Bowhead whales and whaling in the central and eastern Canadian Arctic, 1970–2021

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ABSTRACT

The history of bowhead whaling and hunt management in the eastern and central Canadian Arctic is reviewed. Subsistence hunting of bowhead whales by Inuit resumed in the 1990s under co-management arrangements that were part of land-claims settlement agreements. Removals by whaling in both Canada and Greenland have been accounted for in IWC Scientific Committee assessments of the Eastern Canada-West Greenland (EC-WG) stock, but Canada, having withdrawn from IWC membership in 1982, has no legal obligation to consider IWC management advice. From 1994-2021 the total reported catch of bowheads in the central and eastern Canadian Arctic was 39 (not including struck-and-lost whales or whales that died from entanglement in fishing gear). Sixteen different communities, most of which had a long history of bowhead whaling prior to the arrival of commercial whalers, took at least one bowhead over that 27-year period. More than half of the recent catches have been by the communities of Igloolik, Sanijarak, Naujaat and Coral Harbour, all in the Foxe Basin-Repulse Bay-northern Hudson Bay region where at least occasional hunting of bowheads by local people had persisted until well into the 1970s. Greenland's reported landed catches totaled 8 from 2009-2015, with no successful hunts reported since 2015. Well over a third of the whales landed by both countries combined have been mature females, the most valuable class in terms of potential for population increase. Several factors in addition to hunting and entanglement in fishing gear are likely affecting EC-WG bowheads, including increased exposure to killer whale predation (linked to the massive reduction in sea ice) and other changes in ecological conditions driven primarily by climate change (e.g. more industrial activity, more vessel traffic, more noise). Recent analyses suggest the EC-WG stock of bowheads has grown considerably since the end of commercial whaling, with best estimates of current abundance in the range of 6,000–7,000 individuals. Even though the population appears capable of sustaining present levels of removal and disturbance, it is important for monitoring efforts to continue in both Canada and Greenland, with regular Indigenous participation.

KEYWORDS: BOWHEAD WHALE; DIRECT CAPTURE; WHALING – ABORIGINAL; WHALING – HISTORICAL; INCIDENTAL CATCHES; CONSERVATION; REGULATIONS; SUSTAINABILITY; CANADA; GREENLAND

INTRODUCTION

Bowhead whales (*Balaena mysticetus*) have been an important resource for the Indigenous inhabitants of the Central and Eastern Canadian Arctic (i.e. marine waters north of 55°N and east of 100°W) since at least 500 years ago and probably far longer, judging by archaeological evidence (Savelle and McCartney, 1991; McCartney and Savelle, 1993; Savelle, 2010; Stoker and Krupnik, 1993) and oral history (Eber, 1989; Hay, 2000).[3] The commercial

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[3] The term 'aboriginal' has often been used in reference to the Inuit of northern Canada and Greenland but in recent decades it has been increasingly replaced by 'Indigenous'. In this paper, for consistency with the United Nations Declaration on the Rights of Indigenous Peoples, we use 'Indigenous' by preference except when referring to IWC documents where 'aboriginal' has long been and continues to be in use.

whaling industry, started by Basques in the 1500s and later joined by Dutch, English, Scottish, and eventually American whalers on the Canadian side of Davis Strait and by Basques, Dutch, and Danes on the Greenland side, had killed well over 60,000 bowheads in the region by the early 20th century when the enterprise was no longer profitable (Ross, 1993; Higdon, 2010). After adding the more than 8,000 whales taken by Inuit whalers over that same span of time (1530–1915), the total of landed and reported catches approaches 70,000 bowheads. Considering the often-high rate of hunting loss due to escapement, sinking, shipwreck, and other mishaps along with the incompleteness of reporting (Mitchell and Reeves, 1981; Bockstoce and Botkin, 1983; Higdon, 2010), the actual mortality from whaling over four centuries was probably much higher than 70,000.

Commercial whaling for bowheads in all parts of the Arctic and sub-Arctic ended for economic reasons, exacerbated by the shortage of whales, by around 1915 (Ross, 1979; Bockstoce, 1980), and therefore the modest multilateral agreements beginning in the 1930s to manage the industry were largely superfluous where the bowhead was concerned. One of these early agreements, however, did establish a significant and ultimately durable precedent when it came to traditional whaling by Indigenous people for subsistence. The 1931 Convention for the Regulation of Whaling, which Canada, Denmark (on behalf of Greenland), and the United States all signed, explicitly excluded from regulation 'aborigines dwelling on the coasts of the territories of the High Contracting Parties,' although conditions applied concerning vessels (only 'canoes, pirogues or other exclusively native craft propelled by oars or sails' were permitted) and whaling implements that could be used (no 'firearms' were to be used) and the disposal of products from the hunt (i.e. 'interaction with distant markets' was forbidden; Caulfield, 1997, p.114). This set of exclusions, often referred to as an 'aboriginal exemption,' was not included in the Whaling Agreement of 1937 (signed by the United States) or the 1938 Protocol to that agreement (signed by Canada) (Gambell, 1993). Indigenous whaling for bowheads nevertheless continued in Alaska and at least sporadically in the eastern Canadian Arctic (Mitchell and Reeves, 1982) and West Greenland (Caulfield, 1997), but apparently not in the western Canadian Arctic after about 1915 (Reeves and Mitchell, 1985).

By 1946, when the International Convention for the Regulation of Whaling (ICRW) took effect (see below), the numbers of bowhead whales had been reduced to far below pristine levels throughout the species' range (Woodby and Botkin, 1993). Although the International Union for Conservation of Nature (IUCN) Red List in 1965 assessed bowheads as 'very rare', noting that the global population was 'believed to be stable or increasing' (Cooke and Reeves, 2018), this view had changed by the 1970s and 1980s when some scientists and conservationists asserted that all bowhead populations were small and possibly declining, with a high risk of at least regional extirpation due to continued subsistence hunting by Inuit (e.g. McVay, 1971; Mitchell and Reeves, 1980, 1982). The species was red listed as Endangered in 1986 and again in 1988, downlisted to Vulnerable in 1990 (Klinowska, 1991) and 1994, Lower Risk/conservation dependent in 1996, and Least Concern in 2008, 2012 and 2018 (Cooke and Reeves, 2018). These changes in Red List categorisation through time reflect a combination of improved information, evolving perceptions and revised assessment rules, definitions, and procedures.

After more than half a century of complete protection from commercial whaling, the two populations still subject to whaling (only for subsistence) – one in the eastern Canadian Arctic and West Greenland (the Eastern Canada – West Greenland, or EC-WG, stock) and the other in western Canada (Northwest Territories and Yukon Territory), the United States (Alaska), and Russia (Chukotka) (the Bering-Chukchi-Beaufort seas, or BCB, stock) – both now appear to be making strong recoveries (George *et al.*, 2004; Frasier *et al.*, 2015; Rekdal *et al.*, 2015; Doniol-Valcroze *et al.*, 2015; Givens *et al.*, 2016, 2017; Cooke and Reeves, 2018). Moreover, the bowhead whale continues to be regarded in many Indigenous maritime communities, particularly in Alaska (Braund and Associates, 2018) but increasingly also in Canada (Freeman *et al.*, 1998; Kishigami, 2015) and to a much lesser extent Greenland (Caulfield, 1997), as a vital cultural and nutritional resource.

This paper has four main purposes, as follows: (1) to review international and Canadian national efforts to manage bowhead whale hunting; (2) to reconstruct and elucidate the recent history of bowhead whaling in eastern Canada, particularly since 1979 when the Canadian government explicitly prohibited the killing of bowhead whales without a license; (3) to summarise current understanding of population structure, abundance, and trends for the EC-WG stock; and (4) to identify known or potential threats (anthropogenic and natural) to bowheads in the central and eastern Canadian Arctic.

INTERNATIONAL EFFORTS

International Whaling Commission, 1949–1980

Canada was an original signatory of the *ICRW* and sent a delegation to the first meeting of the International Whaling Commission (IWC) in London in 1949 (Mitchell and Reeves, 1986). The convention came into effect in Canada through enabling legislation for the *Whaling Convention Act* of 1951 that allowed the Governor in Council to authorise hunting of protected species (including bowhead whales) under conditions spelled out in Canada's Whaling Regulations issued in 1954, namely that only Indians and Inuit were permitted to hunt, and the meat and other products had to be used 'exclusively by them for local consumption' (Mitchell and Reeves, 1982).

Beginning in the early 1970s, the IWC became increasingly attentive to the subsistence hunting of whales in the Arctic – not only bowhead whales but also gray whales (*Eschrichtius robustus*) in Russia and the United States and humpback whales (*Megaptera novaeangliae*) in Greenland (Mitchell and Reeves, 1980). Particular attention was given to Alaska, where the Land Claims Settlement Act of 1971 was followed by rapid expansion of bowhead whaling and a steep increase in hunting loss (i.e. bowheads struck but not secured by the whalers) (Stoker and Krupnik, 1993). In 1976 the Commission passed a resolution urging member governments to take 'all feasible steps to limit the expansion of the [bowhead] fishery and to reduce the loss rate of struck whales' (IWC, 1977; Gambell, 1982). Then in 1977 the IWC Scientific Committee concluded that 'any taking of bowhead whales could adversely affect the stock and contribute to preventing its eventual recovery, if in fact such recovery is still possible'. The committee noted 'with concern' not only the increased taking of whales in Alaska but also that three bowheads had been killed in Hudson Bay over the previous six years and that 'further unsuccessful hunts' had occurred there (Coral Harbour and Igloolik-Sanirajak area; see Mitchell, 1977) in 1975 and 1976 (IWC, 1978, p.67). At its annual meeting in June 1977, the IWC made a controversial decision, which was to assign, in effect, a zero quota to all Indigenous whalers who hunted bowhead whales by deleting the aboriginal exemption clause in the IWC's Schedule of Whaling Regulations (Gambell, 1982). The response by the Eskimo whaling communities in Alaska, and in turn the US government acting on their behalf, was swift and forceful (Stoker and Krupnik, 1993).

A special meeting of the IWC was convened in Tokyo in December 1977 to resolve two issues, one related to commercial catches of sperm whales (*Physeter macrocephalus*) in the North Pacific and the other how to address the demands of Alaskan Eskimos for a non-zero quota on bowhead whales (IWC, 1979a). In a resolution from that meeting, which took account of 'representations made concerning aboriginal subsistence and cultural needs, the degree of risk inherent in related proposals, and the management and research program prepared by the USA,' a quota of 12 bowheads landed (or 18 total struck) was set for 1978, noting that 'pursuant to undertakings by the Governments of Canada and the USSR, this harvest will be taken exclusively by persons under the jurisdiction of the Government of the United States' (IWC, 1979a, p.4). In other words, the ban on bowhead whaling was lifted for the Alaskan Eskimos but remained in effect for Indigenous whalers in Canada and the Soviet Union. At the Commission's annual meeting in June 1978 the Alaska quota for 1979 was increased to 18 landed (or 27 total struck) but in addition, it was agreed that an *ad hoc* Working Group of the IWC Technical Committee would be formed and meet in early 1979 to 'examine the entire aboriginal whaling problem and develop proposals for a regime for the aboriginal bowhead hunt in Alaska and if appropriate a regime or regimes for other aboriginal hunts to be submitted to the Commission at the next Annual Meeting' (IWC, 1979b, p.26). It is relevant to note that the Technical Committee was chaired at the time by M.C. Mercer, the Canadian IWC Commissioner.

A special Panel Meeting of Experts on Aboriginal/Subsistence Whaling met in Seattle in February 1979 to provide information and develop advice for the Working Group (IWC, 1982). The three panels (all of which included experts from Canadian institutions) met separately and produced independent reports – one on wildlife science, one on nutritional needs, and one on cultural anthropology. These reports were considered at an April 1979 meeting of the Technical Committee's Working Group, which made several proposals that did not align with those of the Scientific Committee. The Technical Committee, on the advice of its Working Group, called for 'interim measures' to be taken 'in the absence of complete information on the stocks', and these included a bowhead catch limit of 18 landed (or 27 total struck) in 1980 and a greatly enhanced research program in Alaska

(IWC, 1980b, p.30). The United States, USSR, and Canada stated their willingness 'to co-operate in appropriate research programmes'. The Scientific Committee, for its part, continued to insist that 'from a biological point of view the only safe course is for the kill of bowhead whales from the Bering Sea stock [= BCB stock] to be zero.' In fact, given the information available at the time, the Scientific Committee expressed its view that 'if present estimates of gross recruitment rate are accepted, then the population will decline even in the absence of catches' (IWC, 1980b, p.30). (It should be noted here that subsequent research showed these positions attributed to the Scientific Committee to be ill-informed and alarmist). Following considerable debate, the Commission adopted a catch limit for the 1980 Alaska hunt and encouraged efforts to improve scientific knowledge of bowheads, particularly the population off Alaska. An official resolution was adopted which at once recognised 'the importance of accommodating the needs of aboriginal people who are dependent upon whales for subsistence and cultural purposes' and specified various steps for the United States to take in terms of documenting the need for whaling and whale products in Alaskan communities, ensuring that the hunting was well managed, conducting a rigorous research program, and providing timely reports on progress to the Commission (IWC, 1980b, p.35). Also, at the 1979 IWC meeting Canada offered to host a workshop in 1979–1980 'on Arctic whales and subsistence whaling to extend consideration on a broader basis' (IWC, 1980a, p.13). This workshop apparently never took place.

At the July 1980 IWC annual meeting, the 8-person Canadian delegation had two Inuit members (IWC, 1981a, p.11) and aboriginal/subsistence whaling was the first item on the agenda (IWC, 1981b). Although the discussion continued to focus on the BCB bowhead stock and the hunt in Alaska, there were two more broadly relevant aspects.

Firstly, a commitment was made to develop 'management principles and guidelines for subsistence catches, parallel to (but separate from) those reflected in the Commission's management procedures for commercial whaling.' The first step in that process would be to establish another *ad hoc* Working Group of the Technical Committee to 'develop management principles, and in particular for the setting of allowable catches for the whale stocks involved' (IWC, 1981b, p.29). The Working Group would include not only members of the IWC Technical and Scientific Committees, but also 'indigenous people who take subsistence catches'. The group was expected to provide a report to the Technical Committee in 1981, but no implementation would be considered before the 1982 annual meeting of the IWC, 'in order that the indigenous peoples involved may review any documents developed' (IWC, 1981b, pp.17, 29). It is relevant here to mention that by the early 1980s, whaling communities in northern and western Alaska had created the Alaska Eskimo Whaling Commission, which in turn delegated responsibility for bowhead research and population monitoring to the Department of Wildlife Management of the North Slope Borough (Suydam *et al.*, 2021).[4]

Secondly, a resolution adopted by the Commission required that all member countries where aboriginal/subsistence whaling was occurring provide annually to the Commission information on 'the utilisation of the meat and products of any whales taken for aboriginal/subsistence purposes' (IWC, 1981b, p.29). It was made clear that this requirement did not apply to small cetaceans (white whales or belugas [*Delphinapterus leucas*] and narwhals [*Monodon monoceros*]), but rather only to those whale species (including the bowhead) customarily understood to fall within the Commission's management competence (IWC, 1981b, p.17).

Also, two papers containing information on bowhead whales and whaling in the eastern Canadian Arctic were received by the IWC Scientific Committee at its 1980 annual meeting (Mitchell and Reeves 1981, 1982). These were considered by the Sub-committee on Other Protected Species and Aboriginal Whaling. Although that sub-committee recommended 'complete protection from all forms of hunting' for bowheads in the eastern Canadian Arctic and Greenland, the Scientific Committee itself made no specific recommendation on the matter (IWC, 1981c).

Canada's decision to withdraw from the IWC, 1981-82

The IWC Technical Committee's *ad hoc* Working Group on Subsistence Whaling met in the United Kingdom (UK) in July 1981, a week before the annual IWC meeting (IWC, 1982c, p.25). It was convened by the Australian

[4] Today, the bowhead quota for Alaskan Eskimos is implemented by the US National Oceanic and Atmospheric Administration and the Alaska Eskimo Whaling Commission manages the hunt (Suydam *et al.*, 2021).

Commissioner and had 'a broad composition, including members of the Technical Committee, a representative of the Scientific Committee and representatives of the aboriginal peoples concerned, the latter being very willing to co-operate.' The Technical Committee expressed its intention to forward the Working Group's report on 'Development of Management Principles and Guidelines for Subsistence Catches of Whales by Indigenous (Aboriginal) Peoples' to Contracting Governments by 31 January 1982.

By the time of the Working Group meeting, Canada had deposited its notice of withdrawal from the IWC (24 June 1981, effective 30 June 1982) (IWC, 1982a; 1983a). Consequently, although Canada was represented officially by three 'Advisers' at the July 1981 annual meeting of the IWC, no Commissioner was included in the Canadian delegation (IWC, 1982a, p.10) and therefore Canada had no vote on the proposals tabled that year for a 'moratorium' on commercial whaling (IWC, 1982c, pp.18–20). The moratorium proposals failed to pass that year, but the global moratorium was approved at the Commission's annual meeting in July 1982, at which Canada was represented by only a representative designated as a 'Non-member Government Observer'. The moratorium on commercial whaling was to begin in the 1986 'coastal' season and the 1985/86 'pelagic' season in the Antarctic (IWC, 1983b).

The official rationale for the decision to withdraw (according to an 'Official Canadian Press Statement' of 26 June 1981) was that Canada 'no longer [had] any direct interest in the whaling industry or in the related activities of the IWC' (IWC 1997, p.55). Two specific matters certainly influenced the decision.

One, which is readily apparent from the published record of discussions and voting within the IWC, was that Canada regularly aligned with countries opposed to the moratorium (e.g. Japan, Norway, Iceland, the Soviet Union, Republic of Korea, Peru, South Africa) (e.g. IWC, 1981b, p.19; IWC, 1982c, pp.18–19). It therefore found itself out of step with the majority of members that was likely to prevail, and ultimately did so, in the long-running debate over the moratorium issue (Caron, 1995). It is important to mention, however, that many of the IWC member states that supported the ban on commercial whaling had consistently spoken (and voted) in favour of an exemption for aboriginal/subsistence whaling, and most have continued to do so (e.g. United States, United Kingdom, Sweden, Australia, Denmark). Moreover, as stated in a resolution of the 1982 annual meeting, the IWC had made clear its intention to 'establish principles and guidelines for the management of aboriginal subsistence whaling which recognise and seek to accommodate conservation, nutritional, subsistence, and cultural needs' of the whaling communities (IWC, 1983b). That resolution triggered a long-term process of developing what has come to be known as the Aboriginal Subsistence Whaling Scheme, which is underpinned by an Aboriginal Subsistence Whaling Management Procedure produced over several decades by the IWC Scientific Committee (Gambell, 1993; Reeves, 2002; IWC, 2018). The scheme and management procedure have been applied only to member states, namely the United States (for its ongoing bowhead hunt), Russia (for its ongoing hunts of gray and bowhead whales) and Denmark (for the ongoing hunts of bowhead whales, fin whales (*Balaenoptera physalus*), common minke whales (*Balaenoptera acutorostrata*) and humpback whales in Greenland).[5]

The second consideration relates to the management of narwhal and beluga hunting. Traditionally, Canada opposed any encroachment by the IWC into range states' responsibility for managing the exploitation of small cetaceans within their own jurisdiction. In 1979 the Scientific Committee made a series of strong statements concerning the inadequacy of research to underpin the management of narwhal and beluga hunting, and indeed the inadequacy of hunt management, not only in Canada but also in the United States, Greenland and the Soviet Union (IWC, 1980c, pp.56–57). In fact, the Committee went so far as to recommend that the Commission consider the aboriginal/subsistence hunts for these two species in a 'similar fashion' to the bowhead hunt in the Beaufort Sea (*sic*), whilst changing the Schedule of Whaling Regulations to define both the narwhal and the beluga as 'whales' in order that 'appropriate management procedures may be discussed and implemented' (IWC, 1980c, p.57). In 1980 the Scientific Committee's standing Sub-committee on Small Cetaceans made further critical comments concerning how stocks of belugas and narwhals were being managed in Canada and the other range states (IWC, 1981c, pp.143–46).

All of the above led in 1981, immediately after Canada's withdrawal had been announced, to a resolution by the Commission specifically directed at Canada, urging that the government respond to Scientific Committee

[5] *https://iwc.int/table_aboriginal.*

recommendations on narwhals and belugas and continue to provide the Committee and the Commission with information on research findings and management measures taken in relation to these 'small cetaceans' (IWC, 1982c, p.36). Canada may well have maintained its membership in the IWC were it not for the problems surrounding Indigenous hunting of belugas and narwhals (cf. Caron, 1995 fn 25). As Reeves (1992, p.167) concluded, 'By its complete withdrawal, Canada was able to avoid at least some of the diplomatic discomfort and public-relations consequences of continued participation in the increasingly rancorous IWC deliberations.' Since the 1980s there has been comparatively little rancour concerning aboriginal subsistence whaling – most of the disagreement within the IWC, and indeed in the public sphere, has concerned matters pertaining to commercial whaling (Reeves, 2002).

According to Kishigami (2015), Inuit in Canada 'vehemently oppose' the idea of Canada rejoining the IWC. This steadfast opposition probably was and still may be linked, at least loosely, to the bitter experience of the 1970s and 1980s when the European Commission's ban on sealskin imports, aimed primarily at curtailing the commercial hunt for harp and hooded seal pups (*Pagophilus groenlandicus* and *Cystophora cristata*, respectively), had an unintended but devastating impact on the Inuit seal-hunting economy in Canada, which centred on ringed seals (*Pusa hispida*) (Wenzel, 1991). A resolution tabled at the Inuit Circumpolar Conference in July 1992 stated, 'the IWC's operations are influenced by animal protection interests which have caused the demise of fur-trapping and sealing' (quoted by Caron, 1995 pp.165–6).

Other instruments

Having left the IWC, Canada signed the United Nations Convention on the Law of the Sea in 2003. According to Freeman *et al.* (1998, p.131), 'in Canada's view' it is possible for a country to meet the letter and spirit of its obligation for whale conservation under that convention to 'work through the appropriate international organisations' by simply providing the IWC Scientific Committee with 'timely information on whales and whaling activities in its waters' and by having its scientists participate 'periodically' in committee meetings. Those authors also reported that Canada had sent a 'Government Observer delegation' which had occasionally been 'invited to address' the meetings. In their view, Canada was thereby continuing, at least through the early and mid-1990s, to participate meaningfully and constructively in IWC affairs as a non-member country and in so doing, meeting one of its commitments under the Law of the Sea treaty.

While Canada has sent at least one delegate (occasionally more; see below) to IWC meetings in some years since withdrawing its membership, it has not always provided 'timely' information to the Scientific Committee. In fact, 'the Canadian government has shown a distinct reluctance to provide information to the commission or to participate fully in scientific discussions' (Reeves, 2002). From 2003–2008 there was extensive discussion of 'Eastern Arctic' bowhead whale stock structure and abundance in the Scientific Committee's Sub-committee on Bowhead, Right and Gray Whales, with at least occasional limited participation by Canadian government and non-government scientists (IWC, 2004, p.214; 2005, p.202; 2006, pp.115–116; 2007, pp.148–150; 2008a, pp.159–161; 2009, pp.177–179). This changed, however, in 2009 when Canada stopped sending government scientists to Scientific Committee meetings and the sub-committee noted repeatedly that although it was aware that catches were being made in eastern Canada, possibly regularly (IWC, 2010, p.169; 2011, pp.170–172; 2012b, p.172), no Canadian government scientists were present and 'timely' information on bowhead biology and hunting was no longer being delivered as it had been for several years. Denmark, however, continued to provide new information on both bowhead biology (much of it from tagging, surveys and genetics work conducted in Canada, often in collaboration with Canadian scientists) and the hunting by Greenlanders. In 2010, the sub-committee recommended that the Commission contact Canada and request such information (IWC, 2011, p.172). No information was forthcoming by the time of the next annual meeting in 2011, but Reeves provided some basic data from the literature and from direct inquiries to the Department of Fisheries and Oceans (IWC, 2012a, p.158; Reeves, 2012). Again in 2012, no information from Canada was formally presented and the Scientific Committee relied on information provided informally and unofficially by Reeves; the Scientific Committee was advised after its meeting that more detailed information on catches in Canada had been received and was on file with the IWC Secretariat (IWC, 2013a, p.175).

NATIONAL EFFORTS

Legislation and regulation pre-land-claims settlements

As mentioned earlier, Canada's Whaling Regulations issued in 1954 specified that only Indians and Inuit were allowed to hunt bowhead whales and the meat, muktuk (maktak, or whale skin) and other products could be consumed only locally by Indigenous people (Mitchell and Reeves, 1982). A licensing system was in place for the next two decades although we are aware of only one permit being issued, this to a resident of Pangnirtung who, as far as we are aware, did not succeed in catching a bowhead. In 1979, a regulation came into effect explicitly prohibiting the killing of bowhead whales by any person in Canada (Mitchell and Reeves, 1982).

Soon after Canada's withdrawal from the IWC took effect in June 1982, Canada repealed its Whaling Convention Act and the Department of Fisheries (DFO) issued the Cetacean Protection Regulations under the Fisheries Act, which allowed the Minister of Fisheries to issue licences to Inuit to hunt bowheads 'for the purposes and under the conditions specified in the license' (see Mitchell and Reeves, 1986).

Land-claims agreements and hunting rights

Before and during the 1970s and into the early 1980s, the Canadian federal government was seen as having a fiduciary obligation to the Inuit and other Indigenous people, and this obligation was largely uncontested. However, major social and political changes began in the 1970s and gained force in the 1980s and early 1990s, causing a significant shift in that relationship (e.g. Berger 1977; Freeman *et al*. 1998). More and more of the responsibility and authority for managing the use, and conservation, of wildlife devolved to newly established governmental bodies, with only limited powers retained by the federal government. There was also an important international element to this development. The Inuit Circumpolar Conference (now Council) (ICC) was established in 1980 to represent the Inuit of Alaska, Canada, Greenland, and Chukotka (Russia). A resolution adopted by the ICC in 1979 stated that 'whaling is a necessary part of Inuit cultural identity and social organisation, and is in no way similar to commercial whaling' (IWC 1982b, p.49). It called upon the IWC to 'defend Inuit rights to hunt the whale,' upon Inuit to make 'wise and full use of subsistence resources,' and upon Arctic nations to 'specifically provide for the determination of safe technology; Arctic population policy; and locally controlled wildlife management.' Already by that time the *James Bay and Northern Québec Agreement* (JBNQA) had been signed by the governments of both Canada and the province of Québec, providing a framework within which the rights of Inuit to hunt whales (and other wildlife) 'sustainably' was guaranteed.

Also, by the late 1970s Inuvialuit and Inuit in the Northwest Territories (NWT; including what is now Nunavut) were speaking out forcefully in support of the Alaskan Eskimos in their resistance to IWC restrictions on bowhead whaling while at the same time negotiating with the Canadian federal government to establish their own land-claims agreements (Freeman *et al.*, 1998). The *Inuvialuit Final Agreement* was signed in 1984, stipulating, among other things, that the Inuvialuit have the right to hunt all marine mammals for subsistence, with quotas 'set jointly by the Inuvialuit and the Government according to the principles of conservation.' For several years prior to this signing, Inuvialuit hunters had attempted to organise a bowhead hunt, but without success. The first successful legally sanctioned hunt for bowheads in the western Canadian Arctic for many decades took place in 1991, with one whale taken and butchered at Shingle Point, NWT (Freeman *et al.*, 1992, p.79). Canada continued to issue licences to the Inuvialuit to take one bowhead per year through 1995, but none were landed until July 1996, again at Shingle Point (Pomerleau *et al.*, 2011a).

The *Nunavut Agreement* between the Inuit of Nunavut and the Government of Canada, signed in 1993, provided Inuit of the central and eastern Canadian Arctic with, among other things, constitutionally guaranteed 'wildlife harvesting rights and rights to participate in decision-making concerning wildlife harvesting,' in part so as to 'encourage self-reliance and … cultural and social well-being.' The first licence to hunt a bowhead whale under the agreement was issued in 1996 (Freeman *et al.*, 1996, p.129). Although there had been sporadic reports of bowheads being chased, struck, and occasionally killed during the 1960s and 1970s, most of them in northern Hudson Bay and Foxe Basin (Mitchell and Reeves, 1982), the legally sanctioned hunting of bowheads in Nunavut (i.e. approved by the federal Minister of Fisheries and Oceans and authorised by the Nunavut Wildlife

Management Board, NWMB, the primary instrument of wildlife management in Nunavut) began with the successful landing of a large whale by the Inuit of Naujaat in 1996 (Ferguson *et al.* 2021). (An unauthorised kill had taken place near Igloolik in September 1994 – Reeves, 2002; Higdon, 2010; Pomerleau *et al.*, 2011).[6]

The *Nunavik Inuit Land Claims Agreement* came into effect in 2007. It applies to marine waters bordering far northern Labrador and northern Quebec, including large offshore islands in Ungava Bay, Hudson Strait, and northeastern Hudson Bay (Nunavik Inuit Land Claims Agreement, 2006, Schedule 3-1). This agreement established the Nunavik Marine Region Wildlife Board (NMRWB), which is similar in composition and function to the NWMB. The first bowhead hunted under the terms of the agreement was taken at Kangiqsujuaq on 9 August 2008. The news item reporting this event also stated that a bowhead had been 'lanced' and 'lashed to a boat' by local hunters in the 1960s but escaped (Nunatsiaq News, Iqaluit, 14 August 2008).

It is relevant to note that whereas in the years immediately following its withdrawal from the IWC (1983–1988) Canada sent only 1–3 official observers to IWC annual meetings (and none, officially, to Scientific Committee meetings), starting in 1989 and continuing through 1993, official observers from Canada numbered 7–11 individuals each year, including representatives of bowhead whaling communities. This marked change appears to have been related to the lead-up to, and aftermath of, the 1991 bowhead hunt in the western Canadian Arctic. At the meeting of the IWC's Aboriginal Subsistence Whaling Sub-committee immediately before the annual Commission meeting in 1992, the September 1991 catch at Shingle Point was noted and an observer from Canada was asked to provide information on the biological data collected from the landed whale, on the subsistence need for this catch in the local community, and whether bowhead hunting would continue in the region. His response confirmed that the biological data would be made available and the following statement was entered into the record: 'The Canadian Constitution guarantees the rights of aboriginal peoples to hunt and fish for subsistence purposes but no decisions have been made concerning the future hunting of bowheads.' The observer also indicated that there had been no request for a licence to hunt bowheads in 1992 (IWC, 1993, p.19).

At the 1993 meeting of the IWC Aboriginal Subsistence Whaling Sub-committee, a Canadian observer was again asked for an update on Canada's plans. The response simply indicated that there had been no hunt in 1992 and that the government had 'not received any notification of plans for the hunting of bowhead whales nor any request for a licence to hunt bowhead whales in 1993 or later' (IWC, 1994, p.17). After 1993, rarely did more than one or two official observers from Canada attend an IWC annual meeting. A 1996 Resolution on Canadian Whaling acknowledged a clause in the *Nunavut Agreement* 'that would allow the taking of at least one bowhead whale' from the EC-WG stock and the recommendation of the NWMB that such a licence be issued accordingly, but it also 'encouraged' Canada to '(1) reconsider any outstanding permits it has issued; (2) rejoin the IWC if it continues to have a direct interest in whaling; [and] (3) refrain from issuing further permits, unless it obtains IWC approval for its whaling activities' (IWC, 1997, p.55). As noted earlier, the Scientific Committee continued to receive information on Canadian bowhead hunts (IWC, 1998a, p.32; 1998b, p.241), but at least in some years such information apparently came directly from Canadian government sources only if an explicit request had been made by the IWC Secretariat (2012a, p.158; 2013a, p.175). Information and data on bowhead demography, biology, natural history, and harvests has not been 'shared' systematically. A summary of basic information on catches in 2016–2020 was presented to the annual Scientific Committee meeting in 2021 (Government of Canada, 2021).

Current regulatory framework

The number of bowheads legally authorised to be taken each year in eastern Canada has increased steadily as more has become known about the conservation status of the EC-WG stock. Before 2008, the 'total allowable harvest' (TAH) in Nunavut was one whale every 2–3 years as established through the *Nunavut Agreement*. In 2008 it was increased to 2 per year and in 2009 to 3 per year for the next 3 years.[7] Also in 2009, the EC-WG stock (designatable unit according to terminology of the Canadian *Species At Risk Act*, SARA) was assessed as Special Concern by the Committee on Endangered Species of Wildlife in Canada (COSEWIC).[8] In 2014 the TAH for Nunavut

[6] Also: Nunatsiaq News, Iqaluit, 23 September 1994, pp.1–2, and 7 June 1996, pp.5, 18; Toronto Globe and Mail, 26 September 1994, p.A7.
[7] Nunatsiaq News, 6 May 2009; the TAH was allocated equally (1 each) to three regions within Nunavut– Kitikmeot, Kivalliq and Baffin.
[8] *https://species-registry.canada.ca/index-en.html#/species/1054-722.*

was increased to 4[9] and in 2015 to 5[10]. The NMRWB has established a total allowable take (TAT) of 2 bowheads per year for the Nunavik Marine Region. According to DFO (Anonymous, 2020), the combined maximum allowable annual take of bowhead whales in the eastern Canadian Arctic in 2020 was 7, of which 5 were allocated within the Nunavut Settlement Area and 2 within the Nunavik Marine Region.

BOWHEAD WHALE HUNTING IN THE CENTRAL AND EASTERN CANADIAN ARCTIC SINCE 1979

Currently, the vast majority of bowhead whales taken and officially reported to the IWC are from Alaska (USA; 1,618 from 1985-2017) and occasionally Chukotka (Russia; 26 from 1998-2017) and Greenland (Denmark; 8 from 2009-2017.[11] Only the whales taken in Greenland (3 in 2009, 3 in 2010, 1 in 2011, and 1 in 2015) are from the EC-WG stock. The annual quota for Greenland has varied between 2-4 since 2007 (except 2019 when it was zero).[12] Catches in Canada (a non-member of the IWC) are not included on the IWC website. Higdon (2010) made a comprehensive search for information on bowhead hunts in eastern Canada and West Greenland through 2009 and reported several events post-1979 that had been overlooked by other authors, including the shooting of a whale near Arviat (Eskimo Point) in western Hudson Bay in 1985 and a possible capture in an unspecified location in Nunavik in 1979.

Basic information on officially reported catches in the central and eastern Canadian Arctic and West Greenland from 1996-2020 was provided by Ferguson *et al.* (2021, table 1). Table 1 (see below) summarises Canadian catch data 1994-2021; the data on struck-but-lost whales may be incomplete. Although whales reported as struck-but-lost were not included in their compilation[13], the catch (removal) input used by Ferguson *et al.* (2021) for modelling the population trajectory from 1500–2020 included a uniform distribution for 'struck and lost correction' that ranged from 1.10 to 1.20 as well as the few known removals caused by entanglement in fishing gear (see later). Fig. 1 shows the approximate locations of catches and the total reported catches by each of the hunting communities.

RECENT SCIENTIFIC DISCOVERIES CONCERNING EC-WG BOWHEAD WHALES

Population Structure

The prevailing assumption through the early 1990s was that there were two separate 'stocks' (for definitions see Rugh *et al.*, 2003) in the eastern North American Arctic (including West Greenland waters): a Davis Strait/Baffin Bay stock and a Hudson Bay/Foxe Basin stock (Mitchell and Reeves, 1981; Reeves and Mitchell, 1990; Moore and Reeves, 1993). The basis for that assumption was that the whales migrating in spring through Lancaster Sound and into Prince Regent Inlet and Gulf of Boothia remained separate from those that overwintered in and near Hudson Strait and migrated into Hudson Bay and Foxe Basin (including Repulse Bay) for the summer. The animals in Cumberland Sound and Isabella Bay were generally thought to be part of the putative Davis Strait/Baffin Bay stock. However, much of the reasoning for the 2-stock hypothesis was merely conjecture.

During the 1990s and early 2000s, genetic analyses (Postma *et al.*, 2006), photo-identification (Heide-Jørgensen and Finley, 1991) and satellite-linked tracking studies of dozens of individual bowheads (Heide-Jørgensen *et al.*, 2003, 2006; Dueck *et al.*, 2006; Ferguson *et al.*, 2010a) led to a scientific consensus that the whales in the central and eastern Canadian Arctic (including Hudson Bay) and in West Greenland comprise a single stock, the EC-WG stock (IWC, 2008a, pp.159–61; 2009, pp.176–78; 2011, pp.170–71). This single-stock hypothesis has been deemed the 'working hypothesis', understood by the IWC Scientific Committee to mean the most plausible hypothesis (IWC 2012, p.157), and the concept of a single EC-WG stock is now widely accepted (Baird and Bickham, 2021). It is important to recognise, however, that with the opening of the Northwest Passage

[9] Allocation: 1 for Kitikmeot, 1 for Kivalliq, 2 for Baffin.
[10] Allocation: 1 for Kitikmeot, 2 for Kivalliq, 2 for Baffin.
[11] *https://iwc.int/table_aboriginal.*
[12] *https://nammco.no/topics/bowhead-whale/#1475844711542-eedf1c7b-5dde.*
[13] Two such whales that were struck but lost in 2010 (locations not indicated) were reported to the IWC (IWC, 2012b, p 71).

Table 1

Reported bowhead whale catches in the central and eastern Canadian Arctic (1994–2021). NU = Nunavut, QC = Quebec (Nunavik). Sources: DFO (2015), Anonymous (2020), Ferguson *et al.* (2021).

Year	Community	Hunt location	Date	Sex	Length (m)*
1994	Igloolik NU**	N Foxe Basin	14 Sept	F	(subadult)
1996	Naujaat (Repulse Bay) NU	Repulse Bay	15 Aug	M	14.9
1998	Pangnirtung NU	Cumberland Sound	21 July	M	12.8
2000	Coral Harbour NU	NW Hudson Bay	16 Aug	M	11.7
2002	Igloolik & Sanirajak (Hall Beach) NU	N Foxe Basin	10 Aug	F	14.2
2005	Naujaat NU	Repulse Bay	18 Aug	F	16.4
2008	Sanirajak NU	N Foxe Basin	18 Aug	M	13.4
2008	Kugaaruk (Pelly Bay) NU	Pelly Bay	4 Sept	M	10.5
2008	Kangiqsujuaq (Wakeham Bay) QC	Hudson Strait	9 Aug	M	14.9
2009	Rankin Inlet NU	W Hudson Bay	28 Aug	F	16.2
2009	Kinngait (Cape Dorset) NU	Hudson Strait	29 Sept	M	15.8
2009	Kangiqsujuaq QC	Hudson Strait	22 Aug	F	17.3
2010***	Pond Inlet NU	Navy Board Inlet	5 Aug	M	12.8
2010***	Naujaat NU	Repulse Bay	28 Aug	F	14.3
2011	Coral Harbour NU	NW Hudson Bay	20 Sept	F	16.4
2011	Iqaluit NU	Frobisher Bay	15 Aug	M	14.3
2011	Kugaaruk NU	Pelly Bay	20 Aug	F	9.0
2012	Arctic Bay NU	Admiralty Inlet	11 Aug	M	9.0
2012	Naujaat NU	Repulse Bay	13 Aug	M	8.0
2012	Taloyoak (Spence Bay) NU	Gulf of Boothia	6 Sept	F	9.6
2013	Pangnirtung NU	Cumberland Sound	6 Aug	M	12.8
2013	Naujaat NU	Repulse Bay	31 Aug	F	15.7
2013	Gjoa Haven NU	Gulf of Boothia	14 Sept	M	9.8
2014	Clyde River NU	Baffin Bay	3 Aug	F	16.2
2014	Kugaaruk NU	Pelly Bay	31 Aug	M	9.8
2015	Naujaat NU	Repulse Bay	16 Sept	F	14.0
2015	Sanirajak NU (struck but lost)	N Foxe Basin	2 Sept		
2016	Igloolik NU	N Foxe Basin	20 Aug	F	8.2
2016	Pangnirtung NU	Cumberland Sound	9 Sept	F	11.7
2017	Kangiqsujuaq QC	Hudson Strait	31 Aug	F	14.0
2018	Coral Harbour NU	NW Hudson Bay	28 June	F	8.0
2018	Naujaat NU	Repulse Bay	26 Aug	F	15.9
2018	Iqaluit NU	Frobisher Bay	14 Aug	F	11.0
2019	Coral Harbour NU	NW Hudson Bay	28 June	M	8.2
2019	Naujaat NU	Repulse Bay	26 Aug	F	14.3
2019	Pond Inlet NU	Eclipse Sound	2 Aug	F	9.1
2019	Igloolik NU	N Foxe Basin	20 Aug	F	9.2
2020	Sanirajak NU	N Foxe Basin	8 Aug	M	12.7
2021	Coral Harbour NU	NW Hudson Bay	10 July	F	10.0
2021	Baker Lake NU	Repulse Bay	16 Aug	M	14.0

*In most instances, lengths are not confirmed; some appear to have been estimated.
**Unauthorized (unlicensed) hunt. Data on sex and life stage are from Pomerleau *et al.* (2011a).
***In addition, 2 whales were reported as struck-but-lost, location(s) not provided (IWC, 2012b, p.71). These two whales are not represented on Fig. 1.

in recent decades, whales from Alaska (BCB stock) and whales from West Greenland (EC-WG stock) can occur at the same time and in the same area of what we refer to here as the central Canadian Arctic (Heide-Jørgensen *et al.*, 2012). Also, it has been noted that at some time prior to commercial whaling, a small, 'surprisingly genetically distinct population' of bowheads (Baird and Bickham, 2021) occurred in Prince Regent Inlet (Alter *et al.,* 2012).

Abundance and Trends

Another (mistaken) assumption by scientists as recently as the 1990s was that both putative stocks in eastern Canada and West Greenland (the Davis Strait/Baffin Bay and Hudson Bay/Foxe Basin 'stocks') were not recovering from the depletion caused by commercial whaling (Davis and Koski, 1980; Mitchell and Reeves, 1981; Reeves and Mitchell, 1990; IWC, 1992, pp.138–139; 1999, p.185–186; Zeh *et al.*, 1993; Finley, 2001). This assumption ran counter to the opinion of Inuit hunters who reported seeing bowheads more and more frequently and in areas where none had been seen for many decades (Freeman *et al.*, 1998, pp.78–79; Hay, 2000).

Fig. 1. Bowhead whaling communities in the eastern and central Canadian Arctic, 1994–2021. The cumulative catch for each community is given in parentheses and a few details are provided in Table 1. Note: For Sanirajak, the total landed catch was 2 and a third whale (*) was struck and lost. The blue-shaded area is the approximate range of the Eastern Canada—West Greenland stock of bowhead whales.

There is no credible estimate of pre-exploitation numbers, but given the scale of removals by commercial whaling during the period 1530–1915 (ca. 70,000 whales caught; Higdon, 2010), 'the pristine population must have been in the tens of thousands' (Givens and Heide-Jørgensen 2021, p.81). By the early 21st century, it had become clear that the EC-WG stock had increased considerably and likely was continuing to increase (Heide-Jørgensen *et al.*, 2007). Two independent estimates of the late winter and early spring aggregation of mainly adults in Disko Bay were remarkably consistent – 1,410 whales (SE = 320, 95% CI: 783–2,038) in 2010 (of which 999 (SE = 231, 95% CI: 546–1,452) were females) using photo-identification mark–recapture methods (Wiig *et al.*, 2011) and 1,229 whales (95% CI: 495–2,939) in 2006 derived from an aerial survey (Heide-Jørgensen *et al.*, 2007).

An aerial survey program in August 2013 was intended to sample the entire summer range of the stock in a short period (Doniol-Valcroze *et al.*, 2020). The resulting estimate, which included 'correction' for availability bias (whales that were missed because they were diving as the plane passed overhead), was 6,446 whales (95% CI:3,828–10,827). Doniol-Valcroze *et al.* (2020) acknowledged sources of both negative and positive bias in their estimate.

A separate and independent set of abundance estimates for the entire stock was obtained from a genetic mark-recapture analysis using 1,177 genetic samples (mainly biopsies) collected over the period 1995–2013 from eight locations in Canada (Igloolik, Pangnirtung, Naujaat, Taloyoak, Kugaaruk, Kinngait, and Arctic Bay) and one in Greenland (Disko Bay) (Frasier *et al.*, 2015). The initial analysis resulted in a 'best' estimate of 7,660 whales (95% highest density interval 4,500–11,100) (Frasier *et al.*, 2015). A follow-up analysis of the same data set resulted in an estimate of 6,877 (highest density interval [HDI] 4,828–11,477) when only the sampling events in the 5-year period 2008–2012 were used and an estimate of 11,682 (HDI 8,620–16,014) when the full data set

was used (Frasier *et al.*, 2020). The 5-year estimate was intended 'to reduce the potential biases in the longer-term data set due to births and deaths occurring within the longer time frame' (Frasier *et al.*, 2020, p.8) although the authors concluded that the estimate based on the full data set 'currently represents the best overall estimate from these analyses' (*Ibid.*, p.14).

Frasier *et al.* (2020, p.14) noted, 'Given their [bowheads'] movement dynamics and heterogeneity, it seems that any estimate of population size is going to have its shortcomings, and [has] to be taken with a degree of caution.' With that proviso in mind, it is reasonable to have confidence that, despite the quantified uncertainties associated with the above estimates and based on the available data and analyses, the EC-WG stock is at a level where the well-organised and closely monitored hunting in Canada and West Greenland should be sustainable and allow for continued population increase toward recovery (Ferguson *et al.*, 2021).

Reproduction

The reproductive cycle of bowhead whales is protracted, with most individuals of both sexes not reaching sexual maturation until 18–31 years of age and roughly half of them being mature by 25 years of age (Rosa *et al.*, 2013). Gestation is estimated to last 13–14 months, the average calving interval is probably 3–4 years, and weaning apparently occurs late in the first year of life (Koski *et al.*, 1993). Nothing is known about reproductive senescence in bowhead whales. However, it is noteworthy that the oldest individual in a sample of 22 female bowheads landed in Alaska was 88.3 (+/– 18.5) years old and pregnant (Rosa *et al.*, 2013). George *et al.* (1999) reported a large (15.2m) male, aged 159 years (SE = 27), to have been reproductively active (semen exuding from the penis). Those authors also mentioned pregnant females > 100 years of age. Female bowheads consistently grow to greater body lengths than males, with maxima of close to 19m and 17m respectively (George *et al.*, 2021b).

The EC-WG stock exhibits a considerable degree of sex and age-class segregation, particularly during the non-winter months (Ferguson *et al.*, 2010a; Heide-Jørgensen *et al.*, 2003; 2006; 2021; Postma *et al.,* 2006). Hudson Strait is thought to be the main wintering ground (Koski *et al*., 2006) and also one of the regions (in addition to Disko Bay and outer Cumberland Sound; Heide-Jørgensen *et al.*, 2010; Hay, 2000) where mating occurs during the late winter and early spring (Heide-Jørgensen *et al.,* 2006). Adults, mostly large females (> 14m long), congregate and forage in Disko Bay in the spring (Laidre *et al.*, 2008). In the summer, Foxe Basin is used mainly by juvenile whales and female-calf pairs (Cosens and Blouw, 2003), whereas the Gulf of Boothia and Prince Regent Inlet appear to be used by all ages and both sexes (Dueck and Ferguson, 2009).

Longevity

The exceptional longevity of bowheads has been a subject of extensive research over the past few decades. It is generally accepted that they are the longest-living cetaceans and among the longest-living mammals, reaching ages well in excess of 100 years (George *et al.,* 2021a). Four of 24 male bowheads from Alaska studied by George *et al.* (1999) had estimated ages of older than 100 years (135, SE = 23; 159, SE = 27; 172, SE = 29; 211, SE = 35). The oldest individual among 18 males in the sample from Alaska studied by Rosa *et al.* (2013) was 145.7 (± 23.2) years old. The oldest individual among the 24 females in George *et al.*'s (1999) sample was 69 (SE = 13) years old, while as mentioned above, Rosa *et al.* (2013) reported an 88-year-old pregnant female. Wetzel *et al*. (2017) estimated ages of several bowheads >100 years old with one individual being ~188 years old.

Feeding

Bowhead whales are exquisitely adapted to take advantage of zooplankton swarms both at the surface and at depth (Simon *et al*., 2009; Sheffield and George, 2021). They consume a variety of small pelagic, sympagic, and epibenthic organisms, primarily copepods, euphausiids, and mysids in West Greenland and the eastern Canadian Arctic (Pomerleau *et al.*, 2011a; 2012). Bowheads monitored with satellite-linked time-depth recorders in Disko Bay in the spring were diving to mean depths of ~50–100m (maximum > 400m) for up to 40 minutes, mainly targeting dense concentrations of calanoid copepods near or on the bottom (Laidre *et al.*, 2007; Banas *et al.*, 2021). A similar study in northern Foxe Basin and Cumberland Sound found that whales tagged in both areas in the early summer moved rapidly through Fury and Hecla Strait (an area with heavy ice coverage) and converged on a major feeding area in the northern Gulf of Boothia where they stayed mostly near the surface (8–16m

depths), presumably foraging intensively on near-surface aggregations of zooplankton for several weeks to 2 months (Pomerleau *et al.*, 2011b). Foraging areas along the east coast of Baffin Island centered in coastal troughs at the mouths of fiords (e.g. Isabella Bay, Clyde Inlet, Eglinton Fiord) are occupied in the autumn (September–October), primarily by adults moving southward from the High Arctic (Finley, 1990). It was recently discovered that some bowheads forage in Cumberland Sound in all months, apparently adapting to seasonal changes in the lipid content and vertical distribution of prey species (Fortune *et al.*, 2020a).

There is likely considerable individual variability in where and when bowheads feed. Unlike most other baleen whales that undertake seasonal migrations and experience periods of 'feast' and 'famine', they apparently forage year-round, with intense focus on traditionally favourable areas but also taking advantage of prey concentrations that they encounter while migrating between such areas (Matthews and Ferguson, 2015; Pomerleau *et al.*, 2018; Citta *et al.*, 2021). Citta *et al.* (2021, p.43 and their fig. 4.5) inferred from the diving behaviour and 'anomalous movements' of radio-tracked bowheads that they sample the water column as they travel, pausing to feed when prey is located, and when no food is found, they sometimes make 'surprising exploratory movements 'circling back' to where they started, apparently to check again for food.'

KNOWN AND POTENTIAL THREATS

Entanglement

One obvious threat to individual bowheads, apart from being shot or harpooned, is entanglement. In comparison to the risk of entanglement faced by whales elsewhere in the world, bowheads, as year-round residents of high latitudes where commercial net fisheries have been limited, are rarely reported as net-entangled. However, off northern Alaska, more than 12% of bowheads bear entanglement scars and the estimated annual probability of acquiring such scars is around 2% (George *et al.*, 2019).

A young individual became entangled and died in a large-mesh net (~30cm mesh width) in Upernavik district, West Greenland, in 1980 (Kapel, 1985). At the time, many local hunters used such nets to catch migrating belugas as they passed through the area in the autumn. Ropes and lines in the water column, particularly associated with pot fisheries for crabs in northern waters, are a well-documented entanglement risk for both bowhead whales and right whales (*Eubalaena* spp.) (Philo *et al.*, 1993; Reeves *et al.*, 2012). Although most entanglements have been attributed to encounters with fishing gear, Philo *et al.* (1993) acknowledged that some entanglements could involve harpoon ropes or lines when whales escape after being struck by whalers.

We are aware of only a few specific records of entanglement in the eastern Canadian Arctic and West Greenland (Table 2). However, commercial fisheries in the range of EC-WG bowhead whales have been expanding, and any increase in the use of entangling nets or lines must be viewed as a concern. As an example, an exploratory fishery for snow crabs (*Chionoecetes opilio*) in Disko Bay, West Greenland conducted in 1991 (Anderson, 1993) led to an active and rapidly growing commercial fishery in the region. The number of vessels licensed to participate increased from approximately 120 in 1999 to 392 in 2002 (Greenland Institute of Natural Resources 2019). Landings peaked in 2001 (c. 15,000 t), decreased markedly by 2006 (c. 2,200 t), and remained stable at around 2,100 t until at least 2018. The intensity of fishing effort declined by more than 90% from 2001–2014 (*Ibid.*). With no regular reporting of whale entanglements, it is impossible to say how representative the numbers given in Table 2 are, but it seems reasonable to assume that the trend of bowhead entanglements in that part of the species range was increasing in the 1990s and early 2000s and has leveled off or declined in recent years. To our knowledge, commercial snow crab fishing in eastern Canada is, for the present, limited to waters to the south of the normal range of bowheads.

Ship strikes

There is relatively little evidence of ship-strike deaths or injuries of bowhead whales (George *et al.*, 1994, 2021c; Reeves *et al.*, 2012). This may be due in part to their avoidance reaction to approaching vessels (see below) and in part to the fact that at least until recently, much of their habitat was devoid of large volumes of ship traffic. It is expected that with the rapid and ongoing increase in vessel traffic in bowhead habitat, the frequency and likely also severity of ship strikes (larger vessels traveling at greater speeds) will increase.

Table 2

Records of entanglement of bowhead whales in the eastern Canadian Arctic and West Greenland.

Year(s)	Location	Circumstances	Comments	Source
Autumn 1980	Upernavik, West Greenland	Young bowhead (9–10 m) died in a large-mesh net set for belugas		Kapel (1985)
Not indicated	Tinnujivik/Cumberland Sound	"… bowheads sometimes swim into nets set for belugas or narwhals (or even fish) and they damage or carry the nets away: Bowhead whales just destroy beluga nets without even seeming to notice them. The nets are usually attached to the floe edge, at the beginning of June. [Adamee Veevee, PA/ws] BB97". "An elder was saying that he used to set nets for beluga at the floe edge but the bowhead whales used to destroy them. The net [mesh] size was 16" × 32". [Peteroosie Karpik, PA/ws] BB144 ...and the bowhead whales have been caught in fish nets or tangled with fish nets. [Mosesee Qiyuakjuk, PA] BB410"		Hay (2000 p.50)
Prior to 2003	Eastern Canada & West Greenland	8 bowheads reported as entangled		Higdon (2010 p.200, citing DFO unpublished data); Ferguson *et al.* (2021)
2003	Disko Bay, West Greenland	1 entangled bowhead	"It is unknown if this 2003 report … represents confusion with the whale … reportedly entangled and then shot (but escaped) in 2004…."	Higdon (2010, p.200)
2004	West Greenland	A bowhead 'caught in a net'; "a kill was attempted but the whale escaped after being injured with rifles (Siku Circumpolar News Service, 2004)"		Higdon (2010, p.200)
2005	Nunavut	2 entangled bowheads		Higdon (2010, p.200)
2006	Pond Inlet	… there was a report … of a Bowhead entangled in gear. Two weeks after the initial report, a Bowhead was seen towing a red buoy at the mouth of Navy Board Inlet. There were no subsequent sightings of this animal."		COSEWIC (2009)
2006	Nunavut	1 entangled bowhead	Likely the same animal reported in COSEWIC (2009)	Higdon (2010, p.200)
Since 2003	Nunavut and West Greenland	4 bowheads reported as entangled in nets	Likely includes the 2006 Pond Inlet whale	COSEWIC (2009, citing DFO, unpublished data)
2007	West Greenland	2 entangled bowheads	Possibly some of the same animals as mentioned in COSEWIC (2009), Higdon (2010)	Government of Greenland (2017)
1998–2017	Inshore from Upernavik and southwards, primarily in Disko Bay	Unspecified numbers of bowheads entangled in snow crab pot lines, April–December		Government of Greenland (2017)
2011	West Greenland	2 entangled bowheads		Government of Greenland (2017)
2013	Disko Bay, West Greenland	1 entangled bowhead		Government of Greenland (2017; Ferguson *et al.* (2021)
2017	Disko Bay, West Greenland	2 bowheads bycaught, at least one of them near Qeqertarsuaq		Ferguson *et al*. (2021); also IWC (2018; cited from George *et al.*, 2021c, p.582)

Noise

Bowheads are among the most vocal baleen whales, with a rich and complex acoustic repertoire (Würsig and Clark, 1993). Their calls in the summer are generally at very low frequencies, between 50–1,000 Hz; in the winter when they sing, at higher frequencies including over 2,000Hz (Halliday *et al.*, 2020). Individuals of both sexes and likely all age classes use sound 'for such basic life functions as communicating between mother-calf pairs and between combinations of individual animals; navigating through and around ice; and coordinating between groups of migrating whales' (Stafford and Clark, 2021, p.325). In addition, songs, which are produced seasonally, are thought to serve as male acoustic displays that can provide 'reliable cues of male attributes attractive to females' or threaten rival males, or possibly both (Stafford and Clark, 2021, p.323).

Consistent with their heavy reliance on sound for communication and navigation, bowheads have proven to be extremely sensitive to underwater anthropogenic noise (Würsig and Koski, 2021; Blackwell and Thode, 2021). In particular, the response of bowheads to airgun noise from marine seismic surveys has been studied intensively since the 1980s, soon after offshore industrial development began off northern Alaska, in the Canadian Beaufort Sea, and in the Lancaster Sound region (Richardson *et al.*, 1995). They react overtly and strongly to airgun sound at ranges of 6–8km and they tend to flee when the received noise level reaches 150–180dB re 1µPa (Richardson *et al.*, 1995, pp.298–99). A study in autumn (August–September) off northern Alaska detected and localised significantly fewer bowhead calls (i.e. vocalisations) at locations within 45km of an active seismic source (median received levels 116–129dB re 1µPa (10–450Hz)) than at median distances of more than 104km from the source (median received levels 99-108dB re 1µPa), leading the authors to conclude that the whales either stopped calling or were deflected around the seismic activities, or both (Blackwell *et al.*, 2013, 2015). Broadly similar responses to noise from industrial machinery (e.g. drilling, towing, anchoring operations) have been documented: the whales initially increase their call repetition rates, possibly to compensate for the reduced detectability of their communication signals, then as noise increases they may stop calling because it is 'no longer worth the effort' (Blackwell *et al.*, 2017).

In addition to the noise from seismic surveys and offshore energy projects more generally, there has been a massive increase of noise in the Arctic from ship traffic, much of it related to the expansion of industrial mining on shore, transport, tourism, geophysical mapping, military exercises, and other human activities – all facilitated by the decline in sea ice (Moore *et al.*, 2012; Halliday *et al.*, 2020; Duarte *et al.*, 2021). The large (and potentially expanding) Mary River Iron Ore Mine, located at the south end of Eclipse Sound, northern Baffin Island, has undeniably altered the low-frequency soundscape in the Lancaster Sound region, and this raises concerns about behavioral disturbance and auditory masking (Erbe *et al.*, 2016; Southall *et al.*, 2019). It is important to recognise that vessel traffic brings not only noise and the risk of ship strikes, but also the ever-present risk of spills or discharges of oil and other toxic substances, the spread of novel pathogens, and the introduction of invasive species.

Climate change

The effects of climate change on bowhead whale phenology, ecology, habitat selection, body condition, behaviour, and population dynamics have been the subject of considerable speculation (e.g. Burek *et al.*, 2008; Pomerleau *et al.*, 2012; Chambault *et al.*, 2018; Fortune *et al.*, 2020a, 2020b). Undoubtedly, change is already occurring in terms of, for example, ice conditions (reduced thickness and coverage, timing of break-up and freeze-up), predation (from killer whales), and prey availability (from competition with other zooplanktivores as well as the relative productivity of various zooplankton species), and more change is on the way (Moore *et al.*, 2019, 2021; Kovacs *et al.*, 2020).

Predation on bowheads by killer whales has become more frequent and widespread as ice conditions in the Arctic have ameliorated (Breed, 2021). The EC-WG stock has been increasingly exposed to killer whale attacks. Young-of-the year and yearling bowheads are especially vulnerable (i.e. subject to successful attacks). Although predation by killer whales has direct demographic effects on the EC-WG stock, the 'fear' or 'risk' effects could be equally, or even more, important – faced with the threat of predation, bowheads 'flee into shallow water near coasts or into denser sea ice' and, contrary to what we might assume, changes in the whales' movement behaviour and habitat selection patterns can be protracted, lasting for weeks (Breed, 2021, p.464). The fear

effects could therefore 'compound the negative consequences of sea ice loss' to bowheads and other Arctic marine mammals 'as they cope with more-frequent, longer exposures to predator threat' (Matthews *et al.*, 2020).

Finley (2001), citing Philo *et al.* (1993), noted the 'potential danger from bowel obstruction' as a result of bowheads ingesting plastic debris. The increasing human activity in the Arctic is bound to be accompanied by a proliferation of plastic debris in bowhead habitat.

The direction and net effects of some changes are difficult to predict. However, the impacts of more frequent attacks by killer whales (Ferguson *et al.*, 2010b, 2012; Breed, 2021), thermal stress from increased sea temperatures (Chambault *et al.*, 2018), and more direct (ship strikes, entanglements) and indirect (noise, oil spills) interactions with human activities (shipping, tourism, offshore industrial development, military operations, etc. (e.g. Reeves *et al.*, 2014; George *et al.*, 2017) can only be deleterious. Bowheads have shown some evidence of resilience, at least so far (Moore *et al.*, 2021). The BCB stock has increased since 1978 at an estimated annual rate of 3.7% (2.9–24.6%), nearly quadrupling in size (Givens and Heide-Jørgensen, 2021), and this is despite the large numbers of animals removed by hunting (nearly 1,500 were landed in Alaska and Chukotka, combined, from 1974-2018; Suydam and George, 2021) and the ongoing environmental changes, including the considerable sea ice retreat within their range over the past four decades (Suydam *et al.*, 2021, pp.615–616). Also, the whales' body condition improved through at least 2011 despite (or possibly because of, at least in part) the progressive loss of summer sea ice for the preceding two and a half decades (George *et al.*, 2015). Initial findings from an extensive satellite-tracking and prey-sampling study in Cumberland Sound led Fortune *et al.* (2020a, p.214) to conclude, 'The apparent flexibility of bowhead whales to exploit seasonally available prey throughout the year in Cumberland Sound bodes well for their ability to adapt to climate-induced changes to their habitat. What is less certain, however, is how climate change will alter the species composition and abundance of their primary prey, and whether bowhead whales can adapt their foraging strategies to contend effectively with such changes to their prey base' (see also Fortune *et al.*, 2020b).

DISCUSSION AND CONCLUSIONS

Patterns in the hunting of bowheads in Canada since 1979

Since the mid 1990s, the hunting of bowhead whales in the central and eastern Canadian Arctic has become an increasingly regular feature of the annual round in several Inuit communities. Sixteen communities have landed at least one bowhead over the past 27 years, with 9 of them landing 2 or more (Naujaat 8, Coral Harbour 5, Igloolik 4, Pangnirtung, Kugaaruk, Sanirajak, and Kangiqsujuaq 3, Pond Inlet and Iqaluit 2). Most of these communities had a long history of bowhead whaling prior to the arrival of commercial whalers as well as during the commercial whaling and trading era (Ross, 1974, 1975, 1984, 1985; McCartney and Savelle, 1985; Eber, 1989). It is noteworthy that more than half of the catches since 1994 have been in the Foxe Basin-Repulse Bay-northern Hudson Bay region (communities of Igloolik, Sanijarak, Naujaat, Coral Harbour) where at least occasional hunting of bowheads by local people persisted until well into the 1970s (Mitchell and Reeves, 1982).

The timing of successful hunts in recent times has spanned a fairly wide range, from late June to late September (earliest 28 June, latest 29 September), but the great majority of catches (>90%) have occurred in August or September. Therefore, the hunting is essentially an open-water activity with no 'ice-edge' phase comparable to the hunting in northern Alaska, which has both ice-edge (spring) and open-water (autumn) components depending on the whales' migratory timing and routing in relation to the geographical location of the hunting communities (Stoker and Krupnik, 1993).

The Canadian catches from 1994-2020 included 16 males and 21 females, and of the 21 females, 12 were > 13m long and therefore could be considered sexually mature adults (Koski *et al*., 1993). Of the 7 bowheads taken by Greenlanders from 2009-2015, 6 were females and only one was a male, all > 14m long and therefore adults (IWC, 2011, p.171; Ferguson *et al.*, 2021).

Sustainability of the hunt

Although the genetic mark-recapture estimate of abundance is less precise than the aerial survey estimate, the close agreement in the mean estimates from these two entirely different approaches to estimation of population

size (around 7,500 and 6,500, respectively; see above) and their concordance with local observations give some confidence that well-organised and carefully monitored hunting in Canada and West Greenland is sustainable and will allow continued population increase toward recovery. Doniol-Valcroze *et al.* (2015) applied the Potential Biological Removal (PBR) approach, a commonly used algorithm for setting 'precautionary' (i.e. conservative or risk-averse) limits on human-caused removals from a marine mammal population, using N_{MIN} of 5,182 (a conservative estimate of population size from their 2013 aerial surveys) and a 'recovery factor' (F_R) of 0.5 (a default constant for populations not considered to be at immediate risk but for which there is considerable uncertainty in regard to their status in relation to their optimum sustainable level), to generate a PBR of 52 whales. In other words, the recent reported removals of fewer than 5 whales per year in Canada and West Greenland, combined, should not only be sustainable but also allow ample potential for population increase. Among the factors that reinforce this conclusion is the relatively high proportion of calves and young juveniles reported by Inuit (Hay, 2000, pp.69–70) and observed during aerial surveys of what is believed to be the stock's main 'nursery' area in northern Foxe Basin (Cosens and Blouw, 2003).

The sex and size composition of reported catches in both Canada and Greenland, however, appears to be less than optimal in terms of seeking to minimise the impact of removals. Of the 11 bowheads landed in Canada during the period 2016–2020, nine were females, one was a male and one's sex was not reported (Government of Canada, 2021). Nearly all bowheads landed in West Greenland are large adult females (Ferguson *et al.*, 2021). Well over a third (probably close to half) of all the whales being landed by hunters (both countries combined) are mature females, the most valuable class in terms of potential for population increase. Although it is very difficult for whale hunters to determine the reproductive status of an animal they are pursuing, by simply avoiding large whales they could greatly reduce the chances of harvesting reproductive females. Such selectivity should be feasible in parts of the Canadian Arctic. However, in Disko Bay, the primary area where Greenlanders have hunted bowheads in modern times, the available whales tend to be very large and are often females (Heide-Jørgensen *et al.*, 2010). The logistical challenges of handling such large animals and processing them with hand tools may help to explain why Greenlanders took so few whales between 2009–2015 and none since then.

Several factors other than hunting are likely also affecting EC-WG bowheads. These include the risk of entanglement in fishing gear, especially vertical lines connecting crab traps with marking buoys; increased exposure to killer whale predation, which is almost certainly linked to the massive reduction in sea ice; and the changes in ecological conditions, driven primarily by climate change (Chambault *et al.*, 2018). Such continuing and probably growing risks to the whales, along with the uncertainty associated with all of them, are grounds for precaution when it comes to decisions regarding how subsistence whaling is managed.

Arctic ecosystems are undergoing rapid changes through climate warming, habitat encroachment, and industrial development projects. Local observations and traditional knowledge are important sources of information. The importance of continuing to monitor the population and to collect and report information on bowhead health and mortality became starkly apparent over the past year. Between October 2020 and October 2021, local Inuit detected and reported 11 bowhead carcasses within a 200 km radius of Kugaaruk (Pelly Bay).[14] Although the causes of this mortality are unknown, predation by killer whales was considered very likely because of their increased presence in the area in recent years (Ferguson *et al.*, 2012).

Biological sampling by Inuit is critical for monitoring the health of bowhead whales. Much of what is known about the physiology, anatomy and health of bowheads, particularly the BCB stock, has come from the sampling of harvested whales (Albert, 2001; Huntington *et al.*, 2021[15]). The participation of Indigenous people from the outset, in disease monitoring, tissue sampling and data collection more generally, is vital and an expectation under modern treaties such as the Nunavut Agreement. Early and regular Indigenous participation in these efforts is bound to improve the likelihood of detecting zoonotic risks as they emerge, and provide a more holistic understanding of such risks in the rapidly changing Arctic (Keatts *et al.,* 2021; Stimmelmayr *et al.,* 2021). Particularly with increasing proposals for new and expanded industrial development, and the rising potential for

[14] Submission to the Nunavut Wildlife Management Board, December 2021. Prepared by S. Ferguson and B. Young, Department of Fisheries and Oceans Science, Winnipeg, 22 October 2021.

[15] *http://www.north-slope.org/assets/images/uploads/ALL_DWM_PUBLICATIONS_as_of_August_2020.pdf*

ecological impacts from climate change, the need for good baseline data becomes ever more critical to inform environmental impact assessments. As one example, comparison of cortisol levels (a stress indicator) in blubber of narwhals harvested by subsistence hunters in northern Baffin Island rose sharply after a surge in vessel traffic related to an iron ore mine (Watt *et al.*, 2021).

Differences in bowhead whale hunt management between Canada and Greenland

Conservation of the EC-WG stock is a joint responsibility of Canada and Greenland. To date, Inuit in Canada have demonstrated a strong interest in adding bowhead whales as a source of 'country food' and the whale hunt as a means of cultural revitalisation (Kishigami, 2015). Thirty-nine bowheads were reportedly landed by Inuit in Canada from 1994–2021. Greenlanders reportedly took only 8 bowheads from 2009–2015; over that same period, 18 were reportedly taken in Canada. No bowheads have been taken by whaling in Greenland since 2015 (Fernando Ugarte, pers. comm., 20 August 2021) even though, as explained below, a national quota of at least 2 'strikes' of bowhead whales per year has been in place in most years. Any Greenlander registered as a full-time hunter who has the suitable equipment and training can apply for a permit to hunt bowheads.[16]

There is no particular reason to believe that the Indigenous people of West Greenland are less eager than Inuit in Canada to harvest bowheads but as mentioned earlier, Denmark has maintained its membership in the IWC and this obliges Greenland to adhere to quotas (catch limits) set by the Commission for aboriginal subsistence whaling. This may help to explain Greenland's comparatively late start in terms of resuming a regular hunt for bowheads (no catches reported in recent decades until 2009). Also, it should be noted that Greenlanders have a long and unbroken history of hunting other baleen whales (humpback, fin, and minke whales) in the summer months when belugas are unavailable and narwhals are available only in the far northern districts, whereas in Canada the Inuit have no tradition of hunting other baleen whales, only bowheads.

In 2007, following long discussions in both the Scientific Committee and the Commission itself, the IWC formally revised its whaling regulations to authorise Greenlanders to 'strike' up to 2 bowhead whales from the 'West Greenland feeding aggregation' each year for the next 5 years (2008–2012) under certain conditions, as follows (IWC, 2008b, p.22): (i) the meat and other products are used exclusively for local consumption, (ii) any unused portion of the annual quota could be 'carried forward' and added to the quota for subsequent years, provided that no more than 2 are added to the quota for any one year, and (iii) the quota becomes operative only after the Commission has received advice from the Scientific Committee that the strikes are 'unlikely to endanger the stock'. No bowheads were taken (or struck) by Greenlanders in 2008 but 7 were landed from 2009–2011, then only 1 since 2011 (see earlier). At the IWC annual meeting in 2012, Denmark proposed (on Greenland's behalf) that the Commission renew the existing arrangement until 2018, considering the Scientific Committee's advice that continuing the small level of removals (up to 2 strikes per year) 'would not harm the [EC-WG bowhead] stock' (IWC, 2013b, pp.19–24). However, this proposal met strong resistance and sparked a lengthy debate leading to an impasse, with the Denmark (and Greenland) delegation resolving to 'return home to make a sensible decision as to its future course of action' (*Ibid.*, p.24). At the next (2014) meeting of the Commission (which had switched to biennial rather than annual meetings after 2012), the above arrangement (2 strikes/year, with conditions) was reinstated for 2015–2018 (IWC, 2016, p.111). At its most recent meeting in 2018 (the 2020 meeting having been postponed to 2021 because of the global COVID-19 pandemic), the Commission agreed that the 2 strikes-per-year arrangement for bowhead hunting in West Greenland could be extended for up to 8 more years (IWC, 2018, pp.13–15).

As explained earlier, the primary instruments of wildlife management in northern Canada with settled modern-day treaties are the co-management boards but ultimate authority remains with the federal government through modern-day treaties. The Nunavut Wildlife Management Board is the primary instrument of wildlife management in Nunavut and the Nunavik Marine Region Wildlife Board is the primary instrument of wildlife management in Nunavik. Both are institutions of public government which are responsible for establishing total allowable harvests and non-quota limitations as necessary. In their decision-making process, both boards rely on the best available information.

[16] The executive order that regulates hunting of large whales in Greenland is available at *http://lovgivning.gl/lov?rid={D09EBA1A-6A0E-4745-980A-43E001D5194A}*.

While the IWC has often requested that Canada provide data on removals routinely so that such data can be considered in population assessments by the Scientific Committee and in decisions on catch limits by the Commission, reporting has been partial and often ad hoc. We believe that data and samples from bowhead whales taken in subsistence hunts should continue to be collected routinely and in a standard manner, and shared widely to improve knowledge and to support sound management.

The EC-WG stock appears to have increased substantially during the century following overexploitation by commercial whalers, and this is due in no small measure to the stewardship of Inuit in both Canada and Greenland. The revival and continuation of non-wasteful hunting of bowheads in both countries, under different but equally risk-averse management approaches, is to be welcomed and encouraged. Sharing of data and samples can only serve to strengthen the ability of all concerned to learn about and to monitor the bowhead population, assess the health of the animals, and ensure that future human generations can benefit from a functioning and diverse marine ecosystem.

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