Gear Tending Time Frames in the Arctic and Atlantic Canada: Conservation Considerations in Selected Longline and Gillnet Fisheries

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GEAR TENDING TIME FRAMES IN THE ARCTIC AND ATLANTIC CANADA: CONSERVATION CONSIDERATIONS IN SELECTED LONGLINE AND GILLNET FISHERIES

by

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Abstract

Prodaehl, A.W., and Burt, A. 2026. Gear Tending Time Frames in the Arctic and Atlantic Canada: Conservation Considerations in Selected Longline and Gillnet Fisheries. Can. Manuscr. Rep. Fish. Aquat. Sci. 3315: viii + 69 p. https://doi.org/10.60825/b1q0-w543

This report reviews conservation considerations associated with gear tending time, commonly referred to as soak time, in the scientific literature relating to longline and gillnet fisheries in the Arctic and Atlantic Canada. Soak time, defined as the period between gear deployment and retrieval, is regulated under the *Atlantic Fishery Regulations, 1985*, which currently prohibit leaving gear unattended for more than 72 hours (h). Fisheries and Oceans Canada (DFO) is exploring amendments to allow flexibility in soak time where conservation objectives are not compromised. The review synthesizes literature on ecosystem-level and catch-related impacts of soak time across five representative species: Arctic Char (*Salvelinus alpinus*), Atlantic Cod (*Gadus morhua*), Swordfish (*Xiphias gladius*), Atlantic Halibut (*Hippoglossus hippoglossus*), and Greenland Halibut (*Reinhardtius hippoglossoides*). Findings indicate that extended soak times increase entanglement risk for marine mammals, turtles, and birds, contribute to ghost gear formation, and accelerate catch degradation and unaccounted mortality. Effects on total catch and catch-per-unit-effort (CPUE) are variable and often non-linear, with longer soak times generally associated with increased bycatch and catch spoilage rather than improved yield. Mitigation measures such as gear modifications, spatial or temporal closures, and alternative bait or hook designs are discussed, though quantitative cost-benefit analyses remain limited. This report highlights significant knowledge gaps, particularly regarding cumulative impacts and species-specific responses, underscoring the need for further research before regulatory changes are implemented.

Résumé

Prodaehl, A.W., and Burt, A. 2026. Gear Tending Time Frames in the Arctic and Atlantic Canada: Conservation Considerations in Selected Longline and Gillnet Fisheries. Can. Manuscr. Rep. Fish. Aquat. Sci. 3315: viii + 69 p. https://doi.org/10.60825/b1q0-w543

Le présent document passe en revue les considérations de conservation associées à la surveillance des engins (ou à leur durée d’immersion) qui sont énoncées dans la documentation scientifique portant sur les pêches à la palangre et au filet maillant pratiquées dans les eaux canadiennes de l’Arctique et de l’Atlantique. La durée d’immersion d’un engin, définie comme le temps s’écoulant entre le déploiement et la récupération de celui-ci, est assujettie au *Règlement de pêche de l’Atlantique de 1985*, en vertu duquel il est actuellement interdit de laisser un engin de pêche dans l’eau sans surveillance pendant plus de 72 heures (h). Pêches et Océans Canada (MPO) envisage d’apporter des modifications en vue de permettre une marge de manœuvre quant à la durée d’immersion lorsque les objectifs de conservation établis ne sont pas compromis. Ce document fait la synthèse de l’information trouvée dans la documentation sur les effets de la durée d’immersion en ce qui concerne l’écosystème et les prises pour cinq espèces représentatives, à savoir l’omble chevalier (*Salvelinus alpinus*), la morue franche (*Gadus morhua*), l’espadon (*Xiphias gladius*), le flétan de l’Atlantique (*Hippoglossus hippoglossus*) et le flétan du Groenland (*Reinhardtius hippoglossoides*). Les résultats indiquent qu’une durée d’immersion prolongée augmente le risque d’empêtrement pour les mammifères marins ainsi que les tortues et les oiseaux de mer, favorise la présence d’engins fantômes, accélère la dégradation des prises et contribue aux mortalités non comptabilisées. Les effets sur les prises totales et les captures par unité d’effort (CPUE) sont variables et souvent non linéaires; les durées d’immersion prolongées sont généralement associées à une augmentation des prises accessoires et de la détérioration des prises plutôt qu’à une amélioration du rendement. Les analyses coûts-avantages quantitatives demeurent limitées, mais le document aborde des mesures d’atténuation, telles que les modifications des engins, des hameçons ou des appâts, ainsi que les fermetures spatiales ou temporelles. Il met en évidence d’importantes lacunes dans les connaissances, particulièrement en ce qui concerne les effets cumulatifs et les résultats propres à l’espèce, soulignant la nécessité de poursuivre les recherches avant la mise en œuvre de changements réglementaires.

1. Introduction

Gear tending time, referred to as "soak time" herein, is the period between deployment and retrieval of fishing gear and a component of license conditions for commercial fisheries in Canada (Department of Justice 1985). The *Atlantic Fishery Regulations, 1985* (AFR) Section (s.) 115.2 currently prohibits any person from leaving fishing gear unattended in the water for more than 72 consecutive hours (h) to minimize loss of fishing gear, incidental mortality, the potential for gear conflict, and spoilage of catch (Department of Justice 1985). The AFRs currently do not use the specific wording "soak time" to describe the period of time in which gear should be removed from the water.

Soak time is an issue that has been the subject of limited study, especially for the smaller fisheries in this review. Research has rarely included soak times greater than 72 h, using standardized soak time to reduce impacts of long soak times on catch and bycatch (Bérubé *et al.* 2000; DFO 2010, 2014c; Gallagher and Dick 2010; Gallagher *et al.* 2021; Lea *et al.* 2023). Nevertheless, enough information exists to identify general conservation considerations related to soak time in longline and gillnet fisheries.

Consistent with its Forward Regulatory Plan 2019-2021, Fisheries and Oceans Canada (DFO) is pursuing an amendment to the AFR s.115.2 to provide for flexibility in fixed gear tending time period within licence conditions, on a fishery-by-fishery basis, where conservation objectives would not be compromised or could be achieved through other means (DFO 2019a). To support that pursuit, this literature review addresses the conservation considerations associated with longline and gill net soak times and variation in those considerations across fisheries for representative species in the Arctic Region and select parts of Atlantic Canada, chosen for their financial importance and data availability:

- Arctic Char (*Salvelinus alpinus*) – Arctic Region
- Atlantic Cod (*Gadus morhua*) – Newfoundland and Labrador Region
- Swordfish (*Xiphias gladius*) – Newfoundland and Labrador Region, Maritimes Region
- Atlantic Halibut (*Hippoglossus hippoglossus*) – Newfoundland and Labrador Region, Maritimes Region
- Greenland Halibut (*Reinhardtius hippoglossoides*) – Arctic Region, Newfoundland and Labrador Region

A separate report examines the effects of soak time for pots and traps (Clark *et al. In Press.*).

2. Methods

Using the objective provided by DFO in their request for proposal (Solicitation No. 30006029), North/South Consultants Inc. (NSC) performed a search of the extant literature for articles pertinent to the topic of soak time as it relates to the Ecological and Catch-related Conservation Concerns listed by DFO. Search tools used included Canadian Science Advisory Secretariat (CSAS), the Fishery and Oceans Canada Library, Google Scholar, ScienceDirect, Elsevier, SciHub, and documents already stored in NSC's data hub, EndNote©. Online science directories generally provide a cross-referenced list of papers that cite, or are cited by, other articles. This provided additional articles related to the soak time topic, beyond the original search parameters, which could provide additional supporting information.

Once an initial pool of resources was built, articles and reports were screened for their relevance to the topic. This screening process helped to identify data gaps as well as create a list of species which:

- Were representative of the fisheries of the Maritime, Newfoundland and Arctic Regions
- Are currently actively fished in either commercial or exploratory fisheries in Atlantic Canada
- Comprise sufficient data to include in the literature review.

This list of species was provided to DFO for comment and approval before analysis and writing commenced. DFO's Soak Time Amendments Working Group reviewed the species list. Once the species list was reviewed by the Soak Times Amendments Working Group, further screening of the resources occurred to remove outdated sources that lacked robust controls. With regard to Canadian Government publications, CSAS was used to identify any updates to existing resources, in which case older documents were replaced with the latest iteration/version.

Information was then extracted from the resources and pooled for analysis. In this way, conflicting results were recognized and considered, and further data gaps were identified. Data were collated, units standardized, and the results presented within the text. Where applicable, conflicting results were reported alongside each other to identify variability, data deficiencies, or weak conclusions in order to provide perspective with regard to the results of the literature review.

DFO Reviewers suggested further literature as per their areas of expertise.

3. Background

3.1 Longlines

Longlines consist of a long horizontal main line, with branch lines or 'snoods' or 'gangions' attached at intervals along the main line (Figure 1). Each branched line is fitted with a baited hook. Bait varies but is often frozen fish or squid, depending on the target species of the fishery (Brazner and McMillan 2008; DFO 2007; Løkkeborg *et al.* 2010). Hook shape and size can also vary to aid in the selectivity of the target fishery (DFO 2019c; Løkkeborg *et al.* 2010). Longlines are currently used more frequently in Atlantic fisheries than Arctic fisheries (DFO 2007).

Longlines may be deployed suspended from or floating on the surface, to target pelagic fishes, floating off the bottom at varying depths (semi-pelagic) or on the sea floor (demersal) to target groundfish (Figure 1).

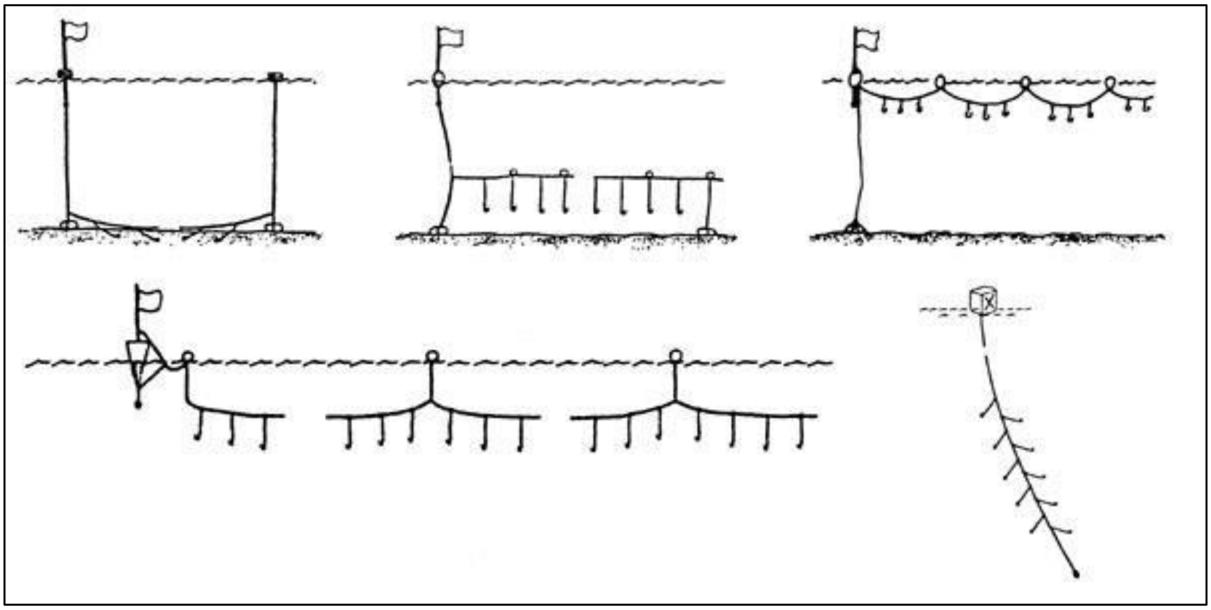

Figure 1. Pelagic and demersal longline configurations (FAO 2024).

As technologies and conservation efforts evolve, upper limits of hook numbers and line lengths may change; however, as of 2007, some vessels that operate longlines may have up to 40,000 hooks set and baited every day (DFO 2007). In general, pelagic longlines tend to have fewer hooks with longer mainlines (up to 100 kilometres (km) long) while demersal lines tend to be shorter (up to 15 km in length) but have denser hook placement (DFO 2007). The configuration of the longline varies with the target fishery (Table 1), and with the area being fished, therefore there is likely variation in the impact of soak time among fisheries. For example, Greenland Halibut longlines in Northwest Atlantic Fisheries Organization (NAFO) subarea (SA) 0 range from 4,000 to 8,000 hooks, whereas the 2J3KL Northern Cod Fishery may employ up to 15,000 hooks (DFO 2024a,b).

Table 1. Species targeted via longline in Atlantic and Arctic Canada (DFO 2007, 2009a, 2014b, 2016ab, 2018ac, 2021b, 2024bi).

Demersal	**Type**	**Pelagic**	**Type**
Atlantic Zone			
Greenland Halibut, *(Reinhardtius hippoglossoides)**	Directed and Multi species	Yellowfin Tuna (*Thunnus albacares)*	Directed
Atlantic Cod *(Gadus morhua)**	Directed and Multi species	Bigeye Tuna *(Thunnus obesus)*	Directed
White Hake *(Urophycis tenuis)*	Multi species	Bluefin Tuna *(Thunnus thynnus)*	Directed and Multi species
Atlantic Halibut *(Hippoglossus hippoglossus)**	Directed and Multi species	Swordfish *(Xiphias gladius)**	Directed
Skates (Rajidae family)	Directed and Multi species		
Haddock *(Melanogrammus aeglefinus)*	Multi species		
Pollock *(Pollachius pollachius)*	Multi species		
Arctic Region			
Greenland Halibut *(Reinhardtius hippoglossoides)**	Directed		

* Selected as a focus species for this report

3.2 Gill Nets

Gill nets consist of panels of fishery-specific mesh sizes and can be set up in a variety of configurations to help target particular species and sizes of fish (Table2; Government of Newfoundland and Labrador 2001; DFO 2019c; FAO 2024; Zhu *et al.* 2024). Gill nets are designed to be nearly invisible in the water, and to ensnare fish by the gills where they are held until the net is retrieved (Bycatch Solutions Hub 2024). Gill nets are attached to floating buoys by vertical ropes which can be altered to set the fishing depth (Bycatch Solutions Hub 2024; DFO 2019c; FAO 2024). Varying the depth and orientation of the set can also help to increase selectivity toward the target catch. Benthic gill nets, sometimes known as trammel nets or set gill nets, are set at the bottom of the ocean floor, while pelagic and mid-pelagic gill nets drift suspended in the water column (Figure 2; Zhu *et al.* 2024). Gill nets may be baited with a variety of bait species, in a variety of configurations such as bagged, frozen, or thawed, to increase selectivity and decrease the potential for bycatch (Løkkeborg 1990; Løkkeborg *et al.* 2014).

Studies involving gillnets often standardize soak time in order to study the effects of other variables such as mesh size or gillnet length, and there are often other confounding factors present, such as time of day, weather, water clarity, target species and more (Jensen 1986; Shawyer and Medina Pizzali 2003; Askey *et al.* 2007; Zhu *et al.* 2024).

Table 2. Species targeted via gill net in Atlantic and Arctic Canada (Bycatch Solutions Hub 2024; DFO 2007, 2014b, 2018a, 2019c, 2021bc; Government of Newfoundland and Labrador 2001).

Demersal	**Type**	**Pelagic**	**Type**
Atlantic Zone			
Greenland Halibut (*Reinhardtius hippoglossoides)* *	Multi species	Atlantic Herring (*Clupea harengus*)	Directed
Atlantic Cod (*Gadus morhua)* *	Multi species	Atlantic Mackerel (*Scomber scombrus*)	Directed
Haddock (*Melanogrammus aeglefinus)*	Multi species		
Pollock (*Pollachius pollachius)*	Multi species		
Atlantic Halibut (*Hippoglossus hippoglossus*) *	Multi species		
Lumpfish (*Cyclopterus lumpus*)	Directed		
Skates *(*Rajidae family)	Directed and Multi species		
Winter Flounder (*Pseudopleuronectes americanus*)	Directed and Multi species		
American Plaice (*Hippoglossoides platessoides*)	Multi species		
Silver Hake (*Merluccius bilinearis*)	Multi species		
White Hake (*Urophycis tenuis*)	Multi species		
Arctic Region			
Greenland Halibut (*Reinhardtius hippoglossoides*) *	Directed	Arctic Char (*Salvelinus alpinus*; spring) *	Directed
Arctic Char (*Salvelinus alpinus*; summer) *	Directed		

* Selected as a focus species for this report

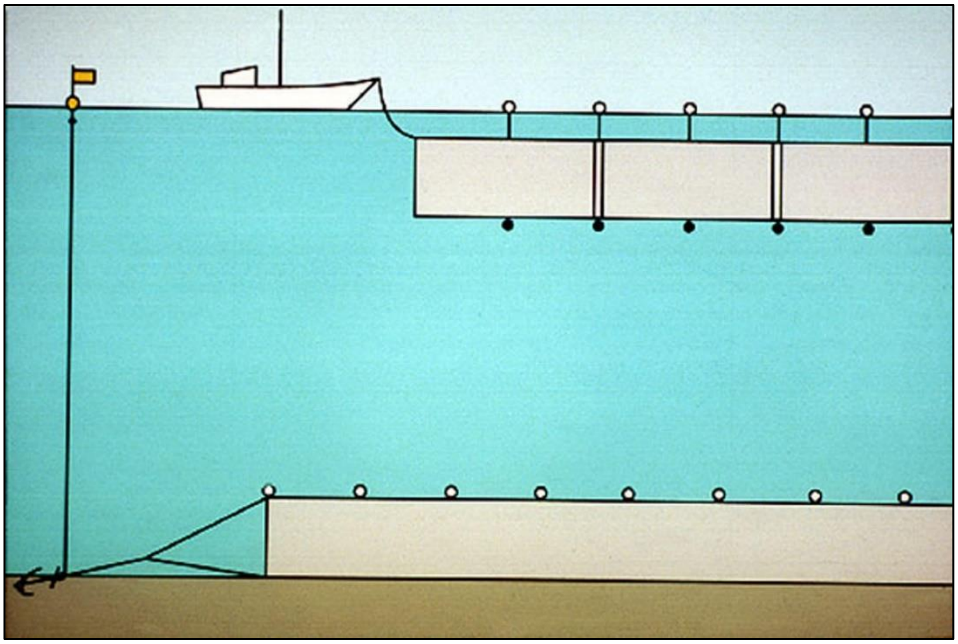

Figure 2. Drift and Set gill nets (FAO 2024).

4. Conservation Considerations of Gear Tending Time

Conservation considerations regarding soak time fall into two categories: ecosystem-related and catch-related. Ecosystem-related conservation considerations are discussed in Section 4.1 and include entanglement, habitat damage, and microplastics. These considerations do not vary significantly among the focus species (Arctic Char, Atlantic Cod, Swordfish, Atlantic Halibut, and Greenland Halibut) and the discussion is therefore limited to that section. Catch-related considerations are discussed in Section 4.2 and include attraction area and effective fishing area, total catch, fish length frequency, catch per unit effort, catch damage and mortality, gear saturation, and incidental capture. These considerations often differ based on the fishery in question, and fishery-dependent differences for each focus fishery (Arctic Char, Atlantic Cod, Swordfish, Atlantic Halibut, and Greenland Halibut) are discussed in Section 5. Considerations that are consistent across fisheries are presented in Section 4.2.

4.1 Ecosystem-related Conservation Considerations

The use of gill nets and longlines can have ecosystem-level effects if they cause harm to discarded, bycaught, or non-target species, particular size classes of target species, or habitat. These considerations are relatively standard among all longline and gill net fisheries and, therefore, are discussed in general terms in this section.

4.1.1 Entanglement

Research on the effects of soak time on entanglement rate is often reported alongside the effects of soak time on bycatch rates. This report deals with entanglement and bycatch separately: bycatch is the direct capture of non-target taxa (such as non-target fishes – whether kept or discarded, mammals, reptiles or birds) by a net or hook during its intended use, whereas entanglement refers to accidental ensnarement by parts of active fishing gear not intended to catch things, such as mooring or floating ropes, getting snagged by hooks, tangled in snoods, or caught by derelict or abandoned, lost or otherwise discarded fishing gear (ALDFG), known as ghost gear (Innis *et al.* 2010; Johnson *et al.* 2007). Unlike bycatch, which is fishery-dependent, the reported effects of entanglement are similar across longline and gill net fisheries (Hamelin *et al.* 2017; COSEWIC 2010b; Government of Canada 2022; Brazner and McMillan 2008). Therefore, entanglement is discussed here, while bycatch is discussed in relation to each focus species in Section 5.

Entanglement can occur with both active and ghost gear. Entanglement with active fishing gear is a conservation concern with regard to soak time; however, entanglement with ghost gear is not related to soak time, beyond the fact that increased soak time often contributes to the creation of ghost gear (Breen 1990a; Brown *et al.* 2005; Gilman 2015; Ward *et al*. 2005). However, entanglement studies often do not discern between entanglement with active fishing gear versus entanglement with ghost gear. Therefore, in this report, data and physical implications of entanglement with abandoned or lost "ghost-fishing" gear will be considered concurrently with entanglement with active fixed fishing gear, but the effects of soak time will be limited to active fishing gear. Ghost fishing gear and its relation to soak time are discussed in Section 4.1.2. In Atlantic Canada, the taxa most often affected by entanglement are marine mammals, sea turtles, and marine birds (DFO 2007; Brazner and McMillan 2008; Brown *et al.* 2009). In Arctic Canada, Greenland shark (*Somniosus microcephalus*) are the species most affected by entanglement, followed by birds (DFO 2007; Wheeland and Devine 2018).

North Atlantic Right Whales (Right Whales; *Eubalaena glacialis*) are listed as Endangered under the Species at Risk Act (Brown *et al.* 2009; DFO 2025f). Compared to other species, they are particularly susceptible to entanglement in fishing gear (Vanderlaan *et al.* 2011). Longlines and gill nets were found to pose a higher risk to Right Whales than other types of fixed gear (Johnston *et al.* 2007; Brillant *et al.* 2017). Their range in Canada extends from the south coast of Nova Scotia to the north coast of Labrador (COSEWIC 2015), and therefore they may be impacted by entanglement with fishing gear in DFO's Maritimes, Gulf, and Newfoundland and Labrador Regions. In the Gulf of Maine, a study found that 72% of Right Whales had evidence of previous entanglement with fishing gear in general (Johnson *et al.* 2005). Other studies show entanglement rates of up to 83% (Knowlton *et al.* 2012; van der Hoop *et al.* 2017). A 2011 study indicated longlines posed the most significant risk for Right Whale entanglement of all gear types in the summer months (Vanderlaan *et al*. 2011), and a 2007 study found gill nets and pots were the largest sources of entanglement in all seasons combined (Johnson *et al.* 2007). It appears that whales are attracted to the bait or catch on longlines or in nets, and then become entangled by the ropes and filaments (Gilman *et al.* 2006).

Entanglement poses a threat of serious injury and mortality for Right Whales. If drowning does not occur directly, injuries associated with previous contact with gill nets can cause death many months after the animal has freed itself (Cassoff *et al.* 2011), or the animal may drag the gear along with it for many years after the entanglement event, leaving it permanently impeded (Moore *et al.* 2005). Even sublethal entanglements create a significant energy imbalance for whales as they are forced to swim harder and burn more calories to overcome the drag created by ropes and nets (Johnson *et al.* 2005, Johnson *et al*. 2007; Brown *et al.* 2009). This is particularly true for pregnant females which may experience 8% more drain on their energy reserves than they would otherwise, delaying their recovery from parturition by months or years (van der Hoop *et al.* 2017). Considering that an estimated 350 Right Whales, with a maximum of 70 reproductive females remain in the western Atlantic population, this poses a serious risk for the future of the species (Brown *et al*. 2009; NOAA Fisheries 2024a).

Over 50% of North Atlantic Humpback Whales (Humpback Whales; *Megaptera novaeangliae*) in the United States show evidence of previous entanglement with fishing gear (Hanson *et al.* 2023; Waring *et al.* 2004; Johnson *et al.* 2005; Robbins and Mattila 2000). Rates of Humpback Whale entanglement in Canada have not been studied exhaustively; however, the range of Humpback Whales extends into Canada along the continental shelf in the North Atlantic and the Arctic Ocean, putting them at risk of entanglement in fishing gear (Government of Canada 2004).

Contact of Bowhead Whales (*Balaena mysticetus*) with fishing gear is less common, with evidence of previous entanglement observed in only 10 to 13% of Bowhead Whales (Citta *et al.* 2013; Philo *et al.* 1992; George *et al.* 2015). This lower rate of entanglement may be due to the presence of relatively few commercial fisheries in the Arctic Region, rather than an assumption that Bowhead Whales avoid entanglement more than other whale species. The Eastern Canada-West Greenland population of Bowhead Whales is currently recommended by COSEWIC for listing as Special Concern in Canada (COSEWIC 2009; DFO 2025f; Moshenko *et al.* 2003).

Studies targeting Northern Bottlenose whale (*Hyperoodon ampullatus)*, listed as Endangered in Canada, have also found evidence of entanglement with fishing gear, particularly in an area known as "The Gully" on the Scotian shelf (COSEWIC 2002; Dufault and Whitehead 1994; Gowans and Whitehead 1995; Whitehead *et al.* 1997). While in many instances, the exact gear at fault for the entanglement is unknown, in at least one case, the cause was longline gear (COSEWIC 2002). Furthermore, as annual cetacean surveys are often completed before the commencement of the swordfishing season, a suspected source of Northern Bottlenose whale entanglement, the incidence of entanglement leading to fatality may be underestimated (COSEWIC 2002). A study by Feyrer *et al.* (2025) reported that entanglement rates for endangered northern bottlenose whales exceeded limits considered sustainable under current recovery objectives for the species.

Pinnipeds such as seals and sea lions are also at risk of entanglement with both active fixed fishing gear and ghost fishing gear (DFO 2007; Gregory 2009; NOAA 2014). It is estimated that 58% of seals worldwide have experienced some level of entanglement with anthropogenic waste (Hogan and Warlick 2017), but it is unclear what the statistic is for Canadian waters. Additionally, these entanglement numbers include plastic packaging and trash, as well as fishing gear. It is estimated that between 3 and 50% of seal entanglements involve fishing gear (Hogan and Warlick 2017;

NOAA 2024). Seals may ingest hooks, parts of nets and ropes, or become entangled in the gear, which affects their ability to move or feed. Seals appear to be attracted to the vibrations created by struggling fish caught in fishing gear (Clean Catch 2023; Kraus *et al.* 1997) and are particularly prone to becoming entangled in large mesh-size gill nets (Moreno *et al.* 2020).

Both species of sea turtles that might become entangled in Canadian fisheries gear, Leatherbacks (*Dermochelys coriacea*) and Loggerheads (*Caretta caretta*), are listed as Endangered in Canada (DFO 2025f). These species can become entangled in the ropes and lines associated with longline and gillnet fisheries (Brazner and McMillan 2008; COSEWIC 2010b; Hamelin *et al.* 2017; Government of Canada 2022). In a multi-year study (2012-2015), it was found that 19% of Leatherbacks at both ends of their migratory path (Nova Scotia, Canada, and a nesting island in Trinidad) had previously been entangled with fishing gear (DFO 2022). This interaction may occur while the gear is actively deployed, or when ghost gear is encountered. Leatherbacks with a history of fishing gear entanglement show signs of skin abrasions, lesions, ulcerations, as well as other severe injuries and signs of exertion that could affect the long-term health of the turtles (Innis *et al.* 2010). Loggerhead populations are also at risk due to encounters with active or ghost fishing gear (Brazner and McMillan 2008); however, the risk of entanglement is relatively low for both species compared to the high risk of becoming part of the incidental catch or 'bycatch' of active fisheries (Government of Canada 2022).

The proportion of marine birds entangled worldwide in all sources of plastic waste, including ghost gear, increased from 16% to 25% between 2008 and 2018; this is expected to be an underrepresentation of the problem (Ryan 2018). These numbers include birds entangled in both ghost fishing gear and other anthropogenic waste. Bird injury and mortality due specifically to active fishing gear generally occurs when birds are foraging on bait rather than being passively entangled by lines or ropes (Phillips *et al.* 2010; Dietrich *et al.* 2025), and become bycatch in gill nets or longline arrays. Birds are therefore discussed within the context of each focus species, where applicable.

Non-governmental organizations have published guidelines and recommendations about soak time of fixed fishing gear and its effect on entanglement (Clean Catch 2023; Bycatch Solutions Hub 2024). It is well documented that increasing gill net soak time increases the risk of bycatch and entanglement for some taxa (Brazner and McMillan 2008; Cosgrove *et al.* 2013; Davis 2002; Li and Jiao 2011; Northridge *et al.* 2016; Reeves *et al*. 2013; Shester and Micheli 2011; Zaharieva *et al.* 2021)

The relationship between soak time and cetacean entanglement is not well understood because whales are often found entangled days to years after the event, and it is often unknown if the gear was actively deployed or derelict at the time of entanglement (Bolling *et al.* 2023). A 2021 study in the Black Sea found that soak time, ranging from 1 to 3 weeks, did not appear to be related to dolphin entanglement rate (Clean Catch 2023; Zaharieva *et al.* 2021). Whereas a study in Alaska spanning 1991 to 2022 found that any soak time, for both gill nets and longlines, that exceeds the breathing interval for killer whales (*Orcinus orca*), increases the risk of entanglement, and as a result, NOAA recommended a reduction in soak times (Bolling *et al.* 2023).

Increased soak time has been shown to increase entanglement of both seals and turtles (Innis *et al.* 2010; Hamelin *et al.* 2017; Clean Catch 2023; Bycatch Solutions Hub 2024). Therefore, shorter soak times would result in less impact to seal and turtle populations (Clean Catch 2023; Bycatch Solutions Hub 2024). However, a limit on soak time alone is not likely to eliminate entanglement of marine mammals and reptiles (Northridge *et al.* 2016; Bycatch Solutions Hub 2024).

Additional mitigation measures can help to reduce entanglement of non-target species. So far, measures that have been attempted or suggested include: mapping whale migratory routes in relation to fisheries and shipping footprints; the closure of fishing grids during critical points of Right Whale migration; reconfiguring gear to include fewer ropes and buoys, sinking and/or break-away materials, ropeless elements, high visibility lines and ropes, acoustic markers, and target species-specific net configurations; proper gear marking; education, incentivization, and phase-in periods to increase awareness and uptake of new practices (Bycatch Solutions Hub 2024; COSEWIC 2015; Downing 2021; Eayrs and Pol 2019; Gilman *et al.* 2006; Government of Canada 2024b; Johnson *et al.* 2022; Johnson *et al.* 2021; Kraus *et al.* 1997; Lancaster and Wedegartner 2024; NOAA 2024; NOAA Fisheries 2024a; Northridge *et al.* 2016; WWF Global Arctic Programme 2024). Canada's Whalesafe Fishing Gear Strategy supports the implementation of fishing gear innovations designed to reduce the risk of harm to whales from entanglement in fishing gear by promoting on-demand gear, low breaking strength gear, or the configuring of gear to reduce entanglement risk (DFO 2026).

4.1.2 Ghost Fishing

Ghost fishing occurs when passive fishing gear is lost or discarded and continues to trap or entangle fish, marine mammals, birds, sea turtles and invertebrates as it drifts with currents or becomes entangled with the substrate. This negative effect is often compounded as the organisms that are initially caught by the gear attract predators or scavengers that themselves become entangled (Brown *et al.* 2005; Gilman 2015; Kaiser *et al.* 1996; Stelfox *et al.* 2016). Ghost gear can also cause habitat damage through abrasion of the benthic substrate and unintentional uprooting of benthic vegetation as nets or ropes drift with the current (Brown *et al.* 2005).

Studies on ghost fishing are available from fisheries worldwide, and show that the amount of ghost fishing that occurs as a result of each fishery is dependent on target and non-target species biology, gear type, fishing practices, bottom type, and oceanographic conditions (Al-Masroori *et al.* 2004; Breen 1990a, 1990b; Brown *et al.* 2005; Drakeford *et al.* 2023; Gilman 2015; Kaiser *et al.* 1996; Matsuoka *et al*. 2005; Stelfox *et al.* 2016; Clark *et al. In Press.*). The end effects of ghost gear, such as entanglement (Section 4.1.1) and habitat damage (Section 4.1.3), are not directly related to soak time because ghost gear continues to fish and entangle for long periods of time as the gear deteriorates. The formation of ghost gear, however, is related to soak time.

Gear loss is known to increase with soak time. For example, longlines are often snapped as a result of large bycatch such as sharks spending more time on the hook (Walsh 2008). If tending gear less often makes fishing more cost effective, the amount of time that gear is fished annually may increase, thus the risk of gear becoming derelict might increase. Increasing soak time may also mean that gear is deployed for the same amount of time, but checked less frequently. Thus, decaying or worn ropes and floats or improper deployment may go unchecked, allowing gill nets to break away from buoys or drift due to weather (Breen 1990a; Brown *et al.* 2005; Gilman 2015). Because longlines sink to the bottom, and other fixed gear such as pots and traps fill up over time until reaching capacity, gill nets are the gear most commonly associated with ghost fishing.

Gear specially designed to break away or biodegrade is frequently cited as a potential mitigation for the negative effects of ghost fishing (NOAA Fisheries 2024a). Another potential mitigation measure to reduce ghost fishing is the recovery and prevention of lost gear through the use of radio or GPS transmitter gear tags (DFO 2016b). Additionally, since 2020, all lost gear must be reported as a condition of licence (DFO 2025b).

4.1.3 Habitat Damage

Habitat damage from fishing activity can occur if fishing gear disturbs the substrate or otherwise impacts benthic flora and fauna. This type of damage is most associated with active fishing methods such as trawls and seines (Clark *et al.* 2016), although some habitat damage associated with fixed fishing gear does occur.

Longline fishing has less impact on benthic habitat and benthic communities than other forms of bottom-contact fisheries (Pham *et al.* 2014). However, bottom-set longlines have negative impacts on certain benthic communities, such as corals and sponges, because hooks or anchors can snag or break such organisms (Clark *et al.* 2016; Brewin *et al.* 2021). These impacts can often be mitigated with fishing closures in sensitive areas (DFO 2009b).

Gillnet fishing, particularly with demersal stationary nets (rather than pelagic gill nets), may also cause habitat damage as the net is dragged into place along the seafloor. For example, kelp, corals and other benthic organisms are often damaged or completely removed within one metre (m) of the net path (Shester and Micheli 2011). As inshore fisheries use gill nets more often than offshore fisheries, gill nets more frequently impact shallow water habitats (Clark *et al.* 2016).

Habitat effects from gill nets and longlines are generally associated with the active setting and retrieval of the gear, rather than the amount of time it is deployed. Nevertheless, gear that is improperly anchored can drift with strong currents or storm events and cause habitat damage that continues for the duration of soak time (Shester and Micheli 2011). Aside from habitat damage due to ghost gear scraping the benthic substrate (Section 4.1.2), habitat damage from gill nets and longlines is generally considered low in comparison with other bottom-contact fishing methods such as trawling (Clark *et al.* 2016).

4.1.4 Microplastics

A growing number of studies and reports address the problem of microplastics, including the presence of microplastics on beaches and in intertidal sediments of the Maritimes Region (AMAP 2021; Ašmonaitė and Almroth 2019; Avise and Walker 1999; Hamilton *et al.* 2022; Karbalaei *et al.* 2018; Laufer *et al.* 2012; Lusher *et al.* 2017; Mathalon and Hill 2014; Mato *et al.* 2001; NOAA 2014; Provencher *et al.* 2022; Suhring *et al.* 2021; Teuten *et al.* 2007; Walker 2006, 2018). Microplastics and the contaminants that they transport have been shown to cause inflammatory responses, developmental delays, compromised intestinal function, and other biological and chemical interactions in marine organisms (Teuten *et al.* 2007; Lusher *et al.* 2017).

The breakdown of ghost fishing gear, or wear and tear of active fishing gear as it is deployed and retrieved, both lead to the production of microplastics (plastic particles less than 5 millimetres (mm) in diameter) that are released into marine environments (Armstrong 2020; Ašmonaitė and Almroth 2019). Exposure to UV light, weather, water, extreme temperatures, and friction all speed the breakdown of plastics, creation of microplastic particles, and subsequently their release into the marine environment (Lusher *et al.* 2017; NOAA 2014). If increased soak time increases the total time gear is deployed, it would increase the duration that plastic is exposed to these catalysts, thereby increasing the release of microplastics into the ocean. If increasing soak time results in the same total fishing duration, but with fewer deployments and retrievals, then the release of microplastics may decrease due to the reduced amount of friction on the gear.

4.1.5 Species at Risk

When deployed at or near the surface, or on the ocean floor, fixed fishing gear can inadvertently attract and/or entangle a variety of non-target wildlife including sharks, whales, sea turtles and marine birds, as well as other non-target fishes, which can lead to mortality (DFO 2007, 2016a, 2018a, 2021b; Moore and Van der Hoop 2012; van der Hoop et al. 2017). Of particular concern is the interaction of fixed fishing gear with aquatic species at risk, which may compound the stressors already faced by these species (Table 3). Species listed under Schedule 1 of the *Species at Risk Act* (SARA) as Extirpated, Endangered, or Threatened are subject to a series of prohibitions, including against killing, harming, harassing, and taking, as well as destruction of their critical habitats, once identified and legally protected via a Critical Habitat Order. Species listed as Special Concern are not subject to these prohibitions (DFO 2014a).

If drowning or death does not occur immediately, injuries associated with previous entanglements can impact normal life processes and lead to death many months after the animal has freed itself (Cassoff *et al.* 2011), or the animal may drag the gear along with it for many years after the entanglement event, leaving it permanently impeded (Moore *et al.* 2005).

Table 3. Aquatic Species at Risk listed under Schedule 1 of the *Species at Risk Act* (SARA) in the Northwest Atlantic and Arctic Oceans (NB = New Brunswick; NK = Nunavik; NL = Newfoundland and Labrador; NS = Nova Scotia; NU = Nunavut; NWT = Northwest Territories; PEI = Prince Edward Island; QC = Quebec; YT = Yukon Territory).

Species	**Scientific Name**	**Category**	**SARA Status**	**Distribution in Canada**
Atlantic Mud-piddock	*Barnea truncata*	Mollusc	Threatened	NS, Atlantic Ocean
Atlantic Salmon (Inner Bay of Fundy population)	*Salmo salar*	Marine Fish	Endangered	NB, NS, Atlantic Ocean
Atlantic Walrus (Northwest Atlantic population)	*Odobenus rosmarus rosmarus*	Marine Mammal	Extirpated	NB, NL, NS, PEI, QC, Atlantic Ocean
Atlantic Wolffish	*Anarhichas lupus*	Marine Fish	Special Concern	NU, NL, Arctic Ocean, Atlantic Ocean
Beluga Whale (Cumberland Sound population)	*Delphinapterus leucas*	Marine Mammal	Threatened	NU, Arctic Ocean
Beluga Whale (St. Lawrence Estuary population)	*Delphinapterus leucas*	Marine Mammal	Endangered	QC, Atlantic Ocean
Blue Whale (Atlantic population)	*Balaenoptera musculus*	Marine Mammal	Endangered	NB, NL, NS, PEI, QC, Atlantic Ocean
Bowhead Whale (Bering-Chukchi-Beaufort population)	*Balaena mysticetus*	Marine Mammal	Special Concern	YK, NWT, Arctic Ocean
Fin Whale (Atlantic population)	*Balaenoptera physalus*	Marine Mammal	Special Concern	NB, NL, NS, PEI, QC, Atlantic Ocean
Grey Whale (Atlantic population)	*Eschrichtius robustus*	Marine Mammal	Extirpated	Atlantic Ocean
Leatherback Sea Turtle (Atlantic population)	*Dermochelys coriacea*	Reptile	Endangered	NB, NL, NS, PEI, QC, Atlantic Ocean
Loggerhead Sea Turtle	*Caretta caretta*	Reptile	Endangered	NB, NL, NS, PEI, QC, Atlantic Ocean
North Atlantic Right Whale	*Eubalaena glacialis*	Marine Mammal	Endangered	NB, NL, NS Atlantic Ocean
Northern Bottlenose Whale (Scotian Shelf population)	*Hyperoodon ampullatus*	Marine Mammal	Endangered	NL, NS, Atlantic Ocean
Northern Wolffish	*Anarhichas denticulatus*	Marine Fish	Threatened	NU, NL, Arctic Ocean, Atlantic Ocean
Sowerby's Beaked Whale	*Mesoplodon bidens*	Marine Mammal	Special Concern	NB, NL, NS, PEI, QC, Atlantic Ocean
Spotted Wolffish	*Anarhichas minor*	Marine Fish	Threatened	NU, NL, Arctic Ocean, Atlantic Ocean
White Shark (Atlantic population)	*Carcharodon carcharias*	Marine Fish	Endangered	NB, NL, NS, PEI, QC, Atlantic Ocean

Of these species, the North Atlantic Right Whale, sharks, wolffish species and sea turtles are the most frequently mentioned with regard to encounters with longlines and gill nets (DFO 2007, 2008a, 2024bi; Hamelin *et al.* 2017; Kraus *et al.* 2005; Moore and Van der Hoop 2012). Approximately 370 Right Whales are left in the world, and between 2017 and 2025, 11 died from entanglement with fishing gear, and an additional 91 experienced injury or illness due to entanglement, and these figures are believed to be an underrepresentation (Pace *et al.* 2021; NOAA 2025). Longlines and gill nets were found to pose a higher risk to Right Whales than other types of fixed gear (Johnston *et al.* 2007; Brillant *et al.* 2017). It is estimated that up to 83% of Right Whales have become entangled in these gear types at some point in their lives (Knowlton *et al.* 2012; van der Hoop *et al*. 2017).

Studies targeting Northern Bottlenose whale, listed as Endangered in Canada, have also found evidence of entanglement with fishing gear, particularly in an area known as “The Gully” on the Scotian shelf (COSEWIC 2002; Dufault and Whitehead 1994; Gowans and Whitehead 1995; Whitehead *et al.* 1997). In many instances, the exact gear at fault of the entanglement was unknown, but in at least one case, the cause was longline gear (COSEWIC 2002). Furthermore, as annual cetacean surveys are often completed before the commencement of swordfishing, a suspected source of Northern Bottlenose whale entanglements, the incidence of entanglement leading to fatality may be underestimated (COSEWIC 2002). A study by Feyrer *et al.* (2025) reported that entanglement rates for endangered northern bottlenose whales exceeded limits considered sustainable under current recovery objectives for the species.

Pelagic longlines pose a larger entanglement risk to Leatherback sea turtles (Leatherbacks; *Dermochelys coriacea*) and Loggerhead sea turtles (Loggerheads; *Caretta caretta*) than other types of gear (Brazner and McMillan 2008; Hamelin *et al.* 2017). Turtles appear to be attracted to bait and/or catch associated with pelagic longlines in foraging areas (Brazner and McMillan 2008). A study was done to determine if bait type, water temperature and hook style might be used to reduce the risk of bycatch to turtles (Brazner and McMillan 2008) . While the post-release survival of loggerhead turtles is high (87%), indicators that turtles experience health distress as a result of interaction with fishing gear exist (Innis *et al.* 2010), and any additional stressors on species at risk should be avoided if possible (Hamelin *et al.* 2017; DFO 2024f).

While there is no directed fishery for these species, Northern Wolffish (*Anarhichas denticulatus*), Spotted Wolfish (*Anarhichas minor*) and Atlantic Wolffish (*Anarhichas lupus*) are frequently caught as bycatch in gill net and longline fisheries, in particular the Greenland halibut fishery (DFO 2019a; Wheeland and Devine 2018). The proportion of wolffish mortality attributed to bycatch and habitat damage from fishing activity is unknown (DFO 2013). Fisheries bycatching Northern and Spotted wolffish are exempted from SARA’s prohibitions through their SARA recovery strategy (DFO 2013, 2019d). A requirement of that exemption is that there is a licence condition that bycaught wolffish be released alive and in the manner causing least harm (COSEWIC 2012a, 2012b, 2012c; DFO 2013, 2019a).

A variety of shark species are commonly caught as bycatch in the Swordfish fishery in the Atlantic Ocean and the Greenland halibut fishery in Baffin Bay (DFO 2016b, 2019b; ICCAT 2024ab; Walsh 2008; Wheeland and Devine 2018). Shark mortalities may occur following interactions with fixed fishing gear. As a condition of license in the Arctic offshore fishery, Greenland shark are required to be returned to the water in a manner that causes the least harm. White Shark (*Carcharodon carcharias*) are listed, and therefore protected, under SARA; however, bycatch of White Shark is currently permitted under SARA through section 74. Other species, such as Porbeagle and Shortfin Mako, are under consideration for listing as of 2025.

Pelagic longlines have the highest rate of bird bycatch among longline fisheries, due to the easy access to floating bait. Diving birds, such as gulls, albatross, shearwaters, and Northern Fulmar (*Fulmarus glacialis*) are most at risk (Dietrich *et al.* 2025). Some birds will dive as deep as 60 m to feed on bait, become entangled in demersal lines, and drown (DFO 2007). Even if not on Schedule 1 of SARA, marine birds are protected by the *Migratory Birds Convention Act* (MBCA; Government of Canada 2024a), making any encounters with fishing gear, fatal or otherwise, of particular concern (COSEWIC 2010b, 2015). There is no mechanism under the MBCA to permit bycatch of protected migratory birds.

It is well documented that increasing soak time increases the risk of bycatch and entanglement with fixed fishing gear (Bolling *et al.* 2023; Brazner and McMillan 2008; Cosgrove *et al.* 2013; Davis 2002; Li and Jiao 2011; Northridge *et al.* 2016; Reeves *et al.* 2013; Shester and Micheli 2011; Zaharieva *et al.* 2021). This, in turn, increases the risk of harm and/or mortality to federally protected species at risk.

4.2 Catch-related Conservation Considerations

The following section on catch-related conservation considerations is based on studies that generally investigate the effects of soak time at static increments of time. As a result, many of these studies do not capture the cumulative effects of soak time and unaccounted for mortalities, such as catch consumed by predators or catch that escaped (Fogarty and Addison 1997; Ward *et al.* 2005; Uhlmann and Broadhurst 2015; Chamberland and Benoît 2024; Benoît *et al.* 2025). A recent study by Benoît *et al.* (2025) used modeling to confirm and predict the cumulative effects of soak time and unaccounted for mortalities, such as catch that was consumed by predators or decomposers, or which drops out of the net. While studies to date have not used this model to predict cumulative effects, it is possible that this method will be used in the future. The results below should be interpreted with the understanding that the effects of soak time are likely non-linear, and studies finding “no impact of soak time” may in fact have cumulative impacts that are unobserved due to study design.

4.2.1 Attraction Area and Effective Fishing Area

The attraction area is the zone within which a target organism is drawn towards bait. This is often known as the odour plume of a bait (Løkkeborg 1990). The bait’s attraction area is related to its effective fishing area, which is the area within which 100% of target organisms will be captured (Miller 1975; Miller and Hunte 1987; Lapointe and Sainte-Marie 1992; Aedo and Arancibia 2003).

Attraction area and effective fishing area vary across and within fishing areas due to changing depths, current speed and direction, and oceanographic conditions (Miller 1975; Lapointe and Sainte-Marie 1992; DFO 2020d). Target species behavior also influences attraction area and effective fishing area (Thomsen *et al.* 2010).

It was found that the effectiveness of both traditional and artificial food baits decreased rapidly during the first 1.5 h after deployment and then decreased slowly over the next 22 h (Løkkeborg 1990). Therefore, increasing soak time would result in gradually less effective bait and corresponding decreased catch rates (Løkkeborg *et al.* 2014). Species-specific information is presented, where available, in Section 5.

4.2.2 Total Catch

Total catch is the total amount of fish caught during a fishing session, either by number or by weight. The effect of soak time on total catch is better documented than other conservation considerations.

It is often presumed that longer soak times with gillnet sets will result in a higher total catch of the target species, but that assumption is discounted by freshwater studies that show gill net catchability decreases when soak time increases past a certain point because the net becomes saturated with fish or debris, or the catch is afforded more time to escape (Olin *et al.* 2004; Prchalová *et al.* 2011, 2013). A study in a coral reef area showed no change in catch rate with increased soak time (Acosta 1994). It may be that other variables such as visibility of the net due to light levels and water clarity are of more, or similar, importance than soak time (Olin *et al.* 2004).

The species studied and the study methodologies vary, as do the results for individual species and fisheries. A key concern is cumulative impacts: the total catch estimated when gear is hauled does not account for mortalities from causes like predation and competition (Richards *et al*. 1983), while the gear is deployed. Studies that use point estimates are much more common than studies that account for cumulative impacts.

Four patterns emerge from the literature: an increase in total catch with increased soak time, a decrease in total catch with increased soak time, an increase and then a decline in total catch with increased soak time, and no decline in total catch with increased soak time. Generally, any increase in total catch is asymptotic rather than proportional to the increase in soak time (Ricker 1975; Bennett and Brown 1979; Bacheler *et al.* 2013).

The change in total catch due to changes in soak time varies widely by study and by species. Where available, species specific effects of soak time on total catch are provided in Section 5.

4.2.3 Length Frequency Distribution

A length frequency distribution is a measurement that indicates the most commonly captured length in a range of distribution for fish size in total catch (UNESCWA 2025). A length frequency distribution allows researchers to infer information about the growth and size of fish in a population; changes to the length frequency may indicate changes in the population dynamics. A shift towards smaller fish may indicate over-fishing of the breeding population, whereas a shift towards larger fish may indicate other changes to the fishing dynamics, such as habitat or gear selectivity (Ricker 1975).

Typical fish length frequencies have been provided, where available, for catches of focus species (Section 5), but there was no information available on the effects of soak time on these metrics. Where applicable, minimum size allowances have also been reported, which indicate that fish length frequencies have been calculated and the optimum target size for population conservation has been estimated.

4.2.4 Catch per Unit Effort

Catch per unit effort (CPUE) is a relative measure of abundance that is defined as the number or weight of fish that are harvested per unit of fishing effort (Ricker 1975). For gill nets and longlines, the unit in which CPUE is expressed may be the number or biomass of target fish caught per h of soak time, per length of net, or per hook h (Etienne *et al.* 2024). The units vary between individual studies. This can indicate the relative "catchability" (the proportion of the stock removed by 1 unit of fishing effort (FishBase 2024)) of the target species relative to other species or other areas and can also be an indirect indicator of a species' abundance in a given area.

The effects of soak time on CPUE can vary by target species and location. Species specific information is presented, where available in Section 5. It is clear that the relationship between soak time and catch efficiency is non-linear (Prchalová *et al.* 2011). General research suggests that soak time is less important to catchability than ensuring the time of set overlaps with the daily feeding period of the target species, or that the net is set at an orientation, or in a habitat, favourable to catch the target species (Løkkeborg and Pina 1997; Løkkeborg *et al.* 2010; Løkkeborg *et al.* 2014).

4.2.5 Catch Damage and Mortality

Catch damage is defined as the spoilage or physical deterioration of captured target species that makes them unmarketable and results in waste (FAO 2021). It is attributable to fishing practices such as delays in removing the catch from the gear, and intraspecific or interspecific predation of the target species in the gear before it is hauled (FAO 2021).

Increasing soak time during trawl and gill net fishing increases catch damage and causes a lower grade of catch (Savina *et al.* 2016). As fish struggle to escape, tissue damage such as bruises or cuts may occur, possibly leading to death of the fish, which then begins to spoil. Damage and mortality can result in decreased quality of the product (Bjordal 2002; Savina *et al.* 2016; Prchalová *et al.* 2011). For example, Savina *et al.* (2016) found that net sets of 24 h on a coastal European plaice (*Pleuronectes platessa*) gillnetter resulted in more damage than net sets of 12 h. Fish captured in gill nets frequently die before the net is hauled. A 2022 study on the southeast coast of Labrador found that 55% of cod caught in gill nets were either dead or injured (Nguyen and Morris 2022). Spoiled fish can account for nearly 25% of the catch in some cases (Shawyer and Medina Pizzali 2003). Larger fish often sustain less damage than smaller fish; however, some species are also more susceptible to injury than others, either due to physiology or behaviour (Prchalová *et al.* 2011; Savina *et al.* 2016; Shawyer and Medina Pizzali 2003). Dead fish in gill nets begin to decay or spoil immediately following death (Government of Newfoundland and Labrador 2001).

Catch damage is related to product quality in that damaged fish may be unmarketable. The effect of catch damage on the fish product depends on whether the fish is sold whole or filleted because external damage is often no longer visible once a fish has been filleted (Savina *et al.* 2016). Catch on both longlines and gill nets may also be damaged by predation or scavenging from other species like invertebrates, such as amphipods, larger fish or marine mammals (Lowry and Smith 2003). The level of depredation on captured fish increases with soak time (Cosgrove *et al.* 2013; Gilman *et al.* 2006). Colder water temperatures may slow the rate of tissue decay, and preserve catch quality, thus supporting the contention that increased soak times in colder water could be considered without increased risk to catch quality (Huss 1988). However, mortality rate of captured fish varies greatly by gear type and species (Ward *et al.* 2005). Even in colder water, longer soak times have been found to lead to increased mortality, increased catch decomposition and an overall reduction in product quality (Bjordal 2002; Prchalová *et al.* 2011; Savina *et al.* 2016).

4.2.6 Gear Saturation

Gear saturation refers to a point at which total catch stops increasing either due to the gear having reached capacity, for example all hooks are full, or the gear has ceased attracting new catch because of bait depletion (Somerton and Kikkawa 1995). Saturated gear may also experience a decrease in catch if predation occurs, or if fish begin to escape.

In general, total catch in gill nets and longlines increases with soak time; however, the rate of catch peaks and then gradually decreases with time as the net or line becomes saturated with fish (Olin *et al.* 2004; Skud 1975). Controlled experiments investigating gill nets and saturation indicate that total catch is affected more by visibility than net saturation (Olin *et al.* 2004).

4.2.7 Incidental Capture

Incidental capture, often known as “bycatch”, refers to catch of species not targeted by the fishery. It may refer to non-target fishes that are retained, fishes that are discarded, or other taxa that come into contact with, and are caught by the gear deployed in its function. As many fisheries in Atlantic Canada, such as the groundfish fishery, target multiple species at once, the definition of bycatch, or use of the term, may vary between focus fisheries and therefore the definition is refined in the context of each species addressed in Section 5. Incidental capture should not be confused with entanglement (Section 4.1.1), which refers to entrapment of non-target species by parts of the gear not related to fishing, or by ghost gear.

A comprehensive literature review indicated that decreased soak time would help to reduce the bycatch of protected species (Northridge *et al.* 2016). The literature review, as well as other studies, have noted that soak time is usually linked to time of day so they caution confusing changes in soak time with changes in bycatch related to the temporal feeding patterns of bycatch species (Northridge *et al.* 2016; Moreas *et al.* 2024). There are large data gaps in our understanding of bycatch both in Canadian fisheries and globally. An assessment by Tava and Huettmann (2025) raises concerns about fishery governance and sustainable certifications within US fisheries, especially under the Magnuson-Stevens Act (lacking effective bycatch data/policies) and the United Nations Convention on the Law of the Sea (UNCLOS).

5. Focus Species

Five representative species that are fished using gill nets and/or longlines were chosen to explore the potential effects of increased gear soak time. The five species were chosen for their financial importance and availability of data, as well as their ability to represent other related taxa:

- Arctic Char (*Salvelinus alpinus*) – Arctic Region
- Atlantic Cod (*Gadus morhua*) – Newfoundland and Labrador Region
- Swordfish (*Xiphias gladius*) – Maritimes Region, Newfoundland and Labrador Region
- Atlantic Halibut (*Hippoglossus hippoglossus*) – Gulf Region, Maritimes Region, Newfoundland and Labrador Region
- Greenland Halibut (*Reinhardtius hippoglossoides*) – Arctic Region, Newfoundland and Labrador Region

The biology of each species is presented, followed by a description of the active commercial fisheries for that species that are currently in operation. Lastly, a description of the catch-related conservation considerations associated with those active fisheries is given. This section describes the expected effects of increased soak time on total catch, CPUE, catch quality and other harvest metrics, as well as the effects on fishery-specific incidental bycatch.

5.1 Arctic Char

5.1.1 Biology

5.1.1.1 Distribution

Arctic Char (*Salvelinus alpinus*) occur throughout the circumpolar Arctic, including northern Europe, Greenland, Iceland, the Canadian Archipelago, Hudson Bay and Alaska (Figure 3; Reist *et al.* 2013). Arctic Char may be solely freshwater (landlocked or freshwater resident) or they may be anadromous (Moore *et al.* 2015; Roux *et al.* 2011; DFO 2018b).

5.1.1.2 Size

Arctic char size at maturity varies among areas. In Cambridge Bay, the average fork length of anadromous Arctic Char at maturity is 700 mm, which corresponds to a round weight of approximately 4000 grams (g; Harris *et al.* 2020). In Cumberland Sound, length at 50% maturity ranged from 427 mm to 515 mm (Harris and Tallman 2010). In Frobisher Bay, female char historically reached maturity at 450 mm in length (Grainger 1953).

Between 1997 and 2009 in Cumberland Sound (Isuituq River), the average weight of commercially caught char (using 139.7 mm mesh gill nets) was 2,537.3 g, with males weighing more than females (Harris and Tallman 2010).

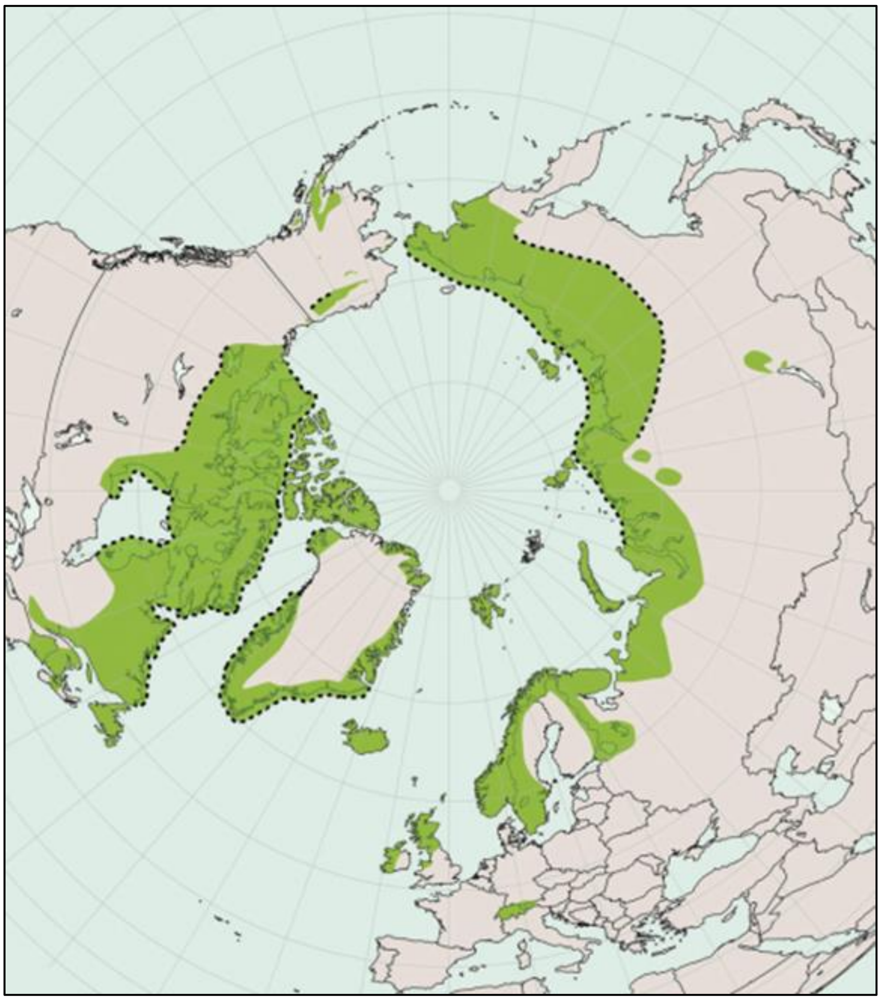

Figure 3. Global distribution of Arctic Char (*Salvelinus alpinus*; Reist *et al.* 2013).

The modal fork length was 550-650 mm (Harris and Tallman 2010). Marine foraging increases growth rates of anadromous Arctic Char in terms of growth potential. Some studies have found that sea-run Arctic Char, after age 7, may be approximately double the size of those that remain in freshwater (2,300 - 4,500 g compared to 200 - 2,300 g) due to increased food availability while anadromous fish are at sea (Young *et al.* 2021; Rikardsen and Amundsen 2005; Gulseth and Nilssen 2001; DFO 2018b).

5.1.1.3 Reproduction and Life History

Arctic Char spawn in freshwater lakes where they rear exclusively until reaching 4-7 years of age (Dutil 1986; Gyselman 1994; Harris *et al.* 2022). After smoltification, anadromous char will migrate to the ocean to feed during the summer months, moving from estuary to estuary to forage (DFO 2010). They rarely travel farther than 1 km from the shore and tend to prefer the top 1-3 m of the water column where salinity is lower, and temperature is warmer (Moore *et al.* 2016; Spares *et al.* 2012; Harris *et al.* 2020) In the fall, they return to the lakes before the rivers freeze and the sea water becomes too cold for their physiology (Spares *et al.* 2012; Harris *et al.* 2020).

Arctic Char do not spawn annually and, unlike Pacific salmon species, can spawn multiple times throughout their lives and live to 30 years of age or more (Harris *et al.* 2022). In years when individuals are preparing to spawn, they often remain in freshwater throughout the summer, although some specimens in spawning condition have been observed in summer foraging studies in estuarine/marine habitat (Harris *et al.* 2020). There is also evidence that some young Arctic Char travel to the ocean before reaching maturity (Harris *et al.* 2022).

5.1.1.4 Predators and Prey

Research indicates the most common predators of Arctic Char are Ringed Seals (*Pusa hispida)* and Bearded Seals (*Erignathus barbatus;* Harris *et al.* 2020); however, they are also preyed upon by larger Arctic Char (Dempson *et al.* 2002), and Polar Bears (*Ursus maritimus*; Lunn and Stirling 1985).

Throughout the year, Arctic Char may be both pelagic and demersal, switching from feeding near the undersurface of the sea ice in the spring, to feeding on benthic invertebrates and fish in the summer (Young *et al.* 2021). Anadromous Arctic Char feed only sporadically while in freshwater during the overwintering period (Young *et al.* 2021). During their summer forays to the ocean, they feed in the estuaries on mysid shrimp and amphipods, as well as a variety of fish such as Arctic cod, Sculpins, smaller Arctic Char and, more recently, increasing proportions of Capelin (*Mallotus villosus*) and Sand Lance (*Ammodytes* spp.; Dempson *et al.* 2002; Ulrich and Tallman 2021; Faulkner *et al.* 2024). This food sustains them over the winter, and potentially through the spawning period (Harris *et al.* 2022).

5.1.2 Fisheries

Canadian fisheries for Arctic Char in the Arctic Region consist of commercial, exploratory, recreational and subsistence harvests, which provide economic benefit to northern communities while also supporting food security.

There are two main commercial/exploratory Arctic Char fisheries in Canadian waters, both in the Arctic region although commercial fisheries also exist along the Kivalliq coast and exploratory fisheries are being established in many areas throughout Nunavut. The Cambridge Bay commercial fishery occurs on Victoria Island, near the Community of Iqaluktuuttiaq, and includes Ferguson Lake and several rivers and their estuaries (DFO 2021d). Harvest methods include both gillnet and weir fishing, with weir being the preferred method in locations where geography is favourable. In 2019, 48,087 kilograms (kg) of Arctic Char were commercially harvested from Cambridge Bay, which represented 99% of their targeted quota of 48,493 kg (DFO 2021d). Arctic Char harvested through this fishery are processed locally by Kitikmeot Foods Ltd. (DFO 2021d).

There is also an exploratory licence fishery for Arctic Char in Isuituq (Cumberland Sound), which is primarily an open-water gillnet fishery, at the mouth of the Isuituq River in Clearwater Fjord on Baffin Island (waterbody code PG080). As of 2010, a quota of 2,500 kg existed for this exploratory licence (DFO 2010).

There are also myriad smaller commercial and exploratory Arctic Char fisheries throughout the Canadian Arctic (Figure 4; Roux *et al.* 2011; Galappaththi *et al.* 2022), including near:

- Rankin Inlet
- Cumberland Sound
    - Robert Peel Inlet (Iqaluit Lake)
    - Kipisa, Nauliniavik Lake
    - Anaktuayuit
    - Avituajuit Chidlak Bay
    - Kingnait Fjord
    - Qasigiyat Lake
    - Ikpit Bay (Kanayuktuk)
    - Tagioyuk Lake
    - Qasigialiminiq Lake
    - Isuituq (Head of Clearwater Fjord)
    - Millut Bay
- Qikiqtarjuaq
    - Confederation Fjord
- Pond Inlet
    - Koluktoo Bay
    - Ipiutalik
    - Tuapak
    - Saatut
    - Saviit

Licences issued under Section 7 of the *Fisheries Act* are considered Stage II (Exploratory). This stage is reached if and as soon as feasibility has been demonstrated. The objective of this stage is to determine whether a species/stock can sustain a commercially viable operation and to collect biological data in order to build a preliminary database on stock abundance and distribution (DFO 2008b).

Stage I (Emerging) fisheries occur near Kangiqtugaapik (Clyde River), Uqsuqtuuq (Gjoa Haven), Naujaat (Repulse Bay), Sanikiluaq, and Taloyoak. These fisheries are currently in a preliminary feasibility stage to determine if harvestable quantities of Arctic Char exist, if the stock can be captured by a particular gear type, to identify multi-species and habitat impacts, and to determine if markets exist (DFO 2008b).

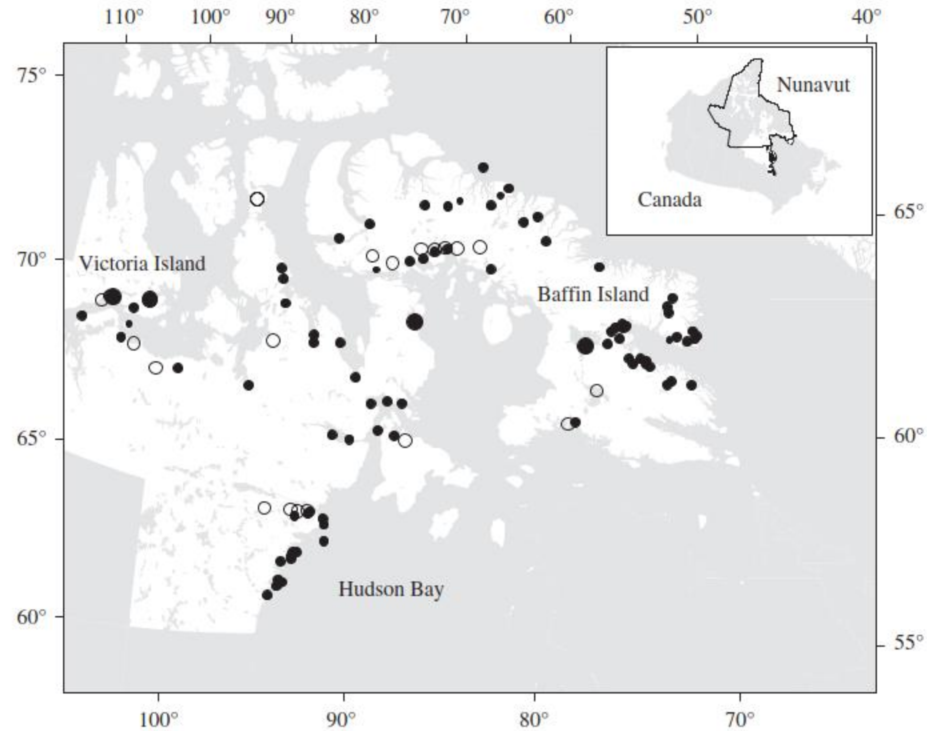

Figure 4. Commercial and exploratory waterbodies for *Salvinus alpinus* in Nunavut (Roux *et al.* 2011).

5.1.3 Catch-related Conservation Considerations

5.1.3.1 Attraction Area and Effective Fishing Area

Bait is not used in Arctic Char commercial fisheries, therefore no conclusions can be drawn about the effects of soak time on attraction area or effective fishing area.

5.1.3.2 Total Catch

Studies on total harvest of Arctic Char use 24-h standardized soak times, or report their findings by standardizing their results to 24-h increments, and therefore cannot provide information on the effects of soak time on total catch (DFO 2010, 2014c, 2021d; Gallagher and Dick 2010; Gallagher *et al.* 2021; Lea *et al.* 2023).

5.1.3.3 Length Frequency Distribution

Studies for Arctic Char recording fishing effort as well as weight and morphology use 24-h standardized soak times, and therefore cannot provide information on the effects of soak time on fish length (DFO 2010, 2014c, 2021d; Clean Catch 2023; Gallagher *et al.* 2021).

5.1.3.4 Catch per Unit Effort

CPUE collected via fisheries-dependent surveys is based on logbooks that are a requirement of the commercial license. Filling out logbooks completely, including soak time is a condition of the licence (DFO 2021d). The effects of extended soak times on CPUE are not yet known for Cambridge Bay. Fisheries dependent CPUE studies began in 2012 in Cambridge Bay and fisheries independent surveys have been conducted at Jayco River, Halokvik (both weir fisheries) and Paalik (DFO 2014c). Studies conducted in Cumberland Sound using standardized 24-h soak time show no variability in CPUE between gill net styles, but show tremendous annual variability (DFO 2010; Harris and Tallman 2010). Another anadromous Arctic Char study conducted in Ulukhaktok, Northwest Territories used soak times ranging from 0.25 to 600 h, but indicated no obvious trends in CPUE related to soak time (Lea *et al.* 2023). Similar studies conducted on landlocked Arctic Char populations indicate the same degree of variability of CPUE, also with standardized soak times of 24 h (Gallagher *et al.* 2021). The only two other incidental records of soak time were in the 50 to 55 h range, in freshwater at Ikaluit Lake, Nunavut and showed similar CPUE values to each other, but cannot be compared with the 24-h soak times for which CPUE was highly variable (DFO 2023a).

5.1.3.5 Catch Damage and Mortality

No specific data on catch damage or mortality related to soak time are available for Arctic Char.

5.1.3.6 Gear Saturation

There is no information available on gear saturation for Arctic Char.

5.1.3.7 Incidental Capture

In general, the incidence of bycatch and incidental capture increases with increased soak time of both gill nets and longlines (Scott *et al.* 2023; Bycatch Solutions Hub 2024; Cosgrove *et al.* 2013; Northridge *et al.* 2016). However, the Cambridge Bay Arctic Char commercial fishery is ecosystem-based, and uses targeted fishing gear (i.e., weirs) and targeted fishing seasons to reduce incidental catch of aquatic organisms (DFO 2021d). In addition, any incidental catch of fishes or invertebrates that does occur is often used as food in the local community and therefore is not wasted (DFO 2014c, 2021d). Incidental catch in the Arctic Char fishery was studied between 2012 and 2018 and bycatch included Snow Crab (*Chionoecetes opilio)*, Bearded Seal*,* Ringed Seal and a variety of non-target fish including wolffish, cod and sculpin (Wiens *et al.* 2025). The diversity and abundance of bycatch was found to be highly variable year to year (Wiens *et al.* 2025).

To date, seabird bycatch surveys for commercial Arctic fisheries have been limited to offshore fisheries and may have underestimated the bird bycatch that exists in estuarine areas where Arctic Char are normally harvested (Mallory *et al.* 2022). A 2022 study in Cambridge Bay yielded a bycatch of 291 loons (Gavidae family) over a five year period (high bycatch rate of 15.7 birds/1,000 net-m-days), making them second only to Greenland Halibut fisheries' bycatch of Northern Fulmar in terms of Arctic avian bycatch (Mallory *et al.* 2022). Clearly more studies are required.

5.2 Atlantic Cod

5.2.1 Biology

5.2.1.1 Distribution

Atlantic Cod (*Gadus morhua*) range along the coasts of Nova Scotia, Quebec, New Brunswick , Prince Edward Island, and the Newfoundland and Labrador Shelf, north into Hudson Bay, Hudson Strait and Davis Strait, and east around Greenland to the North Sea, Baltic Sea, and Barents Sea (Figure 5; DFO 2021f).

5.2.1.2 Size

Atlantic Cod varies in size throughout its range in Canadian waters (COSEWIC 2010a). Sexual maturity may be reached between 35 and 85 centimetres (cm) in length depending on their location (COSEWIC 2010a). Ultimately, Atlantic Cod may reach nearly 1 m in length and weigh more than 40 kg (DFO 2021ef).

5.2.1.3 Reproduction and Life History

Atlantic Cod is a demersal fish that can live to an age of 24 years (Muus and Dhalström 1974). They reach sexual maturity as early as 2 to 3 years of age in warmer southern waters near Georges Bank, up to 5 to 7 years of age in the Barents Sea (COSEWIC 2010a; DFO 2019d, 2021ef, 2024agh, 2025c). Spawning occurs in spring, at which time each mature female releases 300,000 to several million eggs. After hatching, juveniles settle in shallow near-shore habitat where they live on the bottom among eelgrass for protection from predators (COSEWIC 2010a).

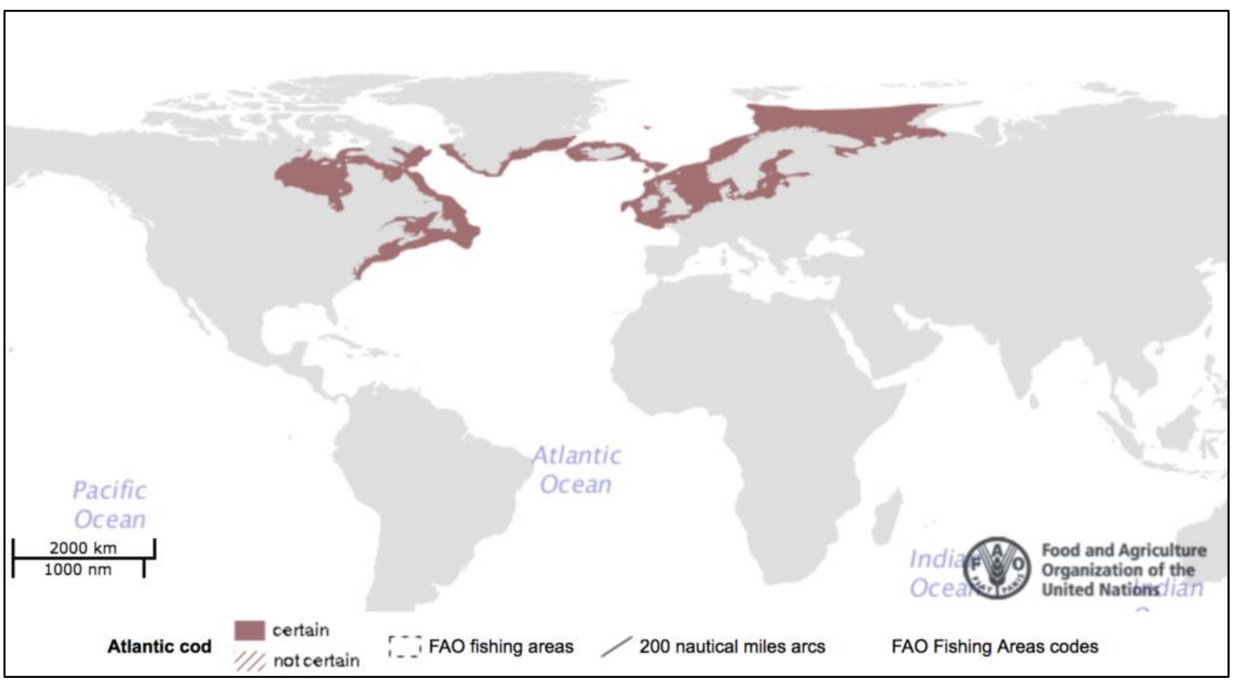

Figure 5. Global distribution of Atlantic Cod (*Gadus morhua*; FAO 2019).

They begin seasonal inshore to offshore migration as they approach maturity, after which they show little habitat preference (COSEWIC 2010a; DFO 2019d, 2021ef, 2024gh, 2025c) . Throughout their lives, Atlantic Cod are vulnerable to fishing pressure, food availability, and predation (COSEWIC 2003; DFO 2021f), although predation of adult cod is less significant (Løkkeborg 1998; DFO 2021f).

5.2.1.4 Predators and Prey

Atlantic Cod are demersal generalist predators for the most part, feeding on krill, shrimp, small fish, and Capelin (DFO 2019d, 2021ef, 2024gh, 2025c). Larval Atlantic Cod eat mainly phytoplankton and small zooplankton, switching to shellfish and shrimp as they grow. Adults feed primarily on fish (DFO 2021f). Adult cod, especially those greater than seven years old, are apex predators on the Newfoundland and Labrador shelf and, as such, have few natural predators there, although in other areas, seals are a concern (DFO 2021e). For example, in NAFO Divisions 4T-Vn predation by Grey Seals (*Halichoerus grypus*) is considered the primary factor preventing stock recovery (Neuenhoff *et al.* 2019; Swain *et al.* 2019), and even with no fishing, the stock is projected to continue to decline (Swain *et al.* 2019), making rebuilding unlikely (Sutton *et al.* 2025). Atlantic Cod mortality is otherwise driven by fishing pressure and prey item availability. Juvenile cod are known prey of Harp Seals (*Pagophilus groenlandicus*; Stenson *et al.* 2016; Stenson *et al.* 2020; Tucker *et al.* 2009), Greenland Halibut (Treble and Bowering 2002; Dwyer *et al.* 2010) and adult cod (DFO 2021f).

5.2.2 Fisheries

There are 10 stocks of Atlantic Cod in Canadian waters and three are open to directed fishing in 2025 (Table 4). Since 1997, Atlantic Cod in NAFO Division 3Ps are co-managed with France, as a directed longline and gillnet fishery, with respect to St. Pierre and Miquelon, and a total allowable catch (TAC) of 1,304 tonnes (t) for the 2023-24 fishing season (DFO 2024g). Directing for cod is permitted in 2025 by fixed gear fleets in the groundfish fishery on the Canadian portion of Eastern Georges Bank (5ZEjm). There is no directed fishing of cod allowed for mobile gear fleets in 5ZEjm.

Commercial fishing for the 2J3KL Northern cod stock was closed in 1992 due to a population collapse (DFO 2021f). Following stock assessments that took place between 2018 and 2023, in October 2023, Fisheries and Oceans Canada implemented a revised assessment model for the 2J3KL (Figure 6) Northern cod stock that included an update to the Limit Reference Point (LRP) and resulted in the stock being considered to be in the Cautious zone of the Precautionary Approach (PA) Framework. Based on results of the updated model and application of the new LRP, it was determined that the stock had not been in the Critical zone and was instead in the Cautious zone since 2016. It should be noted that this population of Atlantic Cod has not shown any actual increases since 2016 (Kennedy 2023; Kennedy and Cole 2024; DFO 2024d). As a result of the change in stock status to “cautious”, as of June 29, 2024, the stock was reopened as a commercial fishery with a TAC of 18,000 t (DFO 2021f; Kennedy and Cole 2024; Kennedy 2023; DFO 2024d).

Table 4. Ten Atlantic Cod (*Gadus morhua*) stocks in Atlantic Canada and their fishery status.

NAFO Division	Stock	Directed Fishery as of May 2025 (Y or N)	Bycatch Allowed as of May 2025 (Y or N)
2J3KL	Northern cod	Yes	Yes
2GH	Northern Labrador	No	Yes
3NO	Southern Grand Bank	No	Yes
3Ps	St. Pierre Bank	Yes	Yes
3Pn4RS	Northern Gulf of St. Lawrence	No	Yes
4T-Vn	Southern Gulf of St. Lawrence	No	Yes
4Vn	Cabot Strait	No	Yes
4VsW	Eastern Scotian Shelf	No	Yes
4X5Y	Bay of Fundy/Western Scotian Shelf	No	Yes
5ZEjm	Canadian portion of Georges Bank	Yes	Yes

This fishery authorizes otter trawl, longline, gill net, handlines and cod pots to harvest cod (DFO 2021f). Gill nets are the most common gear used for the inshore fleet, accounting for 85% of landings between 2017 and 2019, and the bulk of the inshore harvest occurs in the NAFO Divisions 3KL (DFO 2021f). Cod is also an allowable bycatch of other fisheries in 2J3KL (DFO 2021f).

Atlantic Cod is landed as a bycatch of fixed gear groundfish fisheries in NAFO Divisions 3Pn4RS , 4T-Vn, 4X5Y, and 5ZEjm when harvesters direct for other licensed groundfish species [such as Haddock (*Melanogrammus aeglefinus*), Pollock (*Pollachius pollachius*), Silver Hake (*Merluccius bilinearis*), and redfish (*Sebastes spp*.)]. Landing cod as bycatch in any other fishery is not permitted (DFO 2019d, 2021ef, 2025c). Recreational, sentinel and food, and social ceremonial (or FSC) fishing for cod also occur in some areas (DFO 2025c).

5.2.3 Catch-related Conservation Considerations

5.2.3.1 Attraction Area and Effective Fishing Area

White Hake are frequently caught and used as bait in groundfish longline fisheries in the Maritimes, while bait type is not specified for 3Ps (DFO 2016a, 2018a). Longlines baited with mackerel in northern Norway have been observed to have a maximum attraction area of 698 m for Atlantic Cod (Løkkeborg 1998), and the majority of fish were hooked within the first 2.5 h of soak time due to the higher concentration of bait stimulus early in the set time (Løkkeborg and Pina 1997).

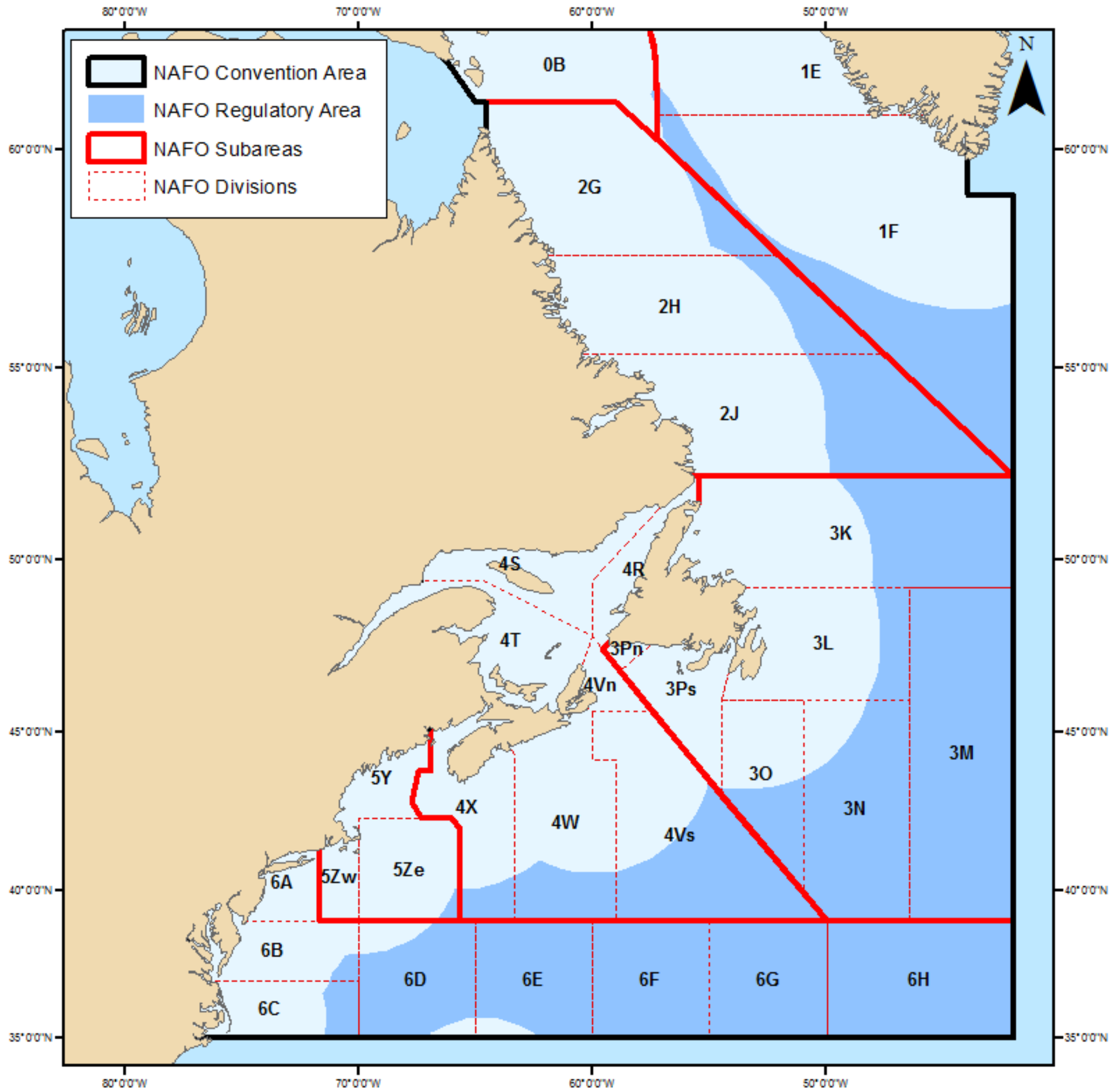

Figure 6. Northwest Atlantic Fisheries Organization (NAFO) fishing zones in Atlantic Canada (NAFO 2025).

5.2.3.2 Total Catch

Information regarding cod total catch and soak time is not available for the western Atlantic Zone. In the eastern Atlantic, the total catch of cod has been found to decrease with increased soak time, as catch damage, mortality and predation all increase (Løkkeborg and Pina 1997; Prout 1993).

5.2.3.3 Length Frequency Distribution

Surveys conducted on the southeast coast of Labrador measured length frequency for both pots and gillnets. Total length ranged from 37.2 to 91.5 cm for pots and 41.5 to 91.5 cm for gillnets.

During that study, 89.5% of fish captured by pot and 99.4% of those caught by gillnet were within legal size limits (Nguyen and Morris 2022).

The cod rebuilding plan for 2J3KL and 3Ps includes a minimum catch size of 45 cm, and the fishery may be closed if more than 15% of the catch is below this size (DFO 2021f, 2024h). In 3Pn4RS, 4T-Vn, and 5Z, the minimum allowable size is 43 cm, with the same requirement that sublegal catch must remain below 15% (DFO 2019d, 2024g, 2025c). Minimum size requirements are unknown or not set in 4X5Y and 3Pn (DFO 2021e, 2024g), as these divisions are not open to commercial cod fishing.

There is no indication in the literature as to whether soak time has any effect on the length frequency distribution of Atlantic Cod.

5.2.3.4 Catch per Unit Effort

The results of studies examining soak time in relation to cod CPUE are varied. A study on both longline and gillnet cod fisheries in the Gulf of St. Lawrence showed no relationship between soak time and CPUE (Bérubé *et al.* 2000). A study of an English gill net fishery found that cod catch rates decreased as soak time increased, with the overnight period (after 15-24 h of soak time) seeing an increase in crab predation and bycatch rates (Prout 1993). A literature review on the effects of longline soak times on cod CPUE across multiple fisheries showed mixed results, ranging from a proportional increase in CPUE with soak time, to an asymptotic relationship between soak time and CPUE, to an inverse relationship due to bait loss over time (Løkkeborg and Pina 1997; Løkkeborg *et al.* 2014). It therefore cannot be concluded that soak time has a definitive effect, whether positive or negative, on CPUE, possibly due to other confounding factors.

5.2.3.5 Catch Damage and Mortality

There is a lack of information regarding catch quality and mortality for cod in the northwest Atlantic. A 1991 study examined the effects of soak time on cod catch quality on the east coast of England. The study used gill net set times ranging from 3 to 48 h in water that was 11 °C (Prout 1993). Nets soaked for 9 h or more experienced net mortality that increased proportionally to soak time with corresponding catch decomposition. Quality decreased with increased soak time, with half the catch unmarketable due to spoilage by the time the nets had been in the water for 48 h (Prout 1993). Struggling to escape the net also resulted in increased catch damage for eastern Atlantic Cod after 9 h of soak time. If fish were damaged and then perished, catch spoilage accelerated (Prout 1993). Additionally, after 15 h soak time, predators and scavengers such as whelks, sea stars and crabs began feeding on the captured cod (Prout 1993). At the colder water temperatures (i.e., 0 °C) experienced in the western Atlantic Cod fishery, it is expected that spoilage would occur up to four times slower (Prout 1993), but catches would still begin to spoil before the currently regulated maximum 72 h gear tending time frame.

Beyond soak time, gear type is also known to have an effect on catch damage and mortality. A 2019 study in Gilbert Bay Marine Protected Area (Labrador Sea) found that cod captured by gill net (average soak time 23 h) experienced more damage and mortality than cod caught by pots (average soak time 24 h; Nguyen and Morris 2022), although it is acknowledged that soak time was standardized for both gear types and not analyzed as the primary variable.

5.2.3.6 Gear Saturation

While studies about the effects of soak time for pot saturation are available, studies specific to longline and gill net gear saturation are not available for the western Atlantic.

5.2.3.7 Incidental Capture

In Atlantic Canada, fixed gear fishing fleets are licensed to catch cod as part of multi-species groundfish fisheries (DFO 2025a). In these fisheries, cod is caught alongside other groundfish species with similar life history characteristics, and participants usually have quota for multiple species (DFO 2025a). In some cases, gillnet and longline vessels are authorized to direct for cod while in others, cod is caught as bycatch only when fixed gear vessels direct for other licensed groundfish species (e.g. Halibut, Haddock, Pollock, or redfish; DFO 2025a). In certain fisheries, other groundfish species are marketable and licensed to be landed as "bycatch only". Examples are White Hake in 4VW and 4X5, haddock in 4TVW, Atlantic Wolffish in 4VWX5, and skates in 4VsW (DFO 2025a).

The longline cod fishery also includes bycatch of turtles, sharks and birds, many of which perish as a result of incidental capture (Løkkeborg *et al.* 2010). Bycatch of most species increases concurrently with soak time and therefore increasing soak time would increase the negative effects on bycatch species (Prout 1993; Cosgrove *et al.* 2013; Northridge *et al.* 2016; Scott *et al.* 2023; Bycatch Solutions Hub 2024). However, some mitigation measures are effective in reducing bycatch independently of soak time. The use of nylon leaders is known to be effective in reducing shark bycatch on longlines (Ward *et al.* 2008). Carbon steel circular hooks are shown to be effective reducers of turtle and non-target fish bycatch due to their shape and biodegradability (Løkkeborg *et al.* 2010). Seabird bycatch is unrelated to soak time, and is actually highest at the beginning of a fishing event because the birds have seen the baited hooks enter the water (Ward *et al.* 2005). The use of bait bags, or bait otherwise hidden from sight instead of exposed bait, reduces the attraction of birds to baited hooks and therefore reduces bird bycatch (Løkkeborg *et al.* 2014; Bull 2007).

5.3 Swordfish

5.3.1 Biology

5.3.1.1 Distribution

Swordfish (*Xiphias gladius*) occur throughout the temperate to tropical oceans of the world (Figure 7). In the western Atlantic, swordfish migrate along the east coast of North America, reaching as far north as the Grand Banks of Newfoundland and the Scotian Shelf to forage, from spring through fall (May to November), when the water is warmer (DFO 2023c). They show high site fidelity to these summer feeding grounds (DFO 2016b). Canadian fisheries for Swordfish exist in the Maritimes and Newfoundland and Labrador regions.

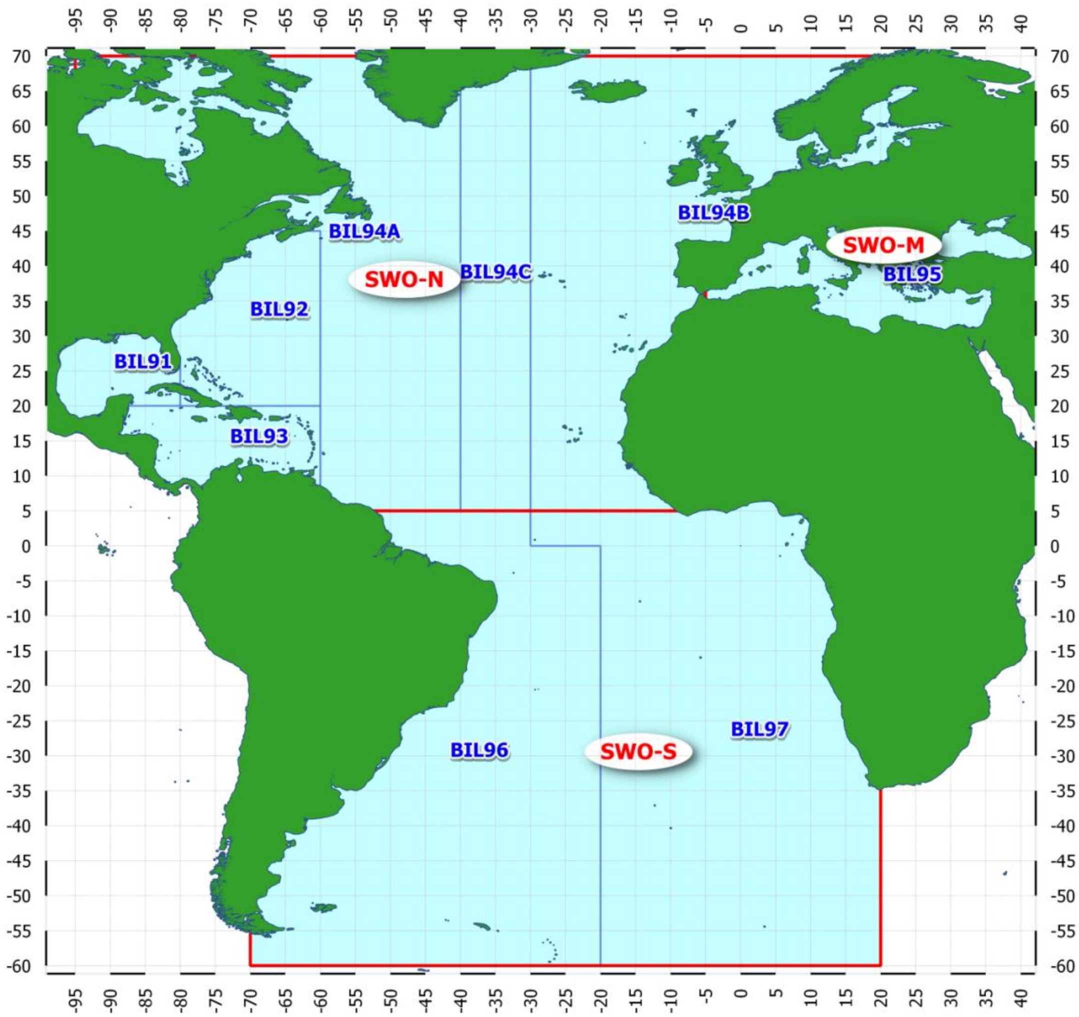

Figure 7. Distribution of the Swordfish stocks in the Atlantic Ocean. North (SWO-N) and South (SWO-S) Atlantic stocks are separated at latitude 5°N (ICCAT 2016).

5.3.1.2 Size

Adult swordfish may weigh as much as 500 kg and reach a length of 4.5 m when fully grown. Young swordfish may reach 140 cm (fork length) by age three, after which growth rate slows (DFO 2016b). Female swordfish grow faster than males and reach a larger maximum size (Andrushchenko and Hanke 2015).

5.3.1.3 Reproduction and Life History

Swordfish age is difficult to determine; however, the median age of maturity for female swordfish is thought to be five years and aging and tagging studies indicate they can live up to 15 years (Ehrhardt 1992; Wilson and Dean 1983; ICCAT 2024b). Swordfish may spawn throughout the year, generally in warm tropical or sub-tropical waters (DFO 2016b). A typical mature female may release between 1 million and 29 million eggs with each spawning event (NOAA Fisheries 2024b). Swordfish are highly migratory, moving to cooler northern waters in the summer to forage (DFO

2016b). They feed nocturnally and bask near the surface during the day (DFO 2016b; ICCAT 2024a; NOAA Fisheries 2024b).

5.3.1.4 Predators and Prey

Swordfish are pelagic, moving vertically throughout the water column during the day to feed on a wide variety of prey including many different fish species and invertebrates such as squid (DFO 2016b; NOAA Fisheries 2024b). Their wide variety of prey choices makes them very adaptable to change (NOAA Fisheries 2024b).

Adult swordfish have few natural predators with the possible exception of some shark species (DFO 2016b). Juvenile swordfish may be preyed upon by sharks and other large predatory fish (NOAA Fisheries 2024b).

5.3.2 Fisheries

The Canadian fishery for swordfish occurs primarily in the Maritimes Region along the Scotian Shelf and Grand Banks break in the Canadian Exclusive Economic Zone (EEZ). Traditionally, commercial fishing for swordfish occurred via harpoon during the daylight hours, targeting basking swordfish, and pelagic longline overnight, targeting foraging swordfish (DFO 2016b). Fishing with deep drop lines and buoy gear is becoming more prevalent as it offers high catch rates with low bycatch. The majority of the longline fishery occurs between April and December, tracking west to east and back again as the swordfish migrate with warm currents in the Gulf Stream (DFO 2016b). The southern end of the Canadian swordfish fishery is at Georges Bank near Nova Scotia, and the northern edge is at Flemish Cap east of Newfoundland (DFO 2016b).

There are two pelagic longline fleets that fish for swordfish in the EEZ. The directed swordfish pelagic longline fleet, which contains 77 licences, and the offshore tuna pelagic longline fleet, which contains one licence. The offshore tuna pelagic longline fishery licence directs for tuna species, including Albacore (*Thunnus alalunga*), Bigeye (*Thunnus obesus*), Yellowfin (*Thunnus albacares*) and Bluefin tuna (*Thunnus thynnus*) and has a bycatch allocation for swordfish (DFO 2016b). The pelagic longline fishing season is open between April 1 and March 31 annually, but fishing effort within the open season varies from year to year (DFO 2016b).

Swordfish are highly migratory, and as such, are managed cooperatively among multiple stakeholders. Atlantic swordfish stocks are therefore managed by the International Commission for the Conservation of Atlantic Tunas (ICCAT). The North Atlantic stock (SWO-N; Figure 7) is the stock that Canadian fisheries target. In 1991, conservation measures were put in place by ICCAT to help rebuild and preserve swordfish populations. The Canadian quota was thereby reduced in subsequent years (DFO 2016b). In 2000, a rebuilding program was established for swordfish in order to improve stock stability and maximum sustainable yields (ICCAT 2000). Between 2003 and 2009 the TAC was 14,000 t. It was reduced to 13,700 t in 2010, and again reduced in 2018 to 13,200 t (ICCAT 2025). A management procedure (MP) tested through Management Strategy Evaluation (MSE) was adopted for North Atlantic swordfish by ICCAT in 2024 and set a TAC of

14,769 t for 2025-2027 (ICCAT 2024a). Canada's allocation increased to 1,880 t for 2025-2027 (ICCAT 2024a, 2024b).

The swordfish longline fishery is managed domestically under a Conservation Harvesting Plan (CHP) which serves to further reduce harvesting pressure on swordfish through Individual Transferable Quotas (ITQ) that were implemented in 2003, which allow commercial fish harvesters to transfer quotas between one another. A maximum concentration of 5% of the fleet's quota can be permanently transferred by any individual licence holder (DFO 2016b).

5.3.3 Catch-related Conservation Considerations

5.3.3.1 Attraction Area and Effective Fishing Area

Standard methods for the Swordfish longline fishery are hooks baited with mackerel, herring or squid, or a mixture of these (Carruthers *et al.* 2011). Specific data on the effects of soak time on the effectiveness or attraction area of bait with regard to swordfish are lacking. Anecdotal evidence from Canadian waters indicates that location and timing are more important than bait type or soak time.

5.3.3.2 Total Catch

In a two-year Canadian study of the pelagic longline fishery for Swordfish, it was found that across 120 sets, total catch of swordfish did not increase with soak time, which ranged from 1 to 18 h (Carruthers *et al.* 2011).

5.3.3.3 Length Frequency Distribution

The Integrated Fisheries Management Plan (IFMP) for swordfish has minimum size requirements for Swordfish of 1.25 m lower jaw fork length (79 cm dressed; DFO 2016b). The average size caught in commercial fisheries is approximately 100 kg and 3 m in length (DFO 2023c; NOAA Fisheries 2024b). There is no indication in the literature as to how this size is targeted by the longline fishery, nor if soak time has any effect.

5.3.3.4 Catch per Unit Effort

A ten-year (2003 to 2013) study on CPUE in the Canadian Swordfish longline fishery revealed a peak rate of catch of 0.015 fish per 1,000 hooks (Andrushchenko and Hanke 2015). A CPUE ranging from 0.073 to 0.426 fish per 1,000 hooks was reported in a 52-year study (1968 to 2020) in Taiwan (Su *et al.* 2022). A 25-year study near Portugal (1995 to 2020) found CPUE ranged from 174.4 to 462.7 kg per 1,000 hooks, and stated that catch in the autumn and winter months tended to be higher than observed in the summer months (Coelho *et al.* 2022). The relationship between soak time and CPUE was not explored in any of these studies, and soak time is fairly consistent among boats and years in the Canadian pelagic longline fishery for Swordfish. As noted in Section 4.2.4, soak time is less important to catchability than ensuring that set duration overlaps with the feeding period of the target species (Løkkeborg and Pina 1997; Løkkeborg *et al.* 2010; Løkkeborg *et al.* 2014).

5.3.3.5 Catch Damage and Mortality

Studies relating catch damage or mortality to soak time are sparse; however, swordfish catch mortality from a 2018 study in Portugal, indicated that haul-back mortality is high overall (85.2%) and that mortality increased with decreased size, reaching 88.1% for specimens smaller than 119 cm (lower-jaw fork length), but the study found no relationship between on-hook mortality and soak time (which ranged from 11 to 21 h; Coelho and Munoz-Lechuga 2018). Data collected through the United States Pelagic Observer Program (USPOP) indicate that increased soak time leads to increased depredation of swordfish on longlines by sharks (MacNeil *et al.* 2009).

5.3.3.6 Gear Saturation

There is no information available on gear saturation for Swordfish; however, the CPUE of 0.15 fish per 1,000 hooks, with total catch not increasing with soak time (Andrushchenko and Hanke 2015) indicate that swordfish gear does not become saturated.

5.3.3.7 Incidental Capture

The IFMP for Swordfish and Other Tunas allows Albacore, Bigeye and Yellowfin Tuna to be retained as a bycatch allowance by the swordfish fishery under licence conditions (DFO 2016b). A variety of shark species are common bycatch of the Swordfish fishery (DFO 2016b). Most incidentally caught shark species, such as Bigeye Thresher Sharks *(Alopias superciliosus)* and Shortfin Mako (*Isurus oxyrinchus*), cannot be retained; however, Blue Shark (*Prionace glauca*), for example, may be retained, although generally they are not (DFO 2016b). In the past, Shortfin Mako was the most landed shark in the pelagic longline fishery, accounting for ~80 t annually (ICCAT 2024b). A 2020 retention ban on Shortfin Mako in Canadian pelagic longline fisheries, and a 2014 Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) listing of Porbeagle Shark have resulted in several years without a single shark reported landed by the pelagic longline fishery (DFO 2016b; ICCAT 2019, 2021, 2024b).

Leatherback and Loggerhead sea turtles are SARA-listed species, whose bycatch by the swordfish fleet must be reported, and special precautions must be observed when releasing them (COSEWIC 2010b; Watson *et al.* 2005). Incidental catch of Loggerheads and Leatherbacks increases with soak time (COSEWIC 2010b; Pradhan and Leung 2006; Watson *et al.* 2005). A 2008 study off the Scotian Shelf, Georges Bank and Grand Banks observed 701 Loggerheads captured as bycatch in the Canadian Swordfish and Tuna pelagic longline fishery between 1999 and 2006, which they extrapolated to an estimated 1,199 turtles per year for the entire Swordfish longline fishery in Canada (Brazner and McMillan 2008). Not all turtles caught by the Swordfish fishery represent mortalities. Recent studies indicate that 87.7% of juvenile Loggerheads survive, post-release (DFO 2024f). Regulations and procedures are in place to dehook and release turtles from longlines (DFO 2016b), and the use of alternative gear, such as carbon steel circular hooks, increases the success of these releases (Brazner and McMillan 2008).

Brazner and McMillan (2008) report a mean soak time of 20 h for the pelagic longline fishery, while Stone and Dixon (2001) report a 6-12 h soak time. The positive relationship between increasing soak time and increasing sea turtle bycatch has been studied with emphasis on time of day. A study in the Mediterranean found that 93% of Loggerhead bycatch occurred during daytime sets, while swordfish catch did not depend on time of day (Báez *et al.* 2007), although these results may or may not be applicable to the Canadian swordfish fishery. Similar but less conclusive results from a North Atlantic study (Watson *et al.* 2005) indicate that fishing for swordfish overnight rather than during the day may reduce the bycatch of Loggerheads while maintaining or even increasing the total catch of swordfish (Løkkeborg *et al.* 2010). However, no similar association with time of day was apparent for Leatherbacks, so night sets may not be a reliable mitigation method for that species (Pradhan and Leung 2006).

In a scenario of increased soak time, mitigation measures that offset increased bycatch might be considered. Bycatch of turtles could also potentially be reduced, independently of soak time, by switching from squid bait (which turtles prefer) to fish bait, using carbon steel circular hooks, or suspending longline fishing where water temperatures are above 20 ºC (Brazner and McMillan 2008; ICCAT 2022). Setting longlines deeper than 20 m (Bycatch Solutions Hub 2024) or 40 m (Brazner and McMillan 2008) would also reduce turtle and bird bycatch, without substantially reducing Swordfish catch (Brazner and McMillan 2008).

5.4 Atlantic Halibut

5.4.1 Biology

5.4.1.1 Distribution

Atlantic Halibut (*Hippoglossus hippoglossus*) are demersal fish that live on or near sand, gravel or clay bottoms at depths commonly between 200-500 m (DFO 2018c). Atlantic Halibut span from the Gulf of Maine and Georges Bank in the south to Greenland in the Northeast, including the Gulf of St. Lawrence (Figure 8; Li *et al.* 2025).

5.4.1.2 Size

Atlantic Halibut are the largest of the flatfish, with females growing faster and reaching larger sizes than males (Li *et al.* 2025). The largest Atlantic Halibut in the Maritimes Region Industry Surveys Database was a 278 cm female caught in 1992 (Li *et al.* 2025). On the Scotian Shelf and southern Grand Banks, the minimum legal size is 81 cm and most of the catch is less than 115 cm (DFO 2024c; Johnson *et al.* 2024).

5.4.1.3 Reproduction and Life History

Atlantic Halibut are a demersal species (DFO 2018c). They are flattened laterally, and by the age of six months, both eyes have migrated to the right-hand side, facing the surface (DFO 2018c). They are generally found in waters ranging from 3 to 5 °C at depths between 200-500 m (DFO 2017), although anecdotal evidence suggests they may spawn at depths of 300-700 m (DFO 2018c). Adults tend to be found at greater depths than juveniles (Sigourney *et al.* 2006). Likely spawning rises have been identified with pop-up satellite tags between December and March along the shelf and channel edges (DFO 2018c; Shackell *et al.* 2021). Potential breeding areas

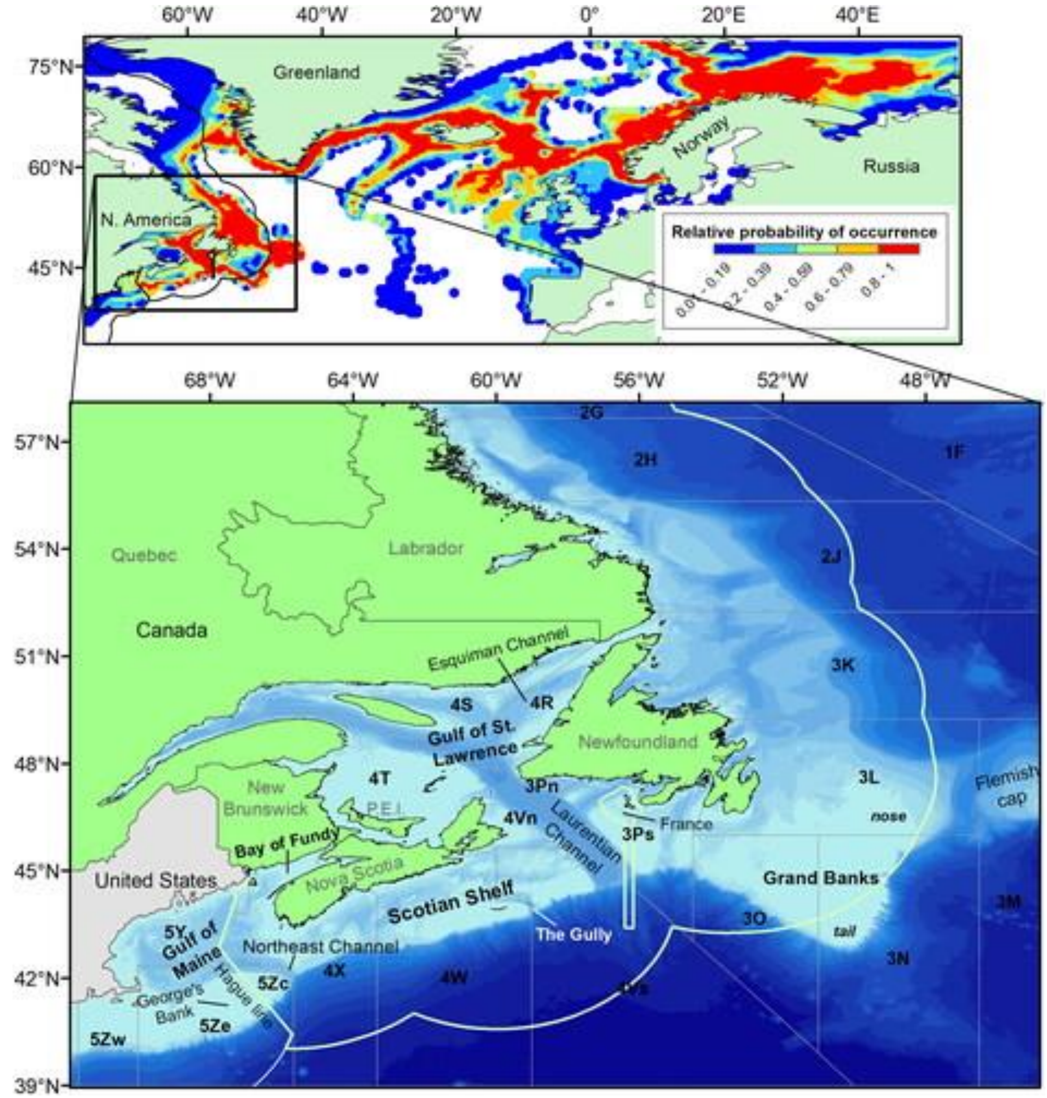

Figure 8. Global distribution of Atlantic Halibut (*Hippoglossus hippoglossus*; Shackell *et al.* 2021).

have been identified in 4RST in Gulf of St. Lawrence channels where Atlantic Halibut have been observed making rapid vertical migrations of greater than 300 m (DFO 2024c). Females generally reach 50% sexual maturity at approximately 119 cm, and males around 77 cm (Li *et al.* 2025). Although the age at which this typically occurs is uncertain (DFO 2024c), there is variation throughout the range (Shackell *et al.* 2019). One study conducted in the Gulf of Maine-Georges Bank region (1976–2000) and an experimental longline fishery off the coast of Maine (2000–2001) estimated sexual maturity at 6 years for males, and 7.3 years for females (Sigourney *et al.* 2006). For the most recent stock assessment for the Scotian Shelf and southern Grand Banks stock, age-at-50%-maturity for females was estimated to be 11.5 years (and 14.5 years at 95% maturity; DFO 2024c).

5.4.1.4 Predators and Prey

Atlantic Halibut feed on benthic and demersal organisms such as crabs and shrimps when they are young, and as they increase in size, the occurrence of fish in their diet increases (e.g., herring, silver hake, flatfish, redfish and pollock; DFO 2018c, Li *et al.* 2025). As adults, Atlantic Halibut are preyed upon mainly by Greenland Shark, though they are also eaten by seals and orcas (DFO 2018c).

5.4.2 Fisheries

There are two Atlantic Halibut fishing management units in Canada, both on the Atlantic Coast, fished generally via longline gear deployed on the ocean floor. The Scotian Shelf and Southern Grand Banks (SSsGB) management unit includes NAFO Divisions 3NOPs4VWX5Zc and the Gulf of St. Lawrence (GSL) management unit includes NAFO 4RST (Figure 8).

Fishing for halibut in Atlantic Canada was designated to the two management areas, GSL and SSsGB in 1987 (DFO 2025d). The first TACs for each area were set in 1988 and were followed by several years of declining landings (DFO 2025d, DFO 2025e). A minimum size limit of 81 cm was introduced in 1995 and 1997 in the SSsGB and GSL, respectively (DFO 2025d, DFO 2023d). This size limit was increased for the GSL to 85 cm in 2010 (DFO 2023d). In recent years, the TACs for both stocks have increased, with the highest landings seen at roughly 2,000 t in 2023 and 2024 in the GSL (DFO 2025d) and over 5,400 t in 2021 in the SSsGB stock (DFO 2025e).

5.4.3 Catch-related Conservation Considerations

5.4.3.1 Attraction Area and Effective Fishing Area

Herring, mackerel, and squid are the most common bait used for the Atlantic Halibut commercial fishery (Smith 2016). There has been no analysis of the effects of soak time on attraction area and effective fishing area, so no species-specific conclusions can be drawn about the effects of soak time on attraction area or effective fishing area.

5.4.3.2 Total Catch

A survey of available longline data, conducted in 2016, found no significant trends in total catch with soak times between 180 and 1,250 minutes (3 to 20.8 h), although a peak in total catch appeared to occur in the 600 minute (10 h) range (Smith 2016). There are currently no commercial fisheries data available for the effects of soak time on total catch for Atlantic Halibut; however, these relationships could be evaluated using At-Sea Observer data (den Heyer *pers. com.*). Studies of Pacific Halibut (*Hippoglossus stenolepis*) showed catch increased with soak time, although the rate of increase slowed the longer the gear soaked and that catch was expected to drop off substantially past dusk, which is the preferred feeding period for the species (Skud 1975; Løkkeborg and Pina 1997). For information regarding total catch in Greenland Halibut fisheries, see Section 5.5.3.2.

5.4.3.3 Length Frequency Distribution

In 1994, management plans and licence conditions were put in place that forbid the capture of Halibut less than 81 cm in 3NOPs4VWX5Zc (DFO 2018c), and 85 cm in 4RST, as of 2010 (DFO 2023d). Stock assessments in 3NOPS4VWX5Zc have indicated that introduction of the minimum legal size limit contributed to the recovery of the Atlantic Halibut stock (DFO 2009a; Johnson *et al.* 2024; Trzcinski and Bowen 2016; Cox *et al.* 2016). The size composition of halibut caught in the longline survey and the at-sea observed trips informs the size selectivity of the survey and the fishery (DFO 2009a; Johnson *et al.* 2024; Trzcinski and Bowen 2016; Cox *et al*. 2016). The impact of soak time on size selectivity has not been evaluated in the framework assessments.

5.4.3.4 Catch per Unit Effort

Novel methods to standardize catch per unit effort from the longline survey, which uses soak time to model hook competition, have been developed (Luo *et al.* 2022; McDonald *et al.* 2024). These indices were not used in the 2021 framework assessment (Johnson *et al.* 2024), and an analysis of the effects of soak time on CPUE is not available.

5.4.3.5 Catch Damage and Mortality

There has been no analysis of data relating catch damage or mortality to soak time for Atlantic Halibut. In 2022, Quebec Region estimated that the instantaneous fishing mortality rate for Atlantic Halibut was 0.017, calculated using a recapture model of tagged fish (DFO 2023d). In the Martimes region, estimates of natural mortality in a model were allowed to vary over the time series, with recent (2014–2021) estimates of mortality ranging from 0.128 to 0.143 for males and from 0.120 to 0.133 for females (DFO 2024c). While fishing mortality was calculated as 0.14 prior to the last framework (DFO 2024c), a more recent stock status update applied a fishing mortality of 0.104 (DFO 2025e).

5.4.3.6 Gear Saturation

There is little information available on the effects of soak time on gear saturation for Atlantic Halibut. It has been reported that gear saturation, at least at a local level, is possible for the Atlantic Halibut longline fishery (Smith 2016).

5.4.3.7 Incidental Capture

Atlantic Halibut is part of a multi-species fishery targeting groundfish. Bycatch consists of species that are caught and discarded at sea, including sublegal sized halibut, fish caught to use as bait, and other groundfish species retained as part of the groundfish fishery (DFO 2023d). Incidental capture in the Atlantic Halibut longline fishery varies depending on the location and the seasons fished, and may include other taxa besides fish (Hurley *et al.* 2019; Bowlby *et al.* 2024). Bycatch in 4WX and 5Zc is largely unknown due to a lack of data (Figure 8; DFO 2009a). Although the percentage of sublegal Atlantic Halibut discarded in 3NOPs4VWX5Z decreased by half between 2009–2013 and 2014–2020, and bycatch of other non-target species decreased (Themelis and den Heyer 2015; Bowlby *et al.* 2024). Some argue that an increase in abundance of halibut, not a change in gear selectivity, resulted in lower bycatch rates (Themelis and den Heyer 2015; Bowlby *et al.* 2024). In 2007 and 2008, an assessment was conducted in NAFO Divisions 3N, 3O, 3P and 4V (DFO 2009a). The assessment indicated that incidental catch of non-target species composed 40 to 60% of the total catch, with White Hake (*Urophycis tenuis*) being the most frequently caught species, accounting for approximately 30% of the bycatch (5 to 75% depending on area). The second most common incidental catch species was cod (*Gadus* spp., approximately 7% of the catch), followed by Cusk (*Brosme brosme*), which averaged 5% of the catch. Fifteen different species were reported in the incidental catch of the Atlantic Halibut fishery (DFO 2009a, 2017).

Another study of the Industry-DFO Halibut longline survey (in NAFO 3NOPs4VWX) which compiled data between 1998 and 2016, calculated incidental catch rates of 70 to 85% of the total catch, with over 100 non-target species of fish, birds, invertebrates and mammals recorded among the bycatch (Hurley *et al.* 2019). The species composition of the incidental catch indicated that Spiny Dogfish (*Squalus acanthias, n*=60,073), White Hake (*n*=24,169), and Atlantic Cod (*n*=20,564) were most common (Hurley *et al.* 2019). Compared to pelagic longline fisheries, turtles were less frequently part of the bycatch in the demersal longline fishery (Brazner and McMillan 2008).

The Industry-DFO Halibut Longline Survey conducted by commercial fish harvesters uses standard soak times ranging from 6 to 12 h, and the relationship between soak time and bycatch was not analyzed. Hurley *et al.* (2019) used a soak time of 8.5 h to simulate the conditions of a commercial longline set.

5.5 Greenland Halibut

5.5.1 Biology

5.5.1.1 Distribution

Greenland Halibut (*Reinhardtius hippoglossoides*) in the Northwest Atlantic are migratory and therefore cannot be divided easily into individual populations with the exception of a population of fjord-dwelling Greenland Halibut in northwestern Greenland (Boje 2002), a resident population in the Gulf of St. Lawrence (Bassi *et al.* 2023), and another resident population in Cumberland Sound (Treble 2003). Recent genetic studies have indicated that these populations are all globally part of a single, large genetic population (Estévez-Barcia *et al.* 2025; Gíslason *et al.* 2023; Roy *et al.* 2014; Westgaard *et al.* 2017). The inshore populations in NAFO Division 0A rely on immigration from the bulk of the population in Baffin Bay and Davis Strait (DFO 2019a). The distribution of Greenland Halibut stretches from Baffin Bay east to Greenland, and they occur as far south as the Maritimes and Gulf of St. Lawrence (Figure 9; DFO 2019a,b). Canadian fisheries for Greenland Halibut occur in the Arctic Region as well as Atlantic Canada.

5.5.1.2 Size

Size-at-maturity for Greenland Halibut varies by region and by time (Harris *et al.* 2009; DFO 2024b). Females at 50% maturity have ranged from 67-80 cm in Division 0A and 62-67 cm in Division 0B, which is within the size range being targeted by gill nets (DFO 2021a, 2024b). In the

Gulf of St. Lawrence, they reach sexual maturity at 36-45 cm (Chamberland and Benoît 2024). Gill nets catch larger, more mature fish, ranging from 50-85 cm, compared to mobile fishing gear such as trawls, which have typical catch sizes ranging from 35-65 cm. The average weight of Greenland Halibut caught commercially is 3.5 to 10.5 kg, and they can grow to over 1 m in length (DFO 2014b; Dyck *et al.* 2007). Size and percentage of mature adults appear to be decreasing in NAFO SA 0 catches (Harris *et al*. 2009); however, aging methods for Greenland Halibut are lacking, so determining age-at-maturity is challenging (DFO 2019a,b).

Figure 9. Distribution of Greenland Halibut (*Reinhardtius hippoglossoides;* Hedges *et al.* 2017).

5.5.1.3 Reproduction and Life History

Greenland Halibut spawn in February or March, but peak timing varies from year to year (Boje 2002; DFO 2019a,b) and may involve spawning migration from other areas (Gundersen *et al.* 2010). Greenland Halibut appear to have a multi-year maturation cycle, wherein one group of eggs mature in the ovaries for the current spawning year, while another, smaller group of eggs begins to develop for the next spawning year (Kennedy *et al.* 2011). This fact should be considered when estimating the reproductive potential of Greenland Halibut.

It is possible that spawning activity of Greenland Halibut is limited due to the harsh environmental conditions present in Baffin Bay, and the lack of energy reserves experienced by fish in these waters (Simonsen and Gundersen 2005). Water temperature and depth may play a role in growth and reproduction (DFO 2019a,b). When Greenland Halibut do spawn, eggs and larvae drift for up to four months before settling onto benthic habitat; juveniles occur in shallow nursery areas and move to deeper water as they mature (Jørgensen 1997; Boje 2002).

5.5.1.4 Predators and Prey

The main predators of adult Greenland Halibut are Narwhal (*Monodon monoceros*) and Greenland Shark, while Beluga (*Delphinapterus leucas*), Hooded Seal (*Cystophora cristata*) and Ringed Seal are also common predators (DFO 2019a). Young Greenland Halibut and larval stages are eaten by Atlantic Cod and adult Greenland Halibut (DFO 2019a).

Greenland Halibut are a demersal species whose feeding habits are linked to their size and life stage. Smaller Greenland Halibut (less than 20 cm) feed on crustaceans, while mid-sized Greenland Halibut (20-60 cm) feed on small fish and shrimp. Larger (greater than 60 cm) individuals feed on larger fish such as cod, redfish and grenadiers (Treble and Bowering 2002; Dwyer *et al.* 2010).

5.5.2 Fisheries

Commercial fisheries for Greenland Halibut in Arctic waters occur in NAFO Divisions 0A (Baffin Bay) and 0B (Davis Strait; Figure 10), along with an additional Greenland Halibut fishery within the Cumberland Sound Turbot Management Area (CSTMA; DFO 2019a,b).

The fishery in Division 0A began in 1996 as an exploratory fishery and was converted to a commercial fishery in 2007. The most recent published quota was 8,704.99 t as of 2023, and it has remained at this level as of 2025 (DFO 2019a,b; 2023b). The Division 0A fishery uses a mix of mobile and fixed gear. Gill nets with squid-baited bags, and to a lesser-degree, longlines, are used in the offshore fishery, while mainly longlines have been used in exploratory inshore fisheries. Between 2010 and 2014, an annual average of between five and nine vessels were using fixed gear for harvesting Greenland Halibut in Division 0A.

In Division 0B, commercial fishing for Greenland Halibut began in 1981. The TAC has remained at the 2023 level of 7,797.51 t as of 2025, and uses both fixed gear and mobile gear (DFO 2019a,b; 2023b). Annually, between ten and 16 vessels are involved in the fixed gear fisheries in this area. They use a combination of baited gill nets and longlines and are responsible for 44% of the annual Greenland Halibut catch in Division 0B. Additionally, in the CSTMA, winter longline fishing through the ice began as an emerging fishery in 1986 with catches varying between 100 to 500 t per year depending on ice conditions (DFO 2019a,b). This ice fishery has been undertaken annually since then, and has been thriving since 2011 (DFO 2019a,b), with a commercial quota of 500 t.

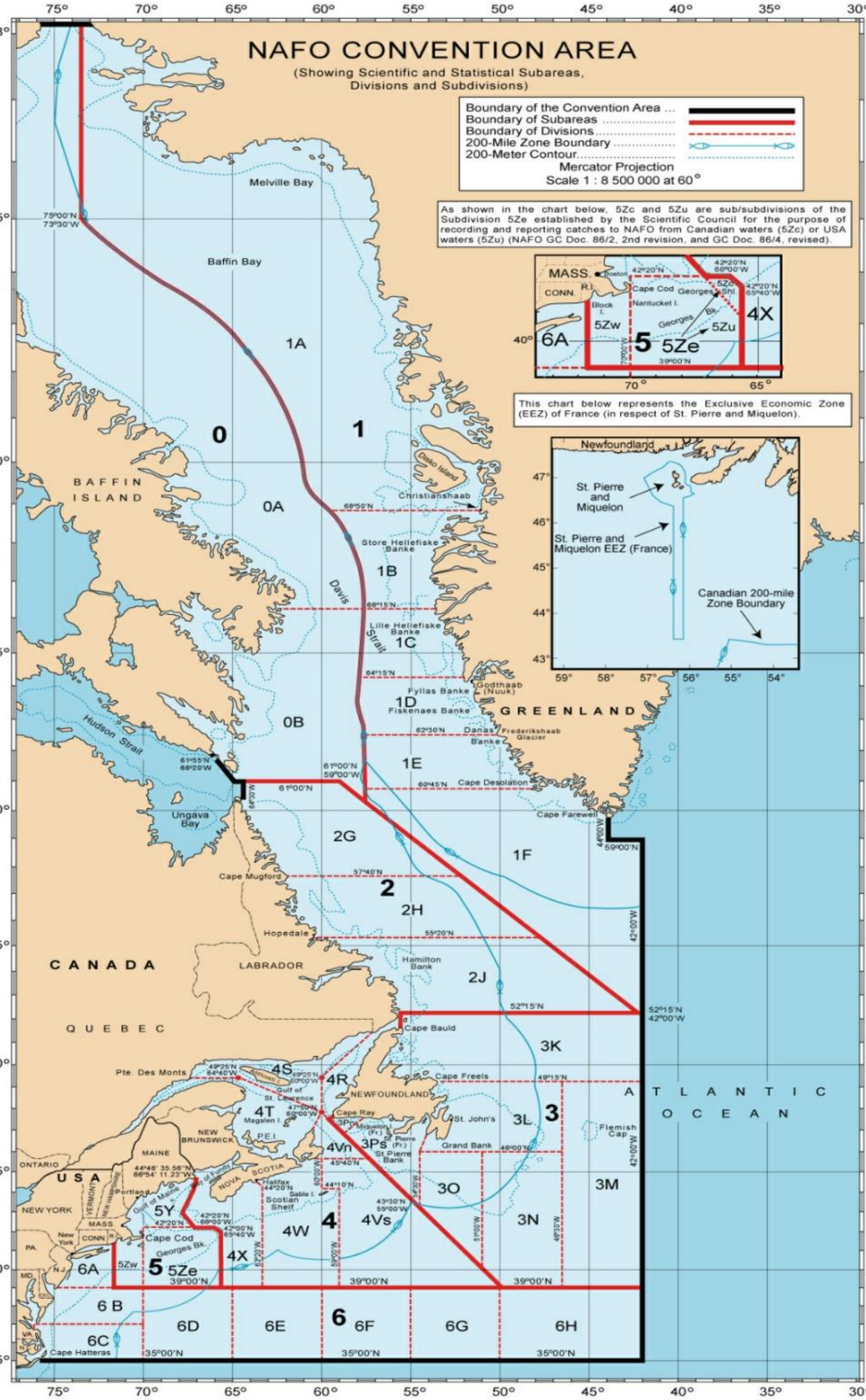

Figure 10. Northwest Atlantic Fisheries Organization (NAFO) subareas and divisions for Greenland Halibut (NAFO 2025).

In the Newfoundland and Labrador Region, there are two Greenland Halibut fisheries. There is a fishery in Division 2GHJ3KL, using both gill nets and longlines, with a TAC of 15,900 kg (round weight) in 2024 (DFO 2024b). Additionally, there is a gillnet fishery for a genetically distinct population of Greenland Halibut in Division 4RST (Chamberland and Benoît 2024) off the coast of Quebec and Newfoundland with an annually variable TAC. The minister approved TAC for all sources was 2,400 t in 2023-2024, and 2,000 t in 2024-2025 (DFO 2024e). There are indications that the 4RST stock is declining, as undersized fish currently exceed 30% of the harvested catch (DFO 2024b).

5.5.3 Catch-related Conservation Considerations

5.5.3.1 Attraction Area and Effective Fishing Area

Gill nets and longlines set for Greenland Halibut are generally baited with squid (DFO 2019a; Woll *et al.* 2001). A 2001 bait study in east Greenland using longlines indicated that longlines baited with grenadier had 25% higher CPUE for Greenland Halibut and 20.7% less bird and non-target fish bycatch than longline hooks baited with squid (Woll *et al.* 2001). The same study showed no significant change in CPUE due to differences in soak time, which ranged from 5 to 14 h. The effects of soak time on attraction area or effective fishing area beyond 14 h are unknown.

5.5.3.2 Total Catch

The Greenland Halibut longline fishery is known for having particularly long soak times ranging from 6 to over 68 hours, though a recent pooling of data from three separate longline studies showed no reliable trends between total catch and soak time (Madigan *et al.* 2022). This may be due to the tendency of hooked Greenland Halibut to escape over time, the prevalence of Greenland Shark predation of captured fish, and the loss or degradation of bait from longline hooks (Ward *et al.* 2005; High 1980). Likewise, the Greenland Halibut gillnet fishery is also known to utilize soak times in excess of the regulated 72 h, with 25% of activities exceeding that threshold in the Gulf of St. Lawrence as a whole (Chamberland and Benoît 2024). This trend may reduce overall catch due to unaccounted for mortalities (Chamberland and Benoît 2024). Melindy and Flight (1992) found that soak times over 8 days (> 192 h) decreased catch rate and quality and increased discards in the 2GHJ Greenland Halibut gillnet fishery. Similarly, Wicks (1993) suggested that lower catch rates in 0B compared to 2GH were due to longer soak times and net damage later in the season. Catch rates declined sharply with increased soak time, with the highest catches occurring between 3–4.9 days. The study emphasized reducing soak time in the fishery to improve catches.

5.5.3.3 Length Frequency Distribution

Canada has a lower catch size limit for Greenland Halibut of 45 cm (18 in) in Divisions 2GHJ3K, and if the proportion of fish caught below 45 cm exceeds 15% of the total number of Greenland Halibut caught, an area may be closed to fishing (DFO 2024b). Minimum gill net size in 4RST is 44 cm (DFO 2024b). No information is available on fish length with regard to gill net soak time; however, increasing the mesh size used in 4RST from 140 mm to 152 mm between 1995 and 1996 resulted in an increase in the average length of Greenland Halibut caught in the commercial fishery from 44 to 47.6 cm (DFO 2024b), indicating that fish length in the commercial gill net fishery is linked to mesh size. A 2000 longline study in Northwest Greenland found no relationship between soak time and fish size; instead size appeared to be related to fishing depth (Simonsen *et al.* 2000).

5.5.3.4 Catch per Unit Effort

CPUEs according to soak time have been studied for the GSL Greenland Halibut gillnet fishery. After controlling for spatial and temporal variation, CPUE decreased from 6 to 15 h, increased from 18 to 72 h, after which it began show a greater degree of variability and an apparent stabilization (Chamberland and Benoît 2024). A longline study with soak times ranging from 5 to 14 h reported CPUE ranging from 281 to 435 kg per 1,000 hooks, with differences in CPUE showing no apparent relationship to soak time (Woll *et al.* 2001). Another study in Northwest Greenland in 2000, similarly found no relationship between CPUE and soak time, which ranged from 6 to 12 h (Simonsen *et al.* 2000). A multi-year longline study in Cumberland Sound found that CPUE increased with depth rather than soak time, which ranged from 6 to 68 h (Madigan *et al.* 2022).

5.5.3.5 Catch Damage and Mortality

Although no data relating to catch damage or mortality with regard to soak time are available for Greenland Halibut, it is postulated that prolonged soak time (in excess of 72 h, as is common in SAs 0 and 4RST) increases degradation of catch and unaccounted fishing mortality (Wicks 1993; Chamberland and Benoît 2024). It was found that the average probability of fish being landed in a state of decomposition after a 24 h soak time was approximately 50%, and this increased to 80% after a 48 h soak (Chamberland and Benoît 2024). As fish in a state of decomposition often fall from the net or are taken by scavengers, there could also be additional unaccounted mortalities (Figure 11; Uhlmann and Broadhurst 2015; Chamberland and Benoît 2024).

5.5.3.6 Gear Saturation

In a 2001 longline study in east Greenland, catch concentration for Greenland Halibut ranged from 5.2% to 6.7% of hooks occupied with no apparent effect due to soak time, which ranged from 5 to 14 h (Woll *et al.* 2001). The study indicated that if gear saturation were to occur, it would occur beyond 14 h of soak time.

Figure 11. Photo of Greenland halibut soaked for 24 hours. The fish at the bottom was considered dead fresh even though it would not be consumable, while the other 3 were considered decomposed (from: Chamberland and Benoît 2024, Figure 79).

5.5.3.7 Incidental Capture

In Division 0A, the most common bycatch of Greenland Halibut gillnet and longline fisheries are Greenland Shark, Thorny Skate (*Amblyraja radiata*), Arctic Skate (*Amblyraja hyperborea*) and Roughhead Grenadier (*Macrourus berglax*; DFO 2019a; Walsh 2008; Wheeland and Devine 2018). In Division 0B, Greenland Shark and Thorny Skate are the most common bycatch, while redfish (*Sebastes* spp.), Northern Wolffish (*Anarhichas denticulatus*) and several species of grenadiers are also frequently caught (DFO 2019a; Wheeland and Devine 2018). Bycatch of Northern Wolffish is particularly concerning because the species was listed as threatened in 2001 by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), and federal recovery plans require that wolffish bycatch be released alive and intact (DFO 2019a; COSEWIC 2012b).

Gill nets and longlines used for harvesting Greenland Halibut also represent entanglement and entrapment risks for marine mammals such as Beluga, Narwhal and Bowhead Whales, as well as Sperm Whales (*Physeter macrocephalus*) and Northern Bottlenose Whales (*Hyperoodon ampullatus)* in deeper waters in Baffin Bay (DFO 2019a).

Marine birds, especially Northern Fulmar, are also at risk of entanglement and bycatch in longlines and gill nets set for Greenland Halibut fishing where baited hooks remain on the surface for too long, thus attracting foraging birds that dive as deep as 60 m for the bait, get hooked, and ultimately drown (DFO 2007, 2019a). Mitigation for bird bycatch is therefore not dependent on soak time, but instead related to quick longline deployment, concealment of bait and the use of thawed or weighted bait that will not float on the surface, attracting birds (Ward et al. 2005; DFO 2007).

One study in Scott Inlet (Baffin Island) in 2007 found that soak time, which ranged from 4 to 46 h, appeared to have no effect on the number of Greenland Shark caught as bycatch in Greenland Halibut commercial nets (Walsh 2008). Another study conducted in Jones Sound and Admiralty Inlet between 2014 and 2018 standardized soak time (which ranged from 14 to 42 h), and therefore no conclusions could be drawn (Wheeland and Devine 2018). A study in Cumberland Sound in 2022, with soak times ranging from 6 to 68 h, indicated that Greenland Shark bycatch increased when soak times increased past 10 h (Madigan *et al.* 2022).

While Northridge *et al.* (2016) concluded that shorter soak times are associated with lower bycatch of mammals, birds and reptiles, reduced soak time alone is not expected to reduce bycatch significantly without the use of other taxa-specific mitigation measures such as ropeless gear, alternative hooks, twines, mesh or floats, or the use of acoustic and visual deterrents (Northridge *et al.* 2016; Scott *et al.* 2022). Canada has a national plan for reducing bird bycatch in longline fishing operations through educational initiatives and the implementation of low cost mitigation measures such as the use of tori lines, weighted hooks, and other means (DFO 2007). Without changing soak time, a switch from wire to monofilament leaders reduced reported shark bycatch by 41% with no change to catch rate, and also broke less, thereby reducing the creation of ghost gear (Scott *et al.* 2022). The use of carbon steel circular hooks, which decay in a matter of days, reduces the risk of entanglement of turtles and marine mammals (NOAA 2014). Switching to pot fisheries may also further reduce the risk of bycatch in Greenland Halibut fisheries, although total catch of Greenland Halibut may also decrease (Folkins *et al.* 2021; Grant 2015).

6. Summary

6.1 Ecosystem-related Conservation Considerations of Gear Tending Time

6.1.1 Entanglement

Increased soak time of gill nets and longlines is associated with increased entanglement of seals, turtles, whales, and birds, and the literature consistently recommends shorter rather than longer soak times for both gillnets and longlines (Bolling *et al.* 2023; Bycatch Solutions Hub 2024; Clean Catch 2023; Dietrich *et al.* 2025; Hamelin *et al.* 2017; Innis *et al.* 2010). While taxa-specific mitigation measures may exist (Northridge *et al.* 2016; Scott *et al.* 2022), there have been no studies that quantify the benefits of these measures against the increased entanglement risk posed by increased soak time.

6.1.2 Ghost Gear

The formation of ghost gear has been shown to increase as soak time increases (Breen 1990a; Brown *et al.* 2005; Gilman 2015). Ghost gear can cause habitat damage to corals and vegetation as it drifts (Brown *et al.* 2005). Ghost fishing gear traps or entangles fish, marine mammals, birds, sea turtles and invertebrates as gear drifts with currents (Kaiser *et al.* 1996; Brown *et al.* 2005; Gilman 2015; Stelfox *et al.* 2016). Reducing soak time would reduce the formation of ghost gear. No studies that quantify the benefits of other mitigation measures against the increased risk of ghost gear formation posed by increased soak time have been conducted.

6.1.3 Habitat Damage

Habitat damage from gill nets and longlines is generally considered low in comparison with other bottom-contact fishing methods (Clark *et al.* 2016). Soak time is not related to habitat damage because that damage only occurs as the net is deployed or retrieved, regardless of how long it is set (Clark *et al.* 2016). Where critical habitat is a concern, impacts can often be mitigated with fishing closures in sensitive areas (DFO 2009b).

6.1.4 Microplastics

Increased soak time contributes to the formation of microplastics through increased exposure of fixed gear to UV light, weather, water, extreme temperatures, and friction (NOAA 2014; Lusher *et al.* 2017). No studies that quantify the benefits of other mitigation measures against the formation of microplastics due to increased soak time have been conducted.

6.1.5 Species at Risk

Fixed fishing gear may inadvertently interact with endangered and threatened species listed under Schedule 1 of the federal *Species at Risk Act*, which includes prohibitions against their killing, harming, harassing, and taking (DFO 2025f). At-risk marine mammals, sea turtles, fish, and birds may face entanglement, injury, or death as a result of interactions with gear from longline and gillnet fisheries (Johnston *et al.* 2007; Brazner and McMillan 2008; Dietrich *et al.* 2025; COSEWIC 2002). Increasing soak time of fixed fishing gear increases the risk of interactions (Northridge *et al.* 2016; Bolling *et al.* 2023).

6.2 Catch-related Conservation Considerations of Gear Tending Time

As discussed throughout Section 5, results of studies that have examined the effects of soak time on attraction area, length frequency distribution, and gear saturation are scarce, or have been conducted using soak times less than 72 h, so current understanding of the impacts of soak time are limited to catch metrics (total catch and CPUE), catch damage, and incidental catch. The impacts of soak time on the conservation considerations are discussed here by fishery gear-type. In addition, throughout this report, methods that could be implemented to mitigate the impacts of increased soak time have been discussed. While taxa-specific mitigation measures may reduce the incidence of bycatch with longer soak times, no studies have quantified the cost to benefit ratio (Northridge *et al.* 2016).

6.2.1 Longlines

Of the three focus species that use longline fixed gear (Swordfish, Atlantic Halibut and Greenland Halibut), none show any reliable correlation or conclusive results linking increased soak time to increased total catch, fish length distribution or CPUE. Several studies of Greenland and Atlantic halibut (demersal longline fisheries) report catch rates peaking with soak times under 72 h and then beginning to decline (Ward *et al*. 2005; High 1980). The focus fisheries using pelagic longlines (swordfish) showed a positive correlation between longline soak time and incidental bycatch, especially for Endangered Leatherback and Loggerhead sea turtles. No fishery had species-specific information on catch damage, spoilage or predation with respect to soak time; however, evidence indicated an increase in catch damage and mortality with increased soak times (Cosgrove *et al.* 2013; Gilman *et al.* 2007; Prchalová *et al.* 2011; Savina *et al.* 2016).

6.2.2 Gill Nets

Of the three focus fisheries that use gill net fixed gear (Arctic Char, Atlantic Cod and Greenland Halibut), none showed any reliable correlation or conclusive results linking increased soak time to increased total catch, fish length distribution or CPUE. Many studies have found that increased soak time may actually decrease total catch due to target fish predation, and gear saturation (Olin *et al.* 2004; Prchalová *et al.* 2011; Prchalová *et al.* 2013). All focus fisheries showed a positive correlation between soak time and incidental capture (bycatch; Brazner and McMillan 2008; Bull 2007; Cosgrove *et al.* 2013; Northridge *et al.* 2016; Wheeland and Devine 2018). Only the Arctic Char fishery did not have references that mention a decrease in fish quality due to catch damage, spoilage or predation associated with longer soak times.

6.3 Uncertainties

Studies comparing soak time with Ecosystem-related Conservation considerations were plentiful; however, information on Catch-related Conservation considerations was sparse, and fishery-specific data were even more limited. Soak time was often not recorded by commercial fishing vessels (Johnston *et al.* 2007). Studies that focused on catch metrics often standardized soak time, whether for ease of data analysis or because the fisheries themselves tend to follow fixed patterns (Johnston *et al.* 2007). Other studies have started off using soak time as a variable but switched to standardized soak times after initial results found no correlation (Meintzer *et al.* 2018). More studies need to be conducted with soak time as the main variable (Henriques *et al.* 2023). These quantifiable results could then be compared to quantifiable benefits of each additional (i.e., non-soak time related) mitigation method, such as acoustic pingers and other deterrents, gear marking and GPS tags, to do a cost to benefit analysis for offsetting the inherent risks of increasing soak time. There is evidence that each of these methods can provide incremental mitigation benefits (DFO 2006, 2016b, 2025b; Murray *et al.* 2023).

Studies including soak time often fail to consider the cumulative effects of soak time, or to investigate hidden effects that may occur between hauls. Some soak time studies that haul and count traps repeatedly throughout a long soak period are better designed to report cumulative effects of the trap throughout the entire soak.

Many studies that have considered the effects of soak time caution that results are often obfuscated by failing to consider the effects of time of day as well as actual soak time. Bycatch and/or total catch metrics can often be impacted by the time of day a gill net or longline is set and retrieved, rather than the length of time it is deployed (Northridge *et al.* 2016). These additional, often fishery-specific, variables would need to be examined as components of dedicated soak time studies.

The uptake of new fishing regulations, such as changes in soak time, is often slow and would benefit from education, slow phase-ins, as well as financial incentives (Eayrs and Pol 2019).

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