Puget Sound and the Strait of Juan de Fuca. Preferred uses for SSWS are designed to:

- Recognize and protect statewide over local interests
- Preserve the natural character of the shoreline
- Result in long-term rather than short-term benefits
- Protect shoreline resources and environment
- Increase public access to publicly-owned shoreline areas
- Expand recreational shoreline opportunities for the public

The SMA establishes a state-local partnership for managing Washington's shorelines. SMPs are designed to implement the goals and policies of the SMA, considering local planning goals and geographic uniqueness. SMPs are created by local government, then reviewed for consistency with the SMA and SMA Guidelines (Chapter 173-26 WAC Part III) before being approved by Ecology. Local governments have the primary responsibility for administering shoreline master programs, and are typically the lead agency for net pen projects.

SMP PROCEDURES AND GUIDELINES – CHAPTERS 173-26 AND 173-27 WAC

The Shoreline Master Program Procedures and Guidelines are the state rules guiding the development and implementation of local SMPs. These rules translate the broad policies of the Shoreline Management Act into standards for regulating new development and uses within shorelines of the state and their shorelands. WAC 173-26 addresses the SMP approval/amendment procedures and master program guidelines, and [WAC 173-27] describes the SMP permit and enforcement procedures.

The guidelines identify elements that are required to be included in SMPs:

- Shoreline environment designations (SEDs) with customized management policies, regulations, and use allowances/prohibitions
- Policies and regulations for each major shoreline use (commercial, residential, recreational, aquaculture, etc.) and each major shoreline modification type (fill, docks/piers, shoreline stabilization, etc.)
- Vegetation conservation standards
- Public access requirements
- Shoreline buffers and/or setbacks
- Critical areas protection standards

Ecology also maintains an SMP Handbook to provide guidance to local governments about developing or amending their SMPs. The handbook provides guidance for complying with the requirements of the SMA, guidelines and procedural rules, as well as for complying with federal rules and regulations. The handbook also provides information and resources to help in making decisions on SMP environment designations, policies and regulations.

Chapter 16 of the handbook addresses the SMP Planning Process for Aquaculture, including marine net pen aquaculture. When considering how net pen facilities may fit into their SMP, local governments should take special notice of the following SMP guidelines:

- WAC 173-26-186(8) - direction to include policies and regulations designed to achieve no net loss of current and future ecological functions.
- WAC 173-26-211(5)(c) – the "Aquatic environment" purpose, management policies, and designation criteria
- WAC 173-26-221(2)(a) - (c) - Critical areas applicability, principles, and standards
- WAC 173-26-221(2)(c)(iii) - Critical saltwater habitat applicability, principles, and standards
- WAC 173-26-241(3)(b) - Shoreline use provisions for aquaculture

The authority to develop policies and regulations ultimately rests with local jurisdictions – specifically, municipal and county governments. However, all SMPs must meet certain standards and receive Ecology approval.

SHORELINE MASTER PROGRAMS

Local governments develop their Shoreline Master Programs (SMPs) in a manner that addresses the unique characteristics of their shorelines and natural resources. Each Shoreline Master Program is unique, with locally focused land-use policies and regulations. Although all SMPs prioritize water dependent uses, such as aquaculture activities, a specific use allowed in one location may not be allowed elsewhere in the same jurisdiction. In addition, each SMP applies to new uses and developments and is not retroactive.

The SMP guidelines recognize that even water dependent uses require limitations. Specific to aquaculture, WAC 173-26-241(3)(b)(i)(C) states:

> *Aquaculture should not be permitted in areas where it would result in a net loss of ecological functions, adversely impact eelgrass and macroalgae, or significantly conflict with navigation and other water-dependent uses. Aquacultural facilities should be designed and located so as not to spread disease to native aquatic life, establish new nonnative species which cause significant ecological impacts, or significantly impact the aesthetic qualities of the shoreline.*

Under SMP guidelines, net pens must be reasonably accommodated as a water dependent use, but local governments may apply restrictions to protect public health and ecological function.

Each SMP describes regulations and policies that apply to all shoreline development, and more that apply specifically to aquaculture. Typically, SMPs also identify additional conditions and criteria that apply to commercial net pens. In order to locate and install a new commercial net pen facility, the project proponent must consult the local SMP and under most circumstances will need to obtain a Substantial Development Permit (SDP) and a Conditional Use Permit (CUP).

Water Quality Regulations

Federal and Washington state regulations permit the discharge from net pen operations in a manner to prevent water pollution.

The federal Clean Water Act (CWA) established water quality goals for navigable waters of the United States. The NPDES permit program is one mechanism for achieving the goals of the CWA. The EPA has delegated responsibility to administer the NPDES permit to Washington state on the basis of the state's Water Pollution Control Act (RCW Chapter 90.48). Ecology's authority and obligations are defined in RCW 90.48. EPA specifies effluent limit guidelines in 40 CFR Part 451 and Chapter WAC 173-221a specifies further the minimum discharge standards for marine net pens in the state of Washington.

An NPDES permit translates the general requirements of the federal Clean Water Act and the state Water Pollution Control Act into specific provisions tailored to each operation discharging pollutants. This is to help ensure activities do not cause water quality impairment or adversely affect designated uses. The permit is akin to a revocable license that allows the permittee to discharge to state waters under specific requirements or conditions.

Fish Health Regulations

Federal and state regulations are in place to prevent the introduction and spread of disease that would put native fish stocks at risk.

Some regulations work to prevent aquatic pathogens and disease, especially non-native pathogens, from entering Washington waters, where they could spread. These regulations focus on the importation and transport of gametes, embryos, and live fish into and through the state.

- Federal rules (50 CFR 16) apply only to international importation.
- State rules (Chapter 220-370 WAC) apply to all gametes, embryos, and live finfish that are transported into or through Washington, regardless of their origin.

Both federal and state rules require that the live fish or the brood stock that produced the gametes or embryos be free of viruses and other pathogens collectively referred to as "regulated finfish pathogens" (see Chapter 220-370 WAC).

Regulations also reflect the importance of controlling aquaculture disease in the net pen. All aquatic farms, including marine net pens, are subject to inspection by WDFW "for the prevention and suppression of aquaculture diseases, including, but not limited to, taking samples for detection of regulated finfish pathogens and other diseases" (WAC 220-370-080).

Aquatic farmers are required to report the detection of regulated pathogens regardless whether fish are showing symptoms of disease or appear healthy (WAC 220-370-190(2)). If an outbreak occurs at any aquaculture facility, the aquatic farmer is required to report the outbreak to WDFW immediately (WAC 220-370-180). WDFW has great latitude to order emergency actions if is determined that such actions are necessary to protect native stocks from disease that will cause severe mortality. These actions include denying a transport permit, quarantining the aquaculture products, confiscating or ordering the destruction of the aquaculture products, or requiring that the products be removed from state waters (WACs 220-370-190 and 220-370-240)[5]. In administering a disease control program, the Director of WDFW "shall not place constraints on or take enforcement actions in respect to the aquaculture industry that are more rigorous than those placed on the department or other fish-rearing entities" (RCW 77.115.010(6)).

Table 1 Key state statutes and administrative codes, by lead agency.

Agency	Revised Code of Washington	Washington Administrative Code
Local govt. or state agency—varies by project or decision	Chapter 43.21C RCW – State Environmental Policy Act	Chapter 197-11 WAC - SEPA Rule

[5] WDFW's aquaculture rules and regulations are described in Chapters 77.115 and 77.125 RCW. Changes made to Chapter 77.125 RCW in 2018 include direction to update the rules (Chapter 220-370 WAC) regarding administering a disease control program. The update process began March 2020 and was still in progress as this guidance was being published.

Agency	Revised Code of Washington	Washington Administrative Code
Agriculture (WSDA)	Chapter 15.53 RCW - Commercial Feed Chapter 15.85 RCW - Aquaculture Marketing Chapter 6.36 RCW - Animal Health Chapter 69.07 RCW - Washington Food Processing Act	Chapter 16-250 WAC - Commercial Feed WAC 16-603-010 - Aquaculture identification requirements
Ecology	Chapter 90.48 RCW - Water Pollution Control Act Chapter 90.58 RCW - The Shoreline Management Act of 1971	Chapter 173-27 WAC - Shoreline Management Permit and Enforcement Procedures Chapter 173-201A WAC - Water Quality Standards for Surface Waters of the State of Washington Chapter 173-204 WAC - Sediment Management Standards Chapter 173-220 WAC - National Pollutant Discharge Elimination System Permit Program Chapter 173-221a WAC - Wastewater Discharge Standards And Effluent Limitations
Fish and Wildlife (WDFW)	RCW 77.12.455 - Prevention and suppression of diseases and pests RCW 77.15.290 - Fish and Wildlife Enforcement Code, Unlawful transportation of fish or wildlife—Penalty Chapter 77.115 RCW - Aquaculture Disease Control Chapter 77.125 RCW - Marine Finfish Aquaculture Programs	Chapter 220-370 WAC - Aquaculture
Natural Resources (DNR)	Chapter 79.105 RCW - Aquatic Lands – General Aquatic Use Permit Application and Aquatic Lands Lease Chapter 79.135 RCW - Aquatic Lands – Oysters, Geoducks, Shellfish, Other Aquaculture Uses, and Marine Aquatic Plants	Chapter 332-30 WAC - Aquatic Land Management

2Authorizations

Net pen projects require multiple authorizations such as project approvals, permits, licenses, and leases. Requiring these authorizations prior to a net pen facility being installed prevents negative impacts by identifying and addressing issues before actions are taken. Permit applications provide the project-specific information needed to make informed decisions. SEPA allows conditions to be placed on permits, and approved permits document conditions and other expectations.

This section takes a closer look at several key permits and the permitting process. Refer to the table at the end of this section.

Local shoreline permits

Under its Shoreline Master Program, a local government can issue three types of permits: Substantial Development, Conditional Use, and Variance. One or more of these permits may be required for a net pen project. All three types of permits can include conditions of approval to ensure consistency with the Shoreline Master Program (SMP). Projects that include prohibited uses cannot be authorized.

When an operator applies for permit(s) through the local government for a commercial finfish net pen, they are required to provide a range of information about the proposed activity, including a characterization of the habitat and resources that are beneath and adjacent to the chosen site.

The local planning department and Ecology review the application and materials provided by the project proponent for accuracy, missing information, and compliance with the local SMP. Each proposed action or project within the shoreline jurisdiction is reviewed for the following:

- Use – Is the proposed use allowed in the Shoreline Environmental Designation? Are the applicable use provisions being met? Is the proposed use water-oriented?
- Development – Does the proposed action meet the definition of development? Is the proposed development or shoreline modification allowed in this Shoreline Environmental Designation? Are any special reports or minimization measures required for this type of development?
- Bulk, Dimensional, and Performance Standards – These can include buffers, setbacks, height restrictions, lot size minimums, impervious surface limitations, vegetation protection, mitigation sequencing, view corridors.

Permit application review should include each required SMP element:

- Shoreline environment designations with customized management policies, regulations, and use allowances/prohibitions
- Policies and regulations for each major shoreline use (commercial, residential, recreational, aquaculture, etc.) and each major shoreline modification type (fill, docks/piers, shoreline stabilization, etc.)
- Vegetation conservation standards
- Public access requirements
- Shoreline buffers and/or setbacks
- Critical areas protection standards

Ecology has created a Shoreline Permitting Manual that provides guidance for local government planners who review applications for shoreline permits. The manual may also be helpful for consultants and applicants who develop information for shoreline permits and submit permits to local governments.

SUBSTANTIAL DEVELOPMENT PERMITS

Under the Shorelines Management Act, a Substantial Development Permit is required if a proposed shoreline development would materially interfere with the normal public use of state waters and shorelines, or if the total cost or fair market value of the proposed project exceeds a certain dollar amount. Every five years, the amount is adjusted for inflation. The current (2021) threshold is $7,047.

Local governments may approve substantial development permits as long as the permits are consistent with the Shoreline Management Act and applicable shoreline master program provisions.

All proposals for new commercial net pens would require a locally-issued Substantial Development Permit because of the cost threshold and because net pen facilities include constructing or placing structures, thus meeting the definition of development within shorelines of the state or within shorelines of statewide significance (SSWS).

> *"Development" means a use consisting of the construction or exterior alteration of structures; dredging; drilling; dumping; filling; removal of any sand, gravel, or minerals; bulkheading; driving of piling; placing of obstructions; or any project of a permanent or temporary nature which interferes with the normal public use of the surface of the waters overlying lands subject to the act at any stage of water level. "Development" does not include dismantling or removing structures if there is no other associated development or redevelopment*; (WAC 173-27-030(6))

CONDITIONAL USE PERMITS AND VARIANCES

Conditional Use Permits (CUPs) may be required for commercial net pen facilities. Each Shoreline Master Program defines the types of uses and developments that require CUPs, usually within an allowed use matrix and with additional use-specific provisions.

A Conditional Use Permit helps ensure the use of the site and project design will be compatible with other authorized uses in the area, and that the proposed use will not cause significant adverse effects to the environment. Consideration also must be given to cumulative impacts of additional requests for like actions in the area.

Under WAC 173-26-241(2)(b), Conditional Use Permits can provide the opportunity to require specially tailored environmental analysis or design criteria for types of uses or developments that may otherwise be inconsistent with a specific environment designation. This can provide flexibility without outright prohibitions. This is especially useful for water-dependent uses such as net pens.

The SMP Guidelines recommend Conditional Use Permits for the following:

- Uses and development that may significantly impair or alter the public's use of the water areas of the state.
- Uses and development which, by their intrinsic nature, may have a significant ecological impact on shoreline ecological functions or shoreline resources depending on location, design, and site conditions.
- Uses and development in critical saltwater habitats.

Local governments may approve CUPs where applicants demonstrate consistency with review criteria found in Ecology rules (WAC 173-27-160), including demonstration that the:

- Proposal is consistent with the policies of the SMA (RCW 90.58.020);
- Project's use of the site and the design will be compatible with other authorized uses in the area;
- Proposed use will not cause significant adverse effects to the environment;
- Proposed use will not interfere with the normal public use of public shorelines; and
- Public interest suffers no substantial detrimental effect.

Conditional Use Permits and variances require approval from both the local government and Ecology. Either or both entities may attach special conditions to the permit to ensure consistency with the SMP. Conditional Use Permit decisions are first issued by local governments and then submitted to Ecology for further review. Ecology may then approve, approve with conditions, or deny a project based on the project's ability to meet criteria of WAC 173-27-160 and WAC 173-26-170.

A variance allows a project to deviate from specific bulk, dimensional or performance standards, and is not a means to vary a use of a shoreline.

Department of Ecology permits

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) PERMIT

A net pen facility must obtain an NPDES permit if the operation qualifies as a Concentrated Aquatic Animal Production (CAAP) facility. The rule WAC 173-221A-110 further states that marine net pen facility need a discharge permit if:

(i) All facilities which produce more than 20,000 net pounds of finfish a year; or

(ii) Feeds more than 5,000 pounds of fish food during any calendar month; or

(iii) Is designated as a significant contributor of pollution by the department in accordance with 40 C.F.R. 122.24.

An NPDES permit is valid for five years after issuance and must be applied for every cycle. NPDES permits incorporate EPA's effluent limit guidelines from 40 CFR Part 451 and the minimum discharge standards for marine net pens from Chapter WAC 173-221a 110. Permits are written to so the discharge meets the water quality standards (WAC 173-201) and source control discharge limits and compliance procedures in WAC 173-201-412.

Net pen federal effluent limit guidelines and state standards specify minimum operating requirements and best management practices to prevent, reduce, or eliminate water quality impacts. Fish feed, metabolic waste, and disease control chemicals are all considered potential water quality pollutants produced by a net pen facility. Also, fish authorized by WDFW to be reared in commercial net pens are prohibited from being released and must be contained in the net pens.

NPDES permits require permittees to perform sediment, water quality, and fish escape monitoring and reporting, enhanced emergency response planning and training, pollution prevention, net hygiene, regular maintenance, and structural assessments by licensed professional engineers. In summary, NPDES permits for commercial net pens in Washington will require plan submittals and reporting in accordance with permit conditions so to operate and discharge without violating water quality standards. Generally plan submittals and reporting include:

- Fish Escape Prevention, Reporting, and Response Plan
- Pollution Prevention Plan
- Operations and Maintenance Manual
- Net Pen Structural Integrity Assessment Report
- Operational log
- Fish escape reporting within 24 hours and follow-up response reporting
- Annual Fish Escape Report
- Sea lice monitoring and reporting of irregularities
- Fish mortality monitoring and reporting of irregularities
- Monthly disease control chemical use report
- Monthly fish biomass, numbers of fish, feed, and feed conversion ratio reporting
- Underwater videography and photographic survey
- Annual summary of disease control chemical use, monthly biomass and feed fed, fish escapement, and noncompliance notifications.
- Water column dissolved oxygen profile and daily monitoring during critical period (August 15 through September 30)
- Sediment monitoring and analysis for compliance. If the results of sediment quality monitoring exceed the limits listed in the Sediment Management Standards, an enhanced sediment quality monitoring plan is implemented. Permits will also require closure monitoring to evaluate benthic recovery if pens are moved or removed.

New net pen operations or operations that exceed 50% of permitted production if in operation before 1995 will be required to conduct an environmental study to ensure compliance with applicable water quality standards (WAC 173-221a-100(5))

CLEAN WATER ACT - SECTION 401 WATER QUALITY CERTIFICATION

Passed by Congress in 1972, the federal Clean Water Act grants states the authority to approve, conditionally approve, or deny proposed projects, actions, and activities directly affecting waters of the United States. Under Section 401 of the Clean Water Act, federal agencies cannot issue a license or permit before a state makes a determination on a water quality certification request. The conditions the state sets can become conditions of a federal permit or license.

If a federal permit or license, such as a U.S. Army Corps of Engineers Section 404 or Section 10 permit, is being proposed so a project proponent can construct a new net pen or expand an existing net pen operation, a Section 401 Water Quality certification will likely be required. When Ecology issues a Section 401 water quality certification, it means that the agency has determined a project or action, as proposed and conditioned, will comply with state water quality standards and other requirements to protect state aquatic resources.

Another type of 401 certification Ecology issues may be required if the commercial net pen operation needs a federally issued NPDES permit from EPA for activities on tribal or federal land.

COASTAL ZONE MANAGEMENT (CZM) FEDERAL CONSISTENCY DECISION

Activities and development located within Washington's coastal zone that require federal licenses or permits (such as a U.S. Army Corps of Engineers Section 404 or Section 10 permit) also require an applicant to prepare a written consistency certification and send it to Ecology, which manages the state's Coastal Zone Management program. Ecology will issue a decision regarding the project's compliance with the state's approved enforceable policies, including the state Water Pollution Control Act, Clean Air Act, and Shoreline Management Act. Projects outside the coastal zone that have impacts on coastal uses or resources may also be reviewed for federal consistency.

Washington Department of Fish and Wildlife (WDFW) permits

MARINE FINFISH AQUACULTURE PERMIT (WAC 220-370-100)

Marine aquatic farmers must possess an aquaculture permit from WDFW for rearing or holding a species, stock or race of marine finfish, defined as finfish being raised in marine waters, in net pens, cages, or other rearing vessels. The permit application must be accompanied by an operations plan, escape prevention plan, and an escape reporting and recapture plan. The permit is valid for five years.

If the proposed fish rearing program poses significant genetic, ecological, or fish health risks to naturally occurring fish and wildlife, their habitat or other existing fish rearing programs, WDFW can either deny a permit application or approve the permit with attached mitigating provisions or conditions. These conditions would be designed to reduce the genetic, ecological, or fish health risks to naturally occurring fish and wildlife, their habitat, or other existing fish rearing programs. WAC 220-370-100 also prohibits the use of “transgenic fish (as defined by the actual transfer of genetic material from one species to another).”

LIVE FISH TRANSPORT AND IMPORTATION PERMITS (WAC 220-370-190)

Anyone wishing to transport gametes, embryos, or fish into or through Washington must obtain a Fish Transport Permit (FTP). The purpose of the FTP is to protect aquaculture products and native fish species from disease.

No FTP application will be approved unless the aquaculture products being transported are free of finfish regulated pathogens (see WAC 220-370 definitions). In addition, conditions can be place on the permit:

- To protect aquaculture products and native finfish from disease when there is a reasonable risk of disease transmission associated with the finfish aquaculture products;
- To ensure the structural integrity of the net pen facility; and
- To prevent the captive finfish from escaping.

AQUATIC FARM REGISTRATION

State code requires that an aquatic farm be registered with WDFW to produce cultured aquatic products. State code also requires that registrations must be renewed annually and that reporting of aquaculture activities during the previous year constitutes renewal for the following year. Registered aquatic farms are also required to report quarterly on the species cultured, quantity harvested for sale, and unit value.

Washington Department of Natural Resources (DNR) authorizations

AQUATIC USE AUTHORIZATION (AQUATIC LANDS LEASE)

By law, any project taking place on or over state-owned aquatic lands requires an Aquatic Use Authorization from DNR. (RCW 79.105) This includes most marine net pen projects because of the type of location they require.

An Aquatic Use Authorization is not a regulatory permit**.** It is a lease, a legal contract which outlines the terms and conditions of the use and conveys certain property rights to the user in exchange for rent. These leases specify location, structural development, operational practices, lease terms, environmental monitoring, rent, and other requirements including compliance with all other applicable laws and regulations. They also require insurance and financial security (e.g., bonds).[6] DNR leases include provisions intended to ensure environmental protection. For net pens, provisions include requiring the lessee to maintain the net pens in good order and repair. Leases for net pen uses have ranged from 10 to 15 years.

[6] WAC 332-30-122(5): Insurance bonds, and other security. http://apps.leg.wa.gov/WAC/default.aspx?cite=332-30-122

An Aquatic Lands Use Authorization may be obtained through a streamlined application process called the "Joint Aquatic Resources Permit Application (JARPA) and Attachment E." (See Section 2.3 Permitting process)

By law, DNR cannot approve a lease before all necessary permits are approved. (WAC 332 30 - 122. Lessees must obtain all other local, state, and federal permits before DNR will grant the lease. To avoid delays in receiving an authorization, project proponents should contact DNR's Aquatic Resources Program early in the design process, before applying for permits, in order to:

- Ensure the land is available.
- Determine if the proposed use is appropriate.
- Reduce impacts to aquatic resources.

DNR reviews the proposal for consistency with state laws and rules, for potential impacts to aquatic lands and associated natural resources, and for risks to public health and safety. DNR coordinates with other agencies during the application review process. DNR may develop lease conditions for construction and operations to minimize impacts, but by law, DNR may not allow nonnative marine finfish aquaculture as an authorized use of any new or renewed lease.[7]

When deciding whether to issue a lease of state-owned aquatics lands, DNR considers the following on a case-by-case, site-by-site basis:

- Whether the proposed use is consistent with DNR-administered laws and rules
- Whether it is an appropriate use of state-owned aquatic lands in that location,
- Whether the proposed footprint is available for the proposed use,
- Any potential environmental, habitat, or public health and safety risks, and whether there are measures available to mitigate such risks, and
- The rights of the public under the Public Trust Doctrine or federal navigation servitude; and Treaty rights of Indian Tribes.

[7] HB 2957 - Reducing escape of nonnative finfish from marine finfish aquaculture facilities. http://lawfilesext.leg.wa.gov/biennium/2017-18/Pdf/Bills/Session%20Laws/House/2957.sl.pdf. Accessed 7 October 2020

Permits and authorizations typically required for net pen projects, by issuing authority

Not all permits shown apply to all projects nor is it presented in order of application or receipt. Additional permits or statutory requirements not listed may apply.

Table 2: Permits and authorizations typically required for net pen projects by issuing authority

Issuing Authority	Permit or Authorization
Local – County/City	Substantial Development Permit
Local – County/City, Ecology	Conditional Use Permit
Local – County/City, Ecology	Variance
State agencies and local governments	SEPA determination
Ecology	National Pollution Discharge Elimination System (NPDES) Permit
Ecology	Washington Coastal Zone Management Federal Consistency Determination
Ecology	Section 401 Water Quality Certification
WDFW	Aquatic Farm Registration
WDFW	Marine Finfish Aquaculture permit
WDFW	Finfish Import/Transfer Permits
DNR	Aquatic Use Authorization (aquatic lands lease)
US Army Corps of Engineers	Section 404 permit
US Army Corps of Engineers	Section 10 permit
US Coast Guard	Private aids to navigation permit (PATON)
US Environmental Protection Agency (EPA)	National Pollution Discharge Elimination System (NPDES) Permit *(on tribal or federal land)*

Order of operation to obtain authorizations

When applying for authorizations (approvals, permits, licenses, and leases), it is important to initially engage all the right agencies to get critical information before getting too far into any single permit process. This approach allows for making adjustments.

Net pen project proponents in Washington have the option to complete one application that can be submitted separately to several regulatory authorities by using the Joint Aquatic Resource Permit Application (JARPA).[8] However, submitting a JARPA is only a starting point and does not include all authorizations necessary to construct and operate a new or expanding net pen aquaculture facility.

It is recommended that project applicants consult individually with each regulating and licensing authority—even those under JARPA—to understand how to apply for all the necessary permits and licenses, and then work with those agencies to provide additional information as needed and reach agreement on requirements.

It can help to approach the required permits as being on parallel tracks, rather than being sequential. The following is a suggested approach:

1. Start by working through the JARPA form, and directly contacting the appropriate associated agencies (city or county, DNR Aquatics, Shorelands & Environmental Assistance program at Ecology, Habitat Program at WDFW, USACE, USCG) to work out permitting needs for the physical structure and location. The form can be found at this link: https://www.epermitting.wa.gov/site/alias__resourcecenter/jarpa_jarpa_form/9984/jarpa_form.aspx.

2. Simultaneously, contact the Fish Program at WDFW to begin the application process for a Marine Aquaculture Permit, register as a farm, and to scope the potential permit requirements for fish health and the species of interest.

3. And, again at the same time, contact the Water Quality Program at Ecology to initiate and learn what is necessary for the NPDES permit application process.

Typically, the city or county where the proposed project is located completes their review first, with the USACE's review overlapping in time. The state and local agencies are required to conduct an environmental review under the State Environmental Policy Act (SEPA). The SEPA review starts when the applicant completes and submits an Environmental Checklist with the required permit application.

[8] State of Washington, Governor's Office for Regulatory Innovation and Assistance. ePermitting – home of the JARPA. http://www.epermitting.wa.gov/site/alias__resourcecenter/9978/default.aspx Accessed 7 October 2020

Permitting resources

In addition to the individual agencies involved, the state Office of Regulatory Information and Assistance (ORIA) can be a valuable resource for proponents and authorities.

ORIA consultants help citizens, industry, and businesses navigate the regulatory processes in Washington. Its consultants work in collaboration with agency partners, and can help identify which environmental permits and approvals may be applicable to a project. Its online resources (ORIA.wa.gov) include a regulatory handbook, JARPA form and instructions, and basic information on SEPA and permits, including schematics to illustrate permit processes.

Interagency Coordination

Because multiple agencies are involved with regulating net pen projects, coordination between them is important.

The state departments of Natural Resources, Ecology, and Fish and Wildlife meet regularly to discuss ways to improve interagency coordination with respect to inspections and enforcement, and where applicable, permitting. By working together closely, the three agencies are working in coordination to manage net pen aquaculture in Washington.

This section looks at coordination in permitting, inspections and enforcement, and incident response, and also includes recommendations for continued coordination.

Permitting

Interagency coordination during permitting helps ensure that a net pen facility, though a generally allowed use, is only allowed where appropriate, protections are in place, and is consistent with other authorities. Coordination also helps to ensure operations are consistent with policy goals and adjacent uses.

As new information or facts emerge, agencies share that information and seek to integrate the information into lease contracts, best management practices, and permits, as allowed within existing contract and regulatory limitations.

During permitting, partner agencies share new permit applications and modification requests early in the process. Plan submittals, reviews, and approvals are coordinated between the partners for the respective authority and timeline.

Inspection and enforcement

When possible, DNR, Ecology, and WDFW work together on reviews, inspections and enforcement to reduce the risk of another net pen failure in Puget Sound. The agencies conduct joint inspections on all site facilities (where the subject matter correlates with the agency's expertise and jurisdiction) and undertake post-compliance follow-up. For example, DNR contracted a marine engineering assessment that conducted engineering inspections of all net pens from November 2017 through January 2018. All three agencies worked with the net pen operator to ensure that problems identified during inspections were corrected. This included conducting follow-up inspections by DNR of any identified concerns.

Future required net pen structural engineering assessments will continue to be reviewed jointly. If necessary, the agencies may consult outside experts to further review the findings and recommendations on current structures and maintenance plans to ensure farm's short-term capacity to continue to rear fish safely.

Incident response

In the event of an escape or other incident, Ecology, WDFW and DNR communicate directly with each other so each agency's authority and expertise is applied at the right time and place.

One tool is a detailed and extensive list of key contacts that operators must use in the event of an escape or net pen incident. Timely communication to all three agencies as soon as an unusual event is recognized allows the agencies to immediately coordinate a response, including forming the lead response agency or an Incident Response team on site, should the situation rise to that level of concern.

Recommendations for continued interagency coordination and joint efforts

1. Continue ongoing collaboration between agencies for renewed authorizations and review of mutual permit reports or plans.
2. Conduct Joint Incident Command System training for inspection staff from each agency.
3. Continue joint inspection of net pens for lease and permit requirements. Where appropriate, inspections include review of the operator's regular, internal maintenance and inspection documentation to ensure stability and net hygiene.

Environmental Considerations: Risks and Best Practices

This chapter describes various aspects of the natural environment, risks, and best practices for marine net pen aquaculture.

Many of the known risks associated with the aquaculture industry are addressed through regulatory requirements. However, following best practices further reduce risk to the environment. Each section provides a more detailed look at the overall subject, followed by a list of best practices, generally categorized when appropriate as follows:

- **Site selection** – The process of siting new marine net pen facilities must consider a range of criteria, including but not limited to: local water quality, tidal currents, benthic composition, aesthetics, proximity to sensitive and critical habitats, and proximity to navigation and shipping lanes.
- **Structure design and construction –** Appropriate design, materials and structural integrity are important for minimizing a variety of environmental impacts. How external forces affect net pen structures needs to be considered, as well as what maintenance the structures will require.
- **Operations and maintenance** – Routine net pen management practices can affect a wide range of resources. It's important to ensure they are not undermining protections that permits, site selection, and design have put in place. Paying attention, monitoring conditions, inspecting key elements, and responding to problems in an appropriate and timely manner can prevent a variety of negative impacts.
- **Governance –** Agencies execute laws and regulations as defined by RCWs and WACs. In some cases, there is discretion for how those laws and rules are applied. Some of these best management practices may already be in use but we draw attention to them here because they can help further reduce the impact to the environment.

Certain sections below provide best management practices that are even more specific than these categories. Some best practices provide multiple benefits and may be included in more than one section. See Appendix B – Fish Health Glossary for a list of useful definitions.

Siting

Deliberate, well-informed site selection for new marine finfish net pen facilities is critical for reducing the various impacts to natural resources that may occur. Negative effects on water quality, sensitive fish and wildlife habitats, and aesthetics can be significantly reduced or avoided by careful site analysis and selection.

Finding sites that are suitable for new net pen aquaculture is primarily the responsibility of the project proponent and their proposed location will face significant scrutiny by permitting and leasing authorities to ensure that the chosen site and nature of the their operations will minimize any potential negative impacts.

The process of siting new marine net pen facilities must consider a range of criteria, including but not limited to: local water quality, tidal currents, benthic composition, aesthetics, proximity to sensitive and critical habitats, and proximity to navigation and shipping lanes. Many of these criteria have already been described in detail. Below are additional parameters and processes that have not yet been described.

Shoreline Master Programs

As described in the Legal Framework section, the Shoreline Master Program was developed to comprehensively manage development and use of state waters and shorelines. Each county and municipality that has jurisdiction over state waters is required to develop a Shoreline Master Plan (SMP). Local governments are given the authority to develop their plans in a manner that addresses the unique characteristics of their shorelines and natural resources.

The Shoreline Management Act (SMA) provides a broad policy framework for fostering reasonable and appropriate water-oriented uses, promoting public access, and protecting the natural resources and ecology of Washington's shorelines. State SMP Guidelines establish the standard of "no net loss" of shoreline ecological functions as the means of implementing that framework through Shoreline Master Programs.

In order to locate and install a new commercial net pen, the project proponent must consult the local SMP and under most circumstances will need to obtain a Substantial Development Permit (SDP) and a Conditional Use Permit (CUP). Each SMP describes regulations and policies that apply to all shoreline development, and more that apply specifically to aquaculture.

If an operator applies for permit(s) for a commercial finfish net pen through the local SMP, they will be required to provide a range of information about the proposed activity, including a characterization of the habitat and resources that are beneath and adjacent to the chosen site.

Appendix A: Guidance on Local Shoreline Permitting describes the process that local governments use to assess SMP related permits and summarizes the relevant best practices offered in this guidance document that can help inform decision making.

Aquatic Use Authorization

In most cases, a marine net pen operation will be required to obtain an Aquatic Use Authorization in the form of a lease. When DNR decides whether or not to issue a lease of state-owned aquatics lands, DNR considers the following on a case-by-case, site-by-site basis:

1. Whether the proposed use is consistent with DNR laws and rules
2. Whether it is an appropriate use of state-owned aquatic lands in that location
3. Whether the proposed footprint is available for the proposed use

4. Any potential environmental, habitat, or public health and safety risks, and whether there are measures available to mitigate such risks

5. The rights of the public under the Public Trust Doctrine or federal navigation servitude; and Treaty rights of Indian Tribes

Sensitive Marine Habitats

Net pens may impact the area around them, including plant and animal species. Many of the potential impacts stem from the sheer concentration of fish in one location, overwater structures, and that items heavier than water tend to sink to the bottom. Particulates become sediment; larger items become debris. Chemistry and currents then define the type and level of impact. How close a net pen is located to sensitive marine habitats may pose a risk to those habitats and the organisms that use it. Also, the presence of fish in the pen may attract predators and the net pen structure may become a hazard to them. Compliance with regulations and permit conditions, coupled with good siting, construction, and operations and maintenance practices can greatly reduce the risk of negative impacts.

Sensitive marine habitat refers to specific aquatic areas that are important to marine vegetation, invertebrates, fish, birds, and mammals. These habitats provide resources that support various species for their entire lifetime, while supporting other species during critical life stages.

In Washington, a number of marine habitats hold particular ecological, economic, and social value. Accordingly, these habitats have garnered significant attention and resources to ensure their long-term health and function. Sensitive marine habitats include eelgrass beds, kelp beds (floating and understory), forage fish spawning areas, shellfish harvest areas, pocket estuaries, and certain habitats used by federally-listed salmon and steelhead (Christiaen et al. 2017, Pfister et al. 2018, PSP 2018, WMRAC 2017).

Many state laws explicitly call out these habitats for protection or mitigation, while others provide indirect mechanisms for their protection. The Shoreline Management Act (SMA) requires counties, towns, and cities with shorelines to develop and implement Shoreline Master Programs (SMPs) that protect the important ecological function of critical saltwater habitat.

The SMP Guidelines (WAC 173-26-221(2)(c)(iii)) and the local SMP critical areas protections standards establish critical saltwater habitats as kelp beds, eelgrass beds, spawning and holding areas for forage fish, such as herring, smelt and sand lance; subsistence, commercial and recreational shellfish beds; mudflats, intertidal habitats with vascular plants, and areas with which priority species have a primary association. These protections are usually found within the SMP dock, pier, bulkhead, bridges, fill, float, jetty, utility, or in-water structure standards. They may also be located in the critical areas fish and wildlife habitat protection standards.

Similarly, the Growth Management Act (GMA) requires state and local governments to identify and protect critical areas and natural resource lands.

Various aspects of net pen aquaculture may potentially threaten the presence and sustainable ecological function of sensitive marine habitats in state waters. The information below is meant to assist in minimizing negative impacts by careful site selection for any new net pen facilities.

Priority habitats to avoid

The Puget Sound and Strait of Juan de Fuca are home to numerous sensitive marine habits. Several of the most important and legally protected marine habitats and the potential risks posed by net pen presence and operation are described below.

Kelp

Significant losses of the native floating kelp (Nereocystis luetkeana) have been documented throughout Puget Sound (Pfister et al. 2018, Berry et al. 2019). Kelps are often relied upon as indicators of ecosystem health because they are highly responsive to environmental conditions and human activities (Bell et al. 2015). Over the last several decades a decline in kelp populations have been detected globally (Krumhansl et al. 2016). The reasons for the loss of floating kelp in Puget Sound are not fully understood.

Studies have shown light intensity and water temperature are the factors primarily responsible for the observed patterns of growth and productivity in the subtidal kelp, when adequate water flow and holdfast substrate is present (Bearham et al. 2013, Lee and Brinkhuis 1988, Tait 2019). Minimum required photosynthetic active radiation (PAR) values vary, not only by species, but also by species life stage. If adequate light does reach the sediment bed for the microscopic gametophyte phase to transition to juvenile sporophytes, they are then in competition for light with fucoids and other macroalgae that require less PAR for survival (Tait et al. 2019). In the absence of adequate light, kelp beds will likely be replaced by low lying dense mats of “turf algae” (Filbee-Dexter and Wernberg 2018). Turf algae are small, fast-growing, opportunistic species with high cover and turnover rates that can be highly stress tolerant compared with larger fleshy macroalgae (Airoldi 1998). They trap and accumulate fine sediments, thus modifying the chemical environment by reducing oxygen and concentrating contaminants. The shifts from kelp forests to these low-structure, mat-like turfs are considered a degradation of habitat with associated losses of biodiversity, food, and productivity (Connell et al. 2014).

Particulate discharge fine enough to remain suspended in the water column reduces water clarity, obstructing light available for all life stages of prostate, stipitate and floating kelp (Schiel and Foster 2015). Studies of kelp in Norway have shown that elevated water turbidity has also been associated with an increase in epiphytes on kelp fronds. Just as with eelgrass, heavy epiphyte loads can deprive the host plant of light (Sogn Andersen 2011).

Larger particles discharged from net pen farms may settle and accumulate on the sediment floor (Ballester-Moltó et al. 2017; Holmer et al. 2007, Sanz-Lázaro et al. 2011). If turf algae have begun to grow, then the deposited particles can become trapped, thus creating a nutrient rich layer on the sediment surface that can smother microscopic kelp spores and prevent reproduction and germination (Springer et al. 2010). Increased bacterial decomposition can also lead to decreases in oxygen concentrations and increases in ammonia and sulfides. A shift in bacterial communities has been observed where marine sediments are exposed to long-term nutrient loading (Bisset et al. 2007). Large white mats of sulfide oxidizing bacteria (Beggiatoa spp.) are often observed beneath net pens, and are considered visual indicators of the benthic impact of aquaculture (Hawkins et al. 2019). At net pen sites in Newfoundland, Canada, these bacterial mats have been shown to displace native kelp species (Hamoutene 2014).

Eelgrass Beds

The most predominant seagrass in Washington is *Zostera marina,* a flowering perennial (but may also grow as an annual) nearshore aquatic plant. In addition to the ecosystem services it provides, eelgrass helps create shelter and spawning grounds for many native species, including Pacific herring (Haegele and Schweigert 1985), Dungeness crab (McMillan et. al 1995, Williamson 2006), juvenile and migrating salmonids (Fresh 2006), and the harpacticoid copepods salmon feed on (Fujiwara and Highsmith 1997, Haas et al. 2002). Acknowledging its functional importance, the Puget Sound Partnership has identified eelgrass as a "Vital Sign" of ecosystem health and set a 2020 recovery target (http://www.psp.wa.gov/). Additionally, eelgrass receives both federal and state protections.

Factors with negative influence on eelgrass in Puget Sound include increased shoreline development and periodic physical disturbances, as well as degradation in water quality (Thom and Hallum 1990, Thom 1995, Thom et al. 2011, Thom et al. 2014). Losses in Puget Sound have especially occurred in small embayments and heads of bays (Christiaen et al. 2017), showing a dynamic distribution even while the overall amount appears stable over the past 40 years (Shelton et al. 2017).

Forage fish spawning areas

Pacific herring (*Clupea pallasi*), surf smelt (*Hypomesus pretiosus*), and Pacific sand lance (*Ammodytes hexapterus*) are small, schooling fish that live and spawn in the nearshore and beaches of Washington's marine waters. They are primary prey species for many larger fish, including salmonids, birds, macroinvertebrates, and wildlife (Pentilla 2007). Because of their important role in the marine food web they are collectively referred to as "forage fish." Ecosystem sustainability depends on resilient forage fish populations.

In the past, Washington has supported robust forage fish populations. However, in the last several decades forage fish populations have experienced major population collapses (Chavez et al. 2003), which have spurred studies to investigate potential stressors and inform development of management plans (Essington et al. 2015). These population collapses have tangible economic and cultural impacts. An estimated annual revenue of over $20 billion is generated from the fishing, tourism and recreation industries of California, Oregon, and Washington, industries which rely on robust forage fish populations (Enticknap et al. 2011). In addition, all three forage fish species are culturally significant to Washington Indian tribes.

Forage fish have a diverse life history and use a variety of habitats throughout. It is not well understood what, if any impact net pen aquaculture has on forage fish. Potential impacts of net pen aquaculture on forage fish habitat is not well understood, but will likely differ by location, species, season, and the facility's configuration and operation. To date, little research has examined if there are impacts from net pen aquaculture on forage fish habitat. The proximity of forage fish migration and spawning areas should be considered when siting net pens.

Bird and Mammal Habitats

Loose lines and nets may pose an entanglement risk to marine wildlife. Marine mammals may be attracted to the net pen structure by the caged fish, other aggregating fish near the pen, or food waste. Entanglement may pose a threat to birds. If net pen mesh size is sufficiently large, diving birds may become entangled and drown in underwater nets used to contain the fish. Birds may become entangled in above water predator exclusion nets, resulting in potential harm to the birds. Net type and mesh size can play a significant role in reducing entanglement risk (Hawkins et al. 2019).

The potential for net pen aquaculture to exclude marine mammals or birds from critical habitats depends on the size and concentration of farm sites, farm operations, and the behavior of the particular marine mammal or bird species. Net pen structures that occupy a portion of the water column may present navigation obstacles that may deter some species from navigating, although some animals may be attracted to the sites (Hawkins et al. 2019). When siting net pens, the proximity to bird nesting and foraging areas, marine mammal haul outs, migration corridors, and foraging areas should be considered.

Pocket estuaries

Estuaries are areas where one or more sources of freshwater meet the marine environment. Pocket estuaries are protected estuaries and lagoons within which there is too little wave action to form beaches. The protected nature of these estuaries can be formed by natural geologic features or by sediment formations such as barrier beaches or spits.

Waste and nutrients discharged into pocket estuaries will have similar, but likely enhanced impacts. Pocket estuaries are naturally protected from strong currents and waves. The small opening between the pocket and the open water reduces the rate of water entering and exiting the area. This reduces flushing, thereby increasing the length of retention time in the pocket estuary for the waste discharged from the pens.

The ambient hydrodynamics at a site are changed when floating or submerged structures such as fish net pens are introduced to the water (Gansel et al. 2008). Water flow velocity passing through net pens is slowed by drag forces (Klebert, 2013). Depending on the cage design, materials and placement of the net pen array (Xu et al. 2012) within or near the entrance of a pocket estuary may slow the exchange of water into and out of the greater estuary. This reduced flushing can rapidly lead to eutrophication. In such a state, the capacity of a pocket estuary to support salmonid foraging or provide refuge is greatly diminished.

Best practices to protect sensitive habitats

New Site selection

- The project proponent should submit the following information when applying for Shoreline Master Plan and Aquatic Use Authorization permits:

- A characterization and analysis of the marine environment adjacent to the proposed site, including but not limited to:
  - Water quality
  - Benthic quality
  - Adjacent and nearby sensitive and critical saltwater habitats
  - Aquatic vegetation
  - Existing facilities and land uses adjacent to site

- Require comprehensive site assessments that characterize localized physical, chemical and biological conditions, when new facilities are proposed.

- Net pens should be sited appropriate distances away from sensitive and critical saltwater habitat. Measures to avoid impacts should be applied based on specific site conditions.

- Minimum depths may be required when net pens and mooring systems are proposed in close proximity to aquatic vegetation.

Structure design and construction

- Net pens and mooring systems should never be located over native aquatic vegetation. Mooring systems should be sited appropriate distances away vegetation to prevent physical damage.

Operations and maintenance

- In certain cases, periodic monitoring of habitats adjacent to net pens may be necessary to ensure appropriate protection throughout the life of the use.

Additional Siting Considerations

Anchoring systems

As seen in the 2017 Cypress Island net pen collapse, mooring systems can and do fail. If forces on the net pen exceed the holding capacity of the moorage system, anchors may drag along the sea floor. In the case of Cypress Island, the mooring system experienced both anchor dragging and breaking of attachment points between the moorings and the net pen (Clark et al.2018). While there were no documented losses to aquatic vegetation from this incident, potential impacts from anchor dragging or mooring system failure should be considered when siting a net pen.

Aesthetics and use conflicts

Aesthetics are highly subjective and pose no inherent risks to natural resources. Nonetheless, it is still a requirement that aquaculture activities do not "significantly impact the aesthetic qualities of the shoreline.[9]" The *Aquaculture Siting Study* (Ecology 1986) is a comprehensive assessment of visual impacts of Washington aquaculture practices. It found that, "At distances greater than 1,500-2,000 feet off shore, the visual presence of most facilities is reduced to a line near the horizon" if viewed from the shoreline. However, elevated structures and vantage points will have a clearer view of the facilities but they would not obscure the horizon.

Ecology recommends that local governments rely on flexible standards that incorporate the 1,500-2,000 foot distance to address visual impacts from net pens and other aquaculture overwater structures. Local governments may also consider requiring a visual impacts assessment for aquaculture proposals that include structures. The siting study contains an example of an assessment that could be required as part of a project application.

Lighting and Noise-Related Impacts

A variety of activities associated with net pen operations can produce noise that may disturb wildlife and local residents, including: watercraft traveling to and from the facility, power generators, feeding systems, and cleaning systems. Noise can travel great distances over water and net pen operators can minimize that noise by shrouding equipment. They must also comply with local noise ordinances, meaning that activities that produce noise must occur during the day, avoiding "quiet hours." Lighting can attract wildlife and can also be a nuisance to local residents. The Shorelines Hearings Board has affirmed that local light restrictions may be imposed and that noise restrictions should be consistent with residential noise standards.[10] However, since net pen facilities are located in navigable waters, some lighting must be used in order to make the structure visible to watercraft.

Navigation

Net pens that are located in a navigable waterway must not significantly conflict with navigation and other water dependent uses, and are required to receive approval from and meet the standards set by the U.S. Coast Guard (USCG). In water structures must avoid shipping lanes and follow rules that protect public safety. Fatal watercraft collisions with net pens have occurred in Washington State which further emphasizes the need for facilities to be properly marked and illuminated. A Private Aids to Navigation (PATON) permit[11] must be obtained from the USCG to ensure proper marking and public safety.

User conflicts

The quantity and intensity of other water dependent uses also needs to be considered when evaluating locations for net pen facilities. Areas with existing high intensity uses should be avoided to minimize conflict. Depending on the type of use(s), it may also be necessary to avoid

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[9] WAC 173-26-241(3)(b)(i)(C)

[10] Marnin v. Mason County, SHB No. 07-021; Taylor Shellfish Farms v. Pierce County, SHB No. 06-039

[11] ORIA. Private Aids to Navigations. https://apps.oria.wa.gov/permithandbook/permitdetail/98 Accessed 18 September 2020

locations with low intensity uses if those uses are of high importance or is a prioritized type of activity.

Tribal consultation

As described in the *Tribal authorities and requirements* section, through the SEPA process and each state permit action, there is an obligation to engage with the adjacent tribes and broader Puget Sound tribal community by the agencies. This should include a tribal notification of the potential project or permit action and an offering of government to government consultation. This is important especially when a tribe's resources and usual and accustomed areas may be impacted by the installation of a net pen.

Best practices to address other siting concerns

Site selection

- Consult local governments and their SMPs to ensure compliance with local requirements related to aesthetics, lighting, and noise.
- Consult with the U.S. Coast Guard during permitting process to avoid recognized shipping lanes and protect public safety.

Structure design and construction

- Consult with the U.S. Coast Guard during permitting process, and regularly thereafter, to ensure minimum marking and lighting requirements are met.
- Unless necessary, lighting should be minimized, with the exception of lights required by the U.S. Coast Guard for purposes of navigation and safety.
- Equipment that produces significant noise should shrouded appropriately to minimize disturbance to wildlife and local residents.

Governance

- Local and state agencies shall notify the appropriate tribal governments when a marine net pen operation is proposed.
- When appropriate, local governments should perform an analysis of use conflicts between floating aquaculture and other water dependent uses to inform siting decisions.

Water quality

Good water quality is important—for aquatic species as well as for the health and safety of the people that live, work, and play in or near state waters. The dynamic nature of water means that activity in one area can impact water quality in another. Tides and currents can carry pollutants, trash, and debris far from their source.

Puget Sound is characterized by fluctuating levels of nutrients, salinity, and temperature, primarily influenced by the Pacific Ocean and the Fraser River, and on a local scale, the adjacent watersheds. Primary production in marine systems is usually limited by the availability of nitrogen, and the same is true for Puget Sound. However, Puget Sound is also subject to localized areas of algal blooms and low dissolved oxygen, both which can be harmful. Dissolved oxygen can decrease either because of the fishes' own oxygen consumption (respiration), natural and enhanced biological processes (i.e., photosynthesis and decomposition), and local stratification and upwelling events.

Risk to water quality

The congregation of fish and the activities necessary to rear fish in net pens can potentially affect surrounding waters. Commercial finfish net pen aquaculture is considered a concentrated animal feeding activity and regulated as a pollution point source (40 CFR 122.24 and appendix C of 40 CFR part 122). The primary concern is the release of nutrients and organic matter that can enrich the surrounding waters, giving rise to increased algae production in the affected areas, and potentially leading to reduced dissolved oxygen from decomposition and respiration. The level of concern depends in part on the scale of the operations and flushing characteristics of the receiving waters.

Various operations and activities can produce or have a potential to create a discharge that could have a negative effect on water quality, aquatic life, and other beneficial uses. These discharges include:

1. Metabolic waste from the fish – could contribute various nitrogen and carbon species that may lead to biological oxygen demand
2. Feed – could contribute uneaten feed waste, which contains nitrogen, carbon, and phosphorus, fines (turbidity), persistent bioaccumulative toxics such as polychlorinated biphenyls and antibiotics.
3. Biofouling of nets –cleaning the nets of biofouling organisms can contribute to turbidity and the lack of cleaning can lead to occlusion creating a drag hazard.
4. Operational debris and trash – if not secured, could enter water and litter surrounding beaches and the sediment bottom.
5. Dead fish, blood and other fish waste – if discharged, could contribute to biological oxygen demand.
6. Disinfectants, cleaning products and other chemicals such as oil and fuel – if discharged or spilled has potential to affect aquatic life
7. Commercial fish (product) – if not contained in net, could interact with native fish.

Mitigating risk to water quality

In Puget Sound, siting for optimal water depth and tidal currents will be critical. After that, using best management practices in the operation of the farm further has the largest role in reducing and eliminating risk to water quality. These practices are provisions in net pen NPDES permits, the tool that regulates point source pollution in a manner to meet water quality standards and not impair the waterbody or impact the designated uses. Water quality impacts must be minimized or prevented for the surrounding beneficial uses stated in WAC 173-201A-210 (1-4).

Siting

Siting net pen facilities in deep areas with sufficient flushing, consideration of the cumulative effects of multiple farms, and farm size are among the best tools to limit impacts to water quality. Site specific conditions to consider include how restrictive is the bathymetry and the potential for stratification, because both can lead to a low energy location providing little mixing and flow. The effects are nutrient enrichment, which can lead to lower dissolved oxygen, increasing biological oxygen demand, and changing primary productivity in the near-field and sometimes in the far-field (Hawkins 2019).

Site-specific water quality and bathymetric/tidal current modelling is necessary for siting new net pens. Project proponents must work with local jurisdiction using their Shoreline Master Plan criteria and site-specific data to best locate suitable locations for a net pen facility.

Avoiding areas of Puget Sound with low dissolved oxygen is critical to prevent further impairment. Puget Sound and other state waterbodies are assessed on a regular basis for water quality, including dissolved oxygen. Ecology maintains this list, called the Clean Water Act 303(d) list and provides a mapping tool that can be used to identify areas in Puget Sound with dissolved oxygen impairments (https://ecology.wa.gov/Water-Shorelines/Water-quality/Water-improvement/Assessment-of-state-waters-303d). Future net pens should not be located in any area of Puget Sound considered impaired for dissolved oxygen. Site-specific analysis should include near and far-field assessment so no other dissolved oxygen impaired portion of Puget Sound is affected by the location of the net pen facility.

NPDES Permit Requirements

NPDES permit requirements include the mandated use of operational practices that limit or prevent the following pollutants from being discharged (see Appendix A for an example):

- Feed: A requirement of an NPDES permit is that feed must be free of fines or dust (<1 percent). Operators must also feed fish in a manner that minimizes the amount of uneaten fish food and maximizes ingestion. These actions include that the feed must be properly sized for the fish and have high digestibility. These practices reduce the risk of creating excessive turbidity and also prevents excessive feed and fecal matter from reaching the sea floor for the protection of sediment quality. Additionally, feed ingredients must be from low PCBs sources as practically as possible.

- Biofouling of nets: There is a collection of practices performed regularly on the fish containment nets that are considered necessary net hygiene to prevent excessive biofouling. These practices could impact to water quality such as reduced dissolved oxygen for fish health within the net pens and lead to excessive biofouling debris collecting below the pens. These same practices are also important to maintain structural integrity and preventing fish release. Cleaning must be done during strong current action so the biofouling material can readily mix with the water to reduce the turbidity and the ability to settle. Net hygiene is described in detail in the Biofouling section.
- Operational debris and trash: Operational debris and trash must be disposed in an approved off-site landfill or recycled. No debris or trash shall enter the water from a net pen facility. Operators must recover floating debris that enters the water as soon as it is safe to do so.
- Dead fish, blood, and other fish waste: Dead fish should be collected three times per week. Fish must be disposed of in approved land-based facilities. Between disposal events, dead fish must be stored in leak proof containers. Dead fish are not to be disposed of in the water. Harvest blood, leachate, or entrails are prohibited from entering the water during harvest and taken off-site to an approved disposal facility.
- Other chemicals: All chemicals, such as oils, gas, detergents, disinfectants, and anesthetic, used at the net pen facility, must be properly stored and disposed of. None of these chemicals nor any toxic pollutant in a toxic amount is allowed to be discharged. All quantities on the net pen facility must be minimized or stored off-site. Net pen operators must follow a pollution prevention plan that has prescribed actions to limit and reduce the risk of discharge of these chemicals.
- Release of fish: The fish raised within the net pens are a commercial product that are approved to be reared by WDFW through Marine Aquaculture and Transfer permits. The fish must be contained and prevented from being released at all times for purposes of protecting water quality. Best practices must be employed to prevent releases during transfers, harvesting, and other events such as net damage. The chapter on Fish Escapes describes all the practices necessary to contain the fish for the protection of native fish species and disease transmission. Most of these practices are considered necessary to protect water quality and are conditions of the NPDES permits. These practices include regular monitoring of nets for damage, maintaining good net hygiene, regular topside inspections and maintenance, and biennial structural integrity assessment to ensure the facility is in good working order. Permit conditions require an operator to create and follow plans for the prevention of a release, the response for a release, and the reporting of a release for both NPDES permits and WDFW aquaculture permits.

Further Risk Reduction Recommendations

Use of newest technology to prevent and limit discharge of pollutants

Wastewater discharge standards and effluent limitations were established in 1995 for marine finfish rearing facilities (WAC 173-221A-110). Chapter 173-221A WAC sets the minimum discharge standards which represent "all known, available, and reasonable methods of prevention, control, and treatment" (AKART).

The WAC identifies the minimum standard and is implemented through the NPDES permit issued to net pen operators. However, a requirement in new or reissued net pen NPDES permits may direct permittees to conduct a new AKART analysis to identify and implement improved preventative, source control, and treatment technologies. AKART is interpreted as technology-based approaches to limiting pollutants from a discharge and the analysis requires an engineering and economic judgement. The purpose requiring a new AKART analysis is to continue to move industries toward implementing the most up-to-date technology that is economically feasible to reduce pollutant discharge.

Since 1995 when the minimum standards were set, floating fish net pens, fish containment and feeding technology have all improved to reduce costs but also to reduce the industry's environmental footprint. The aquaculture industry is using floating closed containment for more marine based aquaculture around the world and in some, smaller scale cases using land-based recirculating aquaculture systems. Feeding technology has improved to reduce feed wastage. Containment technology has improved so that structures are more robust to better withstand the elements and reduce the risk of fish escape.

An AKART analysis can be required of proponents seeking a new NPDES permit or existing permittees upon reissuance. The analysis must determine the prevention, source controls and treatment technology the permittee will choose to implement and this new AKART standard can be incorporated into the NPDES permit.

Outside of the permitting process, an independent study of aquaculture techniques to reduce pollutant discharge and their economic feasibility can be conducted. Any independent AKART analysis must identify new and improved minimum technology to reduce or eliminate feed wastage and improve fish containment so to reduce or eliminate metabolic waste discharge and fish escape.

Calculate specific loading rate

While current net pen operations meet water quality standards, a better understanding of the nutrient loading a net pen operation contributes may be necessary. It should be a requirement of the water quality modeling for siting new net pens and periodically at permit reissuance for existing net pens to calculate the nitrogen load produced. The amount of nitrogen released is directly related to farm biomass, the nitrogen content of fish feed, the fish's food conversion ratio (FCR), and the fish's nitrogen assimilation efficiency (Hawkins et al. 2019)

Best practices to protect water quality

Site Selection

- Conduct site-specific water quality and bathymetric/tidal current modelling. This is essential to appropriately site new net pens.
- Locate net pens only in areas not considered impaired for dissolved oxygen. Site-specific analysis should include near and far-field assessment so no other dissolved-oxygen-impaired portion of Puget Sound is affected by the location of the net pen facility.
- Locate farms and individual pens for adequate water flow to ensure dissolved oxygen is available to the fish and nutrients are mixed and assimilated.
- At a minimum, locate farms in waters at least twice as deep as the pens, or allow for at least 15 meters between the pen bottom and substrate (Cardia and Lovatelli 2015).
- If a site shallower than the depths listed above is desired, use a model to demonstrate that local conditions will be favorable for water exchange.
- Avoid areas known to be nutrient sensitive and that may develop algal blooms.
- Avoid areas where currents will bring waste into shallow or enclosed areas.
- Avoid areas where fish kills have occurred.
- For fish health, avoid areas that have regular dissolved oxygen levels below 6 mg/L (Burt et al. 2012).
- Avoid areas that are known to have turbidity levels above the standard levels explained in WAC 173-201A-210.

Structure Design and Construction

- Ensure the position of predator nets does not prevent tidal exchange or water flow that normally encourages dissolution of fish waste products.

Operations and Maintenance

Feeds and feeding

- Use dry pellet feed.
- Use cameras or divers to actively monitor feedings to control the rate at which food is disseminated and consumed.
- Consider the current speed and direction when feeding so pellets are not flushed out of the pens before they can be consumed.
- Do not feed when conditions decrease fish appetite, such as during low DO, temperature extremes, algal blooms, or transfer and handling.

Net hygiene

- Conduct net hygiene in way that minimizes turbidity, such as frequent, regular in-situ cleaning during a tidal exchange to reduce the turbidity in the immediate vicinity and prevent settling of solids on the seafloor.

Marine debris management

- Secure all trash and gear to prevent entry into water. Mark gear that could conceivably be blown or washed away so it can be identified and recovered for either proper disposal or storage. Retrieve trash and gear as quickly as is reasonable.

Other activities

- For fish health, use supplemental aeration or supplemental oxygen to increase DO in the net pens if naturally occurring levels are below 80 percent or at a threshold that the operator deems critical.
- Use aeration, as necessary, during harmful algal blooms to prevent algae from entering the pens and potentially cause fish mortality.

Benthic environment

The benthic environment is the land under the water (the sea bed) and the water at the lowest levels. It's also where many things that go into the water end up, and what goes into the water matters. Particulates that settle to the bottom become sediment. The quality of the sediment affects the plants and animals that make up the benthic community (the benthos).

The physical and chemical characteristics of sediment vary considerably throughout Puget Sound. Natural variation in sediment characteristics further leads to variable benthic communities. Weakland et al. (2018) reported that benthic community structure throughout most of the region was related to the water depth and sediment grain size. There are areas of Puget Sound where conditions are naturally less favorable for a diverse benthic community (such as areas of depositional sediment having hypoxic conditions), but in several areas of the Sound, human activities have had a negative effect on diversity.

Risk to the benthic environment

Deposition of organic matter leading to degradation of the benthic environment is a well-documented risk associated with net pen aquaculture (Nash 2003 and Hawkins et al. 2019). *The State of Science on Net-Pen Aquaculture in Puget Sound, Washington* (Hawkins et al. 2019) summarized the benthic impacts from organic enrichment resulting from the accumulation of uneaten food, fecal pellets, and biofouling drop off (organic debris from organisms growing on the net pens).

Organic enrichment alters the benthic environment by changing sediment chemistry, physical properties, and the biological community. Microbes such as bacteria, feeding on organic particulates (such as fish fecal matter and the biofouling organisms from net cleaning), transforms the nitrogen, carbon, and phosphorous it contains into an inorganic form that can be utilized by organisms living within the sediment. As organisms thrive and die there, it can lead to an increased level of sediment total organic carbon (TOC) that is then used as an indicator parameter to manage and limit the discharge from net pens.

Deposition and accumulation of nitrogen, carbon, and phosphorus in benthic sediments below marine net pens is widely studied and highly variable. How and where particulate organic matter accumulates is directly related to farm size, concentration of farms, depth, topography, and current pattern/strength.

Mitigating risk to the benthic environment

In Washington, local jurisdictions play an important role in applying the siting criteria of potential net pens to reduce and mitigate benthic impact. In addition, DNR leasing and NPDES permitting requires project proponents to conduct baseline studies, implement numerous best management practices, monitor for benthic impact, and limit thresholds further reducing the risk. Net pen facilities sited on state-owned aquatic lands may have additional stewardship measures and lease requirements as part of their use authorizations to maintain long-term sustainable use of the aquatic land.

Water depth, currents, and management practices minimizing feed loss and release of biofouling debris reduce negative impacts to the surrounding benthic environment but do not eliminate the risk. Regular monitoring of the surrounding sea floor demonstrates whether siting and operations are adequate. Additionally, state sediment standards (Chapter 173-204 WAC) identify what level of impact to TOC from baseline or referential conditions is allowable and when mitigation is necessary.

Siting

Selecting a site with certain characteristics helps limit the amount of organic matter that builds up on the seabed from net pen operations. Siting of net pen facilities in deep areas with sufficient flushing and consideration of the cumulative effects of multiple farms and farm size are among the best tools for minimizing long-term harmful impacts to the surrounding sea floor. (Hawkins et al. 2019). Another important component is siting net pens over erosional substrates which helps prevent the accumulation of organic compounds (Price and Morris 2013).

In Washington, project proponents work with local jurisdictions using their Shoreline Master Plan criteria and site-specific data to best site a net pen facility. Proponents of new net pen projects must also perform a sediment quality study and a bathymetric/current assessment to understand baseline conditions and determine where particulate matter may be deposited.

Feed and feeding best practices

NPDES permits include requirements that limit, reduce, or eliminate the release of excess feed and its impacts on the sea floor:

- Feed fish in a controlled, managed manner that maximizes ingestion. This minimizes the amount of uneaten food exiting the net pen once fish are satiated. NPDES permits require feeds be properly sized for fish size so nothing is too large for the fish to eat. Feed must be free of excessive fines (<1 percent) and have high digestibility. Operators must regularly (monthly) monitor the number of fish, size, growth and feed conversion to ensure optimal feeding.
- Monitoring zinc levels. Zinc is a common micronutrient in fish food; it also can be toxic to benthic organisms. Historically, elevated zinc levels were found in the sediment below net pens. However, newer fish feed formulations have made zinc more bioavailable, thus reducing zinc from concentrating below (Hawkins et al. 2019 and Nash 2001). Still, zinc cannot exceed the cleanup screening value (see Appendix A). To manage the risk of zinc toxicity to the benthos, zinc is monitored on a regular basis as a requirement of the NPDES permit.
- Monitoring sediment bacteria for resistance to antibiotics. Antibiotics are milled with fish feed after being prescribed by a state licensed veterinarian. Medicated feed use is reported monthly to the permit authorities, WDFW and Ecology. Use rates are monitored. If rates of use increase and there is concern the benthos may be at risk of concentrating uneaten medicated feed, monitoring may be required under the NPDES permit authority.

Net hygiene

Net hygiene practices that prevent excessive biofouling (marine organisms growing on net pen structures) also help reduce the impact to the benthic environment. Controlling biofouling limits the amount of organic matter available to become sediment. These same practices are also important to protect water quality and maintain structural integrity to prevent fish escape. The practices necessary to protect the benthos are required through NPDES permits.

Cleaning activities include the physical disruption of the initial biofouling organisms while the nets are in the water during high flow events to reduce turbidity. No detergent or any anti-fouling agents can be used on nets when in the water. While biofouling is managed in-situ, the second line of defense is net replacement and cleaning fouled nets at an uplands facility after either grow out is complete or net swapping during mid grow out if in-situ net hygiene cannot keep up with growth.

Cleaning prevents excessive accumulation of marine growth on both the stock and predator exclusion nets. Net pen operators must integrate regular physical in-situ cleaning with net material, net mesh size, net swaps, and uplands cleaning to combat biofouling. Since stock nets have smaller mesh, cleaning must occur more frequently than that of the predator exclusion nets. Net hygiene methods must be described in the operations and escape prevention plans. Net pen operators must adhere to a schedule for in-situ cleaning that considers and adapts to seasonal growth rate, changes in species makeup of the biofouling community, mesh size, tidal currents, and cleaning equipment effectiveness. Operators must monitor net hygiene using numeric, verifiable scores and adjust net hygiene activities (cleaning, net swaps) if certain thresholds are exceeded. During the fallow period, stock nets must be removed, cleaned, and inspected in an upland facility.

Operators also must monitor regularly the sediment around the net pen to assess that the benthos is not being adversely affected by the biofouling debris that does concentrate under the net pens. In addition, if a biocide such as copper is used in the construction of the mesh, regular sediment monitoring must be conducted to assess that copper is not exceeding the sediment criterion, indicating an impact to the benthic community. The biocide tributyltin is prohibited from use in net mesh.

Fallowing

Fallowing to reduce risk of disease transmission also reduces impact to the benthic environment. Aquaculture permits include a condition that requires a net pen facility to remain fallow for at least six weeks (42 days) between harvest and restocking to end disease transmission. This also allows the benthos time to assimilate the nutrients from excess feed, fish waste, and biofouling debris that has concentrated under the pens before more is deposited. NPDES permits adopt this six week minimum for fallowing. Currently, all existing net pen operations comply with the sediment standards indicating fallowing duration is sufficient.

If the benthos is found to not recover sufficiently, fallowing periods may need to align with relevant biological processes including benthic species recruitment seasonality and the resilience of the local benthic system. Thus, a fallowing period starting before or early in the reproductive period may be more effective than one that starts in summer. If biological recovery is a concern, site rotation where the farm is left to fallow for at least one year is more prudent than a period of a few months (Zhulay et al. 2015).

Further Risk Reduction Recommendations

Use of newest technology to prevent and limit discharge of pollutants

Described in detail in the Water Quality chapter, one risk reduction recommendation is for project proponents to report or for the state to mandate a study to identify the new minimum standard treatment technology to further reduce feed wastage. This reduction of wastage has direct benefit to the benthos. If feed can no longer accumulate or even enter the water body, nutrient enrichment and mineralization will be reduced or eliminated, preventing benthic impacts. Therefore, it is recommended that the same economic and engineering analysis to determine new, economically feasible aquaculture feeding technology and containment systems to protect water quality be assessed additionally for the benefit of protecting the benthic environment.

Additional indicator parameters to track sediment impact

Washington State Sediment Management Standards or SMS (WAC 173-204-412) applied through the NPDES permits for net pens include monitoring and applying thresholds for TOC and benthic abundance to limit the impact from the facility’s discharge. Since 1996 when the

SMS were adopted, Ecology's long-term sediment monitoring from the Environmental Assessment Program (EAP) has developed a suite of benthic community indicators that includes abundance, species richness, evenness, dominance, and the presence or absence of disturbance of sensitive and tolerant species to determine whether the benthos population is considered healthy or impacted. (M. Dutch-EAP Feb. 2019 personal communication). Additionally, other biogeochemical factors such as total nitrogen, total carbon, and total sulfides are important to consider as indicators of enrichment.

TOC criterion

Current sediment standards and sediment impact zone compliance relies on total organic carbon (TOC) as the initial indicator of impact from net pen operations. The sediment TOC values must be below maximum levels based on categories of percent clay and silt (i.e., fines). The categories established in 1996 were based on data that had very few samples to establish the lowest percent fines category (J. Rensel-Technical Memo April 2019). Data accumulated by Ecology's Environmental Assessment Program from non-impacted locations has increased to provide further accuracy for categorical and referential assessment. Assessing and updating the referential and categorical TOC criteria in addition to using species richness along with biochemical indicators will better identify impact of net pens at present for compliance but also overall ecological effects over time.

Measure change within sediment impact zone

The NPDES permit prescribes sediment compliance monitoring in accordance with the Sediment Management Standards for source controls (WAC 173-204-412). This monitoring occurs only at the outside edge of the sediment impact zone, which means there is no sediment monitoring that occurs regularly immediately near or under the pens throughout a grow-out operation.

New net pen project proponents must conduct a baseline assessment of the benthic environment when applying for a DNR state aquatic land lease. To fill the data gap of what occurs to the benthos during an operation after a net pen operation is installed, regular benthic monitoring similar to the benthic assessment for the lease requirements should be conducted to track and document changes to seafloor beneath.

Best practices to protect the benthic environment

Site Selection

- Locate farms and individual net pens to optimize water circulation (Belle and Nash 2008).
- Locate farms in waters at least twice as deep as the pens, or allow for at least 15 meters between the pen bottom and substrate (Cardia and Lovatelli 2015).
- If a shallower site is under consideration, demonstrate that specific environmental conditions (current) or management practices (feed levels or biomass) will prevent adverse effects to the benthos.

- Locate pens where larger sediment particle sizes may allow for faster mineralization of deposited material (Martinez-Garcia et al. 2015).
- Locate net pen operation far enough away from aquatic vegetation to avoid impact from underwater structures such as the anchors.

Structure Design and Construction

- Ensure stock and predator nets are not positioned to prevent tidal exchange and water flow that would lead to solids deposition.

Operations and Maintenance

Feeding

- Use cameras placed inside stock nets to actively monitor fish feeding to control the rate at which food is disseminated and consumed.

Net cleaning

- When cleaning in-situ, clean when current conditions will encourage dispersal of fouling organisms preventing accumulation.
- Clean regularly to reduce the size of the biofouling debris preventing accumulation below on sediment bottom.
- Use non-toxic methods and materials to prevent fouling growth.

Fallowing

- Fallow net pen farms for at least six weeks for benthos recovery and assimilation. Adjust duration if necessary.

Governance

- Future DNR leases should include as requirements the voluntary net hygiene protocols that DNR and Cooke Aquaculture Pacific jointly developed in 2018. This includes weekly scoring of biofouling and periodic video confirmation of randomly-selected nets submitted to DNR. This operational focus by DNR will complement existing WDFW and NPDES requirements that address design, siting, construction, inspection, and maintenance of net pen arrays.

Biofouling

Biofouling is the accumulation of marine organisms growing on underwater surfaces. In net pen aquaculture, management of biofouling typically focuses on controlling growth on nets. Biofouling is a concern for net pen aquaculture because it impedes water flow through the nets, diminishing dissolved oxygen levels inside the pen and negatively affecting the fish. Biofouling also increases drag on net pens, which can cause stress on the infrastructure, resulting in deformed cages and, in extreme cases, net pen failure. In addition, biofouling can impact the benthic sediments underneath the net pens through the organic buildup of dislodged organisms when the nets are cleaned.

Net hygiene is the practice of controlling biofouling on net pens. Proper net hygiene will prevent excessive biofouling, thereby reducing the risk to the net pen structural integrity and fish escape. Such practices are required through permit requirements and lease agreements with several state agencies.

Condtions in Puget Sound tend to support swift colonization by marine organisms. Puget Sound supports a rich diversity of marine life, partially due to the multiple estuaries it contains as well as its proximity to the Pacific Ocean. In addition, because of its northern latitude, Puget Sound experiences ample sunshine during the summer months, with nearly 16 hours of daylight at the summer solstice.

Mitigating risk of biofouling

Biofouling on net pens must be aggressively managed, especially during the summer months when marine growth is at its highest. There are two primary methods of management: net replacement and in-situ cleaning. Net replacement involves swapping out biofouled nets for fresh ones at periodic intervals, typically between grow-out cycles. The biofouled nets are then typically cleaned on uplands off-site. In-situ cleaning involves using a variety of mechanical means to dislodge organisms from the nets while they are in the water (Hawkins 2019).

There are different costs and risks associated with each management method. Net replacement is the most effective, but it can be costly. In addition, there may be an increased risk of escape when the nets are being swapped (Hawkins 2019). In-situ cleaning is more cost effective, but it must be done regularly during high growth periods and relies on specialized equipment. Recent experience has shown that the equipment is labor intensive to maintain and may not provide sufficiently reliable service to stay ahead of growth (Hawkins 2019, Clark et al. 2018). Once marine organisms, especially mussels, are established they can be very difficult to remove, making subsequent in-situ cleanings less effective; therefore, it is imperative cleanings are performed regularly, with increased frequency during high growth periods. (Clark et al. 2018).

In short, net replacement and in-situ cleaning are complementary techniques for net hygiene that are best if used together. High growth rates of biota in summer make net swaps impractical. Conversely, in-situ net cleaning controls but does not eliminate biofouling. Periodic net swaps are required to “re-set” biofouling to zero and prevent pathogen transmission between crops.

Because biofouling can increase drag on net pens, tidal currents and wind patterns are relevant when considering net pen siting. Puget Sound is subject to two low and two high tides per tidal day, with differences between the lowest and highest tides ranging from 8-14 feet. Maximum tidal currents can occur in the range of 9-10 knots, depending on the location. Puget Sound can also experience strong windstorms, including mid-latitude cyclones that can achieve hurricaneforce winds. Terrain and geography strongly influence wind speeds during storm events, and specific conditions can be localized and difficult to predict.

Both tides and wind can impact net pens, particularly if excessive biofouling increases drag on the structures. Current-induced forces on a fouled net may be 12.5 times that of a clean net (Milne 1970). Horizontal drag forces can be increased up to three times by common fouling by hydroids and mussels (Swift et al. 2006). Highly deformed nets increase structural stresses on the cage at specific points, with a two- to six-fold increase in horizontal forces in the cage corners (Tomi et al. 1979). In the case of the 2017 Cypress Island net pen collapse, investigations revealed that excessive biofouling was likely the primary cause of the failure (Clark et al. 2018).

Best practices to prevent biofouling

- Regularly perform cleaning to prevent larger, more difficult-to-remove organisms from populating.
- Frequency of cleaning should increase during high growth, warmer months.
- Use the largest mesh size possible, to extend the time it takes for fouling to occlude the net.
- Use net replacement when necessary. If net replacement is planned in advance partway through the growth cycle as means of controlling biofouling, switch to larger mesh size for the replacement net (consistent with the larger size of the fish).
- Consider site specific tides and wind conditions when developing a cleaning schedule.

Marine debris

Marine debris includes any persistent, manufactured, or processed solid material that makes its way into the marine environment (UNEP 2009, Hawkins et al. 2019). Marine debris poses a risk to human health and safety as well as to the environment (NOAA 2008, Hawkins 2019). Debris may pose a hazard to navigation or recreation on the water, may contain toxic chemicals, petroleum products, or other harmful substances, and may harm, entangle, or be ingested by fish, seabirds, or marine mammals.

While net pens are generally not significant contributors of marine debris, certain amount of marine debris may be associated with normal net pen aquaculture operations. This can include supplies and equipment that are lost or swept away during storms or high waves, debris that breaks off from the main infrastructure, and general waste (Hawkins 2019). In the case of a catastrophic net pen failure, such as what occurred at Cypress Island in August 2017, the net pen may contribute thousands of items of marine debris from the array itself, including nets, ropes, metal, plastics, cables, and machinery.

On Aug. 19, 2017 a 10-cage net pen owned by Cooke Aquaculture Pacific, LLC, began collapsing. The failure of the structure produced tons of marine debris comprised of thousands of pieces. Following the net pen collapse, Cooke was instructed to remove all debris associated with the structure. Cooke conducted this work in September 2017; however, an inspection in October by DNR revealed a substantial amount of debris remaining (Hawkins 2019). Cooke then initiated a second cleanup by contracting the work to a salvage company. This resulted in the removal of 468 additional pieces of debris (Hawkins et al. 2019). After the cleanup effort was complete, 16 acres of seabed had been surveyed and cleared of debris.

Challenges associated with cleanup include the sheer number of debris items, hazards due to the large or extremely heavy fragments of the net pen array, the depth of the water, the need to retrieve sunken debris using divers, and the movement of debris items due to wind and currents. While the vast majority of debris was from the catastrophic failure, some of the debris was in place prior to the failure, either as a result of relatively recent daily operations at the net pen facility or from historical activities in previous decades (Hawkins et al. 2019).

Best Practices to prevent marine debris

- Farms should mark gear that could conceivably be blown or washed away so it can be identified, measured, monitored, and recovered.
- DNR leases should have greater emphasis on structural net biofouling management, requiring the net hygiene protocols that DNR and Cooke Aquaculture Pacific jointly developed in 2018. This includes weekly scoring of biofouling and periodic video confirmation of randomly-selected nets submitted to DNR. This operational focus by DNR will complement existing WDFW and NPDES requirements that address design, siting, construction, inspection, and maintenance of net pen arrays.
- DNR leases should indicate requirements for fish farms to thoroughly inspect and clean the ocean bottom at the time the net pen array is replaced or removed, or at the time of lease renewal.
- Increase the financial security requirements as part of the lease agreement with DNR, which could help ensure that debris cleanup is achieved even if a company goes out of business.
- Encourage aquaculture companies to be partners in the Washington Marine Debris Action Plan to share information, coordinate efforts, and implement actions to prevent, reduce, or mitigate impacts of marine debris.

Fish health

Disease in an organism is a function of the interaction between the environment (e.g., stress resulting from too high or low temperatures, high densities, lack of food, pollution, decrease dissolved oxygen, culture practices), the infectious (e.g., pathogen) or non-infectious (e.g., toxin) agent, and the organism itself (e.g., genetics, immune system) (Reno 1998). In aquaculture there is an attempt to manage all three components to control pathogens and parasites and to prevent disease (McVicar 1997).

Commonly expressed concerns associated with open net pen finfish aquaculture is that marine aquaculture:

- Promotes the introduction of non-native pathogens
- Amplifies rate of infection and therefore amplifies pathogen abundance
- Promotes the increase in virulence of existing pathogens or is the nexus for the emergence of new pathogens
- Promotes disease in wild finfish.

The first line of defense for disease management in marine aquaculture begins with the source material – the origin and health of the brood stock, of the embryos, and of juvenile fish reared in freshwater hatcheries that eventually get planted in the marine net pens. By preventing the introduction of pathogens at the onset, especially the introduction of non-native pathogens, into the cultured environment, the health status of the populations may be maintained. Hawkins et al. (2019) summarized the state of the science for marine aquaculture fish health and disease management. From a global perspective, these authors described measures taken by the aquaculture industry to prevent disease in and maintain the health of reared finfish.

This section considers the marine aquaculture risks, processes, and management actions that help protect the health of wild free-ranging finfish populations in Washington.

Risks

Net-pen aquaculture can present a variety of disease risks to wild populations (McVicar 1997, Kurath and Winton 2011). Left unmitigated, these risks may have negative effects on these populations. Aquatic farms are monocultures where fish may be handled extensively and are crowded into unnaturally high densities in environments that are not optimal for the fish. These conditions may lead to immune suppression, placing finfish at risk of infection and disease (Murray and Peeler 2005, Kurath and Winton 2011). Fish are subjected to a new environment that contributes to stress when they are moved from the freshwater hatchery environment to the marine net pens. These fish also are exposed to “wild” pathogens. The monoculture, high densities, suppressed immune systems, and the presence of wild pathogens to which these fish are naïve are conditions that can promote the amplification and transmission of these pathogens among the cultured fish (Kurath and Winton 2011). These conditions can lead to disease outbreaks, placing the farm fish population at risk.

In the following two sections, we discuss the pathogen (including sea lice) and disease transmission risks that are often perceived to be associated with Puget Sound finfish net pen aquaculture. However, these risks are greatly mitigated by natural processes, and further reduced through best practices and regulations described below.

Pathogen and Disease Transmission

Kurath and Winton (2011:73) demonstrated that “viruses move from wild fish reservoirs to infect domestic fish in aquaculture more readily than ‘domestic’ viruses move across the interface to infect wild stocks.” They also showed 15 examples of pathogens moving from wild populations to domestic populations, and only five examples for the reverse transmission. Taranger et al. (2015:1008) state "[f]or most pathogens, clear evidence for transmission from farmed to wild fish is limited . . . . [and that] [m]ost of the diseases that currently cause problems in fish farms are likely enzootic, originating from wild fish stocks." Overall, although there may be a few documented cases of bacterial or viral transmission from fish culture to wild populations, only a small subset of those involve marine finfish (Kurath and Winton 2011), and there is limited evidence that these transmissions result in disease in the wild populations, even if the transmission is associated with disease outbreaks in the net pens (Wallace et al. 2017).

The stresses within a net pen environment are more severe than those experienced in the wild environment, thus affecting pathogen transmission and the incidence of infection and disease. This helps explain why the amplification of native pathogens by farmed fish does not appear to put wild populations at increased risk of disease. Wild salmonid populations, for example, would be exposed to pathogens from net pens as they migrate from fresh- to marine-water as juveniles and when they return to freshwater as adults. These populations are not subjected to the same stresses present in the crowded net pen environment because they travel in densities considerably lower than what occur in net pens (Kennedy et al. 2016). The pathogens themselves do not stay concentrated in halos around net pens, as water movement diffuses the pathogens (Brooks 2005, Brooks and Stucchi 2006), and solar radiation and microbial activity may further reduce pathogen numbers (Garver et al. 2013). Disease is intermittent within the net pen environment, and net pens are not a continual source of pathogens. There is evidence that pathogens can remain in sufficient concentrations to cause infection as they are dispersed from their source net pen, but the evidence is based only on farm to farm transmission, not farm to wild transmission, and that transmission is limited by distance and time (e.g., Gustafson et al. 2007, Salama and Murray 2011, Murray 2013, Salama and Murray 2013). Compared with farmed fish, wild fish are not immune compromised, and they travel through environments that are not favorable for the transmission of pathogens. Except perhaps in freshwater spawning aggregations, and in freshwater hatcheries, wild fish are exposed to pathogen densities that are lower than that within net pen facilities, even in the wild environments in the vicinity of farms that are experiencing a disease outbreak.

Sea Lice

Although sea lice infestations associated with fish farms are problematic in some regions, this is not the case in Puget Sound. However, since there are public concerns in Washington that are based on sea lice issues in British Columbia, we provide the following discussion.

Sea lice are ectoparasitic marine copepod crustaceans that are associated with infestations and economic loss in salmonid aquaculture (reviewed in Boxaspen 2006). The copepods undergo a life cycle that starts with a nauplius larva, a planktonic stage that ultimately molt into a planktonic and infectious copepodids. The distribution, abundance, and viability of sea lice is affected by sea temperature and salinity. Bricknell et al. (2006) showed that the survival and parasitic ability of planktonic *Lepeophtheirus salmonis*, a sea louse common in both the North Atlantic and North Pacific oceans, is severely compromised at salinities less than 29 parts per thousand (ppt). Similarly, Crosbie et al. (2019) showed that *L. salmonis* nauplii from Norway completely avoided salinities less than 30 ppt, while copepodids tolerated salinities as low as 16-20 ppt.

In the eastern North Pacific Ocean there are two predominate species of sea lice that affect salmonids, *L. salmonis* and *Caligus clemensi*. At a commercial Atlantic salmon farm near the Broughton Archipelago, British Columbia, the seasonal abundance of plankton larvae for both species of sea lice varied directly with water salinity, and consistent with the North Atlantic Ocean studies, larval abundance dropped when salinities fell below 30 ppt (Byrne et al. 2018).

Farm and wild fish populations in British Columbia have experienced infestations (e.g., Marty et al. 2010, Krkosek et al. 2011), although the link between farm and wild fish infestation is not clear, nor is the link well understood between number of sea lice at farms and wild fish productivity (Morton et al. 2004, Brooks 2005, Beamish et al. 2006, Brooks and Stucchi 2006, Krkosek et al. 2006, Morton et al. 2008, Marty et al. 2010, Krkosek et al. 2011).

Sea lice may be a problem for the salmonid net pen industry in the North Atlantic Ocean and in British Columbia, and sea lice infestations at net pen facilities in these regions may have a negative effect on wild salmonid population. In Puget Sound, although sea lice do occur in net pen facilities and they are monitored, their numbers do not reach a level of concern. Water circulation is complex within Puget Sound, affected by a variety of factors, including the Strait of Juan de Fuca, river discharge, and bathymetry. Nevertheless, on average, through an entire year, surface water salinities with Puget Sound remain at or below 30 ppt (Khangaonkar et al. 2011, Sutherland et al. 2011), which results in high mortality for sea lice pelagic larvae and minimizes the likelihood of significant sea lice infestations.

Existing risk mitigation

Risk mitigation is a three-pronged approach:

- Prevention—regulations and operations that reduce the risk of infection and disease occurring.
- Monitoring—regularly checking for signs of infection or disease.
- Response—acting to prevent the spread of infection or disease once it has been found

Any disease outbreak is detrimental to the aquaculture industry. Diseased individuals require treatment and treatment is expensive. Some fish will die, further eroding profit margins. For these reasons, the aquaculture industry is motivated to reduce the incidence of disease. For example, in Norway, risk of salmon alphavirus (SAV) and infectious salmon anemia virus (ISAV) transmission was mitigated by coordinating the stocking, harvesting, and net pen fallowing among neighboring farms. Vaccination and early pathogen detection programs were implemented, as were veterinary prescribed treatments (Jones et al. 2015).

Overall, stocking strategies such as single-aged cohort stocking limit the number of times fish are handled thereby reducing some stress that may promote infection and disease. Net-pens are fallowed, and nets are cleaned following harvest eliminating potential sources of pathogens and breaking pathogen transmission chains. At the onset of certain diseases, fish are treated with antibiotics. These mitigating operations reduce the risk of infection and disease within marine aquatic farms.

WDFW implements its regulatory authority for marine aquaculture to prevent the introduction of specific pathogens by requiring that fish, gametes, and embryos be tested at their source and preventing their transport if they test positive for these specific pathogens. Farm operators implement best management practices while the fish are cultured in marine waters to reduce stress thereby reducing risk of infection, and disease amplification and transmission. This includes the use of vaccinations to prepare the individual organisms' immune system to combat pathogens, and to reduce the risks of infection, pathogen amplification and transmission, and disease.

Prevention: Importation of non-native pathogens

There are both federal (50 CFR 16) and state regulations (see below) that govern the importation of salmonid gametes, embryos, and live fish into Washington to manage the risk of importing non-native pathogens. Federal rules apply only to international importation, while state rules apply to all gametes, embryos, and live fish that are transported into or through Washington, regardless of their origin. Both federal and state rules require that the live fish or the brood stock that produced the gametes or embryos be free of "regulated finfish pathogens" (see WAC 220-370 definitions section).

In addition, since early 2018, WDFW requires that the live fish or the brood stock that produced the gametes or embryos be tested for both piscine orthoreovirus-1 (PRV-1) and PRV-3. Currently, transport permits will be denied if the fish or brood stock test positive for North Atlantic Ocean variants of PRV-1, any variant of PRV-3, or any of the regulated viruses listed above. Lastly, WDFW requires a second round of tests after hatching when the fry's yolk sack is absorbed, roughly 30 days post swim-up after hatching. If at this time the lot of fish tested positive for regulated pathogens, North Atlantic PRV-1, or any variant of PRV-3, WDFW would require either destruction of the lot or deny any transport permit application to move live fish out of the freshwater hatchery.

Prevention and Monitoring: Biosecurity

We define biosecurity as precautions taken to minimize the risk of introducing, establishing, and spreading an infectious disease in an aquatic animal population. This includes, but is not limited to, disinfecting equipment, using foot baths, limiting personnel movement, fish health monitoring, and general cleaning practices. Biosecurity also includes management activities that are designed to reduce or eliminate stress to the cultured fish. Stress can negatively affect the immune system, which can increase the fish's vulnerability to disease.

"To promote good health in farm stocks, it is in the self-interest of fish farmers to maintain good environmental conditions in their farms and in the surrounding areas" (McVicar 1997:1095). To accomplish this, and as required by WDFW, each year the aquatic farmer provides an updated "Regulated Finfish Pathogen Reporting Plan" that is reviewed and requires approval by WDFW. Within this plan is a biosecurity section that includes descriptions of specific management activities that are designed to reduce the risk of disease occurrence and to help prevent transmission of pathogens. The biosecurity activities start at the spawning facility where embryos are disinfected prior to shipping. Fish are tested for regulated pathogens twice, first at 30 days post swim-up after hatching, as discussed above for importation of non-native pathogens, and again prior to transport to marine net pens. Biosecurity measures continue while the fish are reared in the net pens, and there are routine fish health exams administered by the aquatic farmer. WDFW inspects each facility at least once per year. During these inspections, fish will be sampled for the presence of regulated pathogens.

Prevention: Vaccinations

The purpose of a vaccine is to provide immunological protection against a specific pathogen to prevent the onset of disease. Vaccines work by providing an initial or primary immunization – a response to an antigen (i.e., the vaccine) that results ultimately in the production of antibodies (Newman 1993). Vaccines prime the immune response through the creation of B-cell lymphocytes (plasma cells) that produce the antibodies that are specific to the antigen presented by the vaccine. When an individual fish encounters the pathogen for which the vaccine was produced, the immune system is already primed to secrete antibodies specific to that pathogen. This can result in a range of responses from the amelioration of clinical signs to a rapid immunological response and the prevention of infection and disease. The efficacy of a vaccine varies depending on the type of vaccine, the immunological response, and the pathogen itself.

Not all vaccines are 100% efficacious, and when they are effective, that effectiveness may not last through the life of the individual fish. Vaccines have not been developed for all pathogens, and which vaccines are administered to farmed finfish in Washington is based on the experience and knowledge of the veterinarian of record (VOR) who is licensed in Washington and has established a veterinary-client-patient-relationship (VCPR) with the aquatic farmer and the fish. At a minimum WDFW anticipates that for the farming of salmonids in Puget Sound, the aquatic farmer will vaccinate for IHNV, *Vibrio anguillarum*, *V. ordali*, and *Aeromonas salmonicida*, providing protection from IHN disease, vibriosis, and furunculosis, respectively.

Prevention: Stocking strategies

Similar to the amplification of wild pathogens within aquatic farms discussed above, stocking densities and aquacultural practices can lead to the emergence of new diseases and the increase in virulence of existing pathogens (Murray and Peeler 2005, Mennerat et al. 2010, Pulkkinen et al. 2010, Walker and Winton 2010, Kennedy et al. 2016). Based on the evolution of virulence theory, Kennedy et al. (2016) outlined factors related to aquaculture operations that may lead to the increase in virulence of existing pathogens. These factors include rearing at high densities, compressing the rearing cycle, use of brood stock with limited host genetic diversity, and accepting endemic disease in cultured populations. These factors together can contribute to unbroken pathogen transmission chains, which can lead to increase in virulence or the emergence of new pathogens (e.g., Breyta et al. 2016). For example, high densities can occur in healthy wild populations spawning naturally. However, the high densities are not sustained and only exist during one part of the life cycle, thereby breaking pathogen transmission chains associated with high densities. In aquatic farms, transmission chains are maintained by immediately stocking after harvest the empty net pens with new smolts from freshwater hatcheries, resulting in continuous occupancy of the aquatic farm.

To reduce pathogen risk, WDFW requires that net pens be maintained as single generation operations, be fallowed for at least 42 days, and be cleaned following harvest. These processes maintain fish health and breaks pathogen transmission chains. In addition, prior to transport into net pens, as discussed above, each lot of fish is tested for regulated pathogens and PRV, and fish are vaccinated. While in the net pens, when necessary, fish are treated with antibiotics to remedy disease and reduce mortality, with a secondary benefit to prevent the transmission of endemic pathogen infections. These processes maintain fish health and break pathogen transmission chains.

Response: Antibiotics, medicated feed, and common pathogens

Antibiotics are administered to net pen fish usually through medicated feed, referred to as Veterinary Feed Directives (VFDs). These are prescriptions written by licensed veterinarians that have established a VCPR with the aquatic farmer and the fish. A veterinarian with a VCPR is formally recognized as the VOR for a facility. VFDs, VCPRs, VORs, veterinary licenses, and the drugs that can be used for treatment of specific pathogens are regulated by both federal and state rules. It is the VOR's obligation to adhere to these rules (i.e., violations of these rules can result in fines, loss of license and livelihood). The "client" (owner of the fish, or the aquatic farmer) has the freedom to refuse treatment, but only a licensed veterinarian with a VCPR can order a VFD. It is the licensed veterinarian's and the VOR's license that are at risk if VFDs or other chemicals used on the fish are applied improperly or illegally, even if it is without the knowledge of the veterinarian. It is also the veterinarian's responsibility to adhere to the U.S. Food and Drug Administration's (FDA) Judicious Use of Antimicrobials policy.

The most common pathogens (and their associated diseases) of the cultured Atlantic salmon in Puget Sound are: *Tenacibaculum maritimum* (yellowmouth); *A. salmonicida* (furunculosis); *V. anguillarum* (vibriosis); *Piscirickettsia salmonis* (salmon rickettsia syndrome, SRS); and *Moritella viscosa* (winter ulcer) (J. Parsons, pers. comm 2020). Farm fish are particularly vulnerable to *T. maritimum* when they first enter salt water and are frequently given antibiotics to treat for yellowmouth. In fact, yellowmouth is the most common disease for which antibiotics have been applied to Atlantic salmon in Puget Sound.

Experimental trials with culturing triploid steelhead trout in Puget Sound in 2012 showed that steelhead trout are more resistant to yellowmouth than are Atlantic salmon (J. Parson, pers. comm 2020). Each of these bacteria, except for *A. salmonicida* and *P. salmonis*, are obligate marine or brackish water pathogens, and the fish become infected by these "wild" pathogens only after they enter the marine environment.

Best Practices to Reduce Disease Risk[12]

[12] Actions not already included in WACs, permit provisions, or plans. These practices were developed in consultation between WDFW and United States Department of Agriculture (USDA) Animal and Plant Health Inspection Services (APHIS) Veterinary Services.

The following practices and guidance provide a minimal approach to optimize fish health and reduce disease risks. Specific permits or plans should include additional preventative, monitoring, and response requirements particular to the local conditions and situation.

Minimum Fish Health Monitoring

The minimum fish health monitoring requirements are intended to promote the health, productivity, and well-being of commercially-cultured and free-ranging fish. Monitoring and laboratory testing described in this section are conducted by the aquatic farmer at their expense.

Fish health monitoring requirements at marine aquaculture facilities

- The health of each lot at a farm site will be monitored on a regular basis (target monthly) by a certified fish health specialist.
- Monitoring will include visual observation of the fish in the net pens for abnormal behavior as well as necropsy examination of internal and external organ systems from live, moribund, and recently dead fish.
- A certified fish health specialist will promptly investigate any substantial changes in fish behavior or elevation in morbidity or mortality above baseline. What constitutes a substantial change will be in the clinical judgement of the certified fish health specialist.
- If a presumptive diagnosis is made by the certified fish health specialist of an infectious agent causing increased mortality and/or morbidity, identification and confirmatory testing will be performed by an authorized testing laboratory, or by other sources approved by WDFW on samples from one or more fish during each disease event.
- If an infectious agent is confirmed and implicated in fish loss that is above baseline mortality, chemical and nonchemical-based strategies, where appropriate, will be implemented to reduce the impact of the disease agents on both the wild and cultured fish populations. If therapeutic measures are needed to reduce morbidity and mortality, they will be administered in compliance with state and federal regulations.
- If a presumptive cause of an epizootic is not determined within 10 days of the certified fish health specialist's initial examination of the effected fish population, the certified fish health specialist and aquatic farmer will work with WDFW and fish health professionals selected by WDFW to develop an appropriate sampling and testing plan to identify the cause of the event and effective control, treatment, and containment measures if necessary.

Sea Lice Monitoring

- The number of sea lice will be counted and recorded on at least 50 live fish per Farm Site per month.

- If the number of sea lice is found to be greater than an arithmetic mean of five (5) adult lice per fish or is negatively impacting the health of the fish, steps will be taken to control and reduce those numbers of sea lice in the effected Site.
- Sea lice species to be monitored are *Caligus elongates* and *Lepeophtheirus salmonis*

Minimum Fish Health Inspection

The following minimum inspection requirements for fish health are intended to prevent the dissemination and spread of pathogens. Activities described in this section are conducted by WDFW, except where noted.

- Authorized WDFW employees shall have access to marine net pen facilities to conduct inspections, to collect samples for disease surveillance, and to inspect net pen infrastructure
- Sixty (60) fish from each lot at each farm site will be inspected annually for regulated pathogens. Results from at least two sampling time points separated by a minimum of three months will be added together to meet the 60 fish goal. Tissues collected will be appropriate for the fish size, life stage, testing method, and for the disease agent under investigation. Collection of moribund fish is the priority – healthy fish are collected only to achieve the appropriate sample size.
- Inspections shall be conducted at a time or times of the year conducive for the detection of pathogens with regard to the age and size of fish and environmental conditions. Fish must have been present at that farm site for at least 30 days prior to sampling.
- A visual exam of all net pens at the farm site shall be conducted during the inspection sampling to assess general health status of fish at that site. Underwater cameras may be used as a part of this examination but not constitute the entire visual exam.
- Tissue samples for inspection shall be collected by the inspector.
- It is the responsibility of the inspector to select the animals for tissue collection. Moribund and/or freshly dead fish will be included if present, and all samples will not be taken from the same raft if there is more than one raft per farm site to ensure the results are representative of the entire population at the farm site.
- The laboratory testing of samples will include both a screening method, generally culture, and a confirmation method, generally molecular or serological. Other methodologies may be used. Confirmatory tests will be conducted only on those samples that tested positive on the screening test.
- Laboratory testing must be conducted in an authorized testing laboratory or by other laboratories and methods pre-approved by WDFW.

Notifications for Pathogens and Disease Outbreaks or Epizootics

Notifications as described below apply to cases of both presumptive and confirmed infectious agents. Notification for regulated and reportable pathogens and their disease conditions will be made by the aquatic farmer to the agencies listed below, regardless of whether the pathogen was detected during monitoring or inspection activities and the method of communication will be such that receipt of the information by an agency representative is confirmed (answered or returned phone call, reply to text or email).

- A notification list containing agency name, name of representative, phone number(s), and email addresses will be posted at each farm site. At a minimum, this list will be reviewed and updated annually.
- Immediate notification to WDFW is required upon presumptive identification of an exotic pathogen, World Organization for Animal Health (OIE) pathogen, or a new pathogen causing significant biological loss to the aquatic farmer. Upon notification, WDFW will coordinate an emergency meeting with the state veterinarian, fish health representatives from relevant tribal and federal agencies to discuss further management actions to contain the pathogen.
- Immediate notification to WDFW is required in the event of a disease outbreak or epizootic as specified in WAC 220-370-180.
- Notification to WDFW is required within 24 hours of the initial detection of a regulated pathogen within a fish lot at a farm site.
- Notification to WDFW is required within five working days of the initial detection of a reportable pathogen within a fish lot at a farm site. Only the initial detection per calendar year is required.
- Monthly reports to WDFW and Ecology are required, listing the biomass, amount of feed, feed conversion rates, and amount and type of chemicals used to control disease at a farm site.
- Monthly reports to WDFW and Ecology are required, estimating (1) the number of live individuals at each farm site, and (2) the number of fish lost due to predation and disease.

Pathogens Monitored

Currently, these pathogen lists are focused on pathogens that readily affect salmonids. The lists will be updated by WDFW, as needed. Unless specified otherwise, listed pathogens would include all genetic variants of the pathogen. Other pathogens may be added to these lists, by action of the WDFW, based on recommendations of a Finfish Pathogen Advisory Committee (as of April 2021, this committee has not yet been established). The complete list of regulated finfish pathogens will soon be published on the WDFW website.

Regulated Pathogens

- Infectious hematopoietic necrosis virus (IHNV)
- Infectious pancreatic necrosis virus (IPNV)

- Infectious salmon anemia virus (ISAV)
- *Oncorhynchus masou* virus (OMV)
- Viral hemorrhagic septicemia virus (VHSV)

Reportable Pathogens

- All viral replicating agents other than those listed as regulated pathogens that are found on cell culture using procedures outlined in the AFS-USFWS specific procedures for aquatic animal health inspections or OIE Aquatic Code.
- Strains of pathogenic bacteria resistant to antimicrobial agents approved for use in fish or used through an extra-label prescription or INAD permit.
- *Piscirickettsia salmonis*
- *Nucleospora salmonis*

Fish Transfer

All live fish transfers into, within, and out of Washington are regulated by WACs 220-353-130 and 220-370-190). Live fish transfers from freshwater to saltwater sites, between saltwater Farm Sites, from saltwater to freshwater sites, and movement of pens containing fish for distances greater than one kilometer, will be managed to prevent the introduction and spread of regulated and reportable pathogens. All transfers will be required to meet the minimum requirements listed below, and will require a Transport Permit issued by the WDFW Director or designee. Fish health information is required prior to transfer.

- Inspection, conducted by an agency-approved certified fish health specialist, within eight weeks of the proposed transfer at the farm site of origin. Required samples to be collected at the 5% or 1% assumed pathogen prevalence level (APPL), dependent on prior incidence of pathogens, and as determined by WDFW.
- Summary of reportable pathogens detected in the lot proposed for transfer at the farm site of origin, or detected in other lots currently reared at the site.
- Summary of any epizootics and diagnostic cases experienced by the lot proposed for transfer and other lots currently reared at the site.
- A fish health monitoring report on the lot proposed for transfer performed by a certified fish health specialist no earlier than four weeks prior to proposed transfer. The report should include a description of the health status of the lot of fish being transferred.
- Risk assessment report if a reportable pathogen was detected in the lot proposed for transfer. This report will include:
    a) The likelihood that the proposed transfer will result in the introduction and establishment of the reportable pathogen to free-ranging or commercially-cultured fish in the new location.

b) The consequences to commercially-cultured and free-ranging fish populations in the new location if the pathogen did become established.

- Fish transfer will not be allowed without approval from WDFW if any of the following conditions exist:

  a) Fish lot tests positive for regulated or emerging pathogens while in saltwater.

  b) Fish lot is experiencing an epizootic at the time of the proposed transfer.

  c) Fish are to be moved by relocation or movement of the net pen structure.

- Fish transfer will not be allowed if the lot tests positive for an exotic pathogen or exotic pathogen genetic variant.
- Fish transfers will not be allowed unless the fish are being moved into net pens with current and valid leases, that are structurally sound, as determined by a third party marine engineering firm.
- No fish will be transferred into a farm site unless the required fallowing period has elapsed.

Biosecurity Plan

Biosecurity policies and procedures reduce the risk of introducing disease agents into an animal production facility from free-ranging fish and human activity. These measures are taken to protect the commercially-cultured and free-ranging fish from the spread of infectious organisms and the diseases caused by these organisms. Biosecurity procedures include methods used in the movement of personnel and materials during activities associated with routine animal rearing and harvesting practices plus additional activities necessary during a disease event response. An updated biosecurity plan for each aquatic farm is required each year, and submitted to WDFW for approval no later than November 30 of the calendar year. This plan will be finalized by January 31 of the following year and apply for the duration of that year.

Minimum Routine Biosecurity and Disease Prevention Measures

- A minimum fallowing period will be required at each farm site between routine harvest and restocking with a new lot of fish. The length of the fallowing period will be determined by WDFW and be stated in appropriate permits. The fallowing period does not start until containment nets are removed, and farm and dive equipment have been disinfected. The containment nets must be replaced or disinfected and repaired as part of the fallowing process.
- Foot baths will be used by farm personnel and visitors before entering the farm site and maintained as appropriate for the disinfectant used.
- No dead or moribund fish shall be released into state waters.

- Carcasses and moribund fish will be removed regularly (at least twice weekly, weather permitted) from each net pen and placed in leak proof containers.
- Dead fish will be removed from the farm site the day they are collected and disposed of by a WDFW-approved method that prevents dissemination of pathogens to other fish. These methods will include but not be limited to landfill, rendering, or composting using WDFW-approved facilities.
- Gear used to remove mortality, including hoses, nets, and dive gear, will be cleaned and disinfected regularly.

Site Specific Biosecurity Plan Requirements

- The aquatic farmer must submit a site-specific biosecurity plan to WDFW for approval. Fallowing period and equipment cleaning procedures will include the following:
  a) Description of the procedures that will be used between harvest and restocking to clean and disinfect farm equipment such as containment nets and pen structure
  b) Description of foot baths and their management
  c) Locations of foot baths on the Farm Site
  d) Disinfectant compound that will be used
  e) Maintenance procedures for the foot baths such as frequency for cleaning, changing and/or recharging of the solution
  f) Disposal methods of foot bath disinfection solutions after use.

- Carcass and moribund fish removal:
  a) Method that will be used for removal
  b) Frequency of removal
  c) Disposal method
- Gear cleaning and disinfection: This will include things such as dive gear, hoses, nets, buckets, totes, footwear, and raingear – and include:
  a) Frequency of cleaning
  b) Method of cleaning such as soaking, spraying, or scrubbing. Method of cleaning must be consistent with NPDES permits and must not violate water quality standards.
  c) Disinfectant compound used
  d) Target concentration of the disinfectant compound and contact time on the gear
  e) Location of log documenting gear cleaning and disinfection

Disease Containment

Disease containment measures reduce the risk of spreading pathogenic agents among pens, farm sites, and free-ranging fish if pathogens are present in the cultured population. An updated disease containment plan for each aquatic farm is required each year, and submitted to WDFW for approval no later than November 30 of the calendar year. This plan will be finalized by January 31 of the following year and apply for the duration of that year.

Minimum Disease Containment Measures for Routine Harvest

- Platforms and/or boat decks will be kept clean.
- Vessel holding areas and totes used for carcass transport will be water tight and will be cleaned and disinfected before leaving the shore based disposal or processing facility and returning to the farm site.
- No untreated biological fluids, solids, or wastewater from harvest activities will be discharged to state waters.

Minimum Disease Containment Measures during an Epizootic Event

- Carcass and moribund fish removal efforts will be increased as much as possible to reduce potential pathogen shedding from these individuals.
- Access to the farm site will be restricted to necessary personnel who are trained in disease containment procedures.
- Any therapeutic treatments will be administered in full compliance with state and federal legal requirements. These requirements may include, but are not limited to (a) the involvement of a licensed veterinarian with a valid veterinary-client-patient-relationship (VCPR) and veterinarian of record (VOR) agreement, (b) INAD Protocols, and (c) FDA withdrawal times for harvesting of the fish.
- If only a subset of the net pens is affected, routine fish care such as feeding and carcass removal will be performed on unaffected net pens first, and then care will be provided to the fish in the affected net pens.
- Additional foot baths will be installed as needed to reduce pathogen spread by people moving around the farm site. Placement will be determined by the certified fish health specialist and WDFW Inspectors as defined in this document.
- Containers used to transport mortality will be leak proof to prevent splashing and spilling of carcasses and contaminated fluids during transport.
- Totes will be disinfected prior to being returned to the facility or used again at the farm site.

- Trucks, trailers, boats, and all equipment used to collect and transport mortality will be cleaned and disinfected using appropriate methods and compounds.
- Depending on the pathogen involved, the farm site may be placed under quarantine or depopulated by order of the WDFW Director.

Minimum Disease Containment Measures for Depopulation or Harvest Due to a Disease Event Caused by a Pathogenic Agent

- Fish will be removed as quickly and humanely as possible.
- If only a subset of the net pens is affected at the same level, priority will be given to the highest mortality pens for harvesting first.
- Access to the farm site will be restricted to necessary personnel only and who are trained in disease containment procedures.
- Additional foot baths will be installed as necessary to reduce pathogen spread by people moving around the farm site. Placement will be determined by the certified fish health specialist and WDFW inspectors as defined in this document.
- Containers used to transport carcasses will be leak proof to prevent splashing and spilling of carcasses and fluids during transport.
- Totes will be disinfected prior to being returned to the facility or used again at the farm site.
- Trucks, trailers, boats, and all equipment used to collect and transport carcasses will be cleaned and disinfected using appropriate measures and compounds before returning to the farm site.
- No untreated biological fluids, solids, or wastewater from fish depopulation or harvest activities will be discharged into state waters.

Site-Specific Disease Containment Plan Requirements

- The aquatic farmer must submit a disease containment plan for each farm site to WDFW for approval. At a minimum, the procedures and descriptions in the plan will include the following:
    a) The geographic boundaries of the farm site, including a description of the rafts contained within the farm site.
    b) An emergency notification list will be developed and posted at each farm site. At a minimum, this list will be reviewed and updated annually.
    c) Procedures that will be used during harvesting and depopulation to keep platforms and boat decks clean.

d) Disinfection procedures, compounds, concentrations, and minimum contact times of chemicals used on equipment and gear during harvesting or depopulation of fish.

e) Treatment measures used on biological fluids, solids, and any wastewater produced during harvesting or depopulation of fish. If treatment is performed by aquatic farmer personnel, this will include compounds, concentrations, and minimum contact times to be used in the treatment.

f) Description of leak proof containers that will be used to transport carcasses.

g) Disinfection procedures, compounds, concentrations, and minimum contact times of chemicals applied on totes used to transport carcasses before being returned to the farm site.

Fish genetics and ecological issues

Genetic and ecological effects to native marine species from marine open net pen finfish aquaculture can result from the:

- Escape of the cultured fish
- Aquatic farm operations (rearing and harvesting of the fish contained in the net pens)
- Physical presence or siting of the net pen infrastructure

The published literature on the relative risks from open net pen aquaculture mostly emphasizes pathogen and parasite transmission (see Fish Health section) and the effects from escaped farmed fish. The discussions concerning escaped farmed fish have focused on the genetic effects to wild populations, rather than ecological interactions between escaped and wild fish. For example, Forseth et al. (2017) developed a two-dimensional classification system of different anthropogenic factors to assess their relative risk to wild Atlantic salmon populations in Norway. The authors used 15 factors ranging from habitat alteration and hydropower to overpopulation and climate change. Included among the 15 factors were three aquaculture-related factors: sea lice, infections related to fish farming, and escaped farmed fish. The description of the escaped farmed fish factor was limited to the genetic risk to wild populations (Forseth et al. 2017).

There have been several general reviews of the genetic and ecological risks associated with open net pen aquaculture (e.g., Amos and Appleby 1999, Nash 2001, Waples et al. 2012, Price and Morris 2013, Rust et al. 2014, Hawkins et al. 2019). In this chapter we will not duplicate these previous efforts. Here we will summarize many of the risks discussed in these reviews and other documents, provide a discussion of existing management actions that mitigate for these risks, and recommend future management actions that may offer additional protection to native marine species. We also provide a section on the risks and mitigation of farming non-salmonid marine fish (e.g., sablefish) in open net pens in Washington.

Risks due to escapes of farm fish

Genetics

The consequences of escaped native or endemic species of farmed finfish interacting through reproduction with wild stocks are major concerns with open net pen aquaculture (Hindar et al. 1991, Amos and Appleby 1999, Bolstad et al. 2017, Forseth et al. 2017, Glover et al. 2017, Yang et al. 2019). It is important to note that a wide variety of outcomes, ranging from no detectable genetic effects (Glover et al. 2012) to substantial introgression and even total population displacement (Saegrov et al. 1997, Glover et al. 2012), were initially observed following escapes of Atlantic salmon from open net pens in Europe where they are endemic (reviewed in Hindar et al. 1991, Glover et al. 2017). In the long term, escapes of fertile Atlantic salmon from open net pen aquaculture in the North Atlantic have been shown to have damaging impacts on the genetic variability both within and between native populations (Fleming et al. 2000, Houde et al. 2010, Karlsson et al. 2016, Bolstad et al. 2017, Glover et al. 2017).

The most comprehensive data originate from Norwegian waters where five decades of farming Atlantic salmon was punctuated with escapes of millions of fish of different life stages (Diserud et al. 2019, Glover et al. 2019). Escaped, fertile, and domesticated farm fish interbred with wild Atlantic salmon, thereby reducing fitness and placing more pressure on sometimes already dwindling wild populations (Fleming et al. 2000). Results show that invasions of escaped farm fish reduce reproductive fitness and population productivity, disrupt local adaptations, and reduce the genetic diversity of wild salmon populations (Fleming et al. 2000, Bourret et al. 2011, Karlsson et al. 2016, Bolstad et al. 2017, Glover et al. 2017). Many of these impacts could be mitigated using sterile fish in fish farms (Cotter et al. 2000, Benfey 2001, Cotter et al. 2002, Janhunen et al. 2019; see below).

The impacts of escapes may vary depending on the status of the native stocks. In one example, Glover et al. (2012) studied introgression in 21 native populations of Atlantic salmon that had been exposed to large numbers of escaped farm fish and found that some populations were heavily introgressed (one native population was completely replaced with farm fish) while other populations were genetically intact. The authors concluded that healthy stocks of native fish that densely populated streams were resistant to introgression while depleted populations were much more vulnerable (see similar conclusions in Sylvester et al. 2018). This finding suggests that threatened populations of steelhead trout and Chinook salmon in Puget Sound would be similarly vulnerable to genetic impacts from fertile farm escapees: populations of both are listed as Threatened under the federal Endangered Species Act with a category of "Likely to Become Endangered."

Large-scale escapes resulting from infrastructure failure, such as the 2017 accident at Cooke Aquaculture's Cypress #2 facility, have happened wherever the farming of fish in open net pens is practiced. These large-scale incidents have been caused most frequently by mooring failure (e.g., Cypress #2), steel floats breaking down and sinking, or major tears in the nets (Jensen et al. 2010). In December 2019, a fire destroyed part of a plastic float system in a pen in British Columbia and nearly all the 21,000 ready-for-harvest Atlantic salmon escaped (https://globalnews.ca/news/6328416/bc-fish-farm-fire-salmon/). Other, often small-scale escapes, termed leakage, may occur due to errors during transfer of fish, maintenance errors, or small holes in nets, floating debris, or vandalism (Jensen et al. 2010). Leakage of salmon from farms is typically undetectable (Britton et al. 2011, Fisher et al. 2014) and recent research shows that more gradual, low-level leakage of fertile fish can have a greater negative demographic and genetic impact on native species than the rarer, large escape events (Baskett et al. 2013, Yang et al. 2019).

Ecological

Naylor et al. (2005) attempted a comprehensive assessment of the risks of escaped farmed fish to wild populations, including ecological, genetic, and socioeconomic concerns. Among the ecological risks were competition and predation. However, most of the discussion about competition and predation concerned interactions in freshwater among juvenile fish, involving escapes from freshwater facilities or offspring from escapes. Naylor et al. (2005) stated that little is known about the competitive interactions between escaped farmed and wild fish in the marine environment, but then speculated that competition may exist since the fish show similar feeding patterns. Impacts due to competition are not well studied, but no impacts due to competition between Atlantic salmon and native Pacific salmon have been documented in Washington despite several large escape events since the 1990s. The majority of evidence for impacts of competition originates from studies of Atlantic salmon within their native range. Fleming et al. (2000), in a large-scale study of sexually mature farm salmon invading a Norwegian river, found that the farm fish were less fit, achieving less than one-third the lifetime breeding success of the native fish. They did, however, find evidence of resource competition and competitive displacement that depressed the productivity of the native salmon. Sundt-Hansen et al. (2015) examined the density dependent effects of wild and farmed Atlantic salmon in confined stream channels; their results suggest that during early life stages, farmed parr could adversely affect survival of wild offspring. Similar results were found by McGinnity et al. (1997) in a study from Ireland where progeny of farmed salmon grew fastest and competitively displaced smaller native fish.

It is important to note that some impacts of competition may be more acute than others in Puget Sound where the ratio of farmed fish to wild fish is comparatively much lower than that observed in Europe (cf., Lund et al. 1991, reviewed in Hawkins et al. 2019). For example, spawning of farmed fish may reduce the spawning success of wild fish by digging up their redds (cf., Lura and Saegrov 1991), and even such small impacts on ESA-listed salmonids would be unacceptable. Alternatively, competition for prey might not be a major factor given the current level of farm production and escapes (Hawkins et al. 2019).

The ability of escaped farm fish to switch from pelleted feed to wild prey appears to depend upon their life stage at escape. Older, larger fish that escape often do not switch to live feed and survive poorly to sexual maturation. For example, fish from the 2017 Cypress Island event, that were harvest size at about ten pounds when the incident occurred, were found not to feed in the wild (e.g., only one of 71 fish examined (1.4%) had eaten, possibly a small forage fish). In contrast, fish that escape at early life stages appear to have a higher likelihood of adapting, feeding, and migrating to return as maturing adults. Jensen et al. (2010) captured Atlantic salmon that had escaped early in the post-smolt stage, migrating and dispersing through the

Arctic Ocean after one winter at sea; the growth and size of the escaped fish were similar to those of wild fish captured at the same time in the same area. Likewise, Skilbrei (2010) found that smolt and post-smolt escapees were capable of surviving and adopting the marine migratory pattern of their wild conspecifics.

Risks from net pen presence

Attraction and entrapment

Two potential ecological risks to wild populations from open net pen aquaculture that have received limited attention in the literature are:

- (1) The attraction of wild populations to the net pen facilities
- (2) The potential entrapment and inadvertent harvest of wild fish within the net pen cages

Callier et al. (2018) provided a comprehensive review of the relationships between finfish and shellfish aquaculture structures and their activities with the attraction (or repulsion) of wild populations. The authors indicated that these relationships are complicated and vary spatially and at several temporal scales. Many of the effects depend on fishery regulations and practices. That is, are the areas around net pen facilities protected from fisheries, or deliberately avoided by or attract fishing activities? Callier et al. (2018) concluded that there may be effects to wild fish from finfish aquaculture structures and activities related their condition, growth, and reproductive success, and to their population's overall biomass and migratory patterns. However, these factors are poorly understood and the overall effect to population viability is unknown. Callier et al. (2018) reviewed 21 publications involving the aquaculture of eight finfish species, including Atlantic salmon and steelhead trout. The overall conclusions by these authors were consistent among the different farmed fish species. The interaction between Puget Sound net pen facilities and aquaculture practices and the behavior of wild fish populations have not been studied, but we assume that such interactions occur. We also assume that the interactions in Puget Sound may be like those described by Callier et al. (2018).

Fish smaller than the mesh size of the net pen cages can enter and pass through the cages. While in the cages some fish may forage and grow. Fjelldal et al. (2018) document the entrapment of eight wild species within seven Atlantic salmon net pen facilities in Norway. The seven net pens held a total of 4,182 Atlantic salmon, and 3,154 entrapped wild fish. The authors did not investigate if this was a normal occurrence in Atlantic salmon farms in Norway, or if there was a negative ecological effect of this bycatch. There exists the possibility that wild fish can become entrapped in open net pen facilities in Puget Sound and become bycatch mortalities when the farmed fish are harvested. The Canadian government compiles and makes available the incidental finfish bycatch within British Columbia's marine finfish aquaculture farms.[13] From 2011 through September 2019, there were 1256 bycatch incidents reported by the Canadian government that involved a total of 708,574 fish. However, two of these incidents

[13] https://open.canada.ca/data/en/dataset/0bf04c4e-d2b0-4188-9053-08dc4a7a2b03

were the deliberate and rapid depopulation of the net pens to control the spread of IHNV outbreaks. These two incidents involved a single bycatch species (Pacific herring) and 406,366 herring were harvested as bycatch – 57% of the nine-year total. Overall, Pacific herring accounted for 638,950 (90%) of the total bycatch. The median number of fish caught as bycatch was eight individual fish per incident. A total of 308 Pacific salmon were caught in 87 incidents (median = 9 fish and mean = 3.5 fish per incident in which Pacific salmon were caught; and mean = 0.25 fish per total incidents), and no steelhead trout were caught in any incident. The population-level effects of this bycatch are not known, but the number of fish caught per incident is small absolutely, and small relative to their population sizes.

Protected species

Risks to protected species (federal Endangered Species Act (ESA), state listed species, or species of concern) can be either direct (e.g., genetic, ecological, disease transmission), or indirect through effects on prey or habitat (see other sections in this chapter, or Fish Health or Sensitive Habitats chapters). Hawkins et al. (2019) provided a recent review of the potential risks of open net pen aquaculture to Puget Sound species of marine mammals, marine birds, wild fish, and benthic invertebrates, including a focus on protected and priority species. This review frequently referenced the biological evaluation by Morandi et al. (2016) which addressed the relocation of the open net pen facility in Port Angeles Harbor to a site 1.5 miles offshore of Morse Creek in the Strait of Juan de Fuca.

Morandi et al. (2016) analyzed the biological effects of the installation and operation of a new net pen array at the proposed site on nine species of marine mammals, 29 species of marine fish, including eight species of salmonids, one species of marine invertebrates (geoduck), and nine species of birds. Morandi et al. (2016) concluded that the installation and operation of the new net pen array may affect each of these species, but that the effect was not likely to be adverse. Hawkins et al. (2019) analyzed 69 species or species-groups, including 23 species of ESA-listed species. It is beyond the scope of this document to provide a detailed review of species-specific risks of open net pen marine aquaculture, and we refer the reader to Hawkins et al. (2019), Morandi et al. (2016), and Parametrix (1990) for detailed reviews. Here, we summarize how protected species in Washington may be at risk from open net pen aquaculture.

Marine mammals

Habitat exclusion, entanglement, and behavioral alterations (attraction, avoidance, or food preference) are the primary risks posed to marine mammals by finfish net pen facilities and their operations (e.g., Nash et al. 2000, Díaz López 2012, Clement 2013, Price et al. 2017, Hawkins et al. 2019). Hawkins et al. (2019) lists 10 species of cetaceans, five species of pinnipeds, and two species of otters that may occur in Puget Sound, and have the potential to interact with net pens. Interactions between cetaceans, including Southern Resident Killer Whales, and Puget Sound net pens have not been recorded, although a humpback whale drowned in a British Columbia net pen after breaching the predator net (Price et al. 2017). Pinnipeds and river otters do interact with Puget Sound net pens (Parametrix 1990, Hawkins et al. 2019), but the interactions do not appear to put the pinniped or river otter populations at risk. Pinnipeds can damage net pen infrastructure and along with otters can prey on the fish stocked within the net pen cages (Nash et al. 2000, Price and Morris 2013, Price et al. 2017). The net pen industry employs predator exclusion netting and electric fences to deter predation (Hawkins et al. 2019).

Marine fish

Hawkins et al. (2019) recorded 20 protected species of marine fish in Washington, including nine species of ESA-listed fish. Among the ESA-listed fish are two rockfish (Bocaccio and Yelloweye Rockfish) and three salmonid species (Chinook and Coho salmon, and steelhead trout). We address disease risk to marine fish, in particular salmonids in the Fish health Section, and genetic and ecological risks above. Overall, marine net pens in Puget Sound may present low risk (i.e. limited spatial scope) to the physical habitat of listed marine fish species (Morandi et al. 2016, Hawkins et al. 2019).

Benthic invertebrates

Negative effects to the benthic environment and to protected benthic invertebrates resulting from net pen aquaculture have been a concern for several decades and has been well-studied (see reviews in Nash et al. 2000, Nash 2001, Keeley 2013, Price and Morris 2013, Morandi et al. 2016, Hawkins et al. 2019). Among the nine species of megafauna benthic invertebrates discussed by Hawkins et al. (2019), only the pinto abalone into is an ESA-listed species. Pinto abalone are associated with kelp beds and rocky reef habitats (Morandi et al. 2016), and their decline has been due to a variety of hazards, including harvest, predation by sea otters, disease and loss of kelp habitat (Hawkins et al. 2019). See Benthic Chapter for discussion of other issues related to benthic invertebrates.

Marine birds

Entanglement in anti-predator or in the containment (cage) nets is the risk of greatest concern to marine birds, especially diving birds, from net pen aquaculture (Price and Morris 2013, Sagar 2013, Price et al. 2017). However, this risk can be mitigated by using nets with a mesh size small enough to prevent entanglement. Sagar (2013) recommended that mesh sizes be smaller than 6 centimeters for net pen aquaculture in New Zealand, where there have been no reports of seabird drowning from entanglement. Hawkins et al. (2019) recorded 18 species or species-groups of protected marine birds, of which two, Brown Pelican and Marbled Murrelet are ESA listed. There have been no recorded incidents of entangled marine birds in Washington finfish net pens, although there was one reported case of entanglement in 68 net pen farms in British Columbia (Rodway et al. 1993 in Hawkins et al. 2019).[14]

Aquatic invasive species

Net pen aquaculture may present a risk to native finfish and shellfish populations, and to finfish and shellfish aquatic farms through the introduction and spread of invasive non-native aquatic

[14] Hawkins et al. (2019) incorrectly cite Rodway et al. 1993 as Rodway et al. 1992, and there is no mention of Marbled Murrelet entanglement in net pen aquaculture in Rodway et al. 1993.

micro- and macro-organisms. Aquatic invasive species (AIS) can be any non-native animal, plant, or algal species that threaten the environmental, economic, and cultural values of the state. Examples include the inadvertent introduction of molluscan pathogens and parasites that can have detrimental effects on wild and farmed mollusk populations, or invasive species such as European green crabs that can predate on native mollusks and destroy native eelgrass and salt marsh habitat. Net pen operations that may pose invasive risks include the transport of holding water and the farm to farm use of insufficiently decontaminated gear and equipment. Protocols for mitigating these risks may be the same or similar to those that mitigate the risks of introduction of pathogens and parasites discussed in the Fish Health section. An interdisciplinary team should be assembled to research the risks of AIS from net pen aquaculture and to develop best management practices for controlling AIS.

Existing risk mitigation

Sterile fish

The most effective strategy to mitigate the risk of genetic introgression from escaped farm finfish is to limit farms to use of sterile all-female fish (Thorgaard 1992, Cotter et al. 2000, Baskett et al. 2013, Lerfall et al. 2017). Sterile females are preferred because sterile males in many species may undergo sexual maturation and attempt to spawn even though these males produce no viable offspring (Hindar et al. 1991, Oppedal et al. 2003, Tiwary et al. 2004, Feindel et al. 2010). Such spawning behavior from escaped males could lower the spawning success of native fish. For example, the release of sterile males has been used to reduce reproductive potential of wild populations to suppress populations of unwanted pests (Twohey et al. 2003, Bergstedt and Twohey 2007, Siefkes 2017). Sterile females will not be able to successfully breed with native males and will eventually senesce and die (Tiwary et al. 2004, Lerfall et al. 2017).

Sterility is most frequently produced by inducing triploidy – producing fish with three sets of chromosomes rather than the normal two. Biological regulation of chromosome sets is not as rigorously controlled in fish as in other vertebrates (Miller et al. 1994): triploidy is naturally common in some species (Qin et al. 2016, Zhigileva et al. 2017, Wu et al. 2019), and has been seen at low rates in wild salmonids (Thorgaard et al. 1982). The technology for producing triploid lots or groups of fish is simple and easily applied on a commercial scale (Lerfall et al. 2017). Inducing triploidy to produce sterile Pacific salmon was optimized at Washington State University (Thorgaard et al. 1982, Parsons et al. 1986, Seeb et al. 1986, Thorgaard 1992). Triploids were raised in growth trials in net pens by the Squaxin Island Tribe more than 30 years ago (Seeb et al. 1993). Triploidy can be induced at rates approaching 100% by shocking newly fertilized eggs with heat or pressure (Benfey and Sutterlin 1984). Induced triploidy is practiced by some aquaculturists to reduce product loss due to precocious maturation prior to harvest (Janhunen et al. 2019) and used by management agencies who require sterile fish for sportfish stocking programs (e.g., more than 9 million triploid rainbow trout have been stocked in freshwater by WDFW since 1995).

The use of sterile finfish in open marine net pen aquaculture has the obvious benefit of mitigating the major impact of introgression. However, the use of sterile fish may also reduce ecological interactions. Nearly all research on the behavior and survival of escaped farmed fish is based on diploid – fertile Atlantic salmon in Norway. However, in an experimental release of paired diploid and triploid Atlantic salmon from marine net pens in Ireland, Cotter et al. (2000) and Wilkins et al. (2001) showed that significantly fewer triploid fish returned as adults to the coastal fisheries and to freshwater compared with their diploid siblings (see also Johnson et al., 2019).

These triploid Atlantic salmon may be less resistant to stressful environmental conditions and have significantly higher occurrence of lens cataracts than the diploid fish (Cotter et al. 2000, Wilkins et al. 2001, Cotter et al. 2002). Wilkins et al. (2001) and others (e.g., Glover et al. 2016) also postulated that the migration behavior of adult female triploid Atlantic salmon to freshwater was reduced by non-normal gonadal development. Laboratory, experiments pairing full-sibling diploid and triploid Atlantic salmon subjected to seawater challenges show that the triploid fish grow a suite of developmental deformities that may compromise their fitness in marine waters (Leclercq et al. 2011). These deformities include higher incidence and severity of lens cataracts, jaw malformation, vertebral deformities, and heart deformities possibly related to higher cardiac workloads.

Poorer survival and performance of triploid fish compared with diploid fish is not limited to Atlantic salmon. Scott et al. (2015) compared full-sibling diploid and triploid rainbow trout performance in the laboratory and showed that the triploid trout had significantly poorer hypoxia tolerance than their diploid siblings. The same result was observed in the five different strains of rainbow trout and three different brood years used in the experiment. Similar results were not seen in the adult, lake-reared trout, but Scott et al. (2015) considered that several factors may have confounded the analysis of the adult fish. Johnson et al. (2019) used hatchery rearing of full-sibling diploid and triploid steelhead trout to compare survivorship and growth in both fresh- and salt-water. After 15 months in saltwater, the survivorship of the triploid fish was only 35% of their starting population, compared with 72% for the diploid fish. Withler et al. (1995) showed results like those in Johnson et al. (2019) using Coho salmon.

Amos and Appleby (1999), in their review of issues to mitigate the escapes of farm fish in Puget Sound, recommended requiring fish farm operators in Washington to use mono-sex or triploid fish. WDFW now requires as a provision of Marine Finfish Aquaculture Permits for salmonids that only sterile all-female individuals can be reared in open marine net pens. The currently accepted method for sterilization is induced triploidy. The success of the methods used to create triploid fish is not 100%. This means that in every batch of triploid fish there may be fish that are fertile and can spawn with wild individuals of the same species. Operators must implement a statistically robust quality assurance process to certify >99% triploidy in each batch of fish prior to transfer to marine net pens and for the approval of a transport permit.

Escape monitoring

Escape monitoring is essential to detect leakage of farm fish at all life stages, especially to implement prevention strategies for leakage of small fish. Escape monitoring in Washington has been sporadic—no continuous effort was made prior to the Cypress #2 event. This may have been in part because escaped Atlantic salmon were easily identifiable by spot patterns. WAC 220-370-140 established an Atlantic salmon watch program that required monitoring and reporting of escaped Atlantic salmon, determination of the potential effects of escaped fish on wild populations, and WDFW coordination with aquatic farmers and the public. However, as stated in the WAC, this program is contingent on funding, which currently does not exist. This existing WAC can be used to establish an escaped cultured finfish watch program.

Escaped diploid and triploid native species will not be easily detectable without unique externally visible tags or marks. Escape monitoring can only be done if all fish transported into net pens are marked with externally visible marks, other than body shape, that unambiguously identify each as a commercial aquaculture fish. Salmon escapees have been monitored in Norwegian rivers since 1989, and, an improved program focusing upon genetic effects was established in 2014 (Glover et al. 2019). These efforts provide insight into a needed state native finfish monitoring program, funded by government or industry, to detect the presence of escaped farm fish. Monitoring, such as that done in Norway, could be done in several steps:

1. The first and most important step is for the aquatic farmers to develop a reporting system, approved by the state, which accounts for the number of live fish and mortalities, starting from the numbers of live fish departing the freshwater hatchery, then stocked into each net pen array, through to the number of fish harvested. The number of live fish, mortalities, and known and estimated escapes will be reported each month. Any deviation between running totals of live fish and known losses, beyond accepted accounting error rates, would indicate loss due to leakage.

2. Screen for marked farm fish in existing angling surveys.

3. Screen for marked farm fish in existing escapement surveys.

4. Screen for naturally occurring multi-locus genotypes that mark farm genes in native gene pools. Genetic monitoring techniques have reached levels of accuracy where extended pedigrees can connect escapees from different recovery sites back to the pen of origin (Karlsson et al. 2011, Zhang et al. 2013, Quintela et al. 2016). The same data types can detect introgression of genes from farmed fish into wild populations in second or later generation hybrids (Pritchard et al. 2016, Keyser et al. 2018, Sylvester et al. 2018, Sylvester et al. 2019). The state currently conducts an array of genetic monitoring programs; multi-locus genotypes from farm brood stocks are required for tracing these impacts from farm fish of native species.

5. Depending upon results from above, complete snorkeling surveys in a set of indicator streams.

WDFW now requires as a provision of Marine Finfish Aquaculture Permits for salmonids that aquatic farmers must:

1. Externally mark their fish so that they can be identify unambiguously as escaped farmed;

2. Provide to WDFW an appropriate sample (minimum 150 fish) for genetic identification and marking; and
3. Report numbers of live and dead fish in monthly reports, enabling an accounting systems to estimate missing, and presumably escaped fish.

Risks and mitigation associated with net pen culture of non-salmonid marine fish

Non-salmonid farms share many of the same challenges and ecological and genetic risks as salmonid farms. Escapes of marine species are inevitable (Skjaeraasen et al. 2010). Experimental releases of Atlantic cod using acoustic transmitters showed rapid dispersal to local spawning areas (Uglem et al. 2010). In Europe, Atlantic cod may be more prone to escape that Atlantic salmon (Uglem et al. 2008).

Atlantic cod tend to bite holes in the nets, attacking discontinuities or loose fibers, sometimes facilitating escapes to access feed sources outside of the cages (cf., Damsgard et al. 2012). Moe et al. (2009) concluded that netting materials for cod aquaculture must be resistant to bites or be repellant or uninteresting. Pen and net construction for non-salmonid marine species may require a set of standards separate from the standards for salmonids.

Unlike salmonids, other marine species may spawn in the net pens. They can produce viable larvae small enough that they leave the net pen and mix with wild populations, further exacerbating escape risks. Termed “escape through spawning,” this phenomenon has been documented in sea bream, Atlantic cod, and other species (Uglem et al. 2012, Somarakis et al. 2013). Using genetic tags, Jorstad et al. (2008) demonstrated a high degree of larval dispersal, confirming that farmed cod can produce viable larvae that mix with wild cod larvae. The risk of escape though spawning increases with increasing age of the farmed individuals (Uglem et al. 2012).

Eliminating reproductivity of farmed marine fish for future net pen aquaculture

The use of sterile triploids is being studied to improve performance characteristics of marine species and to prevent spawning (Vargas et al. 2017, Puvanendran et al. 2019). But, triploidy alone is not likely to prevent the spawning of every farmed fish. Triploid male Atlantic cod successfully compete with diploid males during spawning and sire offspring, although the offspring will not survive (Feindel et al. 2010). Each potential farmed fish species must be evaluated for the optimal combination of parameters to eliminate reproduction and spawning abilities to reduce the risk of genetic introgression with their native, wild counterparts.

Sablefish aquaculture in the Northwest

Sablefish are a deepwater species native to eastern North Pacific ranging from the Bering Sea to the U.S. West coast and harvested in the commercial fishery. They are highly prized for firm white flesh and omega-3 fatty acids and rank third in economic value behind walleye pollock and Pacific cod (NOAA_Fisheries 2019). Sablefish are fully exploited (at maximum sustainable yield), which creates strong interest in aquaculture of this species (NOAA_Fisheries 2019).

Aquaculture of sablefish in Washington and British Columbia waters is relatively new (e.g., Sumaila et al. 2007, NOAA_Fisheries 2019). Recent research initiatives have focused on an improved understanding of the life history and population structure as well as research on aquaculture technologies, development of all-female captive brood stocks, and reducing duration of larval rearing.

Females grow significantly faster than males, so production of all female juveniles could result in a significant commercial advantage for aquaculture. Researchers have developed the techniques to produce sablefish neomales (XX males) to be used to make all-female stocks (Luckenbach et al. 2017). Coupling this technology with the production of triploids could help to establish a successful commercial net pen industry in Puget Sound (NOAA_Fisheries 2019). The use of all-female triploids in sablefish (or other marine fish) aquaculture would mitigate the genetic risks posed by the escape of farm fish.

Best practices to minimize genetic and ecological risks

- Alternative escape recapture plans should be considered given that the best possible recapture plans may not achieve the desired goals. Dempster et al. (2018) suggests alternative approaches to reduce escapee numbers in wild habitats:
    a. Construct programs where farm operators can offset unavoidable environmental damage caused by escapes by paying for habitat improvements elsewhere. Penalty payments should be strong enough to provide a direct incentive for farmers to invest in efforts into escape avoidance.
    b. Ensure technical standards are legislated, such as in Scotland (Scotland 2015) and Norway (Norway 2009), so that fish farmers are required to invest in preventative technologies to minimize escapes.
- Operators must implement a statistically robust quality assurance program to certify >99% triploidy in each batch of fish prior to transfer to marine net pens.
- The state must develop and implement a watch program for escaped aquaculture fish using both visual marks and genetic marks. The watch program should include:
    a. Screening for marked farm fish in existing angling surveys.
    b. Screening for marked farm fish in existing escapement surveys.
    c. Screening for naturally occurring multi-locus genotypes that genetically identify farm populations genes in native gene pools.
- The state should implement a bycatch monitoring program to ground truth the assertion that ESA-protected species are entering pens and later harvested as sub adults.

- Aquatic farmers should inspect gut contents of fish during routine fish disease examinations to help determine if wild fish are consumed by aquaculture fish (Cornelisen 2013).
- Mesh size of predator and containment nets must be small enough to prevent entanglement of marine birds and mammals.
- The state and industry engage in public education efforts to inform residents of the science-based risks of marine aquaculture as well as of the benefits of same to the economy and prosperity of Washington.
- The state and industry should fund and seek federal funding to conduct the necessary research to better inform risk mitigation.

Escape Prevention and Response

Fish escapes are a reality of net pen aquaculture due to the dynamic and unpredictable nature of marine environments (Hawkins 2019). It is important to understand that fish domesticated for and raised in a commercial marine operation are fish not managed or regulated for release into Puget Sound for fishery enhancement. As such, they are to be contained to mitigate risk for disease, genetic and ecological reasons.

Fish escapes most commonly occur in small numbers through damaged nets or during harvest. Termed “leakage,” the quantity of fish that escape will vary depending on the size of the fish, the duration of the event, and the effectiveness of the response (Hawkins 2019). Less common are large escape events caused by net pen failure, in which thousands or hundreds of thousands of fish may escape at one time (Hawkins 2019).

Decades of experience in Europe, Chile and elsewhere has led to the conclusion that it is not possible to eliminate escapes from open net pens (Glover et al. 2019, Holen et al. 2019).While the risk of escapes from open net pens cannot be driven down to zero, the risk can be reduced through improvements in design and maintenance of net pens and by improving operational practices.

Open net pen operators and regulatory/proprietary agencies can follow national and international standards to reduce the risk of large-scale incidents for open net pens. No standards currently exist for the State of Washington. Other governments have enacted engineering standards for open net pens to combat common causes of escapes and reduce their number (Norway 2009, Scotland 2015). The NS 9415 standard applied in Norway in 2006 demonstrably reduced the occurrence of major escapes since its implementation (Dempster et al. 2018). NS 9415 addressed the physical design of net pens, and focused on their design, construction, and mooring systems as they relate to winds and currents of a given site. More recently, the International Standards Organization adopted similar standards (ISO 16488:2015(en) “Marine finfish farms – Open net cage – Design and operation”) that provide a methodology for determining “the adequacy of a given finfish farm's floating structure, nets, and mooring equipment for a given environment" (www.iso.org/standard/56852.html). The standards also include provisions regarding operations and maintenance of open net pens.

Other governments are considering a move to closed containment, offshore[15], or land-based aquaculture to minimize or eliminate the risks of escapes (Liu et al. 2016, Yip et al. 2017, Canada 2018, Gorle et al. 2018, Nilsen et al. 2019).

A hierarchy of risks discussed in the literature can be summarized as:

Uncertified open > Certified open > Closed containment > Offshore > Land-based

Over the past 30 years, salmon farming practices and pen engineering have evolved and improved considerably (Glover et al. 2017, Canada 2018, Holen et al. 2019) although perhaps not as much in Washington. The net pens used in Washington up to 2021, acquired by Cooke Aquaculture Pacific in 2016, are older designs of steel structure cages that Cooke Aquaculture has largely replaced in its eastern Canadian operations. In eastern Canada, Cooke Aquaculture uses a modern design of round plastic rings, commonly termed polar circles that have weighted nets and are more resilient to stress. Improved technologies have the potential to mitigate many environmental concerns associated with open-pen salmon farms beyond escape risk, such as transfer of pathogens, waste, and improve the farm fish product. Many innovations originate in Norway where farms are exploring the profitability of offshore or land-based operations to respond to ecological and social challenges.

The financial viability and profitability of some of these costly options may not fit with the small-scale operations in Washington; yet the success of implementing technical standards to reduce escapes in Europe suggests that more consideration of these standards is appropriate in Washington. Interestingly, a proposed solution to improve net pen operations in British Columbia is to "establish financial incentives to invest in developing and implementing salmon farming technologies that reduce the risk to wild salmon and require their incorporation into siting and operational licenses, as appropriate (Canada 2018)." The NPDES permit program managed by Ecology can require current and future permittees to improve technologies for in-water systems to reduce risk of escapes. Through an economic and engineering study, the most economically feasible net pen structure and technology to further reduce fish escape can be implemented through WAC 173-220-130 (National Pollutant Discharge Elimination System Permit Program: effluent limitations, water quality standards, and other requirements for permits).

The potential effects to native finfish of escaped fish from net pens, regardless of type of escape, are discussed in the Genetic and Ecological Issues section.

Best Practices for Fish Escape Prevention

Preventing escapes must remain at the forefront of the priorities of net pen operators and regulators/land managers. The primary means to prevent escapes is through proper design and

[15] Waters beyond local territorial boundaries, such as Washington State. Consistent with RCW 77.008.010

maintenance of adequate net pen infrastructure and careful operations. Escape prevention must address both types of escapes that occur with open net pens:

- "Leakage" caused by openings in nets that allow fish to escape in numbers not readily detected through visual observation or declines in feed consumed as well as losses of small numbers of fish that can occur during handling and
- Large-scale incidents caused by mooring failure (e.g., the 2017 Cypress Island pen #2 failure), breakdown and sinking of steel floats, or major tears in the nets (Jensen et al. 2010).

The two types of escapes require different prevention strategies that are generally complementary and some stragies are useful for preventing both types of escapes.

Best practices to prevent leakage

The strategy for preventing leakage requires a wide mix of mostly operational practices to reduce the risk of leakage and detecting and correcting when it does occur. These include:

- Thorough out-of-water cleaning, inspection, strength-testing, and repair of nets between crops;
- Retirement of nets when mesh strength-testing results drop below a designed threshold;
- Care during installation to avoid tears, hold the net in the proper position, and ensure proper tensioning (avoiding both over-tensioning and slack that can lead to billowing and snagging);
- Use of chafe guards near the surface and at points where the net contacts hard surfaces of the cage system;
- Use of a secondary predator-exclusion net to reduce the risk of marine mammals and debris penetrating the stock containment net;
- To the degree allowed by federal marine mammal protection laws, use fencing or other design features to prevent access by pinnipeds to the topside of the cage structure;
- Regular inspections from the surface and underwater to look for tears in the nets;
- Immediate follow up inspections when unusual events suggest the possibility of a net tear or opening (presence of a pinniped in a pen, floating debris in a pen, unusual tension/slack on lines, loss of floatation, net billowing, reduction in feed consumption);
- Divers should enter the pens above the water line. If this is not possible, such as when using some submersible pens, specific measures to prevent escape should be detailed as part of an operational plan;

- Immediate repair of tears detected by divers (for example, by equipping divers with materials to make minor repairs during inspection/mortality removal dives);
- Net-pen operators should have access to extra stock nets to conduct emergency net swaps in the event a stock net cannot be repaired in place; and
- Operations involving movement or handling of fish are the times when escapes are most likely to occur. Operators should use standard protocols documented in an operational plan for stocking, transferring fish between pens, and harvest to minimize the risk of escapes during fish handling.

Best Practices for prevention of large-scale incidents

The strategy for preventing large-scale incidents focuses on the design and maintenance of the net pen as a system. This begins with careful site selection, conducting current studies, selecting an appropriate design, and engineering analysis of the mooring design. It also includes assembly of the cage system and moorings according to the manufacturer’s instructions, on-going and episodic inspections, preventative maintenance, and net hygiene. Net hygiene is the practice of controlling biofouling and is addressed in the separate chapter Biofouling.

- At a minimum, the state should adopt an industry standard (e.g., the International Standards Organization, Norwegian guideline, or alternative) and farm facility plan designs should be reviewed using this standard to ensure necessary issues are considered. In most instances, this will also require:
    a. Performing and providing detailed measurement of tidal currents at existing and proposed net pen sites for use in engineering design and review (Clark et al. 2018).
    b. Providing stamped engineered designs and supporting information for net pens during the permitting/lease application process (Clark et al. 2018).
- Operators should be incentivized to move to closed-containment or offshore systems;
- Require that designs for proposed net pens incorporate the best available technology in use in the industry, appropriate to the site (Clark et al. 2018);
- A farm facility inspection and maintenance schedule should be developed and included as part of the permitting process. This plan should include data to support the schedule such as information from other locations where the pen design is used, the suggestions by the system engineers, documents, and useable life of the materials;
- The net pen and mooring system must be inspected on a schedule and components must be replaced when signs of wear are evident or on a prescribed replacement schedule;
- State agencies should conduct or contract for inspections to assess structural integrity of the net pen facility. In the case where the inspection is done by the operator (including

under contract), the inspection reports should be certified by a qualified marine engineer; and

- State agencies should conduct periodic independent (contracted) review of operator-developed net pen mooring plans, site risk analysis, and inspection reports to confirm that the farm continues to operate as originally designed or according to any approved modifications (Clark et al. 2018).

Best practices that address leakage and large scale escapes

- Net pen systems should be inspected regularly and inspections documented. Inspections should focus on the integrity of the individual cage structures, nets, and moorings;
- Maintenance and repair of net pen components should be thoroughly documented to ensure scheduled maintenance is performed, document any structural modifications made, and assist in long-term facility management (e.g., adjusting replacement schedule);
- Use stock nets whose specifications are consistent with the cage system manufacturer's recommendations and appropriate for the species/size being raised;
- Good communication and careful seamanship must be prioritized when maneuvering and docking larger vessels servicing the net pen facility to avoid damaging the pen, including prop-caused damage to billowing nets;
- Maintain an accurate inventory of stocked fish. The use of automated fish counters is encouraged whenever possible. The manner that the operator will use to track inventory should be discussed in the operational plan;
- Record all known escapes, even leakage events that may not warrant immediate notification to regulators so accurate numbers of escapes and inventory are tracked. Large escape events must be reported immediately; and
- Require net pen operators to notify state agencies immediately any time a net pen cage or system is damaged and/or is at risk of failure, regardless of whether a release of fish has occurred. This increases understanding and shortens agency response time if the situation worsens.

The presence of open net pens in navigable bodies of water poses one escape risk that is beyond the ability of net pen operators and the regulatory/proprietary agencies to prevent: vessel collisions with net pens resulting in a large-scale escape. Collisions between small vessels and net pen structures (technically known as "allisions" because the net pen is fixed) occurred in Puget Sound in 2018 and 2019. The net pens were properly marked with private aids to navigation and were shown clearly on navigational charts. While neither incident resulted in structural damage to the net pen or fish escape, the experiences underscored that there is an element of unpredictability on the water. In part for this reason, a robust escape response plan is a necessary part of open net pen aquaculture management.

Finally, recapture of fish that escape from net pens has been shown to be universally inefficient in marine habitats, with rare exception (Dempster et al. 2018). Results show that recapture efforts must be immediate and widespread for best results, but recovery percentages are often still low (Skilbrei and Jorgensen 2010, Chittenden et al. 2011, Dempster et al. 2018).Suggestions that widespread and intense recapture efforts may show some success (Skilbrei and Jorgensen 2010) must be weighed against the risk of bycatch of native non-farm fish. Recapture may cause unacceptable harm in situations where ESA-listed stocks are present. The most effective and least destructive method for recapture is the use of live traps where non-farm fish can be released (Chittenden et al. 2011). Any recapture efforts, including live traps, after escaped fish disperse (which could occur within days or weeks) are not likely to be effective (Chittenden et al. 2011, Dempster et al. 2018). However, the recapture of farm fish within targeted rivers may provide some mitigation to prevent introgression when fertile fish escape from marine net pens (Glover et al. 2019).

Best Practices for Fish Escape Preparedness and Response

The following escape preparedness and response best practices are based on recent experience and current practice in Washington.

- Require operators to develop and train all staff on farm-specific escape response and reporting plans. The plan should include detailed steps on how to mobilize to:
    a. Quickly repair damage that does not necessitate fish transfer to end on-going escapes,
    b. Quickly transfer fish from a pen that cannot be repaired quickly, and
    c. Immediately activate escape response communication plan to decide if an attempt to recapture fish is implimented and, if so, the methods for recapture;
- Fish recapture plans must emphasize rapid recapture. Unless a recapture can begin within 24 hours, escapes based on traditional gear may not be successful, and there may be an unacceptable risk of bycatch of listed species. NOAA Fisheries, Treaty Tribes, and WDFW will need to consult with the operator to monitor and manage recapture efforts to achieve the twin goals of recapture and protection of listed species. Specific measures in recapture plans should include (Clark et al. 2018):
    a. Steps to maximize fast fishing response (within 24 hours) to mass escapes, including use of vessels of opportunity;
    b. Maintaining updated contact info for area tribal governments to coordinate fishing response;
    c. Planning based on site attributes, geography, currents, the type of fishing gear effective for different fish sizes, and seasonal considerations; and

d. Tabletop and deployment drills to maintain recovery plan readiness, similar to preparations for oil spill response.

- Develop a network for rapid recapture with Tribal and commercial fishers. Consider a means to incentivize Tribal and commercial fishers to aid in the recapture effort if a large escape event occurs. The involvement of sport fishers should be allowed only when it will contribute to the objectives of rapid recapture, accountability, and minimal bycatch of listed species.
- Improve operator capacity to manage incident response by requiring net pen operators to (Clark et al. 2018):

  a. Have personnel trained in participating in a Unified Command under the National Incident Management System (NIMS) and consistent with the Northwest Area Contingency Plan;

  b. Actively and cooperatively participate in any Unified Command structure established to respond to a large incident;

  c. Provide regular communication and documentation that ensures adequate response resources are being rapidly mobilized in proportion to the size of the incident; and

  d. Follow their approved spill contingency/response plan (if applicable) unless otherwise directed, or a deviation is agreed to, by the Unified Command.
- To improve governmental agency preparedness to respond to large escape incidents, agencies should conduct drills to test the efficacy of a fish escape plan and to test the ability of net pen operators to effectively implement their fish escape response plan.

Recommendation for Legislative Oversight and Support

Prior chapters in this guidance document have provided recommendations and best management practices specific to the risks that have been evaluated. EHB 2957 also directed state agencies to provide “recommendations for future legislative oversight of marine finfish net pen aquaculture.” The following recommendations are intended to address that directive and to increase the effectiveness of the guidance by providing additional oversight and support. The likely affected agencies are in parentheses.

In passing and signing EHB 2957 the Legislature and Gov. Jay Inslee directed state agencies to develop guidance which “must be designed to eliminate” net pen escapement and “negative impacts to water quality and native fish, shellfish, and wildlife.” As discussed in this document, the complete elimination of these potential negative impacts is not possible. However, through implementation of the guidance and practices detailed in this document by operators and authorizing agencies, the probability that these impacts will occur will be reduced, thereby lowering the risk to the natural resources in our marine waters.

Recommendation #1

Implementing the guidance, ensuring the best practices are being used, and putting appropriate regulatory oversight in place requires funding beyond which is allocated currently in agency budgets. Each agency has different inspection and regulatory responsibilities, and therefore different fiscal needs. These include:

- Fish health inspections in freshwater hatcheries (source of fish) and in marine net pens (WDFW)
- Establish and maintain a “Regulated Finfish Pathogen Advisory Committee,” with the authority to review effects of emerging pathogens and manage the state’s regulated finfish pathogen list. (WDFW)
- Genetically fingerprint each lot of fish transported into net pens. Assists in definitively identifying escaped fish – provides a more useful mark than an otolith mark. (WDFW)
- Monitor harvest for bycatch. (WDFW)
- Establish and maintain a (1) “marine net pen aquaculture watch program,” and (2) a “marine net pen aquaculture education program,” to replace WAC 220-370-140 and WAC 220-370-150. The existing programs described in the WACs are unfunded and therefore non-functional. (WDFW)
- Regulatory and administrative oversight – each agency (WDFW, DNR, and Ecology) will have different needs based on specific regulations, permit and lease requirements.

Therefore, the Legislature should work with each agency to develop decision packages that appropriately funds net pen marine aquaculture monitoring, inspection, and regulatory oversight.

Recommendation #2

The agencies should compile a progress report to be submitted to the Legislature in 2030 that summarizes the following:

- If new net pens are sited, how the guidance have been applied by authorizing agencies;
- Summary results of monitoring conducted in accordance with all permit and lease requirements aimed at avoiding and reducing impacts;
- Any lessons learned in implementing the new guidance, including the need for new adaptive management strategies; and,
- Progress on research gaps, including the economic and engineering study described below.

Recommendation #3

Fund an economic and engineering study to determine the minimum standard technology marine finfish net pen aquaculture should use in Washington for the elimination and prevention of impacts to Puget Sound. This study should consider:

- The viability, benefits, and challenges of upland recirculated aquaculture systems.
- Other alternative in-water closed or semi-closed aquaculture systems to improve prevention of fish escapes and reduce water quality impacts.
- Improved feeding technology for marine net pen operation to reduce feed waste to reduce water quality impacts.

Recommendation #4

There are data gaps in our knowledge of how marine net pen aquaculture may affect the environment and natural resources. This is not atypical for any natural resource management program. These research needs require funding beyond what currently exists for any of the natural resource agencies.

- Develop a pathogen transmission model for net pen to free-ranging (hatchery and wild) populations. Use IHNV as the initial model. This will assess disease risk from pathogens transmitted from net pen aquaculture to natural populations. (WDFW)
- Monitor bacterial antibiotic resistance associated with net pen aquaculture. Requires appropriate experimental design. Bacteria samples taken from benthos and benthic

organisms. Initial bacteria to monitor: *Tenacibaculum maritimum* (yellowmouth), *Aeromonas salmonicida* (furunculosis), and *Vibrio anguillarum* (vibriosis). (WDFW)

- Experimentally determine ecological risk to fish populations resulting from competition with and predation by escaped net pen fish. Conduct experimental releases of female triploid steelhead, with acoustic transmitters inserted, to determine fish behavior and survival. Measure risk at a several life stages. (WDFW)
- Experimentally determine whether there is ecological risk of sea lice transfer to native salmonids from net pens in Puget Sound. Conduct seasonal in-situ experiments to determine if net pens are sources of sea lice and determine if there is ecological risk to native salmonids relative to the life stage potentially exposed. (WDFW)
- Forage fish have a diverse life history and use a variety of habitats throughout. It is not well understood what, if any impact net pen aquaculture has on forage fish. The potential impacts of net pen aquaculture on forage fish habitat is not well understood, but will likely differ by location, species, season, and the facility's configuration and operation. To date, limited research has examined if there are impacts from net pen aquaculture on forage fish habitat. Research should be funded to better understand how forage fish interact with floating structures, such as net pen arrays, and whether these structures and associated activities pose any significant risk to the health of forage fish. (WDFW)
- For newly proposed net pen projects, characterize the change to the benthic environment. Conduct an initial benthic assessment as is required for obtaining a state aquatic land lease and once in operation, conduct a similar assessment regularly to monitor the seafloor under the net pens during the operations to determine change over time. (project proponent, DNR, and Ecology)
- Establish an *ad hoc* interdisciplinary team to research the risks of AIS from net pen aquaculture and to develop best management practices for controlling AIS. (AGR, WDFW, Ecology, DNR)

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Appendix A: Local Government Shoreline Permitting

Introduction

Consistent with the 2018 Legislative directive (HB 2957), Appendix A provides guidance for local governments related to Shoreline Master Program (SMP) provisions and shoreline permitting. This appendix is intended to help local governments apply existing statutes when evaluating whether and where new marine finfish net pen operations might be located in their jurisdictions. Much of the content in the main body of this guidance document focuses on permitting, operating, and oversight of net pens that is outside the authority of local governments. Information useful to local governments is spread throughout the document. This appendix consolidates this relevant information. The guidance and this appendix apply only to net pen operations and siting within Puget Sound and the Strait of Juan de Fuca.

Purpose

The purpose of this appendix is to provide local governments with more specific assistance and management recommendations. Based on the environmental concerns described in the guidance document this appendix provides local governments with information to assess new net pen projects and reduce potential risks under the authorities of the Shoreline Management Act (SMA) and their locally tailored SMPs. This includes environmental assessments under the State Environmental Policy Act (SEPA). The combination of local government authorities results in a permit and SEPA determination process that considers the following:

- Whether a proposed net pen operation and its impacts are compatible with existing and planned shoreline uses;
- Whether there will be visual or navigational impacts;
- Whether there will be significant adverse environmental impacts and if impacts are being avoided, minimized, and mitigated.

The recommendations for local governments include updated siting considerations for both planning and permit implementation, but are limited to those that fall under their SMA and SEPA authorities. These recommendations shall be construed and applied consistent with the policies of the SMA[16] and the SMP Guidelines[17], specifically the use preference, critical areas protections, no net loss standard, and aquaculture use sections of the applicable SMP.

Overview: SMA, Guidelines, and SMPs.

The Shoreline Management Act (SMA), the Shoreline Master Program (SMP) Guidelines and the resulting SMPs produced by counties and cities together guide the process whereby shoreline development is planned and managed for local uses while protecting the state's shorelands.

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[16] RCW 90.58
[17] WAC 173-26

The SMA was passed by the Washington Legislature in 1971 and adopted by the voters in 1972. Its overarching goal is "to prevent the inherent harm in an uncoordinated and piecemeal development of the state's shorelines."

The SMA requires all counties and most towns and cities, those with shorelines of the state, to develop and implement a locally tailored SMP. The law also establishes a state-local partnership for managing, accessing, and protecting Washington's shorelines and defines Ecology's role in reviewing and approving local SMP. Shorelines of the state include all marine waters and their associated upland areas called shorelands that extend at least 200 feet landward of the edge of the ordinary high water mark of these waters.

The SMA promotes three main policies: Environmental protection, public access, and water-oriented uses.

The SMA establishes the concept of preferred shoreline uses. These uses are consistent with controlling pollution, preventing damage to the natural environment, or are unique to or dependent upon use of Washington's shorelines. As much as possible, shorelines should be reserved for preferred "water-oriented" uses, including those that are "water-dependent," "water-related," and for "water-enjoyment."

Preferred uses include:

- Ports
- Shoreline recreational uses
- Water-dependent industrial and commercial developments
- Other developments providing public access opportunities

The SMA states that "the interest of all the people shall be paramount in the management of shorelines of statewide significance" (SSWS)[18]. These shorelines include, among other areas, Puget Sound and the Strait of Juan de Fuca waterward of extreme low tide[19]. Preferred uses for SSWS are designed to:

- Recognize and protect statewide over local interests
- Preserve the natural character of the shoreline
- Result in long-term rather than short-term benefits
- Protect shoreline resources and environment
- Increase public access to publicly-owned shoreline areas
- Expand recreational shoreline opportunities for the public

SMPs are created by the local government, reviewed by the Department of Ecology (Ecology) for consistency with the SMA and Guidelines, and then approved by Ecology. The SMP

[18] RCW 90.58.020
[19] RCW 90.580.030(2)(f)

Guidelines are the state rules guiding the development and implementation of local SMPs. They translate the broad policies of the SMA into standards for regulating new development and uses within shorelines of the state and their shorelands.

WAC 173-26 are the SMP approval/amendment procedures and master program guidelines.

WAC 173-27 are the SMP permit and enforcement procedures.

Ecology created and maintains an SMP Handbook as a guide for local governments developing or amending their SMPs. This Handbook provides guidance for meeting the requirements of the SMA (RCW 90.58), the SMP Guidelines (WAC 173-26, Part III) and the SMP procedural rules (WAC 173-26, Parts I and II.) The Handbook also provides information and resources to help in making decisions on SMP environment designations, policies and regulations. SMP Handbook Chapter 16 addresses the SMP Planning Process for Aquaculture, including marine net pen aquaculture.

Special note should be taken of the following SMP Guidelines:

- Aquatic environment purpose, management policies, and designation criteria of WAC 173-26-211(5)(c)
- Critical areas applicability, principles, and standards of WAC 173-26-221(2)(a) - (c)
- Critical saltwater habitat WAC 173-26-221 applicability, principles, and standards of WAC 173-26-221(2)(c)(iii)
- Shoreline use provisions for aquaculture WAC 173-26-241(3)(b)
- WAC 173-26-186(8) directs that master programs "include policies and regulations designed to achieve no net loss of those ecological functions."

Each local SMP contains the following SMA and Guideline required elements which should be reviewed during permit implementation:

- Shoreline environment designations (SEDs) with customized management policies, regulations, and use allowances/prohibitions
- Policies and regulations for each major shoreline use (commercial, residential, recreational, aquaculture, etc…) and each major shoreline modification type (fill, docks/piers, shoreline stabilization, etc…)
- Vegetation conservation standards
- Public access requirements
- Shoreline buffers and/or setbacks
- Critical areas protection standards

SMP Permit review considers the proposed use, development, and whether it meets the bulk, dimensional, and performance standards of the SMP.

- Use – Is the proposed use allowed in the SED? Are the applicable Use provisions being met? Is the proposed use water-oriented?
- Development – Does the proposed action meet the definition of development? Is the proposed development or shoreline modification allowed in this SED? Are any special reports or minimization measures required for this type of development?
- Bulk, Dimensional, and Performance Standards – These can include buffers, setbacks, height restrictions, lot size minimums, impervious surface limitations, vegetation protection, mitigation sequencing, and view corridors.

SMP Permit Types and Net Pen Projects

All SMP permit authorizations can include approval conditions that are necessary to ensure consistency with the SMP. Projects that include prohibited uses cannot be authorized, even with a shoreline Conditional Use Permit (CUP) or Variance. The local government makes permit authorization decisions on Substantial Development Permits (SDPs), CUPs, and Variances. Both CUPs and Variances are provided to Ecology for a final decision. Ecology can approve, approve with conditions, or disapprove these permits based on the projects ability to meet the approval criteria of WAC 173-27-160 (CUPs) and WAC 173-26-170 (Variances). Ecology does not have authority to approve or condition SDPs.

Substantial Development Permit (SDP)

SDPs are required for developments and uses that meet the following definition of development:

"Development" means a use consisting of the construction or exterior alteration of structures; dredging; drilling; dumping; filling; removal of any sand, gravel, or minerals; bulkheading; driving of piling; placing of obstructions; or any project of a permanent or temporary nature which interferes with the normal public use of the surface of the waters overlying lands subject to the act at any stage of water level. "Development" does not include dismantling or removing structures if there is no other associated development or redevelopment; (WAC 173-27-030(6)).

All proposals for new commercial net pens would require a locally-issued SDP because net pen facilities include the construction or placement of structures meeting the definition of development within shorelines of the state or SSWS.

Conditional Use Permit (CUP)

Each SMP defines the types of uses and developments that require shoreline conditional use permits, usually within an allowed use matrix and with additional use specific provisions. WAC 173-26-241(2)(b) provides that conditional uses permits can provide the opportunity to require specially tailored environmental analysis or design criteria for types of uses or developments that may otherwise be inconsistent with a specific environment designation. This can allow the SMP to provide additional flexibility for uses such as aquaculture or net pens without outright prohibitions. This is especially useful for water-dependent uses that should be fostered within the shoreline, such as net pens. The SMP Guidelines also recommend conditional use permits for the following types of uses or developments:

- Uses and development that may significantly impair or alter the public's use of the water areas of the state.
- Uses and development which, by their intrinsic nature, may have a significant ecological impact on shoreline ecological functions or shoreline resources depending on location, design, and site conditions.
- Development and uses in critical saltwater habitats.

Depending on the standards in each jurisdiction's shoreline program, commercial net-pen facilities may require a CUP. Local governments may approve CUPs where applicants demonstrate consistency with review criteria found in Ecology rules (WAC 173-27-160). The CUP review criteria include a demonstration that:

- the proposal is consistent with the policies of the SMA (RCW 90.58.020);
- the project's use of the site and the design will be compatible with other authorized uses in the area;
- the proposed use will not cause significant adverse effects to the environment;
- the proposed use will not interfere with the normal public use of public shorelines; and
- the public interest suffers no substantial detrimental effect.

In granting of all CUPs, consideration must also be given to cumulative impacts of additional requests for like actions in the area. CUP decisions are first issued by local governments and submitted to Ecology; all CUP approval are subject to further review by Ecology with the option to approve, approve with conditions, or disapproval.

Variance

The purpose of a variance permit is strictly limited to granting relief from specific bulk, dimensional or performance standards set forth in the applicable master program where there are extraordinary circumstances relating to the physical character or configuration of property such that the strict implementation of the master program will impose unnecessary hardships on the applicant or thwart the policies set forth in RCW 90.58.020. Variances cannot be used to allow uses that are otherwise prohibited.

Commercial net-pen facilities may require a variance if the proposed use is allowed, but a specific bulk, dimensional, or performance standard of the SMP is not being met. Local governments may approve variances where applicants demonstrate consistency with review criteria found in Ecology rules (WAC 173-27-170).

Applying SMP authorities to net pen projects

SMPs are development based comprehensive land use programs that include policies and regulations designed to implement the goals and policies of the SMA considering local planning goals and geographic uniqueness. However, the SMPs apply to new uses and developments and is not retroactive. Each action proposed within the shoreline jurisdiction is reviewed to determine if it meets the definition of development, if the use proposed is allowed in the shoreline environment designation it is proposed within, and if all the SMPs bulk, dimensional, and performance standards (i.e. shoreline buffers, setback, critical areas protections, no net loss of shoreline ecological functions, etc…) are being met.

The role of state agencies in marine net pen aquaculture

There are many regulatory aspects of net pen aquaculture that do not fall under the authority of the SMP. These are regulated and authorized by other state agencies such as WSDA, WDFW, DNR, and Ecology, as described throughout the main body of this guidance document. Below is a brief description of state agency authorities relevant to net pens. SMPs should not be amended to create provisions that duplicate state agency regulations implemented under authorities outside the SMA. Local governments should minimize redundancy between federal, state and local permit application requirements. Measures to consider include accepting documentation that has been submitted to other permitting agencies, and using permit applications that mirror federal or state permit applications, such as the JARPA[20]. For a more detailed description of the agencies roles and regulations, see the Legal Framework chapter.

Washington State Department of Agriculture

WSDA is responsible for fostering the state's aquaculture industry and providing market assistance, as well as supporting monitoring or aquaculture diseases and regulating commercial feed production and distribution.

Washington State Department of Fish and Wildlife

WDFW regulates finfish aquaculture through licensing, permits, and fish health and infrastructure inspection programs. Specifically, WDFW registers aquatic farms, issues marine finfish aquaculture permits, and authorizes live fish transport and importation permits. As a part of these permits, WDFW requires operations plans, escape prevention plans, and receives quarterly reports on the species cultured, quantity harvested for sale, and unit value.

Washington State Department of Natural Resources

WDNR manages state-owned aquatic lands and requires a use authorization (lease) from WDNR for aquatic uses such as commercial net pens.

Washington State Department of Ecology

Ecology's Water Quality Program is authorized to issue NPDES permits for net pen facilities to meet state water quality standards. Marine finfish net pen facilities can be point sources of pollution called concentrated aquatic animal production facilities and as such are required to obtain NPDES water quality discharge permits. In these cases, the NPDES permits that local governments implement through their Municipal NPDES permit do not apply as the operation is getting its NPDES permit directly through Ecology. A SEPA review must be conducted and a

[20] Joint Aquatic Resource Permit Application (JARPA) https://www.epermitting.wa.gov/site/alias__resourcecenter/jarpa/9983/jarpa.aspx

threshold determination must be made prior to Ecology considering and issuing the NPDES permit to the net pen owner. The local government is usually the lead agency for SEPA making a threshold determination[21] for new marine net pen operations because these proposal are not categorically exempt under WAC 197-11-800. NPDES permits require permittees to perform sediment, water quality, and fish escape monitoring and reporting, enhanced emergency response planning and training, pollution prevention, net hygiene, regular maintenance, and structural assessments by licensed professional engineers.

The main body of this guidance document is intended to inform state agencies, local governments, and potential net pen operators, so not all the recommendations are applicable to SMP amendments or implementation. The following sections highlight the most relevant information and recommendations for local government SMP implementation. This is focused around project specific siting, because that falls most clearly within local governments SMP implementation authorities.

Information and Guidance for Local Governments

The main body of this guidance document is intended to inform state agencies, local governments, and potential net pen operators. As such, not all the recommendations are applicable to SMP amendments or implementation. The following sections highlight the most relevant information and recommendations for local government administered SMPs. These are primarily focused around project specific siting, which falls within local governments SMP implementation authorities.

Siting for water quality protection

Site specific water quality and bathymetric/tidal current near and far-field modelling is necessary for siting new net pens. Project proponents must work with local jurisdiction using their Shoreline Master Program criteria and site-specific data to best locate suitable locations for a net pen facility.

Avoiding areas of Puget Sound with low dissolved oxygen is critical to prevent further impairment. Puget Sound and other waterbodies in the state of Washington are assessed on a regular basis for water quality including dissolved oxygen. The Washington State Department of Ecology maintains this list, which is called the Clean Water Act 303(d) list, and provides a mapping tool that can be used to identify known areas in Puget Sound with dissolved oxygen impairments (https://ecology.wa.gov/Water-Shorelines/Water-quality/Water-improvement/Assessment-of-state-waters-303d). Future net pens should not be located in any area of Puget Sound that is considered impaired for dissolved oxygen. Site-specific analysis should include near and far-field assessment so no other portion of Puget Sound with dissolved oxygen impairment is affected by the location of the net pen facility.

See the Water quality section of Environmental Consideration: Risks and Best Practices for more information.

[21] WAC 197-11-797

Siting for sediment quality protection

Deposition of organic matter leading to degradation of the benthic environment is a well-documented risk associated with net-pen aquaculture (Nash 2003 and Hawkins et al. 2019). In Washington State, local jurisdictions play an important role in applying the siting criteria of potential net pens to reduce and mitigate benthic impact. Siting of net pen facilities in deep areas with sufficient flushing and consideration of the cumulative effects of multiple farms and farm size are among the best tools for minimizing long-term harmful impacts to the surrounding sea floor. (Hawkins et al. 2019). Another important component is siting net pens over erosional substrates which helps prevent the accumulation of organic compounds (Price and Morris 2013). Project proponents work with local jurisdiction using their Shoreline Master Plan criteria and site-specific data to best site a net pen facility.

WDFW requires that net pen operations fallow between grow-out operations to break any disease transmission cycle. NPDES permits require similar length fallowing for the benthos to assimilate the nutrients to further reduce the impact from any excess feed, fish waste, and biofouling debris that has concentrated under the pens. Local governments may want to review their aquaculture or net pen provisions to ensure this practice will not result in a loss of nonconforming status or is not otherwise discouraged by the SMP.

See the Benthic environment section of Environmental Consideration: Risks and Best Practices for more information.

Siting for critical saltwater habitat protection

As described above, the SMA requires counties, towns, and cities with shorelines to develop and implement Shoreline Master Programs (SMPs). As a general master program provision, WAC 173-26-221(2)(c)(iii) states "Critical saltwater habitats include all kelp beds, eelgrass beds, spawning and holding areas for forage fish, such as herring, smelt and sandlance; subsistence, commercial and recreational shellfish beds; mudflats, intertidal habitats with vascular plants, and areas with which priority species have a primary association. Critical saltwater habitats require a higher level of protection due to the important ecological functions they provide." Critical saltwater habitat protection standards within a SMP can also be addressed through the local government as fish and wildlife habitat conservation areas under their critical areas protection standards.

Various aspects of net pen aquaculture may potentially threaten the presence and sustainable ecological function of sensitive and critical saltwater habitats in Washington's marine systems. Therefore, the siting of net pens must avoid potential impacts to critical saltwater habitat.

See the Siting section of Environmental Consideration: Risks and Best Practices for more information.

Navigation and Use Conflicts

New net pen operations, due to their location in open marine waters, have the potential to pose a navigational risk, interrupt normal public access to state waters, or conflict with other preferred or priority uses. Local governments should work with the U.S. Coast Guard to ensure that potential sites avoid navigation channels and minimize any risk to public safety.

The SMA contemplates this issue, by protecting the public rights of navigation and corollary rights incidental thereto. The SMA policy goes on to establish that “permitted uses in the shoreline of the state shall be designed and conducted in a manner to minimize, insofar as practical, any interference with the public’s use of the water.” (RCW 90.58.020)

Marine net pen farms are located in the “Aquatic” shoreline environment designation under SMPs. WAC 173-26-211(5)(c)(ii)(D) addresses development and uses within the “Aquatic” SED and provides that:

“All development and uses on navigable waters or their beds should be located and designed to minimize interference with surface navigation, to consider impacts to public views, and to allow for the safe, unobstructed passage of fish and wildlife, particularly those species dependent on migration.

Submittal requirements for shoreline permits

WAC 173-27 establishes the procedures and requirements for shoreline permits. Local governments must provide notice and a comment period of at least a 30 days for all shoreline permits. This notification process is usually carried out as part of an integrated local permit notification procedure that includes posting of notice on the proposed development site and mailing or emailing of notice to adjacent property owners, state agencies, and tribes. WAC 173-27-180 establishes the minimum application requirements for shoreline substantial development, conditional use, and variance permits. These minimum requirements can be augmented with additional use specific requirements. Some flexibility should be built into the SMP for aquaculture, as provided in the SMP Guidelines. Pursuant to WAC 173-26-241(3)(b)(i)(B), the SMP should acknowledge that:

“Potential locations for aquaculture are relatively restricted due to specific requirements for water quality, temperate, flows, oxygen content, adjacent land uses, wind protection, commercial navigation, and in marine water, salinity. The technology associated with some forms of present-day aquaculture is still in its formative stages and experimental. Local shoreline master programs should therefore recognize the necessity for some latitude in the development of this use as well as its potential impact on existing uses and natural systems.”

However, this flexibility is not provided without limitation. WAC 173-26-241(3)(b)(i)(C) provides that:

“Aquaculture should not be permitted in areas where it would result in a net loss of ecological functions, adversely impact eelgrass and macroalgae, or significantly conflict with navigation and other water-dependent uses. Aquacultural facilities should be designed and located so as not to spread disease to native aquatic life, establish new nonnative species which cause significant ecological impacts, or significantly impact the aesthetic qualities of the shoreline. Impacts to ecological functions shall be mitigated according to the mitigation sequence described in WAC 173-26-201 (2)(e).”

Therefore, the SMP permit submittal requirement may need to be augmented to ensure that the local government has enough information to conclude that new proposed net pen aquaculture is sited consistent with the policy above. Additionally, the local government may need to place project specific conditions to ensure the full purpose and intent of the SMA policy and the SMP is met by a particular proposal. The following are a list of recommendations for local governments to consider when receiving, reviewing, or conditioning new net pen aquaculture proposals. These recommendations are based on the current science concerning impacts from marine finfish aquaculture operations, best management practices, and recommendations contained within pervious sections of this guidance documents.

Guidance for Local Governments

Best practices to protect sensitive habitats

- Project proponents should submit a characterization and analysis of the marine environment within and adjacent to the proposed net pen farm, including the following:
    - Water Quality
    - Benthic Quality
    - Adjacent and nearby sensitive and critical saltwater habitats
    - Aquatic vegetation
    - Existing facilities and land uses adjacent to the site
- Require comprehensive site assessments that characterize localized physical, chemical and biological conditions, when new facilities are proposed.
- Net pens should be sited appropriate distances away from sensitive and critical saltwater habitat. Measures to avoid impacts should be applied based on specific site conditions.
- Minimum depths may be required when net pens and mooring systems are proposed in close proximity to aquatic vegetation.
- Net pens and mooring systems should never be located over native aquatic vegetation that are protected through the SMPs critical saltwater habitat or critical areas protection standards.
- Mooring systems should be sited appropriate distances away from vegetation to prevent physical damage.

Best practices to protect water quality and the benthic environment

- Conduct site-specific water quality and bathymetric/tidal current modelling. This is essential to appropriately site new net pens.
- Locate net pens only in areas not considered impaired for dissolved oxygen. Site-specific analysis should include near and far-field assessment so no other dissolved-oxygen-impaired portion of Puget Sound is affected by the location of the net pen facility.

- Locate farms and individual pens for adequate water flow to ensure dissolved oxygen is available to the fish and nutrients are mixed and assimilated.
- At a minimum, locate farms in waters at least twice as deep as the pens, or allow for at least 15 meters between the pen bottom and substrate (Cardia and Lovatelli 2015).
- If a site shallower than the depths listed above is desired, use a model to demonstrate that local conditions will be favorable for water exchange and that specific environmental conditions (current) or management practices (feed levels or biomass) will prevent adverse effects to the benthos.
- Avoid areas known to be nutrient sensitive and that may develop algal blooms.
- Avoid areas where currents will bring waste into shallow or enclosed areas.
- Avoid areas where fish kills have occurred.
- Avoid areas that are known to have turbidity levels above the standard levels explained in WAC 173-201A-210.
- Locate pens where larger sediment particle sizes may allow for faster mineralization of deposited material (Martinez-Garcia et al. 2015).
- Allow for net pen facilities to fallow their pens between harvest and restocking or as needed to rotate between pens.

Other best practices and siting considerations

- Local and state agencies shall notify the appropriate tribal governments when a marine net pen operation is proposed.
- Consult with the U.S. Coast Guard during the permitting process to avoid recognized shipping lanes and protect public safety.
- Consult with the U.S. Coast Guard during permitting process, and regularly thereafter, to ensure minimum marking and lighting requirements are met.
- Unless necessary, lighting should be minimized, with the exception of lights required by the U.S. Coast Guard for purposes of navigation and safety.
- Ensure compliance with local requirements related to aesthetics, lighting, and noise.
- Equipment that produces significant noise should be shrouded appropriately to minimize disturbance to wildlife and local residents.
- Farms should mark gear that could conceivably be blown or washed away so it can be identified and recovered.
- If the net pen proposal includes structures proposed within 1500 – 2000 feet of the shoreline, a view study or visual impacts assessment may be necessary to demonstrate potential aesthetic and use conflicts.

- When appropriate, local governments should perform an analysis of use conflicts between floating aquaculture and other water dependent uses to inform siting decisions.

Appendix B. Fish Health Glossary

AQUATIC FARMER: “a private sector person who commercially farms and manages the cultivating of private sector cultured aquatic products on the person's own land or on land in which the person has a present right of possession” (Chapter 15.85.20(2) RCW).

ASSUMED PATHOGEN PREVALENCE LEVEL (APPL): The percent of any Lot of fish that is assumed to have a pathogen at a detectable level; for surveillance purposes that level is usually 2, 5, or 10%. This detection level is used to determine the sample size needed to provide a 95% confidence level of including at least one infected fish in the sample. See Appendix D and Sampling Chapter in USFWS/AFS-FHS Standard Procedures for Aquatic Animal Health Inspections (http://afs-fhs.org/bluebook/inspection-index.php)

AUTHORIZED TESTING LABORATORY: A facility that meets the following criteria:

- Maintains a quality assurance program with third party facility and procedural review such as through the American Association of Veterinary Laboratory Diagnosticians (AAVLD), ISO 17025, or the American Fisheries Society Fish Health Section (AFS-FHS) Quality Assurance Program for Laboratories (https://units.fisheries.org/fhs/certification/fish-health-laboratory-qaqc-program/), and
- Performs assays in accordance with the AFS FHS Blue Book: Suggested Procedures for the detection and identification of certain finfish and shellfish pathogens or other standards as authorized by the Director or their designee.

BASELINE MORTALITY: Baseline mortality or morbidity" is defined as mortality or morbidity in excess of normal for a population in a specific geographic area.

BIOSECURITY: Precautions taken to minimize the risk of introducing, establishing, and spreading an infectious disease in an aquatic animal population. This includes, but is not limited to, disinfection of equipment, use of foot baths, limiting personnel movement, fish health monitoring, and general cleaning practices.

CERTIFIED FISH HEALTH SPECIALIST: An individual with specialized training in evaluating the health of aquatic animals. This individual must have knowledge of the biology and life history of the animal, husbandry practices, disease identification, sample collection, disease treatments, and the aquatic ecosystems inhabited by both wild and cultured animals. This may include state licensed USDA Category II Accredited veterinarians, American Fisheries Society/Fish Health Section (AFS/FHS) Certified Fish Pathologists and Fish Health Inspectors.

CONFIRMATORY TEST: A confirmatory test or assay establishes the accuracy or correctness of the finding in the screening or presumptive assay. The confirmatory assay method should be different from that of the screening assay to ensure the accurate identification of the pathogen. Traditionally the screening method has greater sensitivity to detect small numbers of organisms and the confirmatory method has greater specificity to identify what organism has been detected.

DIAGNOSTIC TEST: A diagnostic test or assay is used on individuals exhibiting signs of disease to help determine the cause. These assays may be the same as the screening test and may require confirmatory tests to identify the pathogen.

DISEASE CONTAINMENT PLAN: A yearly plan required for each Farm Site that is designed to reduce the risk of spreading pathogenic agents among net-pens, Farm Sites, and to Free-Ranging fish if pathogens are present in the cultured population. Minimum requirements for the plan are outlined in Chapter 9.

DISINFECTION: Disinfection is the process of cleaning and applying chemicals to inactivate pathogenic agents on potentially contaminated items. Recommended procedures may be found in the Pacific Northwest Fish Health Protection Committee's Model Policy Section 6 (1989 or current edition, link found at https://drive.google.com/file/d/0Bz5kwZ2PeZQrcjdhWUxLTC1RMFU/view); the Maine Aquaculture Association Finfish Bay Management Agreement Appendices F and G (2015 or current edition); and the OIE Aquatic Animal Code Chapter 4.3 Disinfection of Aquaculture Establishments and Equipment (current edition link http://www.oie.int/index.php?id=171&L=0&htmfile=chapitre_disinfection.htm).

EPIZOOTIC: The occurrence of a specific disease in a specific geographic area and population, at a specific time, with mortality or morbidity in excess of baseline.

ENDEMIC: see Pathogen.

EXOTIC: see Pathogen.

FALLOWING AND FALLOWING PERIOD: Fallowing is the process by which aquatic animal premises are kept vacant of animals for the control and management of pathogens. The fallowing period is the interval between the time fish are removed and when they are restocked to the Site. The fallowing period begins upon completion of the cleaning and disinfection of all pens and equipment at that Site.

FARM SITE: A group of marine rafts or net-pens in close proximity that are managed as a unit or farm. For pathogen control and management purposes, no Farm Site can include rafts that are greater than 1.0 kilometer apart. The boundary of a Farm Site is defined in the Disease Containment Plan.

FISH TRANSFER: Movement of live fish and/or the viable sexual products of fish into, within, or out of Washington State waters to include any movements between net-pen sites or between salt and fresh water sites.

FREE-RANGING FISH: (see also Wild Fish): Fish that are free to migrate in the natural environment and includes both wild (natural-origin) fish and fish released from hatcheries.

INFECTION: Infection means the presence of a multiplying or otherwise developing or latent pathogenic agent in a host. This term is understood to include infestation where the pathogenic agent is a parasite in or on a host.

INSPECTION: Observation of fish in all net-pens at the Farm Site and a statistically based on-site collection of fluids and/or tissues from all lots of aquatic animals at the Farm Site. Fish selected for tissue collection will include moribund and recently dead fish if present, and be collected from more than one net-pen and raft if there are multiple rafts in use at the Farm Site. All fluids and tissues collected during an inspection will be tested by an Authorized Testing Laboratory for the detection of Regulated Pathogens in accordance with procedures set forth or referred to in this Plan.

INSPECTOR: A Certified Fish Health Specialist employed by the Department.

LOT: A group of fish that is composed of the same species and year class originated from the same discrete spawning population have always shared a common water supply in the case of a group being split into two subgroups, such as delayed or accelerated egg incubation, are not expected to have different exposure to pathogens in the water supply based on the timing created by the temperature manipulation in the case of adult broodstock, various age groups may comprise the same "Lot" provided they are of the same species and have shared the same water supply while brood fish.

MONITORING: Periodic sampling and disease detection work performed by a Certified Fish Health Specialist employed or contracted by the Aquatic Farmer in accordance with procedures set forth or referred to in this policy.

NET-PEN: An individual cage, pen or containment unit within which a single year class of fish can mingle. A single net-pen would be considered the smallest management unit on the Farm Site or Raft.

NOTIFICATION: The procedure by which findings of Regulated and Reportable Pathogens and fish escape events are reported by the aquatic animal farmer to the appropriate State, Federal, and Tribal officials as described in the Communication, Notification and Reporting Requirements Chapter of this Plan. Communication of these events must be done in a way that the aquatic animal farmer receives an acknowledgement of the notification to ensure there is no delay in implementing the appropriate response actions.

OUTBREAK: The sudden onset of disease with varying mortality or morbidity that spreads rapidly among individuals in geographic area or in a population.

PATHOGEN or PATHOGENIC AGENT: Pathogen or Pathogenic Agent means an organism that causes or contributes to the development of a disease. The following are some important categories of pathogens:

- **Emerging** – A known pathogen or genetic variant of a pathogen that has newly appeared in a population or that has been known for some time but is rapidly increasing in incidence or found in a new geographic area. Also, a newly identified infectious agent or an infectious agent not previously associated with disease, whose incidence is increasing and associated with specific disease signs in the population in which it is being found.
- **Endemic** – A pathogen or pathogen genetic variant that is known to occur within well-defined geographic boundaries within Washington State.

- **Exotic** - A pathogen or pathogen genetic variant not previously known to occur in Washington State or that is the subject of an eradication program.
- **OIE** – A pathogen listed by OIE in Section 10 (Diseases of Fish) of the Aquatic Animal Health Code. [Section number may change with different editions of the code].
- **Ubiquitous** – A pathogen or pathogen genetic variant known to be widespread in fish within the waters of Washington State.

PATHOGEN GENETIC VARIANT: A specific gene sequence or set of gene sequences that are used to categorize the pathogen into phylogenetic, functional, or geographic units (e.g., pathogenicity, exotic)

PRESUMPTIVE DIAGNOSIS: A diagnosis based on reasonable grounds for conclusions established by previous and commonly accepted experience. It may be used when diagnostic tests are not yet available or cannot be obtained.

PRESUMPTIVE IDENTIFICATION: Detection of a pathogen by a screening assay performed on fish tissues or fluids.

RAFT: Group of net-pens attached to the same floating structure, commonly 6-12 net-pens per Raft. Multiple Rafts within close proximity to each other may be managed as a single Farm Site as long as they are within 1.0 km of each other.

SCREENING TEST: A screening test or assay is used to detect a disease-causing organism in a population not showing signs of disease. Screening tests are often sensitive but not specific so if an organism is detected, a confirmatory test which has greater specificity is used to identify the organism. An example is using cell culture to screen a population for viruses and if there is cytopathic effect (CPE) using molecular techniques such as rt-PCR to identify the virus present.

SIGNIFICANT MORTALITY and MORBIDITY: Any production loss greater than Baseline as defined in this document may be considered significant in the clinical judgement of the Certified Fish Health Specialist.

SITE: see Farm Site

SURVEILLANCE: A systematic series of investigations of defined populations of aquatic animals, conducted to detect the presence of specific pathogens and diseases. These investigations could include inspections, monitoring, diagnostic procedures and non-lethal examination techniques.

WILD FISH: Naturally-born fish from a native species that is Free-Ranging.