# WILD ATLANTIC SALMON BASELINE STUDY

Prepared for

MOWI

Prepared by

LGL LIMITED
Est. 1971
environmental research associates

LGL Report No. FA0287B
April 2025

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Prepared for

**Mowi Canada East Inc.**
2 Salar Crescent
St. George, NB
E5C 3N1

Prepared by

**LGL Limited**
1655 Topsail Road
Paradise, NL
A1L 1V1

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# Acronyms and Abbreviations

| | |
|---|---|
| AAHD | Aquatic Animal Health Division |
| ALS | Accidental Limit State |
| ADCP | Acoustic Doppler Current Profilers |
| AP | Aquaculture Policy |
| AQ | Aquaculture License |
| Ave. | Average |
| BA | Buffer Area |
| BKD | Bacterial Kidney Disease |
| BMA | Bay Management Area |
| C | Celcius |
| CATC | Centre for Aquaculture Technology Canada |
| CFIA | Canadian Food Inspection Agency |
| CHC | Canadian Hurricane Center |
| CI | Confidence Interval |
| CIS | Canadian Ice Service |
| CL | Conservation Limit |
| cm | Centimetres |
| COC | Code of Containment of Salmonids in Newfoundland and Labrador |
| COHFT | Certificate of Health for Fish Transfer |
| COSEWIC | Committee on the Status of Endangered Wildlife in Canada |
| COO | Continent of Origin |
| CPUE | Catch per Unit Effort |
| DAV | Designated Aquaculture Veterinarian |
| DFLR | Department of Fisheries and Land Resources (former name for FFA) |
| DFO | Fisheries and Oceans Canada |
| DU | Designatable Unit |
| ECC | Department of Environment and Climate Change (Government of Newfoundland and Labrador) |
| ECCC | Environment and Climate Change Canada |
| EIS | Environmental Impact Statement |
| EMB | Emamectin Benzoate |
| ESRF | Environmental Studies Research Fund |
| EU | European |
| F1 | First Generation Offspring |
| FFA | Department of Fisheries, Forestry and Agriculture of Newfoundland and Labrador |
| FL | Fork Length |
| FLS | Fatigue Limit State |
| FYC | Fertilization Year Class |
| GPS | Global Positioning System |
| GRI | Global Reporting Index |
| HDPE | High Density Polyethylene |
| HPR | Highly Polymorphic Region |
| IA | Infected Area |

| | |
|---|---|
| IHNV | Infectious Hematopoietic Necrosis Virus |
| IPNV | Infectious Pancreatic Necrosis Virus |
| ISAv | Infectious Salmon Anemia Virus |
| kg | Kilograms |
| L | Litre |
| LRP | Limit Reference Point |
| m | metre |
| MCE | Mowi Canada East Inc. |
| mg | milligrams |
| MNRF | Québec Ministère des Ressources naturelles et de la Faune |
| MSC | Meterological Service of Canada |
| N | North |
| NA | North America |
| NAIA | Newfoundland Aquaculture Industry Association |
| NB | New Brunswick |
| NL | Newfoundland and Labrador |
| NASCO | North Atlantic Salmon Conservation Organization |
| NOAA | National Oceanic and Atmospheric Administration |
| NS | Norwegian Standard |
| PAV | Provincial Aquaculture Veterinarian |
| PCA | Principal Components Analysis |
| PEI | Prince Edward Island |
| PIT | Passive Integrated Transponders |
| ppt | Parts per Thousand |
| PRV | Piscine Orthoreovirus |
| ROV | Remotely Operated Vehicle |
| s | second |
| SARA | *Species at Risk Act* |
| SFA | Salmon Fishing Area |
| SG | Standard for Scottish Finfish Aquaculture |
| SGRP | Salmon Genetics Research Program |
| SJR | Saint John River |
| SLS | Serviceability Limit State |
| SNP | Single Nucleotide Polymorphism |
| SOP | Standard Operating Procedure |
| SWAN | Simulating Waves Nearshore |
| ULS | Ultimate Limit State |
| USR | Upper Stock Reference Point |
| VEC | Valued Environmental Component |
| VHSV | Viral Hemorrhagic Septicemia Virus |
| W | West |

# 1.0 Introduction

As part of the requirements stipulated in the Environmental Impact Statement (EIS) Guidelines for the Indian Head Hatchery Expansion Project (Registration Number 1975), this Wild Atlantic Salmon Baseline Study was prepared. More specifically, this Baseline Study addresses Section 4.3.1 of the EIS Guidelines (see Appendix A of this document; ECC 2024). Mowi Canada East (MCE), through the Indian Head Expansion Project (the Project), is proposing to increase the production of Atlantic salmon (*Salmo salar*) smolt in Newfoundland from MCE established broodstock programs in Atlantic Canada. These smolt will supply MCE's licensed sea farms located on the south coast of Newfoundland. This decreases reliance on smolt from out-of-province sources. As such, two key components of the Project are to increase the production capacity of farmed Atlantic salmon smolt and improve smolt quality at the MCE Indian Head Hatchery (hereafter referenced as Hatchery) in Stephenville, NL. The Project involves upgrades to improve efficiency of the existing Hatchery facility, expansion of the Hatchery to increase production, and installation of supporting infrastructure such as freshwater and saltwater supply and effluent treatment and discharge. The Project also includes the transport, transfer, rearing and harvesting of the additional 2.2 million smolt in MCE's licensed sea farms, which are in Bay Management Areas (BMAs) established under an agreement with the provincial Department of Fisheries, Forestry and Agriculture (FFA) and other salmon growers on the south coast of Newfoundland. These smolt will be stocked at any of the 53 licensed sea farms held by MCE in the Bays East (see Figure 5.2, later) and Bays West (see Figure 5.3, later) areas along the south coast of Newfoundland.

The South Newfoundland population of Atlantic salmon is currently listed as *Threatened* by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and is under consideration for addition to Schedule 1 of the *Species at Risk Act* (SARA). Although Atlantic salmon are not fished commercially in Newfoundland and Labrador (NL), the recreational fishery for this species has social, cultural, and recreational value. In addition, the salmon recreational fishery generates revenue and employment for rural communities in NL, including communities located on the south coast of NL.

Salmon farming within the marine environment may have negative effects on wild salmon populations (e.g., Ford and Myers 2008). Aquaculture operations involving Atlantic salmon in sea cages introduce the risk of escaped farm fish breeding and/or competing with wild Atlantic salmon, thereby potentially affecting the integrity of the wild population. In addition to the potential genetic and ecological interactions between wild and farmed salmon, there is a potential risk of disease and parasite transfer, which is reviewed in this Baseline Study. For the purposes of the EIS, 'wild Atlantic salmon' is considered a Valued Environmental Component (VEC).

The primary objective of this Baseline Study is to provide necessary information to allow for the assessment of potential effects of the Project on the wild Atlantic salmon VEC and to enable effective follow-up monitoring.

# 2.0 Study Area

The Study Area was selected to encompass the area where effects from Project activities on wild Atlantic salmon are reasonably expected to occur. The boundaries of the Study Area correspond to the south coast of Newfoundland with particular focus on Fortune Bay and Hermitage Bay (Figure 2.1). Within the Study Area, the geographic focus of this Baseline Study is on the 13 BMAs of the Project, the scheduled and non-scheduled Atlantic salmon rivers, and salmon migration corridors that are proximal to the sea farms. The Study Area on the south coast was extended 100 km westward of the westernmost BMA to account for the effects of any potential escaped farmed salmon on wild Atlantic salmon (Wringe et al. 2018; Sylvester et al. 2018, 2019; Bradbury et al. 2022) and based on guidance provided by federal regulators (C. Hendry, DFO, pers. comm., 13 August 2024). The areas in the vicinity of the Hatchery in Stephenville, NL and well boat transportation route between the Hatchery and sea cages are also discussed.

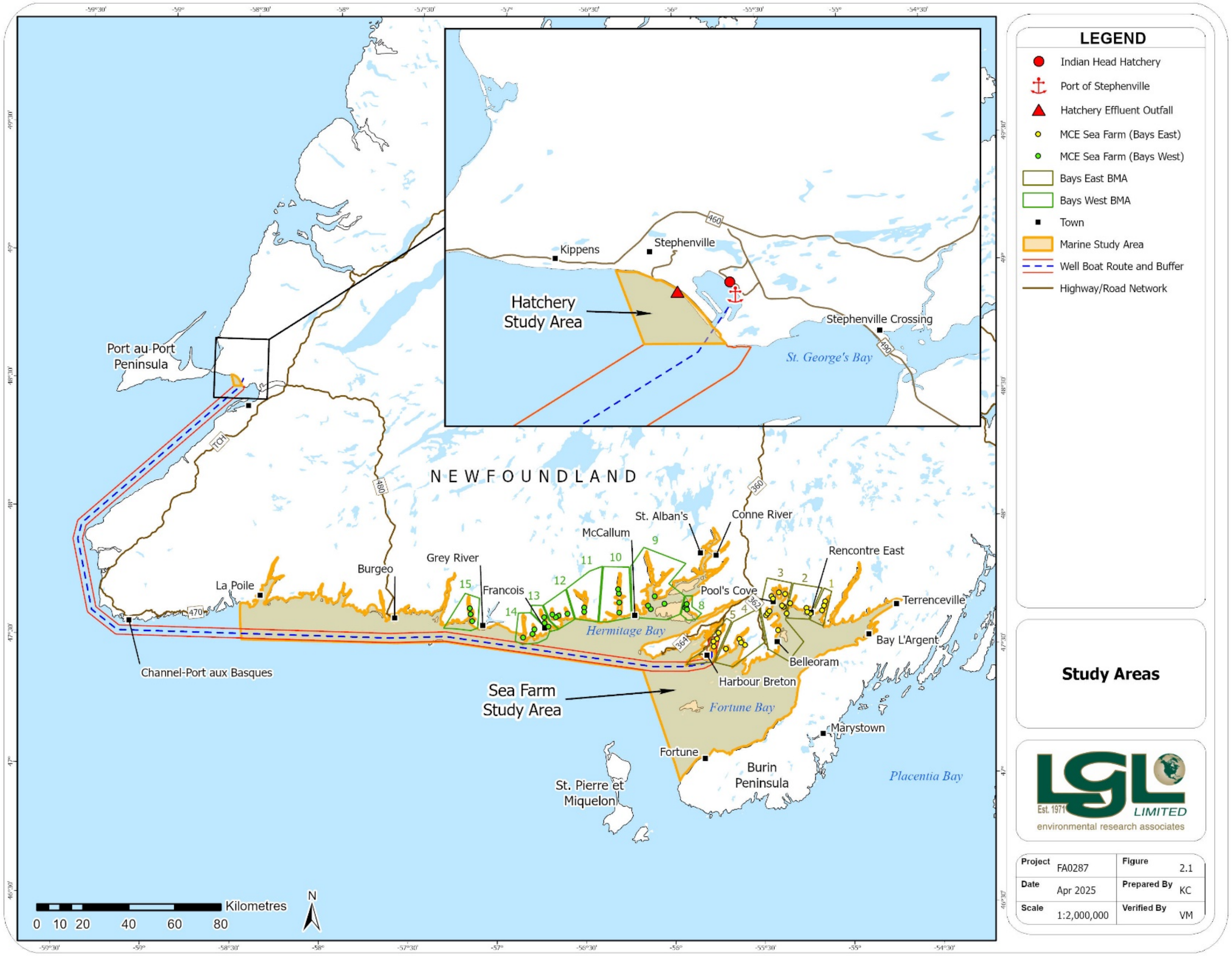

Figure 2.1. The locations of the Hatchery and sea farm Study Areas, for MCE's Project.

# 3.0 Methodology

This Baseline Study is primarily a desktop review of available literature to address the following EIS Guidelines (Table 3.1) with modelling conducted to estimate the potential for farmed salmon escapes.

Table 3.1. Summary of the EIS Guideline requirements for the Wild Atlantic Salmon Baseline Study and the approach taken to address the requirements.

| EIS Guideline | Requirement | Approach | Data Sources |
|---|---|---|---|
| 4.3.1a | A characterization of the current distribution, abundance, genetic population structure, morphology, health and fitness, and migratory patterns of wild Atlantic salmon along the south coast of the island and within the vicinity of all Project components | • Literature review | • Peer-reviewed scientific publications<br>• Government research documents<br>• Technical reports<br>• Consultation with DFO scientists |
| 4.3.1b | Proximity to the sea cages to scheduled and non-scheduled salmon rivers | • GIS analysis | • Database of NL salmon rivers[1, 2]<br>• Database of MCE sea farm locations |
| 4.3.1c | Literature review of the effects of disease and parasites that are prevalent in Newfoundland and affect Atlantic salmon on farms and in the wild, including a review of the transmission of those diseases and parasites | • Literature review | • Peer-reviewed scientific publications<br>• Government research documents<br>• Technical reports<br>• Consultation with DFO scientists and MCE personnel |
| 4.3.1d | Water-quality data at the sea cage sites, including water temperature, salinity, and dissolved oxygen | • Literature review<br>• Analysis of available data from government sites, modelling websites, and data collected by FFA and MCE | • Based upon information in the Sea Farm Sites Baseline Study (LGL 2025 in Vol. 3) |
| 4.3.1e | Genetic and ecological interactions of farmed Atlantic salmon escapees on wild Atlantic salmon along the south coast of the island | • Literature review | • Peer-reviewed scientific publications<br>• Government research documents<br>• Technical reports<br>• Consultation with DFO scientists |
| 4.3.1f | Description of the strain of Atlantic salmon to be produced and a breakdown of the ancestries that make up the broodstock | • Review undertaken by MCE of their broodstock program | • Government Documents<br>• Consultations with DFO<br>• MCE records |
| 4.3.1g | Oceanographic and meteorological data at the sea cage sites, including water currents, wind and wave action, flood and tidal zones, ice dynamics, and storm patterns | • Literature review<br>• Analysis of available data from government sites, modelling websites, and data collected by FFA and MCE | • Based upon information in the Sea Farm Sites Baseline Study (LGL 2025 in Vol. 3) |
| 4.3.1h | Conformity of sea cage design, construction, and installation and mooring to meet or exceed standards in the *Code of Containment of Salmonids in Newfoundland and Labrador* | • Review of aquaculture regulations<br>• Review of current MCE sea cage systems and their design criteria | • Government regulations<br>• MCE sea cage certifications |

| EIS Guideline | Requirement | Approach | Data Sources |
|---|---|---|---|
| | (COC) and ability to withstand oceanographic and meteorological conditions identified above | relative to environmental conditions | |
| 4.3.1i | Discuss existing river monitoring and model the potential for farmed salmon escapees in other salmon rivers identified in proximity to the sea cages | • Literature review<br>• Modelling/analysis of potential farmed salmon escapes from MCE operations | • Primary literature<br>• Technical reports<br>• DFO Escape Model<br>• Farmed salmon production data |

Source: [1] Reddin et al. 2010; [2] River database provided by DFO to LGL.

## 3.1 Escape Modelling for Farmed Atlantic Salmon

The EIS Guidelines for the Project require modelling of the potential for farmed salmon escapees in salmon rivers (Section 4.3.1i in ECC 2024). The EIS modelling used results from the DFO risk assessment model (herein 'DFO model'; Bradbury et al. 2022; DFO 2024c to assess farmed Atlantic salmon escape risk under current and expanded MCE operations. The DFO model[1] provides estimates of the expected number of escapees entering each river from each sea farm based on the maximum stocking numbers licensed at each sea farm. This DFO analysis represents an estimate of maximal risk that could result from sea farm operations, under the assumed parameter values such as the escapee rate per ton of production. No BMAs operate at maximum capacity, so the realized risk will be less than was estimated by the DFO model. MCE operated sea farms have a combined maximum stocking licence of roughly 41 million smolt, but MCE currently operates a yearly Hatchery production of ~4.5 million smolt and are looking to expand Hatchery production to 6.7 million smolt; both of which represent potential stocking levels well below the licensed maximum stocking numbers, and therefore a realized risk that will be well below the maximal risk assessment provided by the DFO model. Specific information on future production plans is commercially sensitive. To account for this limitation, the Hatchery supply of smolt (6.7 million) has been distributed evenly through the BMAs based on year-class and maximum stocking allowances in the analysis presented here. This results in a realistic projection of the number of Hatchery smolt that will supply the BMAs but moderates the distribution of the number of smolt to the sea farms (i.e., farms that may not receive smolt from the Hatchery are allocated fish, and farms that would receive smolt to its maximum allowance maybe allocated less fish).

### 3.1.1 Methods

The analysis considered MCE operational realities by adjusting output from the DFO model to better represent projected per farm operations rather than assume maximum operations. The output from the DFO model shows linear scaling between the predicted number of escaped farmed salmon entering rivers and the maximum stocking size (Figure 3.1). While individual sea farm differences in location relative to Newfoundland rivers results in a small degree of variation in predictions, the overall linear scaling is the result of fundamental model structure being linear,

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[1] DFO and LGL Limited entered into a data release agreement, which allowed LGL to use the DFO aquaculture escapee salmon risk assessment model with restrictions.

which makes it feasible to adjust model output by scaling individual sea farm results. For example, if there was a prediction of 20 farmed salmon entering the river for a maximum stocking licence of 600,000 fish but the actual farm operations resulted in only 300,000 stocked fish at any point in time, then predictions under the realized operations should be 10 instead of 20 escapees entering a river. This correction can be applied at the aggregate level (e.g., total farmed salmon from a given sea farm) or at the per river estimate, as the aggregate is the sum of the individual per river estimates provided by the DFO model.

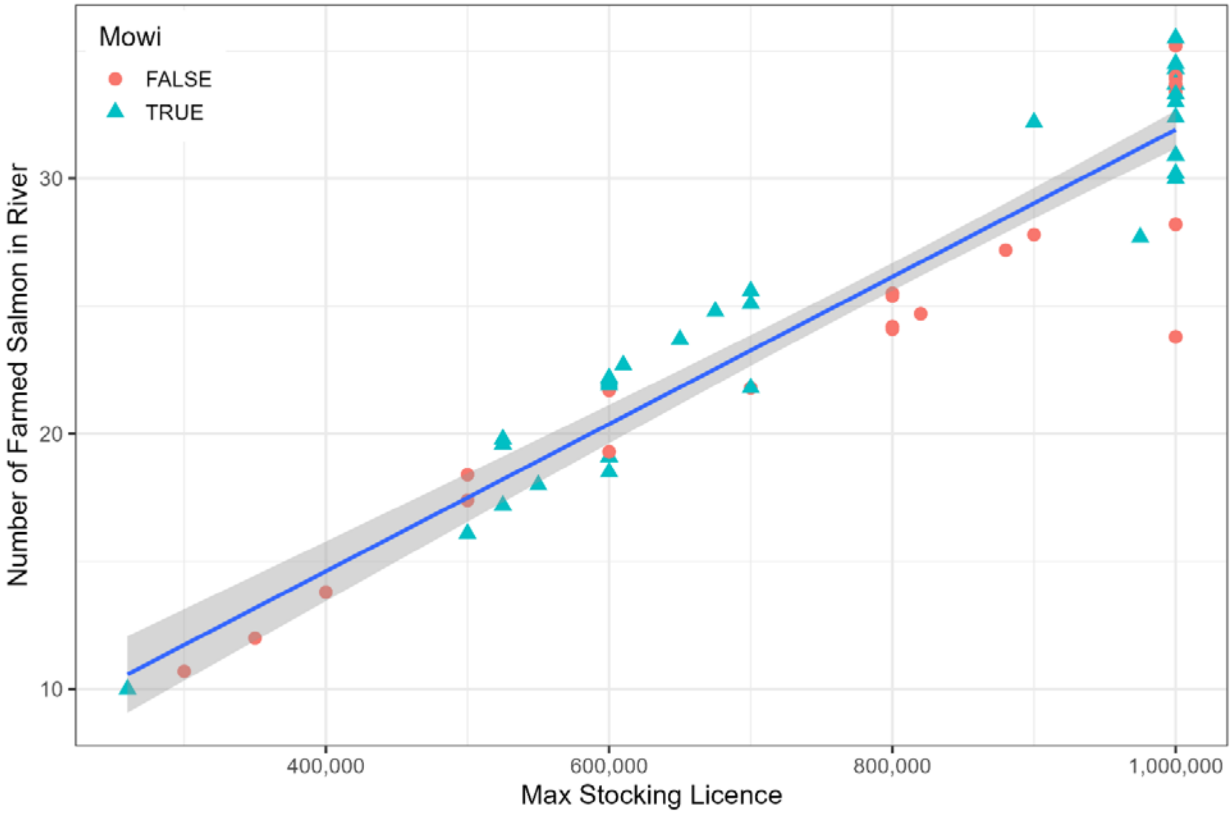


Figure 3.1. Predicted number of farmed salmon entering Newfoundland rivers from a given sea farm relative to the maximum stocking number licensed for that sea farm.

The full EIS analysis will therefore adjust the per river per sea farm results by adjusting the output based on the difference between the maximum stocking licence and the realized operations (current and expanded). A first step is to determine the ratio between Max Stocking License and the realized operations (current and expansion) for each MCE operated sea farm ($A_j^c$ and $A_j^e$ respectively), which are defined as:

$$A_j^c = O_j^c / M_j \text{ and } A_j^e = O_j^e / M_j$$

where $O_j^c$ and $O_j^e$ represent the operational stocking level under current and expanded operations respectively for each Mowi operated sea farm with $M_j$ represents the maximum stocking licence at the sea farm. The DFO model generates estimates of expected number of escapees ($E_{i,j}$) in river $i$ that originated from sea farm $j$. These estimates will then be adjusted based on the operational adjustment ratios to generate estimates of expected escapees under current and expanded operations. The estimated number of sea farm specific escapees by sea farm under current operations will be estimated as,

$$E_{i,j}^c = E_{i,j} * A_j^c$$

with expanded operations estimated as,

$$E_{i,j}^e = E_{i,j} * A_j^e.$$

In both cases, the expected number of escapees will be less than predictions from the DFO model, which represents maximized risk assessment (i.e., $E_{j,i}^c \leq E_{j,i}^e \leq E_{j,i}$).

Adjusted individual river and sea farm specific estimates will be aggregated to produce per river estimates under current operations as,

$$E_i^c = \sum_{all\ j} E_{i,j}^c$$

or under expanded operations as

$$E_i^e = \sum_{all\ j} E_{i,j}^e.$$

Similarly, estimates can be generated by sea farm $j$ by summing over all respective river contributions for a given sea farm.

The DFO model predictions also assumed a singular escapee per tonnage rate that may over represent the number of escapees coming from MCE operations. Like the operational adjustment ratio, a single escapement rate adjustment ratio may be determined by comparing the total number of reported MCE escapees to the numbers generated from the escapee rate assumed by the DFO model. This can then be applied across all the individual $E_{j,i}$ estimates before computing the current and expanded operational estimates.

After adjusted estimates and aggregates have been computed, the EIS analysis will compare current to expanded operations on a per river and per sea farm basis as well as in aggregate to show the relative change in realized risk. These estimates will then be compared to the original

DFO risk model (i.e., maximal risk, using 0.2 escape rate) to fully contextualize the difference between realized and maximal risk estimates.

Furthermore, a series of escape rates based on recent farmed Atlantic salmon escape numbers in Newfoundland and internationally (Table 3.2) were analyzed to examine how various escape rates affected findings on a per river basis. Some escape rates go outside of the range investigated by the DFO model; however, it was determined that the total number of escapees predicted at a given escape rate per harvest tonne scaled linearly with the escape rate value (Figure 3.2). As such, the linear relationship was used to predict total number of escapees for harvest rates outside of the range supported by the DFO model, while the relative contribution across rivers was determined from the DFO model set to an escapee rate of 0.2, which was one of the standard rates used in DFO analyses.

Finally, risk assessments conducted by DFO (i.e., Bradbury et al. 2022; DFO 2024c) report per river risk as percentage farmed salmon entering the river, which within the context of the EIS can be defined as

$$\text{Percent Farmed} = \frac{Mowi + Other}{Mowi + Other + Wild}$$

Where $Mowi$ represent farmed salmon from MCE operations and $Other$ represents farmed salmon from other aquaculture operators in Newfoundland under the DFO risk assessment. Bradbury et al. (2022) established a threshold of 10% percent farmed salmon as the start of population level impacts using this definition. As such, in order to maintain comparability with the original threshold, the denominator was retained and the Mowi contribution within the EIS analysis was computed as:

$$\text{Mowi Percent Farmed} = \frac{Mowi\ EIS}{Mowi + Other + Wild}.$$

where $Mowi\ EIS$ represents farmed salmon from MCE operations as determined in the current EIS analysis, while $Mowi$ and $Other$ represents respectively the contribution from MCE and other operators under the DFO maximal risk assessment (DFO 2024c).

Table 3.2. Farmed Atlantic Salmon escape rate (number of fish per harvest tonne) scenarios used in analyses.

| Escape Rate Scenario | Escape Rate (per Harvest Tonne) |
|---|---|
| Average Newfoundland Escape Rate: Post-MCE Operations (2019–2023) | 0.0001 |
| Upper Bound (95% CI) Newfoundland Escape Rate: Post-MCE Operations (2019–2023) | 0.0002 |
| Average Newfoundland Escape Rate (2014–2023) | 0.027 |
| Upper Bound (95% CI) Newfoundland Escape Rate (2014–2023) | 0.072 |
| Average Mowi International Operations (2019–2023) | 0.130 |
| Upper Bound (95% CI) Mowi International Operations (2019–2023) | 0.288 |

Notes:
95% confidence intervals (CI) were calculated based on escape rates following a Students t-distribution.

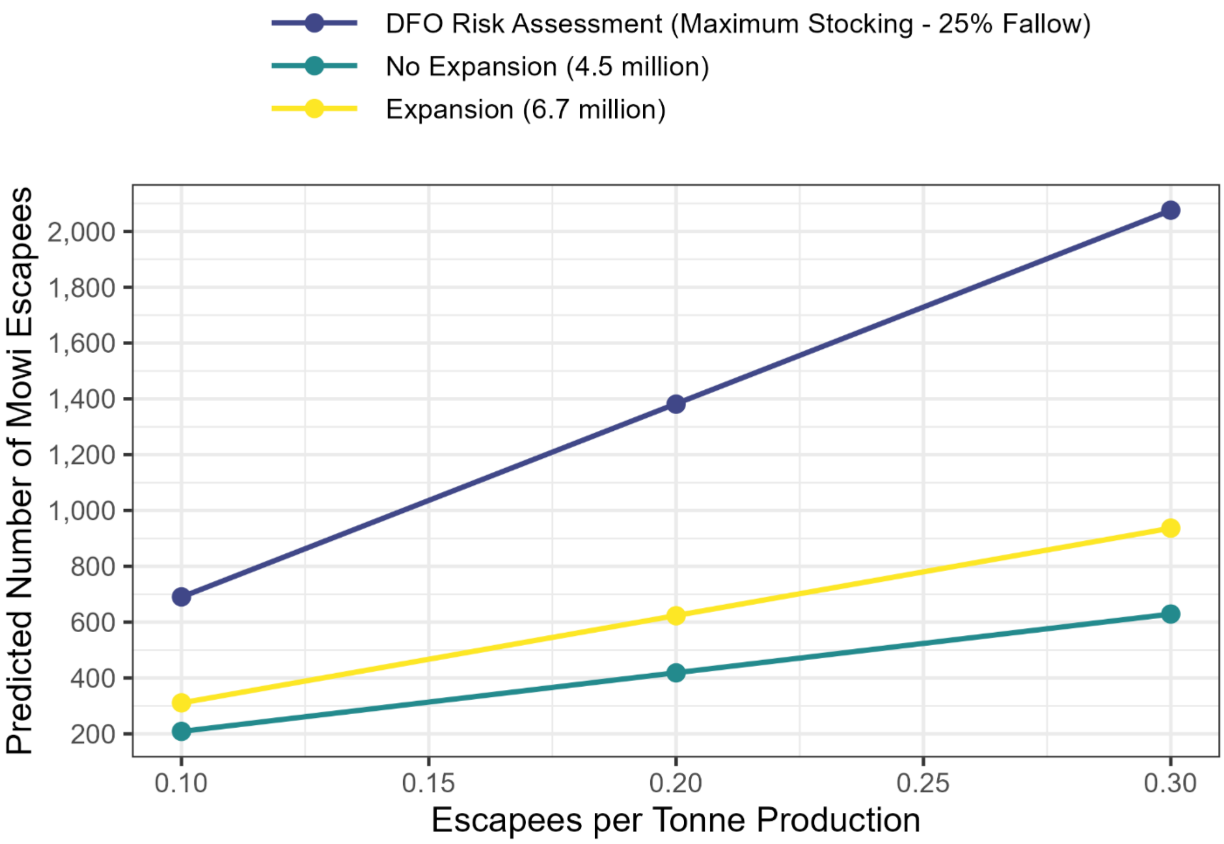


Figure 3.2. Predicted number of escaped farmed salmon of MCE origin based on the DFO model relative to escape rate (per tonne of production) for the maximum stocking number licensed for that sea farm (DFO Risk Assessment), No MCE Expansion (4.5 million smolt), and MCE Expansion (6.7 million smolt).

# 4.0 Characterization of Wild Atlantic Salmon

Atlantic salmon are a cold-water migratory, anadromous fish species found throughout the North Atlantic Ocean. They generally live for <10 years and in NL can reach up to 70 cm in length and weigh up to 4.5 kg (DFO 2018). This Baseline Study focuses on the wild Atlantic salmon populations occurring around MCE's sea farms on the south coast of Newfoundland and near the Hatchery property (Stephenville, NL) on the west coast of Newfoundland as well as along the proposed well boat transit route between the Hatchery and MCE sea farms.

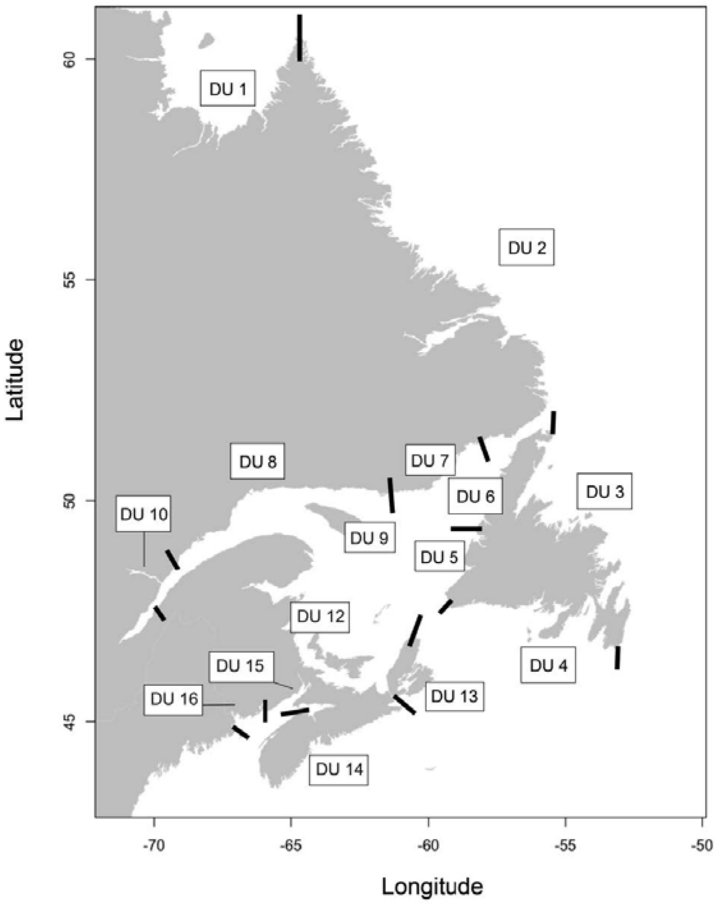
## 4.1 Status

The status of wild Atlantic salmon in NL is assessed by COSEWIC with stock assessments conducted by DFO. The attributes of Atlantic salmon including life history, homing behaviour, and molecular genetics indicate it meets the criterion of 'discreteness' as defined by COSEWIC guidelines for a population to be recognized as discrete and evolutionary significant relative to other populations. Sixteen designatable units [DU] have been recognized by COSEWIC for Atlantic salmon in eastern Canada. DFO recently reassessed the Atlantic salmon stock and proposed various DU border revisions along with three additional DUs, for a new proposed total of 19 for the province (Lehnert et al. 2023). The sea farm and Hatchery Study Areas are located within COSEWIC DU 4 (now proposed to change to DU 6 South Newfoundland – East and DU 7 South Newfoundland - West) and DU 5 (now proposed to change to DU 8 Southwest Newfoundland), respectively (Figure 4.1; Lehnert et al. 2023).

The recreational Atlantic salmon fishery in NL is managed by DFO and the province has been divided into 15 Salmon Fishing Areas (SFA) (DFO 2024a). This Baseline Study focuses on the salmon population in Fortune Bay and Bay d'Espoir areas, which is considered part of the South Newfoundland Population (DU 4) by COSEWIC and SFA 11 by DFO. The Hatchery is adjacent to DU 5 (Southwest Newfoundland Population) and SFA 13. The well boat transit route overlaps with DUs 5 and 4 and SFAs 13, 12, and 11 (Figure 4.1; Figure 4.2).

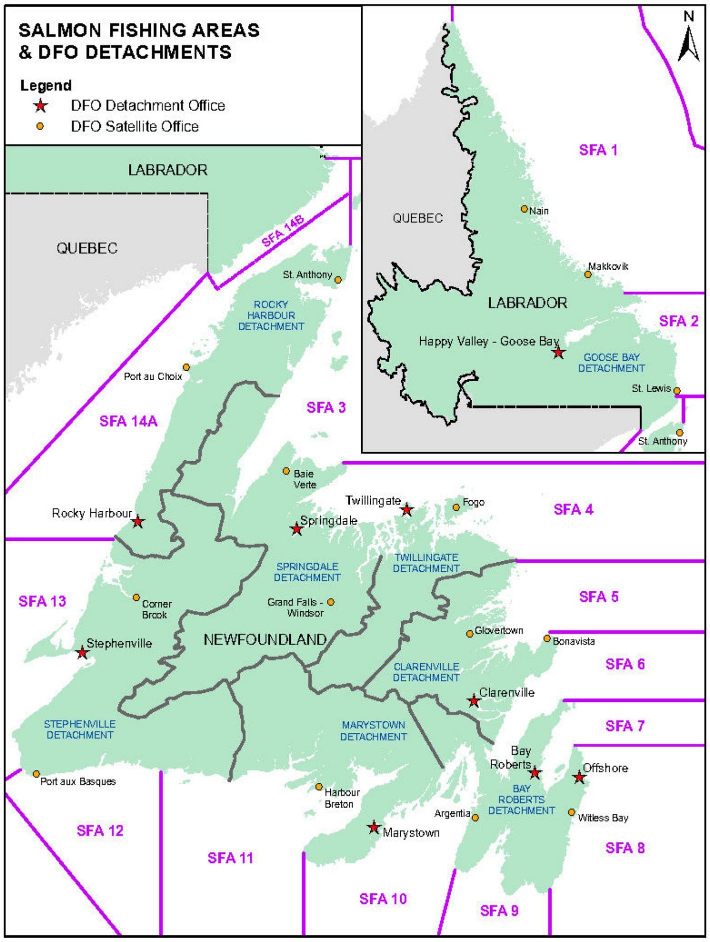
COSEWIC assessed the status of wild Atlantic Salmon in 2010 (COSEWIC 2010), and a new assessment is scheduled to be issued by COSEWIC in November 2025 (COSEWIC 2024). COSEWIC designated the South Newfoundland population of Atlantic salmon as *Threatened* (COSEWIC 2010) and this population is under consideration for addition to Schedule 1 of the SARA. Threats to this population were identified as illegal fishing, commercial fisheries (France [St. Pierre et Miquelon], and Greenland), bycatch mortality, local aquaculture, and changing environmental conditions (COSEWIC 2010). Atlantic salmon commercial fisheries have been closed in the U.S. since 1948 (NOAA 2024a), since 1992 in Newfoundland, and since 1998 in Labrador (DFO 2020). Atlantic salmon have been reported in low numbers as bycatch in the herring bait fishery (Dempson et al. 2024). The reported harvest of wild Atlantic salmon by neighbouring countries ranged from 0.8 tonnes to 5.3 tonnes between 1991 and 2018 by France and 9 tonnes to 58 tonnes between 1998–2018 by Greenland (Kelly et al. 2023). In 2022, the North

Atlantic Salmon Conservation Organization (NASCO) Council invited France (in respect of St. Pierre and Miquelon) to join NASCO. In response, NASCO received a letter acknowledging that St. Pierre et Miquelon are actively working towards the creation of a charter to ensure the longevity of the Atlantic salmon resource. In 2017, the fishing season was reduced and a limit for the number of fishing permits issued annually has been introduced (NASCO 2024). In 2023, the St. Pierre et Miquelon Atlantic salmon fishery harvested 1.4 tonnes (~558 salmon, all North American-origin), which is approximately 50% less than the previous 20-year average (ASF 2024). A 2013 population viability analysis related to conservation spawning requirements for the South Newfoundland population found that there was a low probability (<30%) that Atlantic Salmon in DU4 would meet the population recovery requirements within 15 years (Robertson et al. 2013). In NL, there is an estimated 42% decrease in 2SW salmon spawners (i.e., Atlantic salmon that have spent two years at sea before returning to spawn in the river of their birth) compared to the previous five-year means (ICES 2024). The pre-COSEWIC review proposes to divide DU4 into two based on emerging genetic evidence for discreteness (Lenhert et al. 2023). The Southwest Newfoundland Population (DU 5) is considered *Not at Risk* (COSEWIC 2010) and in the most recent COSEWIC review its boundaries remain unchanged (Lenhert et al. 2023).



Source: Lehnert et al. (2023).

Figure 4.1. Currently recognized 16 designatable units (DUs) for Atlantic salmon in Atlantic Canada.



Source: DFO (2024c).

Figure 4.2. NL salmon fishing areas (SFAs).

DFO conducts stock assessments on a two-year cycle with the most recent available stock assessment for 2022 salmon returns (DFO 2024b). The status assessment criteria of wild Atlantic salmon populations are described in detail in the *Fishery Decision-Making Framework Incorporating the Precautionary Approach* (DFO 2015). Briefly described, the status of each monitored river is assessed relative to two criteria based on a previously defined conservation egg deposition which are the Limit Reference Point (LRP) and Upper Stock Reference Point (USR) (DFO 2023a). Populations below the LRP are considered in the Critical Zone, populations above the USR are considered in the Healthy Zone, and those in between are considered in the Cautious Zone (DFO 2023a). Representative rivers monitored in SFA 11 include Conne River and Garnish River. Little River has been monitored in previous stock assessments (DFO 2023a). Conne River and Little River terminate into Bay d'Espoir. Garnish River is on the Burin Peninsula and terminates into Fortune Bay. These rivers are considered in the Critical Zone and are below the LRP (DFO 2022a; DFO 2023a; DFO 2024b). Conne River and Little River populations are near local extinction (DFO 2022a). Recent studies have indicated that climate change in the North Atlantic could be linked to Atlantic salmon distribution, abundance, size, and possibly productivity (Beaugrand and Reid 2012; Rikardson et al. 2021; Utne et al. 2021).

### 4.1.1 Distribution

The wild Atlantic salmon South Newfoundland Population (DU 4) extends from Mistaken Point on the Avalon Peninsula (~46° 38′N, 53° 10′W) along the south coast of Newfoundland to Cape Ray in the west (~47° 37′N, 59° 19′W) (COSEWIC 2010). MCE sea farms are located within SFA 11, which covers a portion of DU4 (see Figure 4.2). SFA 11 begins at the tip of the Burin Peninsula and ends in the west at Fox Point south of Burgeo. There are 104 known salmon rivers along the south coast of Newfoundland; 48 are scheduled salmon rivers (DFO 2022a; Lehnert et al. 2023) of which 24 (all Class 2, i.e., one retained fish/season and three catch and release fish/day) (DFO 2023b) occur within the Study Area (Figure 4.3) on the south coast. Five scheduled salmon rivers are within the Bays East BMA boundaries and six are within the Bays West BMAs. There are no scheduled salmon rivers in the Hatchery Study Area. There are also several non-scheduled salmon rivers (i.e., rivers with documented occurrences of Atlantic Salmon but not listed by name in the regulations) present in DU 4 (Figure 4.4). Additionally, some scheduled and non-scheduled rivers in the SFA 11 have historical documented occurrences of brook trout and/or sea trout (Porter et al. 1974). In Bay d'Espoir, Hughes Brook, First Brook, Salmon River (East Bay), Northwest Brook, Southeast Brook and Little River are open to rainbow trout fishing year-round (DFO 2024a).

The Hatchery is located within DU 5 (Southwest Newfoundland) and SFA 13. DU 5 starts at Cape Ray and extends north along the west coast of Newfoundland and ends at ~49° 24′N, 58° 15′W (see Figure 4.1). There are 40 known salmon rivers in DU 5 (COSEWIC 2010) of which four scheduled rivers (all Class 2) (DFO 2023b) and 5 non-scheduled (Reddin et al. 2010) terminate at St. George's Bay near the port of Stephenville (Figure 4.3).

The well boat will travel from the Hatchery to the sea cage sites traversing DU 4 and 5, and SFAs 11, 12, and 13. As previously stated, all sea farms are located in SFA 11 and the Hatchery is in SFA 13; thus, no transfer of fish will occur within SFA 12. SFA 12 starts at Fox Point below Burgeo in the east and ends at Cape Ray in the west. There are 10 scheduled rivers in SFA 12 (DFO 2023b) and four non-scheduled rivers (Reddin et al. 2010) (Figure 4.4).

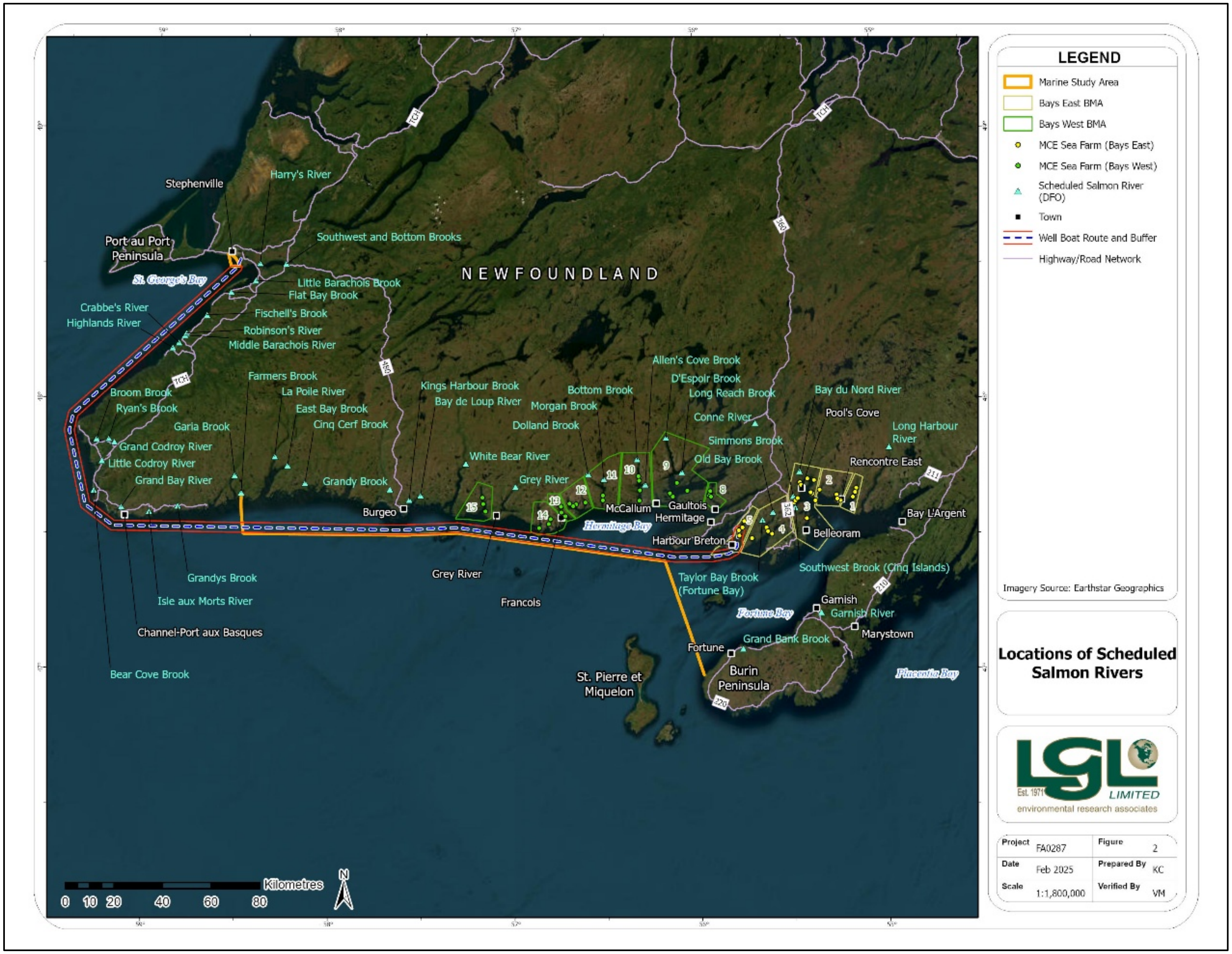


Figure 4.3. Locations of scheduled salmon rivers in the Hatchery and sea farm Study Areas.

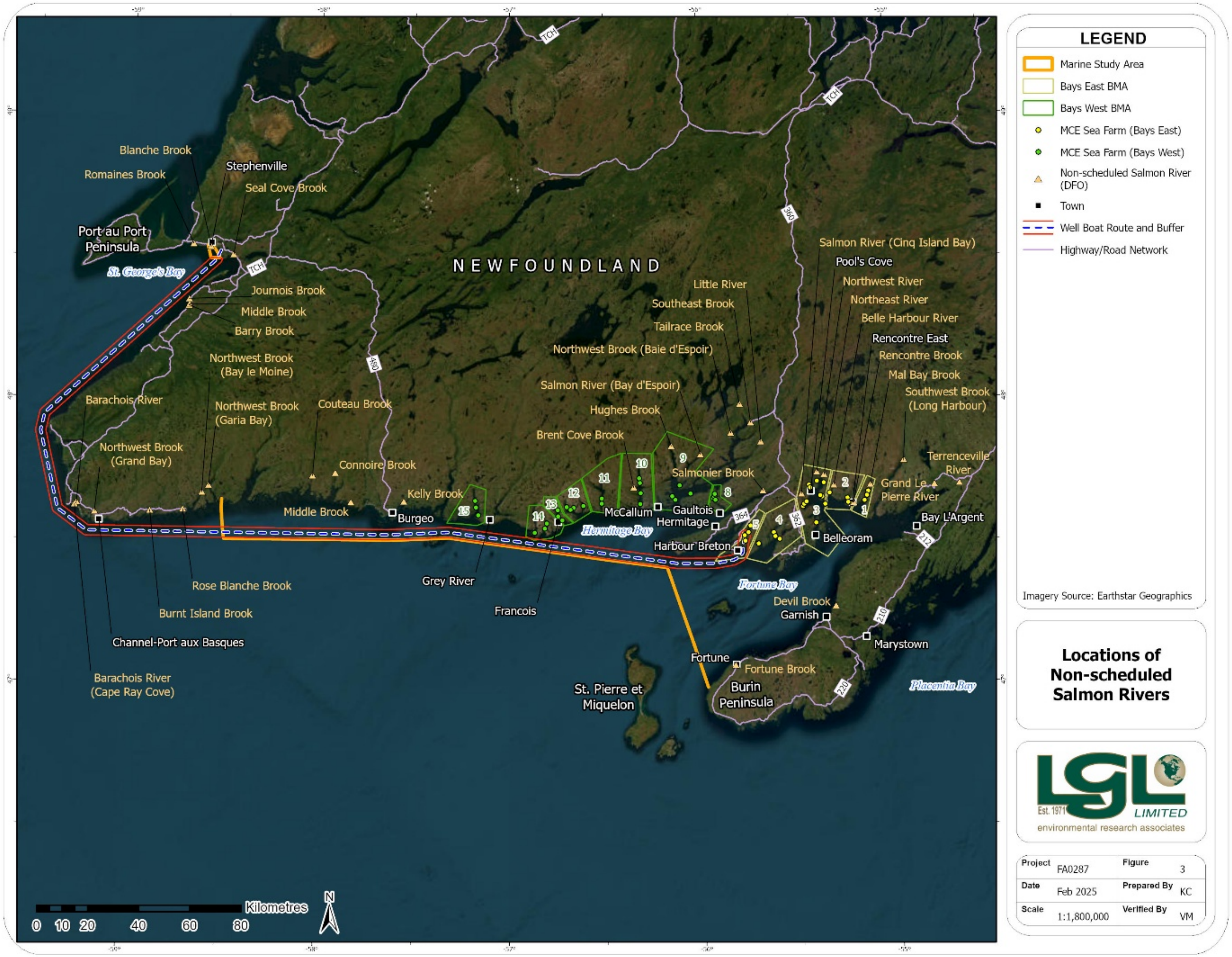


Figure 4.4. Locations of non-scheduled salmon rivers in the Hatchery and sea farm Study Areas.

### 4.1.2 Migratory Patterns

Atlantic salmon mainly have an anadromous migratory behaviour where they are born in freshwater, migrate to the sea to grow (mature), and return to freshwater to reproduce. Unlike Pacific salmon that die after spawning, Atlantic salmon can migrate to the ocean and return to spawn multiple times over their life span. In Newfoundland, juvenile Atlantic salmon usually stay in freshwater habitats (rivers, lakes) for three to four years and migrate to the ocean after undergoing smoltification. During the marine phase of their life history, Atlantic salmon can undergo large migrations to overwintering feeding grounds including those offshore Labrador and western Greenland (COSEWIC 2010). Mature salmon usually return to rivers between May and October with some scheduled rivers in Newfoundland seeing returns between late-May to mid-July (Dempson et al. 2017; Kelly et al. 2023). Spawning typically occurs in October and November (COSEWIC 2010). Run times are influenced by climate conditions with warmer temperatures resulting in earlier run times (Dempson et al. 2017). Rivers to the west of the Burin Peninsula have early run times compared to rivers to the east (DFO and MNRF 2008; Dempson et al. 2017). Most rivers in SFA 11 are considered grilse (one-sea-winter, 1SW salmon) rivers, with small adults spending one year at sea before returning to spawn upriver. Grilse size in the areas west of the Burin Peninsula are also comparatively smaller than other areas of Newfoundland (DFO and MNRF 2008). An acoustic tagging study (2006-2008) of wild Atlantic salmon smolt from Conne and Little rivers revealed that smolt were resident in the Bay d’Espoir fjord for 40 days post tagging (which occurred in late April to mid-May; Dempson et al. 2011). Smolt did not proceed directly to Hermitage Bay but spent one to about two weeks in the immediate Conne River and Little River estuaries before using variable migratory paths to move through the fjord and closer to Hermitage Bay. Many tagged smolt spent 4-8 weeks moving back and forth in the outer part of the fjord. Overall smolt survival to the fjord exit was considered moderately high (54-85%; Dempson et al. 2011). Coastal habitats in Newfoundland, including those in the Study Area, may be important rearing or staging areas for migrating smolts and kelts (Bøe et al. 2019). During migrations between the rivers and the ocean, salmon typically swim in the upper 10 m of the water column, and as close as 2–3 m below the surface (Renkawitz et al. 2012; Thorstad et al. 2012; Godfrey et al. 2015).

In 2019, the Environmental Studies Research Fund (ESRF) announced new research funding for a five-year study on Atlantic salmon migration patterns (ESRF 2024). As part of the study, funding was provided to fit approximately 1300 Atlantic salmon (at three different life stages) with telemetry tags (DFO 2022b). Specifically, in 2021 and 2022, the ESRF Atlantic Salmon Migration Project tagged 29 kelts and 300 smolts (pop-up satellite archival tags [PSATs] and acoustic tags) in SFA 11 (ESRF Atlantic Salmon 2024). The last field season for that Project was 2023 (ESRF Atlantic Salmon 2024), and at the time of writing, study results for smolt tagged in the Study Area were not available (M. Robertson, DFO, pers. comm., 4 April 2025). Data from North American salmon tagged at West Greenland as part of the ESRF study coupled with numerical modelling revealed that the homing migration route of salmon on the Labrador and Newfoundland shelves was largely influenced by the 1°C isotherm (Dufresne et al. 2025).

### 4.1.3 Abundance

From the COSEWIC (2010) assessment, the number of mature Atlantic salmon in the South Newfoundland population, as estimated in 2007, ranged between 21,866 and 29,711 individuals. Wild salmon assessments in NL are based on counts of returning salmon from monitoring facilities (e.g., counting fences and fishways), recreational fishing logbooks from anglers, and in-river snorkel surveys (Kelly et al. 2023). Historically, salmon returns on three rivers in SFA 11 have been monitored with counting fences (Conne River, Little River, and Garnish River). As of 2024, only salmon return counts for Conne River and Garnish River are available. Since the COSEWIC assessment, total returns for Conne River have decreased by 41% from the previous generation average (2017–2022) and have decreased by 89% from the previous three-generation average (2006–2024; DFO 2024c, 2025a). In the last 40 years, the abundance of Atlantic salmon in Conne River fell by an estimated 92% (Dempson et al. 2024). For Little River (next to Conne River), total returns saw an 88% and 97% decline (one-generation and three-generation average, respectively; DFO 2022a). Garnish River has been monitored since 2015, and returns have declined 63% from the previous generation (DFO 2022a). Between 2015–2022, the average annual return rate for the river was 441 salmon, which is well below the 1970s harvest levels of 1000–2000 (DFO 2024c). In 2024 (most recent complete dataset at the time of writing), fishway counts for Garnish River were below the previous generation average[2] while Conne River counts in 2024 had increased substantially relative to 2022 and 2023 yet remained well below the pre-moratorium[3] average (Table 4.1; DFO 2025a). As of the 2020 stock assessment, all three rivers were in the Critical Zone (<20% of LRP) with populations on the Conne River and Little River considered to be near local extinction (DFO 2022a). The 2024 stock assessment indicated Conner River remains in the Critical Zone; however, a stock status zone could not be provided for Garnish River due to an incomplete dataset and counts are no longer available for Little River (DFO 2025a). Between the 1990s and 2023, smolts per conservation limit (CL; 1000 eggs) declined for Conne River, but egg depositions increased up to ~30% of the LRP in 2024, the highest value observed since 2017 (DFO 2025a). Since monitoring began (2015), smolts per CL have increased on the Garnish River (ICES 2024).

Table 4.1. Fishway counts for 2022, 2023, and 2024 (adapted from DFO 2024d, 2025a) and generation averages for monitored Atlantic salmon rivers in SFA 11.

| River (SFA 11) | 2022 Total | 2023 Total | 2024 Total [a] | Prev. Generation 2018–2023 Ave. Total | Moratorium 1992–2023 Ave. Total | Pre-Moratorium 1984–1991 Ave. Total |
|---|---|---|---|---|---|---|
| **Fishway Counts** | | | | | | |
| Garnish River [b] | 397 | 234 | 175 | 331 | 358 | N/A |
| Conne River [c] | 281 | 145 | 659 | 273 | 1971 | 6120 |

Notes:

[a] Final total as of 15 September 2024.

[b] Fence began operations in 2015, fence location moved upstream in 2022

[c] Fence began operations in 1986, fence washout in early-July 2018 could impact counts but estimated 90% of run was completed before this date (Kelly et al. 2023).

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[2] The counting fence for Garnish River washed out in 2024, but available data indicate returns were likely below average (DFO 2025a).

[3] Fishway and fence counts prior to the 1992 Atlantic salmon fishery moratorium.

Currently, in SFA 11, there are only two rivers with counting fences, Garnish River and Conne River (Kelly et al. 2023; DFO 2024a). There is currently no counting fence on Little River and two fences on Garnish River washed out partway through 2024 (DFO 2025a). In 2018, returns of small and large salmon on Conne River were the lowest in the 33-year time series (decline of 76% small (<63 cm Fork Length [FL] and 97% large [>63 cm FL]); Garnish River had the second lowest returns (monitored since 2015); and Little River also had fewer returns (Kelly et al. 2023). The return counts for both rivers are below the moratorium total average and below the pre-moratorium total average (Conne River only; see Table 4.1). However, DFO Atlantic Salmon Fishway Counts for Conne River in 2024 showed double the 2018-2023 average number of wild salmon returning.

Recreational salmon fishing data relies on self-reporting effort by returning fishing logs which has varying return rates (for example 22.5% logs were returned for the 2018 season and log returns averaged ~14% between 2017-2023; Kelly et al. 2023; DFO 2025a). Recreational fishery data cover a broad geographic area; Table 4.2 presents data for 18 rivers in SFA 11 during 2022, 2023, and 2024. In 2022, catch per unit effort (CPUE) ranged between 0.0–1.0, in 2023 between 0.0-2.8, and in 2024 it ranged between 0.0–0.7. Long Harbour River (Fortune Bay) had the highest CPUE in both 2022 and 2023, but was among the lower CPUE levels in 2024; the highest CPUE in 2024 occurred in Grand Bank Brook, Simmons Brook, Bay du Nord River, and White Bear River. In 2021, the Salmon Abundance Index for the entire Newfoundland Atlantic salmon population suggested that returns to monitored rivers had not rebounded to pre-2016 levels but had slightly improved from 2017–2020 returns (DFO 2023a). However, this reversed in 2022, as returns were below average for most monitored rivers, which resulted in the lowest estimated salmon abundance since 2017 (DFO 2024b). Returns to Newfoundland rivers during 2023 and 2024 indicated the lowest estimated salmon abundance in the time series, with more rivers and watersheds indicating more returns below average in 2024 than 2023 (DFO 2025a). While full stock assessments are completed on a two-year cycle, the necessity for an assessment was triggered due to the 2023 total returns, which exhibited more than a 30% decline of more than 50% of monitored rivers. The stock assessment took place in late 2024 and was released in 2025 (DFO 2024e, 2025a).

Table 4.2. Atlantic salmon recreational fishery catch data for scheduled Atlantic salmon rivers in SFA 11 for 2022, 2023, and 2024 (adapted from DFO 2023b, 2025b).

| Scheduled River | 2022 | | | 2023 | | | 2024 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Effort (Rod Days) | Catch [a] | CPUE | Effort (Rod Days) | Catch | CPUE | Effort (Rod Days) | Catch | CPUE |
| Grand Bank Brook | 71 | 9 | 0.1 | - | - | - | 21 | 16 | 0.7 |
| Garnish River | 84 | 19 | 0.2 | 170 | 29 | 0.2 | 484 | 120 | 0.3 |
| Long Harbour River (Fortune Bay) | 109 | 110 | 1.0 | 104 | 295 | 2.8 | 64 | 15 | 0.2 |
| Bay du Nord River | 64 | 18 | 0.3 | 12 | 0 | 0.0 | 171 | 106 | 0.6 |
| Simmons Brook | 6 | 5 | 0.8 | - | - | - | - | - | - |
| Southwest Brook | - | - | - | 105 | 87 | 0.8 | 21 | 15 | 0.7 |
| Old Bay Brook (Bay de l'Eau) | - | - | - | - | - | - | - | - | - |
| Taylor's Bay Brook | - | - | - | - | - | - | - | - | - |

| Scheduled River | 2022 | | | 2023 | | | 2024 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Effort (Rod Days) | Catch [a] | CPUE | Effort (Rod Days) | Catch | CPUE | Effort (Rod Days) | Catch | CPUE |
| Conne River | - | - | - | - | - | - | - | - | - |
| Long Reach Brook | - | - | - | - | - | - | - | - | - |
| Allen’s Cove Brook | 6 | 0 | 0.0 | 6 | 0 | 0.0 | - | - | - |
| Bottom Brook | - | - | - | - | - | - | - | - | - |
| Hare Bay River [b] | - | - | - | - | - | - | - | - | - |
| Grey River | 19 | 5 | 0.3 | 12 | 9 | 0.8 | 21 | 0 | 0.0 |
| White Bear River | 231 | 114 | 0.5 | 86 | 119 | 1.4 | 342 | 190 | 0.6 |
| Bay de Lupe Brook | - | - | - | 25 | 20 | 0.8 | - | - | - |
| King’s Harbour Brook | - | - | - | - | - | - | - | - | - |
| **Total** | **590** | **280** | **0.47** | **520** | **559** | **1.1** | **1124** | **462** | **3.1** |

Notes:

[a] Includes small and large, retained and released.

[b] In previous years, listed as “Hare Bay Rivers” and included Morgan Brook and Dolland Brook; for 2024 only listed as “Hare Bay River” (DFO 2025b).

“– “ indicates “No Data”.

Low marine survival is considered a key threat to Atlantic salmon abundance in Newfoundland (DFO 2017, 2024b, 2025a; Kelly et al. 2023). The average marine survival of adult salmon (return year) on the Conne River was estimated at <1% in 2018 and 2020, 1.2% in 2022, and 3.6% in 2024 (DFO 2022a, 2024b, 2025a; Kelly et al. 2023). Marine survival for Garnish River was 2.8% in 2018, <1% in 2020, 3.9% in 2022, and likely between 1-3% in 2024 (DFO 2022a, 2024b, 2025a; Kelly et al. 2023). A localized marine environmental factor is believed by DFO scientists to be the main contributor in the recent 90% decline in return rates on the Conne River (DFO 2024b). Dempson et al. (2024) identified aquaculture, predation, and climate change as major factors in the decline of Conne River salmon. However, the 2024 Conne River fishway counts increased >100% which adds to the uncertainty of the environmental factors influencing salmon returns (see Table 4.1).

In SFA 13, the percent change in total returns on Harry’s River were lower compared to the average returns over the previous generation(s) (DFO 2025a). In 2024, there was a -28% change versus the previous generation and a -46% change compared to the previous three generations (DFO 2025a). This is in contrast to 2022 values, when there was a -31% change of total returns versus the previous generation and a -32% change versus the previous three generations (DFO 2024b). As of the 2024 stock assessment, there are no counting fences on any river in SFA 12 and there are no abundance data for salmon populations in SFA 12 (DFO 2024b, 2025a).

### 4.1.4 Morphology

Atlantic salmon are an anadromous (marine fish that spawn in freshwater) and iteroparous species (multi-year spawners). Every year adult wild salmon return to their natal rivers to spawn. Adult salmon typically weigh less than 4.5 kg and generally less than 70 cm in length (DFO 2018). Colouration and patterns of young salmon differ from those observed in the adult stage. Juvenile salmon stay in the natal rivers until smoltification when they are able to live in the marine environment and migrate out to sea. Some populations are landlocked in ponds and as such, will not interact with the Project.

Wild Atlantic salmon populations are genetically distinct from one another down to the river level (Fraser et al. 2011; Bourret et al. 2013); however, the degree to which morphological variation is influenced by genetics or environmental conditions is less well known. Variations in salmonid morphology is often a result of adaptations to local watershed characteristics (e.g., body shape changes in response to water velocity, or head and jaw morphology and tropic adaptations) (Taylor 1991; Garcia de Leaniz et al. 2007). Recent studies have found that southern Newfoundland wild Atlantic salmon populations are highly structured and influenced at a fine geographic scale (individual rivers) by climate (e.g., watershed changes) and variation in body shape (Perriman 2022). Morphological differences between wild, farmed, and hybrid salmon can be subtle, and differences may be masked by phenotypic plasticity typically observed in wild salmon (Perriman 2022). A Newfoundland based study of juvenile farmed, wild, and reciprocal F1 (first generation offspring) hybrids released in the tributaries of the Garnish River found slight differences in body shape (mainly body depth) between pure wild and pure farmed salmon and differing number of parr marks (Crowley et al. 2022). On average, wild fish were smaller than wild-mother hybrids and pure farm fish (Crowley et al. 2022). Guidance from DFO for monitors of salmon counting fences in Placentia Bay advise that adult farmed salmon typically have smaller heads, shorter opercula (can see gill rakers), different pigmentation, thicker bodies, more fin erosion/splitting (pectoral and dorsal fins are disformed), and more tail erosion/splitting than wild Atlantic salmon (C. Hendry, DFO, pers. comm., March 2019).

### 4.1.5 Health and Fitness

Interbreeding with farmed Atlantic salmon may have negative health and maladaptive fitness consequences for local wild Atlantic salmon populations. The effects of interbreeding on the fitness and ability of hybrids to adapt to their local surroundings is unpredictable and may not be fully realized until the arrival of second-generation hybrids (Verspoor et al. 2015). A study of wild, hybrid, and feral juvenile salmon in the wild suggested a decrease in survival of aquaculture offspring and a negative impact on the character and size of wild populations experiencing hybridization (Sylvester et al. 2018). Tank experiments with North American-origin farmed fish (Saint John River strain), European-origin farmed fish, wild Newfoundland fish, and the subsequent hybrids found a significant differences in development time, survival, growth, and energy conversion at critical early life stages between these groups and these differences could be maternal strain origin dependent (Islam et al. 2021). Specifically, Islam et al. (2021) found that wild Newfoundland salmon had higher survival rates at all life stages examined, North American-origin had intermediate survival rates, and European-origin farmed salmon had the lowest. Behavioural experiments on juveniles found that North American-origin and European-origin farmed fish outgrew and were more dominant than wild Newfoundland salmon while hybrids exhibited intermediate growth (Islam et al. 2022). Lipids and essential fatty acids are important for fish development and diets deficient in these elements can cause issues with growth and pathogen resistance, which can ultimately affect survival and reproductive capacity

(Tocher 2010). During release experiments of wild vs. farmed vs. hybrid fish, Crowley (2022) found that pure farmed fish had lower storage of lipids and certain fatty acids over the first summer of growth. Section 4.3 provides additional information on disease and parasites in Atlantic salmon including strains/species known to occur in Newfoundland, particularly as it relates to transfers between farmed and wild Atlantic salmon.

### 4.1.6 Genetic Population Structure

COSEWIC relies on genetic analyses to determine delineations for DUs. Each DU is considered to have a population with distinct genetic sequences and variations in life history, environmental variables, and geographic separation (COSEWIC 2010). As noted previously, MCE's operations are located in DU 4 (sea farms) and DU 5 (Hatchery) as outlined in the 2010 COSEWIC report. The genetic population structure of wild salmon in southern Newfoundland is primarily influenced by watershed size particularly available freshwater habitat area (i.e., basin area) (Bradbury et al. 2014). As part of the COSEWIC status update, it was proposed that the South Newfoundland population DU 4 structure be re-evaluated and split into two separate DUs: South Newfoundland East and South Newfoundland West (Lehnert et al. 2023). The proposed subdivision point is Garnish River on the Burin Peninsula that terminates at Fortune Bay (Lehnert et al. 2023). MCE's sea farms are located in the proposed South Newfoundland West DU. The division of DU 4 is supported by genetic differences between the two regions (Moore et al. 2014; Bradbury et al. 2015), and the possible presence of up to four genetically distinct groups (Jeffery et al. 2018; Bradbury et al. 2021). No boundary changes were suggested for DU 5 (Lehnert et al. 2023).

In recent years, the genetic population structure has had other influences. A large aquaculture escape event occurred back in 2013, and genetic monitoring by DFO began in 2014 (DFO 2022a). Consequently, unambiguous detection of first- and second-generation offspring from this escape event (including hybrids and aquaculture offspring) were found (27% hybrids within 75 km of escape site) (Wringe et al. 2018). Since then, repeated sampling showed a decline in hybrids and feral aquaculture parents (Kelly et al. 2023). For example, in 2015, 159 escapees were detected in Fortune Bay and Bay d'Espoir, but none were detected in 2016, 2017, or 2018 (Kelly et al. 2023). Another farmed salmon escape event occurred in 2018 (2,000–3,000 individuals) and a total of 400 escapees were recaptured (Kelly et al. 2023). First-generation hybrids (or crosses) were detected in Fortune Bay in 2019 and 2020 with smaller rivers dominated by hybrids (DFO 2022a). In the Conne River watershed, escaped salmon were found mainly in the lower parts of the watershed (DFO 2022a). First-generation hybrids could be found up to 100 km from the 2013 escape location (Wringe et al. 2018; Sylvester et al. 2018). A population genomic analysis found that some farmed Atlantic salmon had European-origin ancestry that then escaped and hybridized in the wild in southern Newfoundland (DFO 2022a). Genetic impacts could also occur in concert with or in absence of hybridization (Verspoor et al. 2015; Bradbury et al. 2020).

## 4.2 Genetic and Ecological Interactions of Farmed Atlantic Salmon Escapees and Wild Salmon

Decades of artificial selection and domestication of farmed salmon have produced fish that are genetically distinct from their wild counterparts (Clifford et al. 1998). Farmed salmon are selected for traits that increase their economic value (Hindar and Fleming 2007) and can be genetically altered to render them sterile. The farmed salmon discussed in this study, in relation to genetic and ecological interaction, are diploid fish (i.e., fish that contain two sets of chromosomes, one from each parent) unless otherwise stated. Diploidy is the natural genetic state of wild salmon. Other genetic types of fish used in aquaculture include triploid fish. Triploidy refers to fish with an extra set of chromosomes. This genetic state is induced in salmon eggs to make resultant salmon sterile. The strain origin for farmed fish is also an important consideration.

Aquaculture operations on the south coast of Newfoundland have been required to use the Canadian Saint John River strain (New Brunswick) of farmed salmon since 1991 (DFO 2013). The Indian Head Hatchery and other hatcheries in NL and Atlantic Canada currently supply sea farms in the Study Area, and this Hatchery Expansion Project will continue to use Canadian Saint John River strain diploid fish (Hiemstra and Townsend 2023). Canadian Saint John River Atlantic salmon strains have been approved for marine cage aquaculture in NL. The transfer and hatching of Saint John River Atlantic salmon eggs, are routine and established activities under the Government of NL (NB, NS and PEI) permitting processes (outlined in the FFA 2019 Aquaculture Policy and Procedures Manual, AP 12 [FFA 2019]). Triploid European-origin salmon (all-female) have been approved for use in one aquaculture project in southern Newfoundland (Placentia Bay) with the first harvest occurring in 2023 (GSF 2024). Sterile female triploid salmon are considered less likely to interact ecologically with diploid wild male salmon (Glover et al. 2016); therefore, sterility was a prerequisite for approving the introduction and transfer of a non-domestic source of eggs from Europe. Although the genetic risks are substantially mitigated, triploidy does not eliminate the potential risks associated with direct competition or disease between farmed and wild fish, and indirect genetic risks relative to diploid fish are unknown (DFO 2016). In addition, the experience with the use of triploid salmon in Norway and Scotland has been poor, and stable farming success has not yet been demonstrated over multiproduction cycles or varying regional settings. The scale of poor industry outcomes has led to the Norwegian Food Safety Authority suspending further licenses for farming triploid salmon in sea farms in Norway (Fraser et al. 2023). Fraser et al. (2023) acknowledge the need for additional, more scientifically robust studies, that compare triploid and diploid farmed salmon performance.

The majority of genetic and ecological interactions observed between farmed and wild salmon involve escaped diploid salmon. Use of diploid European-origin salmon for aquaculture has not been approved in Canada; however, population genetic analysis of North American farmed Atlantic salmon indicates interbreeding with European-origin salmon in the past and escapees have cross-bred with wild salmon in southern Newfoundland (Bradbury et al. 2022; DFO 2022a). The historical use of various strains of European origin fish and hybrids goes back several decades in the State of Maine (Bay of Fundy) (Baum 1998). Prior to modern day controls on introductions and transfers, monitoring and containment, salmon escapes presented multiple opportunities for historical introgression to have occurred.

Mitigating escapes of farmed Atlantic salmon is important because interactions between escapees and wild salmon could result in negative genetic and ecological effects on the wild fish (Naylor et al. 2005; Ferguson et al. 2007; Verspoor et al. 2015; Glover et al. 2017; Bradbury et al. 2020). Morphological, behavioural, and ecological traits could be affected as a result of breeding between farmed Atlantic salmon and wild salmon, thereby potentially causing negative impact on the character, abundance, and survivability of wild salmon stocks (Cairns 2001; Ferguson et al. 2007; Jensen et al. 2010; Verspoor et al. 2015). Risks associated with direct genetic interactions between farmed and wild salmon are related to the number of farmed salmon escapees, the number of escape events, the subsequent prevalence of interbreeding over successive generations, the seasonal timing of the escape, and the age of escapees (Bridger et al. 2015; Verspoor et al. 2015). It may be the case that continuous escapes of a small number of farmed salmon (i.e., chronic releases) could be more harmful than intermittent escapes of a large number of fish (i.e., acute releases) (Baskett et al. 2013; DFO 2013; Verspoor et al. 2015). In any case, the greater the number of escaped salmon, the greater the associated risk of genetic introgression[4] of gene variants to wild salmon stocks (Keyser et al. 2018). Studies of unique strains of farmed salmon (e.g., New Brunswick, Norway) showed there is potential for unpredictable, negative genetic interactions between farmed and wild Atlantic salmon (Hindar et al. 1991; DFO 2013; Verspoor et al. 2015). Hybrid salmon (offspring of farmed salmon with wild salmon) may have reduced fitness (i.e., outbreeding depression) and ability to adapt to environmental conditions compared to wild Atlantic salmon (Bradbury et al. 2020).

Reproductive and non-reproductive interactions between farmed and wild salmon populations co-occur (Bradbury et al. 2020). Escaped farmed salmon and hybrids (or crosses) may compete with wild salmon for resources including spawning habitat in freshwater systems (Webb et al. 1991, 1993a,b; Fleming et al. 1996, 2000; DFO 2013; Fjelldal et al. 2014), food sources (Cucherousset et al. 2021; Islam et al. 2022), and there is a possible increased risk of exposure to parasites/pathogens (Bradbury et al. 2020), thereby reducing the number of successful wild salmon spawning events and affecting wild salmon stock abundances. Fleming et al. (2000) demonstrated a more than 30% decrease in wild salmon productivity from resource competition and competitive displacement after an experimental release of sexually mature farmed salmon into a river. Cross-breeding between escaped farmed Atlantic salmon and wild salmon has also been documented in the natural spawning grounds of wild salmon stocks (Lura and Saegrov 1991; Webb et al. 1991; Carr et al. 1997; Saegrov et al. 1997; Clifford et al. 1998; Fleming et al. 2000; Milner and Evans 2003; Butler et al. 2005; Fiske et al. 2006; Skaala et al. 2006; Hindar and Diserud 2007; Morris et al. 2008; Madhun et al. 2015; Skilbrei et al. 2015). In southern

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[4] Introgression is defined as the transference of genes from one species to another resulting in hybridization of offspring.

Newfoundland, reproductively viable hybrids and feral salmon were found a year following an escape event (Wringe et al. 2018).

Changes in ecological mechanisms such as competition, disease, parasites, and predation can indirectly influence the genetics of wild populations (Bradbury et al. 2020). Competition for food and space is also a potential ecological interaction between escaped farmed salmon and wild salmon, principally in freshwater systems but also, to a lesser degree, in the marine environment. Studies conducted by Hislop and Webb (1992), Fleming et al. (2000), Einum and Fleming (1997), McGinnity et al. (2003), and Skaala et al. (2012) determined that escaped farmed salmon have a similar diet to wild salmon, which could potentially create competition for food resources (Jensen et al. 2010). Since juvenile farmed salmon may grow faster and may be more aggressive than juvenile wild salmon (DFO 2013; Verspoor et al. 2015), they could potentially outcompete juvenile wild salmon. In studies using tanks and semi-natural experiments found that when competing for food, North American origin (Saint John River strain) farmed salmon were more dominant than Newfoundland wild salmon, and farmed salmon grew quicker than wild salmon (Islam et al. 2022). Growth enhanced fish could also have ecological changes by significantly impacting the local invertebrate community and presence of predatory and primary production invertebrates (Cucherousset et al. 2021).

Genetic impacts could also occur in conjunction with or in the absence of cross-breeding (Verspoor et al. 2015; Bradbury et al. 2020). Wild salmon populations have adapted to local pathogens over both space and time and disease transmission from aquaculture populations can occur (Bradbury et al. 2020). Disease-mediated genetic change could occur in wild populations from novel disease exposure associated with aquaculture activities (de Eyto et al. 2007, 2011). Exposure to diseases/pathogens could come from horizontal transmission (Johnsen and Jensen 1994; Madhun et al. 2018; Nylund et al. 2019; Bradbury et al. 2020). There is evidence that predators select infected prey at higher rates and could amplify disease/parasite associated selection mortality (Krkošek et al. 2011). High rates of mortality from parasite driven selection have the potential for significant demographic change/decline of genetic diversity of wild populations (Karlsson et al. 2020).

Salmonid aquaculture has occurred in NL since the 1980s. Aquaculture operations on the south coast of Newfoundland have had on occasion substantial numbers of escaped diploid farmed salmon (e.g., ~20,000 in 2013 and 2,000–3,000 in 2018; Wringe et al. 2018), with some entering rivers adjacent to sea cages (Morris et al. 2008; DFO 2017; Keyser et al. 2018). It is not fully understood the maximum distances escaped farmed salmon will travel between the sea cages and the rivers entered; however, following a 2013 escape event in Fortune Bay, NL, unambiguous first- and second-generation wild-escapee hybrids and pure feral offspring were detected in rivers within 75 km from the escape site (Wringe et al. 2018), and smaller rivers in the area were dominated by hybrids (DFO 2022a). Hybrid offspring were found in 17 of 18 rivers (rate of 27.1%) and feral farm offspring in 13 rivers (Wringe et al. 2018). In a study in Norway, Keyser et al. (2018) indicated that the majority of escaped farmed salmon were recaptured within 150 km of the release site but that some were recaptured as far as 800 km away. Genetic techniques to trace farmed salmon back to their respective aquaculture operation have also been developed (Norris et al. 2000; Glover 2010), allowing the identification of the aquaculture site that the escaped farmed salmon originated. These techniques can be used to identify which aquaculture operation the escaped fish originated.

### 4.2.1 Project Specific Broodstock Strain

Mowi is a global leader in salmon breeding. MCE operates a breeding program based on Atlantic salmon stocks which originated from the Canadian Saint John River (SJR) in NB. The main broodstock facility is on PEI with back up populations in NB. The program is also supported by the Huntsman Marine Science Centre in combination with Mowi Genetics in Norway. All adult nucleus fish are tagged with Passive Integrated Transponders (PIT) to allow full tracking and traceability of every individual, along with recording traits and genetic information. Through control of its own broodstock program, MCE can ensure its production fish have desirable traits associated with farming in Newfoundland. The control this gives MCE in achieving its GRI goals associated with fish health and welfare, innovation, and product quality for markets is essential to the success of MCE operations. To confirm MCE salmon are all Canadian SJR stock, the MCE breeding program also screens for Continent of Origin (COO). MCE methods confirm that the salmon bred for farming are descendant from SJR salmon. Although, MCE broodstock has been sourced from the wild, historically, there were opportunities for interbreeding of North American and European origin salmon (Baum 1998). Therefore, it is possible that subsequent generations of salmon may express a minority amount of genes associated with this past European ancestry that were not expressed in the previous generation. To mitigate this possibility, the MCE program continues to test each generation of broodstock salmon with the goal to eliminate salmon that express any ancestrally inherited European genes. MCE salmon are approved under the National Code on Introductions and Transfers of Aquatic Organisms. The Code is explicit in its intent to enable such transfers to continue. The MCE COO testing demonstrates a commitment to a level of diligence that exceeds regulatory standards.

Broodstock is held and managed at MCE facilities in Northampton, NB, and Dover, PEI. Separation offers protection and a contingency if there is a catastrophic loss at one location. These hatcheries represent significant assets in MCE and Atlantic Canada that fulfill the essential role of supplying Canadian approved smolt to NB, NL, and PEI.

The broodstock is a SJR strain that has undergone the necessary approval for farming in Atlantic Canada including NL, under the National Code on Introductions and Transfers of Aquatic Organisms. The broodstock health surveillance and the transfer and hatching of eggs are routine and established activities under the Government of NL (NB and PEI) permitting processes (outlined in the FFA 2019 Aquaculture Policy and Procedures Manual, AP 12). Since 2021, cooperation in inter-provincial processes have been guided by a MOU between the governments of NB, NL, PEI and NS where the parties agree to work towards an aligned regulatory and policy environment, to the extent possible, in areas such as leasing and licensing programs, environmental monitoring, reporting, and aquatic animal health (Memorandum of Understanding for the Development and Management of the Aquaculture Industry 2021)[5].

In recent years, MCE has developed procedural changes to further decrease the risk of pathogens originating in its broodstock potentially impacting the production of smolt. Mitigation measures that are in place within the MCE broodstock program include:

- As part of the province's Active surveillance program, broodstock fish are tested for pathogens prior to spawning and must meet the testing requirements under the Certificate of Health for Fish Transfer (COHFT) policy to receive permission to move fish between the Atlantic provinces. Sampling consists of bacteriology, virology, and PCR of select pathogens (including Bacterial Kidney Disease [BKD]) as determined by regulators.
- Every broodstock fish is screened for deleted and non-deleted highly polymorphic region (HPR0)[6], the agent demonstrating infection with non-pathogenic Infectious Salmon Anemia virus (ISAv), and any fish that has tested positive (and all associated eggs or milt) is discarded from the spawning process.
- Approved iodine-based disinfectant (e.g., Ovadine[7]) is used to disinfect eggs prior to transfer and upon receipt to the Hatchery, and prior to incubation.

### *4.2.1.1 History of MCE Saint John River Broodstock Strain*

Access to the history of the origins of Canada's broodstock programs has been impacted as senior staff at DFO retire, in combination with document retention rules tightening within DFO. It has become difficult to locate these historical files (E. Careen, DFO, pers. comm., 12 June 2023). Nonetheless, DFO has been able to offer the following timeline and background as it relates to the use of the Canadian SJR strain in Newfoundland.

The SJR broodstock of Atlantic salmon for aquaculture had its beginnings in 1974 in NB via the Salmon Genetics Research Program (SGRP). SGRP was designed to evaluate genetic components relating to sea "ranching" return rate as well as secondary freshwater traits (i.e., smolting age and precocious parr).

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[5] https://www.gov.nl.ca/ffa/files/MOU-Atlantic-Aquaculture-2021-02-01-Signed.pdf

[6] ISA is caused by infection with the pathogenic highly polymorphic region (HPR)-deleted infectious salmon anaemia virus (ISAv), or the non-pathogenic HPR0 (non-deleted HPR) ISAv. Infection with HPR-deleted (HPR0) ISAv may cause severe disease in Atlantic salmon. However, detection of HPR0 ISAv has never been associated with clinical signs of disease in Atlantic salmon.

[7] A buffered 10% polyvinylpyrrolidone-iodine complex (PVP Iodine).

During 1985–1989, trials were conducted with local and non-local wild stocks:

- Local (Newfoundland): Grey River; Upper Salmon River; Conne River; Exploits River; Robinsons River; and “Labrador” strain (landlocked salmon).
- Non-Local: LaHave River and River Phillip, NS; and Bay Chaleur strain-derived from Tadousac, Cascapedia and St. Jean rivers (noted as 3SW fish).

Prior to the approval for SJR strain in NL there was an initial three-year broodstock plan to produce a mix of hybrid strains with diploid and triploid progeny based on local wild stocks to produce a single strain for cage culture. In 1989, the first importation to NL of SJR strain occurred, and this became the standard commercial strain. From 1989–1994, there was a Grand Codroy River broodstock evaluation and comparison with SJR strain. Throughout the 1990s, SGRP worked with aquaculture companies and local angler associations to develop river specific wild stocking programs. In parallel with the SGRP, corporate breeding programs were developed and since the 1980s, salmon farming companies in Atlantic Canada have been developing and selecting broodstock to optimize growth, survival, and disease resistance (Glebe 1998).

In 1999, there was a Ministerial approval to evaluate alternative North American (NA) origin strains. From 2000–2005, the Gaspe strain was evaluated. Performance was noted as satisfactory, particularly in the freshwater phase. This was originated from Cascapedia and St. Jean rivers in the 1950s and used on the west coast of North America (E. Careen, DFO, pers. comm., 12 June 2023).

The chronology is vague but presents at least a 20-year history of development and assessment initiatives of NA origin fish that ultimately resulted in the continued use of SJR strain as the standard commercial broodstock strain approved for use in Atlantic Canada.

The current North Atlantic salmon populations in MCE, originate from four-year classes (2006–2009 fertilization year class [FYC]) of unpedigreed individuals, that were originally founded from wild stocks taken from the SJR. The breeding program started in the fall of 2010 using the broodstock (2006FYC) that were first kept in the sea cages. Due to its short time history only a few rounds of breeding selection have been made on each year class. The same broodstock management was applied to each of the three-FYC, creating offspring for 2011FYC, 2012FYC and 2013FYC (Table 4.3). Using microsatellite marker technology, the parents of original unknown pedigree were PIT tagged and genotyped to ensure that closely related individuals were not crossed.

Table 4.3. North America Atlantic salmon populations used by MCE, separated by fertilization year class and generation.

| Generation | Fertilization Year Class | | | |
|---|---|---|---|---|
| P0 | 2006 | 2007 | 2008 | 2009 |
| G1 | 2010 | 2011 | 2012 | 2013 |
| G2 | 2014 | 2015 | 2016 | 2017 |
| G3 | 2018 | 2019 | 2020 | 2021 |
| G4 | 2022 | 2023 | | |

In the early phase of the breeding program, the control of related inbreeding was the main focus to maintain the natural genetic diversity of the populations (i.e., microsatellite marker multiplex was to estimate relatedness).

#### *4.2.1.2 Continent of Origin (COO) Using Microsatellite Marker Multiplex and SNP Marker Multiplex*

When the breeding program began using the stock that is now used by MCE, Huntsman Marine Science Centre sought to determine what level of genetic variability might be expected. At the time, it was impossible to determine because there was a large potential for error with the type of identification available. Personnel relied on visual methods to assign families or groups during spawning. The availability of PIT tags and molecular techniques came later.

Prior to 2010, after a period of allowing the use of European stocks (A. Garber, Huntsman Marine Science Centre, pers. comm., 20 September 2024), aquaculture operators in Maine (United States) had started to use the “King 7” test as a requirement to ensure that only North American origin Atlantic salmon were being farmed in Maine. During that time the evaluation of nucleus progeny from commercial harvest did not use PIT tags because metal/glass tags were not permitted in the processing plant. Alternatively, individuals were fin clipped and genotyped. Parents were also genotyped.

The Huntsman Marine Science Centre with its industry partner (i.e., now MCE) chose to apply the “King 7” test in their breeding program. The first Continent of Origin (COO) analysis was done in 2010FYC parents contributing to 2014FYC using the King 7 microsatellite multiplex (King et al. 2001, 2005). A log-likelihood statistical methodology was used to estimate and assign which animals were statistically likely to have EU-ancestry.

The Centre for Aquaculture Technology Canada (CATC) had developed the use of the log-likelihood test using more advanced Single Nucleotide Polymorphism (SNP) genetic markers for determining COO. This functioned very similar to the “King 7” log likelihood test using microsatellite markers. The Huntsman Marine Science Centre used CATC to provide details from the SNP markers to assign parentage, sex and COO to MCE broodstock. Based on this ability and testing, the criteria of removing a family that failed the COO test were as follows:

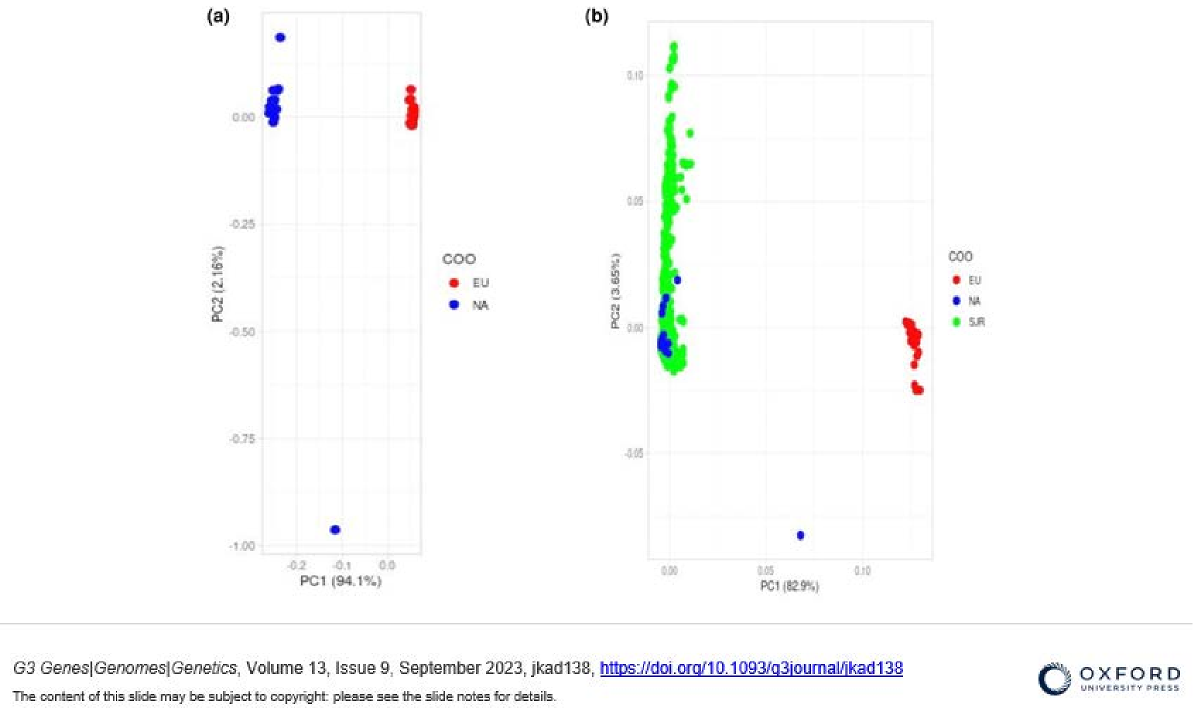
- A family that had one or both parents fail, or one or more progeny offspring fail, resulted in the complete removal of the entire related family from the breeding program.

For example, if there were two passing parents producing 9 of 10 passing progeny, then that family was still removed even if a single sibling failed. This criterion was strict.

The breeding program has removed families based on these criteria. However, it was learned that removal within a generation did not remove all families that might have included individuals, which carried ancestral hybridized genes from previous generations. It was also learned with the testing that the microsatellite based “King 7” test did not always agree with the SNP “King 7” test. Therefore, an additional step was added to test any parents, which were to be used as potential nucleus broodstock using both the SNP and the microsatellite marker test. It has since been found that these tests, while still not 100% accurate, are sometimes more stringent than use of 200+ SNP markers (used by DFO; Bradbury et al. 2022) (i.e., both tests can result in false European origin results).

#### *4.2.1.3 Development of Single Nucleotide Polymorphism (SNP) Markers for COO*

The recognized latest modern SNP markers for differentiating COO was developed by Gao et al. (2023). In brief, 60 samples of EU origin populations and 14 samples from NA Atlantic salmon were genotyped with the 61 SNPs. Principal components analysis (PCA) was performed using PLINK version 1.9 (Purcell et al. 2007). The results of the PCA are shown in Figure 4.5 below (Gao et al. 2023):



*G3 Genes|Genomes|Genetics*, Volume 13, Issue 9, September 2023, jkad138, https://doi.org/10.1093/g3journal/jkad138

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Figure 4.5. Illustration of results of a principal components analysis (EU – European origin Atlantic salmon, NA – North American origin Atlantic salmon, and SJR – Saint John River strain Atlantic salmon).

The samples were distinctly separated into two different clusters according to their COO. The validation set of markers was performed on the 2,512 samples from the SJR aquaculture strain which overlay on the samples from North America Atlantic salmon origin. The validation was done internally and was also supported by information on European salmon from other Mowi Business Units. This approach has been adopted by MCE to further filter out any remaining EU-origin ancestral genes from the broodstock populations.

#### *4.2.1.4 Genomic Analysis*

Since 2018, MCE's family-based breeding program has become a full-scale genomic program supported by the Huntsman Marine Science Centre and Mowi Genetics. In the modern genomic breeding era, four populations in MCE are selectively bred based on their genomic breeding values of economically important traits. Before all selection candidates are selected as parents, they must be evaluated and pass for COO. All selection candidates are genotyped with a high density Thermo Fisher Axiom SNP array (SALMOWN1), that contains the set of 48 validated COO markers as described above.

Fish that fail to pass the COO SNP markers are excluded and culled from the breeding populations. This is to prevent the risk of having any historical EU origin salmon in the populations.

The COO analysis has been performed in all FYC and all populations from different FYC show promising results, and EU origin animals can be "identified" from the NA origin animals. This also verifies the effectiveness of the COO approach based on the set of COO SNP markers.

#### *4.2.1.5 Admixture*

Although each offspring generation, e.g., FYC2022 (offspring of FYC2018) is expected to have no EU origin animals, some offspring may have originated from an ancestral mating between NA origin parents that were introgressed by EU origin animals. This may have historically occurred in the very early years (before 2010) of commercial broodstock development and domestication. It is unknown when this could have happened in the past and it is challenging to trace exactly when it did happen, but it occurred prior to initiation of the broodstock program being discussed. After the COO analysis in FYC2022, it was found that the biplot of principle components show a stratification rather than distinct clusters. Instead of using PCA for clustering the COO, Mowi Genetics investigated two alternative traits: admixture and breed proportion, using the same set of COO SNP markers. Admixture indicates population stratification and can be estimated by the maximum likelihood of individual ancestries using the software ADMIXTURE. Given the information on European and NA alleles in the COO multi-locus SNP genotypes, animals with NA alleles in all COO loci, as developed by Gao et al. (2023), may be considered a pure strain of NA origin. The breed proportion is then calculated as the proportion of NA alleles in all COO loci. Animals with completely monomorphic COO markers will have a breed proportion of 1 (maximum).

Investigation by Mowi Genetics scientists found that admixture offers the advantage of consistent estimation. However, its sensitivity to reference populations may cause estimates to vary across generations or populations, making it unsuitable for future phenotype use in genomic breeding values. Conversely, breed proportion, calculated using NA alleles, provides more consistent and comparable phenotypes. Therefore, it was decided to favour an approach that would be aimed at increasing the proportion of the NA strain breed; this approach is described below.

### *New strategy for Enhancing the North American Breed Proportion when Admixture is Present*

To complement the approach of removal of fish failing COO test threshold, the methodology for selection on a breed proportion 'breeding value' can be summarised as follows:

1. Individual breed proportions are estimated using COO markers. These markers help identify the presence of NA alleles at each locus, allowing for a precise calculation of breed proportion.
2. Breed proportion is incorporated as a trait into the variance component estimation (VCE), and its heritability ($h^2$) is estimated. This step ensures that the breed proportion is accurately represented in the genetic evaluation process.
3. Genomic breeding values (gEBVs) for breed proportion are estimated using the SALMOWN1 array, which provides a comprehensive analysis of the genetic makeup of the population.

The selection process is divided into two stages:

1. Animals are clustered based on their genomic estimated breeding values (gEBVs), which clearly separate them into two distinct clusters. This clustering allows for the identification and exclusion of animals with low gEBVs, typically indicating European origin. By using this method, animals originating from Europe are effectively removed in the initial selection step, refining the group to focus on non-European origins. In the final stage, selection is performed within the NA strain. Each COO locus contains either a European allele or a NA allele. Some animals that pass the first stage may still exhibit variation in gEBVs within the NA strain. This variation arises from the combination of COO genotypes and the single nucleotide polymorphisms (SNPs) in linkage disequilibrium (LD) with COO markers. The final selection step aims to increase the frequency of NA alleles across all COO loci.
2. Breed proportion is incorporated into the selection index by assigning a suitable weighting factor that balances the gEBVs for breeding goal traits and COO. This integration ensures genetic progress towards a higher proportion of NA alleles while preserving overall breeding objectives, leading to harmonious advancement in both breeding goal traits and breed proportion.

### *Example of Implementation of Selection Using this Unified Approach*

In the FYC21 year class, a total of 4,055 selection candidates were genotyped and passed the genotype quality control. The genotypes of these animals were analyzed using 41 COO markers, which were recoded to 0, 1, and 2 based on the number of NA alleles present at each locus. For each individual, the mean of the recoded genotype across loci was calculated, and the breed proportion was subsequently determined by dividing the individual mean genotype by 2. The breed proportion ranges from 0 to 1, where 1 indicates a pure NA strain and 0 represents a pure European strain. The mean breed proportion was found to be 0.927 with a standard deviation of 0.258.

The breed proportion was analyzed using a univariate animal mixed model with either a pedigree-based (A) or genomic (G) relationship matrix. Although the model faced convergence issues, the variance component estimates suggest that genomic heritability ($h^2$) is nearly one. The results show that the genomic relationship matrix (G) provided higher additive genetic variance (Va) and heritability estimates compared to the pedigree-based matrix (A). The heritability estimates for A and G were 0.585 and 0.820, respectively, with small standard errors (SE; Table 4.4). These findings indicate that the breed proportion, as estimated from COO markers, has a strong genetic component, and selection for NA strain is possible.

Table 4.4. Variance components and heritability for admixture in 2021CES1**.**

| Relationship | $V_a$ | $V_e$ | $V_p$ | $h^2$ | SE |
|---|---|---|---|---|---|
| A | 0.0014 | 0.0010 | 0.0024 | 0.585 | 0.017 |
| G | 0.0046 | 0.0010 | 0.0056 | 0.820 | 0.009 |

The genomic breeding values (gEBVs) for breed proportion were estimated using a mixed model equation, with the genomic relationship matrix constructed from 35,445 SNPs obtained from the SALMOWN1 array. The gEBVs clearly clustered into two distinct groups, as shown in Figure 4.6; with green representing NA-origin individuals and red representing EU-origin individuals. Higher gEBVs for breed proportion values indicate a greater proportion of NA-origin.

During the initial stage of selection, 292 animals with gEBVs for breed proportion less than -0.2 were excluded from the population. This exclusion resulted in 92.8% of the animals remaining in the population, increasing the mean breed proportion from 92.7% to 96.2%, reflecting a 3.52 percentage point increase.

In the final stage of selection, breeding goal traits—including growth, jaw deformity, resistance to sea lice, temperature tolerance, and fillet colour—along with breed proportion, were incorporated into the selection index calculation. With truncation selection on the selection index, if the proportion of selected animals is set to 13.8%, the truncation point will be at 1.22 standard deviations of the selection index. This results in the selection of 520 animals out of the initial 3,763. Although the selection proportion presented in this document may not represent the actual selection pressure at MCE, it provides insight into the genetic progress for both breeding goal traits and breed proportion. After applying truncation selection on the index, the mean NA breed proportion increases from 96.2% to 98.0%, and the mean selection index rises from 0.044 to 0.640. This strategy shows that high resolution data from the Axiom genotyping array can be used to estimate breeding values for the NA breed proportion in the Atlantic salmon population at MCE.

Through multi-stage selection based on gEBVs for breed proportion, the proportion of NA breed increased from 92.7% to 98.0%, representing a 5.3 percentage point increase per generation. This approach also represents an efficient and unified method of selecting for COO while at the same time ensuring genetic progress for important traits.

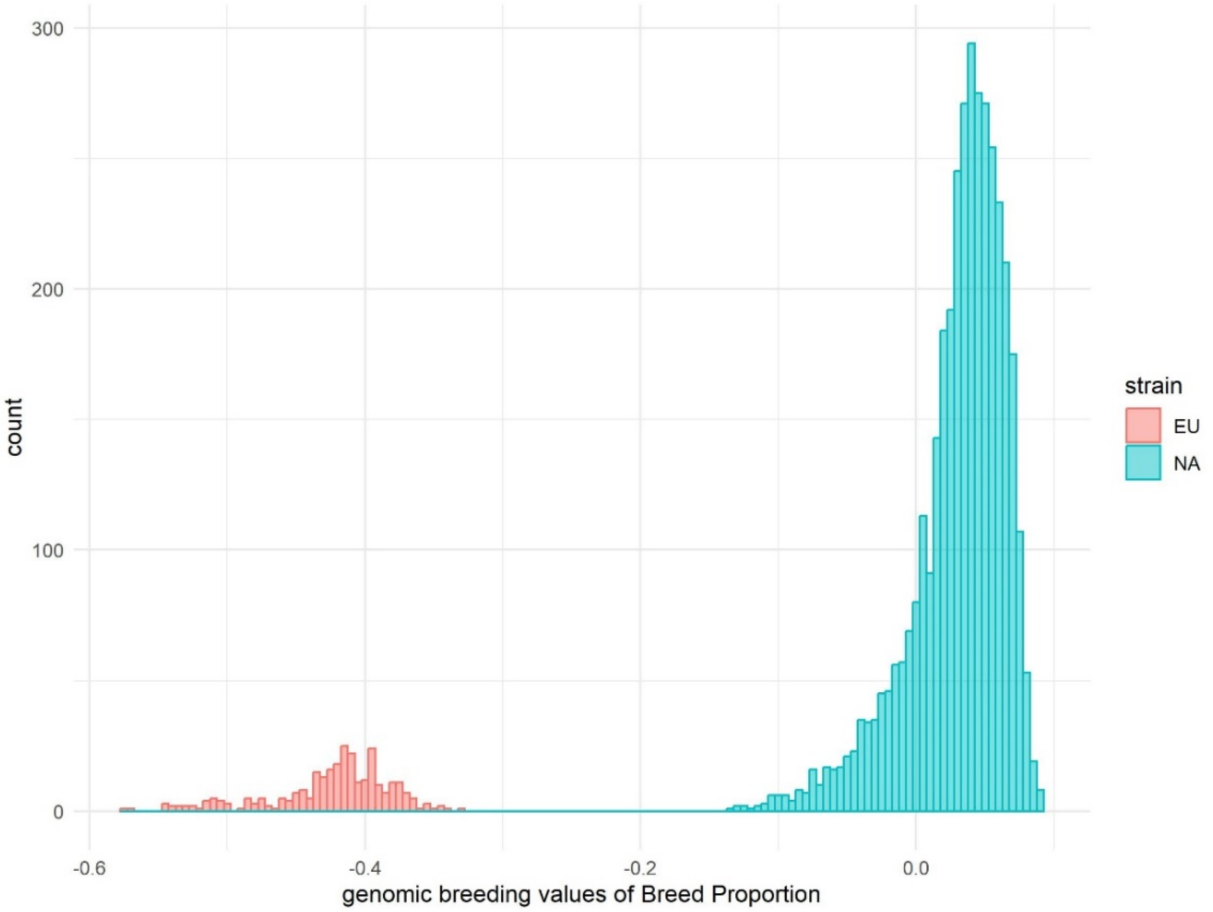

Figure 4.6. Distribution of gEBVs for breed proportion using genomic relationship matrix constructed using ~35k SNPs in SALMOWN1.

Within one generation of COO analysis, all detected EU-origin animals can be removed from the MCE populations. However, past admixture of NA-origin animals with EU-origin animals can result in the detection of EU associated genes over multiple generations. Therefore, it is important that the investigation and screening continues into the admixture of the animals in the NA populations.

### *4.2.1.6 Summary*

In summary, MCEs established broodstock program, its facilities, and partnerships with the Huntsman Marine Science Centre and Mowi Genetics are essential assets, of which the benefits for fish health and production cannot be overstated. MCE knows in detail the genetic make-up of its fish that are and will be used, and their use meet the requirements of the federal and provincial regulators. MCEs partnership with the Huntsman Marine Science Centre and Mowi Genetics to improve its broodstock program contributes unparalleled intellectual knowledge and scientific capacity that cannot be readily replaced.

## 4.3 Effects of Potential Parasite and Disease Transfer from Farmed Salmon to Wild Atlantic Salmon

It is postulated that marine sea cage aquaculture of Atlantic salmon could result in the transfer of parasites or diseases from the farmed salmon to wild salmon. It should be noted that prior to the transport and introduction to the sea cages, all MCE juvenile farmed salmon are vaccinated against disease and are parasite free.

### 4.3.1 Sea Lice

Sea lice are naturally occurring marine copepods with a complicated life history that when in the free-living stages can disperse tens of kilometers (DFO 2014). They co-occur in the same geographic range as wild Atlantic salmon that occur in Newfoundland. Sea lice are parasites of marine fish and feed off the mucus, skin, and blood of infected salmonids and can immunocompromise its host influencing mortality rates. Two of the most common species that infect farmed and wild Atlantic salmon in Atlantic Canada are the parasitic copepods *Lepeophtheirus salmonis* and *Caligus elongatus*. *L. salmonis* is the larger and more commonly associated with damage to the host salmon (Johnson et al. 2004). An adult female produces around 300 eggs each pair of strings. If not removed, an adult female can live for many weeks producing and releasing continuous pairs of egg strings. Released eggs take around four days to develop from egg to nauplii to infective copepodids. During this time they drift passively in the direction of the prevailing currents. These planktonic stages cannot feed until they find a host and moult into the parasitic chalimus stage. Mortality, while drifting as plankton, is around 1% per hour. If no attachment is made the copepodid will eventually die after about 15 days (Murray et al. 2022).

Changes in environmental conditions could have effects on the parasitic relationship between sea lice and Atlantic salmon. A study conducted under laboratory conditions found that as water temperature increased the effects of sea lice on juvenile Atlantic salmon (including growth rate, condition, and survival) worsened (Godwin et al. 2020).

Sea lice are problematic for aquaculture operators, so controlling them is a high priority area of aquaculture research (Rittenhouse et al. 2016). Before being stocked in sea cages, farmed Atlantic salmon are sea lice-free. However, they can be infected with sea lice from passing wild Atlantic salmon or from other salmon farms that also act as hosts for the parasites. Infection intensities or “louse-load” can negatively affect the health of wild juvenile smolt (Bui et al. 2024). Some studies have examined the parasite loading of farmed fish and wild fish associated with sea farms and have found that wild fish could have higher levels of parasite loading than farmed fish (Sepúlveda et al. 2004; Skov et al. 2009; Fernandez-Jover 2010).

To examine the susceptibility of farmed and Newfoundland wild Atlantic salmon to infestations with sea lice, Lush et al. (2019) used Saint John River strain and two southern Newfoundland wild strains (origin Conne River and Garnish River). They found that when exposed to *L. salmonis* under the same conditions, farmed fish had greater fin erosion, surface area coverage, and more sea lice in their gills. The wild salmon had increased sea lice density by 66% (Conne River strain) and more lice on paired fins (Garnish River strain). These findings suggest that there are additional factors (e.g., genetic influences) that can affect the parameters of sea lice infestation.

In addition to the external damage that they can cause to infested salmon, sea lice could facilitate the transfer of pathogens which could lead to disease and increased mortality in both farmed and wild salmon (Jensen et al. 2010; DFO 2014; Verspoor et al. 2015). It is not necessary that farmed fish escape cages to potentially spread sea lice and/or pathogens and disease to wild salmon (Verspoor et al. 2015). If not adequately controlled, particularly during infestations, sea lice on farmed salmon could increase the abundance of sea lice in the vicinity of sea cages and the possibility of sea lice infecting migrating wild salmon passing through the area (Jensen et al. 2010; DFO 2014; Saksida et al. 2015). Fish farms can therefore function as potential "reservoirs" for the potential spread of sea lice to wild salmon (DFO 2014, 2016; Johnson and Jones 2015).

The extent to which sea lice may proliferate and infect farmed and wild salmon depends on several factors, including environmental conditions such as water temperature, salinity, and hydrological conditions (e.g. wind or current); behaviour and movements of adult sea lice; and the prevalence and abundance of infected salmon (DFO 2014; Johnson and Jones 2015). Rittenhouse et al. (2016) conducted modeling to determine peak timing of sea lice reproduction in southern Newfoundland and demonstrated that abundance is affected by environmental parameters such as temperature and salinity. The findings indicate that sea lice abundance is greatest in southern Newfoundland in late summer when ocean temperatures and salinities are at their highest levels. Sea lice reproduction peaks in August and is lowest in December when ocean temperatures are at their lowest. The abundance and density of sea cages containing farmed salmon infected with sea lice may also influence the abundance and degree of sea lice spread (Jansen et al. 2012; Kristopherson et al. 2013 *in* DFO 2014). The greatest consequential risk of sea lice transfer from farmed salmon to wild salmon occurs during the peak period of seaward migration by juvenile wild salmon, between mid-April and early-June (DFO 2014; Johnson and Jones 2015; NASCO 2016). There is little conclusive evidence, however, to support the belief that escaped farmed salmon serve as sources of sea lice that has led to any increased mortality in wild fish (Jensen et al. 2010; Verspoor et al. 2015). A study in British Columbia found no statistically significant association of *L. salmonis* infestation pressure between Atlantic salmon farms and migrating juvenile wild Pacific salmon, and the trend observed cannot solely be explained by infestation pressure from sea farms (DFO 2023c). Similarly, a literature review of Norwegian studies surmised that environmental factors such as salinity and water temperature may influence lice infestation levels on wild migrating smolt more than sea lice levels in nearby sea farms (Nes et al. 2024). In addition, effects on migrating smolt from sea lice cannot be predicted independently from other factors (natural and anthropogenic) that affect marine survival (Nes et al. 2024).

In Newfoundland, aquaculture operators are required to conduct weekly sea lice counts between the spring and fall in an effort to limit the spread of any sea lice among farmed salmon. Sea lice monitoring programs as well as management thresholds have been established for the control of sea lice on farmed fish. Generally, sea lice abundance is determined at the cage/farm level by sampling salmon from a number of cages at a particular site. Sampled fish are anesthetized to allow the enumeration and classification of sea lice life stages (DFO 2014). There are no aquaculture regulatory sea lice concentration thresholds in NL. However, MCE has clear internal thresholds to support its decisions to conduct sea lice treatments and support effective management of sea lice. Once the trigger thresholds (i.e., number of sea lice per fish) have been reached or exceeded, the use of control measures to reduce the levels of sea lice on the farmed salmon are implemented (DFO 2014). Intervention is based on accurate and timely sea lice counts and this occurs under the combined direction of MCE's Designated Aquaculture Veterinarian (DAV), Production Director, and Health Director. There is a very limited range of chemical therapeutants, which may be used to eliminate sea lice and other parasites in farmed Atlantic salmon. The use of therapeutants is considered based on the advice from the DAV and Provincial Aquaculture Veterinarian (PAV) and the age of the affected fish. Physical sea lice removal options are also available and include technologies such as a Thermolicer or flusher. Adoption of the BMA system that separates year classes is an important mitigation strategy for sea lice. During the grow-out cycle, early detection and treatment of sea lice is a critical mitigation strategy for the effective control of sea lice in aquaculture operations in Atlantic Canada. Since 2021, the aquaculture industry provides weekly public reporting on the levels of naturally occurring sea lice on its sea farms (NAIA 2024). MCE has developed and submitted to FFA an Integrated Pest Management Plan (IPMP) (FFA 2019) following the guidance of the provincial Sea Lice Integrated Pest Management Plan (FFA n.d.). Included in this plan are MCE's prevention, monitoring and reporting strategies and procedures for mitigation and monitoring. Prevention is the first line of defense, and several strategies are in place to prevent infections from sea lice.

As mentioned above, farmed fish infected with sea lice may require intervention with chemotherapeutants for the health and welfare of the fish. Sea lice can develop a resistance to treatment products. Sea lice treatment products have been assessed by Health Canada, and Health Canada has developed product instructions to support the efficacy of the treatments and protect the environment.

### 4.3.2 Pathogens

Wild populations of Atlantic salmon are likely to be adapted to local pathogens (Dionne et al. 2007; Tonteri et al. 2010; Consuegra et al. 2011; Kjærner-Semb et al. 2016; Pritchard et al. 2018; Zueva et al. 2018). There are several pathogens that could infect salmonid species including ISAv.

ISAv affects finfish (e.g., Atlantic salmon and brown trout) and outbreaks occur at water temperatures ranging from 3°C and 15°C. The virus is very weak and can only survive outside of a host for a few hours in natural seawater (CFIA 2024a). Quick removal of infected fish can substantially slow or stop the spread of the virus. While not transmissible to humans, it is a federally reportable disease. Detections (or suspicions) must be reported to the Canadian Food Inspection Agency (CFIA). There are several strains of ISAv and not all cause disease or mortality in finfish. Cases of ISAv are regularly reported, and counts are updated for all regions on the CFIA website (CIFA 2024a). Between 2012–2024, ISAv was reported every year in NL; totaling 59 reports. The most recent case in NL occurred in July 2024 (CIFA 2024a). Other federally reportable diseases for finfish include *Ceratomyxa shasta* (status in NL: Free Area [FA]), infectious pancreatic necrosis virus (IPNV; status in NL: Infected Area [IA]), infectious hematopoietic necrosis virus (IHNV; status in NL: FA), viral hemorrhagic septicemia virus (VHSV IVa, status in NL: IA; VHSV IVb, status in NL: FA; and VHSV IVc, status in NL: Buffer Area [BA]), and whirling disease (status in NL: FA) (CFIA 2024b). Clinical outbreaks of these diseases in NL are rare.

The complete list of NL Aquatic Animal Reportable and Notifiable Diseases[8] include:

- IPN (Infectious Pancreatic Necrosis)
- ISA (Infectious Salmon Anemia)
- IHN (Infectious Haematopoietic Necrosis)
- VHS (Viral Haemorrhagic Septicaemia)
- PD (Pancreatic Disease)
- Epizootic Haematopoietic Necrosis
- Viral Nervous Necrosis
- Kudoa
- Heart and Skeletal Muscle Inflammation (HSMI)
- Whirling Disease
- Malpeque disease
- PSP (Paralytic Shellfish Poisoning)
- ASP (Amnesic Shellfish Poisoning)
- DSP (Diarrhetic Shellfish Poisoning)
- *Haplosporidium nelsoni*
- *Haplosporidium costale*
- *Vibrio vulnificus*
- Dermo
- Infection with Francisella
- Ceratomyxosis
- Amoebic Gill Disease
- Proliferative Kidney Disease
- Gyrodactylosis
- Oncorhynchus Masou Virus
- Piscirickettsiosis
- Flavivirus
- Infection with *Bonamia ostreae*
- Infection with *Marteilia refringens*
- Infection with *Mikrocytos mackini*
- Infection with *Perkinsus marinus*
- Infection with *Perkinsus olseni*

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[8] https://www.gov.nl.ca/ffa/files/Newfoundland-and-Labrador-Aquatic-Animal-Reportable-and-Notifiable-Diseases-September-2020.pdf

The list of Notifiable Diseases to be listed in Annual and Quarterly Aquatic Animal Health Reports include:

- BKD (Bacterial Kidney Disease)
- Furunculosis
- Pseudomoniasis
- Saprolegniasis
- Mycobacteriosis
- Streptococcosis
- ERM (Enteric Red Mouth Disease)
- Vibriosis
- Winter Ulcer Disease
- Saddle Back Disease
- Columnaris Disease
- Nodular Gill Disease
- Nocardiosis
- Black Spot Disease
- Microsporidiosis
- Aquareovirus
- Infection with *Flavobacterium* spp.
- Infection with *Exophiala* spp.
- Infection with *Edwardsiella tarda*
- Bacterial diseases with evidence of antibiotic resistance

Research into the resistance of farmed Atlantic salmon to pathogens is ongoing. However, even when salmon are selected for resistance to viruses, new variants can emerge causing increased rates of mortality (Hillestad et al. 2021).

### 4.3.3 Transfer of Parasites and Pathogens to Non-salmonid Fishes

While parasite and disease transfer between farmed salmon and wild salmon has been identified as a potential issue with aquaculture, even less is known about actual parasite/disease transmission between farmed salmon and wild non-salmonid fishes (Uglem et al. 2014). Transmission of parasites and pathogens between farmed salmon and wild fishes could be influenced by several factors including density, environmental conditions, and host specificity. For instance, the higher the host fish densities, the greater the potential for the spread and persistence of parasites and pathogens to host fishes (Krošek 2017). In addition, parasite and pathogen transfer can be influenced by environmental conditions such as water temperature, salinity and other hydrological parameters, behaviours and movements of adult sea lice, and the prevalence and abundance of salmon that are infected (DFO 2014; Johnson and Jones 2015). Salmon lice (*L. salmonis* and *C. clemensi*) appear to be largely host-specific to salmonid species although they are also known to infect three-spined stickleback (*Gasterosteus aculeatus*) in British Columbia (Jones et al. 2006) and *Lepeophtheirus* spp. have been observed on three-spined stickleback (n=3) in Bay d'Espoir, NL (Eaves et al. 2014). The parasitic copepod *Ergasuilus labracis*, which are known to infest farmed salmonids in other regions (Hogans 1989; O'Halloran et al. 1992), have also been documented on stickleback in Bay d'Espoir (Eaves et al. 2014). Three-spined stickleback may act as a minor host for *L. salmonis* and have been observed to host *C. elongatus* in the Gulf of Maine (Pietrak et al. 2019).

Pathogen transmission between aquaculture sites and wild populations of Atlantic salmon are considered quite possible but the effects are uncertain and likely case specific (Bradbury et al. 2020). Nylund et al. (2019) found evidence of ISAv variant consistent with horizontal transmission from farmed salmon to wild populations in Norway. Regarding PRV and salmon farms in BC, Marty et al. (2015) found the prevalence of PRV was not different between fresh samples from wild Coho salmon collected from Alaska (where there are no salmon farms) and BC. Mordecai et al. (2021) assert that Atlantic salmon farms in BC have resulted in the spread of the viral pathogen PRV-1 into local wild salmon populations. Studies in British Columbia have found no statistically significant association between *L. salmonis* infestation pressure from Atlantic salmon farms on migrating juvenile wild Pacific salmon species populations, which indicates other sources of infestation (DFO 2023c). Although there are few studies in Atlantic Canada that have examined the transfer of parasites/pathogens from farmed salmon to wild fish species, there is little conclusive evidence of impact (Teffer et al. 2020); however, it is still thought to be possible (DFO 2014; Verspoor et al. 2015). A study of aquaculture escapees in eastern Canadian rivers found that two independent aquaculture escapees (one from the Magaguadavic River in New Brunswick and the other from the Shelburne Harbour in Nova Scotia) had PRV-1 sequences that differ from those found in wild fish collected at sea suggesting the presence of a common source or transmission within aquaculture facilities (Teffer et al. 2020). Transmission of pathogens does not necessarily result in disease. PRV-1 is an example of transmission that generally is not known to cause disease in farmed or wild Atlantic salmon.

## 4.4 Potential Effect of Proximity of Sea Cages to Salmon Rivers

It has been suggested that the closer sea cages are located to salmon rivers, the higher the potential for escaped farmed salmon to enter the freshwater systems and interact with wild fish (Gausen and Moen 1991; Carr et al. 1997; DFO 2016). However, escaped farmed salmon (and their offspring) have been found in rivers some distance (>100 km) from sea cage sites (Hansen and Youngson 2010; Solem et al. 2013; Wringe et al. 2018; Sylvester et al. 2018, 2019; Bradbury et al. 2022). The likelihood that escapees enter a freshwater system may also depend on the life stage of the escapee and the timing of the escape. Mature escaped farmed salmon tend to enter nearby rivers more than juvenile salmon (Skilbrei et al. 2015). It is thought that juveniles that escape in the spring are more likely to enter the rivers than those that escape at other times of the year (Skilbrei et al. 2015).

As previously described, there are 24 scheduled salmon rivers within the vicinity of the Project sea farms (see Figure 4.3). Six of these rivers are in the Bays East area (Figure 4.7) and nine are in the vicinity of Bays West (Figure 4.8). These rivers all had a Class 2 designation for the 2023–2024 and 2024–2025 season (DFO 2023b, 2024a). Several non-scheduled salmon rivers (i.e., rivers with documented occurrences of Atlantic Salmon but not listed by name in the regulations) are also present near the sea farms in the Bays East (Figure 4.9) and Bays West (Figure 4.10) area. Table 4.5 presents the proximity of sea farms to scheduled and non-scheduled salmon rivers per BMA. BMAs 3, 4, 9, 10, and 11 have scheduled rivers within their boundaries and BMAs 1, 2, 3, 9 and 10 contain at least one non-scheduled river (Table 4.6).

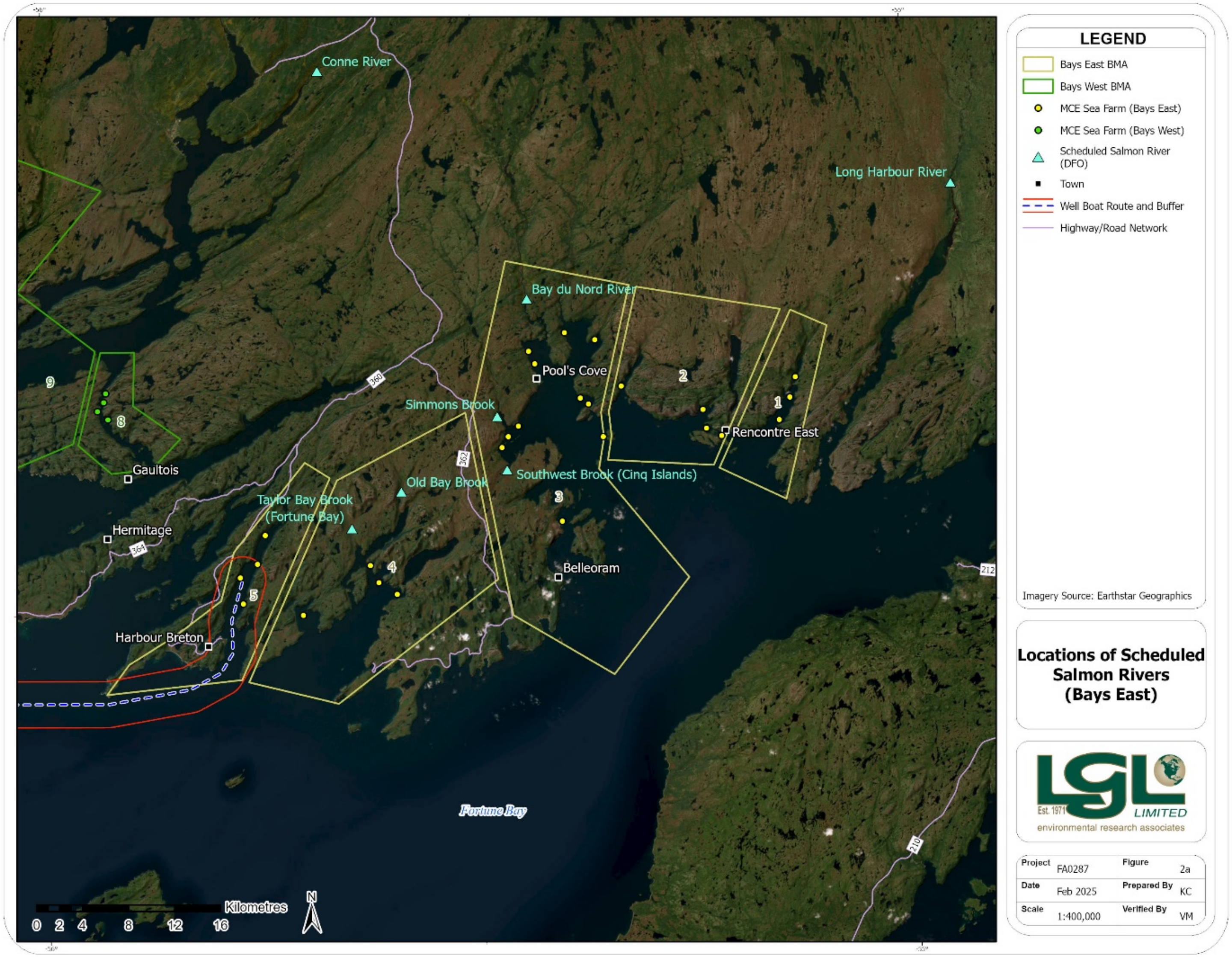

Figure 4.7. Locations of scheduled salmon rivers in and near the Bays East area in relation to MCE sea farms.

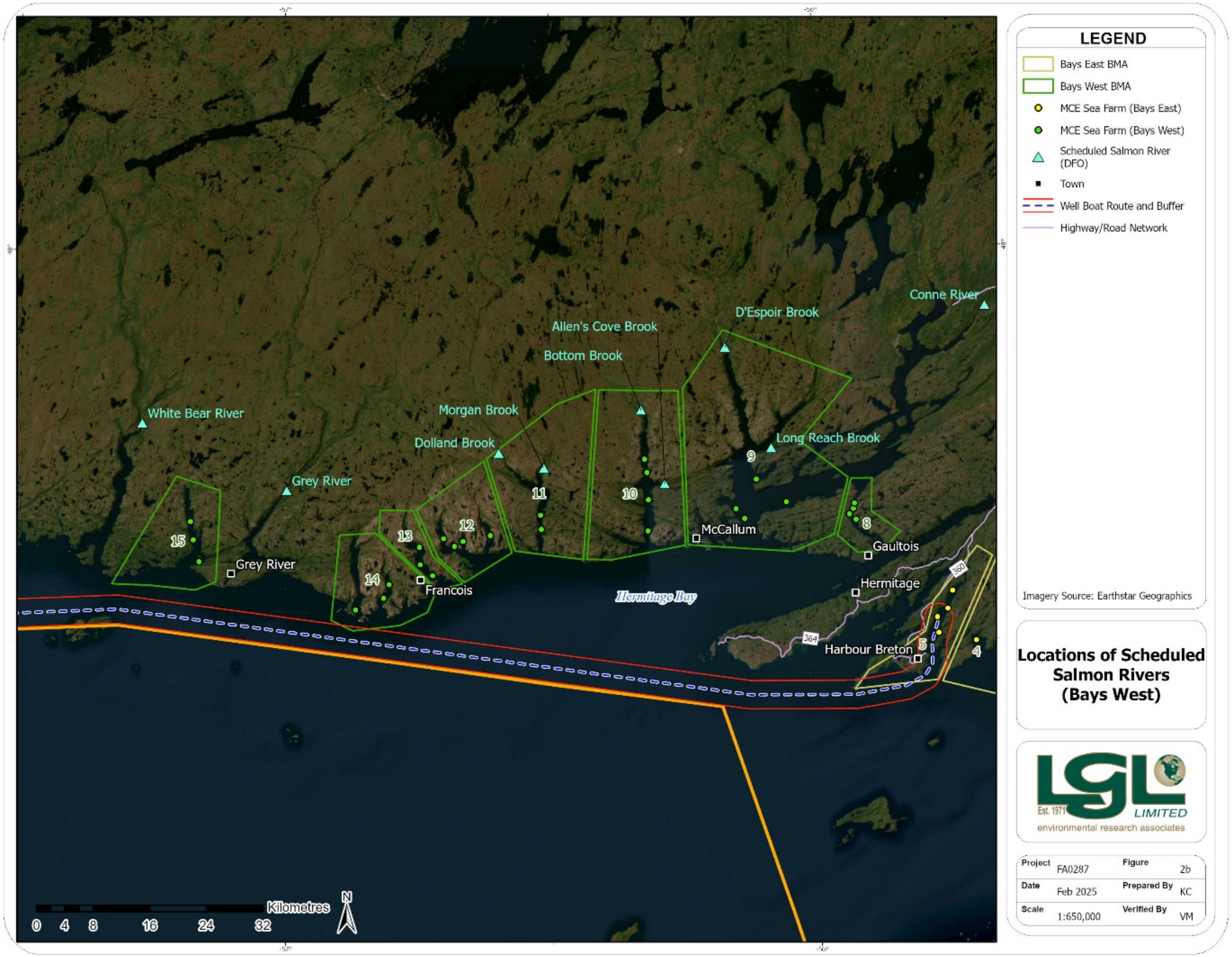

Figure 4.8. Locations of scheduled salmon rivers in and near the Bays West area in relation to MCE sea farms.

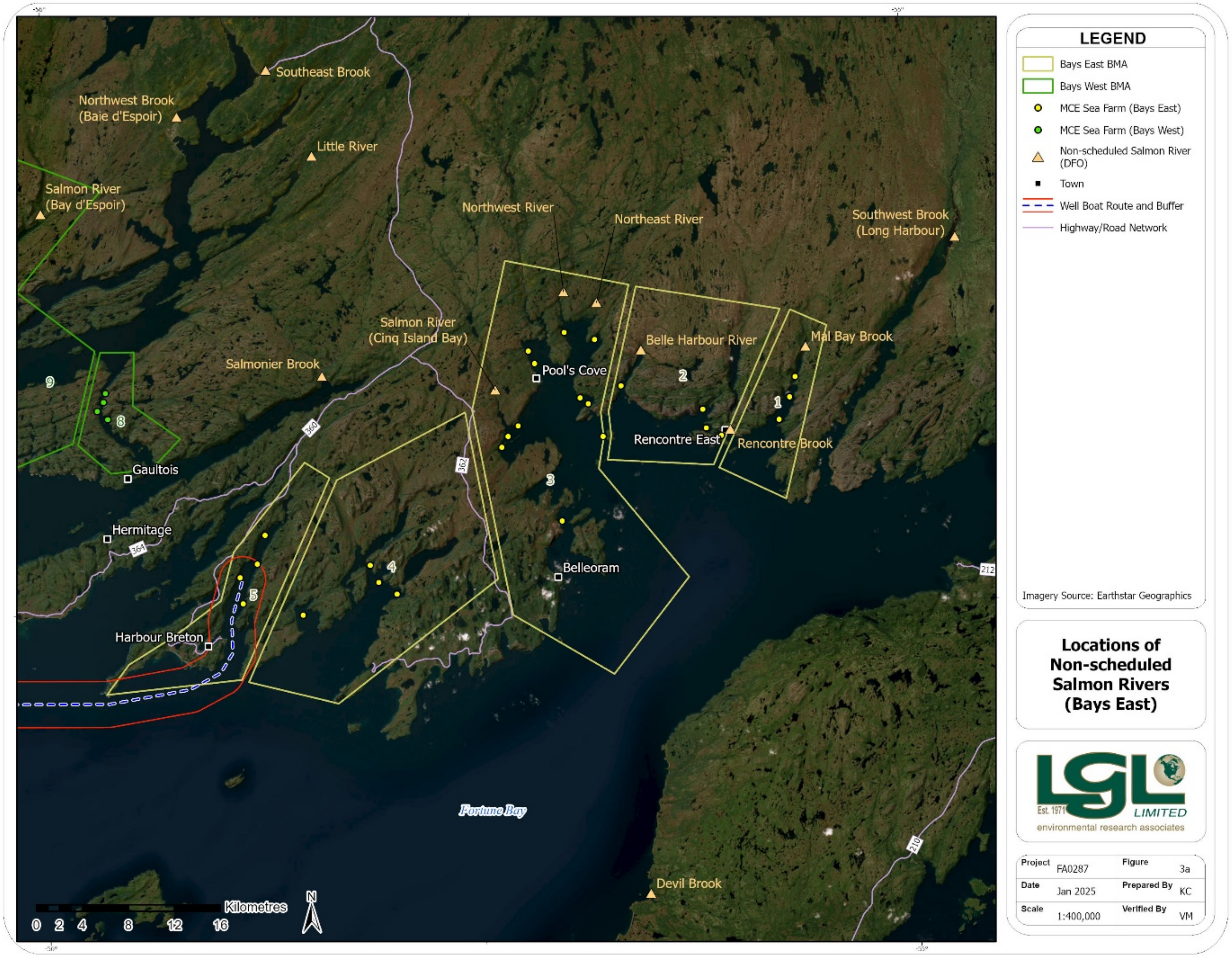

Figure 4.9. Locations of non-scheduled salmon rivers in and near the Bays East area in relation to MCE sea farms.

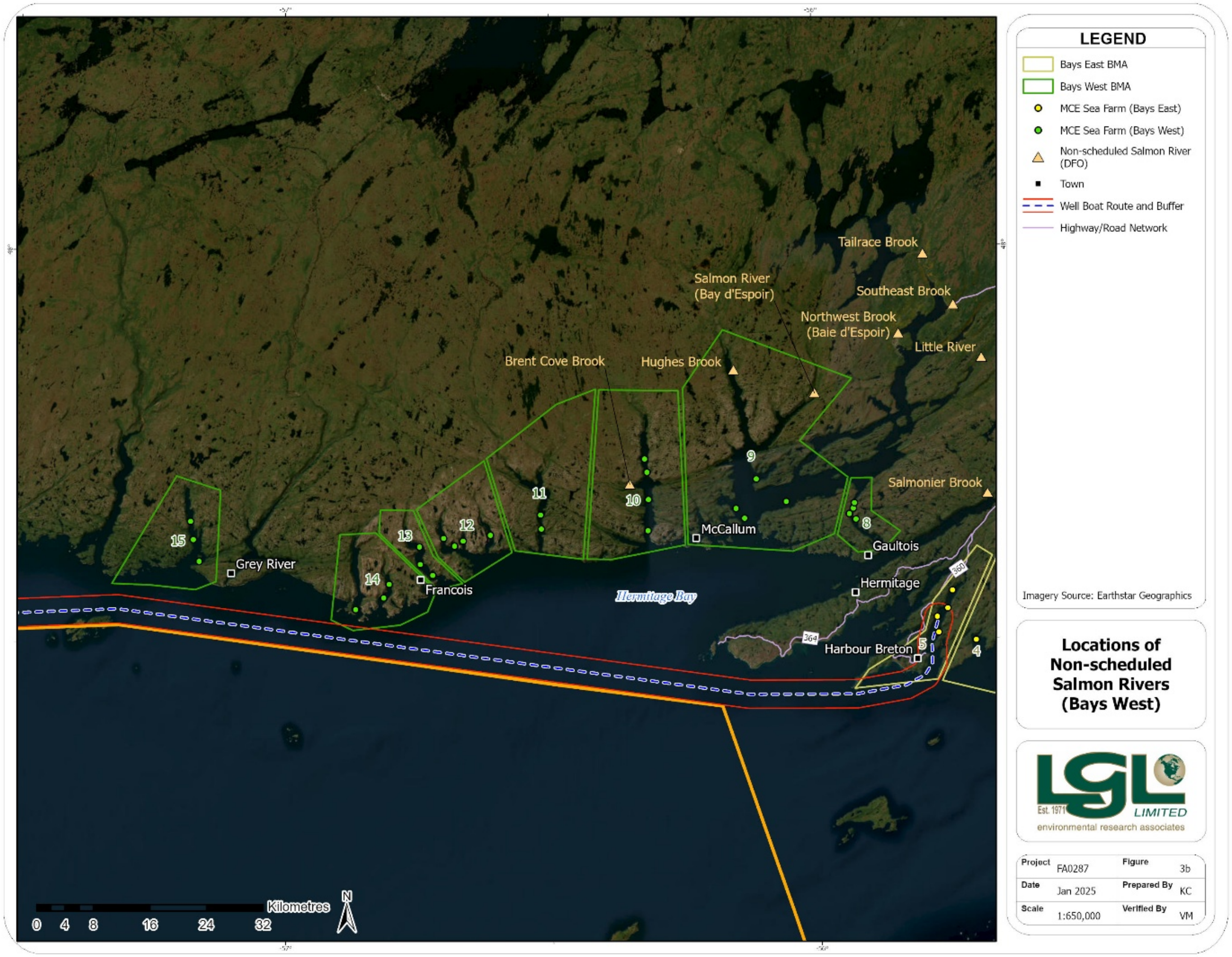

Figure 4.10. Locations of non-scheduled salmon rivers in and near the Bays West area in relation to MCE sea farms.

Table 4.5. Summary of number of sea farms per BMA and proximity (km) to scheduled and non-scheduled NL salmon rivers.

| BMA | Distance to River | <5 km | 6–10 km | 11–20 km | 21–30 km | >31 km | Nearest Salmon River |
|---|---|---|---|---|---|---|---|
| | No. Sea Farms (Total) | No. Sea Farms | | | | | |
| **Scheduled** | | | | | | | |
| 1 | 3 | | | | 2 | 1 | Simmons Brook and Southwest Brook (Fortune Bay) |
| 2 | 4 | | | 3 | 1 | | Simmons Brook and Southwest Brook (Fortune Bay) |
| 3 | 11 | 3 | 5 | 3 | | | Simmons Brook and Southwest Brook (Fortune Bay) |
| 4 | 4 | 2 | 1 | 1 | | | Taylor’s Bay Brook and Old Bay Brook |
| 5 | 4 | | | | 3 | 1 | Taylor’s Bay Brook and Old Bay Brook |
| 8 | 4 | | | | 4 | | Long Reach Brook |
| 9 | 4 | | 1 | 3 | | | Long Reach Brook and D’Espoir Brook |
| 10 | 4 | 3 | 1 | | | | Allen’s Cove Brook and Bottom Brook |
| 11 | 2 | | 2 | | | | Hare Bay Rivers (Morgan Brook and Dolland Brook) |
| 12 | 4 | | | | 4 | | Hare Bay Rivers (Morgan Brook and Dolland Brook) |
| 13 | 3 | | | | 2 | 1 | Hare Bay Rivers (Morgan Brook and Dolland Brook) |
| 14 | 3 | | | | | 3 | Grey River |
| 15 | 3 | | | | 3 | | Grey River |
| Total | 53 | 8 | 10 | 10 | 19 | 6 | |
| Percent | | 15% | 19% | 19% | 36% | 11% | |
| **Non-scheduled** | | | | | | | |
| 1 | 3 | 3 | | | | | Mal Bay Brook and Rencontre Brook |
| 2 | 4 | 4 | | | | | Rencontre Brook, Mal Bay Brook, Belle Harbour River |
| 3 | 11 | 5 | 5 | 1 | | | Salmon River (Cinq Island Bay), Northeast Brook (East Bay), Northwest Brook (East Bay) |
| 4 | 4 | | | | | 4 | Rencontre Brook |
| 5 | 4 | | | | | 4 | Rencontre Brook |
| 8 | 4 | | | | 4 | | Salmonier Brook (Hermitage Bay) |
| 9 | 4 | | | | 2 | 2 | Hughes Brook and Salmon River (Bay d’Espoir) |
| 10 | 4 | 3 | 1 | | | | Brent Cove River |
| 11 | 2 | | | | | 2 | Brent Cove River |
| 12 | 4 | | | | | 4 | Brent Cove River |
| 13 | 3 | | | | | 3 | Brent Cove River |
| 14 | 3 | | | | | 3 | Brent Cove River, and Kelly Brook |
| 15 | 3 | | | | | 3 | Kelly Brook |
| Total | 53 | 15 | 6 | 3 | 6 | 23 | |
| Percent | | 28% | 11% | 6% | 11% | 43% | |

Source: Salmon Rivers: Reddin et al. 2010 and DFO provided data.

Table 4.6. Scheduled and non-scheduled salmon rivers within the boundaries of each BMA.

| BMA | No. Sea Farms (Total) | Scheduled Salmon Rivers | Non-scheduled Salmon Rivers |
|---|---|---|---|
| 1 | 3 | - | Mal Bay Brook |
| 2 | 4 | - | Rencontre Brook, Belle Harbour River |
| 3 | 11 | Simmons Brook, Southwest Brooks (Cinq Island), Bay du Nord River | Northwest River (East Bay), Northeast River (East Bay), Salmon River (Cinq Island Bay) |
| 4 | 4 | Taylor's Bay Brook and Old Bay Brook | - |
| 5 | 4 | - | - |
| 8 | 4 | - | - |
| 9 | 4 | D'Espoir Brook and Long Reach Brook | Hughes Brook, Salmon River (Bay d'Espoir) |
| 10 | 4 | Allen's Cove Brook and Bottom Brook | Brent Cove Brook |
| 11 | 2 | Morgan Brook and Dolland Brook | - |
| 12 | 4 | - | - |
| 13 | 3 | - | - |
| 14 | 3 | - | - |
| 15 | 3 | - | - |

Proximity of sea farms to the closest salmon river ranged from 1 km to ~50 km considering all sea farms. Sea farms in BMAs 1, 5, 8, 12, 13, 14, and 15 are more than 20 km away from any listed scheduled salmon river. Sea farms in BMAs 3, 4, 9, 10, and 11 are all within 20 km of a scheduled salmon river. BMA 2 has four sea farms, of which three are within 20 km of a scheduled river. Of the 53 sea farm sites, 89% are within 30 km of a scheduled river, 53% are within 20 km, and 15% are within 5 km. For non-scheduled salmon rivers, considering all BMAs, 57% of sea farms are within 30 km, 45% within 20 km, and 28% are within 5 km.

BMA 1 (Mal Bay) sea farms are more than 20 km from the nearest scheduled salmon rivers in Cinq Islands Bay (Simmons Brook and Southwest Brook [Fortune Bay]). While there are no scheduled rivers within the boundaries of BMA 1, the scheduled river Long Harbour River is in the adjacent bay to the east of BMA 1. For non-scheduled rivers in BMA 1, Mal Bay Brook is at the head of Mal Bay and within 5 km of the three sea farms in the BMA. There are three non-scheduled rivers (Rencontre Brook, Mal Bay Brook, and Belle Harbour River) within 5 km of the four BMA 2 sea farms and two scheduled rivers more than 11 km away. BMA 3 sea farms are distributed across three bays (East, North, and Cinq Islands). Three scheduled rivers (and their tributaries) and three non-scheduled rivers empty into these bays near the sea farms. The Ironskull Point sea farm in BMA 3 is located farther south in the BMA than the other sea farms and is not in close proximity to these rivers. Taylor's Bay Brook and Old Bay Brook terminate within BMA 4 (Great Bay de I'Eau) and are within 10 km of three of the four sea farms in BMA 4. BMA 5 (Harbour Breton Bay) does not contain any salmon rivers. BMA 8 (Little Passage) also does not contain any salmon rivers but is closest to rivers that terminate in North Bay and Bay d'Espoir. It should be noted that MCE does not have any plans to use BMA 8 at this time. All of BMA 9 (Outer Bay d'Espoir) sea farms are within 20 km of two scheduled rivers (Long Reach Brook and D'Espoir Brook) and three are within 20 km of two non-scheduled rivers (Hughes Brook and Salmon River). Within BMA 9, the Goblin Bay sea farm is the closest to a salmon river (Long Reach Brook). MCE does not have any plans to utilize BMA 9 in the near future. Sea farms in BMA 10 (Facheux Bay) are all within 10 km of one or more of the two scheduled rivers (Bottom

Brook and Allen's Cove Brook) and one non-scheduled river (Brent Cove Brook) that empty into the bay. BMA 11 (Hare Bay) has two scheduled rivers (Morgan Brook and Dolland Brook) that empty into the north of the bay and are within 10 km of the two sea farms in the south of the bay. BMA 12 (Rencontre West), BMA 13 (Chaleur Bay), BMA 14 (Aviron and La Hune Bay), and BMA 15 (Bay de Vieux) do not contain any listed (scheduled or non-scheduled) salmon rivers. For BMAs 12 and 13, the closest scheduled rivers are in Hare Bay (Dolland Brook and Morgan Brook) and for BMAs 14 and 15 the closest scsheduled river is Grey River (>31 km). White Bear River is located to the west of BMA 15 (see Figure 4.8).

Potential effects on wild Atlantic salmon (and other fish species) from the proximity of sea cages to salmon rivers is poorly understood. Effects could result from attraction or farm escape events. Sea farms are a predictable point source for resources (e.g., shelter or food), which can alter the distribution and abundance of wild fish in bays with sea farms (Goodbrand et al. 2013). Dempster et al. (2010) found wild fish aggregations were magnitudes higher within 25 m of sea cages than other locations. The duration and use of association can differ between age classes. Juvenile fish attraction to sea cages may be as a refuge from predators (e.g., cod) or due to the large school of salmon in the cages (Fjelldal et al. 2021). One study found juvenile fish (cod and redfish) were consuming waste feed from sea cages gaining an energetic subsidy, but adult fish were using the cages opportunistically with no sustained subsidy effect (McAllister et al. 2021). Migrating post-smolt salmon could enter the sea cages and remain long enough to outgrow the mesh size becoming trapped (Fjelldal et al. 2018) resulting in possible wild salmonid bycatch (e.g., incidental catch[9]). A Scottish study observed over a three-year period that rivers with sea farms located in or near the mouth had a 62–82% and 44–62% lower mean abundances of wild salmon fry and parr, respectively, compared to rivers without farms (Butler and Watt 2003).

Sea farms are typically placed in protected fjords or coves, which intersect passage between rivers and the open ocean. The proximity of rivers to the ocean and subsequently sea farms, could affect the density of salmon within a given river. Vollset et al. (2014) found an inverse relationship between distance and densities with a shorter migration ocean-river distance resulting in higher salmon densities in rivers. Experimental release of farmed Atlantic salmon from sea farms in Norway and Scotland found most recaptures occurred within 150 km of the release site within fresh water but three salmon released from Scotland were recaptured in Norway (several hundred kilometres away (Hansen and Youngson 2010). A specific farm-to-salmon river separation distance criteria have been suggested to reduce wild-farmed salmon interactions.

Escape events have occurred from sea farms on the south coast of Newfoundland. Following one escape event in 2013 (~20,000 fish), DFO began genetic monitoring (DFO 2022a). The 2013 escape event occurred at a farm in Hermitage Bay. In 2014, 18 rivers were subsequently monitored from the Burin Peninsula to Hare Bay including: Bottom Brook, Conne River, Dolland's Brook, Northwest Brook, Garnish River, Grand Bank Brook, Grand LaPierre, Long Harbour River, Salmonier Brook (Lamaline), Little River, Mal Bay Brook, Northeast Brook, Old Bay Brook,

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[9] In BC, Canada, incidental catch data is collected by DFO for operators (Canada 2024).

Southeast Brook, Simm's Brok, Taylor Bay Brook, Terrenceville Brook, and Tailrace Brook (Wringe et al. 2018). No rivers were monitored within the same bay as the escape event. Of the 18 rivers monitored, hybrids (or crosses) were detected in 17 and feral offspring were detected in 13 (Wringe et al. 2018). Unambiguous detection of first-generation offspring (including hybrids and aquaculture offspring) from the 2013 escape event were found within 75 km of the escape site of which 27% were hybrids (Wringe et al. 2018). No hybrids or feral salmon were found in Salmonier Brook (Lamaline) on the southeastern tip of the Burin Peninsula, but hybrids and feral salmon were found in rivers on the western side of the peninsula and west to Hare Bay. The composition of wild/hybrid/feral salmon identified differed per river. At nine rivers, the majority of fish sampled were either hybrid or feral (Wringe et al. 2018). There was no discernible spatial pattern to the distribution. Since then, repeated sampling showed that the number of hybrids and feral salmon peaked in 2014 and consistently declined thereafter (Kelly et al. 2023). In 2015, 159 escapees were detected in Fortune Bay and Bay d'Espoir, but none were detected in 2016, 2017, or 2018 (Kelly et al. 2023). Another farmed salmon escape event occurred in 2018 at another site in Hermitage Bay. Approximately 2,000–3,000 individuals escaped, and 400 escapees were recaptured (Kelly et al. 2023). First-generation hybrids were detected in Fortune Bay in 2019 and 2020 with smaller rivers dominated by hybrids (DFO 2022a). In the Conne River watershed, escaped salmon were found mainly in the lower parts of the watershed (DFO 2022a).

# 5.0 Oceanographic and Meteorological Overview

The EIS Guidelines (Section 4.3.1g) require the provision of oceanographic and meteorological data at the sea farms including currents, wind/waves, tides, ice, and storm patterns. These factors influence the suitability of sites for growing healthy farmed salmon and/or can influence the risk of farmed salmon escape due to damaged sea cages. As noted previously, MCE has sea farm locations that are located along the south coast of Newfoundland with many situated near coastal communities in Fortune Bay and Hermitage Bay (Figure 5.1). The 53 sea farm locations are divided into two primary areas: "Bays East" (Figure 5.2) and "Bays West" (Figure 5.3), which roughly correspond to Fortune Bay and Hermitage Bay, respectively. A summary of oceanographic and meteorological conditions at the sea farm locations are provided below with detailed descriptions (and an overview of the broader Study Area) provided in LGL 2025.

## 5.1 Water Currents

Water current information at MCE sea farms has been collected using different techniques and over variable time periods depending on specific sea farm licensing processes. Current data were collected at sea farms in Bays East and Bays West (Figure 5.4) for a minimum of one month (ranged from 30–90 days) at various depths including near surface, mid-depth, and near-bottom (typically +5 m above the seafloor). Measurements were made using one or two Acoustic Doppler Current Profilers (ADCP) and Aquadopp current meters. To measure the near-surface, mid-depth, and near-bottom currents, either an upward or an upward and a downward-looking ADCP were used, which were moored in the water column or at the ocean floor. For some sites, an Aquadopp was used to measure the mid-water column and near-bottom currents. The locations of current meters were selected to ensure the data were relevant to site operations and fit the requirements necessary for depositional modelling. Data were collected near the centre of the proposed sea cage array. The moored ADCP(s) measured the water column velocity with a vertical resolution of 2 m and a time resolution of 15 minutes in the upper water column and typically 60 minutes in the lower water column. Summaries of collected current data are provided for Bays East and Bays West areas. As noted previously, detailed information for each sea farm is available in the Sea Farm Baseline Study (see in LGL 2025).

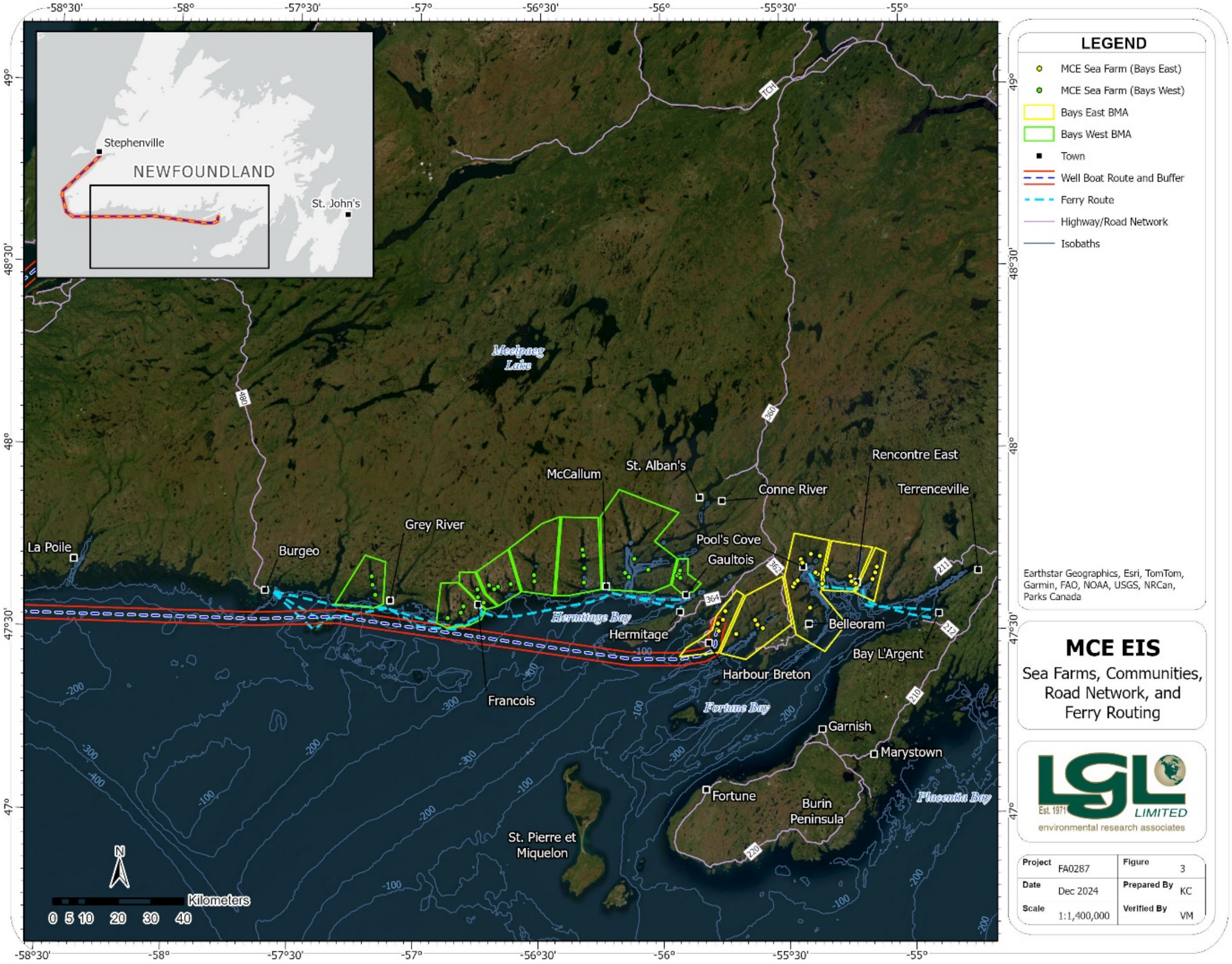

Figure 5.1. Locations of MCE sea farms in the Bays East (yellow) and Bays West (green) areas in relation to coastal communities and access roads/ferry routes.

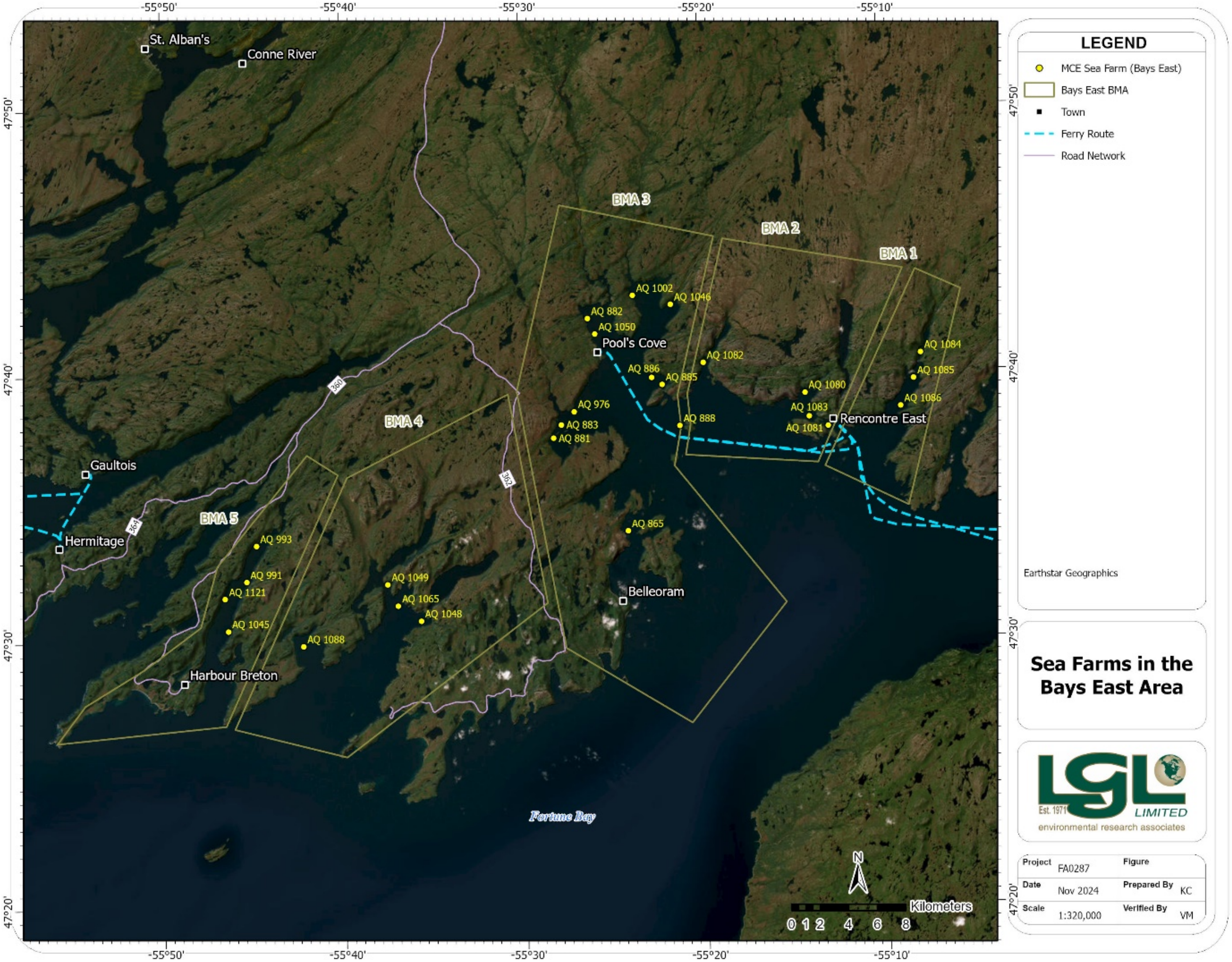

Figure 5.2. Locations of MCE sea farms and BMAs in the Bays East area.

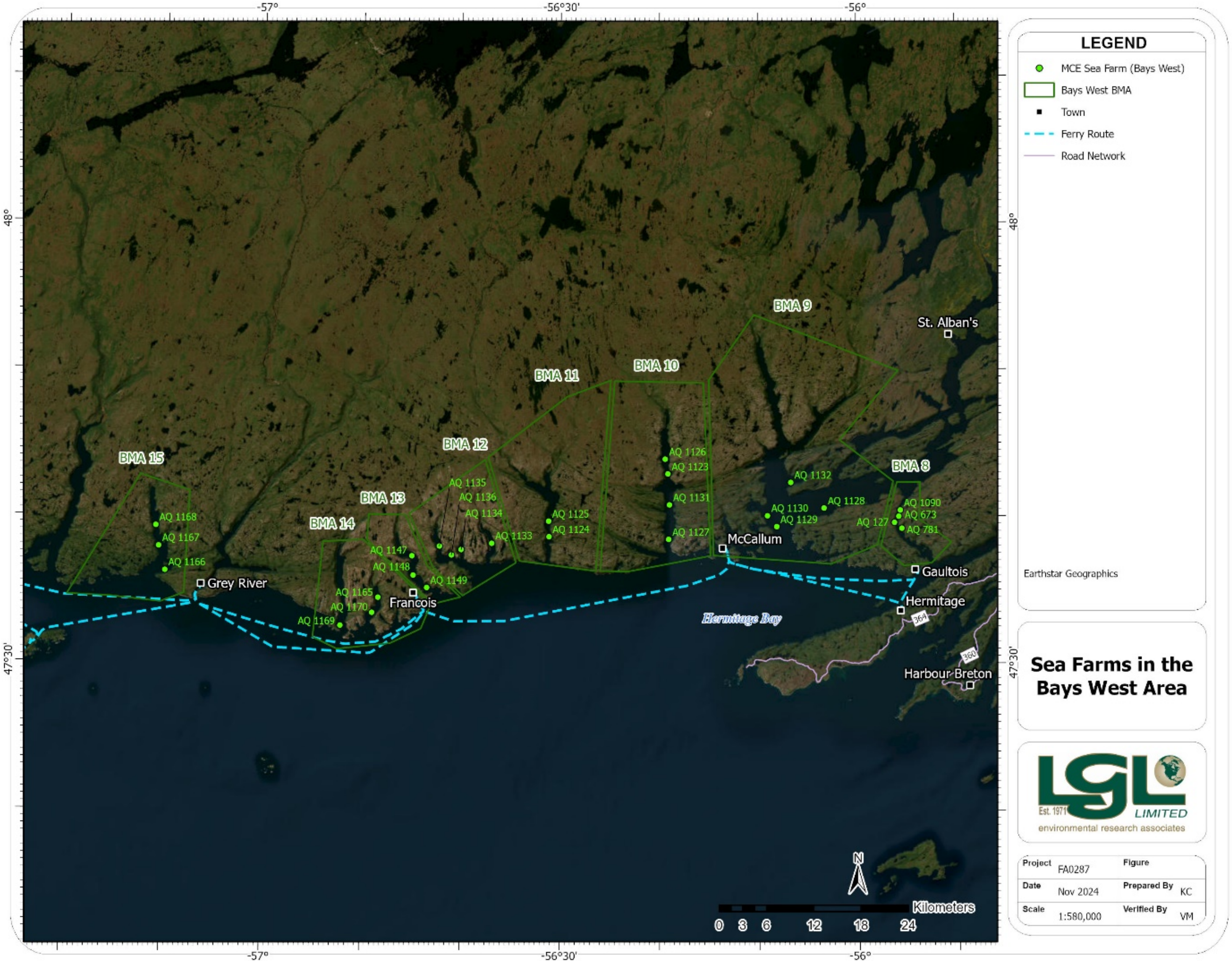

Figure 5.3. Locations of MCE sea farms and BMAs in the Bays West area.

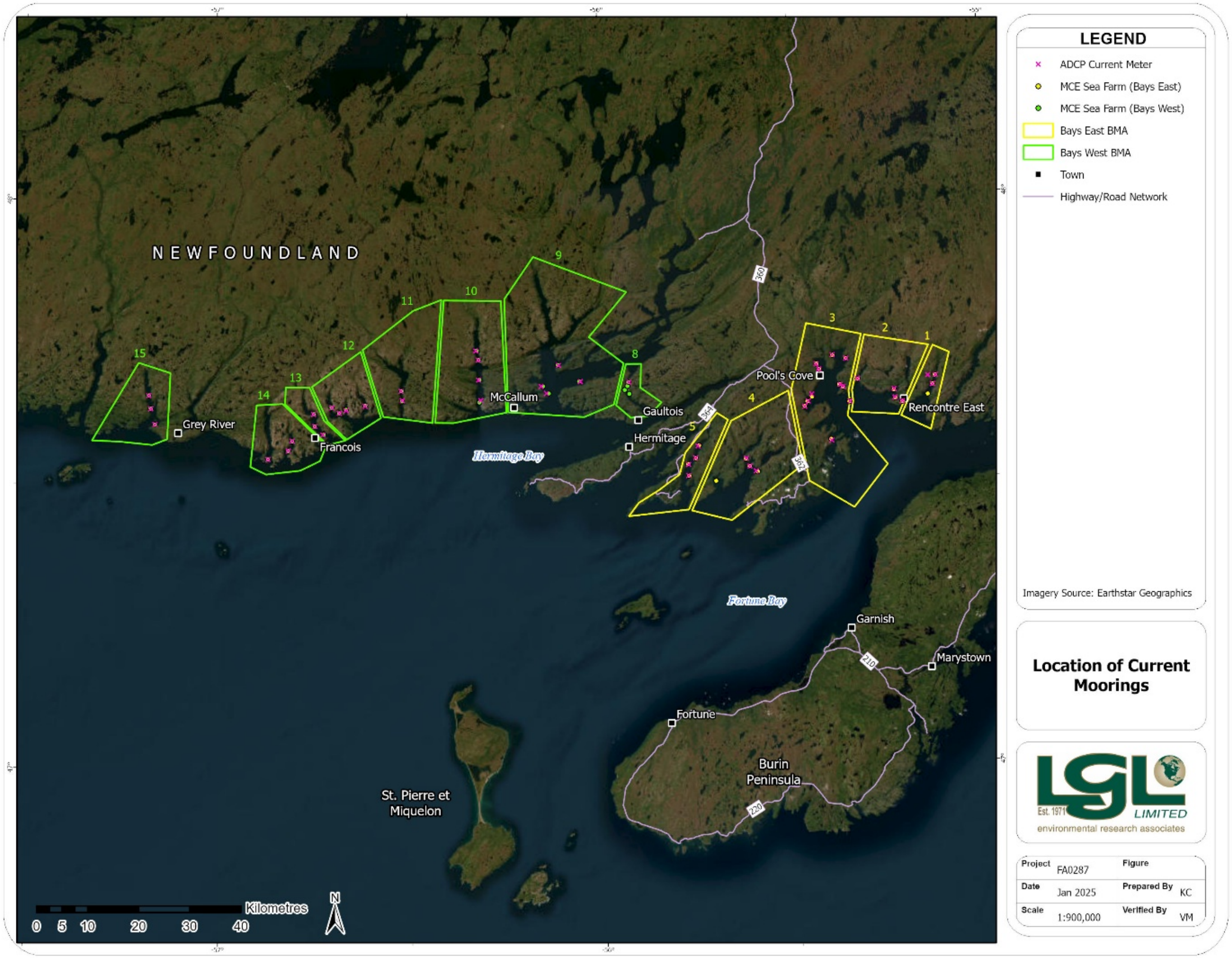

Figure 5.4. Locations of current moorings (ADCP or Aquadopp) used to collect current data in MCE sea farms.

### 5.1.1 Bays East Sea Farms

Current measurements were collected at 25 of the 26 MCE sea farms in the Bays East area (BMAs 1–5; Figure 5.4) during the November–August period in various years (2022–2024). Measurements were collected typically in the upper 20 m of the water column. Some sea farms also had current data collected near bottom and mid-depth (for sites that were considered deep and additional measurements required). For water current summary purposes, a depth of 15 m was selected as this depth is where farmed salmon predominately occur. There is much variation in current direction and speed amongst sea farms (Table 5.1; LGL 2025). At 15 m water depth, minimum mean current speeds (cm/s) during the recording period, ranged from 1.5 cm/s in the Deep Water Point sea farm in Rencontre East (BMA 2) to 3.1 cm/s in Benny's Cove sea farm in Mal Bay (BMA 1). Similarly, maximum mean current speeds were lowest (2.2 cm/s) in Rencontre East Island and Little Burdock Cove sea farms in Rencontre East (BMA 2). The maximum current speeds (mean and overall) were observed in Fortune Bay West (BMA 3) in Ironskull Point sea farm but the overall maximum current speed ranged from 18.6 cm/s in Little Burdock Cove (BMA 2) to 39.6 cm/s in Ironskull Point (BMA 3). At 15 m water depth, the maximum water current speed range in Bays East area was between ~four to ~eleven times the mean speed. There is much vertical variation in the maximum current speed and this variation is larger than the mean current speeds (LGL 2025).

Table 5.1. Current speeds (minimum and maximum mean and maximum values) observed in sea farms in each BMA in the Bays East area. [ ] identifies the sea farm in which the current speed observation was recorded.

| Parameter | Bays East Area | | | | |
|---|---|---|---|---|---|
| | BMA 1 | BMA 2 | BMA 3 | BMA 4 | BMA 5 |
| Measurement Period | Jun–Aug | Apr–Aug | Nov–Feb; Jun–Aug | Mar–Aug | Dec–Aug |
| No. of sea farms with data | 3 | 4 | 11 | 3 | 4 |
| Measurement Depth (m) | 15 | 15 | 15 | 15 | 15 |
| Minimum Mean Current Speed (cm/s) [sea farm] | 3.1 [BC] | 1.5 [DWP] | 2.0 [SEB] | 2.7 [SC] | 2.3 [HHN] |
| Maximum Mean Current Speed (cm/s) [sea farm] | 4.6 [TH] | 2.2 [REI;LBC] | 10.2 [IP] | 4.4 [RC] | 4.6 [HHS] |
| Maximum Current Speed (cm/s) [sea farm] | 23.3 [TH] | 18.6 [LBC] | 39.6 [IP] | 22.4 [RC] | 26.1 [HHS] |

Notes:
BC=Benny's Cove, TH=The Hobby, DWP=Deep Water Point, REI=Rencontre East Island, LBC=Little Burdock Cove, SEB=South East Bight, IP=Ironskull Point, SC=Salmonier Cove, RC=Red Cove, HHN=Harvey Hill North, HHS=Harvey Hill South.

### 5.1.2 Bays West Sea Farms

Current measurements were collected at 24 of the 27 MCE sea farms in the Bays West area (BMAs 8–15; see Figure 5.4) during the May–November period in various years (2017–2024). Measurements were collected typically in the upper 15 m of the water column, mid-depth and near bottom. As in the Bays East Area, there is much variation in current direction and speed amongst sea farms in the Bays West Area (Table 5.1; LGL 2025). At 15 m water depth, minimum mean current speeds (cm/s) during the recording period, ranged from 3.2 cm/s in the Aviron North sea farm in Aviron Bay and La Hune Bay (BMA 14) to 10.98 cm/s in North Bob Locke Cove sea farm in Hare Bay (BMA 11). The maximum mean current speed range observed at the same depth and during the same period was from 3.81 cm/s in the Deer Cove sea farm in Little Passage (BMA 8) to 14.11 cm/s in the Mare Cove South sea farm in Hare Bay (BMA 11). The maximum current speed (55.5 cm/s) was also observed in Hare Bay (BMA 11) in the Mare Cove South sea farm. Seven of the eight BMAs in Bays West recorded maximum current speeds at 15 m >30 cm/s (Table 5.2). There is much vertical variation in the maximum current speed and this variation is larger than the mean current speeds (LGL 2025).

Table 5.2. Current speeds (minimum and maximum mean and maximum values) observed in sea farms in each BMA in the Bays West area. [ ] identifies the sea farm in which the current speed observation was recorded.

| Parameter | Bays West Area | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | BMA 8[a] | BMA 9 | BMA 10 | BMA 11 | BMA 12 | BMA 13 | BMA 14 | BMA 15 |
| Measurement Period | Jul–Aug | Aug–Nov | Aug–Nov | Aug–Sep | Oct–Nov;<br>May–Jun | May–Jun | May–Jun | Jun–Jul |
| No. of Sea Farms with Data | 1 | 4 | 4 | 2 | 4 | 3 | 3 | 3 |
| Approx. Depth (m) | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| Minimum Mean Current Speed (cm/s) [Sea Farm] | 3.81 [DC] | 5.57 [GB] | 4.46 [ITP] | 10.98 [NBLC] | 3.65 [DB] | 4.5 [CB] | 3.2 [AN] | 4.1 [SC] |
| Maximum Mean Current Speed (cm/s) [Sea Farm] | 3.81 [DC] | 12.46 [JI] | 7.98 [WC] | 14.11 [MCS] | 5.31 [LB] | 5.8 [SP] | 4.3 [FC] | 6.4 [DI] |
| Maximum Current Speed (cm/s) [Sea Farm] | 16.15 [DC] | 49.62 [JI] | 44.5 [WC] | 55.5 [NBLC] | 32.75 [LB] | 44 [SP] | 30 [FC] | 36 [DI] |

Notes:

[a] Only Deer Cove sea farm has current data available.

DC=Deer Cove, GB=Goblin Bay, JI=Jervis Island, ITP=Indian Tea Point, WC=Wild Cove, NBLC=North Bob Locke Cove, MCS=Mare Cove South, DB=Devil Bay, LB=Little Bay, CB=Chaleur Bay, SP=Shooter Point, AN=Aviron North, FC=Foots Cove, SC=Shoal Cove, DI= Denny Island.

## 5.2 Wind and Waves

Several methods have been employed to collect wind and wave data at 11 of the 13 BMAs: real-time measurements of wave height; wave period and wave direction with a Spotter buoy; calculations with a numerical wave calculation tool, and hindcast data generated by the Meteorological Service of Canada (MSC). Summaries of collected data are provided for Bays East and Bays West areas. Detailed information for each sea farm is available in the Sea Farm Baseline Study (see in LGL 2025).

The MSC has created a dataset (MSC50) using the hindcast approach for numerous grid points in Atlantic Canada[10]. The hindcast approach consists of the application of numerical wind and wave models together with historical meteorological data to simulate the evolution of surface winds and ocean wave response in an area of interest. This wind and wave dataset is calculated from hourly reanalysis data of historical surface winds and ocean surface waves in Atlantic Canada during 1954–2018. These data are used to characterize marine surface wind and wave climate conditions, trends and variability, and to assist with coastal and offshore operations/risk management. Grid points from the MSC50 dataset (n=18) nearest each BMA (Figure 5.5) were accessed for data to calculate 10-year mean and maximum wind speeds (m/s) and wave heights (m) for most sea farms (2009–2018).

Wave calculation conditions may be determined by using two different methods; (1) a fetch length method in accordance with the Scottish standard (fetch length is measured with Olex marine charts) and (2) numerical wave calculation [e.g., Simulating Waves Nearshore (SWAN)] based on bathymetry, wind strength and directions, and possible swell. The wave calculation method is considered more accurate, as it considers the bathymetry of the sea farm. For sea farms without accurate bathymetric data, the wave parameters are calculated using the fetch length method.

Wave data were collected using a SOFAR Spotter wave buoy. Real-time measurements of wave height, wave period, and wave direction were acquired through the SOFAR Dashboard. Full wave spectra data were obtained from the memory card when the buoy was recovered. The wave buoy measures waves based on the GPS northing, easting, and elevation. Accuracy is stated as approximately +/- 2 cm under good conditions. The Spotter wave data, as output by the buoy, were reviewed for data quality. The spectra of the largest wave events were plotted and assessed.

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[10] See https://open.canada.ca/data/en/dataset/f3f0312d-d28b-400c-b14a-28f51ff7f08a

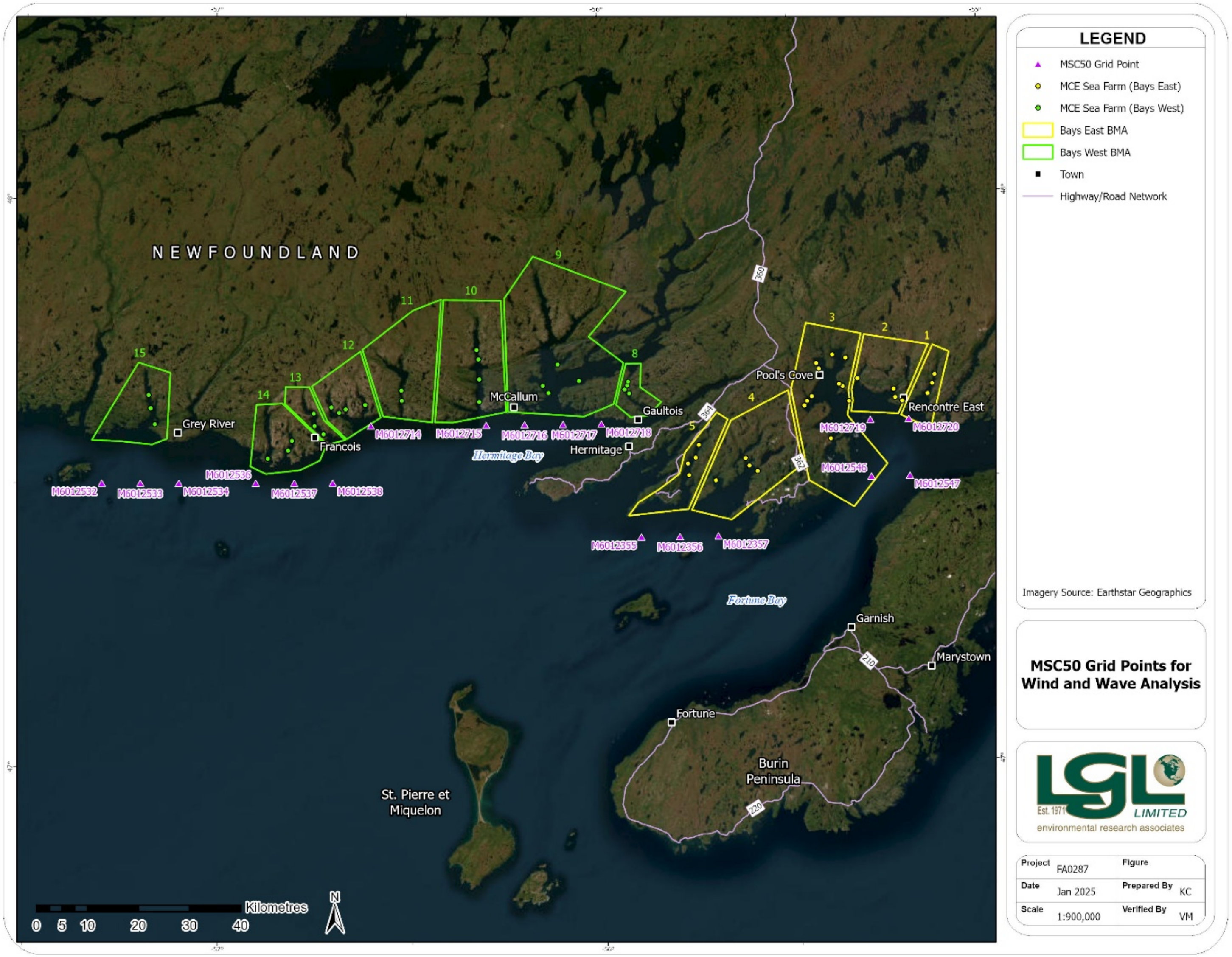


Figure 5.5. Locations of MSC50 grid points used to summarize wind and wave data in MCE sea farms.

### 5.2.1 Bays East Sea Farms

The Bays East area experiences a predominately west to southwest flow throughout the year for wind. West to northwest winds which are prevalent during the winter months begin to shift counter-clockwise during March and April, resulting in a predominant southwest wind by the summer months. As autumn approaches, the tropical-to-polar temperature gradient strengthens and the winds shift slightly, becoming predominately westerly again by late fall and into winter.

In addition to mid-latitude low pressure systems crossing the route, tropical cyclones often move northward out of the influence of the warm waters of the Gulf stream, often passing near the Island of Newfoundland. The tropical cyclone season typically extends from June–November. Once the cyclones move over colder waters they lose their source of latent heat energy and often begin to transform into a fast-moving and rapidly developing extra-tropical cyclone, producing large waves and sometimes hurricane force winds. Low pressure systems crossing the area tend to be weaker during the summer months. As a result, mean wind speeds tend to be at their lowest during this season.

Wind data for the sea cages in each BMA were obtained from the MSC50 hindcast approach for Atlantic Canada (BMAs 1–5; see Figure 5.5). The MSC50 data set was also used for wave predictions in BMAs 1–5 along with sea farm specific wave calculations for some sea farms in BMAs 3 and 4. Sea farm specific wave measurements were collected in BMAs 4 and 5. The predominate wind direction in all five BMAs in Bays East as determined from the MSC50 grid points within the Bays East area was westerly. Mean wind speeds during the period 2009–2018 ranged from 5.4 m/s in July to 10.8 m/s in January. Maximum wind speeds were observed in January (BMA 1) recorded at 21.36 m/s and in February (BMA 5) recorded at 22.0 m/s (Table 5.3).

Wave models from the MSC50 grid points in the Bays East Area predicted monthly mean wave heights ranging from 0.24 m (July)–1.93 m (January) in the Bays East Area with a maximum of 5.12 m in December at the MSC50 grid point representing BMA 5. Wave calculation models (SWAN and/or fetch-length) predicted maximum wave heights for 10-yr period ranging from 2.2 m (BMA 4)–3.3 m (BMA 3) and 50-yr ranges of 2.5 m (BMA 4)–3.8 m (BMA 3). SOFAR wave buoys were deployed in BMA 4 during March–April 2024 and BMA 5 during December–March 2024. The significant wave height means ranged from 0.17 (BMA 5)–0.31 (BMA 4) with a maximum significant wave height recorded during this period measuring 1.5 m (Table 5.3).

Table 5.3. Summary of wind and wave data from MSC50 grid points (2009–2018) representing Bays East (BMA 1–5) as well as wave calculation and wave buoy measurements in Bays East BMAs. [ ] identifies the sea farm in which the observation was modelled or recorded.

| Parameter | | Bays East | | | | |
|---|---|---|---|---|---|---|
| | | BMA 1 | BMA 2 | BMA 3 | BMA 4 | BMA 5 |
| **MSC 50 Data (2009–2018)** | | | | | | |
| WIND | Minimum mean speed (m/s) (month) | 5.5 (Jul) | 5.48 (Jul) | 5.48 (Jul) | 5.42 (Jul) | 5.4 (Jul) |
| | Maximum mean speed (m/s) (month) | 10.8 (Jan) | 10.8 (Jan) | 10.8 (Jan) | 10.8 (Jan) | 10.8 (Jan) |
| | Maximum speed (m/s) | 21.36 (Jan) | 21.43 (Feb) | 21.64 (Feb) | 21.99 (Feb) | 22.0 (Feb) |
| | Predominant Direction | W | W | W | W | W |
| | % occurrence 4-6 m/s | 18 | 18 | 18 | 19 | 19 |
| | % occurrence 6-8 m/s | 27 | 27 | 27 | 26 | 26 |
| | % occurrence 8-10 m/s | 33 | 32 | 33 | 32 | 31 |
| | % occurrence 10-12 m/s | 23 | 33 | 23 | 23 | 24 |
| WAVE | Minimum Mean Height (m) (month) | 0.32 (Jun) | 0.27 (Jul) | 0.24 (Jul) | 0.65 (Jun) | 0.71 (Jun) |
| | Maximum Mean Height (m) (month) | 0.85 (Jan) | 0.85 (Jan) | 0.87 (Jan) | 1.73 (Jan) | 1.93 (Jan) |
| | Maximum Height (m) (month) | 1.97 (Jan) | 1.97 (Feb) | 1.91 (Feb) | 4.59 (Dec) | 5.12 (Dec) |
| | **Wave Calculation (SWAN and/or Fetch)** | | | | | |
| | Predicted Maximum Wave Height for 10-yr Return Period (m) (Sea farm) | | | 3.3 (IP) | 2.2 (SC) | |
| | Predicted Maximum Wave Height for 50-yr Return Period (m) (sea farm) | | | 3.8 (IP) | 2.5 (SC) | |
| | Predicted Direction | | | South | Southwest | |
| | **Wave Measurements (Wave Buoy)** | | | | | |
| | Significant Wave Height Mean (Hs) (m) | | | | 0.31 (RC) | 0.17 (HHS) |
| | Significant Wave Height Max (Hs) (m) | | | | 1.5 (RC) | 0.9 (HHS) |
| | Significant Wave Period Mean (Tp) (s) | | | | 9.63 (RC) | 4.2 (HHS) |
| | Significant Wave Period Max (Tp) (s) | | | | 34.02 (RC) | 16.9 (HHS) |

Notes:
IP=Ironskull Point; SC=Salmonier Cove; RC=Red Cove; HHS=Harvey Hill South.

### 5.2.2 Bays West Sea Farms

As discussed above in the Bays East area, the Bays West area also experiences a predominately west to southwest flow throughout the year for wind with a shift occurring during the seasons, with wind speeds tending to be at their lowest during the summer. Wind data for the sea cages in BMAs 9–10 and 12–15 (see Figure 5.5) were obtained from the MSC50 hindcast approach for Atlantic Canada. MSC50 grid points were not located in an area that was considered representative of BMA 8 and BMA 11 so were not included in summary results. The MSC50 data set was also used for wave predictions in these BMAs along with sea farm specific wave calculations for some sea farms in BMA 14 and 15. Sea farm specific wave measurements were collected in BMA 10. The predominate wind direction in all six BMAs analyzed in Bays West as determined from the MSC50 grid points within the Bays West area was westerly. Mean wind speeds during 2009–2018 ranged from 5.4 m/s in July to 11.6 m/s in January. Maximum wind speeds (22.3 m/s) were observed in February (BMA 15) (Table 5.4).

Table 5.4. Summary of wind and wave data from MSC50 grid points (2009–2018) representing Bays West (BMAs 8–15) as well as wave calculation and wave buoy measurements in Bays West. [ ] identifies the sea farm in which the observation was modelled or recorded.

| Parameter | | Bays West | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **BMA 8** | **BMA 9** | **BMA 10** | **BMA 11** | **BMA 12** | **BMA 13** | **BMA 14** | **BMA 15** |
| **MSC 50 Data (2009–2018)** | | | | | | | | | |
| WIND | Minimum Mean Speed (m/s) (month) | | 5.4 (Jul) | 5.5 (Jul) | | 5.5 (Jul) | 5.4 (Jul) | 5.5 (Jul) | 5.5 (Jul) |
| | Maximum Mean Speed (m/s) (month) | | 10.9 (Jan) | 10.9 (Jan) | | 10.9 (Jan) | 11.6 (Jan) | 11.6 (Jan) | 11.1 (Jan) |
| | Maximum Speed (m/s) | | 21.7 (Feb) | 21.7 (Feb) | | 21.9 (Feb) | 21.5 (Jan) | 22.2 (Feb) | 22.3 (Feb) |
| | Predominant Direction | | WSW | WSW | | W-WSW | W | W | W |
| | % Occurrence 4-6 m/s | | 20 | 21 | | 20 | 18 | 18 | 18 |
| | % Occurrence 6-8 m/s | | 26 | 25 | | 26 | 28 | 28 | 28 |
| | % Occurrence 8-10 m/s | | 31 | 31 | | 30 | 30 | 30 | 29 |
| | % Occurrence 10-12 m/s | | 23 | 23 | | 24 | 23 | 23 | 24 |
| WAVE | Minimum Mean Height (m) (month) | | 0.5 (Jun) | 0.7 (Jul) | | 0.8 (Jun) | 0.3 (Jul) | 0.3 (Jul) | 1.0 (Jul) |
| | Maximum Mean Height (m) (month) | | 1.4 (Jan) | 1.3 (Jan) | | 1.4 (Jan) | 1.0 (Jan) | 2.2 (Jan) | 2.0 (Jan) |
| | Maximum Height (m) (month) | | 3.5 (Feb) | 3.8 (Feb) | | 4.4 (Feb) | 2.2 (Jan) | 6.3 (Feb) | 6.2 (Feb) |
| | **Wave Calculation (SWAN)** | | | | | | | | |
| | Predicted Maximum Wave Height for 10-yr Return Period (m) (Sea farm) | | | | | | | 2.4 (AS) | 1.9 (DI) |
| | Predicted Maximum Wave Height for 50-yr Return Period (m) (sea farm) | | | | | | | 2.7 (AS) | 2.1 (DI) |
| | Predicted Direction | | | | | | | S-SW | W |
| | **Wave Measurements (Wave Buoy)** | | | | | | | | |
| | Significant Wave Height Mean (Hs) (m) | | | 0.2 (WC) | | | | | |
| | Significant Wave Height Max (Hs) (m) | | | 1.5 (WC) | | | | | |
| | Significant Wave Period Mean (Tp) (s) | | | 6.1 (WC) | | | | | |
| | Significant Wave Period Max (Tp) (s) | | | 14.6 (WC) | | | | | |

Notes:
WC=Wild Cove; AS=Aviron South; DI=Denny Island.

Wave models from the MSC50 grid points in the Bays West Area predicted monthly mean wave heights ranging from 0.3 m (July)–2.2 m (January) in the Bays West Area with a maximum of 6.3 m in February at the MSC50 grid point representing BMA 14. Wave calculation models (SWAN) predicted maximum wave height for 10-yr period ranging from 1.9–2.4 m (BMA 15) and 50-yr ranges of 2.1–2.7 m (BMA 15). SOFAR wave buoys were deployed in BMA 10 during February–May 2024. The significant wave height mean was 0.22 m with a maximum significant wave height recorded during this period measuring 1.5 m (see Table 5.4).

## 5.3 Water Quality

The FFA licensing process requires potential finfish cage culture operators to assess site suitability. As part of this assessment, water quality parameters including water temperature (°C), dissolved oxygen (mg/L), and salinity (in parts per thousand, ppt, or ‰) were measured for most MCE sea farms. Water quality measurements are routinely collected with a handheld device with probes for temperature, dissolved oxygen, and salinity. Water quality had also been collected in some areas in Bays West by FFA (formerly NL Department of Fisheries and Land Resources [DFLR]) and was used by MCE during license applications to describe the water quality of the area. The amount and temporal coverage of water quality data collected in the BMAs are variable. Summaries of available water quality data are provided here for Bays East and Bays West areas (see Figure 5.1). To represent each BMA, one sea farm was selected to present detailed data in graphical and/or tabular formats. The selection of a representative sea farm for a BMA was based on an assessment of the available data and/or that which represented the most recent data. Representative water depths for each water quality parameter was typically in the top 15 m of the water column as this is where farmed salmon predominantly occur. Detailed water quality information for each sea farm is available in the Sea Farm Baseline Study (see LGL 2025).

### 5.3.1 Bays East Sea Farms

Water quality data in Bays East sea farms were collected periodically from 2013 (BMA 1) to 2024 (BMA 2, 3, 4, and 5) and include water temperature, dissolved oxygen and salinity.

#### *5.3.1.1 Mal Bay (BMA 1)*

Mal Bay (BMA 1) has three licensed sea farms and water quality data (water temperature and dissolved oxygen) were collected during 2013–2018. Temporal coverage of water quality data collected in the Mal Bay BMA is variable and is available for two of the sea farms. The Foshie's Cove sea farm (AQ 1085; see Figure 5.2) was selected to present detailed water quality data for the Mal Bay BMA as it contained the most complete data sets (with focus on data collected at 5 m).

### *Water Temperature*

Seasonal average water temperatures at 5 m water depth were the same across sea farms with available data (LGL 2025). At the Foshie's Cove sea farm, mean water temperatures ranged from 1.6°C in winter to 14.6°C in summer. Maximum water temperature observed was 18.6°C in summer and minimum water temperatures were 0.3°C in winter at both sea farms with available data (LGL 2025). Historical water temperature data collected during 2013–2018 at the Foshie's Cove sea farm showed an increase in water temperature from April–August and a general decrease thereafter (Figure 5.6). Average water temperatures peaked in August, while the lowest temperatures were recorded in March.

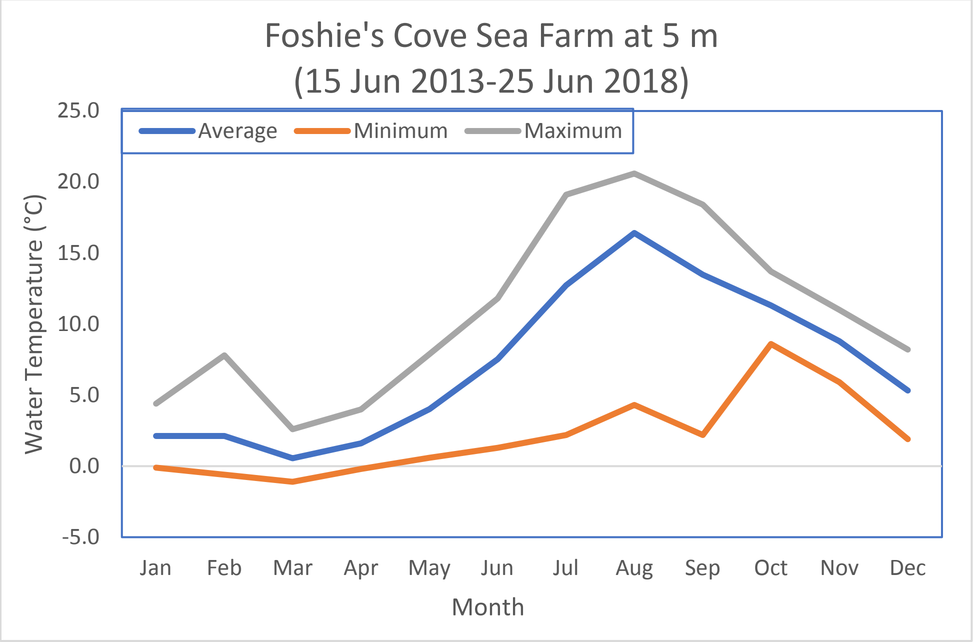


Figure 5.6. Historical water temperatures (°C) at 5 m depth for the Foshie's Cove sea farm considered representative of water temperatures in BMA 1.

### *Dissolved Oxygen*

In BMA 1, dissolved oxygen levels were consistently lower in summer and fall than winter and spring, with the highest average dissolved oxygen levels observed in the Foshie's Cove sea farm (LGL 2025). Mean dissolved oxygen ranged from 8.9 mg/L in summer to 13.1 mg/L in winter (LGL 2025). The maximum observed dissolved oxygen level was 16.0 mg/L at The Hobby sea farm in spring, while minimum dissolved oxygen was 5.0 mg/L in summer at the Foshie's Cove sea farm (LGL 2025). As represented by the Foshie's Cove sea farm, a general decrease in dissolved oxygen levels were observed from May–September, followed by an increase in the cooler months (Figure 5.7). Dissolved oxygen peaked between March and May while the lowest dissolved oxygen levels were recorded in September.

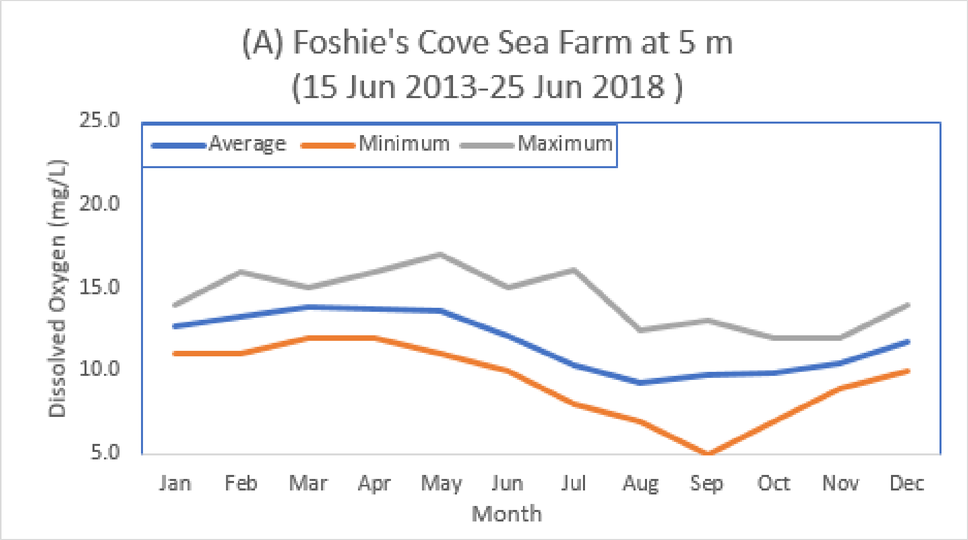


Figure 5.7. Historical dissolved oxygen (mg/L) levels at the Foshie's Cove sea farm at 5 m depth (June 2013–June 2018) considered representative of dissolved oxygen levels in BMA 1.

#### *Salinity*

There were no available data for salinity within the Mal Bay BMA.

### *5.3.1.2 Rencontre East (BMA 2)*

Rencontre East (BMA 2) has four licensed sea farms and water quality data were collected periodically during 2019–2024. Temporal coverage of water quality data collected in the Rencontre East BMA are variable for all four sea farms. The Little Burdock Cove sea farm (AQ 1083; see Figure 5.2) was selected to represent the water quality for the Rencontre East BMA as it contained the most complete and recent data (2021–2024).

#### *Water Temperature*

Seasonal water temperatures were generally consistent across the sea farms with available data in the Rencontre East BMA, though the Rencontre East Island sea farm (AQ 1081; see Figure 5.2) had slightly lower water temperatures compared to the other sea farms in the BMA (LGL 2025). At water depths 10 m and below, water temperatures were slightly warmer in winter but cooler during other seasons. In contrast, at water depths above 10 m, water temperatures were higher in spring, summer, and fall (LGL 2025).

Mean water temperatures ranged from 1.1°C in winter at the Rencontre East Island sea farm (0.5 and 1 m depths) to 17.2°C in summer at the Little Burdock Cove sea farm (0.5 m depth; LGL 2025). Maximum water temperatures at the sea farms were recorded at a depth of 0.5 m in summer, reaching 20.5°C. Minimum temperatures occurred in winter at the same depth, measuring 0.0°C. Lowest water temperatures were observed in March in all sea farms (LGL 2025). In the Little Burdock Cove sea farm, average temperatures were highest in September, with steady increases from April–September, followed by decreasing water temperatures from October onwards (Figure 5.8).

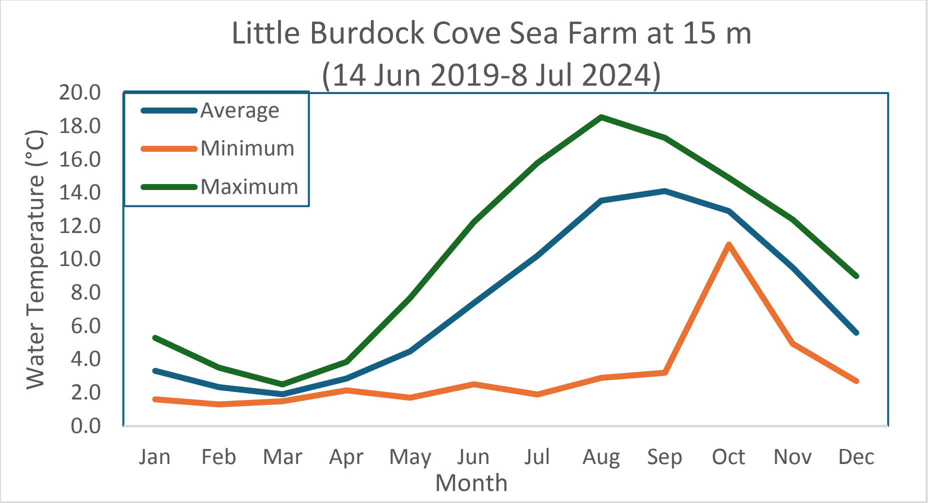


Figure 5.8. Historical water temperatures (°C) in the Little Burdock Cove sea farm at 15 m depth considered representative of water temperatures in BMA 2.

### *Dissolved Oxygen*

In BMA 2, dissolved oxygen levels were consistently lower in summer and fall compared to winter and spring. Mean dissolved oxygen ranged from 7.7 mg/L in summer to 12.8 mg/L in winter at 0.5 m depth. Maximum observed dissolved oxygen was 16.0 mg/L, recorded at a depth of 0.5 m at the Little Burdock Cove sea farm in spring; minimum dissolved oxygen was 5.2 mg/L, measured at a depth of 1 m in fall at the Rencontre East Island sea farm (LGL 2025). During 2019–2022 in the Little Burdock Cove sea farm, highest dissolved oxygen levels were recorded in May and the lowest were recorded in August; dissolved oxygen levels began increasing in November–December (Figure 5.9).

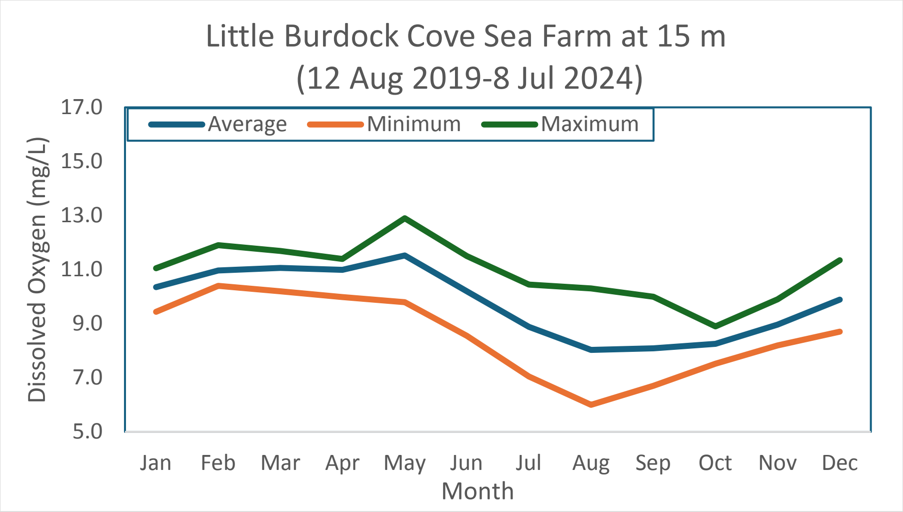


Figure 5.9. Historical dissolved oxygen (mg/L) levels in the Little Burdock Cove sea farms at 15 m depth considered representative of dissolved oxygen in BMA 2.

### *Salinity*

Salinity was fairly consistent across sea farms and seasons in the Rencontre East BMA with averages ranging from 28.0–31.6 ppt. Results indicate a moderate freshwater influence near the surface that was more pronounced at the Rencontre East Island sea farm (LGL 2025). Table 5.5 provides a summary of average salinities in the Little Burdock Cove sea farm.

Table 5.5. Average salinities (‰) in the Little Burdock Cove sea farm in the Rencontre East BMA (2022–2024).

| **Water Depth** | **Sampling Period** | **Winter** | **Spring** | **Summer** | **Fall** |
|---|---|---|---|---|---|
| | | **Salinity (‰)** | | | |
| **Little Burdock Cove** | | | | | |
| Surface | 1 Jul 2022–8 Jul 2024 | 29.0 | 28.2 | 28.6 | 29.8 |
| 1 m | 1 Jul 2022–8 Jul 2024 | 29.6 | 28.7 | 28.9 | 29.9 |
| 5 m | 1 Jul 2022–8 Jul 2024 | 30.0 | 29.3 | 29.4 | 30.1 |
| 10 m | 1 Jul 2022–8 Jul 2024 | 30.1 | 29.5 | 29.7 | 30.2 |
| 15 m | 1 Jul 2022–8 Jul 2024 | 30.3 | 29.7 | 29.9 | 30.3 |
| 20 m | 1 Jul 2022–8 Jul 2024 | 30.3 | 29.9 | 30.1 | 30.3 |
| 30 m | 1 Jul 2022–8 Jul 2024 | 30.4 | 30.0 | 30.4 | 30.4 |

### 5.3.1.3 *Fortune Bay West (BMA 3)*

Fortune Bay West (BMA 3) has 11 licensed sea farms with water quality data available periodically during 2019–2024. Temporal coverage of water quality data collected in the Fortune Bay West BMA is variable for all 11 sea farms. The Cinq Island Cove sea farm (AQ 883; see Figure 5.2) was selected to represent the water quality data for Fortune Bay West BMA as it contained one of the most complete and representative data sets of the 11 sea farms in the BMA.

### *Water Temperature*

Seasonal water temperatures were generally consistent across sea farms with available data, as depths increase, water temperatures decreased except in winter (LGL 2025). Mean water temperatures ranged from 1.3°C in winter at the Cinq Island Cove sea farm (0.5 m depth) to 18.3°C in summer at the McGrath Cove North sea farm (0.5 m depth) [LGL 2025]. Maximum water temperatures were recorded at a depth of 0.5 m in summer, reaching 23.8°C and minimum temperatures occurred in winter at 1 m or above measuring 0.0°C (McGrath Cove North sea farm; LGL 2025). Lowest water temperatures were observed in March in all sea farms. During 2020–2024 in the Cinq Island Cove sea farm, average and maximum water temperatures increased from May–August, while minimum temperatures increased from June–November (Figure 5.10).

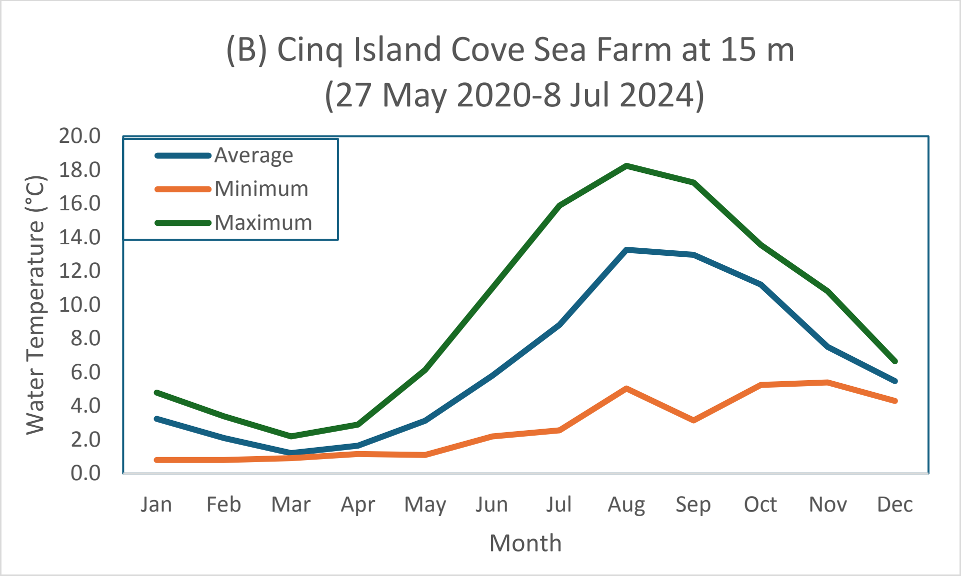


Figure 5.10. Historical water temperatures (°C) in the Cinq Island Cove sea farm at 15 m depth considered representative of water temperatures in BMA 3.

### *Dissolved Oxygen*

Dissolved oxygen levels were consistently lower in summer and fall compared to winter and spring in sea farms in the Fortune Bay West BMA (LGL 2025). Mean dissolved oxygen ranged from 8.0 mg/L in summer to 11.7 mg/L in winter at 0.5 m depth. Maximum observed dissolved oxygen was 15.6 mg/L, recorded at a depth of 1 m at the Ironskull Point sea farm (AQ 865; see Figure 5.2) in spring; minimum dissolved oxygen was 5.9 mg/L, measured at a depth of 1 m and 15 m in summer at the Cinq Island Cove sea farm (LGL 2025). At the Cinq Island Cove sea farm, dissolved oxygen increased from October–May; average oxygen levels peaked in May whereas the lowest oxygen levels were observed in September (Figure 5.11).

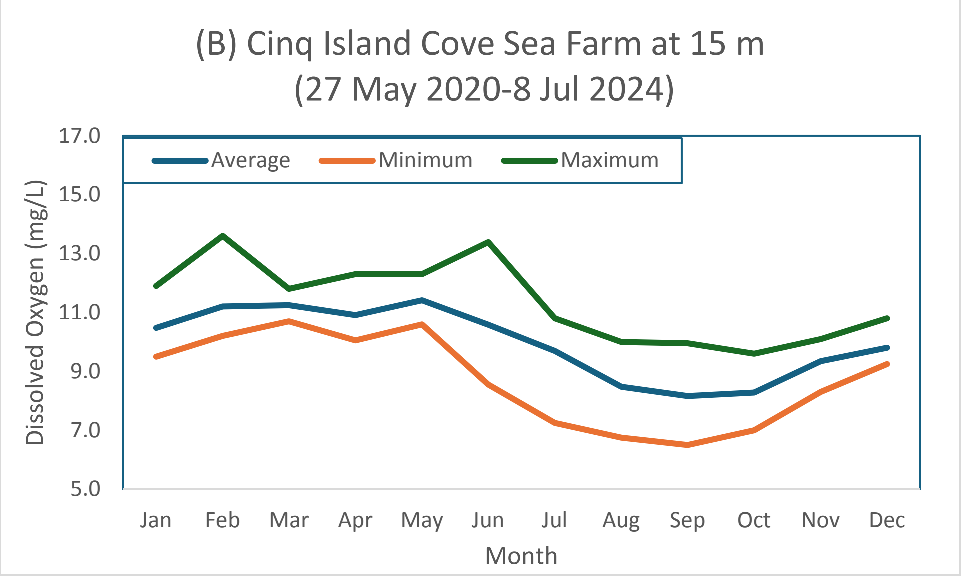


Figure 5.11. Historical dissolved oxygen (mg/L) levels in the Cinq Island Cove sea farm at 15 m depth considered representative of dissolved oxygen levels in BMA 3.

### *Salinity*

Salinity was fairly consistent across sea farms and seasons in the Fortune Bay West BMA with averages ranging from 24.7–31.1 ppt (LGL 2025). Results indicate a moderate freshwater influence near the surface that is more pronounced at Cinq Island Cove and Steamers Head sea farms. Table 5.6 provides a summary of average salinities in the Cinq Island Cove sea farm as representative of the Fortune Bay West BMA.

Table 5.6. Average salinities (‰) in the Cinq Island Cove sea farm in Fortune Bay West BMA (2023–2024).

| Water Depth | Sampling Period | Winter | Spring | Summer | Fall |
|---|---|---|---|---|---|
| | | Salinity (‰) | | | |
| **Cinq Island Cove** | | | | | |
| 0.5 m | Jul 2023–Jun 2024 | 27.3 | 24.7 | 25.1 | 25.7 |
| 1 m | Jul 2023–Jun 2024 | 28.8 | 26.5 | 26.8 | 26.9 |
| 5 m | Jul 2023–Jun 2024 | 30.3 | 29.5 | 29.3 | 29.5 |
| 10 m | Jul 2023–Jun 2024 | 30.6 | 30.2 | 29.9 | 30.0 |
| 15 m | Jul 2023–Jun 2024 | 30.8 | 30.5 | 30.3 | 30.1 |
| 20 m | Jul 2023–Jun 2024 | 30.8 | 30.7 | 30.5 | 30.3 |
| 30 m | Jul 2023–Jun 2024 | 31.0 | 30.8 | 30.8 | 30.4 |

### 5.3.1.4 *Great Bay de l'Eau (BMA 4)*

Great Bay de l'Eau (BMA 4) has four licensed sea farms and water quality data were collected periodically during 2019–2024. Temporal coverage of water quality data collected in the Great Bay de l'Eau BMA are variable and are available for two of the sea farms. The Salmonier Cove sea farm (AQ 1048; see Figure 5.2) was selected to represent the water quality data for the Great Bay de l'Eau BMA as it contained the most recent data set (2022–2024) of the sea farms in the BMA.

### *Water Temperature*

Seasonal water temperatures were generally consistent across the two sea farms with available data. At depths 10 m and below, water temperatures were slightly warmer in winter but cooler during other seasons. In contrast, at depths above 10 m water temperatures were higher in spring, summer and fall (LGL 2025).

Mean water temperatures ranged from 1.5°C in winter (0.5 depth) to 17.0°C in summer (0.5 m depth) at the Salmonier Cove sea farm. Maximum water temperatures at the Salmonier Cove sea farm were recorded at a depth of 0.5 m in summer, reaching 20.9°C. The minimum water temperatures occurred in winter at the same depth, measuring -1.0°C. During 2022–2024, data collected at the Salmonier Cove sea farm indicated an increase in average and maximum temperatures from April–September, while minimum temperatures were highest in November (Figure 5.12).

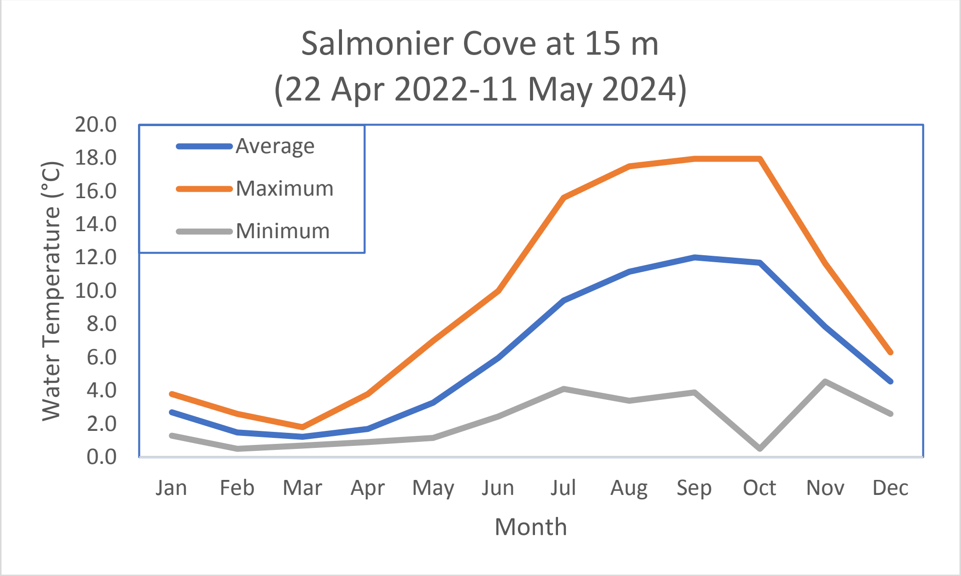


Figure 5.12. Historical water temperatures (°C) data in the Salmonier Cove sea farm at 15 m depth considered representative of water temperatures in BMA 4.

### *Dissolved Oxygen*

Dissolved oxygen levels were consistently lower in summer compared to the other seasons (Figure 5.13). Mean dissolved oxygen levels ranged from 7.8 mg/L in summer (1.0 m depth at Salmonier Cove) to 12.4 mg/L in winter (0.5 m depth at Murphy Point sea farm [LGL 2025]). The maximum dissolved oxygen level was 15.9 mg/L, recorded at a depth of 1 m at the Murphy Point sea farm in winter, while the minimum dissolved oxygen level was 5.1 mg/L, measured at a depth of 0.5 m in summer at the Salmonier Cove sea farm (LGL 2025).

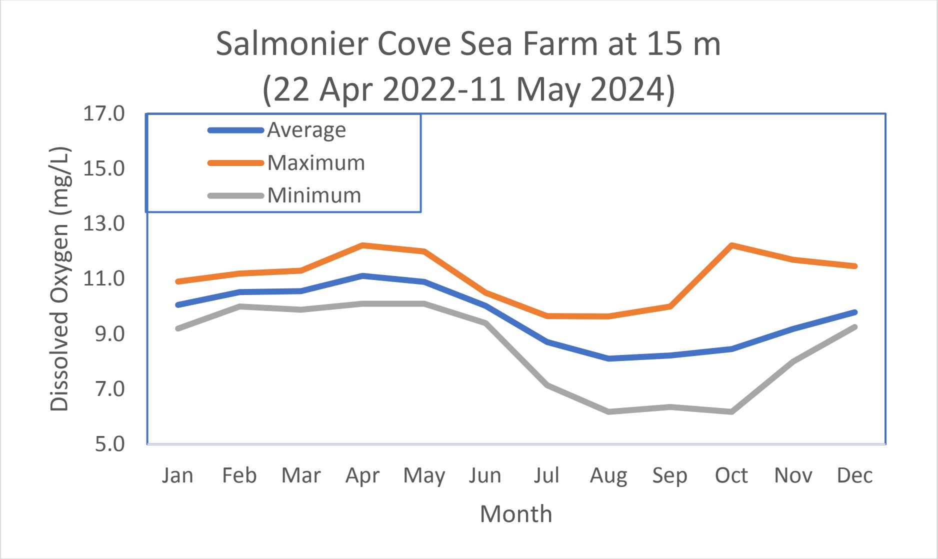


Figure 5.13. Historical dissolved oxygen (mg/L) levels at the Salmonier Cove sea farm at 15 m depth considered representative of dissolved oxygen levels in BMA 4.

### *Salinity*

Salinity was generally consistent across sea farms and seasons with averages ranging from 27.05–31.01 ppt. Results indicate a moderate freshwater influence near the surface. Table 5.7 provides a summary of average salinities at the Salmonier Cove sea farm as representative of the Great Bay de l'Eau BMA.

Table 5.7. Average salinities (‰) in the Salmonier Cove sea farm in the Great Bay de l'Eau BMA (2022–2024).

| Water Depth | Sampling Period | Winter | Spring | Summer | Fall |
|---|---|---|---|---|---|
| | | Salinity (‰) | | | |
| **Salmonier Cove** | | | | | |
| 0.5 m | 22 Apr 2022–11 May 2024 | 28.46 | 28.75 | 27.05 | 28.20 |
| 1 m | 22 Apr 2022–11 May 2024 | 29.81 | 29.74 | 28.56 | 29.25 |
| 5 m | 22 Apr 2022–11 May 2024 | 30.51 | 30.64 | 29.94 | 30.13 |
| 10 m | 22 Apr 2022–11 May 2024 | 30.96 | 30.79 | 30.41 | 30.21 |
| 15 m | 22 Apr 2022–11 May 2024 | 30.99 | 30.85 | 30.66 | 30.46 |
| 20 m | 22 Apr 2022–11 May 2024 | 30.64 | 30.90 | 30.81 | 30.59 |
| 30 m | 22 Apr 2022–11 May 2024 | 30.61 | 30.96 | 30.85 | 30.66 |

#### *5.3.1.5 Harbour Breton Bay (BMA 5)*

Harbour Breton Bay (BMA 5) has four licensed sea farms and water quality data were periodically collected during 2019–2024. Temporal coverage of water quality data in the Harbour Breton Bay BMA are variable for the four sea farms. The Harvey Hill East sea farm (AQ 933; see Figure 5.2) was selected to represent the water quality data for Harbour Breton Bay BMA as it contained one of the most complete data sets of the four sea farms in the BMA.

*Water Temperature*

In BMA 5, the mean minimum water temperature was 2.1°C (winter in Broad Cove sea farm and the mean maximum was 15.7°C (summer in Harvey Hill East sea farm; LGL 2025). The maximum water temperature observed was 20.2°C (at 0.5 m water depth) in the Harvey Hill East sea farm. The minimum water temperature observed was 0.08°C in the Broad Cove sea farm (<1 m). During the same period, the Harvey Hill East sea farm had a minimum temperature of 0.3°C. During 2019–2024 in the Harvey Hill East sea farm, average and maximum water temperatures increased from April–September, while minimum temperatures increased from August–October (Figure 5.14).

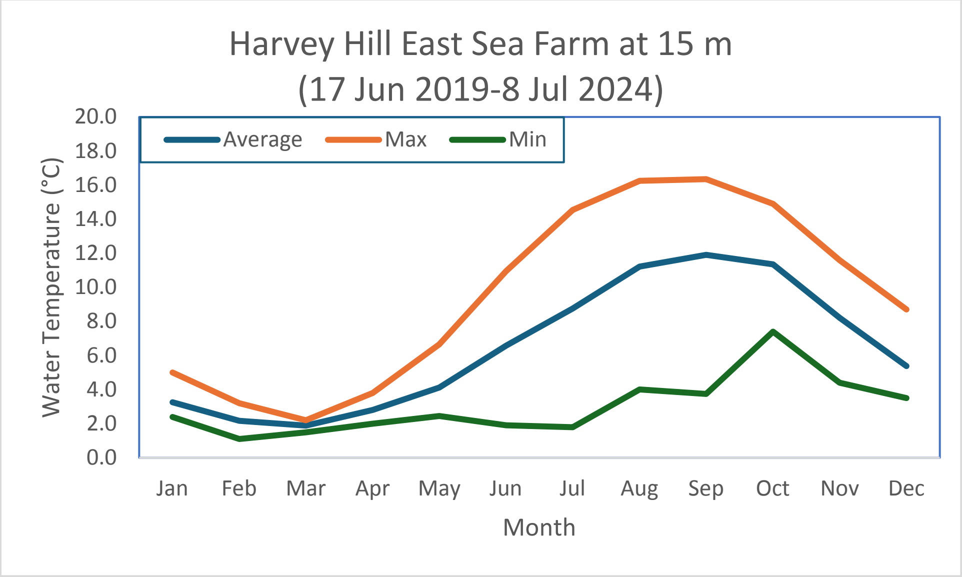


Figure 5.14. Historical water temperatures (°C) at 15 m depth in the Harvey Hill East sea farm considered representative of water temperatures in BMA 5.

*Dissolved Oxygen*

As in other BMAs, dissolved oxygen levels were consistently lower in summer and fall compared to winter and spring. Mean dissolved oxygen ranged from 8.2 mg/L in summer (1 m depth in

Broad Cove sea farm to 11.6 mg/L in fall (10 m depth; Harvey Hill North sea farm LGL 2025). The maximum observed dissolved oxygen level was 13.8 mg/L, recorded at a depth of 15 m at the Harvey Hill North sea farm in summer; the minimum dissolved oxygen level was 5.5 mg/L, measured at a depth of 1 m in summer and fall at the Broad Cove sea farm (LGL 2025). At the Harvey Hill East sea farm, dissolved oxygen levels increased from November–April; average oxygen levels peaked in April whereas the lowest oxygen levels were observed in July (Figure 5.15).

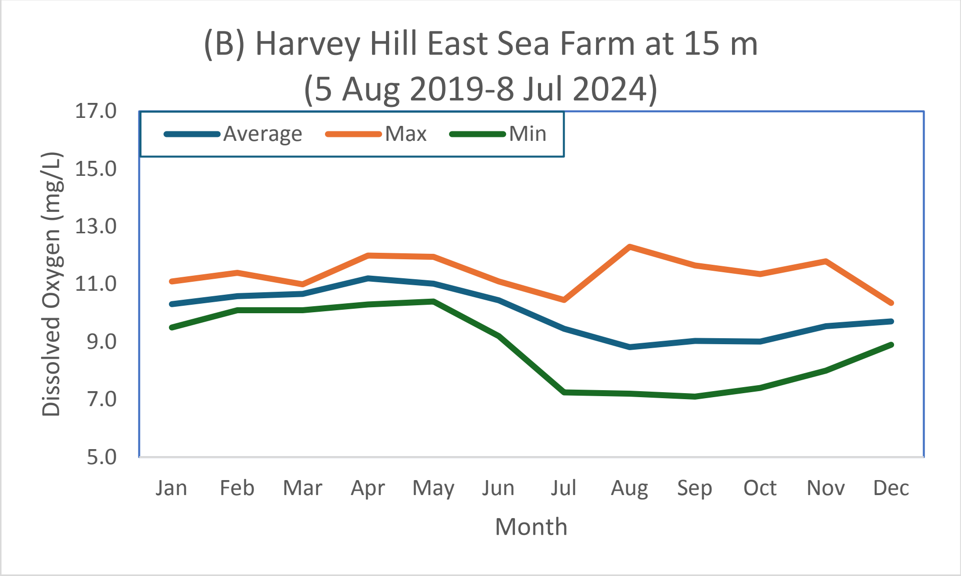


Figure 5.15. Historical dissolved oxygen (mg/L) levels in the Harvey Hill East sea farm at 15 m depth considered representative of dissolved oxygen levels in BMA 5.

### *Salinity*

Salinity was fairly consistent across sea farms and seasons (where data were available) in the Harbour Breton Bay BMA with averages ranging from 27.6–30.8 ppt. Table 5.8 provides a summary of average salinities at the Harvey Hill East sea farm as representative of the Harbour Breton Bay BMA.

Table 5.8. Average salinities (‰) at the Harvey Hill East sea farm in the Harbour Breton Bay BMA (2021–2024).

| Water Depth | Sampling Period | Winter | Spring | Summer | Fall |
|---|---|---|---|---|---|
| | | Salinity (‰) | | | |
| **Harvey Hill East** | | | | | |
| 0.5 m | 26 May 2021–8 Jul 2024 | 29.49 | 29.61 | 29.30 | 29.60 |
| 1 m | 26 May 2021–8 Jul 2024 | 29.80 | 29.79 | 29.44 | 29.80 |
| 5 m | 25 May 2021–8 Jul 2024 | 30.11 | 30.32 | 29.90 | 30.18 |
| 10 m | 26 May 2021–8 Jul 2024 | 30.22 | 30.49 | 30.19 | 30.28 |
| 15 m | 26 May 2021–8 Jul 2024 | 30.29 | 30.52 | 30.37 | 30.33 |
| 20 m | 26 May 2021–8 Jul 2024 | 30.33 | 30.61 | 30.46 | 30.38 |
| 30 m | 26 May 2021–8 Jul 2024 | 30.39 | 30.77 | 30.55 | 30.44 |

### 5.3.2 Bays West Sea Farms

The Bays West area includes BMAs 8–15 (see Figure 5.3) and water quality data were collected by MCE periodically during 2019–2024 (in BMAs 10, 12, 13). The available water quality data in BMAs 10, 12, and 13 are representative of sea farms currently in active production and includes water temperature, dissolved oxygen and salinity data. Two BMAs (BMA 8 and BMA 9) are currently not used for production. These two BMAs are being actively used by another Atlantic salmon producer. In an effort to avoid interaction, there are no immediate plans to supply smolt to MCE's eight sea farms within these two BMAs. The provincial FFA (formerly DFLR) has collected water quality data in the Bays West area in the past. These historical data have been provided to MCE during their license application and where available are included in the summaries for BMAs 9, 11, 14 and 15.

#### *5.3.2.1 Little Passage (BMA 8)*

Little Passage (BMA 8) has four licensed sea farms. No recent water quality data have been collected (since last production in 2009) in sea farms in the Little Passage BMA. The area is actively farmed by other operators and if MCE were to redevelop its sea farms in the area, daily measurements of biophysical data will be collected and reported quarterly as per its aquaculture license requirements.

#### *5.3.2.2 Outer Bay d'Espoir (BMA 9)*

Outer Bay d'Espoir (BMA 9) has four licensed sea farms. Data were collected by FFA (formerly DFLR) in the Outer Bay d'Espoir BMA (undated) and is representative of the general area. Water quality measurements for temperature and salinity are summarized. There are no dissolved oxygen data. If MCE were to redevelop its sea farms in the area, daily measurements of biophysical data will be collected and reported quarterly as per its aquaculture license requirements.

***Water Temperature***

Historical water temperature data were collected (undated) by FFA (formerly DFLR) at the Outer Bay d'Espoir BMA (Table 5.9). Average water temperatures at the surface ranged from 0°C in the winter to 17°C in the summer. Above 10 m water depth, water temperatures were the highest in summer and lowest in the winter. At 10 m depth, water temperatures are only slightly higher in summer and fall (4°C) compared to winter and spring (2°C).

Table 5.9. Historical water temperature (°C) profiles for the Outer Bay d'Espoir BMA collected by DFLR (undated).

| Water Depth | Sampling Period | Winter | Spring | Summer | Fall |
|---|---|---|---|---|---|
| | | Temperature (°C) | | | |
| **BMA 9** | | | | | |
| 0 m | n/a | 0 | 5 | 17 | 10 |
| 1 m | n/a | 0.1 | 4 | 14 | 10 |
| 2 m | n/a | 0.2 | 3 | 13 | 11 |
| 3 m | n/a | 1 | 2 | 13 | 11 |
| 4 m | n/a | 1 | 2 | 12 | 12 |
| 5 m | n/a | 1 | 2 | 12 | 12 |
| 10 m | n/a | 1 | 2 | 4 | 4 |

Notes:
Months were not defined for each season.

### *Dissolved Oxygen*

There were no available data for dissolved oxygen within the Outer Bay d'Espoir BMA.

### *Salinity*

Salinity was relatively consistent at 2 m water depth and below, with averages ranging from 25–30 ppt (Table 5.10). Results indicate a notable freshwater influence near the surface in the winter, spring and summer that is characteristic of Bay d'Espoir and the impact of the hydroelectric generation at the head of the bay. Above 2 m, salinity ranged from 15–17 ppt in spring and summer, and 30 ppt in fall (DFLR undated).

Table 5.10. Historical average salinity (‰) at the sea farms in the Outer Bay d'Espoir BMA (undated).

| Water Depth | Sampling Period | Winter | Spring | Summer | Fall |
|---|---|---|---|---|---|
| | | Salinity (‰) | | | |
| **BMA 9** | | | | | |
| 0 m | n/a | n/a | 15 | 15 | 30 |
| 1 m | | n/a | 17 | 17 | 30 |
| 2 m | | 25 | 20 | 20 | 30 |
| 3 m | | 30 | 28 | 28 | 30 |
| 4 m | | 30 | 30 | 30 | 30 |
| 5 m | | 30 | 30 | 30 | 30 |
| 10 m | | 30 | 30 | 30 | 30 |

Notes:
Months were not defined for each season.

### *5.3.2.3 Facheux Bay (BMA 10)*

Facheux Bay (BMA 10) has four licensed sea farms. Water quality data including water temperature, dissolved oxygen and salinity, were available for the Wallace Cove sea farm (AQ 1123; see Figure 5.3) during 2019–2024.

### *Water Temperature*

In the Wallace Cove sea farm, mean water temperatures ranged from 1.6°C in winter to 16.9°C in summer (at 0.5 m water depth). Maximum water temperatures were recorded at 0.5 m in summer, reaching 22.9°C. Minimum temperatures occurred in winter at the same depth, measuring -0.8°C. During 2019–2024, water temperatures generally increased from April–September, with average temperatures peaking in September and decreasing thereafter. Maximum water temperatures peaked in August (Figure 5.16).

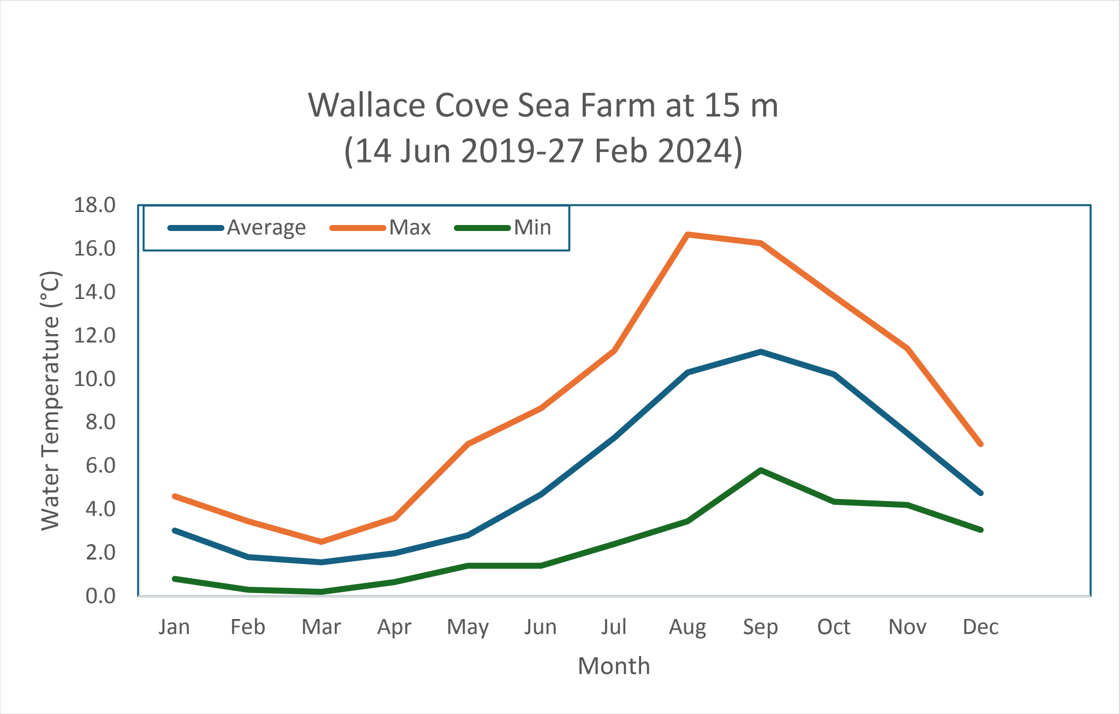


Figure 5.16. Historical water temperatures (°C) in the Wallace Cove sea farm at 15 m depth in BMA 10.

### *Dissolved Oxygen*

Dissolved oxygen levels at the Wallace Cove sea farm were consistently lower in summer and fall compared to winter and spring. Mean dissolved oxygen levels ranged from 8.6 mg/L to 11.3 mg/L in winter (0.5–1.0 m water depth). The maximum dissolved oxygen level was 14.2 mg/L in winter (0.5 m water depth) and the minimum level was 4.1 mg/L in fall (at 1 m).

During 2019–2024 in the Wallace Cove sea farm, a general decrease in dissolved oxygen levels was recorded from June–October, followed by an increase in winter and spring. Average dissolved oxygen levels peaked in April, while the lowest levels were recorded in October. Maximum dissolved oxygen levels were highest in June while minimum dissolved oxygen levels were lowest in August (Figure 5.17).

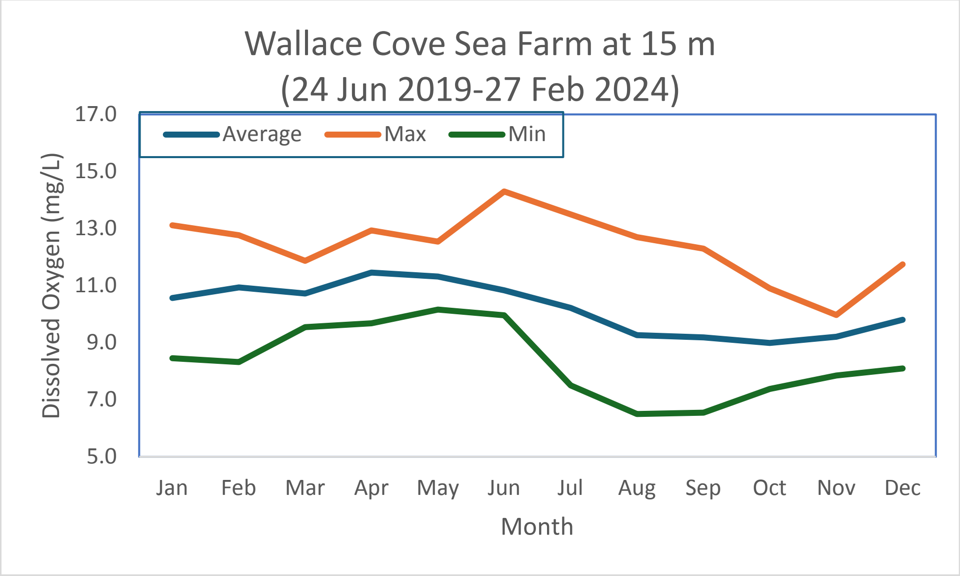


Figure 5.17. Historical dissolved oxygen (mg/L) levels in the Wallace Cove sea farm at 15 m depth in BMA 10.

### *Salinity*

Salinities at the Wallace Cove sea farm was fairly consistent across the seasons with averages ranging from 24.3 (0.5 m) to 31.0 ppt (30 m) (Table 5.11). A moderate freshwater influence is observed near the surface that is more pronounced in the spring, summer and fall.

Table 5.11. Average salinities (‰) at the sea farms in the Facheux Bay BMA (2019–2024).

| Water Depth | Sampling Period | Winter | Spring | Summer | Fall |
|---|---|---|---|---|---|
| | | Salinity (‰) | | | |
| **Wallace Cove** | | | | | |
| 0.5 m | 4 Jul 2019–27 Feb 2024 | 28.70 | 24.32 | 24.42 | 25.52 |
| 1 m | 11 Nov 2019–27 Feb 2024 | 29.06 | 25.42 | 24.69 | 26.76 |
| 5 m | 21 Jun 2019–27 Feb 2024 | 30.13 | 28.49 | 28.32 | 29.70 |
| 10 m | 11 Nov 2019–27 Feb 2024 | 30.57 | 29.43 | 29.64 | 30.25 |
| 15 m | 4 Jul 2019–27 Feb 2024 | 30.70 | 29.77 | 30.02 | 30.60 |
| 20 m | 11 Nov 2019–27 Feb 2024 | 30.80 | 29.91 | 30.29 | 30.76 |
| 30 m | 11 Nov 2019–27 Feb 2024 | 31.01 | 30.02 | 30.35 | 30.94 |

### 5.3.2.4 *Hare Bay (BMA 11)*

Hare Bay (BMA 11) has two licensed sea farms. Salinity data were collected by FFA (formerly DFLR) during 1994–2003. There are no available water temperature or dissolved oxygen data for the Hare Bay BMA.

### *Salinity*

Salinities were relatively consistent across seasons with averages ranging from 25.8–31.7 ppt (Table 5.12) in the Hare Bay BMA during 1994 and 2003. The results indicate a moderate freshwater influence near the surface that is more pronounced in the spring.

Table 5.12. Historical salinity (‰) profiles within Hare Bay BMA collected by DFLR (1994/5–2003).

| Water Depth | Sampling Period | Winter | Spring | Summer | Fall |
|---|---|---|---|---|---|
| | | Salinity (‰) | | | |
| **Hare Bay** | | | | | |
| 0 m | 1994/5–2003 | | | | |
| 1 m | 1994/5–2003 | 28.8 | 25.8 | 29 | n/a |
| 2 m | 1994/5–2003 | 29.1 | 26.1 | 29 | n/a |
| 3 m | 1994/5–2003 | 30.5 | 30.1 | 30 | 27 |
| 4 m | 1994/5–2003 | 31.2 | 31.2 | 30 | 30 |
| 5 m | 1994/5–2003 | 31.3 | 31.5 | 31 | 31.5 |
| 10 m | 1994/5–2003 | 31.6 | 31.7 | 31 | 31.5 |

Notes:
Months were not defined for each season.

### 5.3.2.5 *Rencontre West (BMA 12)*

Rencontre West (BMA 12) has four licensed sea farms and water quality data were collected during 2020–2024 for three of the sea farms. Temporal coverage of water quality data are variable for all three sea farms. The Little Bay sea farm (AQ 1134; see Figure 5.3) was selected to represent the water quality data for Rencontre West BMA as it contained one of the most complete and representative data sets for the BMA.

### *Water Temperature*

Seasonal water temperatures were generally consistent across sea farms with available data. Mean water temperatures ranged from 1.4°C in winter in the Devil Bay sea farm (5 m depth) to 15.1°C in summer at The Gorge sea farm (0.5 m depth; LGL 2025). Maximum water temperatures were recorded at a depth of 0.5 m in summer, reaching 20.1°C (The Gorge) and minimum temperatures occurred in winter, measuring 0.20°C (Devil Bay). During 2020–2024 in the Little Bay sea farm average temperatures increased from April–September, while maximum temperatures increased from April–August (Figure 5.18).

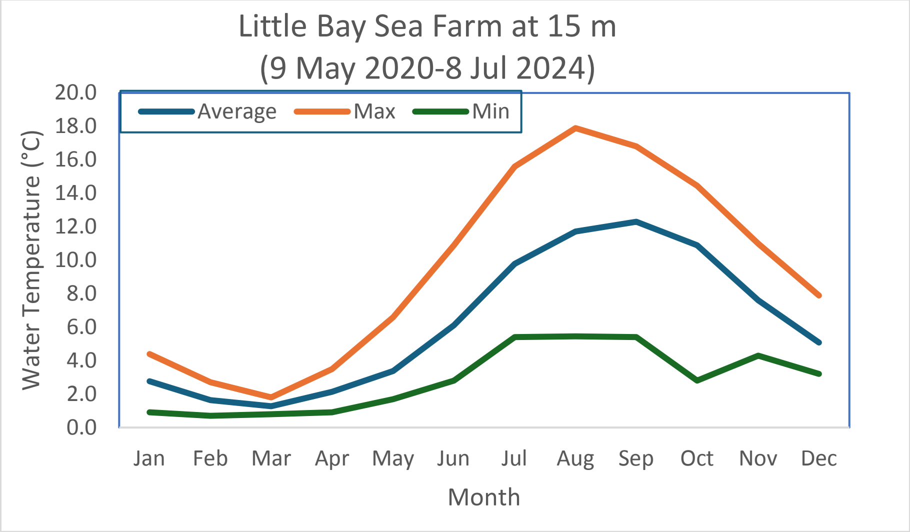


Figure 5.18. Historical water temperatures (°C) at 15 m depth in the Little Bay sea farm considered representative of water temperatures in BMA 12.

### *Dissolved Oxygen*

Dissolved oxygen levels (average) were consistently lower in summer and fall compared to winter and spring (Figure 5.19 and LGL 2025). Mean dissolved oxygen levels ranged from 7.8 mg/L in summer (Little Bay sea farm) to 11.5 mg/L in winter (Devil Bay sea farm) at 0.5 m depth. In the Little Bay sea farm, the maximum dissolved oxygen level was 15.0 mg/L (water depth of 0.5 m) in winter; the minimum dissolved oxygen level was 4.3 mg/L (water depth of 5 m) in summer.

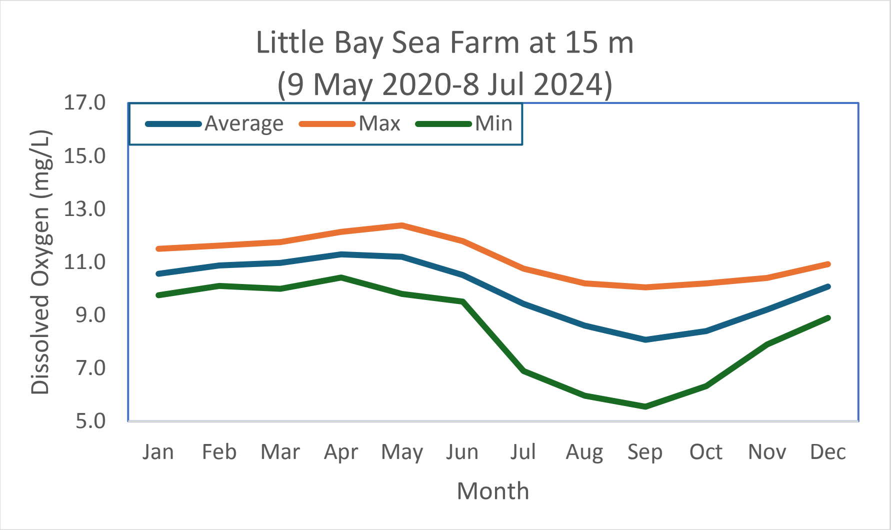


Figure 5.19. Historical dissolved oxygen (mg/L) levels in the Little Bay sea farm at 15 m depth considered representative of dissolved oxygen levels in BMA 12.

### *Salinity*

Salinity was fairly consistent across sea farms and seasons with averages ranging from 27.9–31.0 ppt (LGL 2025). Table 5.13 provides a summary of average salinities in the Little Bay sea farm as representative of the Rencontre West BMA. Near surface salinity concentrations indicate a moderate freshwater influence.

Table 5.13. Average salinity (‰) at the Little Bay sea farm in the Rencontre West BMA (2020–2024).

| Water Depth | Sampling Period | Winter | Spring | Summer | Fall |
|---|---|---|---|---|---|
| | | Salinity (‰) | | | |
| **Little Bay** | | | | | |
| 0.5 m | 9 May 2020–8 Jul 2024 | 29.39 | 28.66 | 28.91 | 28.83 |
| 1 m | 9 May 2020–8 Jul 2024 | 29.57 | 29.18 | 29.16 | 29.00 |
| 5 m | 9 May 2020–8 Jul 2024 | 29.93 | 29.89 | 29.86 | 29.48 |
| 10 m | 9 May 2020–8 Jul 2024 | 30.04 | 30.26 | 30.35 | 29.79 |
| 15 m | 9 May 2020–8 Jul 2024 | 30.10 | 30.37 | 30.62 | 29.91 |
| 20 m | 9 May 2020–8 Jul 2024 | 30.03 | 30.50 | 30.80 | 29.99 |
| 30 m | 9 May 2020–8 Jul 2024 | 30.15 | 30.68 | 30.89 | 30.01 |

### 5.3.2.6 *Chaleur Bay (BMA 13)*

Chaleur Bay (BMA 13) has three licensed sea farms and water quality data were collected during 2021–2024 for two of the sea farms. Temporal coverage of water quality data are variable for both sea farms. The Chaleur Bay sea farm (AQ 1147; see Figure 5.3) was selected to represent the water quality data for Chaleur Bay BMA as it contained the broadest temporal coverage.

### *Water Temperature*

Seasonal water temperatures were generally consistent between both sea farms, with Chaleur Bay sea farm exhibiting slightly higher water temperatures compared to Friar Cove [LGL 2025]. For the available data, mean water temperatures ranged from 2.1°C in winter at Chaleur Bay (0.5 m depth) to 15.6°C in summer at the same site and depth. Maximum water temperatures at both Friar Cove and Chaleur Bay sea farms were recorded at a depth of 0.5 m in summer, reaching 19.6°C and 21.6°C, respectively. Minimum temperatures occurred in winter at similar depths, measuring 0.8°C in Friar Cove and 0.4°C in Chaleur Bay. Water temperatures were the lowest in February at both sea farms (LGL 2025). During 2021–2022 in the Chaleur Bay sea farm, average and maximum water temperatures increased from April–September, while minimum temperatures increased from May–October (Figure 5.20).

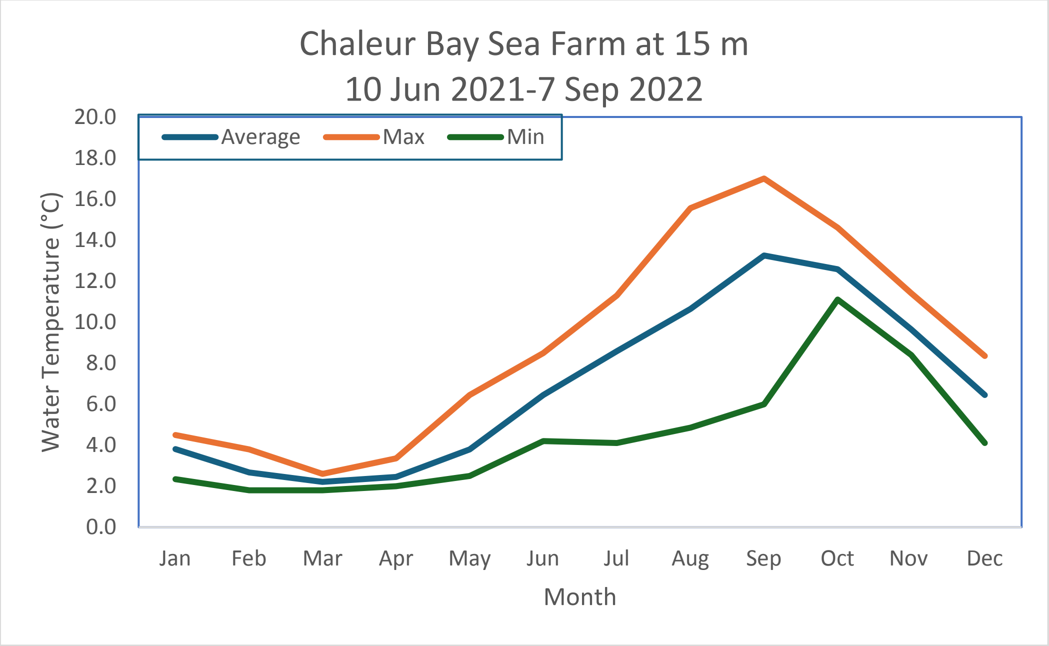


Figure 5.20. Historical water temperatures (°C) in the Chaleur Bay sea farm at 15 m depth considered representative of water temperatures in BMA 13.

### *Dissolved Oxygen*

Mean dissolved oxygen levels ranged from 8.6 mg/L in summer to 11.0 mg/L in winter (at 0.5 m depth at Chaleur Bay). Based on the available data, the maximum dissolved oxygen level was 13.5 mg/L, recorded at 0.5 m depth at Chaleur Bay in spring, while the minimum dissolved oxygen level was 6.4 mg/L, measured at 1 m depth at Chaleur Bay in spring. Dissolved oxygen levels across all water depths showed a seasonal trend, with higher values in winter and spring, decreasing in summer and fall (LGL 2025).

In the Chaleur Bay sea farm, dissolved oxygen levels increased from November–April; both average and maximum oxygen levels peaked in April whereas the lowest oxygen levels were observed in October (Figure 5.21).

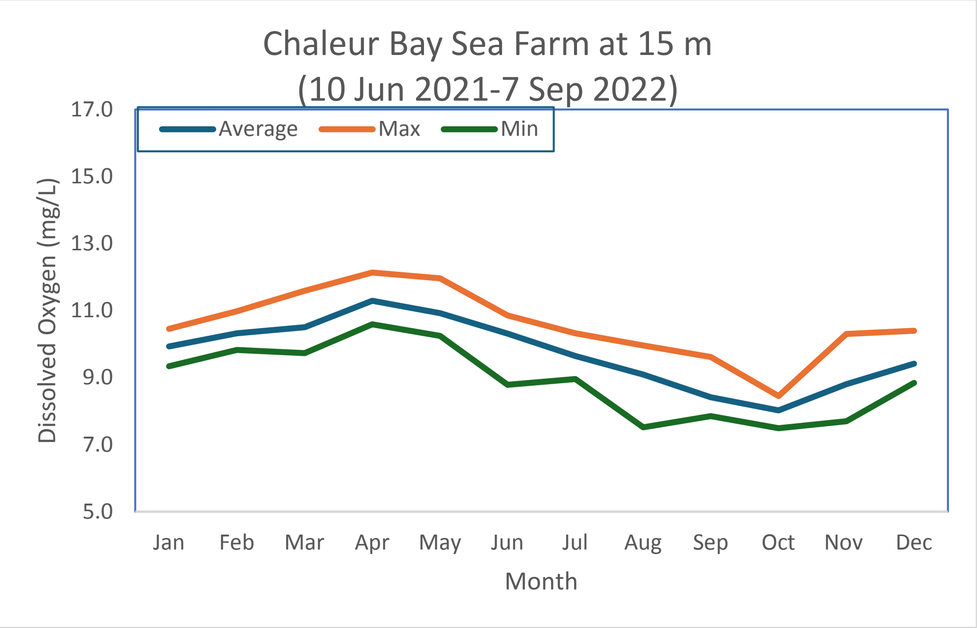


Figure 5.21. Historical dissolved oxygen (mg/L) levels in the Chaleur Bay sea farm at 15 m depth considered representative of dissolved oxygen levels in BMA 13.

### *Salinity*

Salinity was fairly consistent across sea farms and seasons with averages ranging from 27.0 during summer at 0.5 m water depth in Chaleur Bay sea farm to 34.0 ppt in Friar Cove sea farm during winter at 30 m water depth (LGL 2025). In the Chaleur Bay sea farm, salinity concentrations indicated a moderate freshwater influence near the surface in spring. Table 5.14 provides a summary of average salinities at the Chaleur Bay sea farm considered representative of BMA 13.

Table 5.14. Average salinities (‰) in the Chaleur Bay sea farm in BMA 13 (2021–2022).

| **Water Depth** | **Sampling Period** | **Winter** | **Spring** | **Summer** | **Fall** |
|---|---|---|---|---|---|
| | | **Salinity (‰)** | | | |
| **Chaleur Bay** | | | | | |
| 0.5 m | 10 Jun 2021–7 Sep 2022 | 29.88 | 27.06 | 27.01 | 25.98 |
| 1 m | 10 Jun 2021–7 Sep 2022 | 30.37 | 28.29 | 28.15 | 27.06 |
| 5 m | 10 Jun 2021–7 Sep 2022 | 31.21 | 30.13 | 29.86 | 29.76 |
| 10 m | 10 Jun 2021–7 Sep 2022 | 31.52 | 30.41 | 29.96 | 30.36 |
| 15 m | 10 Jun 2021–7 Sep 2022 | 31.67 | 30.52 | 30.22 | 30.65 |
| 20 m | 10 Jun 2021–7 Sep 2022 | 31.78 | 30.58 | 30.33 | 30.65 |
| 30 m | 10 Jun 2021–7 Sep 2022 | 31.76 | 30.81 | 30.48 | 30.77 |

### 5.3.2.7 *Aviron Bay and La Hune Bay (BMA 14) and Bay de Vieux (BMA 15)*

Aviron Bay and La Hune Bay (BMA 14) and Bay de Vieux (BMA 15) each have three licensed sea farms. These six licenses were recently acquired by MCE in 2024. The available water quality data for both the Aviron Bay and La Hune Bay BMA and the Bay de Vieux BMA are a composite of information from several sources including historical data collected by DFLR (1994–1995; 2003–2004), a review of publications for the area, and data collected during production at nearby sea farms (L. Hiemstra, pers. comm., 5 Dec 2024).

#### *Water Temperature*

Based on available data, seasonal average water temperatures were generally consistent across water depths in winter and spring (Table 5.15). Water depths 10 m and below are typically cooler than surface depths in the summer and fall. Mean water temperatures ranged from 3.0°C (10 m water depth) in spring to 12.5°C (0 m water depth) in summer.

Table 5.15. Seasonal temperature for Aviron Bay and La Hune Bay (BMA 14) and Bay de Vieux (BMA 15) based on a composite of data sources including those from FFA, literature, and MCE.

| Water Depth | Sampling Period | Winter (Dec, Jan, Feb) | Spring (Mar, Apr, May) | Summer (Jun, Jul, Aug) | Fall (Sep, Oct, Nov) |
|---|---|---|---|---|---|
| | | Temperature (°C) | | | |
| **Aviron Bay and La Hune Bay and Bay de Vieux** | | | | | |
| 0 m | n/a | 3.2 | 3.5 | 12.5 | 11.3 |
| 1 m | n/a | 3.2 | 3.5 | 12.4 | 11.3 |
| 5 m | n/a | 3.2 | 3.2 | 12.0 | 11.2 |
| 10 m | n/a | 3.3 | 3.0 | 11.0 | 11.0 |
| 15 m | n/a | 3.3 | 2.8 | 9.0 | 11.0 |
| 30 m | n/a | 3.3 | 2.5 | 7.8 | 9.7 |

The FFA (formerly DFLR) collected data on water temperature in Aviron Bay (2003–2004) (Figure 5.22). Surface (3 m) temperatures peaked in August while water temperatures at 9–18 m depth were highest near the end of September. All water temperatures decreased in October, increasing again in April.

#### *Dissolved Oxygen*

There are no available dissolved oxygen data for the Aviron Bay and La Hune Bay BMA and Bay de Vieux BMA. See Section 5.3.2.5, BMA 12 (Little Bay [AQ 1134; see Figure 5.3]) for data from nearby sea farms that serve as a proxy for the Aviron Bay and La Hune Bay BMA as well as Bay de Vieux BMA.

#### *Salinity*

As noted above, available salinity data are a composite from several sources. As in other BMAs, salinities were fairly consistent across sea farms and seasons with averages ranging from 30–32 ppt (Table 5.16).

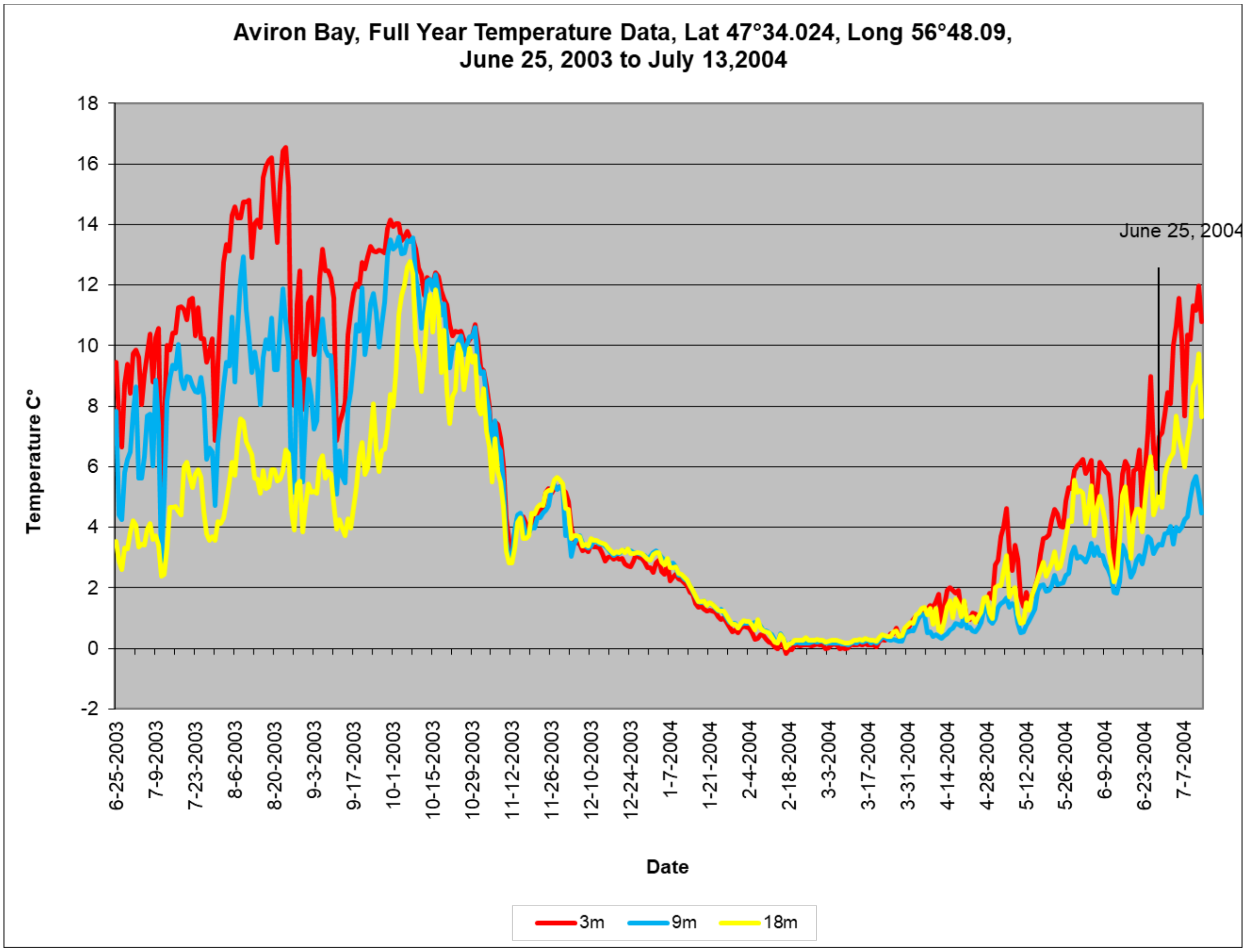


Figure 5.22. Historical water temperatures (°C) at 3, 9, and 18 m depths in Aviron Bay and La Hune Bay (June 2003–July 2004), collected by DFLR and considered representative of Bay de Vieux (BMA 15).

Table 5.16. Seasonal salinities for Aviron Bay and La Hune Bay (BMA 14) and Bay de Vieux (BMA 15) are based on a composite of data sources including those from DFLR, literature, and MCE.

| Water Depth | Sampling Period | Winter | Spring | Summer | Fall |
|---|---|---|---|---|---|
| | | Salinity (‰) | | | |
| **Aviron Bay and La Hune Bay Area; Bay de Vieux** | | | | | |
| 0 m | n/a | 30 | 30 | 30 | 30 |
| 1 m | n/a | 30 | 30 | 30 | 30 |
| 5 m | n/a | 30 | 31 | 30 | 30 |
| 10 m | n/a | 30 | 31 | 31 | 30 |
| 15 m | n/a | 30 | 32 | 31 | 30 |
| 30 m | n/a | 31 | 32 | 31 | 30 |

## 5.4 Flood and Tidal Zones

The Government of Canada maintains tidal stations for time and height prediction of high and low water in Canada including several along Newfoundland's south coast (DFO 2024f). To summarize the tidal conditions for the south coast of Newfoundland, the 2024 predicted hourly tidal heights for two stations in Bays East (Belleoram and Harbour Breton) and four stations in Bays West (Francois, Gaultois, McCallum, and Pushthrough (Figure 5.23) were accessed to calculate the mean, range, minimum, and maximum tide heights for the daily higher-high through lower-low predicted tides for 2024 in the area. Where historical observed data were available, the highest and lowest tides observed for the tide stations are also presented. Tidal predictions use astronomical, and not meteorological effects on tides (DFO 2024f); therefore, the data at three of the Bays West tidal stations where historical information was available were also included to summarize the range and frequency of high and low tides in the area. Although presented, these historical datasets are limited (Francois – June 1998; Gaultois – April–May 1996; and McCallum – December 1995 and July–August 1998) and represent a time period more than 25 years ago.

Tidal heights are affected by meteorological and climatological events beyond that which is captured in the predicted and limited historical data within the immediate vicinity of the south coast of Newfoundland. To assess extreme events, the frequency of tidal heights greater than 3 m (extremely high tides) that occurred in the historical data due to storm surge, precipitation and run-off, spring freshet, and changing sea levels was analyzed. Time-series plots of the historical data showing the exact dates, times, and tidal heights for tides that exceeded 3 m as well as time-series showing the full range of tidal heights recorded at stations with historical data available were extracted to help contextualize the frequency and magnitude of tides that exceeded 3 m. In addition, data from three long-term tidal stations adjacent to Fortune Bay (Port aux Basques, Cabot Strait – 1935–2024; Great St. Lawrence, Burin Peninsula, 1972, 2005–2024; and Argentia, Placentia Bay 1971–2024) were assessed and compared to a 3-m extreme high tide.

Predicted tidal heights for tidal stations in the Bays East area (represented by Belleoram and Harbour Breton) had an overall higher mean tide of 1.33 m compared to predicted tide heights in Bays West (represented by Gaultois, Francois, McCallum and Pushthrough) at 1.08 m. In 2024, the mean predicted overall tidal height for Bays East and Bays West representative stations was 1.16 m (Table 5.17).

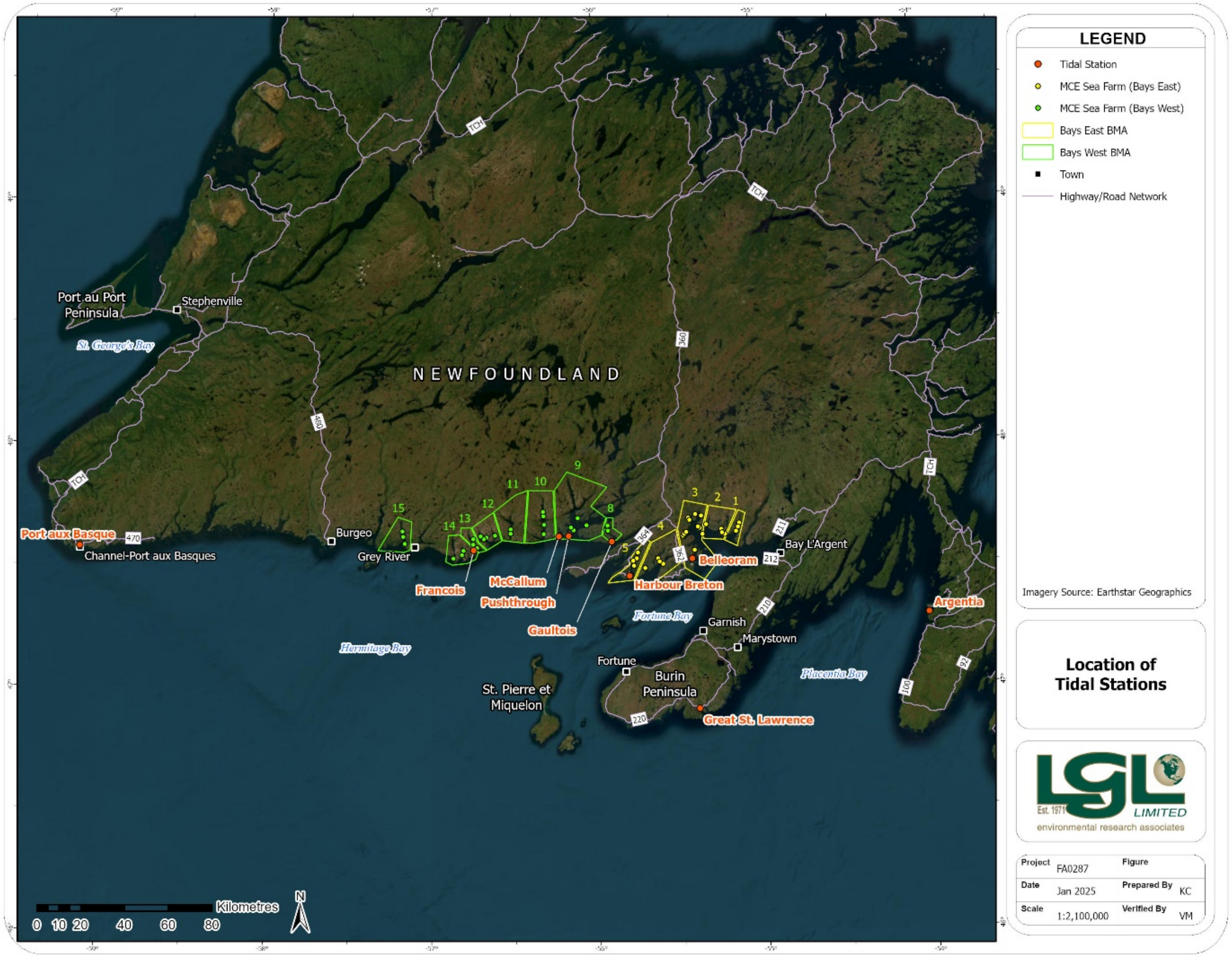
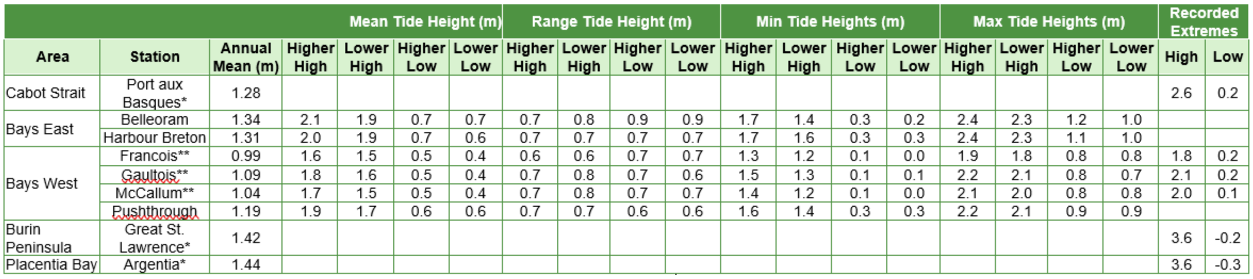


Figure 5.23. Locations of Government of Canada tidal stations used to summarize tidal data (observed and predicted) along the south coast of Newfoundland and near MCE sea farms. Long term stations with historical observed data are Port aux Basque (1935), Great St. Lawrence (2005) and Argentia (1971).

Table 5.17. Summary of 2024 predicted annual mean tidal heights (m) for nine tidal stations near and adjacent to MCE sea farms. Mean, range, minimum, and maximum tide heights for the daily higher-high through lower-low predicted tides in the Bays East and Bays West areas were calculated. Observed recorded extremes (highest and lowest tides) from historical data are presented where historical data were available (1935–2024).



| | | | Mean Tide Height (m) | | | | Range Tide Height (m) | | | | Min Tide Heights (m) | | | | Max Tide Heights (m) | | | | Recorded Extremes | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Area** | **Station** | **Annual Mean (m)** | **Higher High** | **Lower High** | **Higher Low** | **Lower Low** | **Higher High** | **Lower High** | **Higher Low** | **Lower Low** | **Higher High** | **Lower High** | **Higher Low** | **Lower Low** | **Higher High** | **Lower High** | **Higher Low** | **Lower Low** | **High** | **Low** |
| Cabot Strait | Port aux Basques* | 1.28 | | | | | | | | | | | | | | | | | 2.6 | 0.2 |
| Bays East | Belleoram | 1.34 | 2.1 | 1.9 | 0.7 | 0.7 | 0.7 | 0.8 | 0.9 | 0.9 | 1.7 | 1.4 | 0.3 | 0.2 | 2.4 | 2.3 | 1.2 | 1.0 | | |
| | Harbour Breton | 1.31 | 2.0 | 1.9 | 0.7 | 0.6 | 0.7 | 0.7 | 0.7 | 0.7 | 1.7 | 1.6 | 0.3 | 0.3 | 2.4 | 2.3 | 1.1 | 1.0 | | |
| Bays West | Francois** | 0.99 | 1.6 | 1.5 | 0.5 | 0.4 | 0.6 | 0.6 | 0.7 | 0.7 | 1.3 | 1.2 | 0.1 | 0.0 | 1.9 | 1.8 | 0.8 | 0.8 | 1.8 | 0.2 |
| | Gaultois** | 1.09 | 1.8 | 1.6 | 0.5 | 0.4 | 0.7 | 0.8 | 0.7 | 0.6 | 1.5 | 1.3 | 0.1 | 0.1 | 2.2 | 2.1 | 0.8 | 0.7 | 2.1 | 0.2 |
| | McCallum** | 1.04 | 1.7 | 1.5 | 0.5 | 0.4 | 0.7 | 0.8 | 0.7 | 0.7 | 1.4 | 1.2 | 0.1 | 0.0 | 2.1 | 2.0 | 0.8 | 0.8 | 2.0 | 0.1 |
| | Pushthrough | 1.19 | 1.9 | 1.7 | 0.6 | 0.6 | 0.7 | 0.7 | 0.6 | 0.6 | 1.6 | 1.4 | 0.3 | 0.3 | 2.2 | 2.1 | 0.9 | 0.9 | | |
| Burin Peninsula | Great St. Lawrence* | 1.42 | | | | | | | | | | | | | | | | | 3.6 | -0.2 |
| Placentia Bay | Argentia* | 1.44 | | | | | | | | | | | | | | | | | 3.6 | -0.3 |

Notes:

*Extremes for period 1 January 2015 through 1 January 2024.

**Extremes only available for June 1998 (Francois), April–May 1996 (Gaultois), October 1995 and July–August 1998 (McCallum).

### 5.4.1 South Coast of Newfoundland Flood and Tidal Zone Summary

Using the historical data available from tidal stations along the south coast of Newfoundland, there were no instances in which tide heights exceeded 3 m in the periods 1995, 1996, and 1998 (Figure 5.24) nor were tidal heights predicted to be greater than 3 m for any station in Bays West or Bays East during 2024 (Table 5.18). Based on historical observations, there were 28 instances in which tides exceed 3 m at nearby stations (21 events at Argentia, 7 events at Great St. Lawrence, 0 events at Port aux Basques) during the period 1971–2024, 1972 and 2005–2024, and 1935–2024, respectively (Figure 5.25; Table 5.18). The average tidal height exceeding 3 m at Argentia and Great St. Lawrence stations was 3.12 m with the largest tide (3.63 m) occurring at Great St. Lawrence on 11 September 2021 (Figure 5.26).

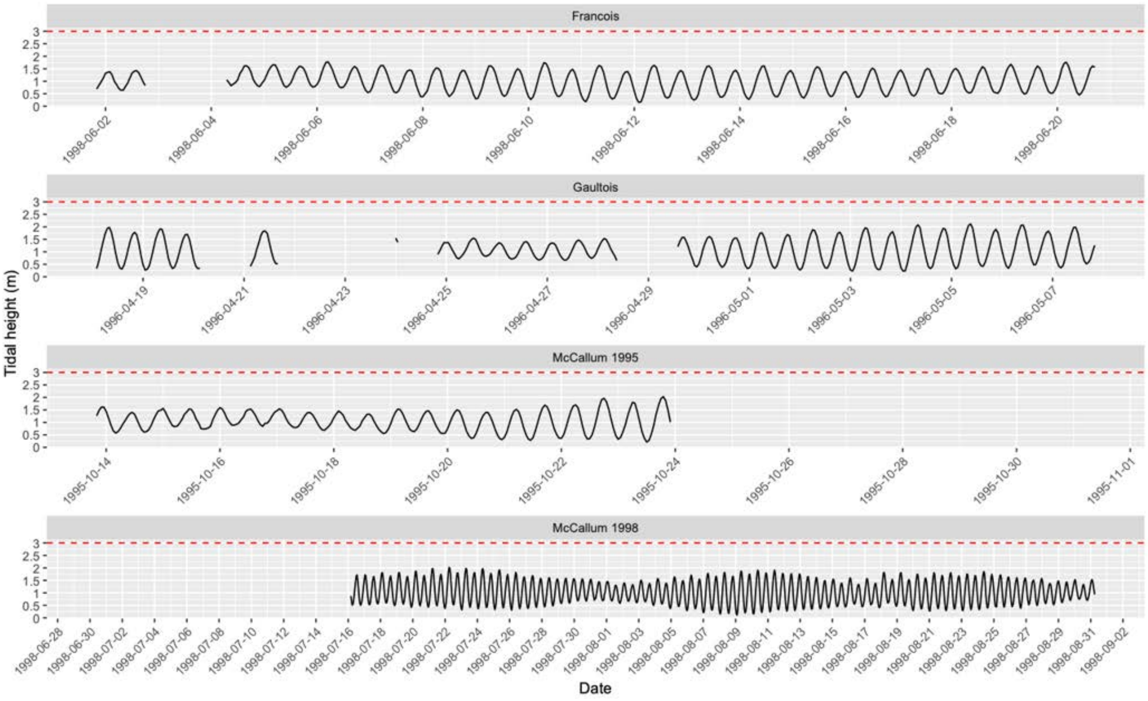


Figure 5.24. Historical observed hourly tide heights (m) for three reporting Stations in Bays West (Francois, 1998; Gaultois, 1996 and McCallum, 1995 and 1998) compared to a 3-m extreme high tide (red dashed line).

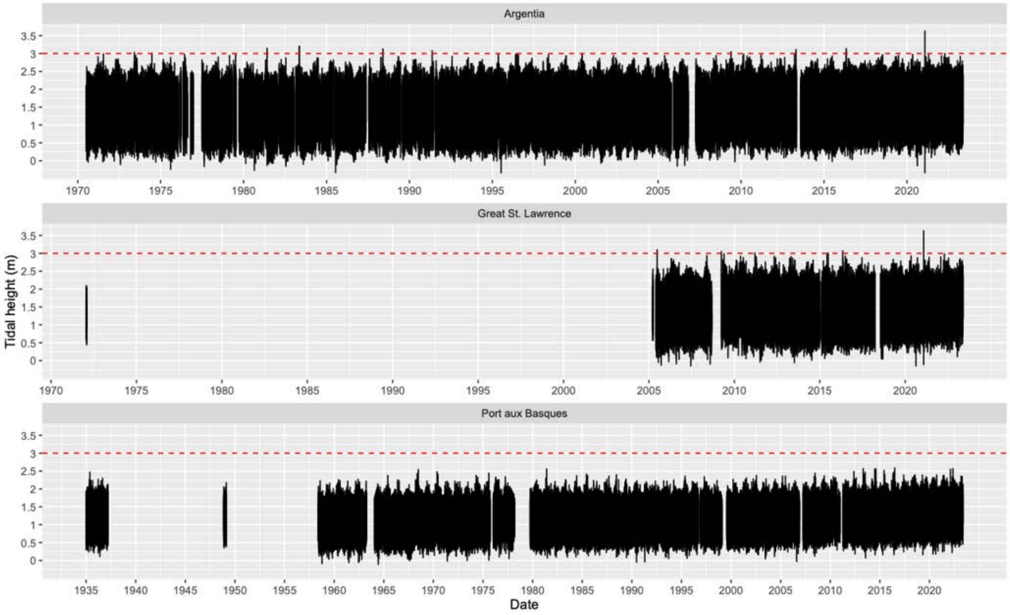


Figure 5.25. Historical observed hourly tidal heights for three reporting tide stations adjacent to Fortune Bay on the south coast of Newfoundland (Port aux Basque, Great St. Lawrence, and Argentia) compared to a 3-m extreme high tide (red dashed line).

Table 5.18. Recorded events where tidal height (m) exceeded 3-m at tidal stations ‘Argentia’ (1971–2024) and ‘Great St. Lawrence’ (1972 and 2005–2024) on the south coast of Newfoundland. Port aux Basque tidal station did not record any events exceeding 3 m during the period historical data was available (1935–2024).

| Date (and Time) Tides Exceeded 3 m | Observed Tidal Height (m) | |
|---|---|---|
| | Argentia Station | Great St. Lawrence Station |
| 10 Jan 1974 (09:00) | 3.03 | |
| 30 Jan 1975 (10:00) | 3.01 | |
| 10 Jan 1982 (10:00) | 3.15 | |
| 10 Jan 1982 (10:00) | 3.08 | |
| 22 Dec 1983 (09:00) | 3.01 | |
| 22 Dec 1983 (10:00) | 3.19 | |
| 22 Dec 1983 (11:00) | 3.2 | |
| 25 Dec 1983 (11:00) | 3.0 | |
| 25 Dec 1983 (12:00) | 3.2 | |
| 05 Jan 1989 (07:00) | 3.13 | |
| 25 Dec 1991 (12:00) | 3.08 | |
| 01 Feb 2006 (11:00) | 3.1 | |
| 06 Nov 2009 (12:00) | | 3.05 |
| 03 Jan 2010 (11:00) | 3.05 | |
| 26 Oct 2011 (07:00) | | 3.01 |
| 04 Dec 2013 (09:00) | 3.11 | |
| 09 Feb 2016 (09:00) | | 3.01 |
| 13 Dec 2016 (07:00) | 3.04 | 3.03 |
| 13 Dec 2016 (08:00) | | 3.07 |
| 15 Dec 2016 (22:00) | 3.14 | |
| 17 Dec 2016 (11:00) | 3.05 | |
| 10 Sep 2021 (23:00) | | 3.63 |
| 11 Sep 2021 (00:00) | 3.63 | 3.08 |
| 11 Sep 2021 (01:00) | 3.08 | |
| 25 Nov 2022 (09:00) | 3.0 | |

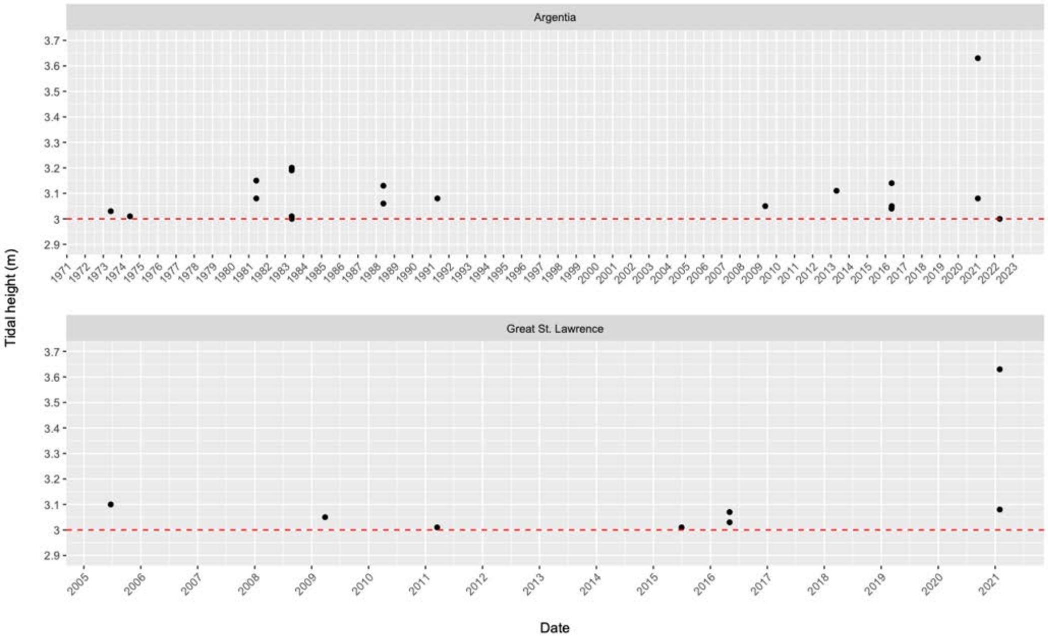


Figure 5.26. Observed tide heights (m) for Argentia (1971–2024) and Great St. Lawrence (1972 and 2005–2024) stations where tides exceeded 3 m (red dash line).

## 5.5 Ice Dynamics

Ice conditions in and near the BMAs were examined based on Canadian Ice Service (CIS) data and from general observations noted by MCE personnel at the sea farms. An analysis of the CIS 30-year median (1990/1991–2019–2020) of weekly ice in and near the BMAs was undertaken to provide information on the spatial extent and temporal occurrence of ice. To provide more up-to-date and detailed sea ice information, daily sea ice charts for the area in and near the BMAs, were selected to represent each week and then analyzed for the past 10 years (2015–2024) for the presence, type, and frequency of sea ice. A summary of the percent frequency of ice conditions within the region is provided.

General information on ice conditions specific to each MCE sea farm was gathered based on an interview with a senior sea farm manager.

### 5.5.1 South Coast Newfoundland Ice Condition Summary

#### *5.5.1.1 Sea Ice*

In comparison to other bays surrounding Newfoundland, the Study Area in and near the BMAs is relatively ice-free due to its location along the south-central coast of Newfoundland. An analysis of the Canadian Ice Service’s 30-year median (1990/1991–2019/2020) of weekly ice in and near the BMAs demonstrates that in years when ice is present, it occurs from January until early-April[11].

Figure 5.27 presents a series of weekly maps (January 1–April 9) of the 30-year median of ice concentration when ice is present in the Study Area in and near the BMAs. The likelihood of ice presence is highest during the week beginning February 19. During this week, the median of ice concentration is 9–9+/10 in years when ice is present.

A detailed map with the weekly analysis of 30-year median of ice concentration in the 13 BMAs during the week beginning on February 19 is shown in Figure 5.28. Figure 5.29 indicates that the frequency of sea ice presence in the 13 BMAs is 1–15%.

To provide more up-to-date and detailed sea ice information, daily sea ice charts for the Study Area in and near the BMAs were selected to represent each week and then analyzed over the past 10 years (2015–2024) for the presence, type, and frequency of sea ice. Table 5.19 contains the percent frequency of ice conditions within the region. The information presented in Table 5.19 represents the worst-case ice conditions which occurred in the area. For example, if half of the area was covered in 1/10th ice, and half classified as ice free, the information was recorded as 1/10th ice for the whole area.

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[11] https://iceweb1.cis.ec.gc.ca/Archive/page1.xhtml?lang=en

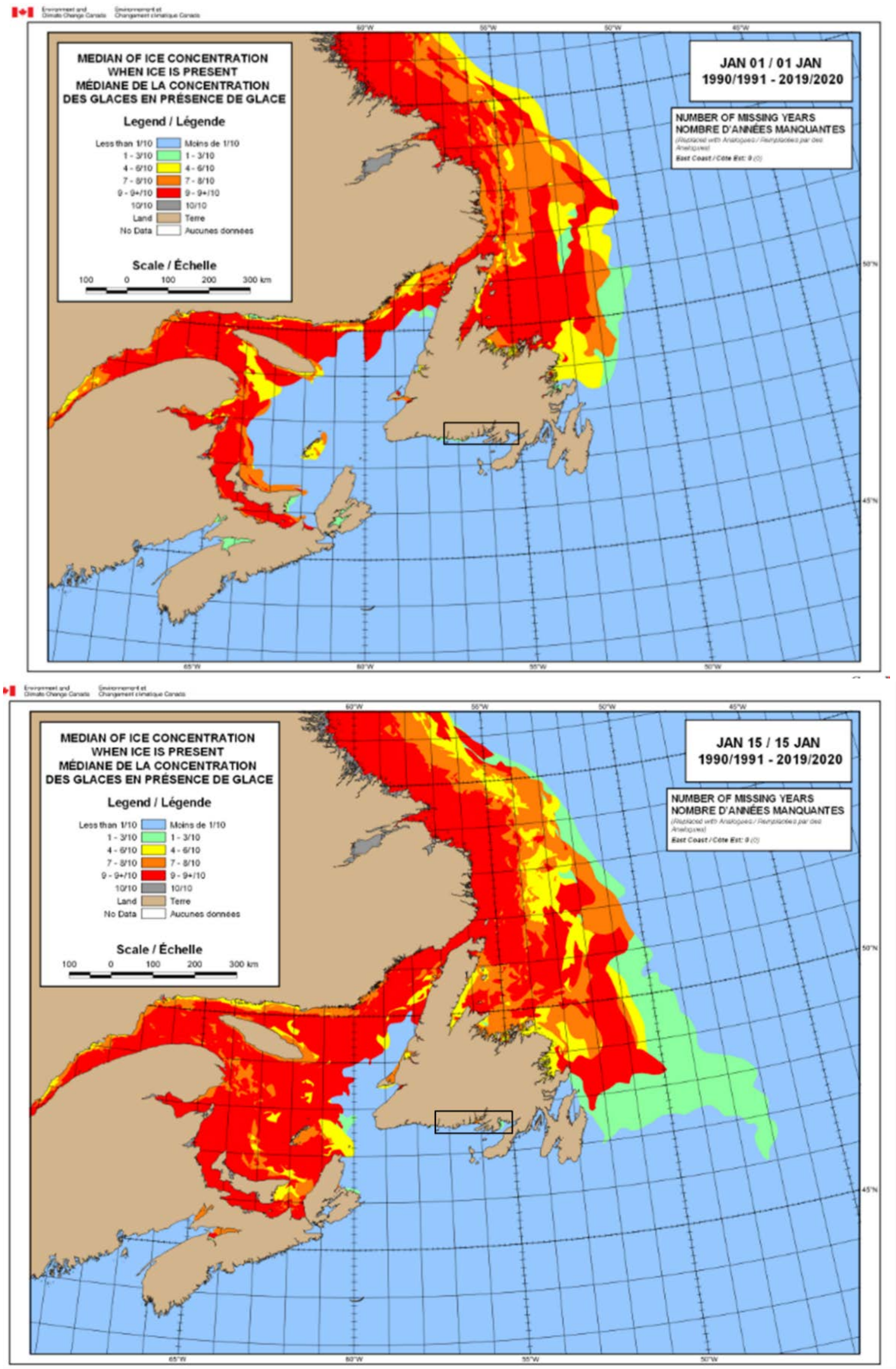


Figure 5.27. Weekly analysis of 30-year median of ice concentration when ice is present in the Study Area in and near the MCE BMAs (black rectangle) from 1991–2020 (Canadian Ice Service).

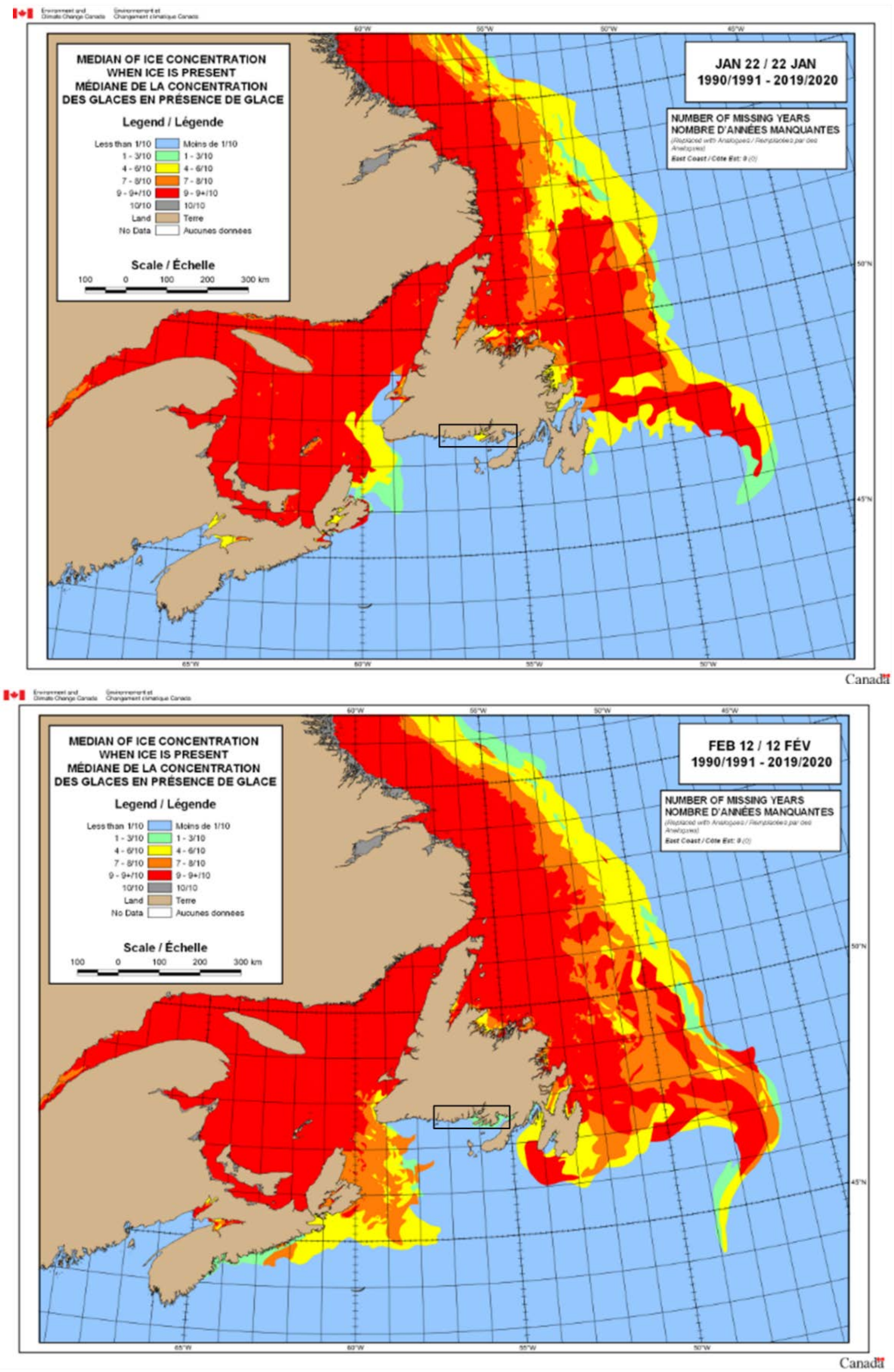


Figure 5.27 (continued). Weekly analysis of 30-year median of ice concentration when ice is present in the Study Area in and near the MCE BMAs (black rectangle) from 1991–2020 (Canadian Ice Service).

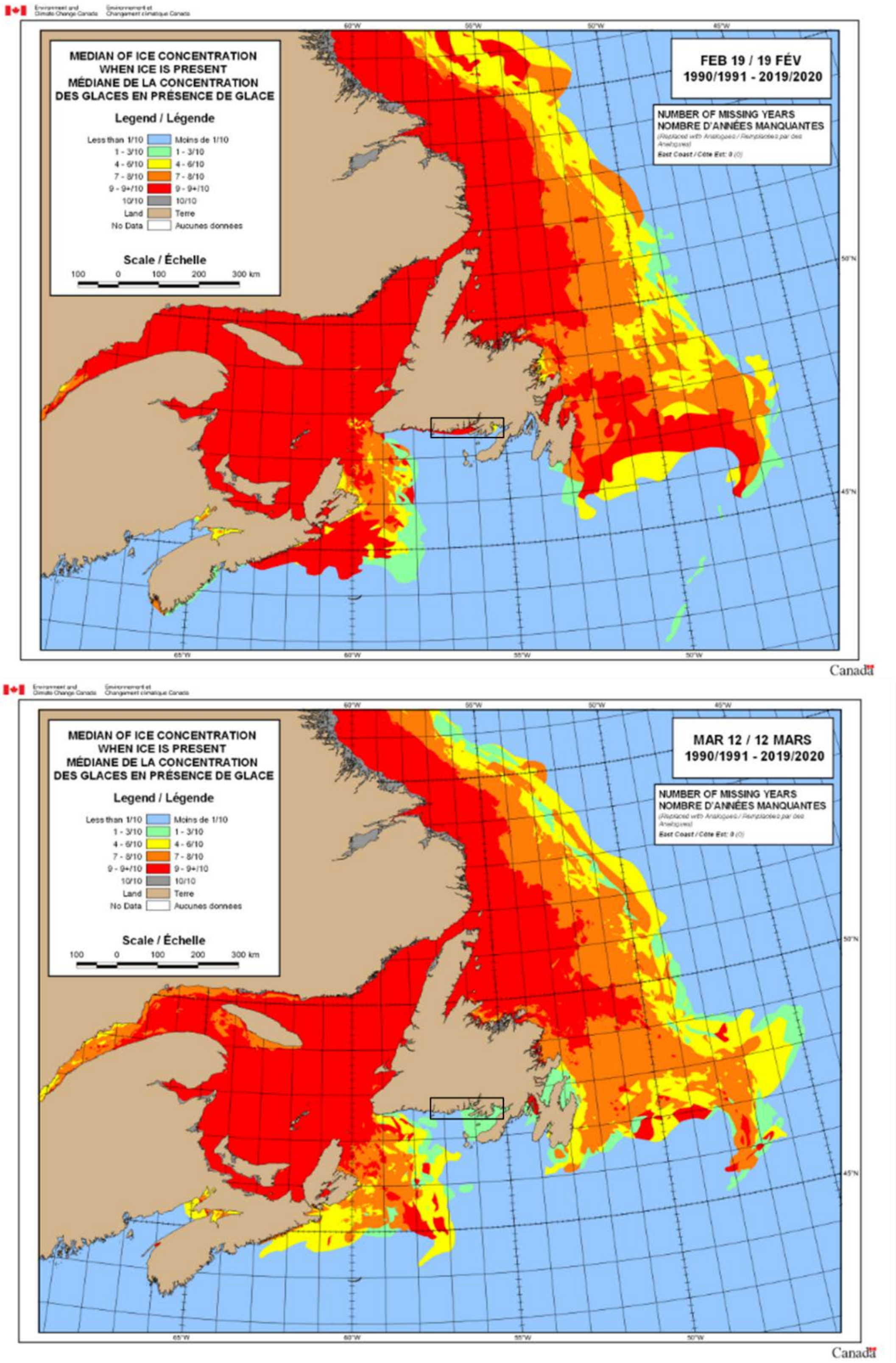


Figure 5.27 (continued). Weekly analysis of 30-year median of ice concentration when ice is present in the Study Area in and near the MCE BMAs (black rectangle) from 1991–2020 (Canadian Ice Service).

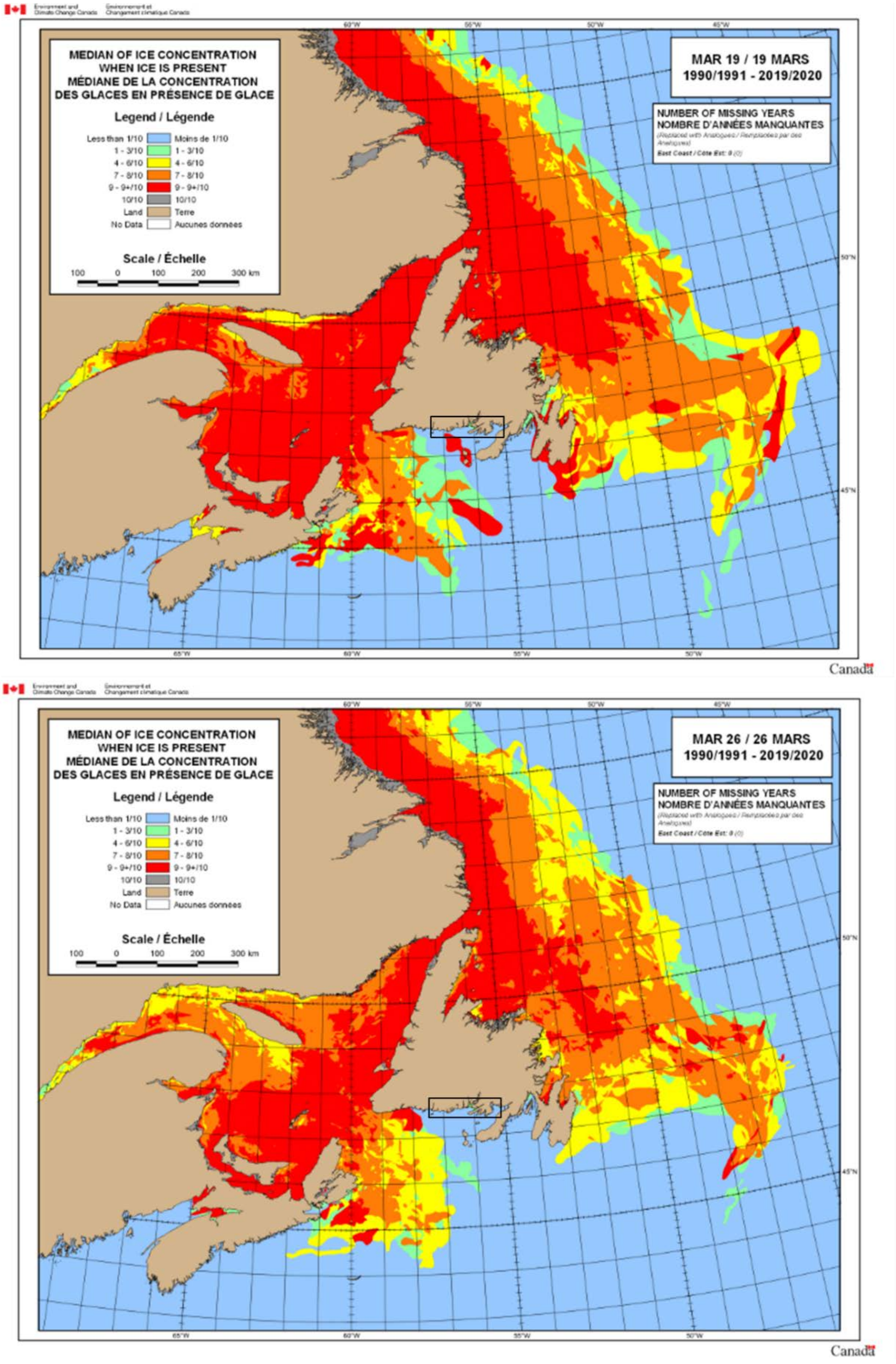


Figure 5.27 (continued). Weekly analysis of 30-year median of ice concentration when ice is present in the Study Area in and near the MCE BMAs (black rectangle) from 1991–2020 (Canadian Ice Service).

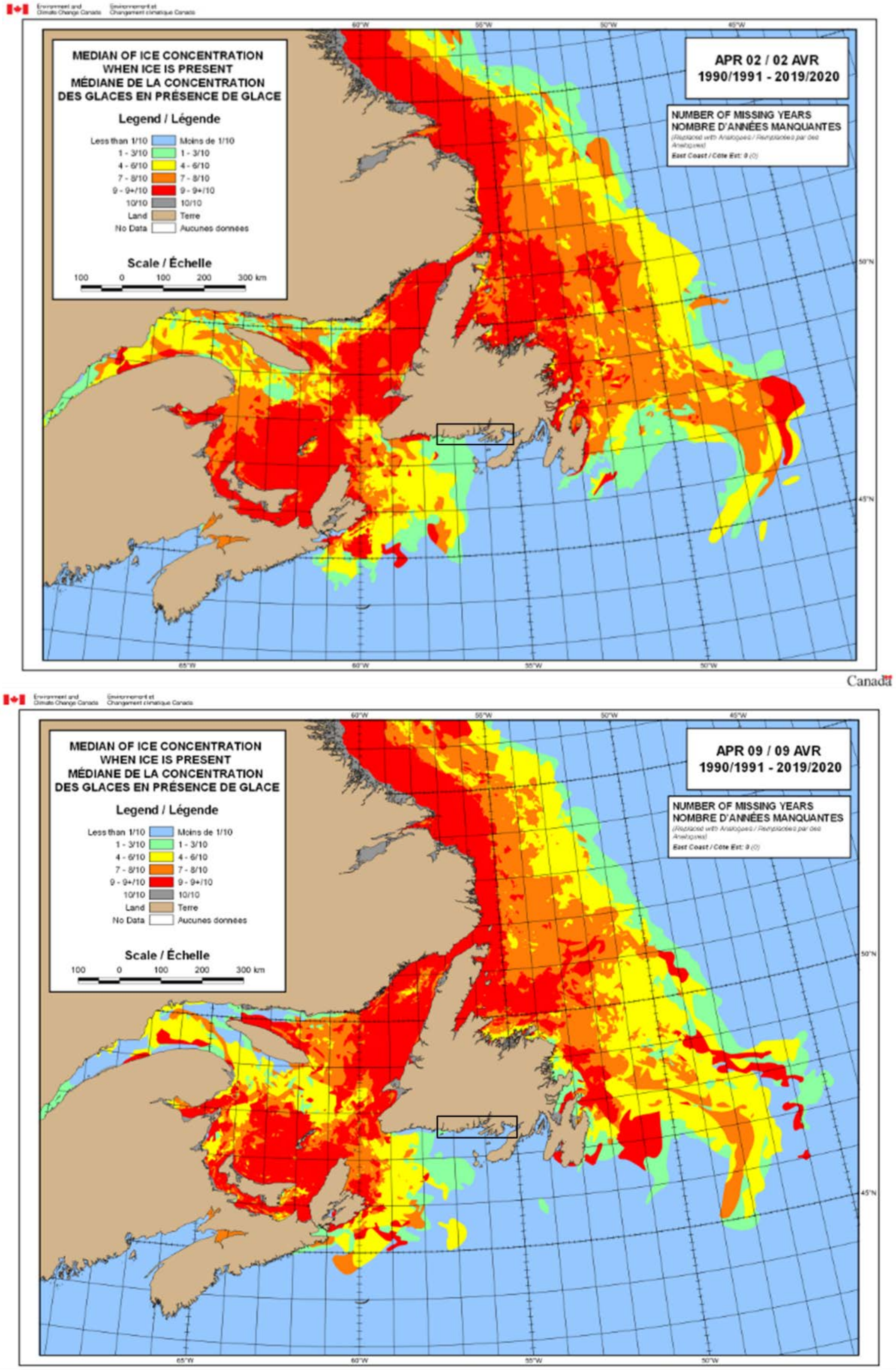


Figure 5.27 (concluded). Weekly analysis of 30-year median of ice concentration when ice is present in the Study Area in and near the MCE BMAs (black rectangle) from 1991–2020 (Canadian Ice Service).

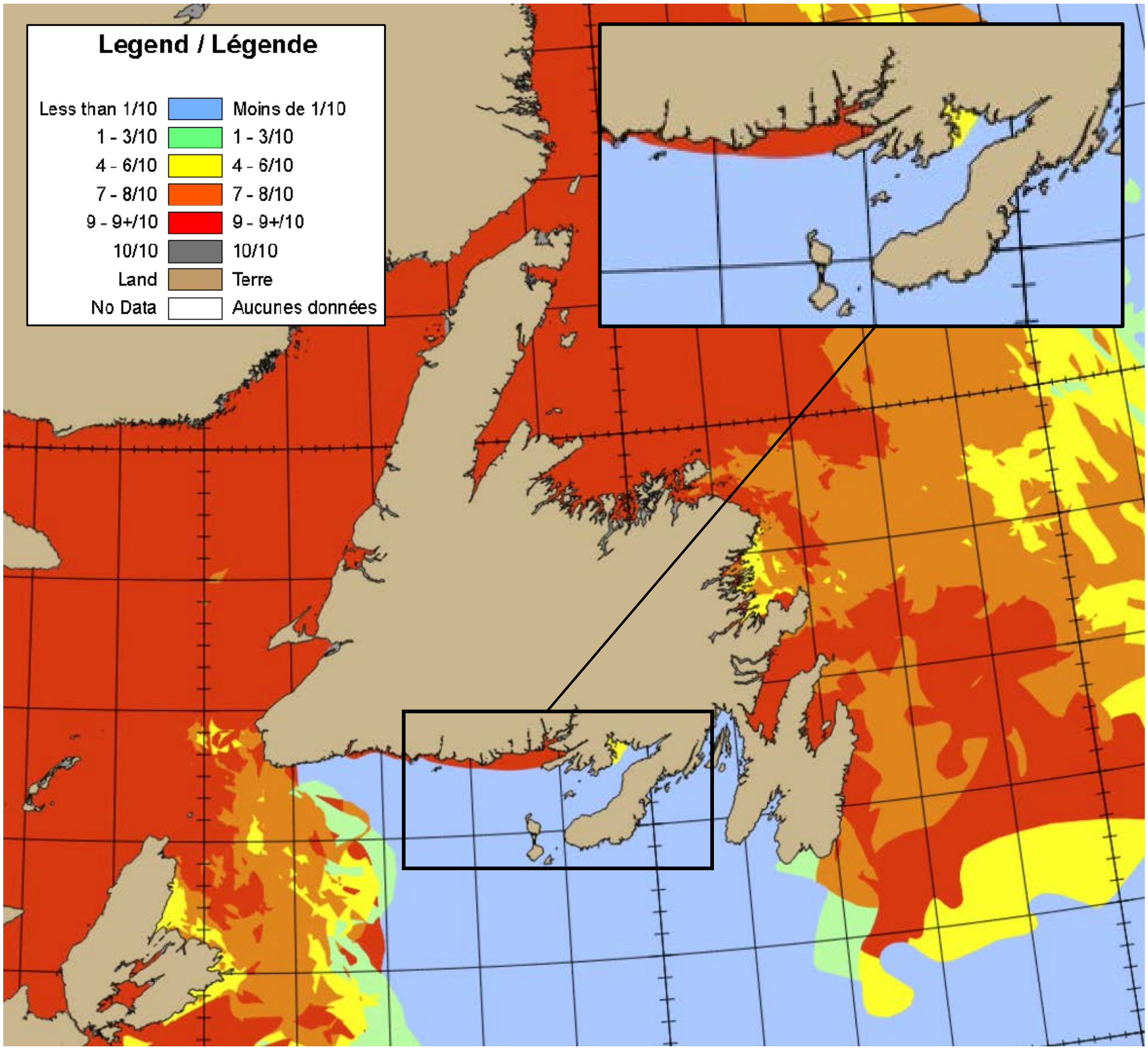


Figure 5.28. Weekly analysis of 30-year median of ice concentration when ice is present in and near the 13 BMAs in the week starting February 19, 1991–2020 (Canadian Ice Service).

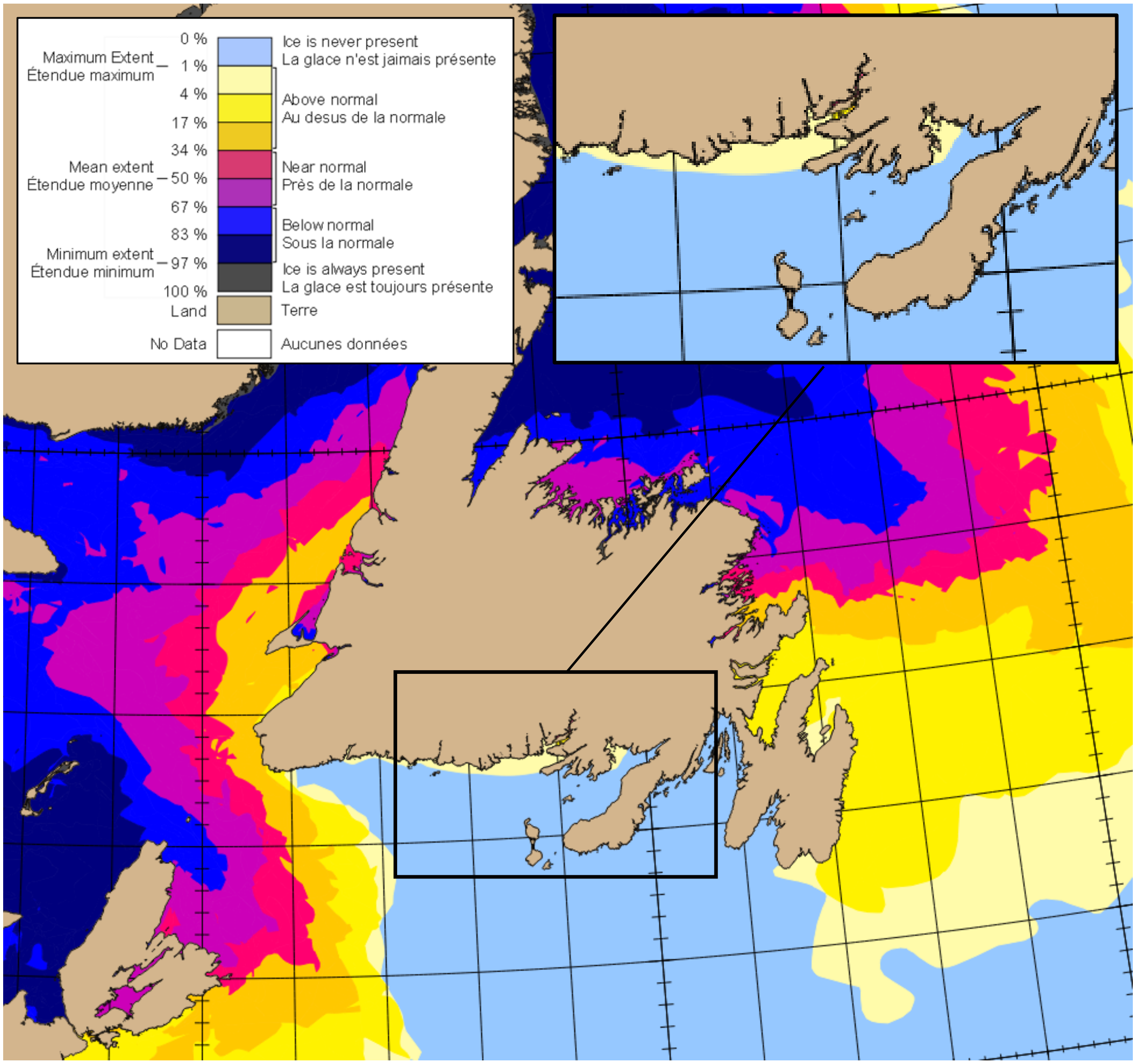


Figure 5.29. Weekly analysis of 30-year frequency of ice presence in and near the 13 BMAs in the week starting February 19, 1991–2020 (Canadian Ice Service).

Table 5.19. Percent frequency of weekly sea ice concentration in and near the BMAs, 1 January 2015–30 April 2024 based on CIS data.

| Month | Week Start Date | Percent Frequency of Sea Ice Condition[a] | | | | Percent Frequency Tenth of Sea Ice Concentration | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Ice Free | Open Water | Bergy Water | Fast Ice | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 9+ |
| Jan | 1 | **40** | **60** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 8 | **30** | **30** | **0** | **10** | 0 | **10** | 0 | 0 | **10** | 0 | 0 | 0 | 0 | **10** |
| | 15 | **20** | **50** | **0** | **20** | 0 | **10** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 22 | **20** | **40** | **0** | **30** | 0 | 0 | 0 | 0 | **10** | 0 | 0 | 0 | 0 | 0 |
| | 29 | **20** | **10** | **0** | **70** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Month | Week Start Date | Percent Frequency of Sea Ice Condition[a] | | | | Percent Frequency Tenth of Sea Ice Concentration | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Ice Free | Open Water | Bergy Water | Fast Ice | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 9+ |
| Feb | 5 | **10** | **10** | **0** | **70** | 0 | 0 | 0 | 0 | 0 | 0 | **10** | 0 | 0 | 0 |
| | 12 | **10** | **10** | **0** | **80** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 19 | **10** | **0** | **0** | **80** | 0 | 0 | **10** | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 26 | **10** | **10** | **0** | **80** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mar | 5 | **20** | **10** | **0** | **70** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 12 | **20** | **20** | **0** | **60** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 19 | **0** | **30** | **0** | **70** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 26 | **30** | **30** | **0** | **40** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Apr | 2 | **50** | **20** | **0** | **30** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 9 | **50** | **30** | **0** | **20** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 16 | **50** | **40** | **0** | **10** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 23 | **60** | **40** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 30 | **60** | **40** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Notes:

[a] Definitions for the terms "Ice Free", "Open Water", "Bergy Water" and "Fast Ice" as defined in the Environmental and Climate Change ECCC Ice Glossary (Environment and Climate Change Canada 2020) are provided below.

**Ice Free:** No ice present. If ice of any kind is present, this term shall not be used.

**Open Water:** A large area of freely navigable water in which ice is present in concentrations less than 1/10. No ice of land origin is present.

**Bergy Water:** An area of freely navigable water in which ice of land origin is present. Other ice types may be present, although the total concentration of all other ice is less than 1/10.

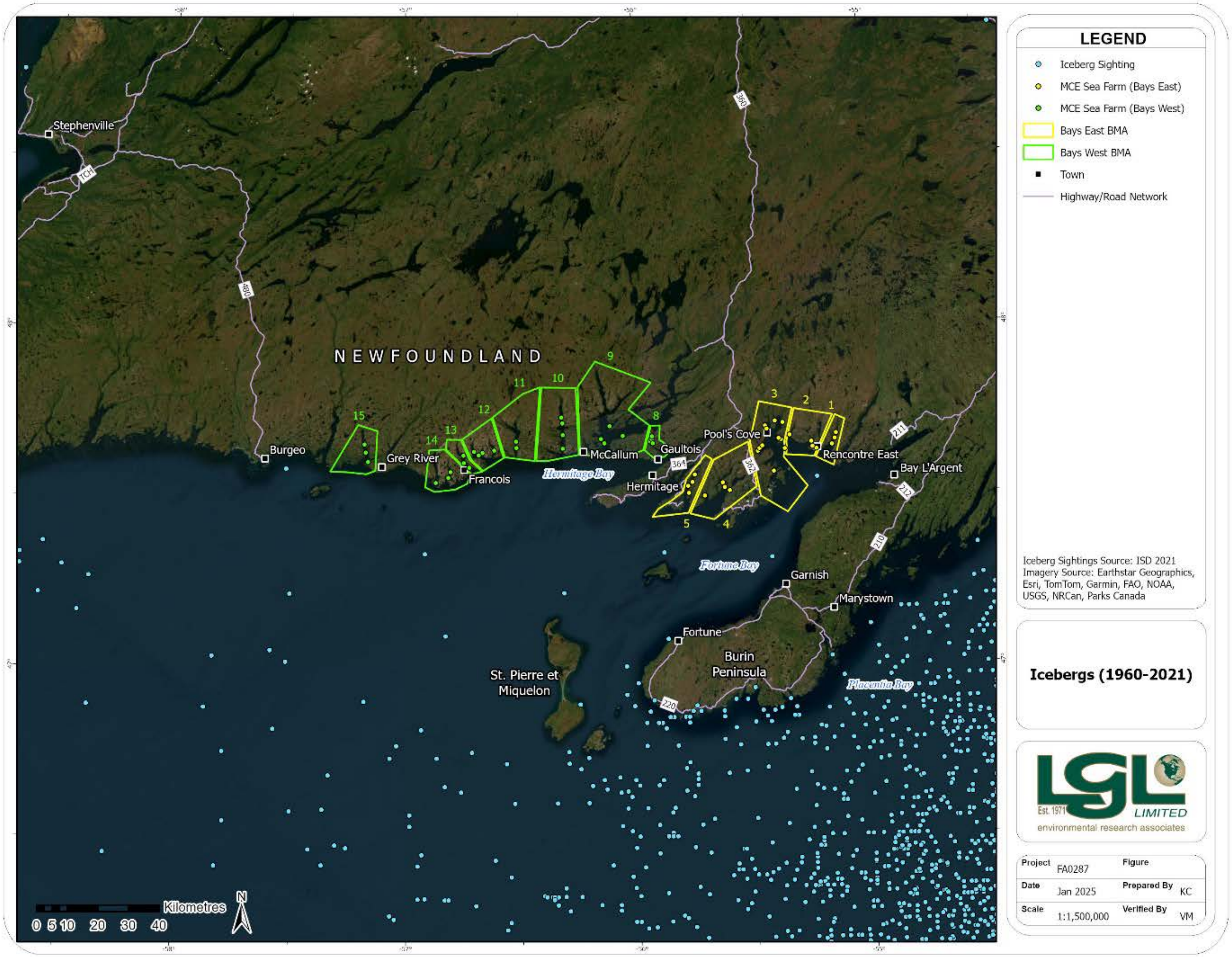
**Fast Ice:** Ice which forms and remains fast along the coast. It may be attached to the shore, to an ice wall, to an ice front, between shoals or grounded icebergs. Vertical fluctuations may be observed during changes of sea level. It may be formed "in-situ" from water or by freezing of floating ice of any age to shore and can extend a few metres or several hundred kilometres from the coast. It may be more than one year old in which case it may be prefixed with the appropriate age category (old, second-year or multi-year). If higher than 2 m above sea level, it is called an ice shelf.

In the last 10 years, the area in and near the BMAs is generally ice free or considered open water until the third week of January when fast ice forms and is present until around the third week of March. Fast ice occurred in the Hermitage Bay-St. Alban's area, with the exception of one year when fast ice formed in the Pool's Cove area.

The concentration of the majority of sea ice present over the last 10 years was less than 1/10th. During this period, sea ice generally occurred in the Hermitage Bay-St. Alban's area. However, on 19 February 2023, a large area in and near the BMAs had 3/10th sea ice concentration. In 2020, the week beginning January 8th had 9+/10ths coverage of sea ice in the McCallum area.

#### *5.5.1.2 Icebergs*

From 1960–2021, no icebergs have been sighted in or near the BMAs and there has been one iceberg recorded in the southwestern portion of the Study Area (Figure 5.30). Icebergs in Newfoundland typically originate from Greenland's glaciers that drift westward and then south; therefore, the south coast of Newfoundland is not an area that icebergs are typically recorded. Iceberg presence in the Study Area is very unlikely and is considered extremely unlikely in the BMAs.



Source: ISD 2021.

Figure 5.30. Iceberg sightings from 1960–2021 in and near the Study Area.

### *5.5.1.3 Local Observations*

Local observations reported by MCE personnel (Mr. Harvey Jenson, Sea Farm Manager, MCE) at the sea farms in Bays East and Bays West areas provide valuable information at a finer spatial scale. In general, drifting sea ice is rarely if ever observed. There are higher concentrations of shorefast (landfast) ice in the heads of bays that have large freshwater inputs (Table 5.20). MCE's ice management practices are used to minimize the risk of ice affecting sea cage infrastructure and operations (Table 5.20).

Table 5.20. Local ice observations by MCE sea farm personnel and the approach for managing ice in MCE BMAs.

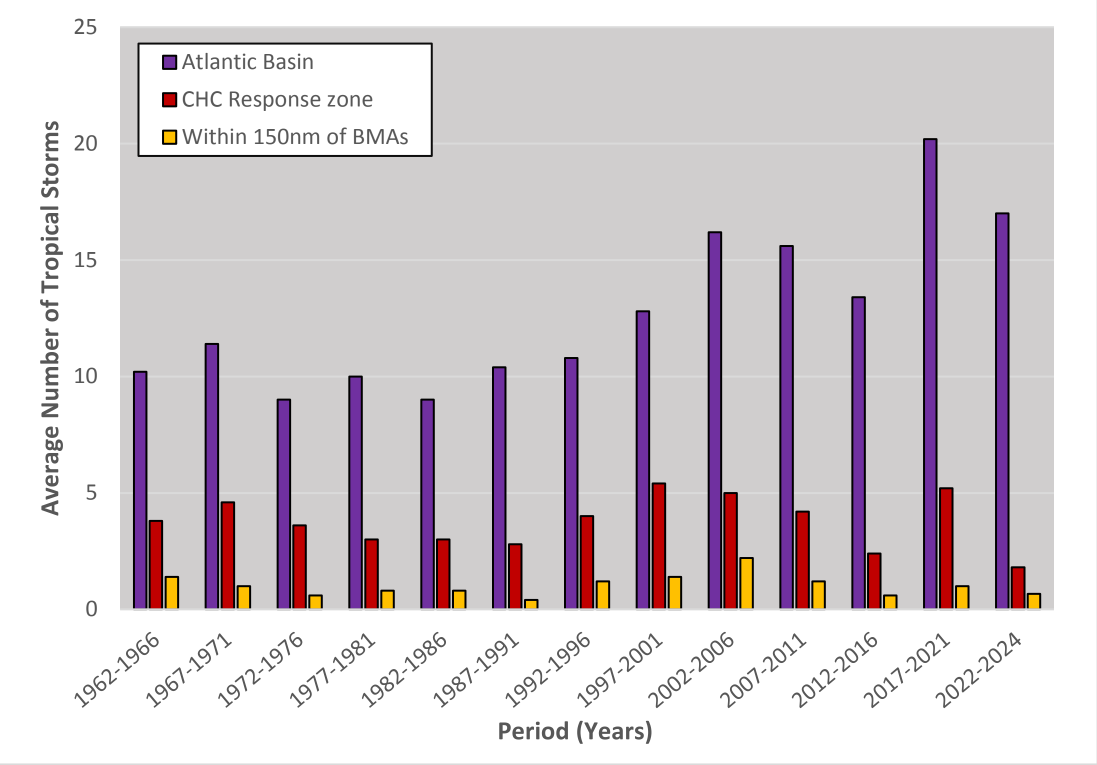
| Bay Management Area | Local Observations |
|---|---|
| Mal Bay (BMA 1) | • Little to no ice.<br>• Some shorefast ice, which may break-off and drift.<br>• Drifting ice pans are thin enough to be left alone, or as needed broken up with the wake of a longliner.<br>• Has not been an issue for infrastructure.<br>• Has not been an issue to navigation and sea farm access. |
| Rencontre East (BMA 2) | • Little to no ice.<br>• Some shorefast ice, which may break-off and drift.<br>• Drifting ice pans are thin enough to be left alone, or as needed broken up with the wake of a longliner.<br>• Has not been an issue for infrastructure.<br>• Has not been an issue to navigation and sea farm access. |
| Fortune Bay West (BMA 3) | • Overall, similar conditions as BMA 1 and 2.<br>• Higher concentrations in the head of the bay (Bay du Nord)<br>• Has not been an issue for infrastructure.<br>• Has not been an issue to navigation and sea farm access |
| Great Bay de l'Eau (BMA 4) | • Little to no ice. |
| Harbour Breton Bay (BMA 5) | • Little to no ice. |
| Little Passage (BMA 8) | • General understanding is some shorefast ice in coves.<br>• MCE has not farmed in recent years (actively farmed by Cold Ocean Salmon).<br>• Would not be an issue for infrastructure.<br>• Has not been an issue to navigation. |
| Outer Bay d'Espoir (BMA 9) | • General understanding is the possibility of drifting ice, originating from outside the BMA from the inner regions of the Bay d'Espoir; however, MCE sea farms are located in the outer areas of the BMA.<br>• MCE has not farmed the area in recent years.<br>• Would not be an issue for infrastructure.<br>• Would not be an issue to navigation and sea farm access. |
| Facheux Bay (BMA 10) | • Some shorefast ice at the head of the bay, which may break-off and drift.<br>• Drifting ice pans are thin enough to be left alone, or as needed broken up with the wake of a vessel.<br>• Young (fresh) ice will form over cold calm nights.<br>• Has not been an issue for infrastructure.<br>• Has not been an issue to navigation and sea farm access. |
| Hare Bay (BMA 11) | • Shorefast ice at the head of the bay, associated with rivers, which may break-off and drift to the outer areas of the bay.<br>• Anticipate drifting ice pans thin enough to be left alone, or as needed broken up with the wake of a vessel.<br>• Young (fresh) ice will form over cold calm nights.<br>• Lower risk to farming in outer regions of the bay regarding infrastructure.<br>• Lower risk to farming in outer regions of the bay regarding navigation and sea farm access. |
| Rencontre West (BMA 12) | • Little to no ice. |
| Chaleur Bay (BMA 13) | • Little to no ice. |
| Aviron Bay and La Hune Bay (BMA 14) | • Anticipated little to no ice. |
| Bay de Vieux (BMA 15) | • Anticipated little to no ice. |

## 5.6 Storm Patterns

Information on historical hurricanes and tropical storms were acquired from the U.S. National Oceanic and Atmospheric Administration (NOAA) database for 1962–2024.[12] Storm tracks of tropical systems that passed within 150 nm (278 km) of the BMAs were reviewed and summarized. Key literature sources were also reviewed for information on storms.

### 5.6.1 Summary of Storm Patterns Along South Coast of Newfoundland

Since the 1970s, the number of tropical storms that have developed within the Atlantic Basin has increased (NOAA 2024b). Figure 5.31 illustrates the 5-year average of tropical storms which have developed in the Atlantic Basin and entered the Canadian Hurricane Centre (CHC) Response Zone, and within ~150 nm of the BMAs since 1962. This rise in activity has been attributed to naturally occurring cycles in tropical climate patterns near the equator, known as the tropical multi-decadal signal (Vecchi et al. 2021). Despite the surge in Atlantic Basin Storms, there has not been a significant increase in the number of storms which have entered the CHC Response Zone, or the number of storms passing through the 150 nm zone surrounding the BMAs.



Source: NOAA 2024b.

Figure 5.31. Five-Year average of the number of tropical storms which formed in the Atlantic Basin and entered the CHC Response Zone and within ~150 nm of the BMAs since 1962.

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[12] See: https://coast.noaa.gov/hurricanes/#map=4/32/-80

In the north Atlantic Basin between 40–55% of tropical cyclones transform into extratropical cyclones (Chunyong and Lackmann 2023). During this transformation, the system loses tropical characteristics and becomes more extratropical, resulting in an increase in size that produces large waves, gale to hurricane force winds, and intense rainfall (Hart and Evans 2001). The likelihood that a tropical cyclone will undergo transition increases toward the second half of the tropical season; with October having the highest probability of transition (Hart and Evans 2001). In the Atlantic Basin, extratropical transition occurs at lower latitudes in the early and late hurricane season and at higher latitudes during the peak of the season (Hart and Evans 2001).

The Atlantic Hurricane Season runs from June–November, though storms sometimes form outside of the designated season. The peak of hurricane season for Newfoundland and Labrador, and the Atlantic Basin, is early- to mid-September (NL WRMD 2024). Since 1962, 71 tropical systems have passed within 150 nm of the BMAs. The names are given in Table 5.21 and the storm tracks for the months of June–October are shown in Figure 5.32. Of the five months in which tropical storms affected the region, the month of September was the most active with a total of 24 named storms. There were no storms of tropical origin during the month of November. It should be noted that the values in Table 5.21 are the maximum 1-minute mean wind speeds occurring within the tropical system at the 10-m asl reference as it entered the area within 150 nm of the BMAs.

Table 5.21. Tropical systems passing within 150 nm of the Study Area (1962–2024).

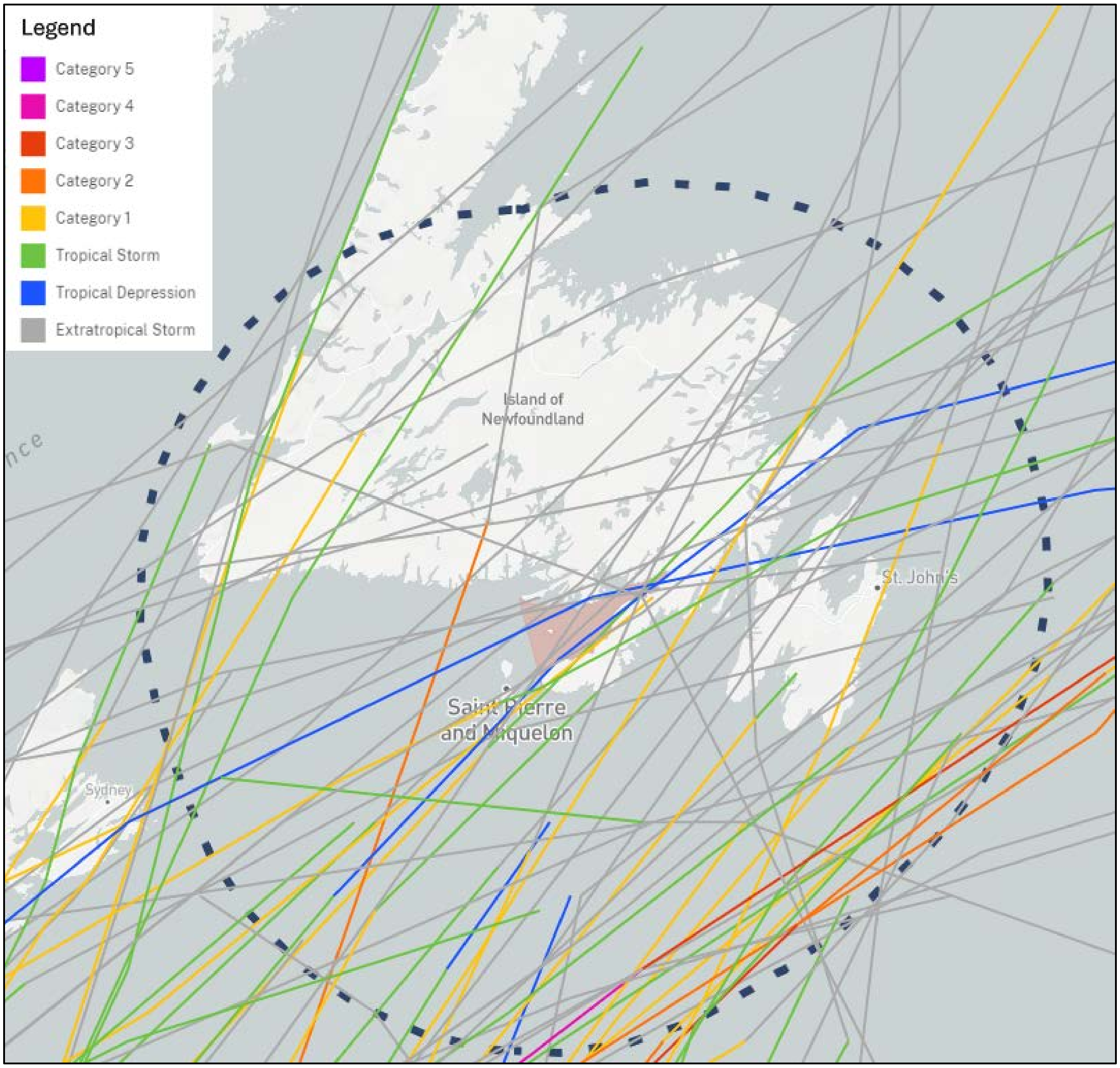
| Year | Month | Day | Hour | Name | Latitude (ºN) | Longitude (ºW) | Wind (kt) | Pressure (mb) | Category |
|---|---|---|---|---|---|---|---|---|---|
| 1962 | July | 4 | 0000 | Unnamed | 47.3 | -54.7 | 40 | n/a | Extra-Tropical |
| 1962 | October | 9 | 0600 | Daisy | 46.0 | -54.7 | 50 | n/a | Extra-Tropical |
| 1962 | October | 22 | 1200 | Ella | 45.7 | -54.0 | 60 | n/a | Extra-Tropical |
| 1964 | July | 27 | 1800 | Unnamed | 47.0 | -58.6 | 35 | n/a | Extra-Tropical |
| 1964 | September | 15 | 1800 | Dora | 47.6 | -55.5 | 55 | n/a | Extra-Tropical |
| 1964 | September | 25 | 0000 | Gladys | 47.5 | -54.5 | 60 | n/a | Extra-Tropical |
| 1966 | July | 3 | 1200 | Becky | 44.7 | -57.3 | 45 | n/a | Extra-tropical |
| 1966 | July | 21 | 1800 | Celia | 46.3 | -59.6 | 55 | n/a | Extra-tropical |
| 1969 | August | 12 | 1800 | Blanche | 46.2 | -54.7 | 65 | n/a | Extra-Tropical |
| 1969 | August | 24 | 1200 | Debbie | 48.0 | -51.9 | 60 | n/a | Extra-tropical |
| 1969 | September | 26 | 0600 | Unnamed | 45.4 | -53.7 | 65 | n/a | Category 1 |
| 1970 | August | 19 | 0600 | Unnamed | 46.0 | -51.9 | 60 | n/a | Extra-Tropical |
| 1971 | July | 7 | 1200 | Arlene | 44.7 | -56.3 | 45 | n/a | Tropical Storm |
| 1971 | August | 17 | 0600 | Beth | 48.4 | -59.0 | 50 | 998 | Extra-Tropical |
| 1973 | July | 6 | 1800 | Alice | 48.3 | -58.8 | 50 | n/a | Tropical Storm |
| 1973 | October | 28 | 0000 | Gilda | 45.4 | -55.1 | 55 | n/a | Extra Tropical |

| Year | Month | Day | Hour | Name | Latitude (ºN) | Longitude (ºW) | Wind (kt) | Pressure (mb) | Category |
|---|---|---|---|---|---|---|---|---|---|
| 1975 | October | 3 | 0600 | Gladys | 43.7 | -56.9 | 85 | 960 | Category 2 |
| 1977 | October | 15 | 1800 | Evelyn | 47.4 | -59.2 | 70 | 999 | Category 1 |
| 1978 | September | 5 | 0000 | Ella | 45.0 | -54.8 | 105 | 960 | Category 3 |
| 1979 | August | 6 | 0000 | Unnamed | 47.5 | -55.3 | 25 | n/a | Tropical Depression |
| 1979 | September | 7 | 1800 | David | 50.0 | -56.9 | 55 | 986 | Extra-Tropical |
| 1979 | October | 25 | 0600 | Unnamed | 47.5 | -58.1 | 50 | 982 | Tropical Storm |
| 1982 | June | 20 | 1800 | Unnamed | 45.4 | -56.0 | 60 | 990 | Extra-Tropical |
| 1982 | September | 19 | 0000 | Debby | 45.3 | -53.4 | 90 | 970 | Category 2 |
| 1984 | September | 16 | 0600 | Diana | 46.0 | -57.7 | 60 | 995 | Extra-Tropical |
| 1985 | July | 19 | 0600 | Ana | 46.0 | -57.6 | 55 | 996 | Extra-Tropical |
| 1989 | August | 8 | 1300 | Dean | 46.9 | -55.9 | 55 | 991 | Tropical Storm |
| 1990 | October | 15 | 0600 | Lili | 46.6 | -56.1 | 40 | 994 | Extra-Tropical |
| 1995 | June | 9 | 0600 | Allison | 48.1 | -55.8 | 40 | 996 | Extra-Tropical |
| 1995 | July | 10 | 0600 | Barry | 48.5 | -59.2 | 40 | 989 | Tropical Storm |
| 1995 | August | 22 | 0600 | Felix | 44.5 | -55.7 | 50 | 986 | Tropical Storm |
| 1995 | September | 11 | 0600 | Luis | 47.1 | -54.1 | 105 | 963 | Extra-Tropical |
| 1996 | July | 15 | 0000 | Bertha | 48.0 | -56.9 | 50 | 995 | Extra-Tropical |
| 1996 | September | 15 | 1200 | Hortense | 46.3 | -59.0 | 60 | 982 | Tropical Storm |
| 1996 | October | 10 | 0600 | Josephine | 48.5 | -57.9 | 45 | 985 | Extra-Tropical |
| 1998 | September | 06 | 0000 | Earl | 47.0 | -53.9 | 50 | 979 | Extra-Tropical |
| 1999 | September | 19 | 0000 | Floyd | 48.0 | -56.2 | 35 | 992 | Extra-Tropical |
| 1999 | September | 23 | 0600 | Gert | 44.6 | -54.4 | 60 | 968 | Tropical Storm |
| 2000 | September | 17 | 1800 | Florence | 45.5 | -52.9 | 50 | 1002 | Tropical Storm |
| 2000 | October | 08 | 1200 | Leslie | 46.0 | -57.0 | 40 | 1003 | Extra-Tropical |
| 2000 | October | 19 | 1800 | Michael | 46.3 | -57.3 | 85 | 965 | Category 2 |
| 2001 | September | 14 | 1800 | Erin | 44.7 | -55.1 | 65 | 984 | Category 1 |
| 2001 | September | 19 | 1800 | Gabrielle | 46.5 | -51.9 | 60 | 986 | Extra-Tropical |
| 2002 | July | 17 | 0600 | Arthur | 46.5 | -53.8 | 45 | 999 | Extra-Tropical |
| 2002 | September | 12 | 0900 | Gustav | 47.6 | -58.5 | 65 | 963 | Category 1 |
| 2004 | September | 01 | 1800 | Gaston | 45.0 | -54.9 | 45 | 998 | Extra-Tropical |
| 2005 | July | 30 | 0600 | Franklin | 44.7 | -54.6 | 45 | 1003 | Extra-Tropical |
| 2005 | September | 18 | 1800 | Ophelia | 47.4 | -56.2 | 45 | 999 | Extra-Tropical |
| 2005 | October | 26 | 1200 | Wilma | 45.0 | -54.8 | 50 | 986 | Extra-Tropical |
| 2006 | June | 16 | 1200 | Alberto | 47.4 | -54.9 | 45 | 985 | Extra-Tropical |

| Year | Month | Day | Hour | Name | Latitude (°N) | Longitude (°W) | Wind (kt) | Pressure (mb) | Category |
|---|---|---|---|---|---|---|---|---|---|
| 2006 | July | 18 | 1200 | Unnamed | 45.5 | -58.0 | 30 | 1007 | Tropical Depression |
| 2006 | July | 22 | 1200 | Beryl | 48.5 | -56.4 | 30 | 1004 | Extra-Tropical |
| 2006 | September | 13 | 1200 | Florence | 45.5 | -55.5 | 70 | 967 | Extra-Tropical |
| 2006 | October | 02 | 1800 | Isaac | 45.5 | -53.7 | 55 | 995 | Tropical Storm |
| 2007 | August | 01 | 1200 | Chantal | 46.0 | -54.4 | 55 | 990 | Extra-Tropical |
| 2008 | September | 08 | 0600 | Hanna | 47.5 | -55.3 | 40 | 996 | Extra-Tropical |
| 2009 | August | 24 | 0000 | Bill | 46.3 | -57.9 | 65 | 973 | Category 1 |
| 2010 | September | 21 | 1500 | Igor | 46.6 | -53.1 | 75 | 950 | Category 1 |
| 2011 | September | 16 | 1800 | Maria | 46.7 | -53.8 | 60 | 983 | Tropical Storm |
| 2011 | October | 3 | 1000 | Ophelia | 46.9 | -55.3 | 60 | 990 | Extra-Tropical |
| 2012 | September | 11 | 1200 | Leslie | 47.7 | -54.8 | 65 | 970 | Extra-Tropical |
| 2014 | October | 19 | 0600 | Gonzalo | 44.5 | -54.8 | 80 | 968 | Category 1 |
| 2015 | July | 15 | 1200 | Claudette | 46.0 | -55.8 | 30 | 1004 | Tropical Depression |
| 2017 | October | 11 | 0000 | Nate | 47.5 | -56.0 | 25 | 1001 | Extra-Tropical |
| 2018 | July | 17 | 0600 | Beryl | 45.5 | -55.7 | 30 | 1012 | Tropical Depression |
| 2018 | July | 12 | 1800 | Chris | 45.7 | -56.4 | 55 | 989 | Extra-Tropical |
| 2018 | October | 13 | 0600 | Michael | 44.8 | -55.6 | 65 | 975 | Extra-Tropical |
| 2020 | September | 24 | 0000 | Teddy | 49.7 | -58.2 | 45 | 975 | Extra-Tropical |
| 2021 | September | 11 | 0300 | Larry | 47.3 | -54.6 | 70 | 958 | Category 1 |
| 2023 | September | 8 | 0600 | Idalia | 45.2 | -58.3 | 30 | 1003 | Extra-Tropical |
| 2024 | August | 20 | 0600 | Ernesto | 46.6 | -51.4 | 65 | 975 | Category 1 |

Source: NOAA (2024b).

Tropical systems occasionally maintain hurricane strength as they enter the area within 150 nm of the BMAs. Nine Category 1, three Category 2, and one Category 3 hurricanes entered this area between 1962 and 2024. The most intense of these storms was Hurricane Ella which entered the area on 5 September 1978 with maximum sustained wind speeds of 54.0 m/s and a central pressure of 960 mb. Most tropical systems that traverse in and near the BMAs have been Extratropical Storms and Tropical Depressions.



Source: NOAA 2024b.

Figure 5.32. Storm tracks of tropical systems passing within 150 nm (278 km) of the BMAs (1962–2024).

# 6.0 Conformity of Sea Cages

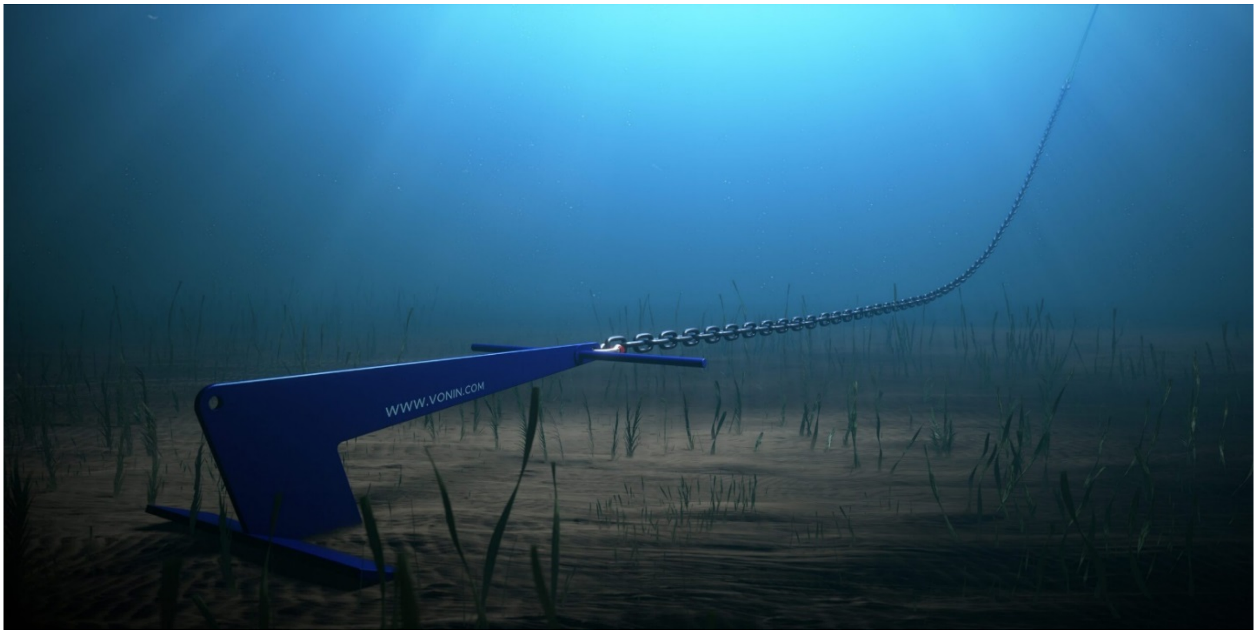
The EIS Guidelines (Section 4.3.1h) require a review of MCE's sea cage systems relative to the standards in the Code of Containment (COC) and oceanographic and meteorological conditions at the sea farms.

## 6.1 Sea Cage System

Primary components of each MCE sea cage include the floating collar, containment net, and mooring system. Sea cages acquired since 2018 (i.e., 140 m and 160 m circumference) also have a gangway, and sinker ring (tube). Features of the sea cage system (i.e., 140 m and 160 m) include a jump net between the water line and the handrail of the cage (~1.4 m above water surface), potentially reinforced double netting installed at the top of the cage at the water line and at the bottom of the cage (predator base), and a bird net surrounding the top of the cage (Figure 6.1). In 2025, the 100 m circumference sea cages MCE has used previously will be phased out and replaced with 140 m circumference or larger sea cage systems.

Figure 6.1. Example of representative sea cage with bird net and poles, jump net, and hand rail on gangway of floating collar.

The sea cages are securely attached to the ocean floor using a mooring system. The mooring system is specifically designed for each of the sea farms in consideration of collected oceanographic data (bathymetry, currents). The mooring system is designed in a grid fashion (longitudinal and transversal lines) with sea cages connected to each other and securely anchored to the seafloor via a series of rock pins and plough anchors made of galvanized steel as appropriate (Figure 6.2). Plough anchors vary in size, depending on the engineering requirements of the mooring system. In the past, plough anchors used were <1 tonne. MCE is currently using 1.5 tonne plough anchors. Brackets, shackles, bridles (ropes), grid plates, chain, and floats all comprise part of the mooring systems as depicted in Figure 6.3. These mooring components connect to each individual cage (Figure 6.4) as well as to the cage grid. Connections for moorings to the cages can be steel, typically used on sea cages with a 140 m circumference (Figure 6.5) or polyester slings which are typically used on sea cages with a 160 m circumference (Figure 6.6). The polyester sling is often used for larger cages as it assists with stabilizing the sea cage during motion from the waves by distributing the weight across two floating tubes. The steel or polyester slings are connected by eight strand 42 mm rope, chains, and shackles into a grid plate located approximately 10 m below the surface.



Source: Vonin (2024).

Figure 6.2. Example of a plough anchor typically used for sea cages (and barges).

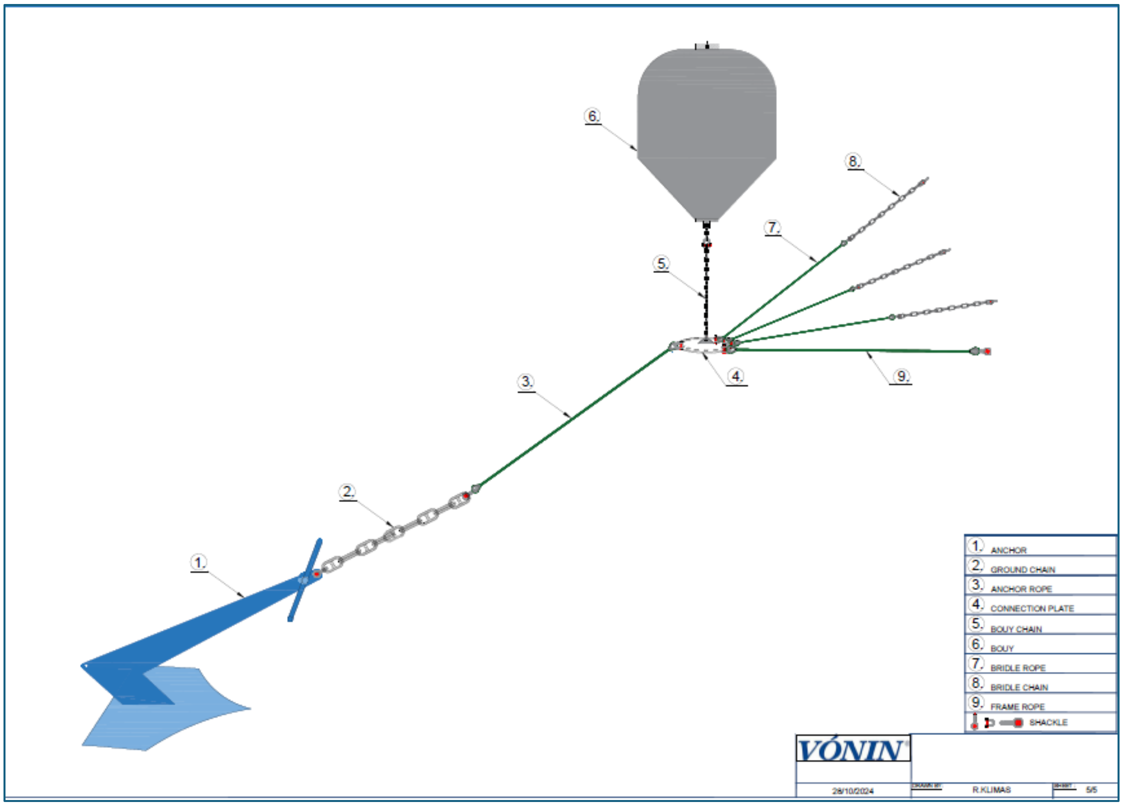


Figure 6.3. Schematic of mooring components used at MCE sea farm.

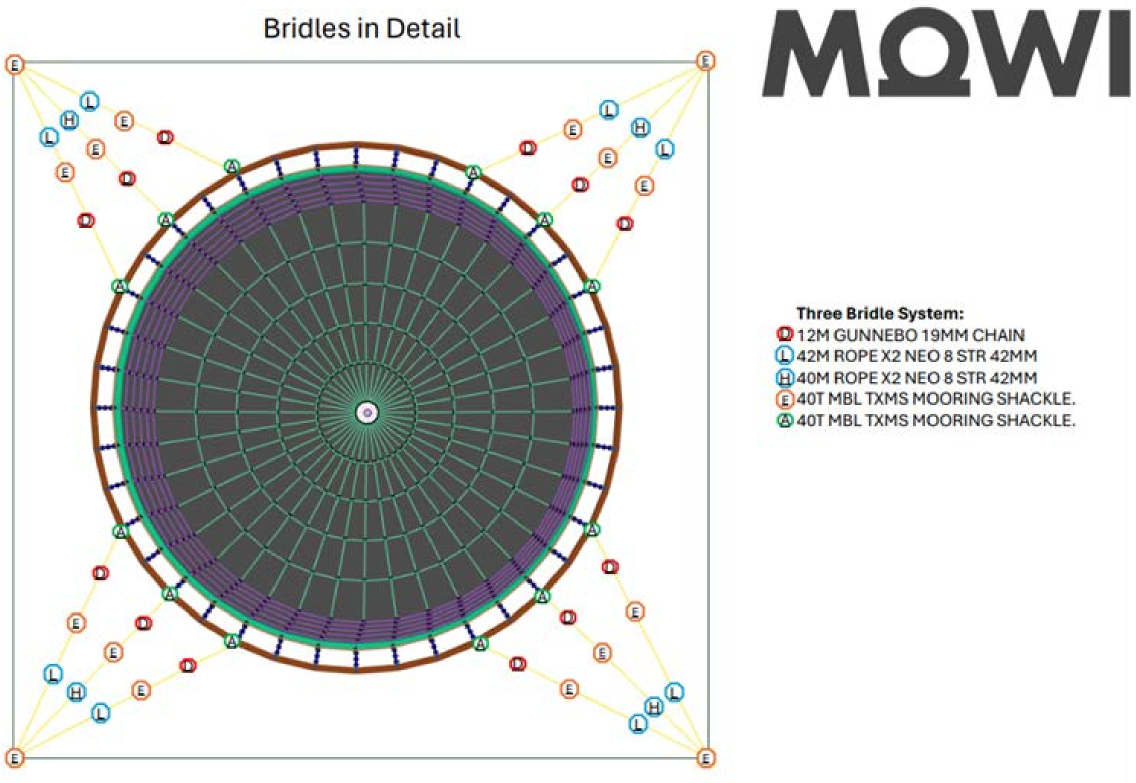


Figure 6.4. Schematic of a three bridle mooring system attachment to a single cage. Cages are moored in an array and connected to each other in a grid fashion.

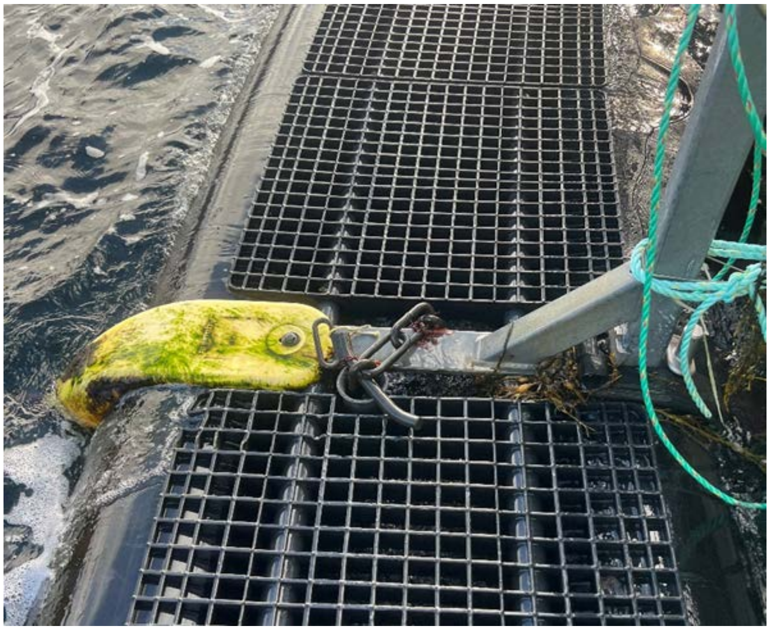


Figure 6.5. Example of a standard steel mooring fastening to sea cage bracket used on 140 m circumference sea cages.

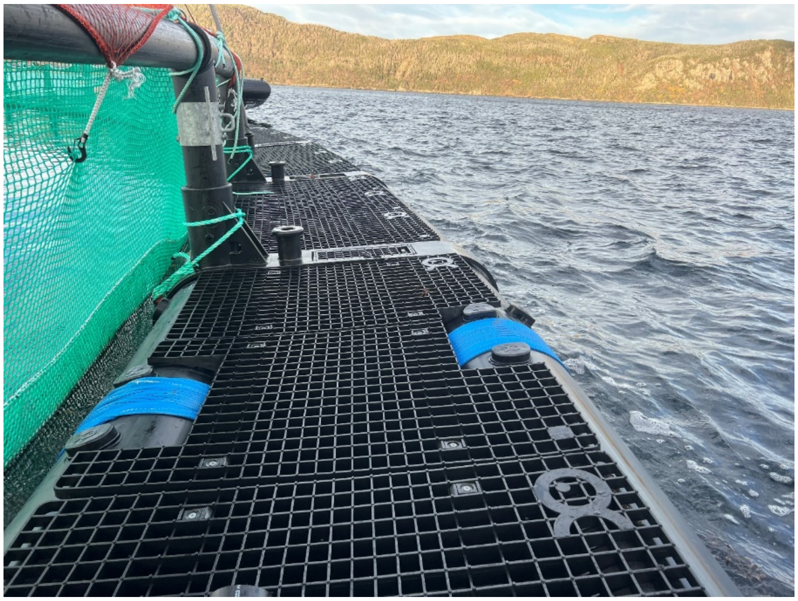


Figure 6.6. Example of a standard polyester sling mooring fastening (to sea cage bracket used on 160 m circumference sea cages).

The sea cages (floating collar) for both Bays East and Bays West areas are constructed of flexible plastic and steel to reduce wear and tear, with a circumference of 100 m (i.e., up to 2025), 140 m or 160 m. Containment nets extend a minimum of 20 m below the water surface. The 140 m and 160 m cage systems that will be exclusively used from 2025 onward are designed to bear extra weight from ice and to withstand significant wave heights from storms and are described here as representative of MCE cages. The netting is affixed to attachment ropes on the outside and it is drawn into an apex at the bottom and affixed to a stainless-steel gyro (Figure 6.7). The gyro at the bottom of the cage apex assists in counter balancing motions from the ocean waves and currents by creating torque and assists with stabilizing the cage system. The cone-shaped net which extends ~15 m below the base of the net, will allow fish to descend deeper into the net to allow for a more even distribution in the water column. The bottom of each sea cage has reinforced netting which minimizes the risk of tears. The floating collar surrounds the net and consists of two floating rings (tubes) with a gangway equipped with anti-slip construction and handrails between to allow for safe maneuvering by personnel around the sea cage (Figure 6.8). As described above, the main supporting system consists of steel/polyester brackets connected to steel rods, chains, and fibre ropes which handles the forces around the circumference of the floating collar. Bushings between the steel brackets and floater tubes reduce friction and the floater tubes can move freely inside the brackets (rotation and longitudinal). The loads from the mooring system are distributed around the circumference of the net and are handled by separate steel mooring brackets. There is expanded polystyrene in both floater tubes to maintain the buoyancy in the event of damage.

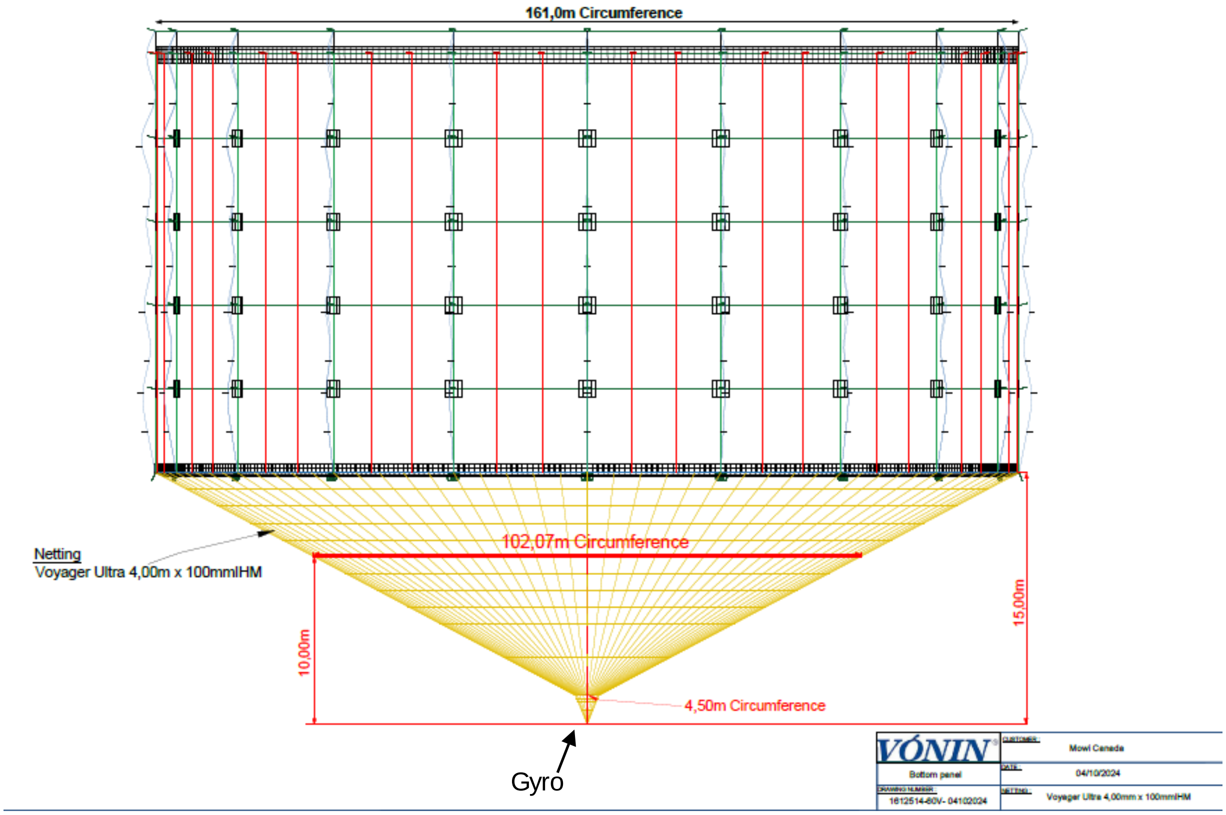
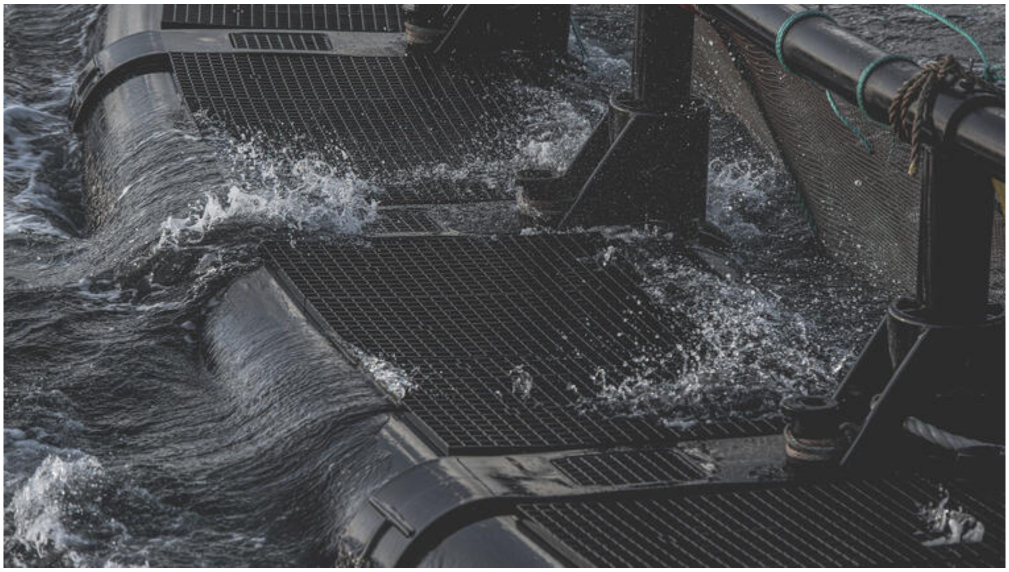


Figure 6.7. Representative HDPE net design used by MCE.



Source: AkvaGroup (2024).

Figure 6.8. Example of representative floating collar with floating rings (tubes) and gangway used by MCE.

## 6.2 Regulatory Guidance and Oversight

The COC is based on internationally recognized principles that focus on procedures which minimize the potential for equipment failures and improve upon handling practices (FFA 2022). There are five primary elements to the COC: (1) Equipment; (2) Handling Practices; (3) Inspections; (4) Documentation and Reporting; and (5) Mitigations. These elements and how they will be specifically applied to ensure conformity of the sea cage to meet or exceed standards in the COC and ability to withstand oceanographic and meteorological conditions at MCE sea farms are described below. MCE is continually adapting its methods in-step with the state-of-knowledge and industry best practice (i.e., containment systems and their placement are being designed with the use of site-specific data and the engineering is now certified by a third-party).

(1) Equipment: As per the COC, all finfish containment systems (cage structures and nets) must be designed, constructed and installed to withstand local weather and ocean conditions including storms, water currents, and waves. Sea cage systems must also be maintained to control biofouling and ice accretion, which can compromise the system. In addition to following the COC requirements for cage structure, nets and moorings, MCE utilizes cage systems, farm design and installation that has met a third-party engineering standard (FFA 2019; AP 2). This standard covers specifications for collar material, net requirements, moorings, and environmental considerations. Factors such as material and load for Serviceability Limit State (SLS), Ultimate Limit State (ULS), Accidental Limit State (ALS), and Fatigue Limit State (FLS) are assessed during the certification process. The sea cage collars are constructed of flexible plastic and strong steel to allow flexibility without compromising on strength during strong sea conditions. The material and design consider moving and fixed ice as well as predicted 50-year storm intensities. This guidance is derived from the Standard for Scottish Finfish Aquaculture (SG 2015) and the Norwegian Standard for Floating Aquaculture Farms NS 9415:2021 (NS 2021). HDPE (High Density Polyethylene) nets are commonly used. These nets provide high abrasion resistance. Staff are trained and tasked with removing ice build-up on nets and cage components. MCE will also use a Remotely Operated Vehicle (ROV) to assist with tasks such as net inspections, if required.

(2) Handling Practices: The COC details Handling Practices and includes appropriate precautions to prevent escapes during all stages of fish handling including transfers, counting, grading, sea lice counts, treatments, harvesting, net changing or cleaning. MCE seeks to minimize net handling to reduce abrasion and weakening nets which may increase opportunities for escapes to occur. As a minimum, MCE adheres to the best practices in accordance with the approved Management Plans and SOPs on file with FFA for grading, weight sampling, sea lice counts, transportation, well boat treatments, and harvesting (e.g., catch net use and deployment SOP). MCE uses new

HDPE generation nets that remain in place during the entire growth cycle. This eliminates the need to change nets with fish inside during a production cycle. This reduces the associated risk of fish escapes. All personnel receive appropriate training in fish handling, net handling and net maintenance procedures upon hire. MCE continues to investigate, through its global research and development teams, innovations in anti-fouling and pest management options to minimize the need for net cleaning and handling.

(3) Inspections: As part of the COC, nets that are over three years old and still in use are tested every 18 months by a third party. Nets are tested for strength (e.g., stress test with a tension scale instrument) and their condition is inspected for visible damage. In addition, as a minimum, nets are visually inspected at a minimum every 30 days by a qualified dive team or trained ROV operator (AP 2). Additional net checks may be conducted following any operational activity or event such as extreme weather conditions, smolt deliveries, predator attacks, vandalism or other operational activities that involves net handling and may increase the risk of net failure. Cages and surface mooring components are also inspected as per the COC. Surface components of mooring systems, cages, nets and ropes on each site are inspected once per week and recorded. Prior to system certification MCE is required to submit a "Mooring Maintenance/Replacement Plan" for each site that will be occupied with fish on an annual basis. With implementation of third-party certification of the sea cage systems, inspections are now dictated by the engineering requirements. In addition, periodic audits of the cage system as specified in COC Procedures for Compliance are conducted and FFA will arrange for audits of net testing procedures. Audits by FFA are conducted at a minimum of twice yearly (one in the spring, after fish entry; one audit in fall/early winter). Any identified damaged equipment is repaired or replaced immediately. Table 6.1 summarizes sea cage system inspection and reporting requirements.

Table 6.1. Summary of sea cage system inspections and reporting requirements.

| Responsible Party | Component | Method | Inspection Frequency | FFA Reporting Frequency |
|---|---|---|---|---|
| MCE | Components of mooring systems, cages, nets and ropes (surface) | Visual | Per week | Every 30 days |
| MCE | Net strength test (surface) | Manual (calibrated device) | 18 months (if nets are >3 years old) | On request |
| MCE | Net inspections (Subsurface) | Diver or ROV | 30 days | Every 30 days |
| MCE | Nets (subsurface) | ROV during in-situ net cleaning | Variable (per cleaning) | Every 30 days |
| MCE | Moorings | Mooring Maintenance/Replacement Plan | N/A | Annually |
| MCE | Salmon (farm inventory) | Fish counts | Per transfer | Annually |
| FFA | MCE site inspection records | Electronic | Twice yearly | Twice yearly |
| FFA | Surface components of mooring systems, cages, nets and ropes | Physical walk around | Twice yearly | Twice yearly |

In addition to the COC, MCE has applied design standards outlined in the Norwegian Standard (NS) 9415 (NS 2021) and the Scottish Standard (SG 2015) to its sea farms, and all new installations going forward.

- Both standards exceed Canadian Standards (i.e., Code of Containment for the Culture of Salmonid in Newfoundland and Labrador).
- Where able, the Norwegian Standard (NS9415) is being followed. This includes material safety factors, currents, and wave conditions. The Scottish Standard is followed regarding the use of some hydrographic data.
- Regarding storms, the NS9415 10-year multiplier 1.65 and 50-year 1.85 is applied and this exceeds the Scottish Standard for a 50-year 1.7 multiplier.
- All materials follow NS9415, this means the tension loads from the models, have been multiplied by the Standard's 1.15 factor and additionally their respective material factor 2 for steel components and 2.5 for fibre components.
- The NS9415 is comprehensive regarding loads, also considering operational factors in addition to environmental factors.
- Regarding wave heights, if more generic wave heights are used due to a lack of site-specific measurements, the JONSWAP calculation has been used.
- Each sites exposure is unique, so there is variability in the conditions and the engineering designs. Ultimately, all sites are custom designed and over engineered based on the location using additional safety factors.

These standards are rigorous and were developed to address areas of technology failure in the past that had resulted in escapes. The provincial COC and AP 2 stipulate that all active farms will be designed and installed to a third-party engineered standard. In line with provincial government timelines, MCE has implemented this requirement on all sites as sea farms enter into production.

(4) Documentation and Reporting: The FFA reporting requirements that MCE adheres to are summarized in Table 6.1. In addition to these inspections and reports, MCE maintains an inventory of all nets. The inventory includes information such as manufacture date, type, size and testing dates. Each net MCE owns has an inventory net number tag that is visible during operations. This inventory is submitted annually to FFA. All documentation is maintained by MCE for inspection by FFA during their routine audits.

(5) Other Mitigation Measures: Sea farms are selected in areas that provide shelter, have suitable current conditions, and are predominantly ice free. Sea cages are then oriented to minimize exposure to the prevailing winds and waves. Additionally, husbandry practices such as maintaining clean nets and continuous monitoring of fish and nets also serve to minimize the risk of fish escapes. With regard to oceanographic and meteorological conditions in the sea farms, MCE personnel continuously monitor weather forecasts and ice conditions. Preparations are made in advance of storms with pre-storm and post-storm inspection checklists completed to ensure site equipment and infrastructure is prepared.

# 7.0 River Monitoring and Modelling Escapees

The EIS Guidelines (Section 4.3.1i) require a discussion on existing river monitoring in salmon rivers proximate to sea cages and the modelling of the potential risk of escaped farm salmon from MCE sea farms occurring in rivers proximate to sea cages.

## 7.1 Existing River Monitoring

Wild salmon assessments in NL are based on returning salmon counts from monitoring facilities (e.g., counting fences and fishways), recreational angler's fishing logbooks, and in-river snorkel surveys (Kelly et al. 2023). Historically, salmon returns on three rivers in SFA 11 have been monitored with counting fences (Conne River, Little River, and Garnish River). In recent years returns on Little River have not exceeded 10 fish annually (2017–2020) (DFO 2022a), and recent monitoring data are not available. Recreational fishery data covers a broad geographic area. This is a voluntary monitoring program and does not capture the entire catch effort over the course of a fishing season. Visual counts from in-river snorkel surveys have been included in previous stock status updates (Kelly et al. 2023).

While both Conne River and Garnish River are within the sea farm Study Area, neither are within a BMA. Garnish River (47.2198 N, 55.33423 W) terminates in eastern Fortune Bay approximately 40 km to the closest sea farm (Ironskull Point, BMA 3). Conne River (47.92351 N, 55.67808 W) terminates at the head of Bay d'Espoir and is approximately 35 km to the closest sea farm (Deer Cove, BMA 8).

The Garnish, Conne, and Little rivers are in the Critical Zone (<20% of LRP) with populations on the Conne River and Little River considered to be near local extinction (DFO 2022a). In 2024 (preliminary data current up to September 15, 2024), fishway counts for Garnish and Conne rivers were below the previous generation averages and well below the pre-moratorium averages (see Table 4.1 in Section 4.1.3). Counts on the Garnish River have declined over the past three years (2022 = 397, 2023 = 234, 2024 = 175). However, the fishway counts on the Conne River increased from 145 fish in 2023 to 659 in 2024. These returns are double the 2018-2023 average number of wild salmon returning to Conne River.

During monitoring, samples from the salmon are collected for analysis and detections of sea lice and farmed salmon are documented. Random samples of fin clippings and scales are collected as part of the fishway monitoring program for genetic and age analyses. The fish are then released to continue passage through the fishway. These collections are temperature dependant with no collections occurring at water temperatures above 20°C. Documenting and collecting sea lice at fishways are relatively new and a formalized monitoring program has not been established nor are there finalized datasets (T. Van Leeuwen, DFO, pers. comm., January 2025). If crosses or feral salmon are visually detected; the whole fish is retained for further analysis.

Fishing logbooks from recreational anglers are also used for monitoring salmon returns. Recreational monitoring data in 2022 and 2023 was collected for 18 rivers in SFA 11 of which 10 had reported returns (see Table 4.2 in Section 4.1.3). Eleven of the monitored rivers are within 30 km of a sea farm including: Simmons Brook, Allen’s Cove Brook, Bay du Nord River, Hare Bay Rivers (Morgan and Dolland), Southwest Brook, Old Bay Brook, Taylor’s Bay Brook, Long Reach Brook, Bottom Brook, and Grey River.

## 7.2 Farmed Salmon Escape Modelling

The DFO model was run with and summarized to indicate the current per river risk determined by DFO and the relative contributions of MCE origin fish assuming a 0.2 escape rate (Figure 7.1). The modelled contribution from MCE origin fish varied by river with rivers closest to MCE sea farms exhibiting higher model percentages of farmed salmon relative to the estimated count of wild salmon in a given river[13] (Figures 4.3 and 4.4 show locations of rivers in the Study Area). Current DFO risk assessment model also indicates a very high level of risk with some rivers exceeding 30% farmed salmon, which represents a large increase over previous assessments. Bradbury et al. (2022) modelled an estimated maximal per river risk of about 15% farmed salmon, with the current DFO risk assessment model representing a doubling in risk.

The realized operations can be expected to be lower due to the DFO model assuming a stocking rate of 75% of the maximum stocking limit. To assess the relative risk of current operations per river risk was assessed assuming stocking load under 4.5 million smolts yearly (i.e., no expansion) and 6.7 smolt (i.e., expansion). The explicit stocking loads used in the analysis is summarized in

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[13] DFO provided estimates of wild Atlantic salmon counts per river as part of the data release agreement with LGL. These count estimates for each river are the same that DFO has used in recent aquaculture licensing review processes (e.g., DFO 2024c).

Table B.1 (Appendix B), and were based on the forecasted 2028 stocking levels, which represented the highest stocking levels under both stocking scenarios. Realized operations under both no expansion and expansion levels showed per river risk to be at much lower levels than the maximal risk assessed by DFO's modelled risk assessment (Figure 7.2). Assuming a 0.2 escape rate, with no expansion, all rivers fell below the 10% benchmark, which is the level above which abundance and genetic character effects on wild Atlantic salmon are predicted to occur (see DFO 2024g). With expansion to 6.7 million smolt, three rivers were predicted to exceed the 10% benchmark (Salmonier Brook, Taylor Bay Brook, and Old Bay Brook in the Bays East area) (Figure 7.2).

Taken in aggregate the total risk under the no expansion was about 23% of the maximal risk assessment determined by DFO, with Hatchery expansion raising the aggregate risk to about 34% of the maximal risk assessment (Figure 7.3).

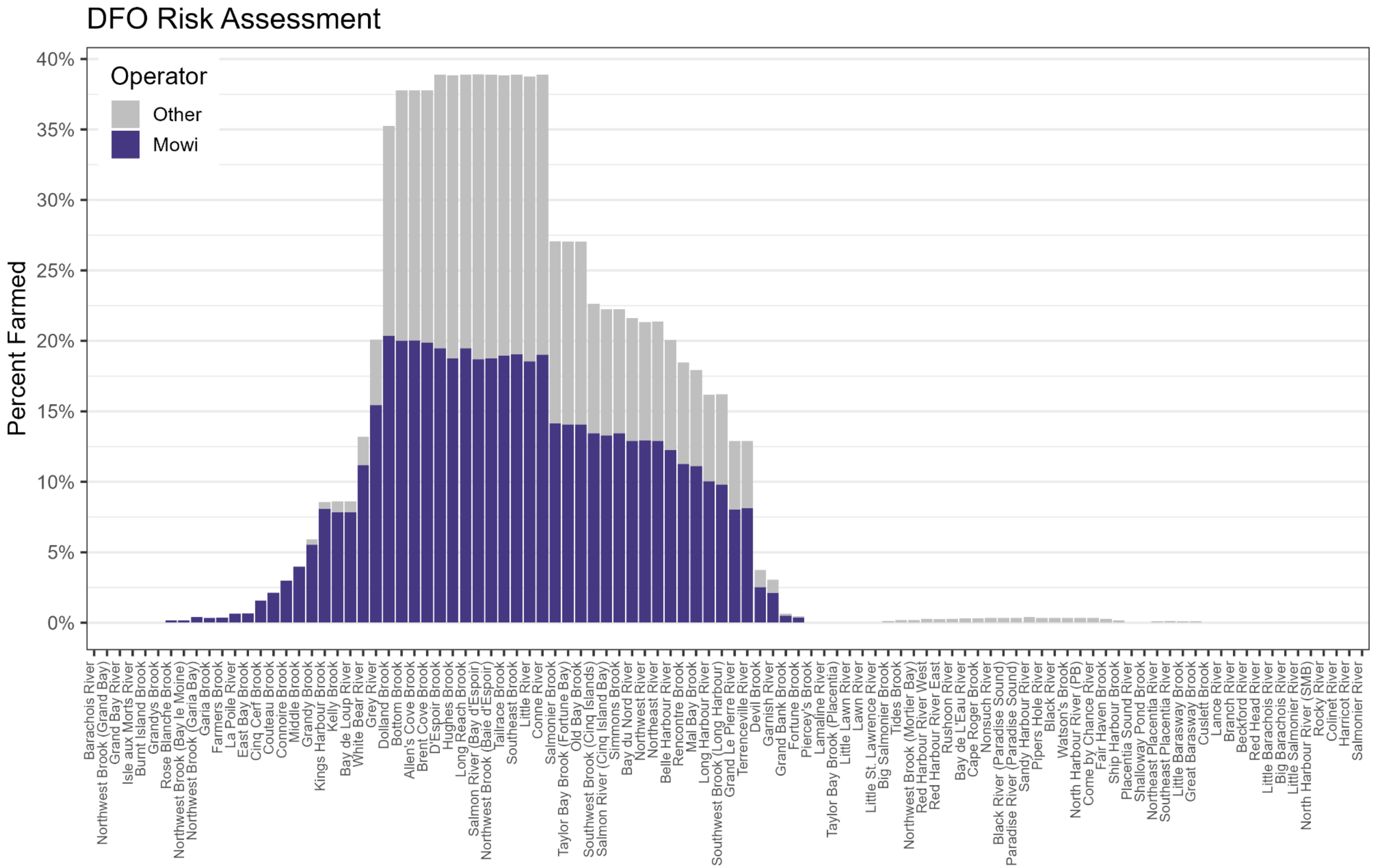

Figure 7.1. Summary of total per river risk (i.e., percent of farmed salmon relative to total salmon) assuming a 0.2 escape rate based on the current DFO model with dark blue colour indicating whether farmed fish were of MCE origin.

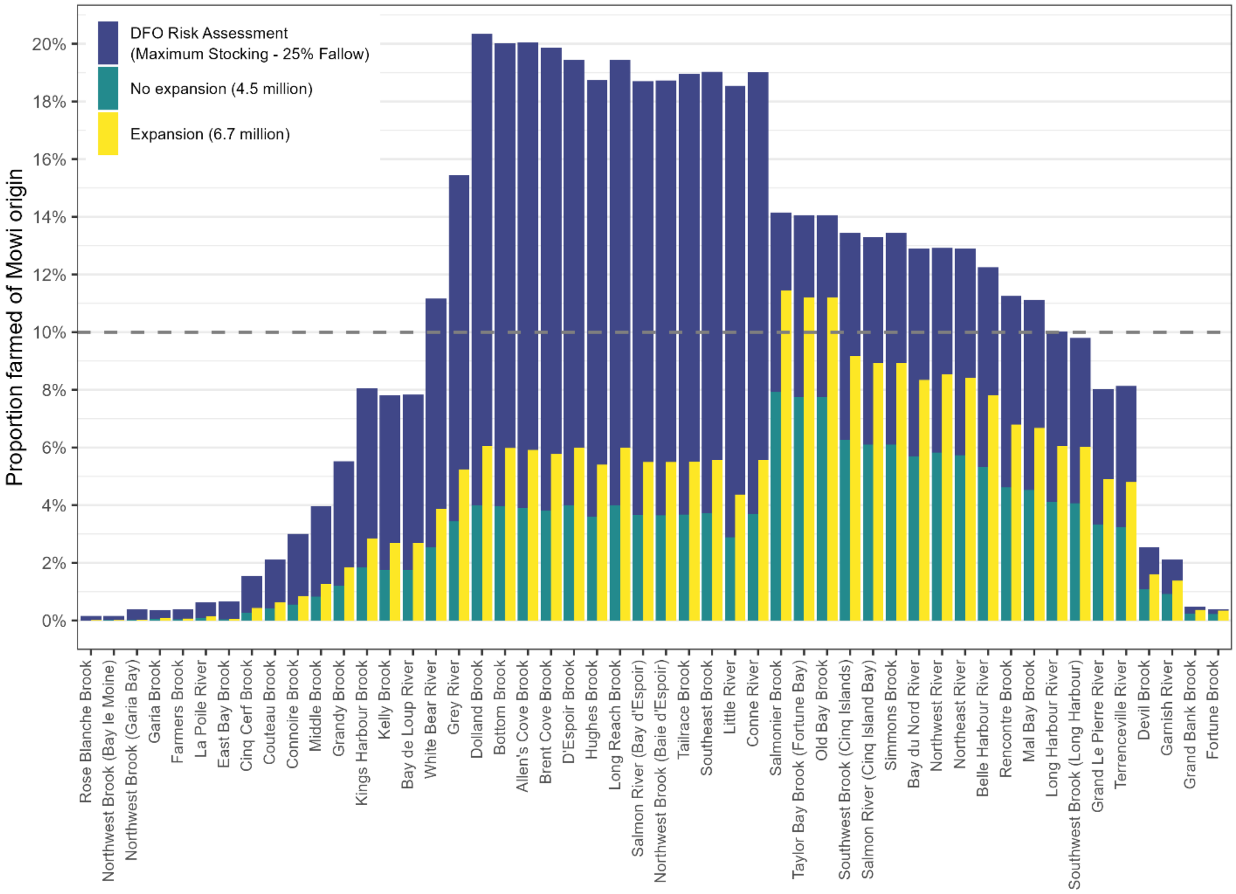

Figure 7.2. Summary of the per river risk (i.e., percentage of farmed salmon relative to total salmon) assuming a 0.2 escape rate under DFO risk assessment (dark blue), no hatchery expansion (green) and after expansion (yellow).

Figure 7.3. Summary of aggregate risk across all rivers relative to the MCE no expansion and expansion scenarios and relative to the DFO maximal risk assessment.

Based on recent and publicly available data for MCE farmed salmon escapes in Newfoundland (2019–2023; 0.001 and 0.002 escape rates), there is minimal risk to wild salmon in rivers along the south coast of Newfoundland; the percent of farmed salmon of MCE origin in rivers is near zero (Figure 7.4). The risk to wild Atlantic salmon increases when escape rates (0.027 average and 0.072 upper 95% CI) based on Newfoundland data from 2014–2023 are used. However, even with expansion to 6.7 million smolt, the percent of farmed salmon of MCE origin in a given river relative to total salmon counts does not exceed 4% (Figure 7.4). Using escape rates from MCE international operations during 2019–2023 (0.13 average and 0.288 upper 95% CI), the risk to wild Atlantic salmon in rivers near MCE sea farms increases as expected. At the average escape rate of 0.13 farmed salmon/harvest tonne, under the expansion scenario, no river is predicted to exceed the 10% benchmark (Figure 7.4). Several rivers (n=3) exceed the 10% benchmark, when an escape rate of 0.288 (upper 95% CI of the international escape rate) is used under the no expansion scenario and this increases to 10 rivers under the expansion scenario of 6.7 million smolt (Figure 7.4).

Figure 7.4. Summary of the per river risk (i.e., percentage of farmed salmon of MCE origin relative to total salmon) assuming various escape rates under no Hatchery expansion (green) and after Hatchery expansion (yellow).

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**Personal Communications**

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|---|---|
| Careen, E. | Senior Regional Aquaculture Management Officer, DFO, 12 June 2023. |
| Garber, A. | Huntsman Marine Science Centre, 20 September 2024. |
| Hendry, C. | Regional Manager, Aquaculture, DFO, March 2019. |
| Hendry, C. | Regional Manager, Aquaculture, DFO, 13 August 2024. |
| Hiemstra, L. | Owner and Project Manager, Mel-More Science, 5 December 2024. |
| Robertson, M. | Research Scientist, DFO, 4 April 2025. |
| Sheppard, M. | ATIPP Facilitator, Government of Newfoundland and Labrador, March 2024. |
| Van Leeuwen, T. | Research Scientist, DFO, January 2025. |

# List of Appendices

# Appendix A: Final EIS Guidelines (Section 4.3 and Section 4.3.1)

## 4.3 Baseline Studies

Baseline studies shall provide a description of existing conditions in biophysical and socio-economic environments that could be affected by the Project, both in the immediate vicinity and beyond. This shall include the components of the existing environment and environmental processes, their interrelations and interactions, as well as their variability over time scales appropriate to the effects analysis. The level of detail shall be sufficient to:

- identify and assess any adverse environmental effects that may be caused by the Project;
- identify and characterize the beneficial effects of the Project; and
- provide the data necessary to enable effective follow-up.

The boundaries of the study area shall be defined for each baseline study and the rational for the boundaries shall be provided. Methodology for each baseline study shall be proposed by the proponent, in consultation with resource agencies, as appropriate, and shall be summarized in the EIS.

Where appropriate and possible to do so, the EIS shall present a time series of data and sufficient information to establish the averages, trends, and extremes of the data that are necessary for the evaluation of potential environmental effects. For key environmental and social components, the Proponent should consider how far back in time and how far into the future the study should be conducted. Rationale for the temporal boundaries chosen should be provided.

Baseline Studies shall be prepared for at least the following components:

- Wild Atlantic Salmon
- Sea Farm Sites
- Fish and Fish Habitat

### 4.3.1 Wild Atlantic Salmon

The baseline study shall provide a detailed description of the status of wild Atlantic salmon in the vicinity of Project components (the hatchery and Bay Management Areas for sea farms). The baseline study shall consider the most recent information from COSEWIC and DFO regarding the at-risk status and stock assessment of wild Atlantic salmon.

The baseline study shall include, but not be limited to, a discussion of the following features:

a) a characterization of the current distribution, abundance, genetic population structure, morphology, health and fitness, and migratory patterns of wild Atlantic salmon along the south coast of the island and within the vicinity of all Project components;
b) proximity of the sea cages to scheduled and non-scheduled salmon rivers;
c) a literature review of the effects of disease and parasites that are prevalent in Newfoundland and affect Atlantic salmon on farms and in the wild, including a review of the transmission of those diseases and parasites;
d) water-quality data at the sea cage sites including water temperature, salinity and dissolved oxygen;

e) genetic and ecological interactions of farmed salmon escapees on wild Atlantic salmon along the south coast of the island;
f) description of the strain of Atlantic salmon to be produced and a breakdown of the ancestries that make up the broodstock;
g) oceanographic and meteorological data at the sea cage sites including water currents, wind and wave action, flood and tidal zones, ice dynamics, and storm patterns;
h) conformity of sea cage design, construction and installation and mooring to meet or exceed standards in the Code of Containment and ability to withstand oceanographic and meteorological conditions identified in g);
i) discuss existing river monitoring and model the potential for farmed salmon escapees in other salmon rivers identified in b);
j) a discussion of historical information of farm performance that is publicly reported and is also applicable to the expansion, such as fish mortality, deposits of drug or pesticides, disease, escapes, and sea lice.

# Appendix B: Escape Modelling Stocking Scenario Summary

Table B.1. Summary of hypothetical stocking scenario under current conditions and proposed Hatchery expansion.

| Site Name | Max Stocking | Next Allowable Year Class | No Expansion (4.5 million) | | | Expansion (6.7 million) | | |
|---|---|---|---|---|---|---|---|---|
| | | | 2026 Year Class | 2027 Year Class | 2028 Year Class | 2026 Year Class | 2027 Year Class | 2028 Year Class |
| Strickland Cove | 1,500 | 2028 | | | | | | |
| Blackfish Cove, Little Passage | 550,000 | 2028 | | | | | | |
| Seal Nest Cove | 700,000 | 2028 | | | | | | |
| Ironskull Point | 700,000 | 2026 | **225,000** | 199,437 | 42,427 | **335,000** | 296,939 | 63,169 |
| Spyglass Cove (Cinq Islands Bay) | 600,000 | 2026 | **225,000** | 199,437 | 42,427 | **335,000** | 296,939 | 63,169 |
| Spoon Cove, Belle Bay | 600,000 | 2026 | **225,000** | 199,437 | 42,427 | **335,000** | 296,939 | 63,169 |
| Cinq Island Cove, Belle Bay | 700,000 | 2026 | **225,000** | 199,437 | 42,427 | **335,000** | 296,939 | 63,169 |
| McGrath Cove South, Belle Bay | 600,000 | 2026 | **225,000** | 199,437 | 42,427 | **335,000** | 296,939 | 63,169 |
| McGrath Cove North, Belle Bay | 700,000 | 2026 | **225,000** | 199,437 | 42,427 | **335,000** | 296,939 | 63,169 |
| Belle Island, Belle Bay | 610,000 | 2026 | **225,000** | 199,437 | 42,427 | **335,000** | 296,939 | 63,169 |
| Tilt Point, Cinq Island Bay, Fortune Bay | 600,000 | 2026 | **225,000** | 199,437 | 42,427 | **335,000** | 296,939 | 63,169 |
| Harvey Hill East, Northeast Arm | 600,000 | 2027 | | **409,091** | 362,612 | | **600,000** | 531,831 |
| Harvey Hill North, Northeast Arm | 500,000 | 2027 | | **409,091** | 362,612 | | **500,000** | 443,192 |
| Hickman's Point, East Bay, Fortune Bay | 600,000 | 2026 | **225,000** | 199,437 | 42,427 | **335,000** | 296,939 | 63,169 |
| Broad Cove, Northeast Arm | 600,000 | 2027 | | **409,091** | 362,612 | | **600,000** | 531,831 |
| South East Bight | 600,000 | 2026 | **225,000** | 199,437 | 42,427 | **335,000** | 296,939 | 63,169 |
| Salmonier Cove, Great Bay de l'Eau | 600,000 | 2028 | | | **321,429** | | | **478,571** |
| Dog Cove, Great Bay de l'Eau | 600,000 | 2028 | | | **321,429** | | | **478,571** |
| Steamer Head | 650,000 | 2026 | **225,000** | 199,437 | 42,427 | **335,000** | 296,939 | 63,169 |
| Red Cove, Great Bay de l'Eau | 600,000 | 2028 | | | **321,429** | | | **478,571** |
| Deep Water Point | 900,000 | 2027 | | **409,091** | 362,612 | | **655,000** | 580,582 |
| Rencontre East Island | 675,000 | 2027 | | **409,091** | 362,612 | | **655,000** | 580,582 |
| Old Woman's Cove | 600,000 | 2027 | | **409,091** | 362,612 | | **600,000** | 531,831 |
| Little Burdock Cove | 525,000 | 2027 | | **409,091** | 362,612 | | **525,000** | 465,352 |
| Benny's Cove | 260,000 | 2028 | | | **321,429** | | | **478,571** |
| Foshie's Cove | 900,000 | 2028 | | | **321,429** | | | **478,571** |
| The Hobby | 525,000 | 2028 | | | **321,429** | | | **478,571** |
| Murphy Point | 975,000 | 2028 | | | **321,429** | | | **478,571** |
| Deer Cove | 525,000 | 2028 | | | | | | |
| Harvey Hill South | 600,000 | 2027 | | **409,091** | 362,612 | | **600,000** | 531,831 |
| Wallace Cove | 1,000,000 | 2028 | | | **321,429** | | | **478,571** |
| Bob Locke Cove North | 1,000,000 | 2026 | **225,000** | 199,437 | 42,427 | **335,000** | 296,939 | 63,169 |

| | | | **No Expansion (4.5 million)** | | | **Expansion (6.7 million)** | | |
|---|---|---|---|---|---|---|---|---|
| **Site Name** | **Max Stocking** | **Next Allowable Year Class** | **2026 Year Class** | **2027 Year Class** | **2028 Year Class** | **2026 Year Class** | **2027 Year Class** | **2028 Year Class** |
| Mare Cove South | 1,000,000 | 2026 | **225,000** | 199,437 | 42,427 | **335,000** | 296,939 | 63,169 |
| Indian Tea Point | 1,000,000 | 2028 | | | **321,429** | | | **478,571** |
| Wild Cove | 1,000,000 | 2028 | | | **321,429** | | | **478,571** |
| Butter Cove | 1,000,000 | 2027 | | | | | | |
| Jervis Island | 1,000,000 | 2027 | | | | | | |
| Pass My Can | 1,000,000 | 2027 | | | | | | |
| Dennis Arm | 1,000,000 | 2028 | | | **321,429** | | | **478,571** |
| Goblin Bay | 1,000,000 | 2027 | | | | | | |
| Devil Bay | 1,000,000 | 2026 | **225,000** | 199,437 | 42,427 | **335,000** | 296,939 | 63,169 |
| Little Bay | 1,000,000 | 2026 | **225,000** | 199,437 | 42,427 | **335,000** | 296,939 | 63,169 |
| The Gorge | 1,000,000 | 2026 | **225,000** | 199,437 | 42,427 | **335,000** | 296,939 | 63,169 |
| Rencontre Bay | 1,000,000 | 2026 | **225,000** | 199,437 | 42,427 | **335,000** | 296,939 | 63,169 |
| Chaleur Bay | 1,000,000 | 2027 | | **409,091** | 362,612 | | **655,000** | 580,582 |
| Friar Cove | 1,000,000 | 2027 | | **409,091** | 362,612 | | **655,000** | 580,582 |
| Shooter Point | 1,000,000 | 2027 | | **409,091** | 362,612 | | **655,000** | 580,582 |
| Aviron North | 1,000,000 | 2028 | | | **321,429** | | | **478,571** |
| Aviron South | 1,000,000 | 2028 | | | **321,429** | | | **478,571** |
| Denny Island | 1,000,000 | 2026 | **225,000** | 199,437 | 42,427 | **335,000** | 296,939 | 63,169 |
| Foots Cove | 1,000,000 | 2028 | | | **321,429** | | | **478,571** |
| Gnat Island | 1,000,000 | 2026 | **225,000** | 199,437 | 42,427 | **335,000** | 296,939 | 63,169 |
| Shoal Cove | 1,000,000 | 2026 | **225,000** | 199,437 | 42,427 | **335,000** | 296,939 | 63,169 |
| | **41,196,500** | | **4,500,000** | **8,488,732** | **9,337,264** | **6,700,000** | **12,638,778** | **13,902,149** |