PEI Seafood Industry Climate Change Adaptation Strategy Report

Contents

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- Prince Edward Aqua Farms, Inc.
- Prince Edward Island Aquaculture Alliance
- Prince Edward Island Energy Corporation
- Prince Edward Island Fishermen's Association
- Prince Edward Island Seafood Processors Association
- Prince Edward Island Shellfish Association
- Raspberry Point Oyster Company, Inc.

Key Terms

The *Prince Edward Island Building Resilience: Climate Adaptation Plan* defines two paths for addressing climate impacts:[1]

- **Climate adaptation:** Actions to prepare for the inevitable impacts of climate change. This includes actions such as avoiding building in high-risk places, designing bridges to accommodate rising sea levels, preserving natural spaces that can absorb heavy rainfall, and preparing for extreme weather events by having an emergency kit and plan.
- **Climate mitigation:** Actions that stop climate change from getting worse. This includes actions such as reducing greenhouse gas emissions, changing to cleaner sources of fuel and power, and planting trees.

This report specifically focuses on **climate adaptation** measures that will increase the resilience of the seafood industry to climate change.

[1] PEI Department of Environment, Energy and Climate Action. "Prince Edward Island Building Resilience: Climate Adaptation Plan." October 27, 2022. https://www.princeedwardisland.ca/sites/default/files/publications/building_resilience_climate_adaptation_plan_oct_2022.pdf

Introduction

Climate change presents a unique set of challenges and some opportunities for Prince Edward Island's (PEI) seafood industry. The Province of PEI has already taken steps to understand and prepare for climate change (see textbox for recent actions). Government commitments and reports commissioned in recent years have paved the way for this seafood focused climate change adaptation plan. This report builds on the findings of the 2021 province-wide *Climate Change Risk Assessment* and the 2023 seafood-specific *PEI Climate Change Risk and Opportunity Assessment for the Seafood Industry* completed as part of this adaptation planning effort (see the Appendix: Overview of the Climate Change Risk and Opportunity Assessment for a summary of key findings). This assessment also partially fulfills Action 13 in the 2022 *Building Resilience: Climate Adaptation Plan*, which commits the province to working with industry partners to identify priority risks to the seafood industry.

Timeline of Key Climate Actions

- 2018: Taking Action: A Climate Change Action Plan for PEI, 2018-2023, includes a commitment to taking proactive measures to reduce PEI's vulnerability to climate change as well as taking advantage of new opportunities.
- 2019: Former Department of Fisheries and Communities Mandate Letter, outlines department priorities, including developing research and knowledge to better understand and promote sustainable fisheries industries.
- 2021: Former Department of Fisheries and Communities Strategic Plan 2021-2024, outlines the department's action items to support a sustainable and growing fishing industry.
- 2022: Building Resilience: Climate Adaptation Plan, includes an action to identify and respond to priority climate risks to the farming, fishing, and tourism sectors.
- 2023: Department of Fisheries, Tourism, Sport, and Culture Mandate Letter, outlines department priorities, including using evidence-based tools to consider the impacts of climate change in the decision-making process.

The Department of Fisheries, Tourism, Sport and Culture (DFTSC) is committed to working with industry partners to establish programs and initiatives that will help ensure sustainable growth and bolster the resilience of the PEI seafood industry in the face of climate change. DFTSC held a series of workshops with industry representatives in August and October 2023 to vet high priority risks facing each seafood subsector and discuss potential adaptation actions. This report outlines several potential priority adaptation actions that DFTSC can take to help support the seafood industry to adapt to climate risks. This report does not prescribe specific adaptation actions for harvesters, growers, and processors, but instead focuses on providing options for provincial-level programs and initiatives related to educational training, infrastructure, planning efforts, research needs, and monitoring activities. Involvement from the federal and provincial governments, industry partners, and the Mi'kmaq of PEI will be critical to the design and successful implementation of the programs and initiatives proposed in this report.

Adaptation in Practice

DFTSC is committed to supporting a sustainable and resilient seafood industry and is already involved in several climate adaptation initiatives including participating in resilience working groups and committees, collaborating and building connections with federal partners, and researching and monitoring key climate and biological variables.

The *2023 DFTSC Mandate Letter* tasks the department with using evidence-based tools to consider the impacts of climate change in the decision-making process. DFTSC has been working to identify and understand its climate risks through internal efforts such as the *PEI Climate Change Risk and Opportunity Assessment for the Seafood Industry*. These efforts have outlined key findings related to climate risks and adaptation options, as well as opportunities for climate mitigation and sustainability and provide a foundation for DFTSC to make climate change-informed decisions.

The province also released the *Building Resilience: Climate Adaptation Plan* in 2022, which is designed to incorporate climate adaptation in planning and program delivery across the provincial government. The plan tasks DFTSC with leading or collaborating with other departments on implementation of 15 adaptation actions, 12 of which have a strong relationship to increasing seafood industry resilience:

- *Lead:*
    - Action 13: Partner with Industry to Respond to Climate Risks of Farm, Fishing, and Tourism Sectors
    - Action 14: Regional Supply Chain Resilience Study
- *Collaborator:*
    - Action 1: Enhance Emergency and Extreme Weather Preparedness and Response
    - Action 2: Develop a Coastal Flood Warning System
    - Action 4: Increase Backup Power for Critical Infrastructure
    - Action 6: Create a Provincial Land Use Plan
    - Action 7: Develop Province-wide Stormwater Management Standards
    - Action 8: Increase Resilience of Public Infrastructure
    - Action 17: Extreme Heat Strategy
    - Action 21: Coastal Development and Habitat
    - Action 25: Research, Monitor, and Model Local Climate Conditions and Impacts
    - Action 26: Provide Expertise and Resources to Departments for Climate Adaptation

DFTSC already participates in several committees, task groups and working groups, to discuss the threats of climate change and potential solutions and advocate for PEI seafood industry needs.

In addition to broader collaboration efforts, DFTSC also actively participates in or leads several monitoring programs and research projects to better understand climate risks to the seafood sector and inform adaptation strategies. Examples include:

- **Lobster Resource Monitoring Program (LRMP):** This program is a collaboration between the PEI Fishermen's Association (PEIFA), Fisheries and Oceans Canada (DFO), and DFTSC. The objective of this program is to collect data from harvesters and commercial vessels on lobster populations around PEI. The program aims to analyze trends in the population, such as size structure, abundance, and catch rates, to inform fishery management decisions.
- **Oyster Monitoring Program:** This program provides information on spat-fall prediction to assist oyster farmers in determining when to deploy their spat collectors.
- **Mussel Monitoring Program:** This program provides information to assist mussel growers and processors in the management of their operations. Information collected includes mussel meat yield, numbers of potentially toxic algae species, and the monitoring of predators and fouling organisms.
- **Water Temperature Maps**: This dashboard provides historical water temperature data from multiple channels around PEI, including oyster growth sites.
- **Lobster Bait Research:** DFTSC completed a research project on alternative bait options for the PEI lobster fishery to reduce overreliance on Atlantic mackerel for bait. This study included an assessment of bait alternatives on the island and an economic sensitivity analysis for one of the most promising bait options.
- **Climate Proofing Blue Mussels (Genome Atlantic):** DFTSC provides support to a blue mussel genomic study to eventually promote selective breeding programs aimed at enhancing resilience of mussels to the changing climate.

The adaptation actions presented in this report are intended to build upon DFTSC's existing adaptation efforts. DFTSC will need to work closely with the federal and provincial governments, industry partners, academic institutions, and the Mi'kmaq of PEI to achieve many of the proposed actions outlined in this report.

Industry Case Study Examples

As part of this project, DFTSC conducted site visits with Acadian Supreme Inc., Prince Edward Aqua Farms Inc., and the Raspberry Point Oyster Company Inc., to better understand how these businesses have been affected by and are adapting to extreme climate change-related events. Although individual adaptation actions for harvesters, growers, and processors are not the focus of this seafood-specific adaptation plan, individual entities are also taking actions to build resilience to extreme weather events and climate change.

Figure 1. Storm surge at Acadian Supreme during Post-Tropical Storm Fiona. Image from Acadian Supreme.

Acadian Supreme, Inc.

Figure 2. Critical electrical equipment at Acadian Supreme. Image from ICF.

Acadian Supreme, Inc., a lobster processing facility on the Island's south side, experienced $600,000 to $700,000 in damages from Post-Tropical Storm Fiona in 2022, including loss of live lobster and infrastructure damage. The *PEI Climate Change Risk and Opportunity Assessment for the Seafood Industry* found that power outages during extreme weather events, such as a post-tropical storm, pose the greatest risk to the processing sector. Acadian Supreme does have an on-site diesel generator which is typically capable of maintaining power during extreme weather events. Unfortunately, the storm surge from Post-Tropical Storm Fiona was so severe that the generator was inundated and damaged. The affected generator was used as a power source for maintaining live lobster holdings. Despite these losses, Acadian Supreme was still able to resume buying operations withing three days and processing operations within five days.

Figure 3. Newly elevated electrical box following Post-Tropical Storm Fiona. Image from ICF.

As Acadian Supreme continues to recover, they are taking several actions to increase resilience to future extreme weather events. For example, as Acadian Supreme replaces the lost generator, they are also elevating the generator above the floodwater levels experienced during Post-Tropical Storm Fiona to better protect against power failures during future storms. They have also elevated their electrical equipment in the parking lot (Figure 3). However, they were limited in how high they could elevate the equipment due to the length of the existing electrical wire. Further adjustments would require coordination with Maritime Electric. They are also considering options for waterproofing the electrical room and elevating refrigeration and pump equipment.

In addition to the efforts made by Acadian Supreme, the Abram-Village, Egmont Bay federal harbour adjacent to Acadian Supreme is being repaired and raised 4 feet from its previous height, as part of a federal project.

Prince Edward Aqua Farms, Inc.

Ahead of Post-Tropical Storm Fiona, Prince Edward Aqua Farms, Inc. sank all of their mussel lines, a strategy aimed at reducing risk of losing or tangling the lines and buoys. However, even with this precaution, the storm caused significant losses. In Malpeque Bay, the deep turbulent waters and tide spun spat collector ties one way and then the other way when the tide changed, knotting and tangling the lines. In other operating areas, the intensity of the storm's waves dislodged lines from their anchors, which then became tangled. The conditions of each post-tropical storm are different, making it difficult for mussel farmers to plan and strategize for these types of events.

Figure 5. DFTSC barge retrieves bundle of rope and buoys. Image from DFTSC and CBC News.

In response to greater unpredictability in the winter season and changing climate conditions, Prince Edward Aqua Farms began many years ago to buy leases in different areas to diversify operations across the island. Diversifying operations can help build resilience and soften the shock to overall operations as only some leases may experience significant losses from a given event. Past post-tropical storms have demonstrated that the severity of impacts on mussel leases across PEI is not consistent and is dependent on the specific characteristics of the storm (landfall location, wind direction and speed, etc.) as well as tidal conditions during the event.

Figure 4. Mussel processing operations at Prince Edward Aqua Farms. Image from DFTSC.

Finally, after a severe ice storm shut down operations for 5 days in 2008, Prince Edward Aqua Farms invested in a backup generator to maintain operations during future power outages. They also keep an emergency fuel supply on site. With this prior investment, they were able to get back to work immediately following Post-Tropical Storm Fiona.

Raspberry Point Oyster Company, Inc.

The Raspberry Point Oyster Company, Inc., faced significant losses from Post-Tropical Storm Fiona, including the destruction and loss of 5,000-6,000 oyster cages. To lessen the impact of the next storm, the company is transitioning to aluminum cages and using a thicker back line rope, both of which should be more resilient to significant wave and tidal action. The company, also plans to sink as many cages as possible in advance of the next storm, focusing on speed rather than technique to move as many oysters as possible to deeper and less turbulent waters and hope for fewer losses when those cages are returned to the surface after the storm.

Figure 6. Damaged cages from Post-Tropical Storm Fiona at Raspberry Point Oysters. Image from ICF.

To improve facility resilience to flooding, they are elevating low-lying buildings and electrical equipment that were flooded by Fiona before resuming operations. They will also put empty storage trays at the bottom of each stack of oyster pods on their holding lease so that if silt does accumulate into the trays, it doesn't affect any product. This method temporarily reduces storage capacity, but keeps oysters elevated above the silt accumulation.

Finally, the company can keep most of their facilities running for up to a week if there is a power outage due to the usage of many stationary and portable generators. They also intend to install solar panels as a sustainable energy source for their operations.

Adaptation Action Plans

DFTSC worked closely with ICF to identify several potential priority climate adaptation options to help the seafood industry adapt to climate risks. These actions focus on establishing provincial-level programs and initiatives to help support and build capacity across the industry through educational trainings, infrastructure, planning efforts, research needs, and monitoring activities.

ICF first developed an initial list of adaptation options to address key risks identified in the *PEI Climate Change Risk and Opportunity Assessment for the Seafood Industry*. Industry partners participated in a workshop hosted by ICF and DFTSC to provide feedback on the initial adaptation options and assess their priority. ICF and DFTSC used this feedback and the prioritization criteria below (see textbox) to select ten potential priority adaptation actions.

Adaptation Action Prioritization Criteria

- **Relevance:** Does the strategy have relevance to high risks or consequence types from the risk assessment?
- **Effectiveness:** How effective is the strategy at reducing key climate risks/ consequences?
- **Cost:** What is the rough order of magnitude cost of the strategy?
- **Fundability:** How easily can funding be obtained?
- **Barriers to Implementation:** Are there known barriers, such as staff time, technical expertise, regulatory/legal barriers, etc.?
- **Unintended Consequences:** Is there potential for unintended consequences?
- **Acceptance:** To what degree is there industry or public support for the strategy?
- **Timeframe:** What is the implementation timeframe of the strategy?

Figure 7 summarizes the potential priority adaptation actions for addressing climate risks to the seafood industry. The implementation timeframe indicates when implementation of that strategy could begin.

Short-Term	Medium-Term	Long-Term
• Hold climate readiness trainings and presentations • Establish a climate impact monitoring program/database • Establish a seafood industry resilience fund • Collaborate with researchers on innovative design solutions and gear guidelines	• Prepare species-specific adaptation plans • Collaborate with researchers on climate-related biological threats • Continue to support broodstock programs	• Promote diversification to adapt to increased variablity • Continue to assess the feasibility and applicability of managed retreat • Optimize shellfish operations

Figure 7. Climate adaptation actions for the seafood industry.

The adaptation action plans are presented in the following sections. DFTSC would lead implementation of each of these actions and work closely with appropriate federal, provincial, and industry partners as well as the Mi'kmaq of PEI to design and implement the proposed actions. Each action plan includes the following information:

- **Risk(s)** that the action plan addresses from the *PEI Climate Change Risk and Opportunity Assessment for the Seafood Industry*
- **Action type:**
  - Education: actions focused on information sharing
  - Planning: actions focused on managing risks through strategic planning initiatives
  - Infrastructure: actions focused on improving infrastructure resilience
  - Research: actions focused on addressing key knowledge gaps
  - Monitoring: actions focused on data collection and tracking
- **Recommended kickoff timeline:**
  - Short-term: implementation could begin within roughly 1.5 years from now
  - Medium-term: implementation could begin in roughly 1.5 years to 3 years
  - Long-term: implementation could begin in roughly 3 or more years
- **Estimated order of magnitude of cost:**
  - Low: Up to $100,000
  - Medium: $100,000 to $1 million
  - High: More than $1 million
- **Related Provincial Climate Adaptation Plan (PCAP) Actions**
  - Action 13: Partner with Industry to Respond to Climate Risks of Farm, Fishing, and Tourism Sectors
  - Action 15: Climate Change Training
  - Action 21: Coastal Development and Habitat
  - Action 25: Research, Monitor, and Model Local Climate Conditions and Impacts
  - Action 28: Public Awareness of Climate Impacts and Personal Adaptation Actions
- **Implementation timeline after kickoff**, including recommended short-term milestones, medium-term milestones, long-term milestones, and suggestions for monitoring success over time

Potential partners that DFTSC could work with to advance climate adaptation efforts for both the seafood industry and broader adaptation goals for PEI include:

- **Federal & National:**
  - Fisheries and Oceans Canada (DFO)
  - Atlantic Canada Opportunities Agency
  - Environment and Climate Change Canada
  - Natural Resources Canadas
- **Provincial:**
  - PEI Department of Agriculture (DA)
  - PEI Department of Environment, Energy, and Climate Action (DEECA)

  - PEI Department of Transportation and Infrastructure (DTI)
  - Information Technology and Shared Services (ITSS)
- **Crown Corporations:**
  - PEI Energy Corporation
  - PEI Marine Science Organization
  - Efficiency PEI
  - Innovation PEI
- **Other Stakeholders:**
  - Mi'kmaq of PEI
  - Industry associations
  - Academic institutions
  - Centre for Marine Applied Research
  - ClimateSense
  - CLIMAtlantic
  - Genome Atlantic

Overview of Actions

Table 1 provides an overview of the proposed adaptation actions, including action type, recommended kickoff timeline, estimated order-of-magnitude cost, and connections to the PCAP.

Table 1. Summary of all recommended adaptation actions.

Action	Action Type	Recommended Kickoff Timeline	Cost	Connections to PCAP Actions
1. Hold Climate Readiness Trainings and Presentations	 Education	 Short-Term (Kickoff 0-1.5 years)	$ $ $	• **Action 15**: Climate Change Training • **Action 28**: Public Awareness of Climate Impacts and Personal Adaptation Actions
2. Establish a Climate Impact Monitoring Program/Database	 Monitoring	 Short-Term (Kickoff 0-1.5 years)	$ $ $	• **Action 25:** Research, Monitor, and Model Local Climate Conditions and Impacts
3. Establish a Seafood Industry Resilience Fund	 Infrastructure	 Short-Term (Kickoff 0-1.5 years)	$ $ $	• **Action 13:** Partner with Industry to Respond to Climate Risks of Farm, Fishing, and Tourism Sectors
4. Collaborate with Researchers on Innovation Design Solutions and Gear Guidelines	 Research	 Short-Term (Kickoff 0-1.5 years)	$ $ $	• **Action 25:** Research, Monitor, and Model Local Climate Conditions and Impacts
5. Prepare Species-specific Adaptation Plans	 Planning	 Medium-Term (Kickoff 1.5-3 years)	$ $ $	• **Action 13:** Partner with Industry to Respond to Climate Risks of Farm, Fishing, and Tourism Sectors

Action	Action Type	Recommended Kickoff Timeline	Cost	Connections to PCAP Actions
6. Collaborate with Researchers on Climate-related Biological Threats	Research	Medium-Term (Kickoff 1.5-3 years)	$ $ $	• **Action 25:** Research, Monitor, and Model Local Climate Conditions and Impacts
7. Continue to Support Broodstock Programs	Research	Medium-Term (Kickoff 1.5-3 years)	$ $ $	• **Action 25:** Research, Monitor, and Model Local Climate Conditions and Impacts
8. Promote Diversification to Adapt to Increased Variability	Planning	Long-Term (Kickoff 3-6 years)	$ $ $	• **Action 13:** Partner with Industry to Respond to Climate Risks of Farm, Fishing, and Tourism Sectors
9. Continue to Assess the Feasibility and Applicability of Managed Retreat	Planning	Long-Term (Kickoff 3-6 years)	$ $ $	• **Action 21:** Coastal Development and Habitat
10. Optimize Shellfish Operations	Research	Long-Term (Kickoff 3-6 years)	$ $ $	• **Action 25:** Research, Monitor, and Model Local Climate Conditions and Impacts

1. Hold Climate Readiness Trainings and Presentations

Risk: The seafood industry faces climate risks to production, infrastructure, and livelihoods.

Extreme weather and climate readiness training sessions could help the seafood sector better prepare for the impacts of climate change. This training series could focus on how the climate is changing in the province, what those changes mean for the industry (i.e., an overview of the seafood climate risk assessment findings), and what actions and best management practices harvesters, growers, and processors can take to reduce risks to production, harvest, infrastructure, and livelihoods.

Figure 8. Workshop on climate risks to the seafood processing sector in August 2023. Image from ICF.

The seafood sector deals with extreme weather and changing environmental conditions on a regular basis. There are likely best practices and lessons learned from past events that could be applicable for enhancing climate preparedness. As such, these trainings should also include guest presentations from PEI processors, harvesters, and growers to share best practices and lessons learned from actions they are taking to adapt (e.g., in the aftermath of Post-Tropical Storm Fiona) as well as representatives from other jurisdictions that are tackling similar climate risks.

Trainings could be integrated into existing programs like the Future Fisher Program, regular industry board meetings or Annual General Meetings (AGMs) or co-hosted with partner organizations.

Action Type	Recommended Kickoff Timeline	Cost
Education	Short-Term (Kickoff 0-1.5 years)	$ $ $

PCAP Connections

- **Action 15**: Climate Change Training
- **Action 28**: Public Awareness of Climate Impacts and Personal Adaptation Actions

Recommended Implementation Timeline

This action could begin right away, leveraging existing education programs. Table 2 provides recommended interim steps and monitoring priorities to track and advance this initiative after kickoff.

Table 2. Recommended implementation timeline and monitoring.

Short-term Milestones:	• Identify and engage key partners to define roles, responsibilities, and logistics of each organization in producing the trainings. • Work with partners to brainstorm potential topics and guest speakers. • Identify an initial set of trainings/presentations to hold. • Hold at least one information session to share the findings of the *PEI Climate Change Risk and Opportunity Assessment for the Seafood Industry*.
Medium-term Milestones:	• Hold at least three trainings (one per sector) that share best practices and lessons learned from another province or another country. • Integrate climate risks and adaptation considerations into a formal training program for harvesters and growers (e.g., Future Fisher Program).
Long-term Milestones:	• Re-evaluate training needs and topics based on program progress and current events.
Monitoring:	• Conduct regular surveys to gather feedback on training formats and topics, as well as to understand how the content is being applied in practice. • Track how many trainings are held and the number of participants.

2. Establish a Climate Impact Monitoring Program/Database

Given that the climate is constantly changing, the establishment of a centralized program that tracks climate events and their impacts on the seafood industry will allow PEI to better understand how climate change is affecting specific species and stakeholders over time, ultimately better informing future adaptation planning. Measuring success of adaptation efforts would be challenging if the climate events themselves are not tracked.

This new tracking effort could also involve the consolidation of data from existing monitoring programs such as the Lobster Resource Monitoring Program (LRMP), the Mussel Monitoring Program (MMP), the Oyster Monitoring Program (OMP), and various other publicly available open datasets.

Risk: The seafood industry faces climate risks to production, infrastructure, and livelihoods.

Figure 9. Photo of coastal erosion monitoring equipment at Crowbush. Image from: Erosion-mitigating infrastructure (princeedwardisland.ca).

Building a platform or utilizing existing platforms for a comprehensive seafood industry climate monitoring program could involve developing a set of key climate indicators and events to track. Examples could include number of days with inland water temperatures over 30°C, frequency of intense storm events and the financial damages incurred, die-offs during marine heat waves, and prevalence of disease. This program could demonstrate the need for future adaptation efforts, such as increased biological testing capacity or expanded water monitoring programs.

This program could also help to identify data gaps and research needs. For example, water temperature monitoring of very shallow waters and tidal pools is limited and could be an informative datapoint for species like soft shell clams and quahogs. DFTSC could engage research institutions to understand how climate change is affecting temperatures in very shallow waters. This could involve more sampling or a pilot project where researchers model shallow water temperatures based on a relationship to either air temperature or water temperatures further upstream.

Action Type	**Recommended Kickoff Timeline**	**Cost**
Monitoring	Short-Term (Kickoff 0-1.5 years)	$ $ $

PCAP Connections

- **Action 25:** Research, Monitor, and Model Local Climate Conditions and Impacts

Recommended Implementation Timeline

This action is classified as a short-term initiative, since there is an imminent need for monitoring climate impacts, and barriers to implementation are relatively low. Additionally, data collected through this program could help inform other adaptation actions in this report. Table 3 provides recommended interim steps and monitoring priorities to track and advance this initiative after kickoff.

Table 3. Recommended implementation timeline and monitoring.

Short-term Milestones:	• Assess the current state of existing monitoring programs to identify next steps for data consolidation and system integration into a unified platform. • Engage partners to decide on any new climate indicators and events that could be helpful to monitor.
Medium-term Milestones:	• Establish a fully operational centralized climate monitoring platform with data available to a variety of stakeholders. • Identify continued data gaps and research needs.
Long-term Milestones:	• Utilize data to inform and guide additional adaptation planning for the industry.
Monitoring:	• Regularly evaluate data collection (e.g., data quality, usefulness of indicators, data limitations) and database usage and make program adjustments as needed. • Monitor trends and take action when necessary to manage risks identified in the *PEI Climate Change Risk and Opportunity Assessment for the Seafood Industry*.

3. Establish a Seafood Industry Resilience Fund

Risk: Climate change threatens all aspects of the seafood industry, including production, infrastructure, and livelihoods.

As climate change continues to impact the seafood industry, increasing investment in innovative resilience measures will be essential for reducing climate change-related impacts and saving costs over time. This action proposes to establish a seafood industry resilience fund to support the industry in preparing for climate change. Funds could be allocated through competitive grants to individuals or businesses in the seafood sector looking to increase their resilience to climate change-related impacts. To ensure equitable access to funding, there could be different funding streams for different sized operations. DFTSC could also develop proposal support materials to assist smaller fishing and aquaculture operations and encourage collaboration to build collective capacity and deeper relationships.

This program could fund a wide range of projects. Examples of eligible projects could include infrastructure upgrades or retrofits to increase the resilience of critical infrastructure to flooding and extreme weather events (e.g., modifying electrical equipment at processing facilities or investing in mobile assets such as boat hoists). This fund could also support new technologies to reduce climate-related risks, upgrades to gear or equipment to be more resilient to climate hazards, and investments in backup generators or distributed renewable energy sources. In addition to implementation activities, eligible projects under this fund could also include resilience planning activities to minimize disruptions, such as contingency plans, business risk management plans, farm management plans, and emergency preparedness plans. For planning activities, funding recipients could also consider making their plan available to other harvesters and growers as an example template.

After funds are awarded, it will also be important to track the success of each project and share best practices and lessons learned with other harvesters and growers across the industry.

Action Type	**Recommended Kickoff Timeline**	**Cost**
 Infrastructure	 Short-Term (Kickoff 0-1.5 years)	$ $ $

PCAP Connections

- **Action 13:** Partner with Industry to Respond to Climate Risks of Farm, Fishing, and Tourism Sectors
    - This action notes a commitment to establishing funding programs for innovative technologies and practices that reduce risk to the industry.

Recommended Implementation Timeline

This action is classified as a short-term initiative, as initial coordination and program development tasks can be completed relatively quickly and more investment in the industry could facilitate other adaptation actions. Table 4 provides recommended interim steps and monitoring priorities to track and advance this initiative after kickoff.

Table 4. Recommended implementation timeline and monitoring.

Short-term Milestones:	• Identify potential funding partners to assist in acquiring funds and set up initial meetings. • Work closely with key partners to define program specifics, including but not limited to eligible projects, request for applications format and timeline, funding availability, and metrics for evaluating applications.
Medium-term Milestones:	• Develop supporting materials for applications, including example project plans, webinars, etc. • Complete at least the first round of funding allocations.
Long-term Milestones	• Establish a consistent funding source for yearly funding allocations. • Complete additional rounds of funding allocations or scale up if needed.
Monitoring:	• Schedule meetings with partners and stakeholders to review progress and challenges acquiring funding, especially at the start of this program. • Collect regular progress reports from awardees on use of allocated funds and success of resilience projects. • Adjust program specifics and requests for applications based on completed allocations/projects.

4. Collaborate with Researchers on Innovation Design Solutions and Gear Guidelines

Risk: Climate change increases the frequency and intensity of extreme weather events, which pose risk to seafood industry equipment and gear.

This action involves collaborating with researchers and industry stakeholders to identify and implement innovative, climate resilient design solutions for seafood industry gear, equipment, and facilities. Changing climate conditions are already creating challenges for some gear and facilities, including increased biofouling on oyster cages and mussel socks, large scale damage or lost mussel lines and oyster cages after storm events, and damage or destruction of processing facilities and equipment from storm surge and flooding.

Figure 10. Vexar bags with oyster seed inside cages with flotation. Image from: Oysters | Government of Prince Edward Island.

This action could first identify the most at-risk infrastructure and gear and then develop recommendations on what design solutions could be implemented to reduce that risk. DFTSC could work with DTI and DEECA to promote resilience guidelines for seafood industry facilities. Simultaneously, this action could be used as an opportunity to set gear guidelines and best practices. For example, DFTSC could collaborate with industry partners to identify appropriate minimum tensile strength for oyster cages to withstand turbulent waters during storms or the material robustness needed for mussel socks to maintain functionality for long periods of time under higher temperatures. The resultant set of best practices could serve as a benchmark for industry stakeholders, guiding decisions when acquiring or upgrading gear/equipment.

Action Type	**Recommended Kickoff Timeline**	**Cost**
Research	Short-Term (Kickoff 0-1.5 years)	$ $ $

PCAP Connections

- **Action 25:** Research, Monitor, and Model Local Climate Conditions and Impacts

Recommended Implementation Timeline

This action is classified as a short-term initiative, as it is relatively easy to begin implementation and potentially highly impactful. Table 5 provides recommended interim steps and monitoring priorities to track and advance this initiative after kickoff.

Table 5. Recommended implementation timeline and monitoring.

Short-term Milestones:	• Initiate partnerships with researchers, industry stakeholders, and other provincial departments. • Work with stakeholders to compile a list of the most at-risk gear, equipment, and facilities in the seafood industry.
Medium-term Milestones:	• Develop recommended design solutions and gear guidelines for industry equipment.
Long-term Milestones:	• Work with local stakeholders to encourage the widespread use of successful upgraded design solutions and gear guidelines. • Complete development and refinement of a comprehensive set of climate-smart guidelines.
Monitoring:	• Regularly evaluate the efficacy of upgraded gear guidelines in collaboration with researchers, designers, and industry stakeholders. • Routinely check in with industry partners to track uptake and performance and ensure that the adoption of new design guidelines is not cost prohibitive or overly burdensome. • Work with DTI/DEECA to routinely review and update climate-smart guidelines for the sector.

5. Prepare Species-specific Adaptation Plans

Risk: Climate change poses some level of risk to all aquatic species, though individual species' response to environmental changes will differ.

This action involves co-developing adaptation plans with stakeholders and industry associations for individual species to help guide management strategies under future climate conditions. Recognizing that key aquaculture and commercial fishing species are exposed to varied risks from projected climate hazards, these plans will be tailored to each species' unique needs. These adaptation plans will leverage findings from existing resources such as NOAA Fisheries' Climate Vulnerability Assessment Tool and the *PEI Climate Change Risk and Opportunity Assessment for the Seafood Industry*, which evaluated how environmental changes such as increases in temperature and more frequent and intense storms, could affect individual species.

These plans could recommend specific actions such as enhanced monitoring of species health, discussions on seasonal harvesting schedules, and food safety/handling best practices. They could incorporate a framework for implementation, detailing both the step-by-step outline of each action and identifying the specific organizations tasked with executing these actions. The plans could also include a summary of existing best adaptation practices for species, leveraging work conducted in other areas. Following the co-creation of species-level adaptation plans, stakeholders can create connections among the plans to identify shared investment opportunities.

Action Type	**Recommended Kickoff Timeline**	**Cost**
Planning	Medium-Term (Kickoff 1.5-3 years)	$ $ $

PCAP Connections

- **Action 13:** Partner with Industry to Respond to Climate Risks of Farm, Fishing, and Tourism Sectors

Recommended Implementation Timeline

This action is classified as a medium-term initiative, with implementation following other short-term strategies such as the establishment of a climate impact monitoring program, which may influence design of adaptation plans. Table 6 provides recommended interim steps and monitoring priorities to track and advance this initiative after kickoff.

Table 6. Recommended implementation timeline and monitoring.

Short-term Milestones:	• Identify species that may require adaptation plans. • Compile existing best adaptation practices for species management from various sources.

Medium-term Milestones:	• Co-develop and share the adaptation plans for key species. • Implement short-term action items from species-specific adaptation plans.
Long-term Milestones:	• Implement long-term action items from species-specific adaptation plans. • Refine and update the adaptation plans based on preliminary results.
Monitoring:	• Track the progress and impact of the implemented actions on species health and habitat conditions. • Continuously gather feedback from stakeholders and adapt the evergreen strategies as necessary to meet evolving environmental challenges.

6. Collaborate with Researchers on Climate-related Biological Threats

This action proposes collaborating with researchers to better understand and address the potential risks of climate-related biological threats to the seafood industry.

Risk: Changing ecosystem conditions, such as increasing water temperatures, could affect predator-prey dynamics, and increase prevalence of invasive species and climate-driven diseases.

Figure 11. Clubbed tunicate covering aquaculture gear. Image from DFTSC.

As climate change alters environmental conditions, the industry faces increased risks from invasive species, diseases, and predators. For instance, higher temperatures could extend the spawning seasons of pests like the clubbed tunicate and expand the habitats of other invasive species not currently found in PEI. Warmer temperatures may also increase the range of other invasive species not currently present in PEI. A robust research program could assist in identifying and prioritizing the most significant and probable biological threats. Research priorities could be identified through an initial gap analysis. Researchers could then explore these gaps and compile existing research to identify the most significant and probable biological threats. Subsequently, DFTSC could work with industry stakeholders to develop and pilot adaptation strategies to mitigate the identified potential adverse effects. Additionally, a set of policy recommendations or guidelines detailing ongoing management best practices could be developed.

Communication and collaboration with neighboring provinces will be crucial for completing this action, particularly for the aquaculture sector, given the movement of live aquatic animals across the Atlantic Provinces. Additionally, DFTSC could collaborate with U.S. states with similar shellfish aquaculture industries to maintain existing partnerships and create new ones.

Action Type	**Recommended Kickoff Timeline**	**Cost**
Research	Medium-Term (Kickoff 1.5-3 years)	$ $ $

PCAP Connections

- **Action 25**: Research, Monitor, and Model Local Climate Conditions and Impacts

Recommended Implementation Timeline

This action is classified as a medium-term initiative, as developing a specific research plan and refining specific objectives could take time. Table 7 provides recommended interim steps and monitoring priorities to track and advance this initiative after kickoff.

Table 7. Implementation timeline and monitoring.

Short-term Milestones:	• Initiate partnerships with research institutions. • Conduct a gap analysis of existing research on climate-related biological threats to key PEI species to determine specific research needs.
Medium-term Milestones:	• Complete research analysis identifying the most significant and probable biological threats to PEI's seafood industry. • Develop and implement a set of pilot adaptation strategies.
Long-term Milestones:	• Refine and scale promising adaptation strategies. • Use results to establish a standardized set of practices and/or policy recommendations to manage and prevent biological threats. • Update research findings and adaptation strategies in response to new threats and environmental changes.
Monitoring:	• Maintain an active communication channel with industry stakeholders to gather feedback and evaluate the effectiveness of implemented adaptation strategies

7. Continue to Support Broodstock Programs

Risk: Changing ecosystem conditions, such as increased heat, affects growth and survival of aquaculture species.

DFTSC's support for advanced broodstock programs is a strategic response to the evolving challenges of climate change in aquaculture. DFTSC has historically supported mussel breeding research programs, which have examined the genomics and genetics of the blue mussel (*Mytilus edulis*) to identify specific traits that will assist in responses to changing ecosystem conditions and potential variability in the successful collection of naturally spawned seed.

Figure 12. Mussel socks in New London Bay. Image from PEI Mussel Monitoring Program 2022 Report.

This action involves ongoing support for existing mussel broodstock programs and the exploration of research opportunities to understand and enhance the broodstock of other species, such as oysters, rainbow trout, and Atlantic salmon. This could also include potential new measures, such as supporting research and development and/or the evaluation of broodstock methodology to help determine what level of benefits, such as improved yield and resilience to higher temperatures, would be necessary to offset the costs of enhancing hatchery capabilities. This work would be important for decision-making, providing the insights necessary to understand when utilizing an enhanced broodstock is a cost-efficient and sustainable choice for the industry. Informed by this type of research product, alongside others, DFTSC could help provide guidance regarding future financial incentives for local growers to implement advanced broodstock practices. By investing in and promoting research into the genomics and genetic diversity and health of key aquaculture species broodstocks, DFTSC aims to enhance their adaptability to changing environmental conditions. This could involve advocating for selective breeding programs designed to enhance specific traits, including temperature tolerance, disease resistance, and growth rates.

Action Type	Recommended Kickoff Timeline	Cost
Research	Medium-Term (Kickoff 1.5-3 years)	$ $ $

PCAP Connections

- **Action 25:** Research, Monitor, and Model Local Climate Conditions and Impacts

Recommended Implementation Timeline

This action is classified as a medium-term initiative, as it may take time to publish the results of ongoing research which this strategy could leverage. Table 8 provides recommended interim steps and monitoring priorities to track and advance this initiative after kickoff.

Table 8. Recommended implementation timeline and monitoring.

Short-term Milestones:	• Facilitate stakeholder consultations to align industry and research goals. • Identify and engage a team of researchers with expertise in aquatic species genomics/genetics.
Medium-term Milestones:	• Establish partnerships with growers who are interested in the future utilization of advanced broodstock.
Long-term Milestones:	• Develop research-based recommendations that describe how the integration of broodstock practices may occur.
Monitoring:	• Hold meetings with stakeholders, including industry partners and academic collaborators, to review progress and gather feedback. • Adjust research and analysis plans as required, based on ongoing findings and stakeholder input. • Prepare regular progress reports, documenting the development and findings of research projects at each stage.

8. Promote Diversification to Adapt to Increased Variability

Risk: Climate change threatens all aspects of the seafood industry, including production, infrastructure, and livelihoods.

This action could identify opportunities for diversification to manage risks and adapt to increasing variability due to climate change. Diversification could reduce any overreliance on specific locations or species/product types and ultimately increase the resilience of PEI's seafood industry to climate impacts. DTFSC could explore options with Innovation PEI for accelerator or startup opportunities at the harvester/grower, association, or sector level.

Examples of diversification could include decentralizing and spreading out the locations of hatcheries, storage facilities, food processing plants, etc. This could include moving aquaculture operations offshore and into deeper waters. Other opportunities for diversification could include further exploration of potential value-added products from commercial species for more utilization and improved circular economy initiatives (i.e., turning byproducts and waste into other sellable products). There are also a number of different and possibly more resilient aquaculture species that could be farmed on PEI. Species diversification may be more challenging, especially for the commercial fishing sector, as they must stay in their allocated fishing regions. This would also fall under the jurisdiction of DFO and would require significant consultations across the provinces.

Action Type	Recommended Kickoff Timeline	Cost
Planning	Long-Term (Kickoff 3-6 years)	$ $ $

PCAP Connections

- **Action 13:** Partner with Industry to Respond to Climate Risks of Farm, Fishing, and Tourism Sectors
  - This action includes providing guidance and support to shift to practices and products that can better withstand climate impacts.

Recommended Implementation Timeline

This action is classified as a long-term initiative as determining how best to diversify can take significant time and research and the need for diversification is a longer-term priority based on the findings of the *PEI Climate Change Risk and Opportunity Assessment for the Seafood Industry*. Additionally, there may be high upfront costs depending on the type of diversification. Table 9 provides recommended interim steps and monitoring priorities to track and advance this initiative after kickoff.

Table 9. Recommended implementation timeline and monitoring.

Short-term Milestones:	• Identify and engage relevant experts to support diversification across locations, product types, and if feasible, species. • Identify potential partners to assist with the funding and/or development of diversification actions and set up initial meetings.
Medium-term Milestones:	• Complete an analysis or assessment to identify priority diversification actions. This could include a stakeholder/public engagement process with harvesters and growers on PEI. • Create a plan that outlines the implementation details for priority diversification actions, including identifying partners to assist with implementation.
Long-term Milestones:	• Adjust diversification action plans based on stakeholder input and monitoring efforts. • Complete a subset of the priority diversification actions.
Monitoring:	• Hold periodic meetings with stakeholders to review progress and gather feedback. • Define metrics to track the success and effectiveness of diversification actions over time.

9. Continue to Assess the Feasibility and Applicability of Managed Retreat

Risk: Climate change worsens storm surge and flooding and increases the frequency and severity of extreme weather events, threatening coastal infrastructure.

As climate change worsens on PEI, certain risks will be unavoidable and managed retreat may be the only viable solution in the long-term. Managed retreat is the purposeful relocation of buildings and communities away from vulnerable areas. This is typically a last resort that is implemented when engineering solutions are not sufficient to reduce risks associated with a climate hazard. For coastal communities, managed retreat often means moving communities away from the shoreline and allowing the shoreline to move further inland rather than trying to hold its position with structural engineering. This action proposes to assess the feasibility and applicability of managed retreat for seafood industry infrastructure (e.g., buildings, access sites, piers, etc.).

DFTSC could leverage ongoing research (e.g., UPEI, CLIMAtlantic) or fund additional research on managed retreat, with a focus on identifying the appropriate circumstances to pivot to this approach within PEI's seafood industry. This research could help determine the threshold conditions under which managed retreat becomes a viable adaptation action, and what the implications could be for the seafood industry. Investigating past instances of managed retreat in similar industries and regions, and assessing the environmental, social, and economic dimensions involved, will provide critical insights.

DFTSC could also assess the number of marine access sites on the island and prioritize those which are best suited to survive the impacts of climate change. This assessment could inform the relocation of certain coastal assets if managed retreat is implemented. Additionally, DFTSC could invest more funding and resources into prioritized sites to ensure they are equipped to withstand climate impacts. One way DFTSC could determine which sites are most vulnerable is by recording the frequency and scale of repairs at each site. DFTSC could also consider which sites are most critical to operations on the island by collecting usage data for each access site.

Action Type	**Recommended Kickoff Timeline**	**Cost**
 Planning	 Long-Term (Kickoff 3-6 years)	$ $ $

PCAP Connections

- **Action 21:** Coastal Development and Habitat
  - This action highlights the need to limit future development in coastal areas and provide support for relocation outside of vulnerable coastal areas.

Recommended Implementation Timeline

This action is classified as a long-term initiative because managed retreat requires thorough planning to execute effectively and will involve multiple stakeholders. Table 10 provides recommended interim steps and monitoring priorities to track and advance this initiative after kickoff.

Table 10. Recommended implementation timeline and monitoring.

Short-term Milestones:	• Meet with partners to better understand ongoing managed retreat research and findings. • Assemble a team to assess the number of marine access sites on the island.
Medium-term Milestones:	• Complete initial research studies and/or assessments to identify the most at-risk access sites and prioritize assets for relocation.
Long-term Milestones:	• Complete an action plan for relocating and/or reducing access sites on PEI. If applicable, plans could also be created for priority assets that were identified for relocation in initial research studies/assessments. • Complete additional research studies and/or assessments to fill gaps identified in the initial managed retreat research efforts, with a focus on seafood infrastructure.
Monitoring:	• Check in periodically with partners to discuss research progress, knowledge gaps, and any next steps for managed retreat.

10. Optimize Shellfish Operations

This strategy proposes conducting research and monitoring efforts to optimize shellfish operations across PEI. The objective is to gather data on the productivity, sustainability, and resilience of current inshore leases through a changing climate. While DFTSC could encourage and help facilitate this research, it would also include collaboration with individual private lease holders. This research could involve monitoring how different leases respond to climate-related events like intense post-tropical storms, heat waves, and hypoxic episodes. Data collection could focus on identifying key factors—such as water flow, temperature, and type of infrastructure in use—that contribute to successful harvests.

Risk: Changing environmental conditions, such as increasing heat, and more frequent intense storms, due to climate change.

Figure 13. Oyster cages in Western PEI. Image from DFTSC.

Action Type	Recommended Kickoff Timeline	Cost
Research	Long-Term (Kickoff 3-6 years)	$ $ $

PCAP Connections

- **Action 25:** Research, Monitor, and Model Local Climate Conditions and Impacts

Recommended Implementation Timeline

This action is classified as a long-term initiative, as coordinating with the private lease owners and developing a specific research plan and objectives could take time. Additionally, this timeline acknowledges that other research efforts may take precedence. Table 11 provides recommended interim steps and monitoring priorities to track and advance this initiative after kickoff.

Table 11. Recommended implementation timeline and monitoring.

Short-term Milestones:	• Establish a team with expertise in aquaculture, climate, and data analysis. • Identify and prioritize a set of pilot mussel/oyster leases and bays for initial study, engaging private lease holders whose sites are prioritized.
Medium-term Milestones:	• Share preliminary findings with lease holders.

Long-term Milestones:	• Expand the study to include a larger number of leases across various bay areas. • Establish best practices guidelines for sustainable lease management in the face of climate change.
Monitoring:	• Identify metrics to continue monitoring lease performance. • Share regular updates and reports with stakeholders on the progress and findings of the research. • Adjust research methodology and focus areas based on emerging trends and data.

Appendix: Overview of the Climate Change Risk and Opportunity Assessment

The *PEI Climate Change Risk and Opportunity Assessment for the Seafood Industry* evaluated potential impacts of climate change on PEI's aquaculture, commercial fishing, and processing sectors.[2] Figure 14 provides an overview of the six-step process for this assessment. ICF completed this analysis in close collaboration with DFTSC and assessment findings were further vetted with key industry representatives during sector-specific workshops in August 2023.

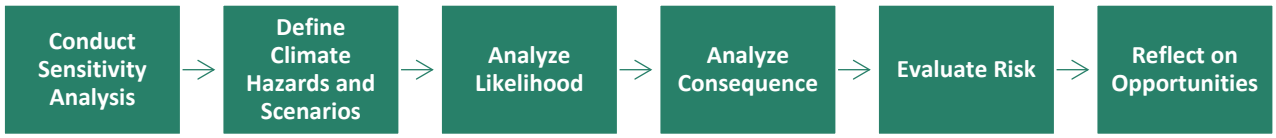

Figure 14. Climate risk and opportunity assessment process diagram.

The climate risk and opportunity assessment focused on 15 species and infrastructure assets that are critical to the aquaculture, commercial fishing, and seafood processing sectors of the PEI seafood industry (Table 12).

Table 12. Focus species or infrastructure assets per sector.

Aquaculture Sector	Commercial Fishing Sector	Processing Sector
1. Mussels 2. Oysters 3. Rainbow Trout 4. Atlantic Salmon	1. Lobster 2. Snow Crab 3. Atlantic Bluefin Tuna 4. Atlantic Mackerel 5. Atlantic Herring 6. Rock Crab 7. Soft Shell Clams	1. Processing Facilities 2. Storage Facilities 3. Buying Stations 4. Inbound/Outbound Transportation

To define the scope of the climate risk and opportunity assessment, ICF first conducted a **climate sensitivity analysis** to identify key climate sensitivities and critical thresholds at which species and assets begin to experience significant impacts. ICF then selected and **defined specific climate hazard scenarios** (Table 13) to further analyze in this assessment. Each scenario represents one possible permutation of that hazard and is used to illustrate the types of consequences associated with the hazard.

[2] This assessment evaluated risks to seafood production, infrastructure, and operations on PEI. It did not, for example, evaluate risks to the shipping of seafood products after the product has left the island. Recognizing that climate impacts to neighboring provinces may also affect PEI's seafood industry, DFTSC will consider opportunities for collaboration with neighboring provinces to adapt to priority risks.

Table 13. Climate hazard scenarios.

Hazard	Scenario	Focus per Sector		
		Aquaculture	Commercial Fishing	Processing
Oceanic/ riverine warming	Average water temperature rises above a species-specific threshold for adults that results in reduced growth, reduced recruitment, or some other indicated non-lethal limit threshold.	X	X	
Marine heat wave	More frequent occurrence of water temperatures above a species-specific lethal limit for adults for mature specimens (if available).	X	X	
Atmospheric heat wave	Three consecutive days with temperatures above 29°C.	X		X
Heavy precipitation and flooding	100mm of rain in 24 hours.	X		X
Post-tropical storm	Multi-day post-tropical storm analogous to Post-Tropical Storm Fiona in 2022.	X	X	X
Acidification	Acidification in the Gulf of St. Lawrence reaches a species-specific threshold (if available).	X	X	
Hypoxia	More frequent hypoxic conditions.		X	
Coastal erosion	Acceleration of the historic rate of erosion (28 cm/year).			X
Ice storm/ freezing rain	Multi-day severe ice storm/freezing rain event in winter.			X

To assess risk, ICF rated the **likelihood** of each hazard scenario occurring (scale of rare (1) to almost certain (5)), and the **consequences** of that scenario on production/output, infrastructure, and livelihoods (scale of insignificant (1) to significant (4)). Risk is a function of likelihood and consequence, so these ratings were combined to calculate risk for present day and 2050 using the risk rating matrix (Table 14) and score-to-rating rubric (Table 15).

Table 14. Climate risk rating matrix.

	Consequence			
Likelihood	**Insignificant**	**Minimal**	**Moderate**	**Significant**
Almost Certain	Low	Medium	High	High
Likely	Low	Medium	Medium	High
Possible	Low	Low	Medium	Medium
Unlikely	Low	Low	Low	Medium
Rare*	Low	Low	Low	Low

*Scenarios that received a “rare” likelihood rating for both the current and future time period were not evaluated further and received a Negligible overall risk rating.

Table 15. Risk rating rubric.

Risk Score	Risk Rating
No score*	Negligible
1-6	Low
7-12	Medium
13-20	High

*Scenarios that received a “rare (1)” likelihood rating for both the current and future time period were not evaluated further and received a Negligible overall risk rating.

Summary of Findings

Table 16, Table 17, and Table 18 summarize the final risk ratings across all species (aquaculture and commercial) and assets (processing).

All four aquaculture species received a high-risk rating for post-tropical storms and mussels additionally face high risk from oceanic/riverine warming and marine heat waves by 2050. Atlantic salmon and rainbow trout may also face moderate risk to atmospheric heat waves, especially if heat waves threaten the power and energy infrastructure. Heavy precipitation and flooding also pose a moderate risk to Atlantic salmon and rainbow trout.

Priority risks for the commercial fishing sector are more varied across species by 2050, including high risk ratings for post-tropical storms (lobster), marine heat waves (Atlantic herring, soft shell clams), and oceanic/riverine warming (snow crab). Atlantic bluefin tuna, Atlantic mackerel, and rock crab did not receive any high-risk ratings.

Unsurprisingly, post-tropical storms emerge as the highest risk by 2050 for processing sector assets, including processing and storage facilities and inbound/outbound transportation. These risks are driven by the potential for significant damage to critical infrastructure and the possibility of an extended power outage. Risk to facilities from atmospheric heat waves are also driven by power outage concerns, which can lead to significant losses of live and refrigerated products.

Aquaculture Sector

Table 16. Aquaculture sector climate risk assessment results.

Hazard	Current Likelihood	2050 Likelihood	Production/ Output	Infrastructure	Livelihood	Current Risk	Future Risk
Blue Mussels							
Oceanic/Riverine Warming	3	5	3	2	4	**Medium (9.0)**	**High (15.0)**
Post-Tropical Storm	4	4	3	4	4	**High (14.7)**	**High (14.7)**
Heat Wave (Marine)	4	5	3	2	3	**Medium (10.7)**	**High (13.3)**
Heavy Precipitation and Flooding	3	4	3	2	2	**Medium (7.0)**	**Medium (9.3)**
Acidification	2	3	3	1	2	**Low (4.0)**	**Low (6.0)**
Oysters							
Post-Tropical Storm	4	4	3	4	4	**High (14.7)**	**High (14.7)**
Heavy Precipitation and Flooding	3	4	3	2	3	**Medium (8.0)**	**Medium (10.7)**
Oceanic/Riverine Warming	1	2	3	2	4	**Low (3.0)**	**Low (6.0)**
Heat Wave (Marine)	1	2	3	2	3	**Low (2.7)**	**Low (5.3)**
Acidification	1	1	N/A	N/A	N/A	**Negligible**	**Negligible**
Rainbow Trout							
Post-Tropical Storm	4	4	4	4	4	**High (16.0)**	**High (16.0)**
Heat Wave (Atmospheric)	3	5	3	3	1	**Medium (7.0)**	**Medium (11.7)**
Heavy Precipitation and Flooding	3	4	2	3	2	**Medium (7.0)**	**Medium (9.3)**
Atlantic Salmon							
Post-Tropical Storm	4	4	4	4	4	**High (16.0)**	**High (16.0)**
Heat Wave (Atmospheric)	3	5	3	3	1	**Medium (7.0)**	**Medium (11.7)**
Heavy Precipitation and Flooding	3	4	2	3	2	**Medium (7.0)**	**Medium (9.3)**

Commercial Sector

Table 17. Commercial sector climate risk assessment results.

Hazard	Current Likelihood	2050 Likelihood	Production / Output	Infrastructure	Livelihood	Current Risk	Future Risk
Lobster							
Post-Tropical Storm	4	4	3	4	3	**High (13.3)**	**High (13.3)**
Acidification	5	5	3	1	3	**Medium (11.7)**	**Medium (11.7)**
Hypoxia	3	4	3	1	3	**Medium (7.0)**	**Medium (9.3)**
Oceanic/Riverine Warming	1	2	4	2	4	**Low (3.3)**	**Low (6.7)**
Heat Wave (Marine)	1	1	N/A	N/A	N/A	**Negligible**	**Negligible**
Snow Crab							
Oceanic/Riverine Warming	3	5	3	2	3	**Medium (8.0)**	**High (13.3)**
Heat Wave (Marine)	3	4	4	2	3	**Medium (9.0)**	**Medium (12.0)**
Post-Tropical Storm	4	4	1	4	2	**Medium (9.3)**	**Medium (9.3)**
Acidification	2	3	2	1	2	**Low (3.3)**	**Low (5.0)**
Hypoxia	3	4	1	1	1	**Low (3.0)**	**Low (4.0)**
Atlantic Bluefin Tuna							
Post-Tropical Storm	4	4	2	3	3	**Medium (10.7)**	**Medium (10.7)**
Hypoxia	3	4	3	1	2	**Low (6.0)**	**Medium (8.0)**
Acidification	2	3	2	1	1	**Low (2.7)**	**Low (4.0)**
Oceanic/Riverine Warming	1	1	N/A	N/A	N/A	**Negligible**	**Negligible**
Heat Wave (Marine)	1	1	N/A	N/A	N/A	**Negligible**	**Negligible**
Atlantic Mackerel							
Heat Wave (Marine)	2	4	4	2	3	**Low (6.0)**	**Medium (12.0)**
Post-Tropical Storm	4	4	2	3	2	**Medium (9.3)**	**Medium (9.3)**
Oceanic/Riverine Warming	2	4	3	2	2	**Low (4.7)**	**Medium (9.3)**
Acidification	2	3	2	1	2	**Low (3.3)**	**Low (5.0)**
Hypoxia	3	4	1	1	1	**Low (3.0)**	**Low (4.0)**

Hazard	Current Likelihood	2050 Likelihood	Production / Output	Infrastructure	Livelihood	Current Risk	Future Risk
Atlantic Herring							
Heat Wave (Marine)	3	5	4	2	3	**Medium (9.0)**	**High (15.0)**
Post-Tropical Storm	4	4	2	3	2	**Medium (9.3)**	**Medium (9.3)**
Oceanic/Riverine Warming	2	4	3	2	2	**Low (4.7)**	**Medium (9.3)**
Acidification	2	3	2	1	2	**Low (3.3)**	**Low (5.0)**
Hypoxia	3	4	1	1	1	**Low (3.0)**	**Low (4.0)**
Rock Crab							
Post-Tropical Storm	4	4	2	3	3	**Medium (10.7)**	**Medium (10.7)**
Oceanic/Riverine Warming	1	3	4	2	3	**Low (3.0)**	**Medium (9.0)**
Hypoxia	3	4	3	1	2	**Low (6.0)**	**Medium (8.0)**
Acidification	2	3	2	1	2	**Low (3.3)**	**Low (5.0)**
Heat Wave (Marine)	1	2	3	2	2	**Low (2.3)**	**Low (4.7)**
Soft Shell Clams							
Heat Wave (Marine)	4	5	4	1	3	**Medium (10.7)**	**High (13.3)**
Oceanic/Riverine Warming	4	5	3	1	2	**Medium (8.0)**	**Medium (10.0)**
Post-Tropical Storm	4	4	3	2	2	**Medium (9.3)**	**Medium (9.3)**
Acidification	3	4	4	1	2	**Medium (7.0)**	**Medium (9.3)**
Hypoxia	3	4	3	1	2	**Low (6.0)**	**Medium (8.0)**

Processing Sector

Table 18. Processing sector climate risk assessment results.

Hazard	Current Likelihood	2050 Likelihood	Production/ Output	Infrastructure	Livelihood	Current Risk	Future Risk
Processing Facilities							
Post-Tropical Storm	4	4	3	4	3	**High (13.3)**	**High (13.3)**
Heat Wave (Atmospheric)	3	5	3	2	2	**Medium (7.0)**	**Medium (11.7)**
Heavy Precipitation and Flooding	3	4	3	3	2	**Medium (8.0)**	**Medium (10.7)**
Coastal Erosion	4	5	1	3	1	**Low (6.7)**	**Medium (8.3)**
Ice Storm/Freezing Rain	4	3	2	2	2	**Medium (8.0)**	**Low (6.0)**
Storage Facilities							
Post-Tropical Storm	4	4	3	4	3	**High (13.3)**	**High (13.3)**
Heat Wave (Atmospheric)	3	5	3	2	2	**Medium (7.0)**	**Medium (11.7)**
Heavy Precipitation and Flooding	3	4	2	3	2	**Medium (7.0)**	**Medium (9.3)**
Coastal Erosion	4	5	1	3	1	**Low (6.7)**	**Medium (8.3)**
Ice Storm/Freezing Rain	4	3	2	2	2	**Medium (8.0)**	**Low (6.0)**
Buying Stations							
Post-Tropical Storm	4	4	3	3	2	**Medium (10.7)**	**Medium (10.7)**
Heat Wave (Atmospheric)	3	5	3	2	1	**Low (6.0)**	**Medium (10.0)**
Heavy Precipitation and Flooding	3	4	2	2	2	**Low (6.0)**	**Medium (8.0)**
Coastal Erosion	4	5	1	2	1	**Low (5.3)**	**Low (6.7)**
Ice Storm/Freezing Rain	4	3	1	1	1	**Low (4.0)**	**Low (3.0)**
Inbound/Outbound Transportation							
Post-Tropical Storm	4	4	4	4	2	**High (13.3)**	**High (13.3)**
Coastal Erosion	4	5	1	3	1	**Low (6.7)**	**Medium (8.3)**
Heat Wave (Atmospheric)	3	5	2	2	1	**Low (5.0)**	**Medium (8.3)**
Heavy Precipitation and Flooding	3	4	2	3	1	**Low (6.0)**	**Medium (8.0)**
Ice Storm/Freezing Rain	4	3	2	2	1	**Low (6.7)**	**Low (5.0)**