SHIFTING PRIORITIES FOR NARWHAL CONSERVATION:

from Trade to Rapid Environmental Change

Report by Randall R. Reeves and David S. Lee

▲ Eclipse Sound (Tremblay Sound), August 2017.

◀ Eclipse Sound (Milne Inlet/Koluktoo Bay), August 2006.

The Narwhal Monodon monoceros *is a small whale endemic to the Arctic, best known for the adult male's long spiralled tusk which has long been valued as a novelty in international trade. Most of the world's Narwhals, currently numbering around 175,000, inhabit marine waters of northern Canada and Greenland, with smaller numbers in Svalbard (Norway) and a few parts of the Russian Western Arctic. Inuit communities with access to Narwhals hunt them for food (the skin—maktaaq—is considered a delicacy) and cash income (the sale of tusks and also maktaaq in Greenland). The export of Narwhal ivory from Greenland has been prohibited since 2006 but at least a few hundred tusks are exported by Canada each year, most of them to "traditional" importing countries like Japan, France, Italy, Germany, and Switzerland but also increasingly to China. Numerous carvings and jewellery items also enter trade. With quotas on removals, and population monitoring programmes now in place, conservation concern has begun to shift away from hunting and trade and now focuses on the direct (habitat loss) and indirect (expanding industrial, commercial, and recreational activity) impacts of climate change. However, the dramatic recent increase in China's imports of Narwhal tusks is noteworthy.*

Introduction

The Narwhal *Monodon monoceros* is a small toothed whale endemic to the Arctic; its nearest living relative is the Beluga *Delphinapterus leucas*. Narwhals have been hunted by the indigenous people (Inuit) of northern Canada and Greenland for millennia. Their *maktaaq* (Canada) or *mattak* (Greenland) (hereafter, maktaaq)—the thick skin with a portion of adhering blubber—is a nutritious delicacy; the blubber was a source of oil for warmth and light, and the sinew was used as sewing thread; Narwhal meat was eaten by people or fed to sled dogs; and the long, spiralled tusk of adult males served various domestic purposes (e.g. hunting implements, tent poles). From the early days of contact between Europeans and Inuit, Narwhal ivory was a prized item of trade. Now, in addition to the strong continuing local demand for maktaaq (Reeves, 1993a, 1993b; Heide-Jørgensen 1994), the commercial value of ivory remains an incentive for targeting large, tusk-bearing males (Reeves, 1992; Reeves, 1993b; Reeves and Heide-Jørgensen, 1994; Shadbolt *et al.*, 2015). However, the significance of hunting as a factor influencing the abundance of Narwhals and a source of concern for their future seems to have declined relative to the multi-faceted threat of climate change and expanding human activity in high-northern latitudes.

Narwhals are most numerous in eastern Canada and Greenland. They also occur regularly, but in comparatively modest numbers, north of Svalbard (Norway) and near Franz Josef Land (Russia) (Fig. 1). Occasional observations are made as far west as the Chukchi Sea and as far east as the Kara Sea. Because of the Narwhal's importance to Arctic communities, as well as the global interest in conserving biological diversity, both Canada and Greenland have invested heavily in monitoring populations, seeking to ensure that hunt removals are sustainable, and ensuring that the impacts of industrial activities are mitigated.

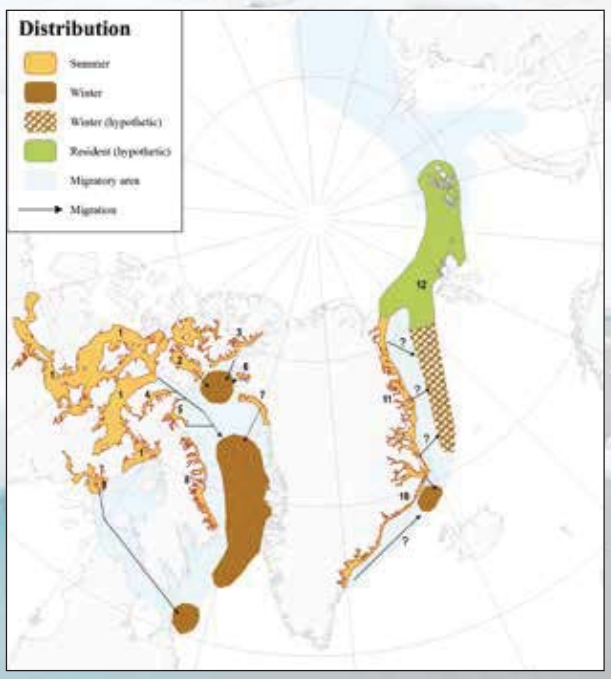

Fig. 1. Narwhal stocks recognised by the Global Review of Monodontids convened by the North Atlantic Marine Mammal Commission (NAMMCO). Stocks are identified by their summering areas. Ranges of stocks are differentiated into summering areas (tan), migration areas (light blue), and known wintering areas (brown) or assumed wintering areas (brown check); arrows show direction of autumn migration. *1. Somerset Island; 2. Jones Sound; 3. Smith Sound; 4. Admiralty Inlet; 5. Eclipse Sound; 6. Inglefield Bredning; 7. Melville Bay; 8. Eastern Baffin Island; 9. Northern Hudson Bay; 10. East Greenland; 11. Northeast Greenland; 12. Svalbard-Russian Arctic.* Map prepared by Rikke Guldborg Hansen; adapted from NAMMCO (2018) and Hobbs *et al.* (in press).

A previous article on Narwhal conservation in the *TRAFFIC Bulletin* (Reeves, 1993b) was followed by a detailed investigation carried out by TRAFFIC and WWF-Canada on the Narwhal ivory trade, regulatory issues, and threats to the species (Shadbolt *et al.*, 2015). In 2017 an international scientific workshop on monodontids (Narwhals and Belugas comprise the family Monodontidae) took place in Denmark (NAMMCO, 2018) and an updated assessment of the Narwhal downlisted the species from Near Threatened to Least Concern on the IUCN Red List (Lowry *et al.*, 2017).

This article reconsiders the role of hunting and the ivory trade when compared to that of rapid environmental change in determining the Narwhal's future.

International Legal Framework

International Whaling Commission

The mandate of the International Whaling Commission (IWC) has evolved considerably over the past 70+ years. Until recently, "small cetaceans" were considered outside its regulatory competence although the Scientific Committee's (SC's) standing Sub-committee on Small

NARWHAL STOCKS	GENERAL DISTRIBUTION	ABUNDANCE (SURVEY YEAR)	TREND IN ABUNDANCE	ANNUAL REMOVALS BY HUNTING[1]	TALCs or QUOTA[1]
Somerset Island	Barrow Strait/Peel Sound/Prince Regent Inlet summer; central Baffin Bay winter	49,768 (CV=0.20) (2013)	Possibly increasing	Hunt in Canada is below TALC	658
Jones Sound	Jones Sound summer; winter unknown	12,694 (CV=0.33) (2013)	Unknown	Low (average is fewer than 20 per year)	50
Smith Sound	Smith Sound summer; winter unknown	16,360 (CV=0.65) (2013)	Unknown	Few (if any)	5
Admiralty Inlet	Admiralty Inlet summer; Baffin Bay winter	35,043 (CV=0.42) (2013)	Stable	Hunt is at TALC	233
Eclipse Sound	Eclipse Sound summer; central Baffin Bay winter	12,039 (CV=0.23; 95% CI 7,768–18,660) (2016)[2]	Unknown	Hunt is at or below TALC	236
Inglefield Bredning	Inglefield Bredning summer; winter unknown	8,368 (CV=0.25; CI 5,209–13,422) (2007)	Stable	"Considerable" numbers in Greenland but judged "sustainable"	98
Melville Bay	Melville Bay summer; central Baffin Bay winter	3,091 (CV=0.50; 95% CI 1,228–7,783) (2014)	Stable	"Above quota advice"	84
Eastern Baffin Island	Fjords along eastern Baffin Island summer; winter unknown	17,555 (CV=0.35) (2013)	Unknown	Increasing since 1970s but judged "sustainable"	206
Northern Hudson Bay	NW Hudson Bay summer; eastern Hudson Strait winter	12,485 (CV=0.26) (2011)	Unknown	Ca 83/yr but judged "likely sustainable"	157
East Greenland	Scoresby Sound south to and including Sermilik Fjord system	Tasiilaq and offshore: 797 (CV=0.69) in 2015–17, Scoresby Sound: 476 (CV=0.38) in 2016[3]	Declining	Decline likely due to a combination of hunting and major changes in ocean conditions	
Northeast Greenland	Dove Bay and Greenland Sea	Dove Bay: 1,395 (CV=0.33; 95% CI 744–2,641); Greenland Sea: 2,908 (CV=0.30; 95% CI 1,639–5,168) in 2017[4]	Unknown	None	
Svalbard – Russian High Arctic	Uncertain	837 (CV=0.50) (Vacquié-Garcia *et al.*, 2017) but considered a minimum	Unknown	None	

Table 1. Currently recognised Narwhal stocks. *Primary source NAMMCO (2018), with a few edits and additions by the authors.* Note: all abundance estimates have been adjusted (corrected) for availability and most also for perception bias*.
[1]For stocks in Canada, TALC (Total Allowable Landed Catch) means the number of whales that can be lawfully killed and secured as established by the Nunavut Wildlife Management Board and approved by the Minister of Fisheries and Oceans pursuant to Sections 5.6.16 to 5.6.18 of the Nunavut Agreement; [2]Marcoux *et al.*, 2019; [3]Joint Scientific Working Group (2017); [4]R.G. Hansen, pers. comm.
**Availability bias* refers to the failure of observers to detect all whales present on the survey trackline because the whales were below the surface and thus "unavailable to be seen" as the survey aircraft passed. *Perception bias* refers to the fact that observers may fail to detect and count all whales that are at or near the surface along the trackline. CV=Co-efficient of Variation

Cetaceans has always tried to report catches and assess the stocks of Narwhals and Belugas. A Commission Resolution in 2014 explicitly directed the SC to deliver advice on the status and conservation of small cetaceans (IWC, 2014) and it now attempts to provide scientific advice on the 75 or so species of small and medium-sized cetaceans as well as the large whales.

North Atlantic Marine Mammal Commission and Joint Commission on Conservation and Management of Narwhal and Beluga

NAMMCO was established in 1992 by several Nordic countries that were disillusioned by the IWC's swing away from "sustainable use" and towards "protection", specifically in relation to commercial whaling. The Greenland Home Rule government is a member of NAMMCO along with Norway, Iceland, and the Faroe Islands Home Rule government. Canada has not joined NAMMCO but has nonetheless always been an active "observer" at meetings, particularly in regard to Narwhals, Belugas, and Walruses *Odobenus rosmarus*. NAMMCO scientists regularly participate in deliberations of the Joint Commission on Conservation and Management of Narwhal and Beluga (JCNB), a bilateral body established in 1989 to assess and provide management advice on "shared stocks" (12 stocks of Narwhals are currently recognised, at least three, and possibly six, of which are known to move seasonally between Canada and Greenland, Table 1). The JCNB-NAMMCO Joint Scientific Working Group (JWG) meets regularly and generates recommendations that, as explained later, are used as the basis for Greenland catch limits and other conservation measures.

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

When CITES came into effect in 1975, the Narwhal was initially listed in Appendix III by Canada. Although Denmark lodged a reservation to the listing in 1977, this was withdrawn two years later when the Parties accepted an EU proposal to list all cetaceans in Appendix II. In principle, this has meant that exports (and re-exports) of Narwhal products must be accompanied by a CITES export permit (or re-export certificate) and covered by a Non-detriment Finding (NDF) from the source country.

USA

The US *Marine Mammal Protection Act* of 1972 prohibits the importation of marine mammal products, therefore tusks are allowed to enter the USA only for non-commercial purposes (e.g., scientific research, bona fide "pre-Act" acquisitions). Substantial demand still exists in the USA, however, judging by recent well-documented smuggling operations involving shipments of large numbers of tusks (in one case approximately 250 over a seven-year period; Shadbolt *et al.,* 2015).

European Union (EU)

Historically, most Narwhal tusks exported from Canada went directly to the United Kingdom (UK), considerable numbers then being re-exported, often to other European countries (Reeves, 1992). Since 1984, the EU has treated all cetaceans as CITES Appendix I species (commercial trade prohibited) although exports from Greenland to Denmark were initially exempted from the prohibition on trade. In 2004 the EU's Scientific Review Group on Trade in Wild Fauna and Flora issued a "negative opinion" for import of Narwhal products from Greenland and a "positive opinion" for import from Canada. The latter was changed to "no opinion" in 2009 and therefore Canadian tusks are allowed into the EU for non-commercial purposes, which normally means under the household and personal effects exemption (Shadbolt *et al.*, 2015).

Trade Regulation by Range States

Canada

The CITES Management Authority for marine species in Canada is Fisheries and Oceans Canada (formerly the Department of Fisheries and Oceans, or DFO). The current Standing NDF for the Narwhal is supported by 15 peer-reviewed reports published by the Canadian Science Advisory Secretariat (CSAS) between 2008 and 2018, most of which are available in both English and Inuktitut (DFO, assorted years).

The first negative NDF for Narwhals in Canada was issued in 2010 (DFO, 2010). Based on information available at the time on stock structure, abundance, and catches, it was concluded that removals from three of the recognised stocks (Admiralty Inlet, eastern Baffin Island, northern Hudson Bay) were unsustainable and that the information on a fourth ill-defined management unit consisting of the Narwhals in Parry Channel, Jones Sound, and Smith Sound was insufficient to verify that hunting in those areas would be non-detrimental. Therefore, the products from only two stocks (Somerset Island, Eclipse Sound) were covered by a positive NDF. This decision was immediately challenged in Federal Court by Nunavut Tunngavik Incorporated (the legal representative of the Inuit of Nunavut as established under a comprehensive land-claims settlement), citing the importance of Narwhal tusk sales as "a significant source of income for many Inuit harvesters" and pointing out that no Inuit organisations had been consulted during preparation of the NDF (Nirlungayuk, 2011). Within a few months after the court challenge (early 2012), a new NDF was issued indicating that, according to updated assessments, hunting removals from the Admiralty Inlet and eastern Baffin Island stocks were sustainable (DFO, 2012a). The negative NDF for the northern Hudson Bay stock remained in effect until 2012, when an analysis of new survey results concluded that the removal rate was sustainable (DFO, 2012b).

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Narwhal tusk sculpture displayed at the National Gallery of Canada, Ottawa. *Top*: carved Narwhal tusk, Inuit artist, ca.1900–60, provenance unknown; *Bottom*: carved Narwhal tusk, sterling silver, Polar Bear claw, Sperm Whale tooth, Muskox horn, blood stone, and baleen; artist: Ruben Komangapik, Inuit. Iqaluit, Nunavut 1976.

For the purposes of tusk traceability, hunters are required under the *Marine Mammal Regulations* to attach a Marine Mammal Tag securely to the tusk, or when there is no tusk, to the carcass of the Narwhal. All tusks must be inspected and certified by a conservation officer or fisheries officer, at which time, a permanent attachment device is used to affix the tag to the tusk. Possession of untagged tusks is illegal, a licence is required to transport Narwhals or Narwhal parts from one province to another, and a CITES export permit is required to export Narwhal products.

However, not all tusks secured by hunters in Canada enter the documented legal international trade. Some are sold within Canada and stay there, "significant numbers" reportedly are in "long-term storage" (Shadbolt *et al.*, 2015), and unknown numbers are exported illegally (even though at least some of them may have been obtained legally by the hunter and dutifully reported via the tag tracking system).

Greenland

Greenland's first NDF opinion for Narwhals was issued by the Scientific Authority (Greenland Institute of Natural Resources) in 2005 and reached a negative conclusion. NDFs in Greenland are based on current information on stock structure, abundance, trends in abundance, and reported catches for each stock (Witting, 2005; Witting *et al.*, 2008). The 2005 NDF notes, "Because of several [unspecified] factors, the statistics on export of Narwhal products cannot be used directly to provide insight into the utilisation of Narwhals in Greenland" (Witting, 2005). The NDF protocol was said not to include any analysis of tusk exports and the implicit assumption was, as in Canada, that the removal rate by hunting is determined primarily by factors other than the cash income from ivory sales.

The rationale for a negative NDF was that estimated catches in West Greenland during the first year of the quota system considerably exceeded the catch limit (quota), and significant numbers of Narwhals were taken in Melville Bay where it had been recommended that there be no hunt. The sparse data available at the time on Narwhals in East Greenland suggested that the level of removals there was sustainable. However, in the absence of a practical method to determine whether tusks in trade originate from West Greenland, Melville Bay, or East Greenland, it was not considered possible to conclude that continuation of Narwhal exports from Greenland would be non-detrimental to the West Greenland and Melville Bay stocks (Witting, 2005).

Because of the 2005 negative NDF, the exportation of Narwhal ivory from Greenland was not permitted in 2006 (Witting *et al.,* 2008). This ban applied not only to whole raw tusks but also to jewellery, carvings, and other items of worked Narwhal ivory that are often sold to tourists. It did not affect the legal trade of Narwhal products within Greenland or their exportation as household or personal effects (Shadbolt *et al.*, 2015).

The next NDF of the Greenland Scientific Authority was issued in 2009, by which time a quota had been set for East Greenland based on an aerial survey conducted in 2008 (Heide-Jørgensen and Ugarte, 2009). The results of that survey and surveys of the other stocks in Greenland in 2006 and 2007, incorporated into a model along with updated catch data, had led the JWG to conclude that earlier assessments for West Greenland had overestimated the level of risk from hunting (Joint Scientific Working Group, 2009). The Greenland CITES Scientific Authority accordingly reasoned that the quotas would "at high probability allow for an increase in the stocks" and that international trade would not have a negative impact "provided that the … quotas are respected" (Heide-Jørgensen and Ugarte, 2009). Greenland has refrained from permitting exports and the prohibition on exportation of Narwhal ivory (including whole tusks as well as carvings and jewellery) remains in effect. The rationale for this continuation of the ban on exports is that catches in Melville Bay and East Greenland have been higher than the scientific advice for several years and, because Greenland has no system to link an export product with the stock of origin, issuance of a positive NDF requires that catches throughout the entire country are sustainable (Fernando Ugarte, Immikkoortortami qullersaq, Head of Department of Birds and Mammals, Pinngortitaleriffik—Greenland Institute of Natural Resources, Nuuk, 7 June 2019).

A premise of the positive NDF opinion by the Greenland Scientific Authority in 2009 was that (i)

Year	bones, carvings, ivory	tusks	skulls	teeth	specimens	other items	total items
1987	173	65	1	50	340	2	631
1988	146	151	2	40		0	339
1989	185	291	1	1		0	478
1990	114	445	2	1		0	562
1991	211 (2)	412		1		4	629 (2)
1992	238	228 (1)				47	513 (1)
1993	290	48 (1)		212		0	550 (1)
1994	520	229 (1)		84		0	833 (1)
1995	627	185		97		0	909
1996	696	207		52	1	0	956
1997	562	244	2	28		1	837
1998	263	197	3	5		0	468
1999	139	184 (2)	5	757	12	0	1,097 (2)
2000	821	260		255		75	1,411
2001	656 (37)	236 (5)		23	307	9	1,231 (43)
2002	2,084	267 (12)	7	62	262	8	2,689 (11)
2003	1,823	186 (24)		59		130	2,198 (24)
2004	3,358	197	6	268	100	157	4,086
2005	2,788	108	1	104		8	3,009
2006	751	135	8	111		9	1,014
2007	0	213	4			0	217
2008	1,556	245	4		250	0	2,055
2009	270	191	3	7	168	8	647
2010	1,159 (1)	347 (5)	8	17	1,074	9	2,614 (6)
2011	6	121	3 (1)	2			132 (1)
2012	2	229 (4)	2		10	3	246 (4)
2013	1	116 (1)	3	20	10	4	154 (1)
2014	14	250 (1)	4	5	85	3	361 (1)
2015	2	528	4	4	259	2	799
2016	2	274	4	4	125	1	408
2017		313	8		22		343
2018		446	3	15			464

Table 2. Narwhal items reported in export data, per year, 1987 to 2018 (1987–2016 includes both Canada and Greenland, 2017–2018 Canada only). *Sources: UNEP-WCMC CITES Trade Database and Shadbolt* et al. *(2015), except for 2017 and 2018 data provided by the Catch Certification Program, Fisheries and Oceans, Government of Canada, Ottawa (see Acknowledgements). Note: numbers in parentheses represent the number of items reported as pre-CITES. Items reported as exported by non-range States are not presented here.*

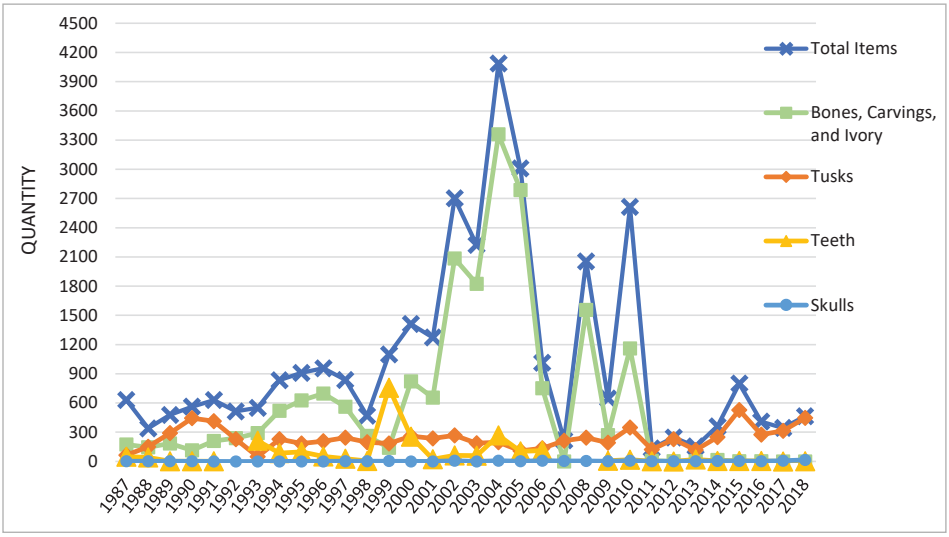

Fig. 2. Reported number of Narwhal items—bones/ivory/carvings, tusks, teeth, and skulls—exported per year, 1987–2016 (from both Canada and Greenland) and 2017–2018 (Canada only). *Sources: UNEP-WCMC CITES Trade Database and Shadbolt* et al. *(2015), except for 2017 and 2018 data provided by the Catch Certification Program, Fisheries and Oceans, Government of Canada, Ottawa.*

maktaaq, not ivory, is the "most valuable [cash-generating] hunting product" obtained from Narwhals in Greenland[1], (ii) maktaaq is not exported and (iii) tusks have low value compared with maktaaq. The authors of the NDF opinion (Heide-Jørgensen and Ugarte, 2009) argued that trade in tusks was not the primary incentive for Narwhal hunting in Greenland. They acknowledged that income from tusk sales contributed to the subsistence economy, and they did not rule out that trade in tusks and crafted parts could be "influencing the harvest of Narwhals".

Determining which item is the "most valuable" product of the hunt is difficult. In reaching its conclusion, the Scientific Authority appears not to have analysed the replacement value of maktaaq (and meat in Qaanaaq district) shared by the hunter with his or her family and other community members, the cash value realised by hunters from selling edible products directly to consumers or wholesalers, and the cash value obtained by selling tusks, whether directly to Greenlanders, to wholesalers, or to visitors and temporary residents. Any such analysis would also need to take account of the value derived from carvings and jewellery crafted wholly or in part from Narwhal ivory, as Hoover *et al.* (2013) attempted to do in Hudson Bay, Canada. The use of Narwhal ivory and bone in handicrafts (almost always exported as "personal effects") is apparently much more frequent in Greenland than in Canada (Shadbolt *et al.*, 2015). Small items such as earrings and necklaces are "easy to find and occasionally sold in art craft shops" in Greenland (Ugarte, pers. comm.). Considering that there is little or no checking of the "personal effects" of tourists on cruise ships and at airports, it seems likely that small-item exports from Greenland (as well as Canada) are considerably under-reported. In any event, the quantity of such items reported as exported (from Greenland and Canada, combined) was very large during the first decade of the 21st century but has greatly declined since then (Table 2, Fig. 2).

Domestic Management of Narwhal Exploitation

Canada

Narwhal hunting in Canada is co-managed by DFO, the regional authority (the Nunavut Wildlife Management Board in Nunavut or Nunavik Marine Regional Wildlife Board in Nunavik), the Regional Wildlife Organizations (RWOs), and the local Hunters and Trappers Organizations (HTOs) or equivalents. They jointly set total allowable landed catches (TALCs) on a stock-by-stock basis, using as guidance a formula developed in the USA to set legislatively mandated limits on the incidental taking of marine mammals in commercial fisheries. This formula determines a potential biological removal (PBR) level as follows: a minimum estimate of population size (the 20th percentile of the log-normal distribution, equivalent to the lower 60% confidence limit) x half the net recruitment rate for the species (assumed to be 0.04 ÷ 2) x a "recovery factor" which is set to reflect known or assumed conservation status (0.1 for critically small stocks, 0.5 for "depleted" stocks, and 1 for stocks that are considered secure) (Wade, 1998; Wade and Angliss, 1997). The PBR for Narwhal stocks, multiplied by a "loss rate factor" of 1.28 (to account for whales seriously injured or killed but not landed), is used to set the TALC (Richard, 2008).

[1]~DK(Danish Krone)30,000–40,000 (~USD4500–6000) per whale in 2019 for maktaaq; ~DK5000–8000 (~USD750–1200) for a good-sized tusk in 2019 (R.G. Hansen, pers. comm.)

Allocation of TALCs to the different hunting communities is a responsibility of the RWO under the Nunavut Agreement. Responsibility for enforcement and monitoring remains with DFO but is facilitated by the local HTO or equivalent. An agreed quantity of numbered, government-issued tags is provided to each HTO for distribution to the hunters (DFO, 1985). The difficulty of monitoring removals of females and young males that lack erupted tusks has been identified as a source of uncertainty because such monitoring relies solely on reported catch statistics.

Greenland

In Greenland, the Department of Fisheries, Hunting and Agriculture is responsible for co-managing the hunt and monitoring catches in collaboration with local municipal authorities, with scientific advice from the JCNB and NAMMCO. As mentioned earlier in regard to NDFs, there is strong reliance on the JWG for science to inform the setting of quotas, and on the JCNB and NAMMCO for guidance with regard to "shared stocks" and Greenland-only stocks, respectively. The issuance of hunting permits is contingent upon receipt of catch-reporting logbooks from the hunters.

Recent Trade Data

The 1984 ruling by the EU had a dramatic effect on the destinations of tusks exported from Canada: the great majority of them started going to Japan and Switzerland rather than the UK, at least in the years immediately following the EU ban (Reeves, 1992). Over the last two decades, Denmark (until 2011), France, Italy, Germany, Switzerland, and Belgium have been the main European importing countries and Japan has remained a leading importer (Shadbolt *et al.*, 2015; Table 3, Fig. 3). A noteworthy new development and potential concern is the emergence of China as by far the most significant Narwhal tusk importing country. It is unclear whether this surge reflects a true increase in demand (and purchasing power) in China, or is instead due to improved reporting. It is also unclear whether Narwhal ivory imported to China is used for decorative purposes, carvings and jewellery, or something else. Ground Narwhal ivory (powder) was used at one time in traditional medicine in the Far East (Reeves, 1992; Shadbolt *et al.,* 2015) but there is no evidence that such use is extensive at present.

Sustainability of Removals by Hunting

Summation of the point estimates of abundance for all the Narwhal stocks that have been surveyed suggests a global population of close to 175,000 individuals (Table 1). The potential rate of increase for Narwhals is 2.5–4% (Kingsley, 1989; Garde *et al.*, 2015).

Shadbolt *et al.* (2015) estimated that 979 Narwhals were landed per year between 2007–2011 (621 in Canada and 358 in Greenland), a figure that is inflated somewhat by a spike in the Canadian catch in 2008 when Pond Inlet hunters secured 624 Narwhals from an ice entrapment but also may be negatively biased due to underreporting in Greenland (Garde *et al.,* in press). As mentioned above, reported landings under-represent the number of Narwhals killed outright or seriously injured. Although loss rates vary widely across areas and seasons, managers in Canada generally assume a loss rate of close to one-third (see Richard, 2008)[2]. The number of Narwhals removed annually by hunting could be around 1,500, which would represent less than 1% of the total global population. However, Narwhal hunting is managed by stock in Canada and by hunting ground in Greenland.

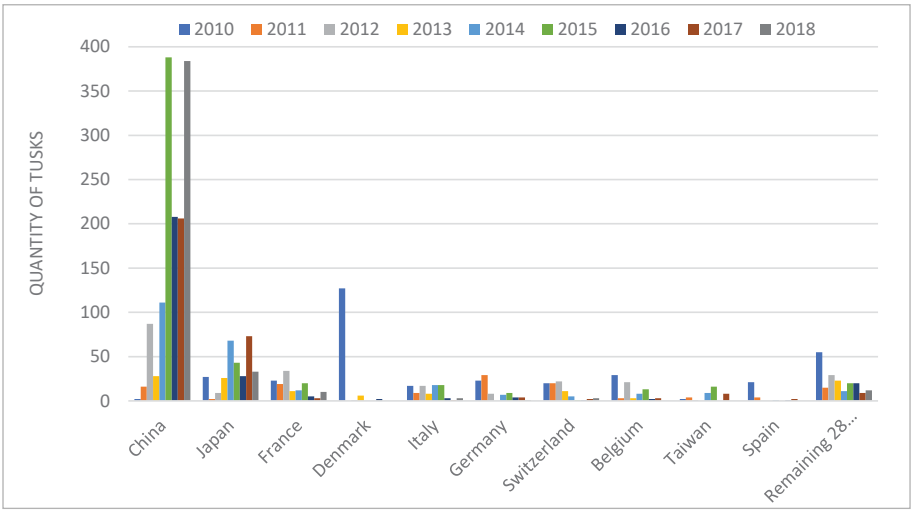

Fig. 3. Top 10 destination countries/territories for reported exports of Narwhal tusks, per year, 2010–2016 (from both Canada and Greenland) and 2017–2018 (Canada only). *Source: UNEP-WCMC CITES Trade Database, except for 2017 and 2018 data provided by the Catch Certification Program, Fisheries and Oceans, Government of Canada, Ottawa.*

[2]Greenland net and kayak hunting usually involves a lower loss rate.

DESTINATION COUNTRY/ TERRITORY (PURPOSE OF EXPORT)	2010	2011	2012	2013	2014	2015	2016	2017	2018	TOTAL
China	**2**	**16**	**87**	**28**	**111**	**388**	**208**	**206**	**384**	**1,430**
Personal			5	2	17	7	13			
Commercial trade	2	16	82	26	94	381	185			
Hunting trophy							10			
Japan	**27**	**2**	**9**	**26**	**68**	**43**	**28**	**73**	**33**	**309**
Personal	9									
Commercial trade	18	2	9	26	68	43	28			
France	**23**	**19**	**34**	**11**	**12**	**20**	**5**	**3**	**10**	**137**
Personal	22	19	32	11	12	19	5			
Commercial trade	1					1				
Educational			2							
Denmark	**127**		**1**	**6**			**2**			**136**
Personal	125			6			2			
Scientific	2		1							
Italy	**17**	**9**	**17**	**8**	**18**	**18**	**3**	**1**	**3**	**94**
Personal	17	9	16	8	18	18	3			
Commercial trade			1							
Germany	**23**	**29**	**8**		**7**	**9**	**4**	**4**	**1**	**85**
Personal	21	27	8		5	7	4			
Commercial trade	1				2	2				
Educational	1	1								
Travelling exhibition		1								
Switzerland	**20**	**20**	**22**	**11**	**5**	**1**	**1**	**2**	**3**	**85**
Personal	7	15	19	1	3		1			
Commercial trade	13	5	3	10	2	1				
Belgium	**29**	**3**	**21**	**3**	**8**	**13**	**2**	**3**		**82**
Personal	29	2	21	3	8	13	2			
Commercial trade		1								
Taiwan	**2**	**4**	**1**		**9**	**16**		**8**		**40**
Personal	2	4	1		9					
Commercial trade						16				
Spain	**21**	**4**			**1**		**1**	**2**		**29**
Personal	21	4			1					
Educational							1			
Remaining 28 countries/ territories	**55**	**15**	**29**	**23**	**11**	**20**	**20**	**9**	**12**	**194**
Educational	2	1			1					
Personal	49	13	29	23	9	16	4			
Commercial trade	3				1	4	16			
Hunting trophy	1	1								
GRAND TOTALS	**346**	**121**	**229**	**116**	**250**	**528**	**274**	**311**	**446**	**2,621**
Educational	3	2	2		1		1			
Personal	302	83	131	54	82	80	34			
Commercial trade	38	34	95	62	167	448	229			
Hunting trophy	1	1					10			
Scientific	2		1							
Travelling exhibition		1								

Table 3. Top 10 destination countries/territories for Narwhal tusks, per year, 2010 to 2016 (exported from both Canada and Greenland) and 2017–2018 (exported from Canada only). *Source: UNEP-WCMC CITES Trade Database, except for 2017 and 2018 data provided by the Catch Certification Program, Fisheries and Oceans, Government of Canada, Ottawa.*

The stock-by-stock or area-by-area assessment and management regime developed by scientists and managers in Greenland and Canada over the past 40 years is considered precautionary. However, removal estimates are sensitive to the loss rate factor applied to data on secured catches (generally 1.28 following Richard, 2008—assuming that slightly more than one out of five Narwhals killed is not secured). Several reports in the literature (Finley *et al.*, 1980; Kemper, 1980; Finley and Miller, 1982) indicate that although loss rates are highly variable for many reasons, they tend to be higher at the floe edge and when the whales are hunted from shore and they are not immediately secured by a harpoon. In some communities (such as Naujaat and Kugaaruk in Nunavut, Qaanaaq and Melville Bay in Greenland), the local authorities require that Narwhals are harpooned first. Not only should more effort be made in other areas to reduce hunting loss, but also other threats besides hunting should be accounted for in the management regime.

Other Threats

Narwhals are well adapted to Arctic conditions. Their relative abundance has allowed them, for at least several millennia, to withstand hunting by humans, predation by Polar Bears *Ursus maritimus* and Killer Whales *Orcinus orca*, and occasional large-scale mortality events due to ice entrapment. However, the recent rapid, extensive, and ongoing changes in environmental conditions are bound to test the resilience and adaptability of these quintessentially Arctic animals, which have been judged to be among the most sensitive marine mammals to such changes (Laidre *et al.*, 2008).

Virtually all of the major conservation concerns for Narwhals in addition to overhunting in a few areas—underwater noise from icebreakers (Finley *et al.*, 1990) and seismic surveys (Heide-Jørgensen *et al.*, 2013), predation by Killer Whales (Higdon and Ferguson, 2009; Breed *et al.,* 2017), ice-entrapment (Laidre *et al.*, 2012), disturbance by ships and barges (DFO, 2012c; NAMMCO, 2015; Smith *et al.,* 2015), and competition with fisheries and other consumers for their favoured prey (e.g., Greenland Halibut *Reinhardtius hippoglossoides*; Laidre and Heide-Jørgensen, 2005; NAFO, 2018; prawns *Pandalus* spp.; DFO, 2019)—are either caused or exacerbated by climate change (Ferguson and Lee, 2017; NAMMCO, 2018). The physiological and behavioural traits that served Narwhals well in a pristine and quiet environment are probably not adequate in an ever noisier and unfamiliar underwater soundscape (Moore *et al.*, 2012). The morphology and skeletal musculature of Narwhals are suited to slow, endurance swimming and deep diving, which enables them to take advantage of dense, wind-blown sea ice refugia (or alternatively, shallows near shore; Breed *et al.*, 2017) to escape Killer Whale predation as well as to reach concentrations of prey in deep offshore areas that are generally inaccessible to potential competitors in winter (Williams *et al.*, 2011). The response of Narwhals to net entanglement and stranding for instrumentation before being released back into the wild (equivalent to experimental disturbance) appeared maladaptive. The animals exhibited initial disorientation, followed by movement away from the source (flight) and powerful bradycardia (heartbeat </= four beats per minute), coincident with extreme exertion. Such a response is a recipe for the depletion of tissue oxygenation and compromised physiological homeostasis, e.g. overheating (Williams *et al.*, 2017).

Discussion and Conclusions

Although no one disputes that obtaining an important local food source and maintaining cultural traditions are the major drivers of Narwhal hunting, the commercial value of Narwhal products, including both maktaaq in Greenland and tusks in Canada, is also a driver. The significance of ivory sales and exports appears to be greater today in Canada than in Greenland given the continuing ban on commercial exports from Greenland. The authors recognise the potential usefulness of detailed studies of economic aspects of Narwhal hunting that incorporate its socio-cultural and nutritional importance as well as the monetary value of products (cf. Hoover *et al.*, 2013) and encourage periodic efforts like those of Shadbolt *et al.* (2015) to analyse and track the commerce in tusks. However, environmental impacts, both direct on the Narwhals and indirect on human activities such as fishing and resource development, may now be a greater cause for conservation concern than overhunting in some stocks—as long as authorities in both range States continue to monitor and manage the hunting as rigorously as they have tried to do in recent years. Also, close monitoring of tusk exports to countries in the Middle East and East Asia, China in particular, is especially important given the trends in available data (Table 3, Fig. 3).

The immediate direct effects of climate change on Narwhals are evident off East Greenland, where sea surface temperatures have increased, ice cover has

Screenshot of raw Narwhal ivory (left) and ► carving posted on social media.

retreated rapidly, tidewater glaciers have disappeared, and boreal and even tropical species have arrived in greater numbers in recent years (Hansen *et al.*, 2018). These major habitat changes have coincided with intensive hunting and declining abundance of Narwhals (Hansen *et al.*, 2018) as well as an apparent decline in fertility (NAMMCO, 2019a). Scientists have advised authorities in East Greenland that Narwhal hunting must be suspended if regional extirpation is to be avoided (NAMMCO, 2019b; R.G. Hansen, pers. comm.).

Although there is no published scientific evidence that Narwhal abundance or recruitment is declining in other parts of their range, this lack of evidence must be considered in a context of irregular and uneven monitoring and the usual lag (of years at least) between the completion of a survey programme and the publication of its results. In other words, it may be only a matter of time before downward trends become evident for stocks in addition to the one in East Greenland. A controversial iron ore mine in northern Baffin Island has been cited repeatedly (e.g. NAMMCO, 2015, 2018; DFO, 2012c) as a major potential threat to the Eclipse Sound stock in particular, but possibly also to the other large stocks of Narwhals that move through Lancaster Sound and Pond Inlet, including the very large Somerset Island and Admiralty Inlet stocks.

One hopeful sign is that, based on differences in stable isotope signatures among three Narwhal populations (Baffin Bay, northern Hudson Bay, East Greenland), they appear to occupy different feeding niches, and this has been interpreted to mean that Narwhals could be "more adaptable in terms of their foraging behaviour than previously thought" (Watt *et al.*, 2013). One can only hope that if indeed this proves true, the Narwhals themselves can make necessary adjustments in their behaviour (and presumably distribution) quickly enough to keep pace with the environmental changes under way in the Arctic. If they are unable to adapt to a milder, noisier, more industrialised Arctic, the global scientific and conservation communities stand to lose another iconic species, and local hunting communities whose traditional economic and cultural life is tightly bound to Narwhals are at risk of losing a valued resource.

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