A Brief History of Fisheries in Canada

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INTRODUCTION

Having the longest coastlines in the world and some of the largest freshwater ecosystems, Canada has a rich history of exploitation and stewardship of its marine and freshwater fisheries resources. For thousands of years prior to European settlement, Indigenous peoples across what is now Canada utilized and managed marine and freshwater fisheries that underpinned food systems, cultural practices, and pre-colonization economies (Berkes 1990). The earliest exploitation of Canadian fisheries by Europeans was by the Spanish and Portuguese fishing for Atlantic Cod *Gadus morhua* in the 15th century (Hutchings and Myers 1995). The importance of fisheries in Canada is highlighted by the enactment of the Fisheries Act, one of Canada's first acts of legislation passed in 1868, one year after Confederation (Fisheries Act 1985). The purpose of the Fisheries Act is to ensure federal management and control of fisheries and the protection and conservation of fishes and fish habitat (Fisheries Act, Section 2.1). In the 1970s, the Fisheries Act was strengthened to protect all fishes and their habitats, and, in 2012, it was weakened to only protect commercial, recreational, or Aboriginal fisheries (Hutchings and Post 2013). Amendments to protect all fishes and fish habitats, strengthening the Fisheries Act once again, were passed in Bill C-68 (2019).

Canada has one of the largest Exclusive Economic Zones at 5,740,544 km^2 (Flanders Marine Institute 2019) and the third-largest supply of renewable fresh water (McKitrick et al. 2018), giving it access to an abundance of marine and freshwater resources. Although Canada has an abundance of fisheries resources, best available science has not always been used to make decisions on quotas and habitat regulations. For example, suppression of scientific uncertainty substantially contributed to the collapse of Atlantic Cod in the early 1990s. Also, industry heavily influenced minimum water-discharge requirements for the conservation of Pacific salmon *Oncorhynchus* spp. and other salmonids in the Nechako River, one of the Fraser River's main tributaries (Hutchings et al. 1997). Despite such discounting of scientific information relevant to the management of Canadian fisheries, the censorship of Canadian government scientists, and delayed protection of species at risk during the Harper administration (Carroll et al. 2017), Canada has strived to develop more sustainable uses of fisheries resources (Ricketts and Harrison 2007).

To celebrate the American Fisheries Society 150th anniversary, we present a brief history of Canadian fisheries, from Indigenous to recreational to commercial. We take you across the country, starting in the Atlantic Ocean, inland through Canada, exploring the Great Lakes and other lakes, north to the Arctic Ocean, and, finally, dive into the Pacific Ocean. We also highlight specific case studies that exemplify the challenges of managing such diverse fisheries resources (Boxes 2–7) and briefly celebrate some of the prominent Canadian fisheries scientists who have helped to build capacity of science-based fisheries management in Canada (Box 1).

INDIGENOUS FISHERIES

For thousands of years before the arrival of European settlers to what we now call Canada, Indigenous peoples from coast (Atlantic; e.g., Mi'kmaq) to coast (Arctic; e.g., Inuit) to coast (Pacific; e.g., Haida), and across the expansive interior (e.g., Cree) relied heavily on ocean and freshwater resources (including fishes, plants, crustaceans, mammals) for survival (Berkes 1990). Although extremely diverse, rich, and vibrant, Indigenous cultures shared a common link to the lands and waters around them (McMillan and Prosper 2016). Possessing place-based knowledge systems and equipped with fishing technologies passed down for generations (Stewart 2008), Indigenous fishing practices were governed by laws and customs embedded into their worldviews and languages, often centering on sustainable uses and conservation for generations to come. For example, the Mi'kmaw concept of *netukulimk* describes achieving nutritional and economic standards of wellbeing for the community without jeopardizing ecological integrity, diversity, or productivity in the future (McMillan and Prosper 2016). A variety of gears and techniques were used including nets, hooks, longlines, spears, harpoons, traps, and weirs. In British Columbia, for example, stone traps were used in low tide to capture salmon, and reef nets (made of cedar and willow) were placed perpendicular to shore where salmon would be pushed in by tidal flow (Langdon 2006). Long before the advent

Box 1. Contributions of Canadians to Fisheries Science

It is difficult to single out only a few Canadians ("The Legends;" Hasler et al. 2019), or significant "made in Canada" contributions to fisheries science, because there are many to choose from and much has been accomplished. The scientific study of fishes in Canada is said to have been started by Sir John Richardson, a British naturalist serving as a surgeon on the voyages led by Captain Sir John Franklin during the early 19th century (Dymond 1964). Richardson spent considerable time in Canada (he was not on Franklin's lost voyage) naming or describing 140 fish species. Despite early observations by Richardson and others, as well as early monitoring of fisheries stocks (e.g., Charles Gilbert's monitoring of Sockeye Salmon), fisheries science as we know it today did not truly take hold in Canada until the 20th Century. In 1937, the Fisheries Research Board of Canada—evolving from the Biological Board of Canada started in 1912—and, in 1921, the Ontario Fisheries Research Laboratory were established. With mandates to monitor fish stocks and dynamics, Canadian fisheries scientists were also free to study fish taxonomy, physiology, and ecology. Canadian scientists have been particularly interested in the taxonomy of salmonids, esocids, lampreys, and sturgeons (Dymond 1964) and have also produced major compendia on the natural history of fishes in Canada (e.g., McPhail and Lindsey 1970; Hart 1973; Scott and Crossman 1973; Scott and Scott 1988) and regional studies (e.g., D.E. McAllister for the Arctic; Coad 2010) that are used to this day. Major contributions have also been made in the discipline of fish physiology, starting with the works of F. E. J. (Fred) Fry and W. S. (Bill) Hoar (see early volumes of the ***Fish Physiology*** book series), and understanding anadromy (e.g., Huntsman 1947; Foerster 1947) and landlocking (e.g., McAllister and Lindsey 1961), which have been aptly studied in Canada, given its vast coastal and inland waters and recent glaciation. And, finally, not to neglect mandates, fisheries dynamics have been thoroughly studied in Canada. The Ricker Curve (Ricker 1954) is an exceptional contribution. W. E. (Bill) Ricker's accomplishments have been much honored: Order of Canada in 1986; first to receive the American Fisheries Society (AFS) Award of Excellence in 1969; and his name honored in the AFS William E. Ricker Resource Conservation Award in 1995. Peter Larkin also received the Order of Canada (1995) for his pioneering use of mathematical modelling of fish stocks and for helping to shape both national and international scientific policies. The AFS Canadian Aquatic Resources Section honors deserving MS and PhD students each year with the Peter A. Larkin Award for Excellence in Fisheries. To end, we also acknowledge that the early figures in Canadian fisheries science were mostly male, however, there were also some notable and pioneering female scientists including Helen Battle (in 1928, she became the first Canadian woman to earn PhD in marine biology) and Nancy Frost, who worked on both marine and freshwater fishes in Newfoundland waters in the 1930s and 1940s. Today, the Canadian fisheries science community is much more diverse and continues to make important contributions to the science and management of fishes and fisheries in Canada and beyond. Valuable progress is being made in new areas, such as stock monitoring (e.g., Ocean Tracking Network), the inclusion of human dimensions in fisheries management and science, and the development of evidence-based policy.

of industrial fishing practices, Indigenous peoples engaged in more than subsistence fishing, and built fisheries-based economies that involved trade with both near and distant Indigenous nations, including exchanges with early European settlers (Stewart 2008). For millennia, Indigenous peoples have regulated and managed their vast fisheries sustainably by controlling harvest pressures, using selective fishing gears according to season and other factors (Menzies and Butler 2007; McMillan and Prosper 2016). Although Indigenous peoples harvested great quantities of fish sustainably and, in many cases, worked alongside non-Indigenous fishers across Canada, tensions grew, which often resulted in unfavorable outcomes for Indigenous peoples across Canada (Menzies and Butler 2007; McMillan and Prosper 2016). An example of such tensions occurred in British Columbia when industrial fishing practices and salmon canneries of non-Indigenous fishers grew in the late 1800s to early 1900s and were heavily reliant on Indigenous peoples for labor and fish (Menzies and Butler 2007). Indigenous peoples' fishing methods and rights clashed with industrial fishing, and Indigenous fishing methods, such as weirs and inland netting, were blamed for poor salmon runs and subsequently banned or destroyed in some areas (Newell 2016).

The Fisheries Act (1868) was legislated to manage and control fisheries supporting the growth and expansion of non-Indigenous fisheries and imposing restrictions on, and often displacing, Indigenous fishing practices, laws, and economies (McMillan and Prosper 2016). The 19th century saw Indigenous fisheries shift from being wholly self-determined to almost entirely state controlled. However, in the late 20th century, two important Supreme Court of Canada decisions altered the course for Indigenous fisheries in Canada. In 1990, in what was later dubbed the "Sparrow Decision," the Court ruled that the Musqueam First Nation in British Columbia possessed the right to fish for food, social, and ceremonial purposes, and that this right has priority, after conservation, over recreational and commercial harvesting activities (*R. v. Sparrow* [1990]; Fisheries Act Section 5.3). In 1999, in the "Marshall Decision," the Court ruled that Donald Marshall Jr., a Mi'kmaw fisher, possessed a treaty right to engage in commercial fishing (*R. v. Marshall* [1999]; Fisheries Act Section 9.3)—questioning the legal authority and management entitlement of the state over Indigenous fishing practices (Davis and Jentoft 2001). Today, in a supposed era of "reconciliation" between Canada and the Indigenous peoples of these lands, and as a direct result of Indigenous activism, amendments to the Fisheries Act are explicitly inclusive of Indigenous knowledge systems and considerate of Indigenous treaty rights (more information about reconciliation between Indigenous peoples and Canada available: https://bit.ly/3cn-5C0L). Nevertheless, the amendments do not require Fisheries and Oceans Canada (DFO) to include Indigenous peoples in fisheries management, nor do they require true inclusion or consideration of Indigenous knowledge systems into policy; the amendments simply encourage DFO to do so (Claxton 2018). Hence, uncertainty remains around whether future Indigenous participation in fisheries management decisions will be substantive and meaningful (i.e., genuine co-management) or purely symbolic. For co-management to be successful, there needs to be a shift away from top-down decision making and Indigenous co-management boards need to be supported, strengthened, and acknowledged, which is an ongoing process in the Arctic (Snook et al. 2018), among other places. This is a time of increasing recognition of the critical and longstanding importance of Indigenous stewardship for biodiversity maintenance (Schuster et al. 2018) as well as cultural preservation (McMillan and Prosper 2016), which will hopefully lead us towards a shared future that respects Indigenous fishing practices, laws, and economies (Infographic: Indigenous fisheries).

RECREATIONAL FISHERIES

Recreational fishing is defined as "fishing of aquatic animals (mainly fishes) that do not constitute the individual's primary resource to meet basic nutritional needs and are not generally sold or otherwise traded on export, domestic, or black markets" (UN FAO 2012). Recreational fishing had been practiced throughout Europe since at least the 1500s and began in Canada with the arrival of European settlers. Early recreational fisheries in Canada exploited natural waters—rivers, lakes, and coastal systems—and, by the 1830s, were being recognized as a recreational asset (Infographic: Recreational fisheries; UEL 1984). Hatcheries became a part of active recreational fisheries management in Canada by the late 1800s and included the supplementation of natural stocks (e.g., Wilmot Hatchery on Lake Ontario was established in 1868 to enhance Atlantic Salmon *Salmo salar* populations) and the creation of private and public put–grow–take fisheries. In many cases, governments engaged in stocking of introduced species (starting in 1870s—including Brook Trout *Salvelinus fontinalis* in the Rocky Mountains, and Pacific salmon in eastern Canada) to support angler preferences. Early fisheries management strategies included the use of "fish sanctuaries" to protect key gamefishes in Canada (e.g., in the 1940s, the Ontario Ministry of Lands and Forests instituted sanctuaries for Largemouth Bass *Micropterus salmoides* in the Rideau Lakes of eastern Ontario). This illustrates that there was concern for the sustainability of recreational fisheries over 80 years ago. Recreational fishing in Canada continued to grow throughout the 20th century, and today it is of great socio-economic importance (Tufts et al. 2015) and in many ways is part of the "Canadian identity" especially in rural areas (e.g., Husky the Musky statue in Kenora, Ontario). The sector supports fishing guides, bait harvesters/dealers, outfitting services, fishing lodges, and many related service industries (from travel to fishing gear to food to boats to beer). Indeed, recreational fishing generates over CAD$8 billion annually for the Canadian economy (Brownscombe et al. 2014)—more than the commercial fishing industry, which had a landed value of CAD$3.4 billion in 2016 (https://bit.ly/3ctCTrr).

Early recreational fishing was almost entirely harvest-oriented, while today more than 60% of fish landed by anglers in Canada are released (Brownscombe et al. 2014). Walleye *Sander vitreus* is an example of a species that still has high rates of harvest, with nothing more Canadian than a "shore lunch," in contrast to release rates of over 90% for species such as Muskellunge *Esox masquinongy* and black basses *Micropterus* spp. (Brownscombe et al. 2014). Competitions have emerged, including the creation of the Tyee Club of British Columbia in 1927, to recognize those who captured a 30-pound Chinook Salmon *Oncorhynchus tshawytscha* from a rowboat (https://bit.ly/2RHowHI), to the more recent (started in 1970s) Orillia Yellow Perch Festival focused on ice angling for Yellow Perch *Perca flavescens* in Ontario. Throughout the Arctic, fishing derbies, usually held during winter, are widespread, involve the entire community, and enhance social and cultural aspects of Indigenous life, as well as being a significant aspect of sustenance (Shannon 2006).

There have been major shifts in target species. For example, some anglers in Canada pursue fishes that were not historically considered gamefish, such as Longose Gar *Lepisosteus osseus* and suckers *Catostomus* spp. and *Moxostoma* spp. The Canadian human population also has changed since early European settlement with many more cultures (spanning the globe) becoming engaged in the sector, as evidenced by the production of fishing regulations in multiple languages by most natural resource management agencies in Canada. The sector also has modernized in that simple "low-tech" gear has largely been replaced by precision-engineered fishing gear and boats equipped with scientific-grade fish finders and GPS units. Moreover, anglers now engage extensively with each other through various social media platforms and phone applications where they are able to share catch data with peers and fisheries managers (Papenfuss et al. 2015) and adjust their behavior by shifting fishing pressure from areas doing poorly towards those where fishing is good, contributing to what has been termed the "invisible collapse" (Post et al. 2002). This has been enabled by greater road access (including basic logging roads) and large increases in off-road vehicle usage that now make even some of the most "remote" areas accessible (Hunt and Lester 2009). Some recreational fisheries truly are "emerging," as evidenced in the Arctic in the last decade. Despite these examples of the historical and current importance of recreational fishing in Canada, its future remains uncertain, given a failure to recruit new (young) anglers, and an overall "aging" of the angling community (Brownscombe et al. 2014), although recreational fishing—specifically derbies—in the Arctic, revolves around the whole community regardless of gender or age (Shannon 2006). Beyond that, recreational fisheries, primarily those in the south, are threatened by a number of activities, including those internal (e.g., bait-bucket transfers [where bait species are transported to, and released from bait buckets at fishing sites (Drake and Mandrak 2014)], overharvest), external (e.g., climate change, habitat alteration, pollution), or both (e.g., aquatic invasive species), to the recreational fishing sector.

FINFISH FISHERIES IN EASTERN CANADA

The European experience in Canada began with fish. The Portuguese and Spanish Basques in the late 15th century (followed by the English and French in the early 16th century) undertook migratory fisheries, travelling from Europe in March/April to fish Atlantic Cod (Box 2) in the coastal and offshore waters of Newfoundland, returning to Europe to sell their catch in early autumn (Hutchings and Myers 1995). By the early 17th century, Atlantic Salmon became another strategically and economically important species, albeit miniscule relative to the value and catch of cod. The eastern Canadian experience with fisheries was dominated by fishes (so-called "finfish," as opposed to the intellectually opaque term "shellfish") until the 1990s. Although prominent today, the earliest commercial fishery for an invertebrate was for lobster *Homarus americanus* in the mid-19th century (Gough 2013).

In terms of longevity, cod fisheries supersede all others in Canada (circa 1470s; Cole 1990). Commercial exploitation of Atlantic Salmon dates to the 1630s when a subsidiary of *Compagnie de la Nouvelle France* (1627–1663) was established at *Le Hève* in Acadia (LaHave, Nova Scotia; Dunfield 1985). The longest time series exists for Newfoundland (1723–1991), where catches steadily increased for more than 200 years before peaking in the 1930s (Figure 7a). Combining all Canadian data, catches reached 6,106 tonnes in 1930 (a probable historical maximum, based on May and Lear 1971; Dunfield 1985; Dempson et al. 1998), before declining thereafter until the mid-1950s (Figure 7b). Efforts to close commercial salmon fisheries began in 1966 (Chase 2003), culminating in moratoria in all regions: Maritimes (1984), Newfoundland (1992), Labrador (1998), and Québec (2000). Currently, the status of Atlantic Salmon designatable units ranges from Endangered in the south to Not at Risk in the north (COSEWIC 2011).

By tonnage, the largest fisheries in eastern Canada are those for groundfishes (Infographic: Atlantic Canada). Before 1950, the total reported landings of Canadian groundfish averaged less than 1 million tonnes (Murawski et al. 1996). From 1950 to 1990, four species dominated: cod, Haddock *Melanogrammus aeglefinus*, redfishes *Sebastes* spp., and Silver Hake *Merluccius bilinearis* (Infographic: Atlantic Canada). The largest fishery was for cod. Even in 1990—immediately before the 1992–1994 moratoria—cod comprised 61% of the groundfish landings (Figure 8; DFO 2019). Thereafter, catches of cod collapsed; in

Box 2. Atlantic Cod *Gadus morhua*

Atlantic Cod has been fished off eastern Canada for millennia. Foremost among harvesters were Indigenous peoples. The Mi'kmaq caught cod under the ice as part of their seasonally varying diet (Pastore 1998). It is unclear whether the species was regularly consumed by the Beothuk (Marshall 1998), but the Norse, whose presence in Newfoundland (circa 1000) may have lasted more than a century (Ledger et al. 2019), almost certainly captured cod (*skrei*) for drying and consumption. Northern cod (southern Labrador to northern Grand Banks), once by far the largest of Canadian stocks (Hutchings and Rangeley 2011), provides an appropriate fishery for historical examination.

Commercial fishing began in the 15th century with the Portuguese, who knew of abundant cod on the Grand Banks by 1472 (Cole 1990). By the early 1500s, several hundred vessels sailed annually from Portugal, the Basque Country, France, and England (Quinn 1979). Cod fished in coastal bays—the "shore" fishery—were split and dried on pebble beaches or wooden stages (Head 1976; Turgeon 1986). The offshore "bank" fishery produced cod of lower quality and market value; unable to be dried, bank cod were cured by heavily salting the fish in a "wet" state. The early 1600s witnessed the beginning of non-Indigenous settlement on Newfoundland and a nascent inshore fishery that would eventually supplant the last European (French) shore fishery in 1904 (de Loture 1949; de La Morandière 1962).

In addition to increased vessel size and power, the 500-year-old fishery bore witness to considerable technological change (Hutchings and Myers 1995; Cadigan and Hutchings 2001). Originally caught by single-hooked hand line, cod were later captured by purse seine (beginning in the 1500s), multiple-hooked longline (1790s), gill net (1840s), trap (1870s), side-hauled bottom trawl (1890s), and stern-hauled bottom trawl (1955). Unsurprisingly for an unmanaged fishery, catches steadily increased (Figure 1), especially in the 1950s and 1960s, caused by a massive influx of bottom trawlers from 18 countries (Hutchings and Myers 1995).

The overfishing of the 1960s persisted, with varying severity, throughout eastern Canada until the early 1990s when fishing moratoria were imposed (1992–1994). Excepting small increases in the late 1970s (when Canada extended jurisdiction to 200 nautical miles), the combined spawning stock biomass of cod throughout Canadian waters declined steadily, showing no discernable signs of recovery by 2009 (Figure 2). As of March 2020, according to the most recent stock assessments (available at https://bit.ly/3czsl4H), none of Canada's cod stocks, including 3Ps cod (cod from a region off southern Newfoundland that extends from Cape St. Mary's to just west of Burgeo Bank, and over St. Pierre Bank and most of Green Bank; O'Brien 2020), had exceeded its limit reference point (B_{lim}), below which stocks are in a "critical" zone and all removals are to be kept to the lowest level possible (DFO 2009). Although a revised Fisheries Act might facilitate stock rebuilding, broad ministerial discretion still permits directed fishing for stocks below B_{lim}, as reflected by the quota increase for Northern cod in 2019.

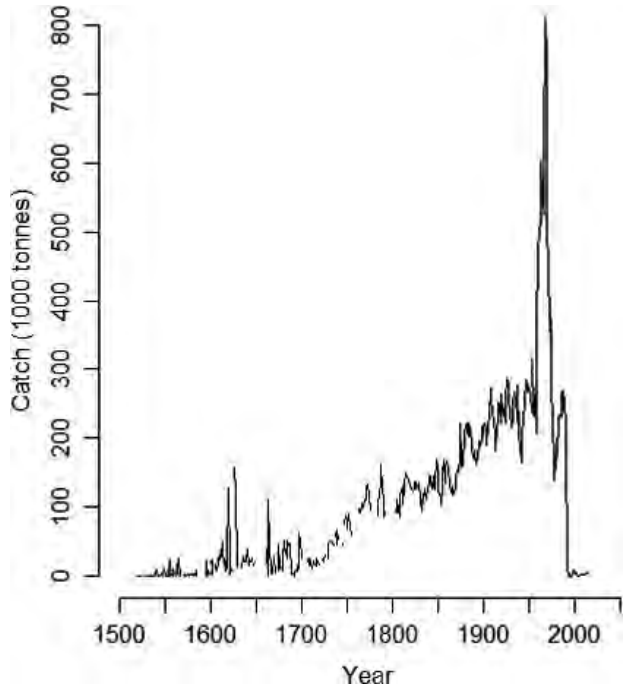

Figure 1. Reconstruction of catches of Northern Atlantic Cod (updated from Hutchings and Myers 1995).

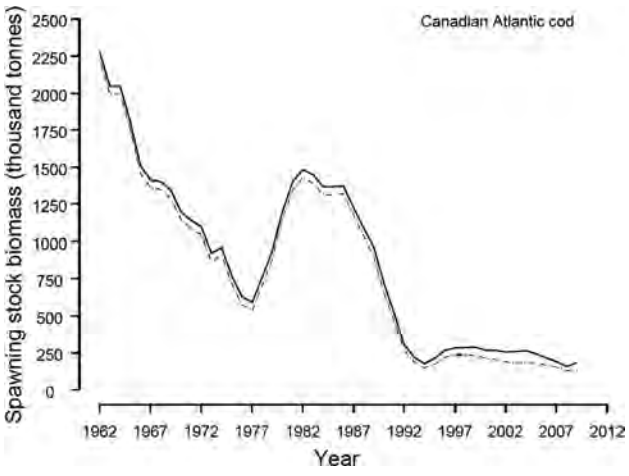

Figure 2. Estimated combined spawning stock biomass of Canadian stocks for Atlantic Cod *Gadus morhua* from 1962 to 2009. The two lines reflect differences in estimated catches for one of the stocks. Full details are available from Hutchings and Rangeley (2011).

the past decade (2008–2017), catches averaged 16,500 tonnes annually. Catches for redfishes, hake, Pollock *Pollachias virens*, and flatfishes (e.g., Atlantic Halibut *Hippoglossus hippoglossus*, and Greenland Halibut *Reinhardtius hippoglossoides* [Box 3]) have declined steadily since the early 1990s. Notwithstanding modest fluctuations, Haddock landings remained stable from 1990 to 2017 (Figure 8).

The largest pelagic fishery is for Atlantic Herring *Clupea harengus*. More than 90% of the catch is from the Maritimes (DFO 2019) where, from 1934 to 1964, annual catches gradually increased, averaging ~100,000 tonnes (FRCC 2009). From 1965 to 1990, catches fluctuated between 110,000 and 540,000 tonnes (FRCC 2009). Since 1990, Canadian catches have declined more than 60% (DFO 2019); in 2017, Maritime catches (73,933 tonnes) were the lowest since 1934.

Box 3. Greenland Halibut *Reinhardtius hippoglossoides*

Greenland Halibut is the basis for the largest commercial fishery in the Canadian Arctic, executed offshore in Baffin Bay and Davis Strait (Figure 5, NAFO Subarea 0) as a transboundary stock shared with Greenland (NAFO Subarea 1). Between 2011 and 2016, Greenland Halibut commercial harvests from the eastern Canadian Arctic constituted 13–18% of all Canadian exports of this species and between 1.8–2.7% of Canadian total fish exports (DFO 2020). There is also a small inshore longline fishery in Cumberland Sound that has been managed independently by Canada since 1988 with a current quota of 500 tonnes. Bottom trawl and bottom-set gill net are the preferred gear in the offshore fishery. This fishery began in Davis Strait in the early 1980s and expanded north to Baffin Bay in the early 2000s with a current quota of 18,200 tonnes. A similar amount is allocated for offshore waters west of Greenland. This offshore stock is assessed using an index of biomass derived from random depth-stratified bottom-trawl surveys. The index is above reference points suggesting the stock is healthy (Treble and Nogueira 2018). The 2017 landed value for 15,935 tonnes was ~CAD$101 million (DFO 2020). This fishery may expand as southern stocks may become depleted and climate change adversely affects more southerly populations.

FINFISH FISHERIES IN THE LAURENTIAN GREAT LAKES

Indigenous peoples have been subsistence fishing in the Laurentian Great Lakes for millennia, since the Wisconsinan continental ice sheet retreated north of the basin, circa 12,000 years ago (Lauer 2015). Gill nets, hoopnets, spears, and weirs were used to capture species such as American Eel *Anguilla rostrata* (Box 4), Atlantic Salmon, Lake Sturgeon *Acipenser fulvescens* (Box 4), and suckers, and the abundance of fishes led to permanent settlements along the shores of the Great Lakes (Bogue 2000). The colonization of the Great Lakes region by Europeans in the 1600s eventually led to the establishment of treaties with First Nations that, although conveying some traditional fishing rights, displaced many nations from prime fishing areas and entirely relocated certain communities. Europeans initially undertook subsistence fisheries, such as for Atlantic Salmon in Lake Ontario tributaries. By the early 1800s, commercial fisheries emerged in the Great Lakes for Atlantic Salmon, Lake Sturgeon, Lake Trout *S. namaycush*, Lake Whitefish *Coregonus clupeaformis*, and Walleye (Bogue 2000). By the late 1890s, commercial fisheries rapidly expanded with technological advances, such as refrigeration, steam-powered fishing vessels to catch the fish, trains, and ships using the newly created Erie and Welland canals to take fish to market (Brown et al. 1999; Regier et al. 1999).

Although many species were landed by the commercial fishery, one of the largest freshwater fisheries in the world (Ontario Ministry of the Environment 2019), only a few species comprised over 90% of the catch by weight from 1879 to 2015 (Infographic: Great Lakes; Baldwin et al. 2018). Ciscoes *Coregonus* spp., including *C. artedi* and the deepwater ciscoes, comprised 39% of the total catch (Infographic: Great Lakes). They were fished extensively in all of the lakes and stocks were largely extirpated by the 1950s (Infographic: Great Lakes) due to overfishing and competition with, and predation by, invasive Alewife *Alosa pseudoharengus* and Rainbow Smelt *Osmerus mordax* (Mandrak and Cudmore 2013). Yellow Perch comprised 12% of the catch (Infographic: Great Lakes), being the most important species in Lake Erie, but also caught in significant numbers in lakes Huron and Michigan. Walleye and its subspecies, Blue Pike *S. vitreus glaucus* (Erie

Box 4. American Eel *Anguilla rostrata* and Sturgeons: The Small and Elusive in Contrast to the Large and Imposing

Two ancient and iconic migratory species that have quite different life history strategies occupy Canadian and, more broadly, the fresh waters of North America. In historical times, these fishes were utilized, sometimes heavily, and were highly revered. But in recent years, they have fallen upon hard times. Both are important indicators of freshwater ecosystems and anthropogenic impacts. They are the elusive American Eel and the imposing sturgeons *Acipenser* spp.

The American Eel is a catadromous fish originating in the Sargasso Sea. Newly hatched leptocephali (willow leaf-like drifters) disperse in oceanic currents into the Gulf of Mexico and northward along the Atlantic coastal waters of North America, where they metamorphose into small glass eels attracted to inflowing estuaries and rivers and migrate into brackish and fresh waters. Some may remain in the ocean, but freshwater occurrence is more familiar. Historically abundant in eastern North America, eels were once heavily utilized and highly valued by Indigenous peoples, particularly in the St. Lawrence River system; they provided important travelling food because of their high caloric content (six times that of any other freshwater teleost; Casselman 2003). The Jesuits reported that Indigenous peoples said eels "enable people to live when all else fails." Model estimates indicate that in the 1600s, 25 to 50 million large yellow eels (up to 131 cm long, 7.3 kg in weight, maximum age 44 years, generation time 21 years) occupied the upper St. Lawrence River and Lake Ontario (USLR-LO) constituting half the inshore fish biomass. Primarily because of anthropogenic stressors (Jacoby et al. 2015), eels at the extremities of the range have declined dramatically and are now relatively rare in the upper Mississippi River and USLR-LO systems. Eel ladder passage in the USLR documents this decline (Figure 3). The number of eels immigrating per day during midsummer peak passage was record-high in 1982–1983, when approximately 1 million eels ascended the ladder each summer. The decline has been precipitous, except for a small pulse in 2005–2015. The USLR-LO system probably now has fewer than 100,000, a 99% decline since 1950. Ontario closed all fisheries in 2004–2005 and officially declared the species Endangered in 2008. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed eels as Special Concern in 2006 and Threatened only 6 years later (COSEWIC 2012). The Atlantic States Marine Fisheries Commission considered the stock to be Depleted in 2012 and 2017 assessments (ASMFC 2017), and the International Union for Conservation of Nature classified American Eel as Endangered in 2014 (Jacoby et al. 2017). Considerable effort is being undertaken to understand and reverse the decline. Upstream passage is being enhanced, and mortalities during downstream passage through hydroelectric facilities are being addressed (e.g., Jacobson 2018). However, fisheries-independent surveys are needed to estimate abundance in all life stages and habitats, to quantify and reduce stressors, and to encourage international data sharing, governance, and management. We are optimistic that the decline is being addressed, but fisheries managers should be concerned whether actions are adequate to reverse the decline of this iconic fish.

Unlike the relatively small, slithery eel that is elusive and primarily nocturnal, very large and more obvious majestic fishes occupy North American fresh waters; the sturgeons. In Canada, there are five species, three well known with broad geographic distributions and with large size and great longevity, taking 15–25 years to mature (Scott and Crossman 1973): Lake Sturgeon of central North America (up to 2.4 m long, 141 kg weight, 155 years), Atlantic Sturgeon *Acipenser oxyrinchus* of eastern North America (up to 4.6 m, 369 kg, 60 years), and White Sturgeon *A. transmontanus* of western North America (up to 6–7 m, 635 kg, >100 years)—the largest North American freshwater fish. The Atlantic Sturgeon is anadromous, spawning in fresh water and migrating to the ocean (Scott and Crossman 1973). Sturgeons were utilized and highly revered by Indigenous peoples, who adorned pottery with embossed impressions of their boney scutes. Most sturgeon species were quite abundant at one time, but were heavily overfished in the developing commercial fisheries of the 1800s and subsequently became rare, depleted by incidental capture in gill nets and considered a nuisance species. It has been alleged that they were stacked like cordwood, dried, and used to stoke the boilers of steamships on the Great Lakes (Harkness and Dymond 1961). Damming of river systems greatly affected their spawning migrations, but after many decades, some populations established more restricted migrations and new spawning locations, while other populations died out in the fragmented river systems (Jager et al. 2016). As a result of regulated exploitation and pollution abatement, some populations are showing a slow and encouraging resurgence, with larger, older individuals increasing in abundance (e.g., upper St. Lawrence River; Figure 4). Extensive telemetry studies are providing new insights concerning the species (Thayer et al. 2017). This is especially well documented in the upper St. Lawrence River system, which once had small but important commercial hook–line fisheries for the species. With the closure of these fisheries in the 1980s and the establishment of new spawning grounds (inflowing river systems), resurgence is occurring. Nevertheless, their status is still precarious, with COSEWIC in Canada, depending upon location and designatable units, considering Lake Sturgeon to be of Special Concern or Endangered, Atlantic Sturgeon to be Threatened, and White Sturgeon to be Threatened or Endangered. Management should consider their basic habitat requirements, unrestricted access to appropriate spawning habitat, and ecosystem role as large benthivores (Auer and Dempsey 2013). With appropriate protection, we can be optimistic that the status and abundance of sturgeon species will improve, but we must remain vigilant concerning their conservation.

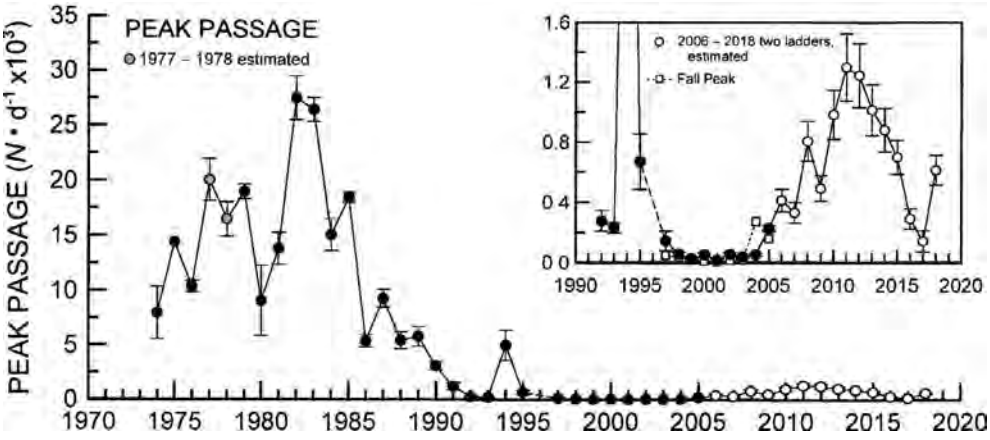

Figure 3. Peak passage index indicated by number of American Eels ascending the eel ladder per day (in thousands) at the Moses–Saunders hydroelectric dam at Cornwall, Ontario, during the 31-day peak migration for a 45-year period, 1974–2018. Annual means and 95% confidence intervals are shown. Data are not available for 1996. Peak passage consistently occurs in midsummer (mid-July to mid-August—peak water temperature); however, in 9 years, 1997–2005, a peak also occurred in the fall (open squares). Inset provides an expanded passage scale for 1991–2018. Peak passage standardizes ladder operating conditions over the years. From Marcogliese and Casselman (2009) updated.

Figure 4. Lake Sturgeon caught in a recent acoustic-telemetry study of the resurgence of the species in the upper St. Lawrence River—a tagged 140-cm, 17.9-kg sturgeon recaptured October 2014. Held by C. M. M. Burliuk.

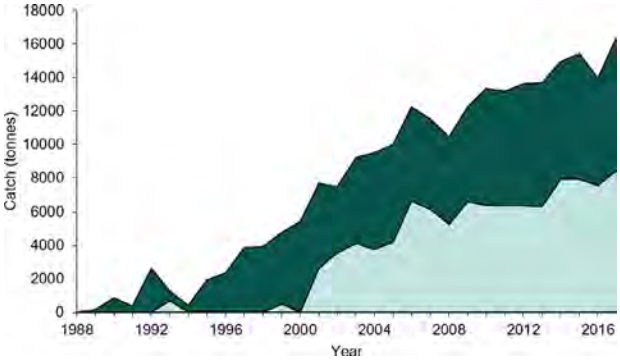

Figure 5. Greenland Halibut catches in tonnes in the Subarea 0, 1988–2017. Light blue area is catch from Division 0A. Green area is catch in Division 0B. Data from Treble and Nogueira (2018).

only), comprised 11% of the catch, primarily in lakes Erie and Huron. The extinction of Blue Pike occurred in Lake Erie by the 1960s due to overfishing (Mandrak and Cudmore 2013), and the catch of Walleye has been much smaller since then (Infographic: Great Lakes). Lake Whitefish also comprised 11% of the catch and was important in all lakes except Erie, with catches increasing since the 1970s. Rainbow Smelt comprised 9% of the landings primarily in lakes Erie and Superior between the 1950s—when it was introduced—and the 2000s, when it collapsed as a result of the dressenid mussel invasion (Infographic: Great Lakes; Mandrak and Cudmore 2013; USGS 2016). Lake Trout comprised 8% of the catch and was important in all lakes except Erie, 1892–1947 (Infographic: Great Lakes), when it collapsed as a result of overfishing and being parasitized by invasive Sea Lamprey *Petromyzon marinus* (Mandrak and Cudmore 2013). The remaining 10% of the catch was a variety of species, including invasive Alewife in Lake Michigan (6%), invasive Common Carp *Cyprinus carpio* (4%)—the first fish introduced into the Great Lakes in 1879—to develop a commercial fishery (Mandrak and Cudmore 2013), and White Bass *Morone chrysops* and non-native White Perch *M. americana* (2%) in lakes Erie and Ontario (4%), and catfishes, suckers, Lake Sturgeon (largely in 1800s), and other species across the lakes.

With the decline of the commercial fishery, its economic value was exceeded by the recreational fishery by the 1970s (Talhelm 1988), which now exceeds it by greater than 100-fold (Hudson and Ziegler 2014). In addition to native Lake Trout, black basses, Walleye, and Yellow Perch, non-native species have become important components of the recreational fishery, including Common Carp, Brown Trout *S. trutta*, Rainbow Trout *O. mykiss*, and Pacific salmons. Although unsuccessfully introduced since the late 1890s, Coho Salmon *O. kisutch* and Chinook Salmon were stocked in large numbers in the 1960s to reduce Alewife numbers and Sea Lamprey predation pressure on native fishes with an unintended consequence of the development of a recreational fishery (Crawford 2001).

Great Lakes fisheries were initially governed through largely uncoordinated federal, provincial, and state regulations (Lauer 2015). The devastating impact of the invasive Sea Lamprey led to the 1954 Convention of Great Lakes Fisheries and the establishment of the Great Lakes Fishery Commission in 1955 to binationally coordinate fisheries management (Gaden et al. 2008).

FINFISH FISHERIES IN LAKE WINNIPEG AND THE NORTHERN GREAT LAKES

The three largest lakes entirely within the borders of Canada are Great Bear Lake, Great Slave Lake, and Lake Winnipeg (Infographic). Precolonial Indigenous fisheries on Lake Winnipeg targeted Lake Sturgeon, Lake Whitefish, and Northern Pike *E. lucius*. By the late 19th century, Winnipeg was booming and 2.5 million pounds of fish were being harvested annually from Lake Winnipeg (Nicholson 2007) with immediate impacts felt by subsistence users (Tough 1984). The rise in catch was partly supported by an influx of Icelandic fishermen who immigrated to the region (Arnason 1994), although the majority of the labor force in the commercial fishery has always been Indigenous. Primary targets for fishers were Lake Whitefish, Lake Sturgeon, and Goldeye *Hiodon alosoides*. Sturgeon catches in Lake Winnipeg peaked in 1900 (446,136 kg; Harkness 1980) then collapsed, never to recover. The continued pull of the market led to fishery expansion beyond Lake Winnipeg (Tough 1999). Winnipeg Goldeye (smoked Goldeye brushed with aniline dye) was a staple in passenger train dining cars until 1930, when the Goldeye stock crashed due to overfishing of spawning stock (Kennedy and Sprules 1967). Overfishing led to a 20-year decline in catch and a collapse culminating in a 2-year closure due to mercury contamination in 1970. Currently, approximately 800 commercial fishers operate under Lake Winnipeg's fixed multispecies quota, and fishers hold individual transferable quotas. The three species managed by quota in the present-day commercial fishery are: Walleye, Sauger *S. canadensis*, and Lake Whitefish, although invasive Common Carp is also harvested in the spring and Goldeye year-round (Manitoba Sustainable Development 2017). In 2013–2014, the fish production of Lake Winnipeg equated to a total landed value of CAD$15,714,994 (Manitoba Conservation and Water Stewardship 2015). Of concern, the lake's fisheries are under threat from invasive species (e.g., zebra mussel *Dreissena polymorpha*, spiny water flea *Bythotrephes longimanus*), eutrophication, contaminants, and hydropower activities. Shifting management practices to ensure sustainable fisheries may help ensure that Lake Winnipeg's commercial fisheries stays healthy long into the future.

To a much lesser extent, Great Bear and Great Slave lakes have had historical and current fisheries. Historically, sustenance fishing on Great Bear Lake in the spring existed for Lake Whitefish, Inconnu *Stenodus leucichthys*, and Walleye,

while winter fishing was done for Cisco (Johnson 1975). Commercial fishing supported a growing resource extraction economy, but was closed following a dismal fisheries survey in the 1940s (Miller 1947). Sustenance fishing by local peoples and recreational fishing, particularly for Lake Trout, is still permitted. Similarly, commercial fishing in Great Slave Lake for Lake Whitefish, Walleye, Lake Trout, and Cisco began in the late 1940s (Rawson 1951). Fisheries production in Great Slave Lake has sagged due to fewer fishers over the past several years and efforts are being made to ensure positive long-term outlooks for the fishery (Government of Northwest Territories 2017).

FINFISH FISHERIES IN THE ARCTIC

Present-day Arctic fisheries can be categorized based on habitat associations (e.g., freshwater, anadromous, marine), the nature of human use of the fish (e.g., subsistence, domestic, commercial, recreational), and general location of the fishery (e.g., inshore vs. offshore). Subsistence fisheries are conducted by an Indigenous person by angling, nets, set lines, spears, snares, or dip nets for food, personal use, or for dogs. These fisheries are unlicensed and may be regulated locally (e.g., subject to co-management restrictions by the local community or formal board if population problems develop). Domestic fisheries are similar in that the goal is personal sustenance, including obtaining dog food; however, these are conducted by licensed non-Indigenous persons. Commercial fisheries, for sale or barter, can also be designated as "local-sale" or "export," with the product being sold in the community or sent south for sale. They are regulated by licence, species, gear type, area, seasons, and harvest levels. Moreover, commercial fishery products for export from the territories must be landed and processed at a federally approved fish plant. Recreational fisheries may include both northern residents and non-residents; they are regulated through licensing, species, size, area closures, seasons, and harvest levels. Previous and present fishery policy recognizes that subsistence fisheries take precedent over other types of exploitation, and this is a primary factor in determining other development in the area (Reist 2018).

Commercial fisheries in the Arctic, defined as the Yukon, Northwest Territories, Nunavut, and Hudson Bay complex (Hudson Strait, Ungava Bay, James Bay), have included non-anadromous and anadromous salmonids (including Lake Trout, whitefishes, ciscoes, Inconnu, Atlantic and Pacific salmons) fished in coastal, estuarine and/or inland areas, and marine species (Greenland Halibut, Pacific Herring *Clupea pallasii*, cods; Infographic: Arctic Canada). Most Arctic commercial fisheries have had a history of waxing and waning due to high costs, small resource bases (hence limited production), logistical issues (e.g., transportation, processing), and low returns on investments (Crawford 1989; Stewart et al. 1993). Exceptions to this include longer-term and sustainable fisheries for Arctic Char *S. alpinus* (Box 5), Greenland Halibut (Box 3), and Pacific salmons. Quotas exist for all taxa noted above (e.g., for Arctic Char, 258.5 tonnes in Nunavut; whitefishes, ciscoes, Inconnu, and chars in Northwest Territories, ~138.3 tonnes; and cods and herring, 71.9 tonnes), however, not all areas are fished regularly (e.g., Roux et al. 2011). Generally, many quotas go unfilled but are retained to allow for the possibility of commercial fishing. Catch statistics for the numerous smaller fisheries are difficult to compile due to reporting delays and difficulties in distinguishing subsistence and commercial portions of catches for Indigenous persons fishing for food and for sale. Additionally, portions of catches sold locally are generally not well documented in comparison to those exported from the Arctic. The reporting issues noted above and the absence of required reporting for subsistence catches have led some authors to claim that gross underestimates of actual catches exist (Zeller et al. 2011). While reporting and statistical aggregating is an ongoing problem, the underestimates for catches, particularly commercial catches, are likely not as extreme as these authors suggest. Development and/or expansion of commercial marine fisheries in the Canadian Arctic is likely to be highly variable and regional. At present, and for the immediate future, moratoria exist for offshore commercial fishing in both the western Canadian Arctic (i.e., Northwest Territories within Canada's Exclusive Economic Zones) and in the adjacent international areas of the central Arctic Ocean. Marine fisheries in the eastern Arctic will likely expand. Further development of local-scale inshore anadromous fisheries will likely occur in all areas particularly focused upon servicing local markets. Issues of food security for northerners and policy shifts towards development of subsidy programs for fishers to supply product for local sharing in communities will likely further increase demand. Given the low percentage of quotas for chars being filled (e.g., 19–34% of total available quota for Arctic Char were harvested from 2001 to 2008; Roux et al. 2011), there appears to be existing capacity to accommodate increased commercial exploitation in this species. Some species that are now primarily harvested in subsistence fisheries (e.g., Capelin *Mallotus villosus*; whitefishes; Arctic Cod *Boreogadus saida*, Greenland Cod *G. ogac*, and Saffron Cod *Eleginus gracilis*) may become the focus of additional local commercial fisheries, particularly if population abundances increase (e.g., as appears to be occurring for Capelin in some areas). Moreover, new fisheries may potentially develop over the medium to longer term, assuming sub-arctic species eventually colonize the

Box 5. Arctic Char *Salvelinus alpinus*

Commercial fishing for Arctic Char has been documented since the late 1940s in what was the Northwest Territories (now the Northwest Territories and Nunavut; Grainger 1953), although some early reports indicate fisheries along the Keewatin coast occurring in the 1930s. In 1973, a test fishery program was established to facilitate development of new fisheries (DFO 2010). This has evolved to an Emerging Fisheries Policy and, as a general rule, new fisheries involve three stages: feasibility, exploratory, and commercial (DFO 2010). All commercial char fisheries are small in scale relative to offshore marine fisheries, often local and primarily focus upon anadromous populations. The number and locations of the fisheries vary to some extent inter-annually, however, about 300 waterbodies have commercial quotas. For example, 81 commercial and 18 exploratory locations were opened in Nunavut in the 2010–2011 harvesting season (1 April to 31 March), 89 of which focused on anadromous chars with a total available annual quota of 427,200 kg round mass (Roux et al. 2011). Harvest information indicates only 19–34% of available quota was harvested in a subset of years in this period (i.e., 75.1–95.5 tonnes; Roux et al. 2011). Catches from most systems appear to be sold locally within the Northwest Territories; however, three areas have ongoing substantive (by northern standards) viable commercial export fisheries: Cambridge Bay (central Arctic), Cumberland Sound (Pangnirtung, eastern Arctic), and Rankin Inlet (western Hudson Bay). These fisheries exploit local stock complexes rather than discrete unit stocks, and sustainable management appears to be successful (e.g., Cumberland Sound; DFO 2018). Historical landings for the Cambridge Bay fishery over 26 years from circa 1960 onwards totaled about 1,100 tonnes with an annual production in 1986 of about 62 tonnes (Crawford 1989) and with the recent amounts between 26 and 48 tonnes (Day and Harris 2013).

Box 6. Pacific salmons *Oncorhynchus* spp. in the Yukon

Commercial fishing for salmons in the Canadian portion of the Yukon River has been on-going since 1898 (YRDFA and YRP 2005). Commercial harvests are focused on Chinook Salmon and fall Chum Salmon; Coho Salmon is also harvested, but catches are limited due to low abundance and late migration timing (JTC 2019). The salmon fishery in Canada is managed by the federal government and was open entry until 1980 (YRDFA and YRP 2005). Since then, the fishery has been restricted to licenced fishers and includes several licences guaranteed for Yukon First Nations under the Yukon Land Claims Umbrella Final Agreement (YRDFA and YRP 2005). Gill nets and fish wheels are typical commercial gear (YRDFA and YRP 2005). Commercial catches of Chinook Salmon and Chum Salmon on the upper Yukon River have decreased in recent years. The commercial harvest for Chinook Salmon has been restricted or closed every year since 1998 and has remained closed since 2009 due to conservation concerns. Counts of Chinook Salmon at the Whitehorse Fish Ladder similarly document the low levels of Chinook Salmon in recent years (JTC 2019). As a result of a limited market, fall Chum Salmon commercial harvests have decreased since 1997. Most of the commercially harvested Chum Salmon on the upper Yukon River are used for personal needs; few are sold (JTC 2011). Commercial harvests of fall Chum Salmon on the Canadian portion of the Yukon River were restricted or closed in 2009 due to conservation concerns (JTC 2019). Elsewhere in the Yukon, the Alesk and Tatshenshini rivers contain salmon but there is no commercial fishery (Johannes 2011).

Box 7. Sockeye Salmon *Oncorhynchus nerka*

Sockeye Salmon has been fished in British Columbia (BC) for millennia, primarily by Indigenous peoples; indeed, Indigenous culture throughout much of western North America has been shaped by this iconic fish and other salmonids (Campbell and Butler 2010). Weirs and stone traps constructed on individual spawning streams were used together with dip nets to secure winter supplies of salmon. The BC commercial Sockeye Salmon fishery began on the Fraser River in 1866 with the first salmon cannery, which expanded northward in 1877 to the Skeena River—Canada's second largest salmon producing watershed. The industry reached a peak of 88 canneries along BC's coast by 1918 (Lyons 1969); each one dependent on the annual abundance of Sockeye Salmon.

There exists a rich history on the commercial Sockeye Salmon fishery in the Skeena River, and modern genetic tools have helped reconstruct population-specific abundances during the early rise of the commercial fishery (Price et al. 2019). Annual commercial catch averaged roughly 1.0 million during its early (1877–1920) period, reaching a peak of 2.5 million in 1910 (Figure 6; Argue and Shepard 2005). Sockeye Salmon was harvested from oar and sail vessels and linen gill nets in the Skeena River and estuary until 1924—after which time, powered vessels and mechanical net drums were permitted, which enabled more efficient capture of fish. The number of boat licences was restricted to 850 until 1914, but then increased to its peak of 1,218 in 1933 (Milne 1955), which compares to more than 3,600 operating on the Fraser River (Rounsefell and Kelez 1938). Nylon replaced linen gill nets in 1955, further increasing capture efficiency of Sockeye Salmon by more than 2.5 times (Todd and Larkin 1971). A seine fishery also was introduced in the 1950s and grew rapidly through the following 2 decades. Canadian commercial catch of Skeena Sockeye generally increased after 1970 in response to the successful production of fish at three spawning channels on Babine Lake (Wood 2008). Recently, the commercial fleet has been greatly reduced because of low Sockeye abundance, and there have been several fishery closures. Indeed, wild Sockeye populations have declined in abundance by 56%–99% (75% overall) over the past century (Price et al. 2019). Given that channel-enhanced production has greatly increased the potential for overfishing of vulnerable wild Sockeye populations in marine areas (Walters et al. 2008), commercial fisheries have begun transitioning to more terminal locations in-river and in Babine Lake in an attempt to conserve diversity of this long-exploited species in the watershed.

Arctic as/if marine conditions ameliorate sufficiently, habitats become suitable, and ecosystems can support sufficient productivities. The occurrences of Pacific salmons harvested as bycatch in subsistence fisheries targeting Arctic fish species are increasing in the western Canadian Arctic in recent years (Dunmall et al. 2013, 2018; Box 6). The broadening diversity of Pacific salmon species harvested, the increasing frequency of years of higher harvests, and the widening geographic area of harvests suggest that the marine distributions of Pacific salmons may be shifting northwards (Dunmall et al. 2013). While no present commercial fishery for Pacific salmons exists in the Canadian Arctic, continued northward shifts in the marine distributions of salmons and colonization may contribute to the potential for an emerging fishery.

FINFISH FISHERIES IN THE PACIFIC

While diverse Indigenous fisheries along Canada's west coast date back at least 13,000 years, the dawn of European commercial fisheries began in the late 1700s, including trade that flourished after the arrival of Captain James Cook on the west coast of Vancouver Island in 1774 (Wallace 1999). Although the focus of trade was in the pelts of sea otters *Enhydra lutris*, leading to a population decline from approximately 300,000 to 2,000 over 60 years (Reidman and Estes 1990), followed by commercial hunting of northern fur seals *Callorhinus ursinus* and whales through the 1800s (Wallace 1999), fisheries for abundant and easily captured finfishes likely flourished, but went unrecorded. Similar to situations elsewhere (e.g., early Canadian Arctic fisheries; Reist 2018), while the commercial focus of early fisheries was on marine mammals, sustenance and local provisioning of the whalers and fishers likely included exploitation of local finfishes, either directly captured or obtained through trade and barter with Indigenous peoples of the area.

There was a steady buildup in fisheries from the late 1870s to 1950, dominated by catch of Pacific Herring and salmons (Infographic: Pacific Canada; Wallace 1999; Pauly and Zeller 2015). After the Second World War, there was a rapid buildup in fisheries, to a peak of 703,000 tonnes in 1963 (Ainsworth 2015). Catches during this period were dominated by Pacific Herring, followed by Pink Salmon *O. gorbuscha*, Sockeye Salmon *O. nerka*, and Chum Salmon *O. keta* (Infographic: Pacific Canada). The peak catch in 1963 was followed by a steady decline in total catches until 1980, driven largely by a sharp drop in Pacific Herring catches. The following decade saw another rapid build-up in catch to a maximum of 700,000 tonnes in 1991, driven by increases in catches of numerous species including salmons and North Pacific Hake *M. productus*. Since the early 1990s, there has been a rapid decline in commercial fisheries to the present day, with landings of approximately 250,000 tonnes per year. Fisheries for most salmon species declined during this period, in part due to reductions in quotas aimed at protecting and rebuilding stocks.

Over the period 1950 to 1970, Ainsworth (2015) estimated that unreported salmon catches comprised approximately 50% of total removals, falling to 35–40% by the late 1990s due to improved monitoring. Since 1950, discards (percentage of fish thrown back and not counted in catch data) were considered to be fairly low, typically 1–5%. Ainsworth (2015) estimated that the total catch along British Columbia's coast during 1950 to 2010 was over 24.4 million tonnes—84% higher than the estimates provided by the FAO.

After more than a century of persistent commercial exploitation, the news on Canada's west coast today is dominated by concerns for Pacific salmon, including Fraser River

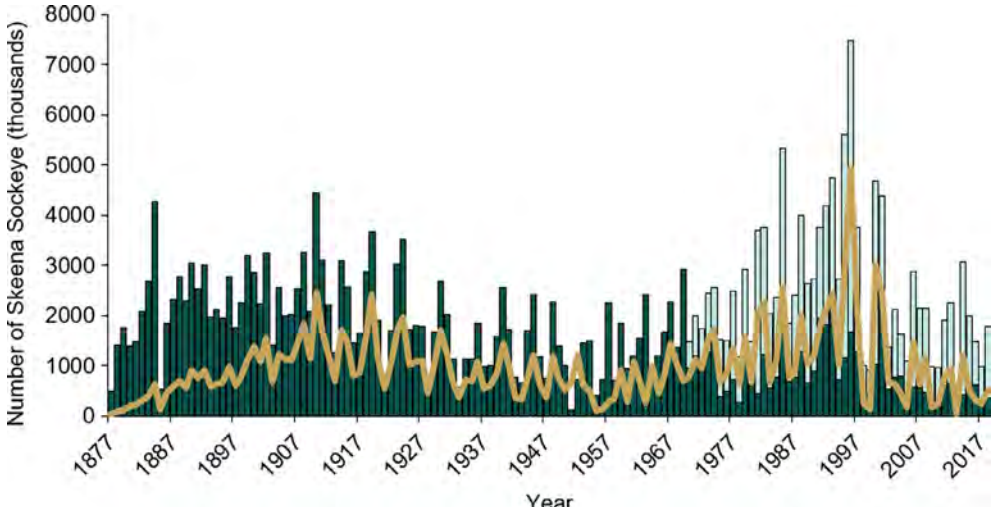

Figure 6. Total abundance of Sockeye Salmon returning to the Skeena River watershed since the beginning of commercial fishing in 1877 to 2018. Green bars are wild only component; blue bars are enhanced production from spawning channels in Babine Lake since 1970; beige lines are Canadian commercial fishery catch (updated from Price et al. 2019).

Sockeye Salmon, which returned in record low numbers in 2019 (Pacific Salmon Commission 2019). Low returns over the recent decade are thought to be driven by poor marine survival, influenced by climate change, as well as warm river temperatures during upstream migration (Beamish et al. 1997; Ruggerone and Connors 2015). These problems were compounded by a catastrophic natural event in 2019—a rockslide at Big Bar, on the lower Fraser main stem near Lillooet, which blocked the upstream migration of adult salmon. While efforts are ongoing to ease fish passage through this bottleneck, which has eliminated access to the upper Fraser watershed, the future of commercial fisheries for Sockeye Salmon (Box 7) and most other salmon species looks bleak, especially in southern British Columbia.

CONCLUSIONS

In this review, we summarize the history of Indigenous, recreational, and commercial fisheries in Canada across our three oceans and our largest freshwater lakes. We acknowledge that these summaries are too brief and do not represent the full rich history of Canada's fisheries resource use, nor can they do justice to the diversity and depth of connections between Indigenous communities and our waterways. Capturing the importance of fishes and fisheries to every Canadian is not possible, and we certainly could have elaborated with more details and fish facts, but we hope readers will appreciate the overview and vignettes of our fisheries history. Over its history, Canada failed in the early management of many important fisheries resources; however, as a result

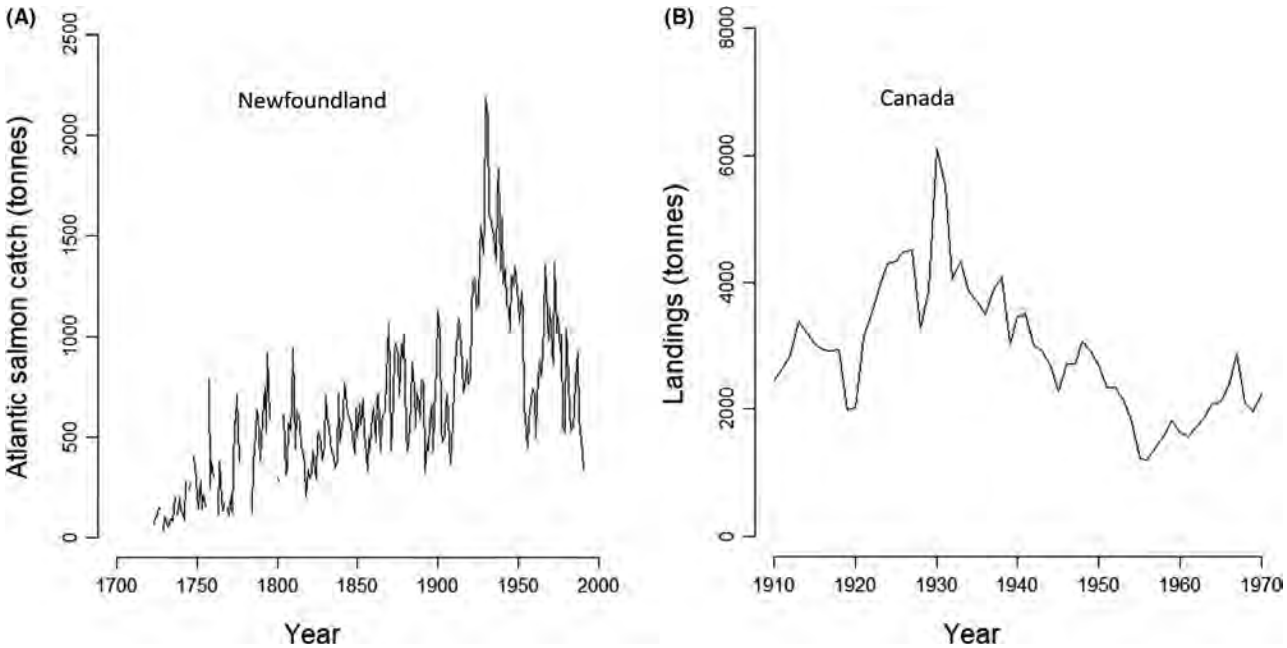

Figure 7. Reported catch (landings) of Atlantic Salmon from (a) Newfoundland (excluding Labrador; incomplete data) and (b) Canada (including Newfoundland and Labrador prior to 1949, Québec, Nova Scotia, New Brunswick, Prince Edward Island). Data sources: May and Lear (1971); Ash (1984); Taylor (1985); O'Connell et al. (1992); Mullins and Jones (1992); J.B. Dempson and D.G. Reddin, personal communications.

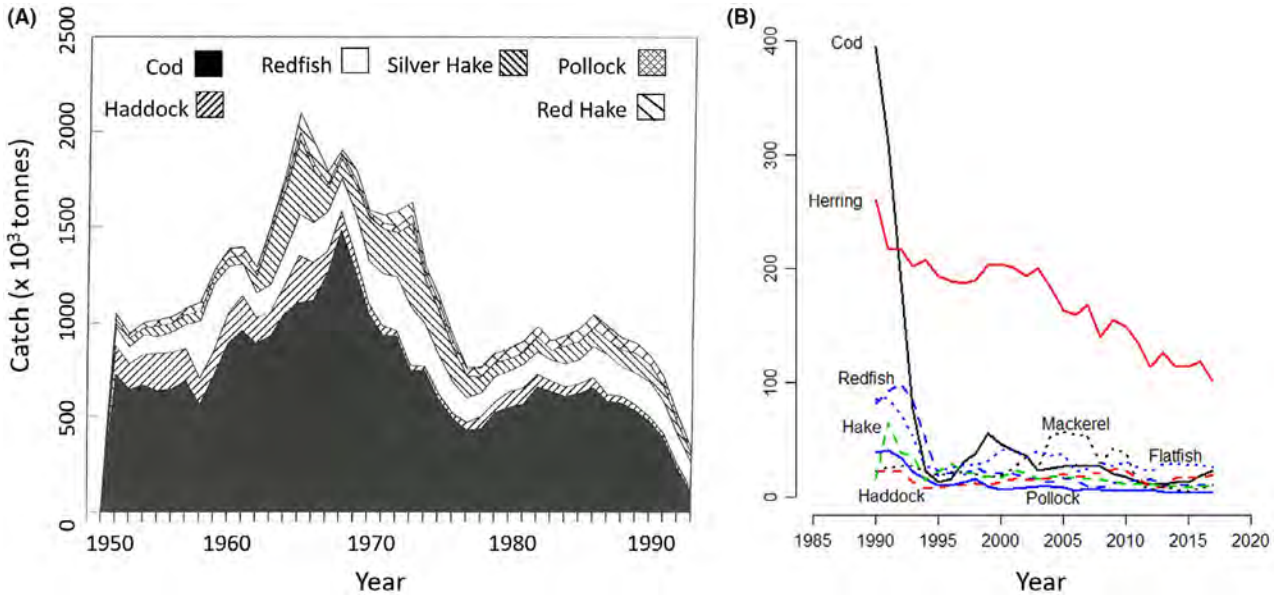

Figure 8. Reported catch (landings) of marine fish species for: (a) Canada and northeast U.S. fisheries from 1950 to 1990 (figure modified from Murawski et al. 1996)—more than 90% of the catch for all but Red Hake is from Canadian waters; and (b) Canada only from 1990 to 2017 (data obtained from DFO 2019).

of lessons learned, Canada has an opportunity to strengthen its fisheries management. By adopting a much-needed "Two-Eyed Seeing" approach that embraces both the strengths of Western scientific and Indigenous knowledge systems and bodies of practice (Bartlett et al. 2012), we can build an improved and shared future for our fisheries so they can uphold the livelihoods, lifestyles, and lifeways for all peoples in this country, without compromising the wellbeing of place, plants, and animals.

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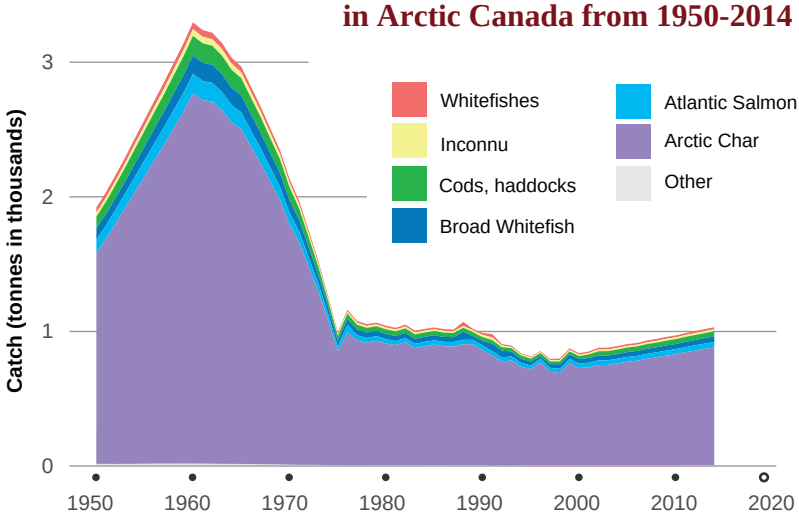
A Brief History of Fisheries in Canada

Inferred catch data of commercial fisheries in Arctic Canada from 1950-2014



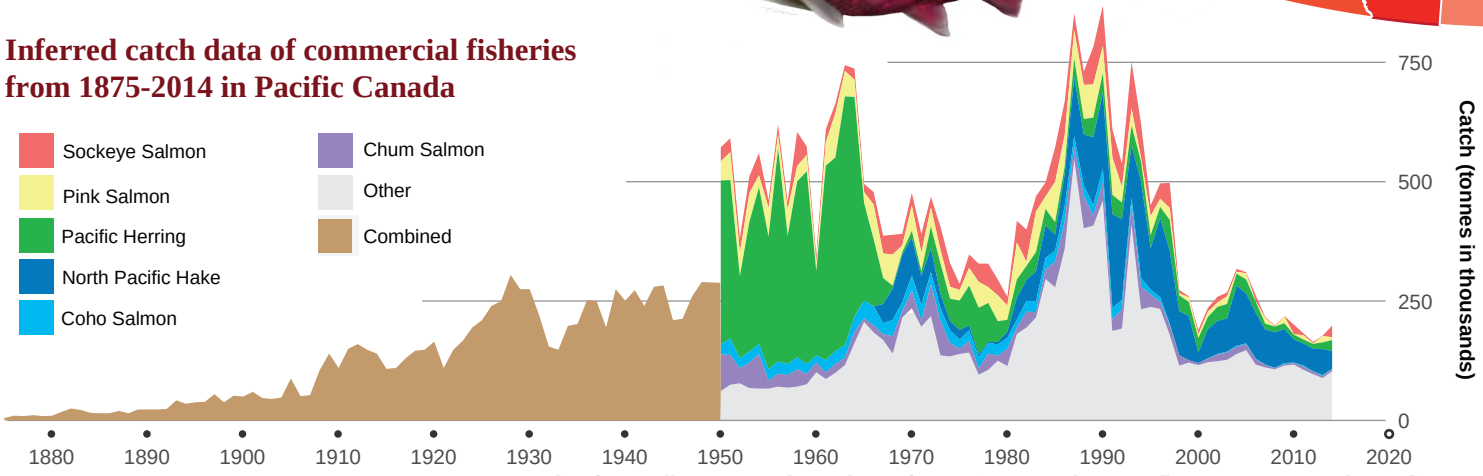
data from Arctic Canada EEZ (Sea Around Us 2020 [http://www.seaaroundus.org/])

Catch data may include uncertainties due to reporting errors or omissions, incorrect inferences from data that do exist, and variances associated with accuracy of reported statistics. While these uncertainties are not indicated on the figures, they should be considered when viewing these data.

Arctic Char

Sockeye Salmon

Inferred catch data of commercial fisheries from 1875-2014 in Pacific Canada



data from Wallace 1999, and Canada Pacific EEZ (Sea Around Us 2020 [http://www.seaaroundus.org/])

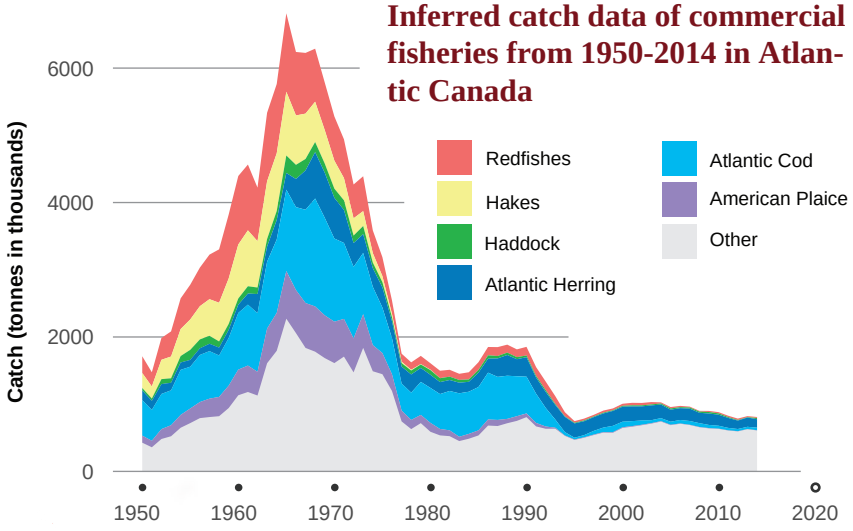
Recreational fisheries

"Recreational fishing can be viewed as an "emerging" fishery in that it did not exist prior to European settlement and now has become the largest (in terms of participation and economic value) of the main three fisheries sectors in Canada."

Left) Juvenile fish are being transported for stocking by staff of the Ontario Department of Lands and Forests. [https://bit.ly/2CbbUnB]. Middle) A group at Idylwild (later Opinicon Hotel) in Chaffeys Lock, Ontario in 1902 [https://bit.ly/3d8s11L]. Right) A Tyee caught in 1925. From the Museum of Campbell River, No. 10613. [https://www.tyeeclub.org/about-us/history/]

Greenland Halibut

Inferred catch data of commercial fisheries from 1950-2014 in Atlantic Canada



data from Eastern Canada EEZ (Sea Around Us 2020 [http://www.seaaroundus.org/])

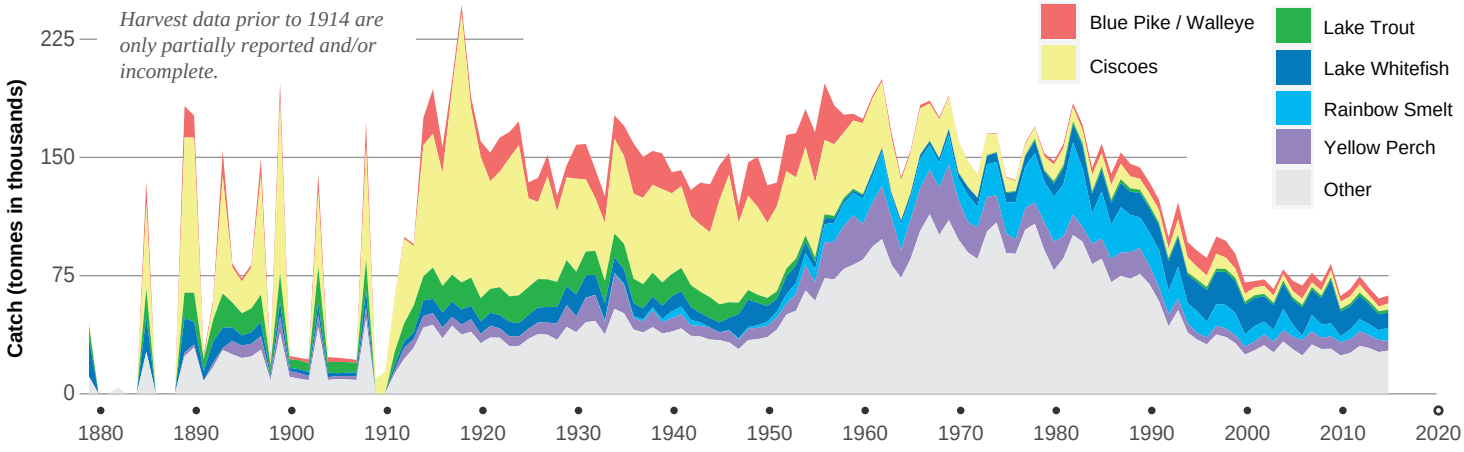
Atlantic Cod

American Eel

Lake Sturgeon

Goldeye

Great Lakes commercial fisheries from 1879-2015



data from Baldwin et al. 2018

Indigenous fisheries

"Long before the advent of industrial fishing practices, Indigenous peoples engaged in more than subsistence fishing, and built fisheries-based economies that involved trade with both near and distant Indigenous Nations, including exchanges with early European settlers."

Left) Nuu-chah-nulth man spearfishing on Vancouver Island (1915). Image D-08321 courtesy of Royal BC Museum, BC Archives (by Edward S. Curtis); Right) Nuu-chah-nulth First Nations' commercial salmon fishery on Vancouver Island. Image courtesy of Nuu-chah-nulth Tribal Council Fisheries [uuathluk.ca].

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