Climate Change Adaptation

Hospitality Newfoundland and Labrador

CBCL

HOSPITALITY NEWFOUNDLAND & LABRADOR

Final Report

Newfoundland & Labrador

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Contents

Appendices

Chapter 1 Introduction

Newfoundland and Labrador has a thriving tourism industry that has been steadily growing over the last decade. The tourism industry contributes over one billion dollars to the provincial GDP and provides approximately 20,000 jobs, which are especially important for rural and remote communities (GovNL, 2021). The distinct physical and cultural landscape makes for unique experiences for travellers, particularly in the sectors of Marine, Winter, and Outfitting tourism. Activities such as whale watching and iceberg tours in the summer, and snowmobiling and downhill skiing in the winter, continue to draw tourists to the province year after year. The province's abundant wildlife such as moose, caribou, bears, and Atlantic salmon have allowed for a flourishing outfitting industry that is one of the largest contributing sectors to tourism revenue. Each year, the non-resident hunting sector contributes nearly $50 million in direct revenue, employs approximately 1,300 people, mainly in rural communities, and draws over 7,000 visitors to the province (GovNL, 2020b).

The COVID-19 pandemic has had a staggering impact on provincial tourism, with 2020 visitor numbers down approximately 76% compared to 2019 levels (GovNL, 2020a). While it may take several years for visitor levels to reach pre-pandemic levels, Hospitality Newfoundland and Labrador (Hospitality NL), supported by the provincial and federal governments, are taking steps to ensure that when tourism does return to normal, the industry will remain robust and prosperous in an ever-changing global climate.

Climate projections show significant changes by mid-century and beyond, including warmer, wetter, and stormier weather impacting the majority of the province (based on industry-standard emission scenarios). Given the province's latitudinal reach, extending from the island portion of the province in the south, to the northern tip of Labrador, climate change across the province is highly varied with some areas projected to experience considerably different impacts than others (Finnis et al. 2018). Hospitality NL and the provincial government have recognized that in order to ensure that the industry remains sustainable in the long term, operators must be able to identify risks to their business in order to effectively plan for adaptation.

The information presented in this report provides a high-level summary of provincial climate projections and key impacts that the industry will face over the coming decades as a result of climate change. Findings are derived from stakeholder consultation where

representatives of the tourism industry were engaged to provide their local perspective and experiences related to climate change.

The findings were ultimately used to support the development of learning and knowledge tools to be used by operators to plan for climate change, including a climate projections summary document, sector-specific impact overviews, case studies to highlight examples of local adaptation measures, and a risk assessment tool for operators. The tools that were developed are discussed in Chapter 4 and are included as stand-alone documents in the appendices of this report.

Chapter 2 Climate Change in Newfoundland and Labrador

Canada's climate will continue to warm, driven by global greenhouse gas (GHG) emissions from human activity. Past warming has occurred in Canada at about double the rate of global warming, and future warming is predicted to follow the same trend (Bush and Lemmen, 2019). This poses risks to all sectors of the economy and to Canadians' quality of life. Action on climate change adaptation (and mitigation) is critically required to limit impacts on people and ecosystems.

Climate projections for Newfoundland and Labrador are different in several ways than projections for other provinces in Canada. The climate in this region is closely tied to several coastal currents, including the cold Labrador Current and the warmer Gulf Stream, and it is highly dominated by natural variability, or in other words, natural changes in climate from year to year as a result of non-human forces (Way and Viau 2015)**.** Although natural variability may cause the local climate to temporarily fluctuate from the projected long-term trends (e.g., with warmer and cooler years), this does not diminish the need to plan for climate change.

The following sections summarize expected climate changes and potentially related changes to the environment or ecosystems in Newfoundland and Labrador for mid- (approximately 2050s) to late- century (approximately 2100s). Only those factors relevant to the marine, winter, and outfitting tourism industry are discussed, including the following:

- Temperature
  - Averages and Extremes
  - Frost and Freeze-Thaw
- Precipitation
  - Average
  - Intensity and Frequency
  - Freezing Rain
  - Snow, Winter Rain, Rain on Snow
- Coastal and Oceanographic
  - Sea Level Rise
  - Coastal Erosion/Deposition

- Sea-Water Temperature, Salinity, and Stratification
- Chemical Oceanographic Variables
- Icebergs

- Wind and Storms
  - Hurricanes, Nor'easters, and winter storms
- Terrestrial Environment
  - Ice Jams and River Flooding
  - Water Temperature and Quality
  - Invasive Species and Pests
  - Vegetation Assemblages
  - Wildfire

Each of the above parameters may directly or indirectly influence one of more of the target tourism sectors (Marine, Outfitting, and Winter) and should be taken into consideration when discussing climate change risks and impact to the industry. Note that the parameters listed above are those brought forward, through stakeholder engagement, as most relevant when discussing impacts to the industry. Other parameters such as ice thickness or fog were not considered as key parameters of interest.

Unless otherwise indicated, temperature and precipitation projections for this study are drawn from a 2018 report by Finnis et al. (commissioned by the NL Department of Environment, Climate Change and Municipalities), for a high emission scenario (RCP 8.5).

2.1 Temperature

Averages and Extremes

Daily average temperatures, daytime high temperatures, and nighttime low temperatures are projected to increase, with a steady rate of change through mid- to late-century. In general, the coldest temperatures are projected to increase fastest. The greatest change is expected in winter and projected changes show the largest increases in the Labrador interior and at high latitudes. Cold extremes are expected to decrease in intensity and frequency, whereas warm extremes will increase in intensity and frequency.

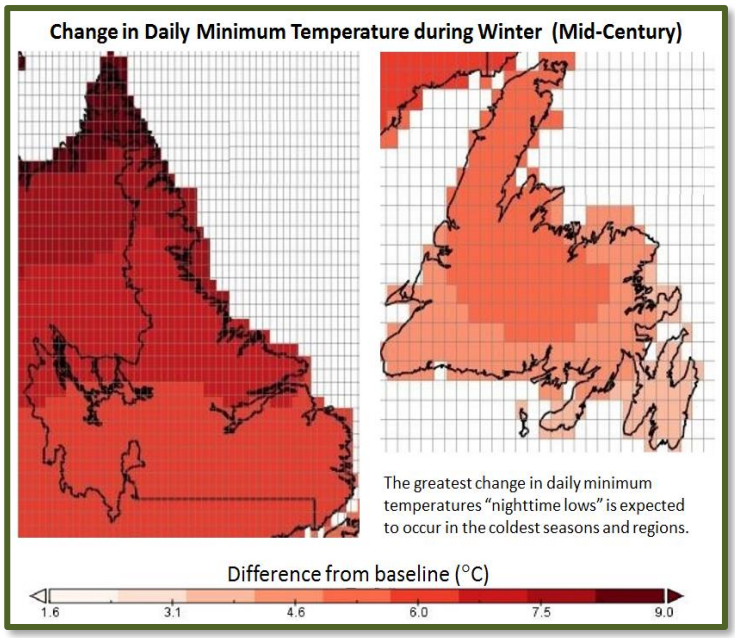

Figure 2.1 – Projections for winter (Dec-Feb) daily minimum temperature (nighttime low), for a high GHG emission scenario (modified from

Frost and Freeze-Thaw

The number of days with frost is expected to decrease, with the greatest change in regions and seasons with daytime temperatures projected to rise above near freezing (see Finnis et al. 2018 for more detail).

Changes in the number of days with frost in Labrador will be less drastic. Even though temperatures in northern latitudes are expected to significantly increase (Figure 2.1), winter temperatures are projected to remain below freezing for longer into the 21st century than in more southerly locations.

Changes in freeze-thaw cycles are likely to follow similar patterns to those described above.

2.2 Precipitation

Average Precipitation

Mean daily precipitation is expected to increase throughout the province. In Newfoundland, widespread increases are expected by late century. Changes in Labrador are typically smaller, but also tend towards an increase. Despite uncertainty in the projections, precipitation is expected to increase in most locations and seasons by mid-century, and larger (nearly universal) changes are expected by the end of the century.

Precipitation Intensity

Precipitation intensity is expected to increase, as shown by several indices, such as: mean intensity of precipitation events; maximum 3-, 5- and 10-day precipitation; and number of days with 10 mm or more of precipitation (frequency). Models predict intensity increases for all of Newfoundland in all seasons, with the greatest increases in winter and on the south coast. Changes in Labrador are generally smaller. There is notable uncertainty in mid-century projections, but by late century strong increasing trends emerge.

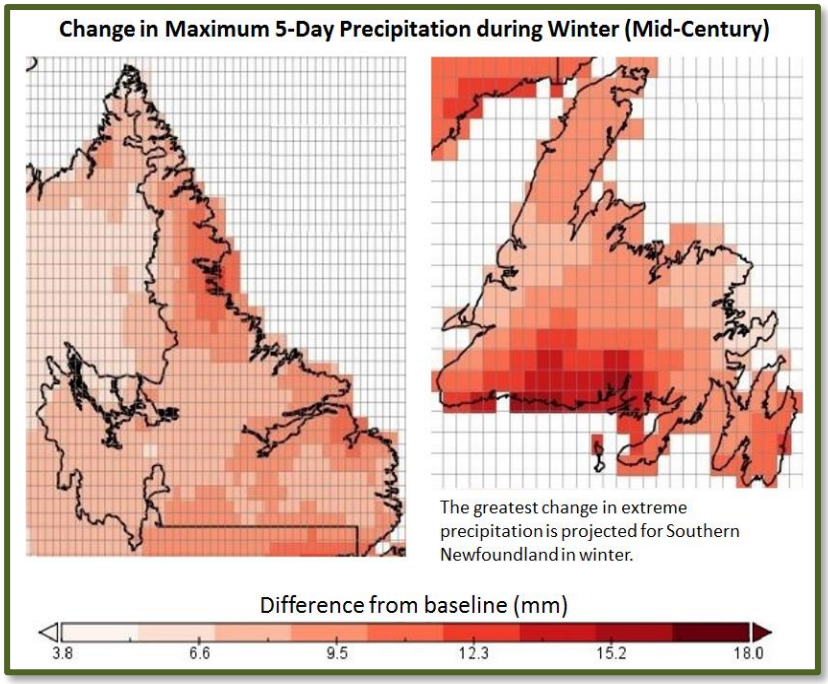

Figure 2.2 – Projections for winter (Dec-Feb) precipitation intensity, for a high GHG emission scenario (modified from Finnis et al. 2018).

Freezing Rain

Future projections for freezing rain suggest an increase over most of Canada, based on the northern movement of the 0°C temperature boundary and of freezing rain-related weather systems. That is, as temperatures increase to near zero in more northern latitudes, precipitation that historically would have fallen as snow will shift to freezing rain. Freezing rain will increase over most of the province (Cannon et al, 2020). The greatest relative increase in freezing rain is expected in Labrador (Cheng et al., 2011).

Snow and Rain-on-Snow

Future projections for seasonal snow amounts suggest that an increase in air temperature due to global warming will lead to a decrease in southern latitudes in the total seasonal ground snow accumulations accompanied by delayed snow onset and earlier snowmelt.

Although there is likely to be less snow and more rain, snow cover duration or snowfall extremes may continue to occur even as average conditions decrease (Finnis et al., 2019; Janoski et al., 2018). These changes also mean more rain falling in winter on frozen ground, as well as rain-on-snow days, in particular in southern regions (Allard and Lemay, 2012; Jeong and Sushama, 2018). In parts of Labrador, the potential increase in rain-on-snow may continue later into the 21st century since the snowpack is expected to persist for longer in more northern latitudes. It should be noted that the uncertainty associated with rain-on-snow processes is high.

2.3 Coastal and Oceanographic

Sea-Level Rise

The global mean sea-level is projected to rise up to 84 cm by the year 2100 for a high-emissions scenario, (IPCC, 2019). Relative sea-level change will significantly vary across the province in part due to vertical land motion (James et al., 2014), as shown in Figure 2.3, varying from 10 cm in central Labrador to 71 cm in the south of Newfoundland by 2100. Land subsidence in the south will increase local relative sea level rise, while land rebound in the north will buffer it. Contributors to extreme sea levels include sea-level rise, an overall increase in storminess (storm surge), and increased wave action due to reduced ice cover. In the south of Newfoundland, sea-level rise is likely to be the primary contribution to extreme sea levels, whereas in the north, storm surges and waves would continue to dominate. The projected increase in extreme water levels across the province will cause increased coastal flooding in low-lying areas.

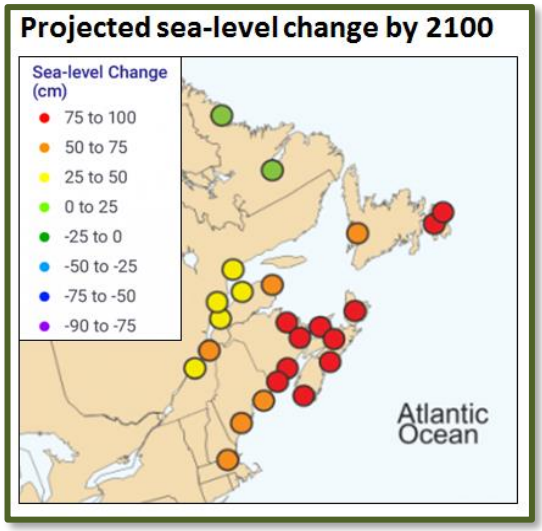

Figure 2.3 - Projected relative sea-level rise for a high GHG emission scenario, compared to 1986–2005 (modified from Greenan *et al.*, 2018).

Coastal Erosion/Deposition

Existing rates of coastal erosion are highly variable across the island portion of the province, with the most change occurring in unconsolidated cliffs and beaches (Irvine, 2015; Catto, 2011). Most of the coasts in Labrador have moderate and low sensitivity to coastal erosion due to the local geomorphology (bedrock, coarse gravel beaches), locally high sediment fluxes, and the prevalence of offshore seasonal ice cover (Catto, 2019). A nominal average coastal erosion rate for the Province is about 20 cm/year (Batterson, 2020). Increases in erosion rates are anticipated in these areas due to changes in the processes that drive erosion (wind, waves, groundwater, and surface water). For example, the rise of extreme water levels will allow waves to get closer to cliffs, and projected increases in precipitation intensity will accelerate erosion from runoff (Irvine, 2015; Batterson, 2020).

Sea-Water Temperature, Salinity, and Stratification

With climate change, sea temperatures are expected to increase throughout the region, in all seasons, and both on the surface and the bottom (DFO, 2013; Han et al., 2015; Han et al, 2019). Due to increases in precipitation over the ocean and ice melt, coastal salinity is expected to decrease in all seasons (except some deep-ocean areas in the south where it may increase) (Han et al., 2019). Vertical mixing will be reduced due to the warmer and fresher conditions at the surface (DFO, 2013).

Chemical Oceanographic Variables

Reduced vertical mixing is likely to reduce the nutrient supply from deeper waters (Han et al., 2015). Dissolved oxygen will also be reduced, although this may be more localized (e.g., coastal), and acidity is projected to increase with increasing global CO_2 levels (DFO, 2013). These projected trends are a continuation of the recently observed trends in the area (Lavoie et al., 2017).

Icebergs

Projections for icebergs indicate a likely reduced occurrence in the Gulf of St. Lawrence (GSL) as well as the Newfoundland and Labrador Shelf/Slope (NLSS) in the near-term (DFO, 2013).

2.4 Terrestrial Environments

Ice Jams and River Flooding

Flooding from ice jams has become more frequent and unpredictable in Atlantic Canada (Turcotte et al., 2019). Although increasing air temperatures will decrease river ice cover thicknesses, increased flows during freeze-up could allow for thicker ice and more severe ice-jam flooding (Belatos and Prowse, 200; Turcotte et al. 2019). Other projected changes that are likely to exacerbate flooding include higher intensity precipitation, more winter rainfall, and sea-level rise combined with changes to storms. Changes to snow

accumulation and mid-winter thaw events may also have an impact in the province (Hickman, 2006).

Water Temperature and Quality

Increase in wash-off events from runoff caused by extreme precipitation are likely to negatively impact water quality. Water temperature in streams and rivers is likely to increase (DFO, 2013).

Invasive Species, Pathogens, and Pests

Changing climate conditions will alter suitable habitats and competition dynamics. Among other factors, modified disturbance regimes have been shown to be conducive to invasive species (Dyderski and Jagodzinski 2018), pathogens, and pests (Hellmann et al., 2008). Changes to sea temperatures may allow for marine invasive species to expand their range northward and deeper into the water column. In addition, changes to ocean currents may affect distribution patterns (DFO, 2013).

Vegetation assemblages

Vegetation assemblages will be impacted as precipitation regimes shift and temperature isotherms move northward (Searls et al. 2021). Species composition also responds to disturbance from wildfire and invasive species (Dyderski and Jagodzinski 2018).

Wildfire

Drier conditions elsewhere in Canada are projected to contribute to increased number and extent of wildfires (Wotton et al., 2010). Even if dry conditions were to remain unchanged in Newfoundland (Finnis et al., 2018), changes to vegetation assemblages and disturbances may affect fire regimes.

2.5 Wind and Storms

Hurricanes, Nor'easters, and winter storms

A possible increase in the intensities of tropical (e.g., hurricanes) and extra-tropical (e.g., nor'easters) storms is anticipated, resulting primarily in increased precipitation rates (Knutson et al., 2019; Liu et al., 2019; Colle et al., 2015). Projected changes in frequencies depend on the storm magnitude bring assessed and are highly uncertain (Knutson et al. 2019). It is possible that extreme wind speeds and surge may increase, which would have more effect as sea levels rise along the south coast and would be particularly damaging for longer duration storms which can span several tidal cycles (Greenan et al. 2018), such as Nor'easters.

Chapter 3 Impact Analysis

This chapter summarizes the findings of a high-level impact analysis for each tourism sector as identified through stakeholder engagement. Impacts developed through research are drawn from both analysis of local impacts as well as other related studies from similar jurisdictions. Impacts and vulnerabilities are focused not only on the tourism experiences themselves, but supporting infrastructure including provincial roads and other transportation routes (e.g., ferry and air travel) due to their importance in ensuring tourists can reach the province or their travel destination. Lastly, health and safety concerns are considered from the perspective of human health and safety, emergency planning and preparedness, as well as insurance requirements.

3.1 Stakeholder Engagement Overview

A stakeholder workshop was held on June 1, 2021, where representatives from the relevant tourism sectors were invited to participate in an open discussion about climate change risks, vulnerabilities, and impacts with Hospitality NL and CBCL staff. The goal of the workshops was to:

- Disseminate information about climate change impacts and risks to relevant parties.
- Gain an understanding about climate change perception and urgency from the sector.
- Ground truth findings from the CBCL's initial research and literature review.
- Identify any factors that are causing operators to hold back from investing in climate change adaptation and planning.

Several industry representatives attended the workshop (e.g., individual tourism companies), as well as representatives from Hospitality NL, GovNL, the Newfoundland and Labrador Outfitting Association (NLOA).

The workshop was held virtually via the Zoom meeting and webinar platform. The session consisted of a brief roundtable introduction of each attendee, an upfront presentation on relevant (and previously existing) climate projections provided by CBCL, and an open discussion between CBCL facilitators and workshop participants on key concepts of risk, opportunities, and barriers to adaptation.

In addition to the workshop, CBCL conducted targeted engagement calls with industry groups or representatives such as Marble Mountain and the East Coast Trail Association. These calls provided CBCL the opportunity to ask targeted questions to smaller groups of

people and fill in any data gaps encountered following the initial literature review and engagement workshop.

Findings from stakeholder engagement that aligns with literature are summarized in the following sections by sector.

3.2 Marine Tourism Industry

NL's marine tourism industry is heavily reliant on the ocean environment, which creates a major tourism draw to the province. Boat tours that advertise whale watching, bird watching, or iceberg viewing are some of the biggest operators in the sector, all of which could be heavily impacted with climate change due to shifting species or changes in the concentration and distribution of icebergs. Extreme weather and changes in the ocean environment are also expected to impact NL's food tourism industry which features fresh, local seafood as a primary attraction. In addition, there are numerous adventure tours such as sea kayaking and diving that are impacted by stormier weather, along with coastal features such as hiking trails, beaches, and heritage sites, many of which will undoubtedly experience impacts related to sea level rise, storm surge, or coastal erosion.

Critical Assets

The first step in assessing the highest priority impacts to the industry was to identify critical assets that are crucial to tourism operations. The following list of assets was developed through stakeholder engagement:

Tourism Experiences
- Marine Sports (e.g., kayaking, diving)
- Boat Tour Operations (e.g., whale watching, iceberg tours)
- Coastal Destinations (e.g., archeological sites, lighthouses, heritage communities)
- Coastal Hiking Trails

Infrastructure
- Wharves, Docks, Piers, Marinas
- Coastal Protection
- Power/Communication
- Water/Sewer
- Supporting Buildings (e.g., ticket offices)
- Supporting municipal infrastructure

Transportation
- Ferry travel
- Air travel
- Cruise Ships
- Provincial roads (driving conditions)
- Causeways

Species and Environment
- Aquatic Species (whales, fish, shellfish)
- Marine Birds
- Ocean Habitat
- Coastline

Health and Safety
- Human Health
- Emergency Planning and Preparedness
- Insurance requirements

Impacts noted in stakeholder engagement are summarized in the following subsections.

Wind and Storms

Storms in Newfoundland and Labrador (hurricanes, tropical storms, post-tropical storms, and extra-tropical storms) generally include high sustained winds, extreme wind gusts, and precipitation in the form of rain. These storms often make it impossible for tourism operators to provide their services due to safety concerns. Furthermore, the storms can wreak havoc on municipal infrastructure that is crucial to tourism operators, such as high winds causing power and communications outages, and disruptions to transportation routes.

Wind and storm related impacts discussed in stakeholder consultation include:

- Unpredictable operating schedule
- Increased frequency of cancelations
- More frequent operations in inclement weather (less enjoyable experience for tourists)
- Possible reduced coastal visibility
- Structural and aesthetic facility damages (e.g., flooding, undermining foundation, roof)
- Increased maintenance and repair costs
- Blocked transportation routes due to downed trees, debris, flooding, and washouts, and resulting impacts to driving conditions or supply-chain
- Travel delays (air and ferry) resulting in increased no-shows due to travel disruptions and road closures
- Damaged/downed electrical and communications equipment impacting operations
- Increase stress on emergency organizations, vehicles, equipment, and facilities
- Increased/more expensive insurance requirements following damages
- Loss/damage of coastal habitats (e.g., bird nests) from extreme winds

Coastal (Flooding and Erosion)

Marine tourism operators are reliant on costal communities not only to draw tourists to their businesses, but to support their day-to-day operations with infrastructure such as roads, wharves, power, and municipal services including water and sewer. Coastal communities and hiking trails are increasingly vulnerable to coastal flooding and erosion due to sea level rise. Devastatingly, loss of life can result from slope movement triggered by cliff and other coastal deterioration and erosion. Proactively mitigating the risks of coastal flooding and erosion on businesses, municipal infrastructure, and coastal features will improve public safety, reduce costly damage and loss, uphold level of service expectations, and maintain critical transportation infrastructure essential for the rural economy.

Coastal flooding (sea level rise, tides, storm surge) and coastal erosion related impacts discussed in stakeholder consultation include:

- Structural and aesthetic facility damages (e.g., flooding, undermining foundation, structural and envelope damage)
- Flooding, undermining, and other damages to wharves, docks, and other coastal infrastructure (e.g., storage sheds, ticket offices)
- Damage to docked boats or other marine vehicles during storm surge

- Long term suitability of infrastructure (e.g., wharves, bollards) for docking boats with sea level rise
- Increased maintenance and repair costs
- Increased damage and/or loss of coastal protection (e.g., breakwater, armour stone)
- Flood damage, undermining, and/or washouts of roads and other transportation routes and resulting impacts to driving conditions or supply-chain
- and possible disruptions in driving conditions and supply chain
- Damaged electrical and communications equipment
- Flood damage to heritage attractions (e.g., lighthouses, archeological sites)
- Damage and cleanup requirements from deposited sediment and debris
- Erosion and damage to coastal trails and heritage attractions, extended closures
- Loss/damage of coastal habitats (e.g., bird nests) from increased sea level and wave action
- Increased turbidity of coastal waters leading to local reductions in light attenuation and productivity of marine plants (food chain disruption and visibility issue)
- Coastal erosion and flood damage creating access issues for emergency responders
- Increased/more expensive insurance requirements following damage

Oceanographic and Terrestrial Environments

Projected air and ocean temperature increases are projected to contribute to a number of oceanographic effects such as melting sea ice, decreased ocean salinity (in regions), and shifts in ocean stratification patterns. Combined, these effects will be far reaching, having an impact on fish and shellfish, plankton, marine mammals, and nearly every other ocean-dwelling species. Furthermore, marine birds such as puffins are seeing similar shifts in species abundance and distribution as rising temperatures, among other environmental factors, cause changes in habitat and food availability.

Oceanographic and terrestrial environment related impacts discussed in stakeholder consultation include:

- Increased ocean temperatures causing increasing stress on native species (e.g., productivity, reproduction)
- Changes in species migration patterns and species shifting to new regions (e.g., moving north as temperatures increase)
- Changes in prey distribution and food competition among species
- Northern migration of invasive species
- Increased susceptibility of native species to disease due to increased stress
- Water temperature and quality impacting species habitats
- Reduced number of icebergs in the long term

Temperature and Precipitation

Projected increases in temperature will contribute to disturbances in the natural environment, such as species distribution for key species that draw tourists to the province. Additionally, increasing temperatures will contribute to increased costs for cooling facilities, as well as health and safety concerns if tourists are exposed to extreme

heat. Increases in precipitation will have impacts on the built environment, such as risks to flooding or undermining of foundations and weathering/washout of provincial roads. Increases in precipitation can also impact marine tours themselves, for example operating in heavier rain conditions could lead to a less enjoyable experience for visitors.

Temperature and precipitation related impacts discussed in stakeholder consultation include:

- Increased exposure to extreme heat and heat waves
- Increased operating costs for cooling requirements in buildings
- Structural and aesthetic facility damages (e.g., flooding, undermining foundation, structural and envelope damage)
- Sewer system backup
- Increased maintenance and repair costs
- Increased/more expensive insurance requirements following damage
- Flood damage, undermining, and/or washouts of roads and other transportation routes and resulting impacts to driving conditions or supply-chain
- Increased weathering to roads and transportation infrastructure due to freeze-thaw, extreme precipitation events
- Washout, flood damage to beaches and coastal features following heavy precipitation
- Increased runoff (following precipitation) introducing higher amounts of nutrients into ocean, leading to low levels of dissolved oxygen and general reduced water quality
- Reduced sub-surface visibility, cloudy water due to increased runoff (possible impact on near-shore activities such as sea kayaking)

Key Findings

Stakeholders indicated that the greatest and highest priority risks to the Marine Tourism industry are related to:

- Winds and storms impacting the ability of tours to operate;
- Sea level rise and coastal erosion, which can lead to flooding and infrastructure damage; and
- The change in oceanographic and terrestrial environments which is causing a noticeable shift in species abundance and distribution.

Additional risks such as the impacts of temperature and precipitation were also recognized due to their impact on both operations and infrastructure, including supporting services such as municipal transportation routes (i.e., road washouts). Though these types of impacts are often outside the control of operators (i.e., provincially or municipality owned supporting infrastructure), there is potential for major operational disruptions.

3.3 Winter Tourism Industry

NL's winter tourism industry caters to both residents and non-residents who travel for adventure-oriented activities such as downhill skiing and snowboarding, and snowmobiling, among others. The provinces large expanses of mountainous, undeveloped

terrain, accompanied by ocean views make for a very unique winter tourism experience unlike anywhere else in Canada.

Winter tourism destinations worldwide are experiencing challenges related to late onset of snow and unprecedented winter melting events that can be detrimental to winter tourism operators. To combat these effects, adaptation measures such as snowmaking at ski resorts has been heavily relied upon, which has additional impacts on businesses including higher energy usage and canceled runs.

Critical Assets

The following assets critical for the winter tourism industry were considered for the impact analysis, as identified throughout stakeholder engagement:

Tourism Experiences
- Snowmobiling/ATVs
- Downhill and cross-country Skiing
- Other recreation

Environment
- Snow conditions
- Snow making capabilities

Infrastructure
- Trails and trail bridges
- Power/Communication
- Water/Sewer
- Supporting Buildings (e.g., ticket offices)
- Supporting municipal infrastructure

Transportation
- Ferry travel
- Air travel
- Cruise Ships
- Provincial roads (driving conditions)
- Causeways

Health and Safety
- Human Health
- Emergency Planning and Preparedness
- Insurance requirements

Wind and Storms

Storm events in the winter often consist of windstorms, extreme snowfall, ice storms, or rain on snow which can lead to major flooding events. For the winter tourism industry, this generally means less than ideal conditions for participating in activities such as downhill skiing or snowmobiling, or weather events that result in reduced snow amounts and reduced snow quality.

Wind and storm related impacts discussed in stakeholder consultation include:
- Unpredictable operating schedule
- Increased frequency of closures/cancellations
- More frequent operations in inclement weather (less enjoyable experience for tourists)
- Downed trees on trails required cleanup/removal
- Changes in snow conditions/snow accumulation from wind gusts and storms

- Possible reduced snow making capabilities during extreme weather
- Reduced visibility, safety concerns
- Structural and aesthetic facility damages (e.g., wind damage)
- Increased maintenance and repair costs
- Blocked transportation routes due to downed trees, debris, flooding, and washouts, and resulting impacts to driving conditions or supply chain
- Travel delays (air and ferry)
- Increased no-shows due to travel disruptions and road closures
- Damaged/downed electrical and communications equipment impacting operations
- Increase stress on emergency organizations, vehicles, equipment, and facilities
- Increased/more expensive insurance requirements following damages

Temperature and Precipitation

Increasing temperatures throughout the entire province means that total seasonal snow accumulation will be impacted by mid-century (with the potential exception of northern and higher-altitude locations). Without low temperatures and sufficient amounts of snow, experiences such as snowmobiling and snowshoeing will become less feasible and potentially more dangerous as winter ice conditions over ponds and other waterbodies becomes thinner. Additionally, year-round extreme precipitation events will cause erosion and increased maintenance needs for infrastructure such as trail bridges that are required for cross-country snowmobiling.

Temperature related impacts discussed in stakeholder consultation include:

- Decrease in season length
- Decrease in amount and quality of snow
- Unreliable forecasted snow amounts potentially leading to smaller operating window, decreased number of patrons
- Unreliable ice conditions, impacts on trails that require crossing waterbodies
- Increased snowmaking requirements, need for upgraded equipment
- Increased water consumption requirements for snowmaking
- Increased operating costs (e.g., energy usage for snowmaking)
- Possible damage to equipment (skis, snowboards, snowmobiles) in less-than-ideal snow conditions
- Access routes to popular snowmobile locations may become unsuitable (e.g., cannot leave from regular locations due to lack of snow at lower elevations)
- Increased weathering to roads and transportation infrastructure in winter due to freeze-thaw
- Increased safety events from unstable snow and ice conditions
- Increased stress on emergency management organizations, vehicles, equipment, and facilities
- Increased/more experience insurance requirements following damage

Precipitation related impacts discussed in stakeholder consultation include:

- Increase in winter melting events and flooding from winter rainfall and rain on snow

- Washout, flood damage to trails following heavy precipitation (on and off season)
- Ice buildup (freezing rain or rain falling on frozen ground) on trails/slopes impacting safety of activities
- Structural and aesthetic facility damages (e.g., flooding, undermining foundation, structural and envelope damage)
- Structural loading from ice on buildings and other infrastructure (e.g., trail bridges, chairlift, power and communications equipment)
- Power outages resulting from ice loading during freezing rain events
- Increased maintenance and repair costs
- Increased/more expensive insurance requirements following damage
- Flood damage, undermining, and/or washouts of roads and other transportation routes resulting in impacts to driving conditions and supply chain
- Sewer system backup
- Undermining of foundation and foundation drains
- Flood damage to transportation routes creating access issues for emergency responders

Key Findings

Stakeholders indicated that the greatest and highest priority risks to the Winter tourism industry are related to:

- The impact of temperature on snow accumulation and season length;
- The impact of precipitation on snow/trail conditions and infrastructure; and,
- Wind and storm events which cause disruptions to both operations and travel.

While some of these impacts are outside the control for operators, for example travel disruptions or damage to shared snowmobile trails, there is potential for major operational disruptions that could require alternative or backup operating plans.

3.4 Outfitting Industry

The Newfoundland and Labrador outfitting industry is known to be among the best in North America and contributes millions of dollars to the provincial economy on an annual basis (GovNL, 2020b). There are nearly 200 outfitting operations throughout the province, the majority of which cater to the hunting or fishing of key species including Moose, Caribou, Bear, Atlantic Salmon, and Brook Trout. Each operation generally consists of a remote lodge, often located along a river, that provides an “all-inclusive” style trip including transportation within the province, meals, and oftentimes other experiences such as canoeing, hiking and backpacking, or ATV trips.

In recent years, population declines in some of the key species have sparked widespread regulations on the industry including smaller quotas, more restricted hunting areas, and tighter regulations for infrastructure development (DFO 2019; GovNL, n.d). These changes, combined with the impacts that outfitters face as a result of climate change, have placed pressure on the industry to become proactive in adaptation. Industry stakeholders

emphasized the importance of developing relationships with federal and provincial organizations, such as DFO, to collect data and communicate observed environmental conditions and trends.

Critical Assets

The following assets critical for the outfitting industry were considered for the impact analysis, as identified through stakeholder engagement:

Outfitting Experience
- Hunting
- Fishing
- ATVs and Trails
- Hiking/backpacking

Species and Environment
- Big game (Moose, Caribou, Bear)
- Fish (Salmon, Trout)
- Food availability
- Habitat

Health and Safety
- Human Health
- Emergency Planning and Preparedness
- Insurance requirements

Infrastructure
- Wharves, Docks
- Accommodations and other buildings (e.g., storage)
- Power/Communications
- Water/Sewer
- Off-grid energy

Transportation
- Ferry travel
- Air travel
- Provincial roads (driving conditions)
- Fly-in fly-out

Wind and Storms

Due to the remote nature of outfitting operations, extreme weather events can have significant consequences on day-to-day operations including transportation of visitors to and from camps, delivery of important supplies such as food and water, or accessibility for emergency responders. Operators noted that it can be extremely challenging to accommodate these situations as there are factors outside their control, such as limited transportation services to remote locations, but that it is crucial to have appropriate emergency preparedness plans ready for such situations.

Wind and storm related impacts discussed in stakeholder consultation include:
- Inclement weather limiting window for hunting/angling
- Possible disruption to services (importing supplies, transportation, communications)
- Damage to wharves, docks, and other coastal/riverine structures
- Downed power and communication lines
- Structural (wind) loading causing damage to facilities and other infrastructure
- Sewer backup and basement flooding
- Impact to essential supplies for remote operations (e.g., food, clean water, medical)

- Disruption to travel plans (more frequent air and ferry cancellations) resulting in increased number of reservation cancellations or delayed visit timeframe
- Washout of vulnerable access roads (not maintained by provincial entities)
- Increased risk of emergency during storms
- Increase stress on emergency organizations, vehicles, equipment, and facilities
- Accessibility of remote locations for emergency responders during storm events
- Insurance requirements as storms become more frequent and intense

Riverine Environment

Outfitting lodges are often located nearby or adjacent to rivers, or other water bodies, that provide easy access to fishing, facilitate travel (e.g., by float plane or boat), and add to the nature-based experience that tourists often seek during remote outfitting trips. While there are many benefits to being located nearby waterbodies, there are also numerous challenges related to flooding and erosion that can result in infrastructure damage. These risks must be considered before upgrading or installing new infrastructure near a flood prone watercourse, particularly with climate change.

Impacts related to the riverine environment that were discussed in stakeholder consultation include:

- Changing river water levels impacting habitat, migration routes of fish and animals
- Warmer water temperatures in important salmon rivers and other waterbodies reducing productivity and reproduction
- Unreliable river levels, particularly during warm temperatures, that may impact timing/suitability of fishing locations
- Unpredictable ice jamming and river flooding potentially impacting camps
- Damage and undermining of wharf and dock structures, impacts to accessibility
- Saturated ground making hiking and/or ATV use difficult or impractical
- Flooding, damage, undermining and/or washouts to roads or other transportation infrastructure. Resulting impacts to supply chain
- Unpredictable river flooding leading to infrastructure damage and flooding of facilities
- Flooding, undermining, and other damages to wharves and docks
- Damaged/flooded electrical and communications equipment
- Flood damage, undermining, and/or washouts of coastal routes or routes adjacent to rivers
- Suitability of infrastructure for docking boats during unpredictable river levels
- Exposure to rapidly changing water levels
- Coastal/riverine erosion and flood damage creating access issues for emergency responders
- Increased/more expensive insurance requirements

Temperature and Precipitation

Shifts in temperature and precipitation will impact ecosystem dynamics. Increased temperatures place heath stress on big game such as moose, impacting their food intake and productivity (Rustad et. al., 2012). In addition to this, increasing temperatures will lead

to an increase in invasive species appearing in the province, meaning that already stressed animals may be susceptible to even more pests and disease. Temperature changes, as well as drought conditions, will impact water temperatures and water levels in rivers. This can lead to frequent river closures as these complex systems are heavily regulated to maintain the health of the salmon population.

Freezing rain, or rain falling on frozen ground, can restrict food availability among big game such as caribou which are not able to retrieve food from under the layers of frozen snow and ice. Precipitation will also impact the built environment, including flooding of transportation routes and lodge infrastructure, as well as damage to power and communications infrastructure.

Temperature and Precipitation related impacts discussed in stakeholder consultation include:

- Increased reproduction, dispersal, and distribution of insects, pests, and pathogens (invasive species)
- Increased heat stress on animals
- Increased river temperatures leading to decreased productivity in fish, river closures
- Increased exposure to extreme heat and heat waves
- Increased exposure to insects, pests (human health and safety)
- Increased operating costs for cooling requirements in buildings
- Increased exposure to wildfires
- Flood damage, undermining, and/or washouts of roads and other transportation routes further resulting in impacts to driving conditions or supply chain
- Increased weathering to roads and transportation infrastructure due to freeze-thaw, extreme precipitation events.
- Disruptions and cancellations in travel (air and ferry) due to intense precipitation events
- Increased number of cancellations or delayed visit timeframe due to disruptions in travel, particularly for remote locations
- Saturated ground making hiking and/or ATV use difficult or impractical
- Structural loading/damage to buildings and other infrastructure (e.g., trail bridges)
- Basement and main floor flooding, undermining of foundations
- Increased maintenance and repair costs
- Power and communications outages resulting from heavy precipitation, freezing rain events
- Sewer system backup
- Increased/more expensive insurance requirements following damage
- Damage to trees and plants from freezing rain, flooding (undermining root systems, suffocated roots from water and mud deposition)
- Food availability following freezing rain event (frozen ground)
- Damage to trees, plants, and other food sources
- Extreme runoff into rivers and lakes impacting fish habitat

Key Findings

Stakeholders indicated that the greatest and highest priority risks to the outfitting industry are related to:

- The impact of temperature on species abundance and distribution, as well as the overall experience for tourists
- The impact of precipitation on infrastructure and overall quality of the experience
- The impact of a changing riverine environment on operations (river closures)
- The impact of wind and storms which cause disruptions to both operations, travel, and essential services or supplies

While some of these impacts are outside the control for operators, for example travel disruptions or damage to shared snowmobile trails, there is potential for major operational disruptions that could require alternative or backup operating plans.

3.5 Impact Analysis Summary

The impacts presented above are those that were identified through consultation with stakeholders from each industry sector. It should be noted that this list is not inclusive, as there are numerous other specific climate-related impacts particularly to individual species that are highly uncertain and often dependant on an operator's specific location within the province.

The impacts presented are wide-reaching, covering possible impacts to the tourists, tourism businesses, as well as municipal infrastructure and other organizations that will indirectly affect operators, such as emergency management and transportation organizations. Presenting the risks in this way highlights the importance of a collective approach to climate change adaptation that is almost always more effective with communication and collaboration across organizations. Because tourism is a key driver of the provincial economy, it will be increasingly important for operators to build relationships across organizations in order to develop effective adaptation plans that will help promote a resilient industry.

Chapter 4 Learning and Development Tools

The data collected and summarized in the previous chapter, as well as a comparative review of tools developed by other jurisdictions, was used as a foundation to support the creation of learning and development tools presented herein. Tourism operators may apply these tools in order to identify top priority climate risks to their operations and plan for adaptation. Each of the tools has been developed such that Hospitality NL can individually distribute them to tourism operators in order to educate and promote climate resilience among its members.

A brief summary of each tool, including its contents and how it was developed, is included below. Each of the tools are included in the referenced Appendices.

Climate Change Projections and Data Sources Overview – Appendix A

A two-page PDF document has been created that provides a high-level overview of the climate change projections relevant to the Marine, Winter, and Outfitting tourism industry. The document has been prepared in a way that can be used as a stand-alone PDF, which Hospitality NL can distribute to operators for educational purposes, in lieu of distributing a lengthy report with detailed climate information. The document can be used on its own or accompanied by the additional tools described below.

Sector Specific Climate Change Impacts Overview – Appendix B

Summary PDF documents have been developed for each industry sector (i.e., Marine, Winter, and Outfitting) that provide an overview of the relevant climate parameters, high-level projected trends, and the potential resulting impacts that the industry may face as a result of climate change.

These documents consist of a two-page PDF for each industry sector and can be used by Hospitality NL as individual stand-alone documents that can be distributed to its applicable members for educational purposes. These documents are intended to communicate the importance of considering climate change in decision making.

Climate Change Adaptation Case Studies – Appendix C

Throughout the stakeholder engagement process, CBCL identified cases where climate change adaptation measures have been implemented by businesses or municipalities which have improved the resilience of their operations or infrastructure.
Adaptation measures were identified for the Marine and Outfitting industry, and are profiled in case studies in Appendix C. The two case studies are as follows:

- Marine – Harbour protection in Bay de Verde
- Outfitting – Data collection in partnership with DFO

Each of the case studies describe the business sector, operations involved, the purpose of the adaptation measures, as well as how they were implemented. The case study

description includes a summary of the benefits these initiatives are having and will continue to have on the industry going forward. The case studies further highlight the importance of developing relationships with key stakeholders for advancing adaptation, including municipalities or DFO.

The case studies are profiled individually in Appendix C and are also incorporated into the content of the Risk Assessment Tool for Operators (Appendix D).

Risk Assessment Tool for Operators – Appendix D

One of the key project outcomes was to develop a resource that operators could use as a tool to plan for climate change. The Risk Assessment Tool for Operators was created as a guideline for tourism operators to use in order to achieve the following objectives:

- Understand which climate parameters are relevant to their business;
- Understand the future projections for each relevant climate parameter identified;
- Identify the impacts and risks that climate change may have on their business, as they relate to each specific parameter;
- Prioritize risks according to which are most likely to impact their business and the severity of those impacts; and
- Understand the long-term benefits of investing in adaptation measures in the shorter term.

The tool walks the operator through a series of steps aimed at achieving the above objectives. As operators complete each step, they will fill out an accompanying workbook that is used to organize information and keep track of findings. Once each step is completed and the workbook is filled out, the operator will have conducted a risk assessment specific to their operation. The risk assessment process is intended to prioritize a short list of risks for consideration of investment in climate resilience measures.

Similar to the other learning and development tools, the Risk Assessment Tool for Operators was developed to be used as an individual document that does not require a detailed knowledge of climate science.

Chapter 5 Closing

This report presents the findings and outcomes from the Tourism Beyond Covid-19 - Climate Change Adaptation project for Hospitality Newfoundland and Labrador. Through stakeholder consultation, CBCL has identified climate change impacts to the Marine, Winter, and Outfitting tourism sectors. Based on the findings of the impacts analysis, learning materials have been developed that are intended to facilitate communication and understanding of key climate change topics among the Tourism sectors. Further, a Risk Assessment Tool was developed for tourism operators which can be used to identify operational risks to their businesses and prioritize investment in adaptation.

The tools developed are intended to be used by Hospitality NL to educate its members on the importance of taking a proactive approach to building climate change resilience into their operations.

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APPENDIX A

Climate Change Summary Document

Climate Change Summary for Tourism Operators in

Newfoundland & Labrador

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Temperature

Averages and Extremes

Daily average temperatures, daytime high temperatures, and nighttime low temperatures are projected to increase, with a steady rate of change through mid- to late-century (2050 to 2100). In general, the coldest temperatures are projected to increase fastest. The greatest change is expected in winter and projected changes show the largest increases in the Labrador interior and at high latitudes. Therefore, overall warmer temperatures are expected across Newfoundland and Labrador.

Frost and Freeze-thaw

The number of days with frost is expected to decrease, with the greatest change in regions and seasons with daytime temperatures projected to rise above near freezing. Changes in Labrador will be less drastic, as cold winter conditions will persist for longer. Changes in winter thaw events and freeze-thaw cycles are likely to follow a similar pattern, with increases in winter.

Precipitation

Average Precipitation

Mean daily precipitation is expected to increase throughout the province. In Newfoundland, widespread increases are expected by late century. Changes in Labrador are typically smaller, but also tend towards an increase. Despite uncertainty in the projections, precipitation is expected to increase in most locations and seasons by mid-century, and larger (nearly universal) changes are expected by the end of the century.

Precipitation Intensity

Precipitation intensity is expected to increase. Models predict intensity increases for all of Newfoundland in all seasons, with the greatest increases in winter and on the south coast. Changes in Labrador are generally smaller. There is notable uncertainty in mid-century projections, but by late century strong increasing trends emerge.

Freezing Rain

Future projections for freezing rain suggest an increase over most of Canada, based on the northern movement of the 0°C temperature boundary and of freezing rain-related weather systems. Freezing rain will increase over most of the province, but rising air temperatures will lead to a decrease in Eastern Newfoundland. The greatest relative increase is expected in Labrador.

Snow, Winter Rain, And Rain-on-snow

Less snow and more rain are projected in locations/season with average temperatures close to zero. These changes also mean more rain falling in winter on frozen ground, as well as rain-on-snow days, particularly in southern regions. An increase in total annual snowfall is projected for the Torngat Mountain region. High latitudes are expected to have an increase in snowpack density.

Wind and Storms

Hurricanes, Nor'Easters, and Winter Storms

A possible increase in the intensities of tropical (e.g., hurricanes) and extra-tropical (e.g., nor'easters) storms is anticipated, resulting primarily in increased precipitation rates. It is possible that winds and surge may increase, which would have more effect as sea levels rise along the south coast and would be particularly damaging for longer duration storms which can span several tidal cycles, such as Nor'easters.

Coastal and Oceanographic

Sea-level Rise And Flooding

The global mean sea-level is projected to rise 84 cm by the year 2100. Relative sea-level change will significantly vary across the province in part due to vertical land motion, varying from 10 cm in central Labrador to 71 cm in the south of Newfoundland by 2100. Land subsidence (sinking) in the south will increase local relative sea level rise, while land rebound (rising) in the north will buffer it.

Coastal Erosion/Deposition

Existing rates of coastal erosion are highly variable across the province, with the most change occurring in unconsolidated cliffs and beaches. Increases in erosion rates are anticipated in these areas due to changes in the processes that drive erosion (wind, waves, groundwater, and surface water). For example, the rise of extreme water levels will allow waves to get closer to cliffs, and projected increases in precipitation intensity will accelerate erosion from runoff.

Sea-water Temperature and Salinity

With climate change, sea temperatures are expected to increase throughout the region, in all seasons, and both on the surface and the bottom. Due to increases in precipitation over the ocean and ice melt, coastal salinity is expected to decrease in all seasons (except some deep-ocean areas in the south where it may increase).

Chemical Oceanographic Variables

Reduced vertical mixing is likely to reduce the nutrient supply from deeper waters. Dissolved oxygen will also be reduced, although this may be more localized (e.g., coastal), and acidity is projected to increase.

Icebergs

Projections for icebergs indicate a likely reduced occurrence in the Gulf of St. Lawrence (GSL) as well as the Newfoundland and Labrador Shelf/Slope (NLSS) in the near-term.

Terrestrial

River Water Quality, Ice Jams, Flooding

Increase in wash-off events from runoff caused by extreme precipitation are likely to negatively impact water quality. Water temperature in streams and rivers is likely to increase.

Flooding from ice jams has become more frequent and unpredictable in Atlantic Canada (Turcotte et al., 2019). Although increasing air temperatures will decrease river ice cover thicknesses, increased flows during freeze-up could allow for thicker ice and more severe ice-jam flooding.

Invasive Species, Pathogens, and Pests

Changing climate conditions will alter suitable habitats and competition dynamics. Among other factors, modified disturbance regimes have been shown to be conducive to invasive species, pathogens, and pests. Changes to sea temperatures may allow for marine invasive species to expand their range northward and deeper into the water column. In addition, changes to ocean currents may affect distribution patterns.

Wildfire

Drier conditions elsewhere in Canada are projected to contribute to increased number and extent of wildfires. Even if dry conditions were to remain unchanged in Newfoundland, changes to vegetation assemblages and disturbances may affect fire regimes.

APPENDIX B

Sector Specific Impact Overviews

Climate Change Impacts to Marine Tourism
Newfoundland & Labrador

Newfoundland & Labrador
Funded by the Department of Environment and Climate Change
Natural Resources Canada
Ressources naturelles Canada
Canada

Temperature

- While the entire province is projected to get warmer in the future, the rate of warming will be relatively higher at high latitudes (e.g., Northern Labrador).
- Number of days with frost are expected to decrease, while thaw events and freeze-thaw may increase in winter.

Key Potential Impacts

Exposure to extreme heat and heat waves	Shifting species, introduction of invasive species
Increased operating costs for cooling facilities	Possible shifting operating season or location

Precipitation

- Average daily precipitation is expected to increase throughout the province. In Newfoundland, widespread increases are expected by late century, whereas changes in Labrador are typically smaller.
- Precipitation intensity is expected to increase in all seasons, with smaller changes Labrador.
- Freezing rain will increase by mid-century (2050) over most of the province, but rising air temperatures will lead to a decrease in freezing rain towards the end of the century (near 2100).

Key Potential Impacts

Increased number of cancellations	Flooding
Quality of services (e.g., operating in rain)	Deposited sediment and debris
Health and safety	Power and communication outages
Road closures/washout	Increased repair and maintenance cost
Facility damage (structural/ aesthetic)	

Sea Level Rise

- The IPCC projects a global mean sea-level rise of 84 centimetres by 2100
- Relative sea-level change in NL will significantly vary across the province due to vertical land motion
    - Land is subsiding (sinking) in the south, which will increase local relative sea level rise (projected 71 cm SLR in south Newfoundland)
    - Land is rebounding (rising) in the north, which will decrease relative sea level rise (projected 10 cm SLR in central/north Labrador)

Key Potential Impacts

Increased flooding in low-lying areas	Long term suitability of infrastructure (e.g., wharves becoming unusable because of sea level rise)
Infrastructure damage (structural and aesthetic)	Damage to docked boats during storm surge
Undermining of infrastructure	

See Climate Change Adaptation Project Summary Report for climate summary references. To assess impacts to your operations, complete HNL's Risk Assessment Tool.

Climate Change Impacts to Marine Tourism
Newfoundland & Labrador

Newfoundland & Labrador
Funded by the Department of Environment and Climate Change Canada
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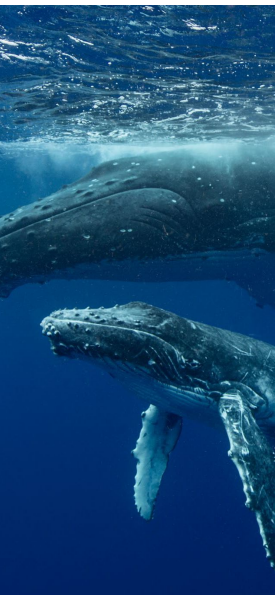
Canada

Coastal Erosion

- Existing rates of coastal erosion are highly variable across the province. Most change occurring in unconsolidated cliffs and beaches.
- Erosion rates are dependent on changing wind, waves, groundwater, and surface water. Sea level rise will allow waves to get closer to cliffs and increases in precipitation intensity will accelerate erosion from runoff.

Key Potential Impacts

Undermining of infrastructure	Increased damage or loss of coastal protection (e.g., breakwaters)
Aesthetic damage to coastal infrastructure and facilities	Damage to coastal habitats (e.g., bird nests)
Increased maintenance and repair costs	Human health and safety
Damage to coastal trails	



Oceanographic and Terrestrial Environment

- Sea temperatures are expected to increase throughout the region, in all seasons.
- Due to increases in precipitation over the ocean and ice melt, coastal salinity is expected to decrease (except some deep-ocean areas in the south where it may increase).
- Changes to ocean currents potentially affecting species distribution patterns.
- Decreases expected in pH and dissolved oxygen.
- Reduced occurrence of icebergs in the long term.

Key Potential Impacts

Changes in species migration patterns, shifting to new regions	Habitat and nutrient loss
Increased pests and disease	Changes in prey distribution and food competition
Changes in water temperature and quality, health impacts	Possible loss/reduction of natural attractions (e.g., icebergs, whales)

Wind and Storms

- A possible increase in the intensities of tropical (e.g., hurricanes) and extra-tropical (e.g., nor'easters) storms.
- Possible future increase in wind speeds.

Key Potential Impacts

Increased tour cancellations or delays	Infrastructure damage
Unpredictable schedule	Increased maintenance and repairs
Travel disruptions	Health and Safety of tourists and workers
Damages to roads, power outages	

See Climate Change Adaptation Project Summary Report for climate summary references. To assess impacts to your operations, complete HNL's Risk Assessment Tool.

Climate Change Impacts to Winter Tourism
Newfoundland & Labrador

Funded by the Department of Environment and Climate Change Canada
Natural Resources Canada | Ressources naturelles Canada

Temperature

- Daily average temperatures, daytime high temperatures, and nighttime low temperatures are projected to increase.
- Coldest temperatures are projected to increase fastest. The greatest change is expected in winter and projected changes show the largest increases in the Labrador interior and at high latitudes.
- Cold extremes are expected to decrease, whereas warm extremes will increase, in intensity and frequency.
- Number of days with frost are expected to decrease, while thaw events and freeze-thaw may increase in winter.

Key Potential Impacts

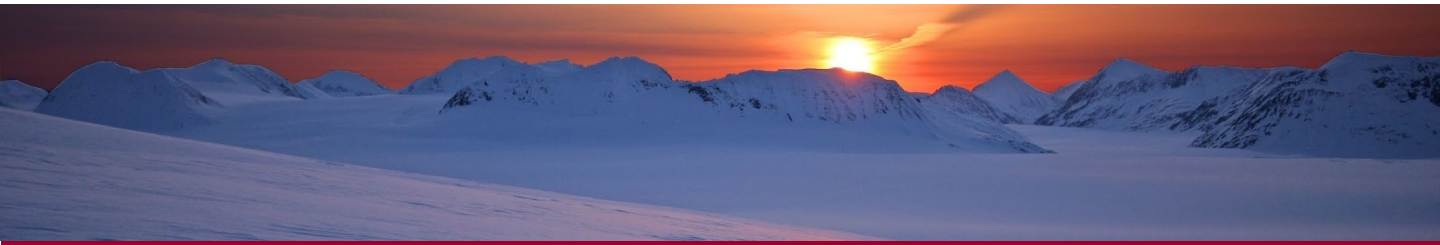
Poor snow conditions	Snow making capabilities and costs
Reduced season length	Decreased number of users due to perception of poor conditions
Health and safety of visitors	Winter melting events impacting snow conditions
Reliability of forecast	
Unreliable ice conditions (lakes, ponds, river crossings)	

Precipitation (Rain and Freezing Rain)

- Average daily precipitation is expected to increase throughout the province. In Newfoundland, widespread increases are expected by late century. Changes in Labrador are typically smaller.
- Precipitation intensity is expected to increase in all seasons with smaller expected changes in Labrador.
- Freezing rain will increase by mid-century (2050) over most of the province, but rising air temperatures will lead to a decrease in freezing rain towards the end of the century (2100).

Key Potential Impacts

Ice buildup on trails/slopes/ski hills following freezing rain events	Road closures/washout
Health and safety of visitors	Deposited sediment and debris
Potential extended closures	Increased repair and maintenance costs
Loads on buildings	Damaged electrical and communication equipment
Structural and aesthetic damage to facilities	



See Climate Change Adaptation Project Summary Report for climate summary references. To assess impacts to your operations, complete HNL's Risk Assessment Tool.

Climate Change Impacts to Winter Tourism
Newfoundland & Labrador

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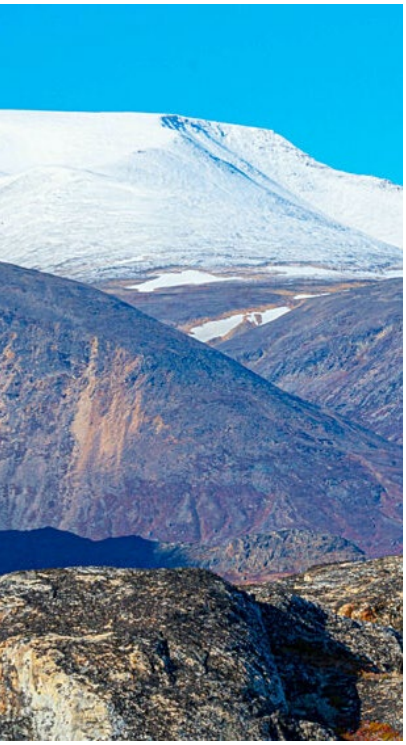

Precipitation (Total Seasonal Snow, Winter Rain, and Rain on Snow)

- In locations/seasons with mean temperatures close to zero, there is likely to be less snow and more rain, but snow cover duration or snowfall extremes may continue to occur even as average conditions decrease.
- An increase in total annual snowfall is projected for the Torngat Mountain region.
- High latitudes are expected to have an increase in snowpack density.
- These changes also mean more rain falling in winter on frozen ground, as well as rain-on-snow days, in particular in southern regions.

Key Potential Impacts

- Reduced seasonal snow accumulation
- Washout and flood damage to trails
- Rain on snow creating slush
- Reliability of forecast
- Health and safety of visitors
- Structural damage to facilities from heavy rain on snow loads
- Facility flooding
- Deposited sediment and debris
- Increased repair and maintenance costs

Wind and Winter Storms

- A possible increase in the intensities of extra-tropical storms (e.g., nor'easters, winter storms).
- Possible future increase in wind speeds.

Key Potential Impacts

- Forecast reliability
- Unpredictable operating schedule
- Increased frequency of closure or delays
- Downed trees and debris on trails
- Structural and aesthetic damage to facilities
- Structural and aesthetic damages to facilities
- Reduced visibility
- Health and safety of visitors
- Power and communications interruption

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Climate Change Impacts to Outfitting Newfoundland & Labrador

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Temperature

- Daily average, daytime high, and nighttime low temperatures are projected to increase.
- The entire province is projected to get warmer, although the rate of warming will be higher at high latitudes (e.g., Northern Labrador).
- Number of days with frost are expected to decrease, while thaw events and freeze-thaw may increase in winter.

Key Potential Impacts

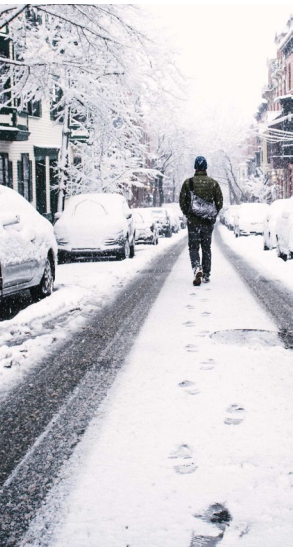
- Health and safety of visitors and operators (e.g., heat waves, ticks)
- Water temperature and quality changes, unreliable angling season
- Increased exposure to wildfires
- Heat stress on animals, shifting species long term
- Increase in invasive species/ and pests

Precipitation (Rain and Freezing Rain)

- Average daily precipitation is expected to increase throughout NL. Changes in Labrador are typically smaller.
- Precipitation intensity is expected to increase in all seasons. Changes in Labrador are typically smaller.
- Freezing rain will increase by mid-century (2050) over most of the province but rising air temperatures will lead to a decrease in freezing rain towards the end of the century (2100).

Key Potential Impacts

- Travel delays, increased number of cancellations
- Possible disruption to supply chain
- Reduced quality of service offering (e.g., heavy rain)
- Damage to facilities
- Road closures/washout
- Flooding of facilities
- Increased repair and maintenance costs
- Damaged electrical and communication equipment



Precipitation (Snow, Winter Rain, and Rain on Snow)

- In locations/seasons with mean temperatures close to zero, there is likely to be less snow and more rain, although extreme may still occur.
- An increase in total annual snowfall is projected for the Torngat Mountain region.
- More rain falling in winter on frozen ground, as well as rain-on-snow days, in particular in southern regions.
- High latitudes are expected to have an increase in snowpack density.

Key Potential Impacts

- Damage to trees and plants impacting food availability
- Runoff into lakes and rivers impacting water quality, fish habitat
- Reduced visibility
- Health and safety of visitors
- Melting events causing flooding and infrastructure damage

See Climate Change Adaptation Project Summary Report for climate summary references. To assess impacts to your operations, complete HNL's Risk Assessment Tool.

Climate Change Impacts to Outfitting
Newfoundland & Labrador

Newfoundland & Labrador
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Ice Jams and River Flooding

- Flooding from ice jams has become more frequent and unpredictable in Atlantic Canada.
- Although increasing air temperatures will decrease river ice cover thicknesses, increased flows during freeze-up could allow for thicker ice and more severe ice-jam flooding.
- Higher intensity precipitation, more winter rainfall, and sea-level rise combined with changes to storms may increase flood risk. Changes to snow accumulation and mid-winter thaw events may also have an impact on flood risk.

Key Potential Impacts

- Undermining/washouts of infrastructure
- Aesthetics of coastal infrastructure
- Damage to coastal trails
- Damage to coastal habitats (e.g., bird nests)
- Human health and safety

Terrestrial Environment (Habitat and Invasive Species)

- Changing climate conditions will alter suitable habitats, competition dynamics (e.g., relating to food).
- Changes to invasive species, pathogens, and pests.
- Possible increased wildfire.
- Increase in wash-off events from runoff caused by extreme precipitation are likely to negatively impact water quality. Water temperature in streams and rivers is likely to increase (DFO, 2013).

Key Potential Impacts

- Shifting species
- Increased pests and disease
- Habitat damage and nutrient loss
- Food competition among species
- Changes in water temperature and quality impacting species health

Wind and Storms

- A possible increase in the intensities of tropical (e.g., hurricanes) and extra-tropical (e.g., nor'easters) storms.
- Possible future increase in wind speeds.

Key Potential Impacts

- Travel disruptions, cancellations, or delays
- Infrastructure Damage
- Health and Safety of visitors
- Increased maintenance and repair costs
- Damage to electrical and communications infrastructure

See Climate Change Adaptation Project Summary Report for climate summary references. To assess impacts to your operations, complete HNL's Risk Assessment Tool.

APPENDIX C

Case Studies

Incorporating Resilience Into Key Coastal Infrastructure:

A Case Study at Bay de Verde Harbour

Newfoundland & Labrador

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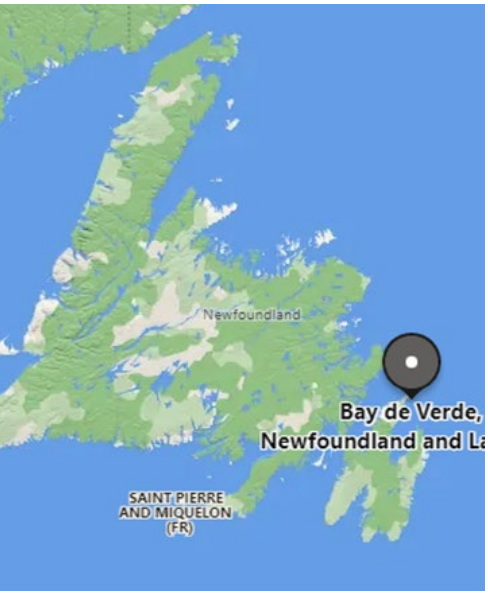
Industry Sector	Marine Tourism
Location	Bay de Verde Harbour
Climate Change Risks	Flooding and infrastructure damage from Sea Level Rise, Storm Surge, and Wave Action



BAY DE VERDE CODFISH EXPERIENCE

Background

The Town of Bay de Verde is located on the northern tip of the Baccalieu Trail and is the northernmost community in Conception Bay. The town has approximately 400 residents and is primarily known as a fishing village, but over the last several years has been placing significant emphasis on growing its presence within the provincial tourism industry. Many of the town's tourism operations rely on its working harbour, which is also used as a boat launch for individuals and local businesses, as well as an event space. The harbour and its infrastructure can be described as follows:

- A marginal wharf parallel to the new fish plant.
- A concrete wharf structure protruding in a north-westerly direction into the basin on the eastern side of the harbour just north of the fish plant.
- A secondary basin sheltered by the concrete wharf north of the harbour entrance and the concrete wharf protruding into the basin on the eastern side of the harbour.
- A number of floating docks in the north basin including a boat launch in the northeast corner, and a slipway (wooden deck) south of the protruding wooden wharf supporting the various floating docks.
- Marginal wharf and parking facilities along the north basin.
- A crib structure with a concrete deck protected by armour stone along the southern extent of the harbour to shelter the facility from Atlantic swell.

Local Tourism

Bay de Verde is located approximately 10 km south of Baccalieu Island, the largest seabird island in Newfoundland and Labrador. Species such as the Atlantic Puffin are found in abundance on the island, as well as significant marine life such as humpback whales, sharks, and codfish in the surrounding waters. The area's wildlife makes the tourism destination a unique location for boat tours, food and culinary experiences, and other adventure activities.

The Bay de Verde Codfish Experience is one tourism draw to the community offering a historical tour of the town's rich fishing history, a private cod fishing experience launched from the town's harbour, followed by an oceanside seafood dinner.

Alongside small tourism operators, the town hosts several festivals and events on its busy wharf, including "Festival on the Wharf", held each summer. This festival involves live music, food trucks, vendors, and performances all taking place on the Bay de Verde wharf. The wharf has become a crucial piece of infrastructure for the town, not only providing livelihoods for those in the fishing industry but allowing the town to draw thousands of tourists each year for its unique oceanside experiences.

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Incorporating Resilience Into Key Coastal Infrastructure:

A Case Study at Bay de Verde Harbour

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Climate Change Impacts

The Bay de Verde Harbour is exposed to swells from the Atlantic Ocean approaching from the east and southeast, and wind waves generated over Conception Bay approaching from the south. Local extreme water levels are caused by the combined effects of tides, storm surge, and sea level rise. Sea level rise in the area is expected to reach 0.43 m above the year 2000 level by 2065. This, combined with increasing winds, storms, and storm surge events, means the harbour will continue to be exposed to more extreme weather and ocean conditions throughout the coming decades.

Adaptation

The harbour entrance is sheltered by two breakwaters on the north and south sides which protect the wharf from wave run up and associated damages. Throughout 2015 – 2018, DFO, who operates the harbor, has commissioned wave transformation studies. These studies assessed the current wave climate as well as future conditions with climate change, in order to recommend and implement upgrades that will better protect the harbor from wave action and overtopping throughout its design life.

This work included upgrading the armor stone protection at both breakwaters to better protect the harbour against wave action and overtopping. Along with climate change projections and local conditions such as ice thickness, the wave studies were used to inform the redesign of the breakwater armour stone, including the optimum elevation of the structure to limit damage.

These upgrades provide an example of incorporating climate resilience measures into coastal structures to proactively mitigate the impacts of climate change and avoid costly repairs or full replacement of the structure in the future. These types of measures help maintain the economic viability of harbour operations in coastal communities and ensure a sustainable future where operators can be confident in the infrastructure that is critical for the viability of their businesses or events.

Conclusion

This case study highlights the importance of climate resilient coastal infrastructure to support businesses, towns, and economies of rural coastal communities. While this example focuses on infrastructure that is owned by a government organization, the same principals can be applied to wharves owned by individual tourism operators.

See Climate Change Adaptation Project Summary Report for climate summary references. To assess impacts to your operations, complete HNL's Risk Assessment Tool.

Data Collection Partnerships for a More Sustainable Angling Industry:

A Case Study at Salmon Rivers

Funded by the Department of Environment and Climate Change

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Industry Sector	Outfitting Tourism
Location	Salmon Rivers throughout Newfoundland
Climate Change Risks	River closures, species vulnerability

Background

There are over 50 outfitting lodges throughout Newfoundland and Labrador that offer salmon fishing experiences to visitors between June and September each year. In recent years, the impacts of climate change have become increasingly prevalent during the fishing season, with low water levels, warmer water temperatures, and fewer fish returning to spawn in salmon rivers each year.

The provincial outfitting industry is one of the largest sources of tourism revenue for the province, welcoming thousands of visitors each year from all over the world. Salmon is one of the most popular species that attracts visitors to the province, making the industry highly vulnerable to shifts in the heath of Atlantic Salmon stocks.

In recent years, the industry has had to adapt to changing salmon stocks by working with DFO to find a solution that allows visitors to experience salmon angling in the province.

Climate Change Impacts

Water temperature has been cited as the most important factor affecting survival of salmon during catch and release season. Studies by DFO have indicated that when temperatures reach above 20°C, adult salmon become lethargic as their energy is re-directed to meet basic metabolic demands such as respirating and blood circulation. External sources of stress, such as the exhaustive physical demand experienced during angling, can be detrimental to the species if already vulnerable from thermal stress.

Adaptation Measures

Recent studies by DFO have sought to identify the optimal window when catch and release salmon angling can reasonably take place without placing the species in duress. Conversely, these studies have identified critical temperature thresholds that can be used to trigger in-season closures of the recreational fisheries.

In-season closure of rivers can be detrimental for nearby outfitting lodges whose services center around salmon angling. For this reason, when water temperatures are high, DFO has elected to close rivers to salmon angling for periods of time throughout the day when temperature parameters are near the critical level, rather than closing rivers altogether. The timespan between one hour before sunrise and 10 a.m., when temperatures remain low relative to daytime highs, remains open for salmon angling. While the hours from 10 a.m. to one hour before sunrise the next morning are closed to angling to protect the species during the warmest hours of the day.

Continued...

See Climate Change Adaptation Project Summary Report for climate summary references. To assess impacts to your operations, complete HNL's Risk Assessment Tool.

Data Collection Partnerships for a More Sustainable Angling Industry:

A Case Study at Salmon Rivers

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Adaptation Measures

This approach to river closures has allowed angling to continue without causing significant harm to the species, ensuring that outfitting lodges can continue to offer their normal services and remain profitable.

Most outfitting lodges have further adapted to offer additional excursions to guests throughout the remainder of the day including ATV tours, hiking, and culinary experiences.

This form of adaptation heavily relies on the relationship between outfitters and DFO. Outfitters maintain a working relationship with DFO where communication remains open, concerns are communicated, and both parties work towards mutually agreeable solutions. This working relationship between the two groups is further promoted through data collection (e.g., water level, temperature) by outfitters, which is passed on to DFO. Because DFO would not necessarily have the resources to collect such a wide range of onsite data, this arrangement allows DFO to use measured data to determine if rivers are safe for operations, as opposed to relying on models and assumptions.

Conclusion

Through strong partnerships, members of the angling industry are working with DFO to collecting data on rivers that may ultimately avoid unnecessary closures. The industry has further adapted by offering alternative experiences during daytime high temperatures which coincide with river closures for angling, when salmon are most vulnerable.

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