

WWF ARCTIC PROGRAMME

# State of Circumpolar Walrus Populations

*Odobenus rosmarus*

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### **About WWF**

Since 1992, WWF's Arctic Programme has been working with our partners across the Arctic to combat threats to the Arctic and to preserve its rich biodiversity in a sustainable way.

WWF's mission is to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature, by conserving the world's biological diversity, ensuring that the use of renewable natural resources is sustainable, and promoting the reduction of pollution and wasteful consumption.

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# LIST OF ACRONYMS

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<b>ADFG</b> Alaska Department of Fish and Game	<b>MTRP</b> Marking Tagging and Reporting Program
<b>ASP</b> Arctic Strategic Plan (WWF)	<b>NAMMCO</b> North Atlantic Marine Mammal Commission
<b>BCS</b> Bering and Chukchi Seas (population)	<b>NOAA NMFS</b> National Oceanic and Atmospheric Administration's National Marine Fisheries Service (United States)
<b>CAP</b> Conservation Action Plan (WWF)	<b>OSP</b> optimum sustainable population
<b>CHA-NWG</b> Canadian High Arctic - Northwest Greenland (population)	<b>PBR</b> potential biological removal
<b>CITES</b> Convention on International Trade in Endangered Species	<b>QWC</b> Qayassiq Walrus Commission (Alaska)
<b>CCA-WG</b> Canadian Central Arctic-West Greenland (population)	<b>RANP</b> Russian Arctic National Park
<b>CI</b> confidence interval	<b>S-FJL</b> Svalbard – Franz Josef Land (population, Norway and Russia)
<b>CLA</b> Canadian Low Arctic (population)	<b>SAP</b> Species Action Plan (WWF)
<b>COSEWIC</b> Committee on the Status of Endangered Wildlife in Canada	<b>SARA</b> Species at Risk Act (Canada)
<b>CV</b> coefficient of variation	<b>SE</b> standard error
<b>DFO</b> Fisheries and Oceans Canada	<b>TAR</b> total allowable removals
<b>DU</b> Designatable Unit (COSEWIC)	<b>TNWR</b> Togiak National Wildlife Refuge (Alaska)
<b>ECU</b> Eurasian Customs Union	<b>TRAFFIC</b> wildlife trade monitoring network (joint program of WWF and IUCN)
<b>EG</b> East Greenland (population)	<b>UME</b> unusual mortality event (USFWS)
<b>ESA</b> Endangered Species Act of 1973 (United States)	<b>UN</b> United Nations
<b>EWC</b> Eskimo Walrus Commission (Alaska)	<b>USFWS</b> United States Fish and Wildlife Service
<b>GINR</b> Greenland Institute of Natural Resources	<b>USGS</b> United States Geological Survey
<b>ITR</b> Incidental Take Regulations (MMPA)	<b>USSR</b> Union of Soviet Socialist Republics (i.e., Russia 1922-1991)
<b>IUCN</b> International Union for Conservation of Nature	<b>WHMP</b> Walrus Harvest Monitoring Program
<b>KS-SBS-NZ</b> Kara Sea - Southern Barents Sea – Novaya Zemlya (population Russia)	<b>WWF</b> World Wildlife Fund
<b>LVS</b> Laptev Sea (population, Russia)	
<b>MMPA</b> Marine Mammal Protection Act (United States)	



# ABSTRACT

The walrus (*Odobenus rosmarus*) is a large gregarious pinniped with upper canine teeth that grow into long tusks. It has a discontinuous, circumpolar Arctic and sub-Arctic distribution and is represented by two subspecies, the Atlantic walrus, *O. r. rosmarus*, and the Pacific walrus, *O. r. divergens* (including the walruses in the Laptev Sea).

Walruses are widely distributed but occupy a relatively narrow ecological niche, requiring areas of shallow water with bottom substrates that support a productive bivalve community, the reliable presence of open water to access these feeding areas, and suitable ice or land for hauling out.

Many walrus populations were historically overharvested, with varying levels of recovery. Walrus populations currently face many potential threats, including effects from climate change, human disturbance, and overharvest.

The World Wildlife Fund (WWF) Arctic Strategic Plan (ASP) has identified walrus as a focal species, and the Arctic Program is working to enhance its understanding of the state of walrus in the Arctic and build circumpolar conservation plans. The ASP objectives for walrus include having conservation measures in place by 2020 that ensure human activities are not detrimental to walrus populations. WWF does not yet have a Species Action Plan or Conservation Actions Plan for walruses.

This report provides WWF with information on the status, management strategies, conservation threats, and knowledge gaps of circumpolar walrus populations, with recommendations for their conservation and management. It complements existing reports prepared for WWF on walrus biology and international trade in walrus products, and will contribute to the development of species conservation plans.



# INTRODUCTION

*The walrus (Odobenus rosmarus) is a large gregarious pinniped with upper canine teeth that grow into long tusks.*

It has a discontinuous, circumpolar Arctic and sub-Arctic distribution and is represented globally by two extant subspecies, the Atlantic walrus, *O. r. rosmarus* (Linnaeus, 1758), and the Pacific walrus, *O. r. divergens* (Illiger, 1815) (Figure 1, Tables 1 and 2). Walruses in the Laptev Sea area were once considered a separate subspecies but are now recognized as the westernmost population of the Pacific walrus (Lindqvist et al. 2009, 2016; Lowry 2015). Walruses occupy a large area but relatively narrow ecological niche (Born et al. 1995). They require areas of shallow water (ca. 80 m or less) with bottom substrates that support a productive bivalve community, the reliable presence of open water to access these feeding areas, and suitable ice or land for hauling out (Davis et al. 1980).

Walruses often gather in large herds, and they are associated with moving pack ice for much of the year (Figure 2). When ice is lacking in summer and fall, they congregate and haul out on land in a relatively small number of predictable locations (Mansfield 1973; Jay and Hills 2005). Atlantic walrus haulouts are often situated on low, rocky shores with steep or shelving subtidal zones where animals have easy access to the water for feeding and quick escape from predators (Figure 2) (e.g., Mansfield 1959; Salter 1979a, 1979b; Miller and Boness 1983; R.E.A. Stewart et al. 2013, 2014a-c; Semyonova et al. 2015). Pacific walruses haul out on a wide variety of substrates, ranging from sand to boulders (Garlich-Miller et al. 2011). Isolated islands, points, spits, and headlands are occupied most frequently (Garlich-Miller et al. 2011) but recently large numbers have been observed on barrier island beaches (Arnbom 2009; CBC 2014).

While walruses are closely associated with seasonal presence of sea ice, Atlantic walruses historically occurred in areas with little or no predictable sea ice such as the Gulf of St Lawrence in eastern Canada, Iceland, and northern Norway (Kovacs and Lydersen 2008:140). These areas were occupied by Atlantic walruses prior to extensive human exploitation and disturbance, but it is not known whether walruses could currently persist there. Hunting has strongly influenced their current distribution, and suitable walrus habitat decreases as human activities expand (Born et al. 1995; Garlich-Miller et al. 2011).

A detailed review on the biology of the walrus is available in Fay (1985). Other sources provide information for the Atlantic (Reeves 1978; Born et al. 1995; Stewart 2002; COSEWIC 2006; COSEWIC in press) and Pacific (Fay 1982; Garlich-Miller et al. 2011) subspecies.





Atlantic walrus, Svalbard,  
Norway.

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## PURPOSE AND SCOPE

The World Wildlife Fund (WWF) Arctic Strategic Plan (ASP) has identified walrus as a focal species, and the WWF Arctic Program is working to enhance its understanding of the state of walrus in the Arctic and build circumpolar conservation plans. The ASP objectives for walrus include having conservation measures in place by 2020 that ensure human activities are not detrimental to walrus populations. WWF has Species Action Plans (SAP) or Conservation Actions Plans (CAP) for other Arctic priority species (polar bears, *Ursus maritimus*; Arctic whales; reindeer/caribou, *Rangifer tarandus*), but at present there is no SAP or CAP for walrus. The purpose of this report is to provide WWF with information on the status (Table 1), management strategies (Table 4), conservation threats, and knowledge gaps (Table 5) of circumpolar walrus populations, with recommendations for their conservation and management. This report complements the existing WWF biological report (Kasser and Weidmer 2012) and TRAFFIC trade report (Shadbolt et al. 2014) for global walrus populations.

### Organization

This overview of the circumpolar status and conservation of the walrus is organized as follows:

1. Atlantic Walrus Population Status
2. Pacific Walrus Population Status
3. Management Regulations
4. Threats to Walrus Conservation
5. Knowledge Gaps and Research Needs
6. Conservation and Management Recommendations

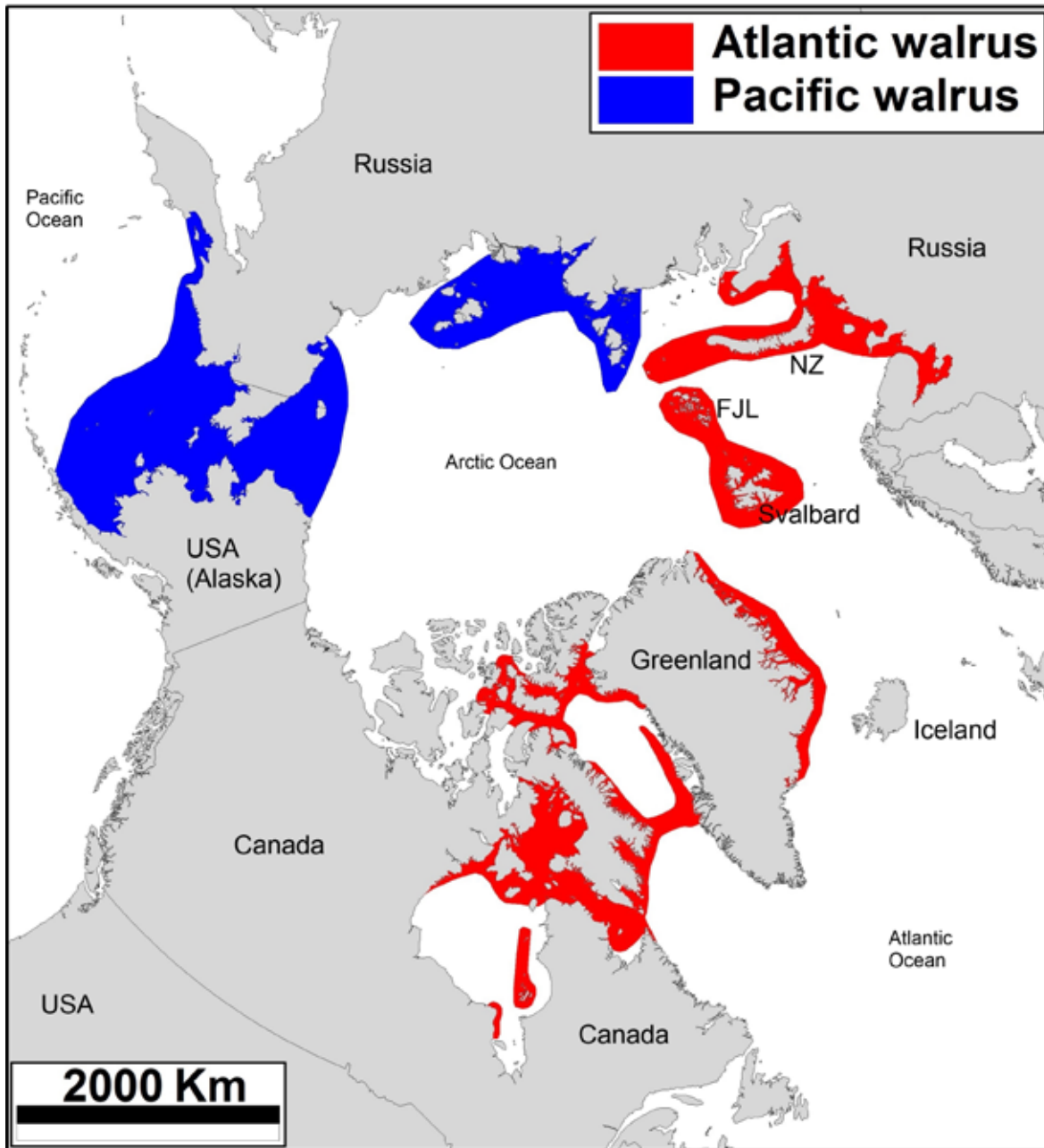




*Despite occurring over a vast area and being common in some regions, walrus face an uncertain future.*

**Table 1.** Conservation status of walrus at the global and range state levels. Definitions for different status ranks are available from the specific listing organizations.

Jurisdiction	Organization	Subspecies	Status/rank <sup>1</sup>	Comments
International	International Union for the Conservation of Nature (IUCN) Red List	All	Vulnerable (2016)	
		<i>O. r. rosmarus</i>	Near Threatened (2016)	
		<i>O. r. divergens</i>	Data Deficient (2015)	<i>O. r. laptevi</i> included with <i>O. r. divergens</i> .
	Convention on International Trade in Endangered Species (CITES)	All	Appendix III (Canada) (1975)	More recent assessments of <i>O. r. rosmarus</i> in 1987 (Canada) and 2008, 2009, 2011, 2015 and 2016 (Greenland)
Canada	Committee on the Status of Endangered Wildlife in Canada (COSEWIC)	<i>O. r. rosmarus</i>	Special Concern (2017)	Two populations (“Designatable Units”) considered - “High Arctic” and “Central and Low Arctic”, neither is listed under the Species at Risk Act (SARA)
		<i>O. r. rosmarus</i>	Extinct (2017)	The Nova Scotia/Newfoundland/Gulf of St Lawrence population, formerly referred to as the Northwest Atlantic population, is listed as Extirpated under SARA.
Greenland	Grønlands Rødliste - 2007 (Greenland Red List - 2007)	<i>O. r. rosmarus</i>	Critically Endangered	Northwater population. Shared with Canada.
			Endangered	West Greenland population. Shared with Canada
			Near Threatened	Northeast Greenland population.
Norway (Svalbard)	Norsk rødliste for arter 2010 (2010 Norwegian Red List for Species)	<i>O. r. rosmarus</i>	Vulnerable	
Russia	Krasnaya kniga Rossii (Red Data Book of the Russian Federation 2001)	<i>O. r. laptevi</i>	Category 3 (Rare)	Pacific walrus ( <i>O. r. divergens</i> ) not listed.
			<i>O. r. rosmarus</i>	Category 2 (Decreasing number)
United States	Marine Mammal Protection Act (MMPA)	<i>O. r. divergens</i>	Not depleted	
	Endangered Species Act of 1973		Not listed	In 2017 the USFWS determined that the Pacific walrus does not warrant listing as threatened or endangered under the ESA.
	Marine Mammal Stock Assessments (NOAA Fisheries and NMFS)		Strategic	Total human-caused removals exceed estimated Potential Biological Removal (PBR) so stock is classified as “strategic”.



**Figure 1.** Approximate current distribution of Atlantic (red polygons) and Pacific (blue polygons) walrus (data from Gjertz and Wiig 1994; Born et al. 1995; Witting and Born 2005; COSEWIC 2006; Lowry et al. 2008; Stewart 2008; Boltunov et al. 2010; Garlich-Miller et al. 2011; LGL Limited and North/South Consultants Inc. 2011; Lydersen et al. 2012; Elliot et al. 2013; Heide-Jørgensen et al. 2013, 2014; Andersen et al. 2014; Dietz et al. 2014; Kovacs et al. 2014; D.B. Stewart et al. 2014b; and M. Puhova, WWF Russia, pers. comm.). FJL = Franz Josef Land; NZ = Novaya Zemlya




# ATLANTIC WALRUS POPULATION STATUS

Atlantic walrus historically ranged from the central Canadian Arctic east to the Kara Sea, north to Franz Josef Land and south to Nova Scotia, Canada (Figure 1).

Within this region, six extant Atlantic walrus populations are recognized for the purposes of this report:

1. Canadian High Arctic - Northwest Greenland (Canada, Greenland)
2. Canadian Central Arctic - West Greenland (Canada, Greenland)
3. Canadian Low Arctic (Canada)
4. East Greenland (Greenland)
5. Svalbard - Franz Josef Land (Norway, Russia)
6. Kara Sea - Southern Barents Sea - Novaya Zemlya (Russia)



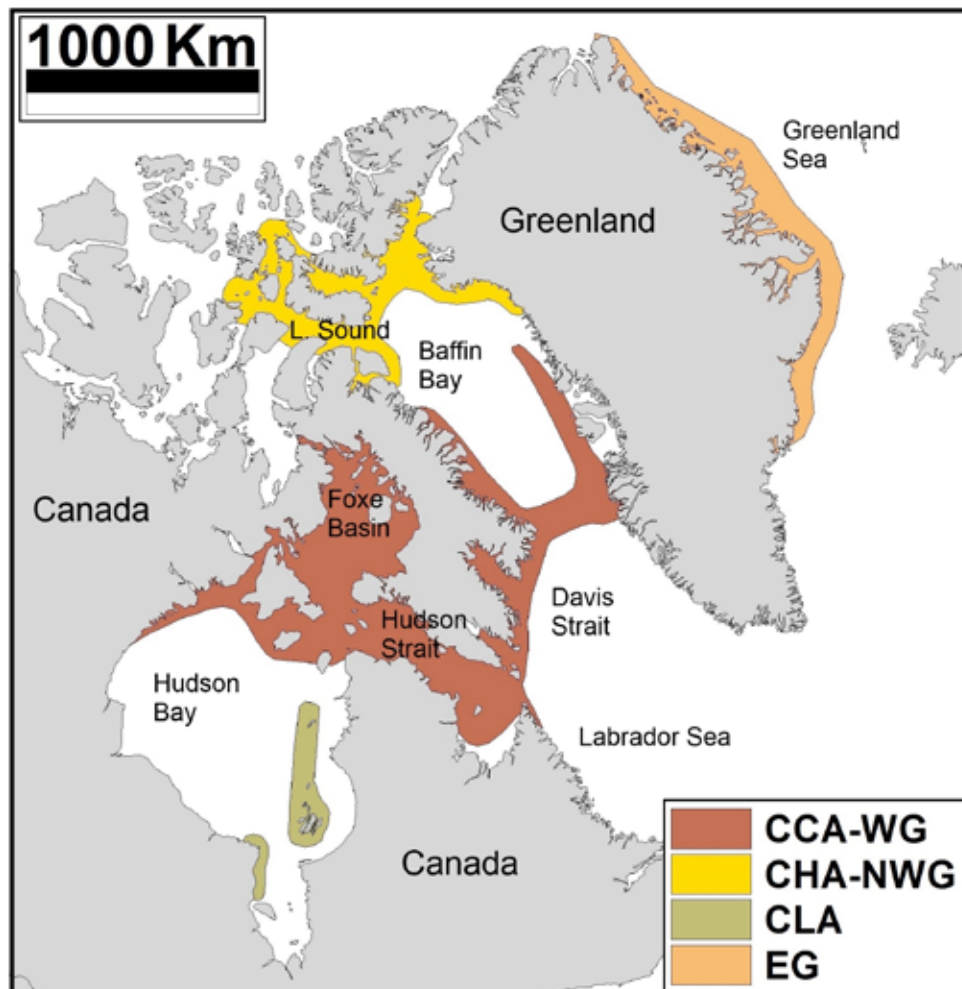
**Figure 2.** Atlantic walrus in Foxe Basin, Canada, hauled out on drifting pack ice in July 2007, and on a rocky haulout in 2010

Above: J.W. Higdon  
Below: R.E.A. Stewart

These populations are distinguished by the degree of genetic interchange and other factors such as geographical separation, contaminants, and lead isotope ratios and signatures. Some populations are comprised of different management stocks that have been identified for harvest management.

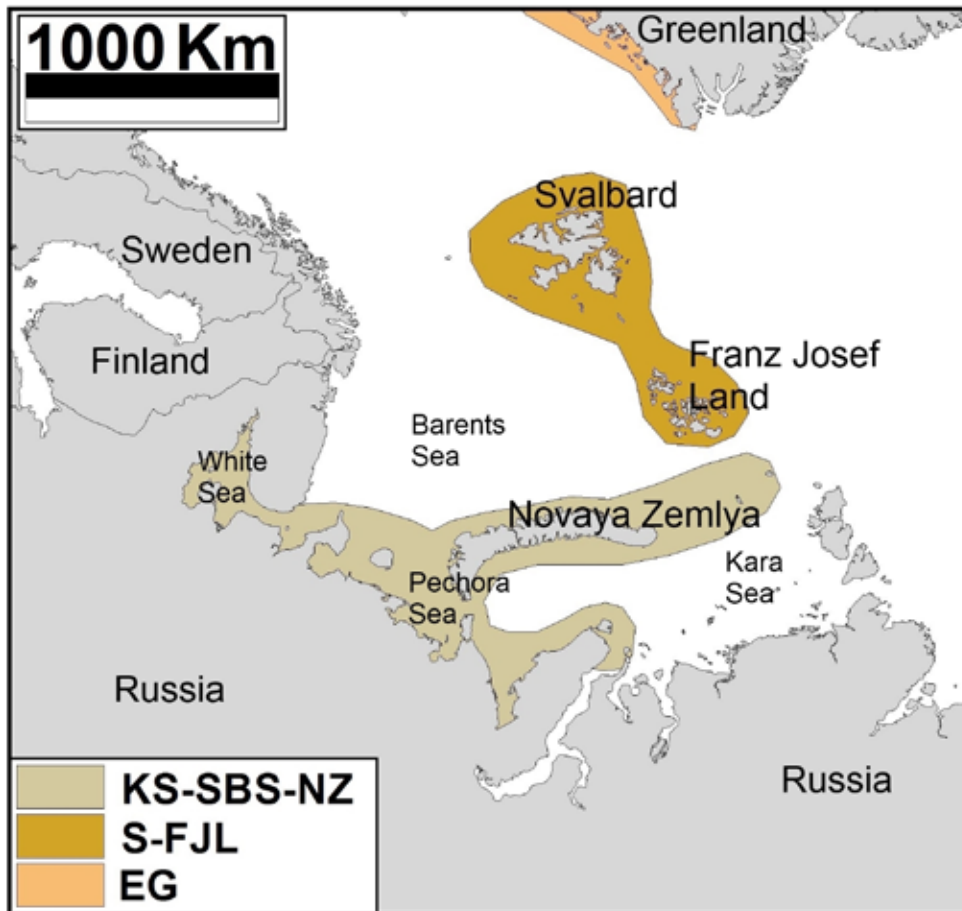
A seventh population (Nova Scotia/Newfoundland/Gulf of St Lawrence) was historically abundant in the southwestern Gulf of St Lawrence and on the Scotian Shelf in eastern Canada (Allen 1880; Reeves 1978; Born et al. 1995). It was extirpated ca. 1850 by extensive commercial hunting (D.B. Stewart et al. 2014a). This population appears to have been morphologically and genetically distinct from other walrus in the north Atlantic (McLeod et al. 2014). Its extirpation has reduced the adaptive potential of Atlantic walrus. Commercial hunting is no longer permitted, but re-establishment of this population is unlikely due to

**Figure 3.** Map of Atlantic walrus populations in North America and Greenland. Populations: CCA-WG = Canadian Central Arctic - West Greenland; CHA-NWG = Canadian High Arctic-Northwest Greenland; CLA = Canadian Low Arctic, EG = East Greenland.



the increase in other human activities in the region. Occasional recent sightings are not considered a sign of re-establishment and population is now considered extinct (COSEWIC 2017).

Available population estimates for Atlantic walrus populations are summarized in Table 2. These estimates are negatively biased due to incomplete survey coverage and methodological problems (e.g., opportunistic counts versus standardized surveys, unknown population composition on wintering grounds). The age-class distributions of these populations are unknown. The International Union for Conservation of Nature (IUCN) recently assessed the conservation status of the Atlantic walrus subspecies as “Near Threatened” (Kovacs 2016). Conservation status ranks assigned to the different populations by the responsible jurisdictions are discussed on the following pages and summarized in Table 1.



**Figure 4.** Map of Atlantic walrus populations in Europe. Populations: KS-SBS-NZ = Kara Sea-Southern Barents Sea-Novaya Zemlya; S-FJL = Svalbard-Franz Josef Land.



**Table 2.** Assessment of Atlantic walrus by population, see text for sources. Reported estimate is generally the most recent available, with some exceptions where older (but still within 5 years) estimates were more precise.

Population <sup>1</sup>	Stock or area <sup>2</sup>	Stock size	Year of estimate	Quality of abundance estimate <sup>3</sup> (method)	Hunted	Est. landed catch	Quality of catch estimate <sup>3</sup>	Population trend
<b>CHA-NWG</b>	PS-LS	727 (CV 0.07, 95% CI 623-831)	2009	G (adjusted haulout counts)	Yes	Canada: 2001-2010 mean 8 ( $\pm 3$ ) (all 3 stocks); Greenland: 2012 quota of 64, historic harvests higher (BB) <sup>4</sup>	Canada: F; Greenland: G	Stable since late 1970s
	WJS	503 (CV 0.07, 95% CI 473-534)	2008	G (adjusted haulout counts)	Yes			Stable since late 1970s
	BB	1,759 (CV 0.29)	2010	G (fully corrected aerial line-transect survey)	Yes			Unknown
<b>CCA-WG</b>	FB	10,379 (CV 0.42)	2011	G (adjusted haulout counts)	Yes	2001-2010 mean 167 ( $\pm 62$ )	F	Unknown
	SEB	2,100-2,500	2007	F (adjusted haulout counts)	Yes	Canada: 2001-2010 mean 42 ( $\pm 10$ ); Greenland: current quota 61 (historic harvests higher) <sup>4</sup>	Canada: F; Greenland: G	Unknown
	Mix: WHB, SUBL	7,100 (95% CI= 2,500 to 20,500)	2014	F (adjusted haulout counts)	Yes	NWHB: 2001-2010 mean 167 ( $\pm 62$ )	F	Unknown
	Mix: WHB, SHSUBL, SEB?	6,020 (CV 0.40, 95% CI 2,485-14,585)	2012	F (fully-corrected aerial strip-transect survey in Hudson Strait)	Yes	SHSUBL: 2001-2010 average 47 ( $\pm 10$ )	F	Unknown
<b>CLA</b>		100-200	2014	F (adjusted haulout counts)	Yes	2001-2010 mean 6 ( $\pm 4$ )	F	Unknown

Population <sup>1</sup>	Stock or area <sup>2</sup>	Stock size	Year of estimate	Quality of abundance estimate <sup>3</sup> (method)	Hunted	Est. landed catch	Quality of catch estimate <sup>3</sup>	Population trend
<b>EG</b>		1,430 (CV 0.45)	2009	F (fully corrected aerial survey)	Yes	Recent catches ca. 9-12 year, current quota of 20/year (historic harvests higher) <sup>4</sup>	G	Uncertain, possibly recovered (stable or increasing)
<b>S-FJL</b>	S	3,886 (95% CI 3,553-4,262)	2012	G (adjusted haulout counts)	No (protected in 1952)	--	--	Increasing
	FJL	?? (common population with Svalbard)	--	No data	No	--	--	Increasing?
<b>KS-SBS-NZ</b>	SBS (PS)	3,943 (95% CI 3,605–4,325)	2011	G (Adjusted haulout counts)	No	--	--	Unknown (possibly stable?) Similar to (less precise) 2014 estimate
	KS-NZ	1,355	2013	P (Direct aerial count, no adjustments)	No	--	--	Unknown

<sup>1</sup> CHA-NWG = Canadian High Arctic - Northwest Greenland (Canada, Greenland); CCA-WG = Canadian Central Arctic - West Greenland (Canada, Greenland); CLA = Canadian Low Arctic (Canada); EG = East Greenland (Greenland); S-FJL = Svalbard - Franz Josef Land (Norway, Russia); KS-SBS-NZ = Kara Sea - Southern Barents Sea - Novaya Zemlya (Russia).

<sup>2</sup> PS-LS = Penny Strait-Lancaster Sound (Canada); WJS = Western Jones Sound (Canada); BB = Baffin Bay (Canada, Greenland); FB = Foxe Basin (Canada); NWHB = North and West Hudson Bay (Canada); SEB = South and East Baffin (Canada, and animals cross Davis Strait to West Greenland); SHSUBL = Southern Hudson Strait-Ungava Bay-Labrador (Canada); S = Svalbard (Norway); FJL = Franz Josef Land (Russia); SBS (PS) = Barents Sea (Pechora Sea) (Russia); KS-NZ = Kara Sea-Novaya Zemlya (Russia).

<sup>3</sup> G = Good (minimal bias, acceptable precision); F = Fair (problems with quality of data, precision uncertain); P = Poor (considerable uncertainty, bias or few data).

<sup>4</sup> More recent data on Greenland catches and quotas are online but catch report verification is on-going: [http://naalakkersuisut.gl/~media/Nanoq/Files/Attached%20Files/Fiskeri\\_Fangst\\_Landbrug/DK/2015/Hvalros%20kvoter%20for%202015\\_DK.pdf](http://naalakkersuisut.gl/~media/Nanoq/Files/Attached%20Files/Fiskeri_Fangst_Landbrug/DK/2015/Hvalros%20kvoter%20for%202015_DK.pdf), [http://dk.vintage.nanoq.gl/Emner/Erhverv/Erhvervsomraader/Fangst\\_og\\_Jagt/Fangststatistik/~media/nanoq/DFFL/Fangst/Fangststatistik/Fangstdata/Final%20Fangsttal\\_kvoterede%20arter\\_oversigt\\_2006%202014\\_DK\\_29\\_08\\_2014\\_2.ashx](http://dk.vintage.nanoq.gl/Emner/Erhverv/Erhvervsomraader/Fangst_og_Jagt/Fangststatistik/~media/nanoq/DFFL/Fangst/Fangststatistik/Fangstdata/Final%20Fangsttal_kvoterede%20arter_oversigt_2006%202014_DK_29_08_2014_2.ashx)

## CHA-NWG

# CANADIAN HIGH ARCTIC - NORTHWEST GREENLAND

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The Canadian High Arctic - Northwest Greenland (CHA-NWG) population is shared by Canada and Greenland (Figure 3), and was formerly referred to as the North Water (Baffin Bay-Eastern Canadian Arctic) population (Born et al. 1995). There are significant genetic differences between walrus in this population and those in the Canadian Central Arctic - West Greenland (CCA-WG) population (Andersen and Born 2000; Andersen et al. 2014; Shafer et al. 2014). Modelling suggests that these populations may have split from one another during the onset of the last glacial period, ca. 145,000 years before present (yBP) (A. Shafer, Trent University, pers.comm.); that gene flow following the split was greater from the CHA-NWG population to the CCA-WG population than vice versa (i.e., asymmetrical); and that beginning ca. 50,000 yBP, recovery of the CHA-NWG population was limited by a bottleneck, probably related to environmental conditions during the last glaciation (Shafer et al. 2015). Information on walrus distribution and movements supports the geographical isolation of this population (Born et al. 1995; COSEWIC 2006; Dietz et al. 2014; Heide-Jørgensen et al. 2017). Observations of walrus farther west, to the north and east of Victoria Island in the Canadian Arctic Archipelago, have been interpreted as extra-limital occurrences of animals from this population (Harrington 1966).

Some walrus in the CHA-NWG population move to ice edges in Lancaster Sound or eastern Jones Sound or into the North Water to overwinter, and others appear to winter at polynyas or in areas of rotten ice within the Canadian Arctic Archipelago (Riewe 1976; Davis et al. 1978; Killian and Stirling 1978; Stirling et al. 1983; Born et al. 1995; Sjare and Stirling 1996). Animals from the Baffin Bay stock (see below for explanation of stocks within CHA-NWG) cross from Greenland to Ellesmere Island in the spring and presumably return in the fall (Born et al. 1995; NAMMCO 2015; Heide-Jørgensen et al. 2017). In May 2009 walrus were distributed in a belt across the southern part of the North Water from Greenland to Ellesmere Island, over both shallow and deep (>500 m) water (Heide-Jørgensen et al. 2013). During the open-water period walrus are concentrated along the east coast of Ellesmere Island and rare in the waters off northwest Greenland (R.E.A. Stewart et al. 2014a). Satellite tracking of animals tagged (n=21) in June 2015 at Wolstenholme Fjord followed them moving across the North Water to the east coast of Ellesmere Island (NAMMCO 2015:29; Heide-Jørgensen et al. 2017). Some animals moved north along the coast of Ellesmere Island, others far west into Jones Sound, and three went south of Devon Island into Lancaster Sound and then west to Cornwallis Island. These movements confirm that this walrus population extends from Greenland westward well into the Canadian high Arctic.

Three management stocks have been tentatively identified within the CHA-NWG population on the basis of satellite-linked radio tagging studies, observed seasonal distribution, and lead isotope ratios in the teeth (Stewart 2008; NAMMCO 2011; see also Outridge et al. 2003). These stocks are located in Penny Strait-Lancaster Sound (Canada), western Jones Sound (Canada), and Baffin Bay (Canada and West Greenland). Results from the 2015 tagging (NAMMCO

2015:29; Heide-Jørgensen et al. 2017) may necessitate revisiting of these stock delineations.

Aerial surveys of walrus haulouts in August 2009 yielded best estimates of about 727 walrus in Penny Strait-Lancaster Sound, 503 in western Jones Sound, and 1,251 in Baffin Bay (east coast of Ellesmere Island) (R.E.A. Stewart et al. 2014a, b; Table 2). The first two stocks seem stable over three decades, and the population trend for the shared Baffin Bay stock is unknown. Baffin Bay walrus were also recently surveyed by Greenland researchers, with abundance estimates from May 2009 (1,238, CV = 0.19), May 2010 (1,759, CV = 0.29; Heide-Jørgensen et al. 2013:605), and April 2014 (2,544, 95%CI = 1,513-4,279; NAMMCO 2015:29) derived from line-transect surveys of the North Water that were corrected for animals submerged below the detection depth (Heide-Jørgensen et al. 2013:605; NAMMCO 2015:29). While there is good agreement among these different Baffin Bay estimates, they should be treated with caution until there is better geographical coverage and improved understanding of the current summer distribution and movements of walrus in the CHA-NWG population.

The biggest change in distribution of this population is in the Avanersuaq (Qaanaaq) area of west Greenland, where walrus were once abundant in summer but are now absent (Vibe 1950; Born et al. 1995). Freuchen (1921) and Vibe (1950) described substantial migrations of walrus northward in the spring along the west coast of Greenland and southward in the fall along the east coast of Baffin Island, but this no longer occurs (Born et al. 1995).

## Conservation Status

In 2017, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), which makes status recommendations to the Government of Canada, assessed this population (“Designatable Unit”, DU) as “Special Concern” (COSEWIC 2017). This status designation identifies it as particularly sensitive to human activities or natural events but not endangered or threatened ([www.cosewic.gc.ca](http://www.cosewic.gc.ca)). While the Baffin Bay stock is listed as *Critically Endangered* on the Greenland Red List (Boertmann 2007), recent population estimates and modeling of population dynamics (Witting and Born 2014) suggest the stock may be in better condition than this designation suggests.

## CCA-WG

### CANADIAN CENTRAL ARCTIC - WEST GREENLAND

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The Canadian Central Arctic - West Greenland (CCA-WG) population occupies a large area of the eastern Canadian Arctic and extends across Davis Strait to west Central Greenland (Figure 3) (Richard and Campbell 1988; Born et al. 1995; Stewart 2002, 2008; Shafer et al. 2014). It has been separated from the CHA-NWG population on the basis of apparent geographical distributions (Born et al. 1995) and genetic differences (Buchanan et al. 1998; de March et al. 2002; Andersen et al. 2014; Shafer et al. 2014, 2015); and from the Canadian Low Arctic (CLA) population on the basis of geographical distributions, changes in abun-

dance (Born et al. 1995), and lead isotope ratios (Outridge and Stewart 1999; Outridge et al. 2003). Walrus in West Greenland and at southeastern Baffin Island, Canada, could not be distinguished from one another genetically (Andersen et al. 2014).

Four management stocks have been tentatively identified within the CCA-WG population on the basis of satellite-linked radio tagging studies, observed seasonal distribution, and lead isotope ratios in the teeth (Stewart 2008; NAMMCO 2011; see also Outridge et al. 2003). These stocks are located in Foxe Basin (Canada), north and west Hudson Bay (Canada), south and east Baffin (Canada) and West Greenland, and southern Hudson Strait-Ungava Bay-Labrador (Canada) (see D.B. Stewart et al. 2014a). Inuit elders recognize two groups of walrus in Foxe Basin on the basis of differences in the animals' size, colour, flavour of meat and blubber, and distribution (DFO 2002). There is exchange of animals between south and east Baffin Island and West Greenland across Davis Strait (Figure 3). Most of these stocks are likely reduced from their historical levels but no trend can be established and survey coverage is incomplete. Inuit have observed changes in walrus distribution and seasonal availability.

Walrus from the Foxe Basin stock are widely distributed in the relatively shallow waters of Foxe Basin, where they live year-round (Mansfield 1959; Loughrey 1959; Crowe 1969; Beaubier 1970; Brody 1976; Orr et al. 1986; Nunavut Department of Economic Development and Transportation 2008). Recent surveys indicate that they are more common and widely distributed in central and southern Foxe Basin than was previously known (LGL Limited and North/South Consultants Inc. 2011). They may be distributed almost continuously from northern Foxe Basin to Hudson Strait. There is some north-south movement of walrus in Foxe Basin but no evidence of concerted movement to or from Hudson Strait (Anderson and Garlich-Miller 1994). Walrus winter in both areas. Their seasonal distribution in southern Foxe Basin is poorly known, although many walrus were harvested in the Cape Dorchester area of Baffin Island in the early to mid-1900s (Reeves and Mitchell 1986; D.B. Stewart et al. 2014a). A September 2011 survey of Foxe Basin haulouts counted 6,043 walrus with a best estimate of 10,379 and corrected estimates ranging from 8,153 to 13,452 (Table 2) (Stewart et al. 2013; also see Hammill et al. 2016a). Both the maximum count and the estimates were much greater than previous estimates for this stock (Orr et al. 1986; Richard 1994) but no temporal trend can be established, as the coverage and methodology were different from the earlier studies.

The North and West Hudson Bay walrus stock occurs year-round in northern Hudson Bay and western Hudson Strait, Canada (Orr and Rebizant 1987; Elliot et al. 2013). Inuit hunters observe seasonal movements in response to changing ice conditions (Orr and Rebizant 1987). This stock was surveyed in 1990, when 1,376 walrus were counted in northwestern Hudson Bay. At the same time 461 walrus were counted on Nottingham Island in Hudson Strait (Richard 1994). An aerial survey of walrus haulouts in northwestern Hudson Bay and Hudson Strait in September 2014 yielded a simple count of 2,144 walrus (Hammill et al. 2016b). Adjusting the count for the proportion of animals hauled out, based on data from other studies, yielded an abundance estimate of about 7,100 walrus in the Hudson Bay-Davis Strait stock (Table 2).



Some walrus from the South and East Baffin - Western Greenland stock summer at southeastern Baffin Island and winter off West Greenland (Dietz et al. 2014), but the degree of genetic exchange is unknown. They cross the shallowest, narrowest portion of Davis Strait. Walrus are also present far offshore in the pack ice of Davis Strait (Vibe 1967; Born et al. 1995). In 2005-2008, tagged walrus left West Greenland in April and May and took an average of seven days to swim an average distance of 338 km across Davis Strait to southeastern Baffin Island (Dietz et al. 2014). Differences in the patterns and levels of organochlorine contaminants in their blubber indicate that walrus sampled in West Greenland and southeastern Baffin Island (Loks Land) on average feed in different areas and/or on different prey (Muir et al. 2000). In summer 2005-2008, aerial surveys were conducted at haulouts in the Hoare Bay area of Baffin Island (R.E.A. Stewart et al. 2014c). The 2007 count yielded an abundance estimate of 2,102 (no error term) walrus when adjusted by the proportion of satellite tags 'dry' on the survey morning, and 2,502 (CV 0.17) when adjusted by the percentage of time satellite-tagged animals spent hauled out on the survey day (Table 2). Some of the animals that summer in the Hoare Bay area winter off West Greenland. Aerial surveys of wintering areas off West Greenland in March-April 2006, April 2008, and March-April 2012 yielded abundance estimates, corrected for animals submerged beyond view, ranging from 1,105 walrus (CV = 0.31, 95%CI = 610-2,002) in 2006 to 1,408 walrus (CV = 0.22, 95% CI = 922-2,150) in 2012 (Heide-Jørgensen et al. 2014). It is not clear what proportion of the stock these shared animals represent, and it is not possible to assess any trends in population size. The summer range of this stock has declined, as the walrus that haul out on pack ice off West Greenland in the winter no longer use land haulouts in Greenland when the ice disappears, as they did historically (Vibe 1967; Born et al. 1995).

There is a general movement of walrus from the Southern Hudson Strait – Ungava Bay – Labrador stock westward through Ungava Bay and Hudson Strait in summer to Nottingham and Salisbury islands in western Hudson Strait, with a return movement in the fall (Degerbøl and Freuchen 1935; Loughrey 1959). There are no systematic summer survey data for this region, but an April 2012 survey estimated the population wintering in Hudson Strait at 6,020 walrus (Elliot et al. 2013), probably comprised of animals from various stocks (North and West Hudson Bay, South and East Baffin, and Southern Hudson Strait – Ungava Bay – Labrador) (Table 2). Historical harvests and observations suggest this stock has been reduced in abundance and distribution (Bell 1884: 33DD; Dunbar 1955; Loughrey 1959; Currie 1963:22; Born et al. 1995; D.B. Stewart et al. 2014a). In September 2014, known walrus haulouts along the southern coast of Hudson Strait, and on Akpatok Island in Ungava Bay, were surveyed twice by fixed-wing aircraft (Hammill et al. 2016b). Only two walrus were seen, both at Charles Island.

## Conservation Status

Following its criteria, COSEWIC did not consider the available information sufficient to support treating the Central Arctic and Low Arctic populations as distinct. Consequently, walrus in these populations were treated as a single

Designatable Unit that was designated as “Special Concern” (COSEWIC 2017). This status designation identifies it as particularly sensitive to human activities or natural events but not endangered or threatened ([www.cosewic.gc.ca](http://www.cosewic.gc.ca)). While the West Greenland stock was listed by the Greenland Red List (Boertmann 2007) as Endangered (Table 1), recent abundance estimates and population modelling (Witting and Born 2014) suggest it is in better condition than this designation suggests (GINR 2011; Wiig et al. 2014).

## CLA CANADIAN LOW ARCTIC

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The Canadian Low Arctic (CLA) population, formerly known as the South and East Hudson Bay population, extends from the Ottawa Islands in eastern Hudson Bay south to the Ekwan Point area of western James Bay (Figure 3). The genetic affiliation and seasonal movements of these animals are unknown. There is no evidence for a concerted movement into or out of southeastern Hudson Bay. Instead, there are local seasonal movements between terrestrial haulout sites during the ice-free period and their wintering areas (Freeman 1964). Animals caught near Inukjuaq (Nunavik, northern Quebec), in eastern Hudson Bay, occupy different geochemical habitats than those caught by Akulavik in Hudson Strait (Outridge and Stewart 1999; Outridge et al. 2003). These differences coincide with a suspected distributional gap in walrus range between the CLA and CCA-WG populations. Until genetic relationships are established, these units should be treated as separate populations for conservation planning purposes.

In both the Belcher and Sleeper archipelagos, walrus are present at the floe edge in winter and move into the islands and onshore as the pack dissipates in summer (Fleming and Newton 2003; COSEWIC 2006). The relationship between animals in these archipelagos and those to the south near Cape Henrietta Maria and inside James Bay is unknown. Walrus are no longer reported from areas of eastern James Bay that they used in the historical past (COSEWIC 2006).

The first systematic aerial survey of CLA walrus population abundance was conducted by Fisheries and Oceans Canada (DFO) in September 2014 (Hammill et al. 2016b). This survey of haulouts in eastern Hudson Bay south to Cape Henrietta Maria yielded a simple count of 55 walrus (Table 2). Adjusting the count for the proportion of animals hauled out, based on data from other studies, yielded an abundance estimate of about 200 walrus in the South and East Hudson Bay stock (aka CLA population). This value is similar to opportunistic counts at Cape Henrietta Maria, Ontario, of 147 walrus in October 2007 (K. Mills, Ontario Ministry of Natural Resources (OMNR), pers. comm.) and 221 in August 1999 (C. Chenier, OMNR, pers. comm.) but lower than earlier estimates of “410+” in 1988 (Richard and Campbell 1988) and “500” in 1995 (Born et al. 1995). This apparent decline has not been accompanied by a similar decline in adjacent areas, suggesting that immigration from Hudson Strait or northern Hudson Bay is limited (Born et al. 1995). Existing data are insufficient to assess whether the population abundance really declined or to establish trend in abundance (Hammill et al. 2016b).

## Conservation Status

COSEWIC (2017) did not consider the status of the CLA population on its own but instead included it with the CCA-WG population, which was designated “Special Concern”. The two populations are separated geographically but genetic samples and tagging data are not available from the small CLA population (COSEWIC in press), so COSEWIC criteria for separating the two populations were not met. A more precautionary approach to assessing status, and to managing the population, is to treat walrus in the CLA as a separate population until they are proven otherwise.

## EG EASTERN GREENLAND

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Walrus occupying the waters of East Greenland are a separate population from those to the west or east (Witting and Born 2014). There is no evidence that these walrus move around the southern tip of Greenland or across the northern coast of Greenland (Born et al. 1995). A walrus has been followed from East Greenland to Svalbard, a distance of at least 700 km over water 2500 m deep (Born and Gjertz 1993), but genetic differences suggest very little genetic exchange between these areas (e.g., Born et al. 2001). Annual site fidelity in both summer and winter seems to be strong in both northeastern Greenland (Born et al. 2005) and Svalbard (Freitas et al. 2009).

This population was depleted by hunting that occurred before walrus in Northeast Greenland north of ca. 72°N were completely protected in 1956 (Born et al. 1997). In 2009, an aerial survey of the coast from Clavering Island to the northern border of the Northeast Water yielded a fully corrected summer estimate of 1,430 (CV = 0.45) walrus (Born et al. 2009). Modelling suggests this population has recovered from its historical depletion but the trajectory of this recovery is uncertain due to lack of a population specific growth rate estimate (Witting and Born 2014).

## Conservation Status

The East Greenland population was listed in the Greenland Red List as Near Threatened (Boertmann 2007) but it may be in better condition than this designation suggests (Wiig et al. 2014).

## S-FJL SVALBARD – FRANZ JOSEF LAND

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The Norwegian archipelago of Svalbard and Russian archipelago of Franz Josef Land share a walrus population (Wiig et al. 2014; Figure 4). These animals are genetically similar (Andersen et al. 1998; Born et al. 2001), move between the

archipelagos (Wiig et al. 1996; Freitas et al. 2009; Hamilton et al. 2015), and are separated from other walruses by wide distributional gaps (Born 1984; Born and Gjertz 1993; Gjertz and Wiig 1994). In 2010, between 29 March and 25 April, an adult male that was genetically similar to walruses in this population travelled from the Faroe Islands to Svalbard, a distance of 2216 km (Born et al. 2014). The relationship of Atlantic walruses in this population to those in the Kara Sea - southern Barents Sea - Novaya Zemlya population is uncertain (Born et al. 1995; NAMMCO 2006; Boltunov et al. 2010; Shitova et al. 2014b).

Walruses in Svalbard follow the same seasonal migration pattern regardless of annual variations in ice and temperature regimes (Freitas et al. 2009). Summer habitat use for both sexes appears to be driven by feeding requirements and the availability of terrestrial haulouts or sea ice. Most of the males summer in Svalbard and most of the females and calves remain in northeastern parts of Svalbard, in the Franz Josef Land archipelago, or between them on Victoria Island (Lydersen et al. 2008; Gavrilov 2010; Kovacs et al. 2014; Wiig et al. 2014). To reach breeding areas the males actively travel through areas of dense ice cover towards Franz Josef Land in winter, regardless of sea ice advances and retreats (Freitas et al. 2009).

Walruses in Svalbard were protected from harvesting in 1952 after having been brought to the brink of extinction by 350 years of unregulated removals (Anon. 1952; Kovacs et al. 2014). Prior to commercial hunting the population must have been very large (Reeves 1978; Gjertz et al. 1998; Weslawski et al. 2000). During the first 30 years of protection, about 100 animals became established within the archipelago. They are presumed to have come from Franz Josef Land to the east. Since then a marked recovery has occurred in the abundance of walruses in Svalbard. Systematic surveys that covered all current and historical haulout sites were flown in August 2006 (Lydersen et al. 2008) and late July to mid-August 2012 (Kovacs et al. 2014). The surveys, adjusted to account for animals that were in the water, estimated there were 2,629 (95% CI = 2,318 - 2,998) walruses in the Svalbard area in 2006 and 3,886 (95% CI = 3,553-4,262) in 2012 (Table 2). This represents an average annual increase of nearly 8% (Kovacs et al. 2014), which matches the theoretical maximum rate of growth that has been calculated for recovering walrus populations under favourable environmental conditions with no food limitations (see Sease and Chapman 1988; Chivers 1999; Witting and Born 2014). However, this estimate should be used with care as it does not control for possible immigration or for variability in haulout use. Over the 6-year period the number of land-based haulout sites increased from 78 to 91, the number of occupied sites from 17 to 24, and the number of sites with mother-calf pairs from 1 (1 calf) to 10 (57 small calves) (Kovacs et al. 2014).

Genetic material from historical samples collected at the Bjørnøya and Håøya haulouts was similar to that of modern Atlantic walruses (Lindqvist et al. 2016). No unique mitochondrial groups were found in historical samples to indicate that a loss of genetic material occurred due to the extensive hunting, although it cannot be ruled out due to small sample sizes.

Lydersen et al. (2008:142) suggested that since the walruses observed on Svalbard in 2006 were predominantly males, and are only part of a common Svalbard-Franz Josef Land population, this population as a whole may number over

5,000 animals. Kovacs et al. (2014) observed more females and calves on Svalbard in 2012 but did not make a similar extrapolation.

Franz Josef Land has not been systematically surveyed for walrus but from 2012 through 2015, surveys attempted to revisit historical terrestrial haulouts and searched for new haulouts. Animals were counted directly from land or vessels, or using detailed satellite images from the National Park Russian Arctic Archives and unpublished reports (M. Gavrilov, Russian Arctic National Park (RANP), pers. comm.). Twelve haulouts and a few temporary sites, visited by small groups of animals, were reported in the 2000s in Franz Josef Land, as well as a large haulout on Victoria Island. Of five historically large haulouts identified by Gjertz et al. (1992), only Hayes Island and Gunter Bay on Northbrook Island were occupied (M. Gavrilov, RANP, pers. comm.). The two haulouts on George Island were unoccupied, and the Hall Island haulout was not visited.

The most complete haulout surveys in Franz Josef Land were conducted in 2012 and 2013 (M. Gavrilov, RANP, pers. comm.). Each survey visited nine of 10 haulouts. Direct counts of animals onshore and in the tidal zone totaled about 2,700 and 2,900, respectively. Haulouts containing 500 to 1,000 animals in at least one of the seasons included Apollonoff Island, Dead Seal Island, Matilda Island, and Gunter Bay. In 2001 and 2006 up to 1,000 animals were seen, from land, near Victoria Island but no haulout was identified (Gavrilov 2010). In 2015, satellite imagery was used to confirm the existence of a haulout with 500 to 1,000 animals on Victoria Island.

Walrus in Franz Josef Land haul out on sea ice as long as ice floes are available (M. Gavrilov, RANP, pers. comm.). The 2012 and 2013 surveys were made during record low sea ice in the archipelago. By mid-August the ice edge had retreated about 160 km to the north. Direct counts at the same six haulout sites in the summers of 2012, 2013, and 2015 counted 2,500, 2,130, and 950 animals respectively. In 2015 lots of drifting and fast sea ice was present, so walrus hauled out on sea ice near the terrestrial haulout were also counted.

Walrus in Franz Josef Land use a core network of haulouts but the numbers of animals on a site can vary widely from year to year. For example, on Apollonoff Island there were about 1,000 animals hauled out in mid-August 2012, whereas during the same period in 2013 only two males were hauled out. Haulouts such as Hoffman Island or Adelaida Island can have several hundred walrus hauled out one year and none the next.

## Conservation Status

Walrus at Svalbard are listed in the 2010 Norwegian Red List as Vulnerable (Swenson et al. 2010). The listing is based on an assumed very low number of reproducing females (< 250) within their Norwegian distribution area (Wiig et al. 2014). Atlantic walrus, including those in Franz Josef Land, are classified as Category II in the Red Data Book of the Russian Federation 2001 (Red Data Book 2001; Boltunov et al. 2010). A change to Category IV status (uncertain status) is expected in a new edition of the Red Data Book that is in preparation (M. Gavrilov, RANP, pers. comm.).



## KS-SBS-NZ

# KARA SEA - SOUTHERN BARENTS SEA - NOVAYA ZEMLYA

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The genetic relationship between walrus populations that summer in the southern Barents Sea and adjacent Kara and White seas to other walrus populations is uncertain, as are their abundance and life history (Boltunov et al. 2010). Movement of walrus does occur within this region. Of 10 walrus satellite-tagged in August at the Vaigach Island (various spellings, e.g., Vaygach) haulout, eight remained in the Pechora Sea, moving offshore from the haulouts in early November as the sea ice formed; two entered the Kara Sea and travelled to the North Island of Novaya Zemlya (Semyonova et al. 2015). Of the latter, one travelled 935 km in 10 days before its tag stopped transmitting, the other travelled farther to haul out on the Oranskie Islands. Tag life ranged from two to 172 days. Male walrus sampled at the Vaigach Island haulout were genetically similar (mtDNA haplotypes) to Atlantic walrus from Svalbard but different from those of Greenland and from Pacific walrus (Shitova et al. 2014a; Semyonova et al. 2015). Male walrus sampled at Oranskie Island (n=8) were genetically similar to walrus (3 female, 6 male) from Franz Josef Land (Shitova et al. 2014b). Samples from female walrus, and more samples from Oranskie Island are needed for more representative comparisons.

The southeastern arm of the Barents Sea (Pechora Sea) is shallow, with high production of the benthic prey species preferred by walrus. A recent survey has shown that this region provides important summer habitat for Atlantic Walrus, and earlier observations suggest that it might also be a wintering area (Lydersen et al. 2012:1555; see also Semyonova et al. 2015). Atlantic walrus used to live in the southwestern arm of the Barents Sea (White Sea), which is within the boreal zone and seasonally ice-covered, but were extirpated by hunting (M. Gavrilov, RANP, pers. comm.).

In August 2011, an aerial photographic survey of 2,563 km of Pechora Sea coastline counted 968 walrus (Lydersen et al. 2012; Chernook et al. 2012). The animals were hauled out at a site on Vaigach Island (Cape Lyamchin Nos; 405 walrus) and two sites on Matveev (various spellings, e.g., Matveev) Island (184 and 379 walrus), and all appeared to be male. Crude measurements of dorsal curvilinear lengths (N = 504) showed that 85.5% were adults and the remainder juveniles (< 225 cm). When an adjustment factor developed for male walrus in Svalbard (Lydersen et al. 2008) was used to account for animals in the water during the survey, the number occupying this area was estimated at 3,943 (95% CI = 3,605-4,325) (Table 2). This is the first estimate of walrus abundance in the Pechora Sea. The absence of females with calves suggests that the population is substantially larger, with a summer distribution that extends outside the survey area.

Haulouts in the Matveev, Golets, and Dolgii (various spellings, e.g., Dolgiy) islands area are occupied from July until late November depending upon ice conditions (Glazov et al. 2013). Walrus leave the land haulouts as soon as the ice

is strong enough to support their weight. Heavy summer use of the area between Vaigach Island and Matveev Island, and October use of waters west of Matveev Island to the Gulayevskiye Koshki shoals suggests that these are important feeding areas for walrus. These areas, which include the Nenetsky Nature Reserve, are perhaps the most important area of the Pechora Sea for walrus (Semyonova et al. 2015).

In April 2014, an aerial survey (helicopter) yielded a preliminary estimate of 3,117 (SE 0.388) walrus on the ice of the Pechora Sea (Semyonova et al. 2015). This estimate was not based on a systematic survey and relies heavily on extrapolation based on habitat similarity. All sex and age groups of walrus, including females with calves of different ages, were seen during the spring survey but in summer Pechora Sea haulouts were occupied primarily by mature males (Semyonova et al. 2015). The summer distribution of females with calves is not yet clear but limited encounter and satellite tracking data suggest they may use the coastal waters of Novaya Zemlya on both the Kara and Barents Sea sides.

Trend in abundance of Pechora Sea walrus cannot be established from the available survey data. However, since the first haulouts were reported from mainland coast and Matveev - Dolgiy Island in the 1990s (Isaksen et al. 2000; Goryaev et al. 2006) more haulouts and larger herds have been reported (M. Gavrilov, RANP, pers. comm.).

In August 2013 an aerial survey of the mainland and western part of the Kara Sea, conducted in preparation for exploratory drilling, counted 1,355 walrus (Chernook et al. 2014; Semyonova et al. 2015) (Table 2). Most were hauled out on Vaigach Island (Cape Lyamchin Nos; 897) on the Barents Sea side, or swimming near the Oranskie Islands (250) or Gemskerk Island (185) which are situated near Severny Island (variously spelled Severniy and Severnyi) at the northern tip of the Novaya Zemlya Archipelago. Females with calves were present at haulouts in the archipelago, unlike those in the Pechora Sea. Terrestrial observations in the summers of 2012 to 2014 found walrus using the Vaigach Island (Lyamchin Peninsula) haulout on each of the 28 observation days, but their numbers were highly variable, ranging from 15 to 1,300 (Semyonova et al. 2015).

The first reports in recent decades of terrestrial haulouts in northern Novaya Zemlya were from the early 2000s, when about 200 walrus were seen on Gemskerk Island (Marine Arctic Complex Expedition of Moscow Heritage Institute, unpublished report). Since then visual counts from land, vessels and fixed-winged aircraft in 2012-2015 (National Park Russian Arctic, unpublished reports and archived data; M. Gavrilov, RANP, pers. comm.) and satellite images and aerial observations from fixed-winged aircraft in 2012-2013 (WWF and Marine Mammal Council) have confirmed the existence and regular use of three major haulouts in northern Novaya Zemlya on the Oranskie Islands, Gemskerk Island, and at Russkaya Gavan (Chernook et al. 2014, Semyonova et al. 2015; M. Gavrilov, RANP, pers. comm.). Maximum counts on the Oranskie Islands have ranged from 160 to 800 animals, and peaked in August 2012 and 2013. In June 2013 several hundred animals were observed hauled out on broken fast ice in Russkaya Gavan (Russian Harbour). About 185 animals were seen from the air on Gemskerk Island in mid-August 2013, but none were present in late September 2014.

Systematic surveys have not been conducted for walrus in the Kara Sea, but over the past decade more terrestrial haulouts and larger herds have been reported (M. Gavrilov, RANP, pers. comm.). In addition to those on Novaya Zemlya, several haulouts have been located in the southwest Kara Sea on northern and western Yamal (Sharapovoy Koshki, Belyi Island) (Semyonova and Boltunov 2015). Haulouts have also been found at the northern edge of the Kara Sea. During vessel-based and aerial surveys in August 2007 and 2008 single walrus were seen on fast-ice of the shallow waters adjacent to Schmidt Island (northeasternmost Kara Sea), and in the coastal waters of Ushakov and Golomyanny islands (west of Severnaya Zemlya Archipelago). About 110 walrus, predominantly males, were hauled out on the northern coast of Ushakova Island, and 120 on Vize Island (Gavrilov 2010). Since then Vize Island has been used regularly by several dozen to 120 animals (M. Gavrilov, RANP, pers. comm.).

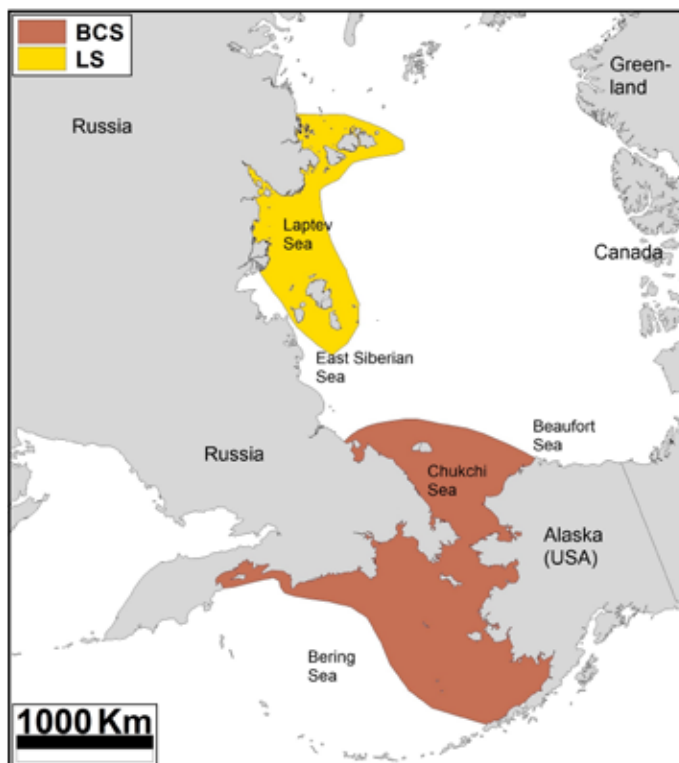
The discovery of haulouts on Vize and Ushakov islands fills the gap in distribution of Atlantic walrus between Franz Josef Land and the Severnaya Zemlya Archipelago, where only single animals have been recorded (Gavrilov 2010). There are no historical reports of haulouts (“rookeries”) northeast of Franz Josef Land at the northern edge of the Kara Sea (Chapsky 1936). Whether the walrus in this area now indicate a range expansion related to climate change or population recovery is unknown. Further study of the spatial and genetic structure of this population is needed in relation to other walrus (e.g., Laptev) in the Russian Arctic.

Trends in the abundance and health of walrus in the Kara Sea - Southern Barents Sea – Novaya Zemlya population are unknown and require the systematic long-term collection and analysis of comparable data for proper assessment (Semyonova et al. 2015). Further data are needed on abundance to establish trends, on the distribution of walrus during the spring breeding season, seasonal movements, genetics, contaminant levels, and interactions with shipping.

## Conservation Status

In 1971, the Novaya Zemlya population of Atlantic walrus was included in the list of rare animals of the USSR (Bychkov 1973a). The Atlantic walrus, including the Kara Sea - Southern Barents Sea – Novaya Zemlya population, is classified as Category II in the Red Data Book of the Russian Federation 2001 (Red Data Book 2001; Boltunov et al. 2010). A change to Category IV status (uncertain status) is expected in a new edition of the Red Data Book that is in preparation (M. Gavrilov, RANP, pers. comm.).

# PACIFIC WALRUS POPULATION STATUS



Recent genetic studies support the existence of two populations of Pacific walrus (Table 3), one in the Laptev Sea area and the other in the Bering and Chukchi seas (Lindqvist et al. 2009; Lowry 2015; but see Garlich-Miller et al. 2011, who retained the Laptev Sea subspecies in their assessment due to uncertainty). Today there is a distributional gap of 500 to 600 km between these populations but they may have formed a continuum (Lindqvist et al. 2009) before their numbers were greatly reduced by heavy exploitation in the Laptev Sea (Belikov and Boltunov 2005) and in the Bering and Chukchi seas (Bockstoce and Botkin 1982; Fay et al. 1989). The IUCN recently assessed the conservation status of the Pacific walrus subspecies, including those in the Laptev Sea, as Data Deficient (Lowry 2015). Conservation status ranks assigned to the different populations by the responsible jurisdictions are discussed below and summarized in Table 3.

**Figure 5.** Map of Pacific walrus populations in Russia and the USA. Populations: BCS = Bering and Chukchi Seas; LVS = Laptev Sea.

**Table 3.** Assessment of Pacific walrus by population, see text for sources.

Population <sup>1</sup>	Stock size	Year of estimate	Quality of abundance estimate <sup>2</sup> (method)	Harvested?	Est. landed catch	Quality of catch estimate <sup>2</sup>	Population trend
LVS	?? <sup>3</sup>	--	--	No	--	--	Unknown
BCS	129,000 (95% CI 55,000-507,000)	2006	F (Aerial strip-transects with thermal scanners, corrected)	Yes	2010-15 mean: USA = 2,126 (SE 23), Russia = 1,708 (SE 718) <sup>4</sup>	G	Unknown (has declined since 1970s-1980s)

<sup>1</sup> LVS = Laptev Sea (Russia); BCS = Bering and Chukchi Seas (United States (Alaska); Russia).

<sup>2</sup> G = Good (minimal bias, acceptable precision); F = Fair (problems with quality of data, precision uncertain); P = Poor (considerable uncertainty, bias or few data).

<sup>3</sup> The population was estimated at 4,000-5,000 animals according to Bychkov (1975 cited in Lowry 2015), current abundance is unknown.

<sup>4</sup> Includes estimated number struck and lost (USA and Russia) and reporting compliance (USA only) (J. MacCracken, USFWS, pers. comm.).



A polar bear investigates a walrus haulout, Laptev Sea, Russia.

© Alexei Ebel / WWF-Canon

## LVS LAPTEV SEA

Walrus that occupy the Laptev Sea, eastern part of the Kara Sea, and western regions of the East Siberian Sea were considered a third subspecies of the Walrus (e.g., Vishnevskaya and Bychkov 1990). Recent morphological and genetic studies support their recognition as the westernmost population of the Pacific walrus (Lindqvist et al. 2009, 2016), however, sample sizes may not be large enough to confirm their status definitively (J. MacCracken, U.S. Fish and Wildlife Service (USFWS), pers. comm.). Little information is available on walrus in the Laptev Sea (Fedoseev 1984). The southern and central areas of the Laptev Sea tend to be <50 m deep, which is suitable for walrus feeding (Lindqvist et al. 2009). From November to July the entire sea is ice-covered, with polynyas in the vicinity of Pyotr and Faddey islands and northwest of the Novosibirsk (New Siberian) Islands (Vishnevskaya and Bychkov 1990). Ice is least abundant in September but in some years the entire sea, with the exception of Khatanga Bay and the pre-estuarine areas of the Lena and Yana rivers, remains ice covered for the summer.

An aerial survey of the Laptev Sea in September 1980 saw walrus in the west, including 88 on the ice in the vicinity of eastern Taimyr (strip transects) and herds of 200 and 397 on Peschanyi Island, and in the east in the Novosibirsk Islands and DeLong Islands, including 150 to 200 on Belkovsky Island, 350 to 400 on Kotel'nyi Island at Cape Ainsia, about 600 on the ice near Vil'kitskii and



Zhokhov islands (Fedoseev 1984). The survey was not systematic and the counts were not adjusted for walrus submerged beyond view, but at least 1,785 to 1,885 walrus were present. An extrapolation of the Taimyr strip count of 88 walrus to 2,340 walrus (Fedoseev 1984) may not be valid. The number of walrus in the Laptev Sea region was estimated at 4,000-5,000 animals according to a report cited in Fay (1982). The largest walrus concentrations observed by ship borne and aerial surveys in the Laptev Sea, from NE Taimyr Peninsula to the Novsibirsk Islands in 2010-2012, were on Petra Island (160; September 23, 2010), on or in the water near Vil'kitskii Island (78; August 27, 2012), and on Bel'kovskii Island at Cape Severnyi (Morzhovy) (63, SD = 2.65; 20 October 2010) (Glazov et al. 2013).

In the Laptev Sea, commercial hunters killed walrus at a haulout (rookery) on the north sand bar (Morzhovaya Kosa / Walrus spit) at the entrance to Maria Pronchishcheva Bay on the east Taimyr coast from 1933 to 1936, but in 1937 no walrus returned (Vishnevskaya and Bychkov 1990). Few data are available on the post-WWII use of this haulout. Studies conducted in July-September 1984 and August-October 1985 observed consistent use of the haulout, sometimes by up to 600 animals. There were about 80 walrus hauled out at this site when it was visited by WWF in August 2013 (T. Arnbom, WWF Sweden, pers. comm.). During the same trip about 1,000 walrus were found hauled out at Cape Tsvetkova, and at least 100 walrus were observed in the waters between Maria Pronchishcheva Bay and Cape Tsvetkova.

## Conservation Status

Laptev Sea walrus are included in the Red Book of the USSR as a rare endemic subspecies that is potentially vulnerable because of its low numbers, limited range, and increasing anthropogenic stress (Category III) (Vishnevskaya and Bychkov 1990).

# BCS

## BERING AND CHUKCHI SEAS

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### Stock Structure

The Bering and Chukchi Seas (BCS) population of Pacific walrus is presently managed as a single panmictic (unstructured, random-mating) unit, although stock structure has not been thoroughly investigated (Garlich-Miller et al. 2011; USFWS 2014). Scribner et al. (1997) found no difference in mitochondrial and nuclear DNA among Pacific walrus sampled from four different breeding areas in the Bering Sea (Gulf of Anadyr, Koryak Coast, southeast Bering Sea, and St. Lawrence Island). More recently, Sonsthagen et al. (2012) assessed genetic relationships among two putative breeding populations and six nonbreeding aggregations. Analyses of mtDNA control region sequence data suggested that males are distinct among breeding populations and between the eastern Chukchi

and other nonbreeding aggregations. Nonbreeding female aggregations were genetically distinct across marker types (microsatellites, mtDNA), as was eastern Chukchi and all other nonbreeding aggregations (Sonsthagen et al. 2012). Jay et al. (2008) found some suggestions of stock structure based on differences in the ratio of trace elements in the teeth of walruses sampled in winter from two breeding areas (southeast Bering Sea and St. Lawrence Island). Further research on stock structure in Pacific walruses is needed (Garlich-Miller et al. 2011; USFWS 2014).

Pacific walruses are found throughout the continental shelf waters of the Bering and Chukchi Seas and occasionally move into the East Siberian Sea and the Beaufort Sea (Figure 5) (Fay 1982; Lowry et al. 2008; Garlich-Miller et al. 2011; USFWS 2014; Allen and Angliss 2015). Vagrants have also been observed south into the North Pacific Ocean to Japan and to southcentral Alaska (Fay 1982). The walruses that are sporadically observed to the south and west of Victoria Island in the Canadian Arctic have tentatively been considered Pacific walruses (Harrington 1966; Stewart and Burt 1994). Commercial harvesting records indicate that Pacific walrus range once extended further south. In the 17th Century they were hunted along the southern coast of Russia in the Sea of Okhotsk and near Unimak Pass (Aleutian Islands) and the Shumagin Islands (Alaska Peninsula) (Elliott 1882). Recently, walruses have been observed in these general areas (J. MacCracken, USFWS, pers. comm.).

Pacific walruses rely on broken pack-ice habitat to access offshore feeding areas (Fay 1982), and their distribution can vary markedly in response to seasonal and inter-annual variations in sea-ice cover (Garlich-Miller et al. 2011; Garlich-Miller (ed.) 2012; knowledge from Bering Strait experts summarized by Kawerak, Inc. 2013). During the late winter (January to March) breeding season, walruses are concentrated in the Bering Sea pack-ice in areas where open leads, polynyas, or thin ice allow access to water (Fay 1982; Fay et al. 1986; Garlich-Miller et al. 2011; USFWS 2014). The specific locations of winter breeding aggregations vary annually depending upon the distribution and extent of sea ice, but one group generally ranges from the Gulf of Anadyr into a region southwest of St. Lawrence Island, and a second group is found in the southeastern Bering Sea from south of Nunivak Island into northwestern Bristol Bay (Fay 1982; Mymrin et al. 1990; Burn et al. 2009; Garlich-Miller et al. 2011; Speckman et al. 2011). As the Bering Sea pack ice deteriorates in the spring, most adult female and juvenile walruses migrate northward through the Bering Strait to summer feeding areas over the continental shelf in the Chukchi Sea (Fay 1982; Garlich-Miller et al. 2011; USFWS 2014). But several thousand walruses remain in the Bering Sea and forage from coastal haulouts in the Gulf of Anadyr, Bering Strait region, and in Bristol Bay (Garlich-Miller et al. 2011; USFWS 2014; Fischbach et al. 2016).

The summer range of Pacific walruses in the Chukchi Sea varies annually depending upon the distribution and extent of sea-ice. When broken pack ice is abundant, walruses are usually found in patchy aggregations across the shallow continental shelf in herds ranging in size from < 10 to > 1000 animals (Gilbert 1999; Ray et al. 2006; Garlich-Miller et al. 2011). Summer aggregations occur in loose pack-ice off the northwestern coast of Alaska between Icy Cape and Point Barrow, and along the coast of Chukotka west to Wrangel Island (Fay 1982; Gilbert et al. 1992; Belikov et al. 1996; Garlich-Miller et al. 2011). In years when the

sea-ice retreats beyond the continental shelf in late summer and early fall, walruses congregate in large numbers at terrestrial haulouts on Wrangel Island, the northern coast of the Chukotka Peninsula, and the northwestern coast of Alaska (Fay 1982; Belikov et al. 1996; Kochnev 2004; Kavry et al. 2006, 2008; Ovsyanikov et al. 2008; Garlich-Miller et al. 2011; Fischbach et al. 2016). In late September and October walruses that summer in the Chukchi Sea begin migrating south ahead of the developing sea ice. Large herds of southbound animals often congregate to rest at coastal haulout sites in the southern Chukchi Sea before moving to winter breeding areas in the Bering Sea (Garlich-Miller et al. 2011). Haulouts in the Bering Strait Region (Big Diomedes, King Island, and the Penuk Islands) are also occasionally used by large numbers of walruses in late fall and early winter, prior to the onset of ice formation (Fay and Kelly 1980). Male walruses that have summered in the Bering Sea begin to move northward towards winter breeding areas in November (Jay and Hills 2005).

## Population size

Commercial over-harvesting led to historical depletion of the Pacific walrus population. Fay (1982) speculated that the pre-exploitation population was at least 200,000 animals given the large harvests that were sustained throughout the 18th and 19th centuries. Population size is believed to have fluctuated markedly in response to varying levels of human exploitation since that time (Fay et al. 1989). Extensive commercial harvests reduced numbers to an estimated 50,000 - 100,000 animals in the mid-1950s (Fay et al. 1997), and the population then increased rapidly in size during the 1960s and 1970s in response to reductions in hunting pressure (Fay et al. 1989).

From 1975 to 1990, visual aerial surveys were carried out by the United States and Russia at 5-year intervals (USFWS 2014; Allen and Angliss 2015). Population estimates ranged from ca. 201,000 to 246,020 animals with 95% confidence intervals that include zero, which adds uncertainty for detecting trends in population size (Gilbert et al. 1992; Hills and Gilbert 1994; Fay et al. 1997; Gilbert 1999). The estimates generated from these surveys are considered minimum values. They are negatively biased because they were not adjusted for walruses in the water and because the walruses tended to aggregate in large closely packed groups when hauled out, which made it difficult to obtain accurate counts of animals observed (USFWS 2014; Allen and Angliss 2015).

Efforts to survey the population were suspended after 1990 due to these methodological issues (Gilbert et al. 1992; Gilbert 1999). A 2000 workshop concluded that it would not be possible to obtain a population estimate with adequate precision using the existing visual methodology and any reasonable amount of survey effort (Garlich-Miller and Jay 2000). Remote sensing systems were viewed as having potential to address the problem of accurately counting walruses in large groups (Udevitz et al. 2001) in addition to being able to sample larger areas per unit of time and reduce observer error (Burn et al. 2006). To account for walruses in the water that were not available to be counted, satellite transmitters that recorded haul-out status (in water or out) were used to estimate the proportion of animals in the water and correct walrus counts (Udevitz et al. 2009). American and Russian scientists developed a survey method that uses thermal imaging sys-

tems to reliably detect groups of walrus hauled out on sea ice (Burn et al. 2006; Udevitz et al. 2008).

A joint U.S.-Russia survey, with coincident satellite-tagging, was conducted in March–April 2006, when the Pacific walrus population was hauled out on sea ice habitats across the continental shelf of the Bering Sea (Speckman et al. 2011; USFWS 2014; Allen and Angliss 2015). Transects were surveyed with airborne thermal scanners using standard strip-transect methodology, and an independent set of scanned walrus groups was aerially photographed. Walrus counts in photographed groups were used to model the relationship between thermal signatures and the number of walrus and estimate the number of walrus in groups that were detected by the scanner but not photographed. The probability of thermally detecting various-sized walrus groups was modeled to estimate the number of walrus in groups that went undetected by the scanner (Speckman et al. 2011). Thermal imagery can detect walrus that are hauled out on sea ice, but not walrus swimming in water, so data from satellite-tagged walrus were used to adjust on-ice estimates to account for animals in the water. The survey estimated a Pacific walrus population of 129,000 animals (95% CI 55,000 - 507,000) within the survey area (Speckman et al. 2011) (Table 3). The estimate is negatively biased as it did not account for areas that were missed, some of which were known to have had walrus present (USFWS 2014; Allen and Angliss 2015).

## Current Population Trend

The 2006 estimate is lower than previous estimates of population size. It is also negatively biased because some areas important to walrus were not surveyed due to poor weather conditions (Allen and Angliss 2015 and references therein). However, earlier population size estimates are also likely to be negatively biased since they did not adjust for walrus in the water. Comparing the different surveys is made difficult because of differences in methodology and timing, the segments of the walrus population surveyed, and incomplete coverage of areas where walrus are known to occur (Fay et al. 1997; Gilbert 1999). The U.S. Fish and Wildlife Service (USFWS) is developing a project to test the feasibility of genetic mark-recapture methods to estimate population size and trend (USFWS 2014).

Available survey estimates cannot be used to identify current population trends, and more surveys are needed to quantify trends in population size (USFWS 2014; Allen and Angliss 2015). But, evidence shows the Pacific walrus population has declined from a peak in the late 1970s and 1980s (Garlich-Miller et al. 2011; Taylor and Udevitz 2015). Demographic data from that period indicated that population growth was slowing (Fay and Stoker 1982; Fay et al. 1986, 1989; Sease 1986). Data on calf/cow ratios collected from harvested animals is also consistent with a population peak in the late 1970s (i.e., low estimates in the late 1970s and early 1980s) and subsequent population decline, suggesting that the population is currently below the assumed carrying capacity (MacCracken 2012; USFWS 2014). The median age of reproduction for female walrus also decreased in the 1990s, consistent with reduction in density-dependent pressures (Garlich-Miller et al. 2006). Data are not available to test whether these changes in walrus life-history parameters might have been mediated by changes in abundance versus environmental changes that affected carrying capacity (Allen and Angliss 2015).

Available evidence suggests that commercial and subsistence harvests prior to the 1960s limited the population, and adoption of harvest quotas in the 1960s resulted in a population increase until the carrying capacity (ca. 300,000, Fay et al. 1997) was reached in the 1970/1980s and productivity began to decline (USFWS 2014). The lack of US harvest quotas starting in 1979 and reduced productivity levels resulted in another population decline. Currently, the population may once again be limited mainly by subsistence harvests (USFWS 2014), although other factors such as haulout mortalities may also be important (Udevitz et al. 2013). Changing sea ice dynamics may also result in further population declines in the future (Garlich-Miller et al. 2011).

## Conservation Status

The Pacific walrus is not designated as depleted under the U.S. *Marine Mammal Protection Act* (MMPA) (USFWS 2014; Allen and Angliss 2015). In February 2008, the USFWS received a petition to list the Pacific walrus under the *Endangered Species Act of 1973* (ESA) (Allen and Angliss 2015). A status review by the USFWS was compiled in 2011 (Garlich-Miller et al. 2011). Due primarily to the combined threats of sea ice loss and harvest the USFWS has determined that listing the Pacific walrus as endangered or threatened under the ESA is warranted, but higher priority listing actions have taken precedence (USFWS 2011; Taylor and Udevitz 2015). The total human-caused removals exceed the estimated potential biological removal (PBR) of 2,580 (USFWS 2014; Allen and Angliss 2015). The Pacific walrus stock was therefore classified as “strategic” in the U.S. In 2017 a detailed and comprehensive final species status assessment was released (MacCracken et al. 2017). Based on this assessment the USFWS (2017) determined that the Pacific walrus does not warrant listing as threatened or endangered under the ESA. While the Pacific walrus will not receive protection under the ESA, it continues to be protected under the MMPA, which affords similar protections. Pacific walruses in the Bering and Chukchi Sea are not listed as at risk in the Red Data Book of the Russian Federation 2001 (Red Data Book 2001).





Walrus haulout, Chukotka,  
Russia.

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# MANAGEMENT REGULATIONS

Human activities that affect Atlantic walrus are managed within their respective jurisdictions by Canada, Greenland, Norway, and Russia: those affecting Pacific walrus are managed by Russia and the United States. The management practices of these countries are summarized briefly in this section and in Table 4. Aboriginal peoples in Canada, coastal-dwelling Alaska Natives in the United States, and indigenous people inhabiting Chukotka (Russia) are permitted to hunt walrus for subsistence purposes (Shadbolt et al. 2014). Greenlanders who hunt as a full time occupation and hold a valid commercial hunting licence can obtain a permit to hunt one walrus (Anon. 2006). Additional information is available in recent management reviews for the Atlantic walrus (Wiig et al. 2014), the Pacific walrus (Garlich-Miller et al. 2011), and for both subspecies (Shadbolt et al. 2014).

A challenge with respect to managing walrus hunting remains the variable and sometimes high rates of hunting losses (animals injured or killed but not secured) (D.B. Stewart et al. 2014a; Wiig et al. 2014). Because walrus occur in remote locations, often under inhospitable conditions, regulatory enforcement is also a challenge.





## CANADA

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### Hunt management

Commercial whalers and land-based traders took many walrus from the CCA-WG and CHA-NWG populations between ca. 1820 and 1928 (D.B. Stewart et al. 2014a). The large removals caused A.P. Low (1906 p.281ff), commander of the Canadian Government scientific expedition to study fisheries and geology in northern Hudson Bay and the Arctic Islands in 1903-1904, to press for the conservation of walrus in Hudson Bay, and to recommend that walrus be reserved for Inuit use. In 1928, Canada established regulations that restricted killing of walrus to Aboriginal hunters for their own food and clothing requirements but allowed walrus to be taken under Ministerial permit for scientific purposes (Canada Privy Council 1928: P.C. 1036). These regulations ended commercial hunting by whalers and traders in the eastern Canadian Arctic and subsistence and sport hunting by non-Aboriginal peoples. This was an important step toward reducing hunting pressure on the walrus populations but it left important loopholes that enabled the traders to purchase hides and ivory.

In 1931 more explicit regulations were issued forbidding the export of walrus hides and uncarved tusks, and limiting the annual harvest of walrus to seven per family (Canada Privy Council 1931: P.C. 1543). In 1980, the Walrus Protection Regulations were enacted under the *Fisheries Act* (Canada Privy Council 1980: P.C. 1980-1216). Under these regulations only “an Indian or Inuk” was allowed to “hunt and kill walrus without a licence” and then “not more than four walrus in one year” (Section 3), except where annual community quotas were scheduled instead for Coral Harbour: 60, Sanikiluaq: 10, Arctic Bay: 10, and Clyde River: 20. In 1993, these regulations were consolidated with those for other marine mammals in the Marine Mammal Regulations of the *Fisheries Act* (SOR/93-56, 1993).

Hunts in Nunavut and Nunavik (northern Quebec) are co-managed by the Nunavut Wildlife Management Board and Nunavik Marine Region Wildlife Board, under the applicable sections of their respective land claims agreements, with scientific advice from DFO, which manages walrus in other jurisdictions in cooperation with other agencies. Community knowledge and Aboriginal traditional knowledge are also used to manage walrus. Walrus co-management working groups for Foxe Basin and the Baffin Bay area are working together to draft an Integrated Fisheries Management Plan for walrus in Nunavut (DFO 2013a:13; A. McPhee, DFO Winnipeg, pers. comm.). Under the Marine Mammal Regulations, trade in edible parts is prohibited, except among First Nations and Inuit. A DFO Marine Mammal Transport Licence is required to transport walrus parts within Canada, except for First Nations or Inuit hunters who are returning home after the hunt. A Scientific Research Licence from DFO is required to do walrus studies in walrus habitat and applicants must demonstrate community support. Live capture is permitted only under licence. Walrus are extralimital in the Northwest Territories (Inuvialuit Settlement Region) and in Nunatsiavut (Labrador) and there is no regular hunting (less than one walrus taken per decade, D.B. Stewart et al. 2014a).

Since 1994 a limited sports hunt has been opened annually for non-resident hunters to benefit communities located near walrus populations (D.B. Stewart et al. 2014a).

Under the *Fisheries Act*, hunters except “Indian or Inuk” non-beneficiaries require a licence under the Marine Mammal Regulations or Aboriginal Communal Fishing Licence Regulation to hunt walrus (DFO 2002; Hall 2003). The Nunavut Wildlife Management Board manages these hunts by limiting the number approved annually. Most of the walrus are taken in northern Foxe Basin and some in northern Hudson Bay. Non-resident hunters can keep the tusks, cape (i.e., pelt from the head and neck of the walrus kept for preparation as a hunting trophy) and baculum but must leave the meat in the village. In 1975, Canada listed the walrus under Appendix III of the Convention on International Trade in Endangered Species (CITES) in order to monitor international trade levels (Hall 2003). Export of walrus parts from Canada requires an export permit from Canadian CITES authorities.

## Habitat Protection

Walrus habitat is protected under sections 34-37 of the *Fisheries Act* (Government of Canada 2015), which prohibits activities that result “in serious harm to fish that are part of a commercial, recreational or Aboriginal fishery, or to fish that support such a fishery” (S35(1)) and the introduction of deleterious substances into waters frequented by fish, or in any place, under any conditions, that results in the deleterious substance possibly entering such water (S36(3)). Under the Act, “fish” are broadly defined to include walrus and other marine mammals.

Existing National Parks, National Wildlife Areas, Migratory Bird Sanctuaries, and other lands owned and managed by the Government of Canada offer temporary protection to small numbers of walrus. Inuit have the right to hunt in National Parks and other conservation areas within Nunavut and Nunatsiavut. This level of habitat protection by itself is certainly insufficient to ensure the long-term survival of the species. The proposed National Marine Conservation Area in Tallurutiup Imanga/Lancaster Sound (Parks Canada 2017), which is in the planning stage, may offer additional protection once it is established.

In Nunavut, the North Baffin Regional Land Use Plan (Sec. 3.3.8) and Keewatin Regional Land Use Plan (Sec. 2.7) mention protection of walrus haulouts (uglit in Inuktitut) but the level of protection is vague (Nunavut Planning Commission 2000a, b). A Nunavut-wide land use plan is being prepared. The most recent (June 2016) draft assigned haulout sites a Protected Area Land Use Designation that prohibits incompatible uses such as mineral extraction, and includes vessel setback requirements of up to 5 km (Nunavut Planning Commission 2016). The walrus haulouts identified and mapped by Nunavut Planning Commission (2016) are incomplete, as only haulouts in Foxe Basin were identified (using data from Stewart et al. 2013). Community Areas of Interest are also assigned a Protected Area Land Use Designation. This designation will protect some important Walrus haulout sites in the Kivalliq region, such as Walrus Island. Numerous other haulout sites have been reported in the literature. WWF-Canada compiled these data (Higdon 2016) and provided the Geographic Information System (GIS) database to the Nunavut Planning Commission, as part of the on-going review of the draft plan (B. Laforest, WWF-Canada, pers. comm.).



## DENMARK (GREENLAND)

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### Hunt management

Walrus stocks in Greenland have been hunted for the past millennium (Wiig et al. 2014 and references therein). Commercial hunting of Atlantic walrus was prohibited in Greenland in 1956 (Anon. 1956a) but licensed hunts continue for subsistence (Wiig et al. 2014). From the early 1900s through 2005, walrus hunting in West Greenland was regulated by limiting the hunting season and hunting methods; there were no catch quotas in place (Born et al. 1994, 1995). On 1 June 1951, walrus in East Greenland, north of 74°24'N, received complete protection from harvesting under a decree from the Danish Ministry of State Affairs (Born et al. 1997). The decree also made the island of Sandøen, in Young Sound, a game preserve, prohibiting access to protect a well-known walrus haulout.

*Parliament Act no. 12 of 29 October 1999* (Anon. 1999) set the current framework for regulating fishing and hunting in Greenland, with ministerial orders that regulate the details for single species such as the walrus. In 2006, a quota system was established by executive order for walrus (Anon. 2006). These annual hunting quotas are based on the recommendations of scientific assessments from the Greenland Institute of Natural Resources (GINR) and North Atlantic Marine Mammal Commission (NAMMCO), using recent population estimates to allow population growth from a depleted population, and taking into account harvests in Nunavut from shared stocks and estimates of loss (Wiig et al. 2014). The Hunting Committee, an independent advisory body to the Government of Greenland on issues related to the development and management of Greenland's living resources, is also consulted (Government of Greenland n.d.; M. Frost, WWF Greenland, pers. comm.). Under the series of executive orders issued in 2006 and still in force, adult females and calves are protected except in the Qaanaaq area (Northwest Greenland) where walrus hunting traditionally has been, and still is, of great importance to the hunting community; walrus hauled out on land are completely protected; there is a year-round ban on hunting south of 66°N; and walrus must be harpooned with floats attached before receiving the finishing shot to reduce hunting losses from sinking (Wiig et al. 2014 and references therein). Only full-time hunters are allowed to apply for a license to hunt walrus, and these licenses are non-transferable (Ugarte 2015). There are also limits on the hunting seasons for each stock and on the maximum size of vehicle (e.g., boat) and minimum rifle caliber that can be used. Reporting of the sex, age class, and harvest date of harvested walrus has been mandatory since 1994 (Wiig et al. 2014).

The current control system is considered largely effective in ensuring the quotas are applied and that reporting is correct (Wiig et al. 2014). But, reporting of animals that are struck and then lost, while mandatory, is rare (APNN 2014b cited in Ugarte 2015). Management authorities set quotas assuming a struck and loss rate of 3% in Baffin Bay, 15% in West Greenland and 11% in East Greenland. These rates are based on information provided by hunters and have not been independently verified. There is a carry-over system whereby unused harvests can be transferred from one year to the next and overharvests are subtracted from the following year (Ugarte 2015).

## Habitat Protection

In 2003, the Greenland Home Rule Government adopted a new *Nature Protection Act (Landstings Act no 29 of 18 December 2003 on the Protection of Nature)* (Government of Greenland 2003) to protect biological diversity, ensure that exploitation is sustainable, and implement international agreements on the conservation of nature under Greenlandic law. This protection is to be based on ecological sustainability in accordance with the precautionary principle and thereby affords some protection to walruses and their habitats. The *Greenland Mineral Resources Act* and other rules, regulations, and guidelines (Government of Greenland 2009), also stipulate a range of measures for protecting nature and the environment (Government of Greenland 2016).

The probability of future large-scale exploration for hydrocarbons offshore Greenland is high, and such exploration can include activities that affect walruses and their habitat. Applications to conduct hydrocarbon exploration must include an environmental impact assessment (Wiig et al. 2014). Before opening new areas for exploration and initiating a licensing process the Greenland Government has been conducting its own Strategic Environmental Impact Assessments (Boertmann et al. 2013). These assessments have been completed for eastern Baffin Bay (Boertmann et al. 2009a), southeastern Baffin Bay - Davis Strait - northern Labrador Sea (Mosbech et al. 2007; Merkel et al. 2012; Boertmann et al. 2013; Frederiksen et al. 2012), and Northeast Greenland (Boertmann et al. 2009b; Boertmann and Mosbech 2012). Future hydrocarbon exploration might adversely impact all three walrus populations that use Greenland waters (Wiig et al. 2014). There are licenses for exploration and exploitation of hydrocarbons in the Greenland Sea but so far only seismic testing is taking place (M. Frost, WWF Greenland, pers. comm.).

The Melville Bay Nature Reserve, created in June 1980 in northwestern Greenland (Government of Greenland 1989), and the National Park of North and East Greenland, established July 1974 (Government of Greenland 1992), both offer some habitat protection for terrestrial walrus haulouts but their boundaries follow the coast and do not extend to offshore waters (Wiig et al. 2014). However, guidelines and marine protection zones have been established to prevent or limit impacts of summer and fall (mid-June through October) seismic surveys on walruses in both northwestern and northeastern Greenland (Kyhn et al. 2011). There is extensive exploration for minerals within the park – most recently the plans to develop a large-scale zinc and lead mine by Ironbark Zinc Ltd. at Citronenfjord in northern Greenland (Ironbark Zinc Limited and Orbicon A/S. 2015; <http://ironbark.gl/>; M. Frost, WWF Greenland, pers. comm.). This development would involve shipping via the Northeast Water Polynya/Fram Strait and increase risk of oil spills in the region. Residents of the Ittoqqortoormiit/Scoresby Sound area with a hunting license are allowed to conduct traditional hunting inside the national park and it is not explicitly stated that walruses cannot be taken during such hunting activity (Wiig et al. 2014).

In anticipation that losses of Arctic sea ice will influence shipping activities and routes in the future, the Danish Center for Environment and Energy and the Greenland Institute of Natural Resources have identified vulnerable marine areas in Greenland (Christensen et al. 2012). Future shipping changes are likely to be



driven by natural resource development and regional trade. The report identifies and ranks marine areas vulnerable to shipping. The North Water Polynya and Disko Bay-Hellefiskebanke are identified as the most vulnerable (Priority 1) areas and the Northeast Water Polynya also ranks high.

## NORWAY (SVALBARD)

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### Hunt management

Norway (including Jan Mayen and Svalbard) does not allow the hunting of walrus. Commercial hunting was banned in 1952 in response to very large harvests by Norwegians in Northwest Greenland in 1949 (n=623) and 1951 (1,251) (Anon. 1952; Øritsland 1973; Witting and Born 2005; Wiig et al. 2014). When Denmark and Norway discussed these catches, they concluded that walrus were so depleted that they could not sustain the Norwegian harvest and, in 1952, a Royal Decree, in accordance to the Norwegian Sealing Law of 1951, gave complete protection to walrus (Anon. 1952; Øritsland 1973). This law applied to “sealing inside the Norwegian fishery limit, and to sealing carried out by Norwegian citizens, inhabitants of the country or by Norwegian companies and other organizations outside the Norwegian fisheries limit” (see also section below on International Agreements: Norwegian-Soviet Sealing Agreement of 1958 (UN 1958)).

### Habitat Protection

Walrus haulouts at Svalbard are well documented (Gjertz and Wiig 1994; Lydersen et al. 2008; Kovacs et al. 2014) and most are within protected areas (WWF 2006; Wiig et al. 2014). In 2008, regulations protecting the Northeast Svalbard and Southeast Svalbard nature reserves in eastern Svalbard were strengthened to reduce the impacts of ship traffic (Wiig et al. 2014). These protected areas serve as reference areas for research. Access by tourist ships with over 200 passengers was prohibited, as was ship use and transport of fuels other than light diesel fuel into these areas. The objectives were to reduce direct disturbances and the risk of oil fouling at haulouts.



## RUSSIA

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### Hunt management

Commercial hunters took large numbers of Atlantic walrus over many centuries from the Kara Sea - Southern Barents Sea - Novaya Zemlya (KS-SBS-NZ) population (Timoshenko 1984). Regulations in the 1930s banned the taking of animals in water and of females with calves (M. Gavrilov, RANP, pers. comm.), but by 1934 only 1,200-1,300 animals were known to remain in the Barents and Kara seas (Chapsky 1936). Hunting of Atlantic walrus in Russia was first limited in 1921; followed in 1935 by cessation of the state harvest from sealing ves-

sels; and in 1949 by the prohibition of killing walrus by any fishing and sealing industry in the Barents and Kara seas (Bychkov 1973a; M. Gavrilov, RANP, pers. comm.). Since 1956, hunting for Atlantic Walrus and for walrus in the Laptev Sea area has been banned for all Soviet citizens, except for subsistence by some Arctic expeditions and native peoples (Anon. 1956b; Bychkov 1973a, 1973b). In 1975 regulations for the conservation and harvesting of marine mammals prohibited sport hunting of walrus, as well as any landing on or littering of shore haulouts at any time (Order No. 300 of the USSR Ministry of Fisheries; Vaisman et al. 2009 cited in Shadbolt et al. 2014; Wiig et al. 2014). It also prohibited possession, manufacture, buying, selling, storage, and transportation of hides and tusks from walrus. These regulations apply to all USSR territory including internal waters and the USSR economic zone (Vaisman et al. 2009 cited in Shadbolt et al. 2014). Quotas are now regulated under Federal Law No. 166 *On Fishery and conservation of Aquatic Biological Resources*.

Hunting of Atlantic and Laptev walrus for subsistence has been prohibited since 1982, when they were listed in the Red Data Book; as such, trade in these walrus is prohibited (Anon. 1982; Shadbolt et al. 2014). Pacific walrus are not afforded the same protection.

Franz Josef Land was discovered in 1865 by Norwegian sealers who kept news of its rich resources to themselves, so it was not until 1873 that the archipelago was officially discovered (Horn 1930). Walrus hunting was limited to subsistence hunts by expeditions exploring the archipelago until ca. 1897, when the Scottish whaling vessels *Balaena*, *Active*, and *Diana* visited to hunt marine mammals (Southwell 1898, 1899). Commercial hunting of walrus, mostly by Norwegian vessels, continued regularly until 1929 when the archipelago was annexed by the Soviet Union (Southwell 1898, 1899; Horn 1930; Lønø 1972; Gjertz et al. 1992). Walrus were also hunted on Victoria Island from 1924 to 1950 (Lønø 1972). The combined overall harvest from Franz Josef Land-Victoria Island has been estimated at over 8,465 walrus (Gjertz et al. 1992). When hunting losses are included, at least 10,000 walrus were killed on Franz Josef Land in the 40 years up to 1931.

The original population size of walrus in Franz Josef Land in 1897 has been estimated at 6,000–12,000 (Gjertz et al. 1998). By 1934, it may have been reduced to less than 700 animals (Gjertz et al. 1998). Local surveys for walrus in the 1990s found as few as several hundred animals during a given season (Gjertz et al. 1998). Walrus numbers have been increasing since 1994, when the archipelago and surrounding waters were declared a nature reserve (M. Gavrilov, RANP, pers. comm.). Walrus continue to use traditional land-based haulouts and establish new ones.

Commercial hunting of Pacific walrus in Russian waters, which accounted for up to 45% of the total Russian harvest in the 1980s, ended in 1991 due to the economic collapse of the industry (Garlich-Miller and Pungowiyi 1999). Russian legislation still allows commercial hunting but to resume it would require an annual decree from the Russian Fisheries Ministry (Anatoli Kochnev, Chukot TINRO, 2010, pers. comm. in Garlich-Miller et al. 2011:43).

Indigenous people inhabiting Chukotka are permitted to hunt Pacific walrus for subsistence purposes. There are no restrictions on possession or sale of Pacific walrus parts and derivatives, provided the harvest was legal and there is



proper documentation to confirm legal origin (Vaisman et al. 2009 cited in Shadbolt et al. 2014). Export of Pacific walrus products out of Russia requires CITES documentation (e.g., certificate of origin), unless it remains within the Eurasian Customs Union (see below: International Agreements).

## Habitat Protection

The Atlantic walrus is classified as Category II in the Red Data Book of the Russian Federation 2001 (Red Data Book 2001; Boltunov et al. 2010). As such, the Federal Law of April 24, 1995 (No. 52 “On the Wildlife”) requires activities that alter its habitat, breeding and feeding conditions, and migration routes to meet the necessary requirements to ensure its conservation. A change to category IV status (uncertain status) is expected in a new edition of the Red Data Book that is in preparation (M. Gavrilov, RANP, pers. comm.).

Atlantic walrus habitats on land and at sea are protected in the following specially protected areas: Franz Josef Land Federal State Zakaznik (Wildlife Reserve), Russian Arctic National Park (northern Novaya Zemlya), Nenetskiy Strict Nature Reserve in the Pechora Sea, Great Arctic Reserve in the Kara Sea, Gydanskiy Strict Nature Reserve, and in the Vaigach and Yamalskiy regional wildlife reserves (M. Gavrilov, RANP, pers. comm.). A national conservation strategy for the Atlantic walrus is currently under development in Russia (M. Gavrilov, RANP, pers. comm.).

Vishnevskaya and Bychkov (1990: Fig. 1) submitted proposals for walrus sanctuaries in the Laptev Sea region. Laptev walrus habitats are now protected in the Taimyr Strict Nature Reserve (NE Taimyr), and will receive formal protection in the New Siberian Islands Zakaznik (Wildlife reserve), which is awaiting approval (M. Gavrilov, RANP, pers. comm.).

Federal Law No. 166 On Fishery and conservation of Aquatic Biological Resources also protects walrus on their haulouts and prohibits access to those areas. It does this by banning vessels from passing within 3 to 5 km, banning aircraft from passing at altitudes of less than 2000 m, and prohibiting hunting within 500 m of rookeries (haulouts) (Vaisman et al. 2009 cited in Shadbolt et al. 2014).



## UNITED STATES (ALASKA)

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### Hunt management

The Pacific walrus population in the Bering and Chukchi Seas sustained large commercial and subsistence harvests throughout the 18th and 19th centuries (Fay 1982). Population size has fluctuated markedly since then in response to varying levels of human exploitation (Fay et al. 1989). Large-scale harvesting prior to the 1960s is thought to have reduced the population to 50,000-100,000 animals (Fay et al. 1997). Numbers are believed to have increased rapidly in the 1960s and 1970s in response to reduced hunting pressure, adoption of harvest quotas, and regulations that limited the hunting of females (Fay et al. 1989).

Harvest quotas in the United States were eliminated beginning in 1979 (USFWS 2014), and available evidence (e.g., demographic data) suggests that the population has since declined (Garlich-Miller et al. 2011; USFWS 2014). The population is currently below carrying capacity (MacCracken 2012) but there is uncertainty regarding the factors limiting the population, since harvests have declined to record-low levels in recent years (J. MacCracken, USFWS, pers. comm.). Population growth may be limited by some combination of factors including habitat change (ice loss), declines in prey availability, subsistence harvest, and mortalities on haulouts (J. MacCracken, USFWS, pers. comm.).

Recent (since 2006) harvest levels have been much lower than the long-term average (USFWS 2014; J. MacCracken, USFWS, pers. comm.). Recent harvest data are shown in Table 3, and are available in a number of sources (Garlich-Miller et al. 2011; Shadbolt et al. 2014; USFWS 2014; Allen and Angliss 2015; J. MacCracken, USFWS, pers. comm.). These harvests have been corrected for struck and lost animals using data from Fay et al. (1994), who found an average struck and lost rate of 42%. The United States estimates are also corrected for non-compliance with reporting requirements. There is no information to suggest that illegal hunting is a significant management concern for Alaska, although charges have been laid in regard to trade in walrus parts (Shadbolt et al. 2014).

At present, the USFWS is responsible for management and conservation of the Pacific walrus in the USA. This authority was transferred to the USFWS from the State of Alaska in 1972 when the *Marine Mammal Protection Act* (MMPA) was implemented (USFWS 1994; Garlich-Miller et al. 2011; Shadbolt et al. 2014). Prior to this, walrus hunting was regulated by the State of Alaska.

Walruses are protected under the MMPA, and only qualified coastal-dwelling Alaska Natives are permitted to hunt Pacific walruses (USFWS 1994; Shadbolt et al. 2014). They can hunt for subsistence purposes or for making and selling authentic Native craft products, provided the harvest is not wasteful. The MMPA also has provisions for cooperative management agreements with Alaska Native organizations to provide for co-management of subsistence use (USFWS 2014). The USFWS signed a formal co-management agreement with the Eskimo Walrus Commission (EWC) in 1997 (Garlich-Miller et al. 2011; USFWS 2014 - see Appendix C of Shadbolt et al. 2014).

Provisions under the MMPA allowed states to re-assume management under guidelines developed by Federal agencies. The State of Alaska briefly resumed management of the Pacific walrus in 1972 with Federal provisions that limited the harvest to 3,000 walruses per year. In 1977, residents of Togiak, AK, filed a lawsuit against the United States arguing that their freedom to hunt marine mammals granted in the MMPA could not be restricted by re-instituting state conservation laws (Shadbolt et al. 2014). The court agreed and management authority was transferred back to the USFWS in 1979 (USFWS 1994).

The Alaska Department of Fish and Game (ADFG) works in cooperation with the USFWS and conducts research to complement projects undertaken by Native organizations and the Federal government. The ADFG promotes co-management of marine mammals with Alaska Native organizations (Shadbolt et al. 2014). A conservation plan for walruses in Alaska was developed in 1994 to ensure that they remain a sustained resource for coastal Native inhabitants of the region (USFWS 1994; Shadbolt et al. 2014).

Prior to the MMPA (1960 to 1972), state regulations imposed a harvest limit of five female walrus per subsistence hunter per year, with no limit on the number of males (USFWS 1994). The MMPA provides for more liberal regulations, and qualified Alaskan Natives are permitted to take walrus at any time of the year for subsistence or handicraft purposes, without restrictions on sex, age, and number of walrus, provided the harvest is not wasteful and the population is not considered to be depleted (USFWS 1994; Shadbolt et al. 2014).

The US government is required to manage the walrus population within optimum sustainable population (OSP) levels (USFWS 1994), which is defined by the MMPA to be “the number of animals which will result in the maximum productivity of the population or the species, keeping in mind the carrying capacity of the habitat and the health of the ecosystem of which they form a constituent element”. Under the MMPA, the Native harvest cannot be restricted if the population is above the level where net productivity is maximized and the harvest is non-wasteful (USFWS 1994; Shadbolt et al. 2014). If the population is considered depleted (i.e., the population falls below its OSP), then actions can be taken to regulate the harvest (USFWS 1994; see MacCracken et al. 2014 and Shadbolt et al. 2014 for additional details).

At present, there are no federally imposed quotas under the MMPA to regulate walrus harvest limits, but some local management programs have been developed (Garlich-Miller et al. 2011). The communities of Gambell and Savoonga on St. Lawrence Island have formed Marine Mammal Advisory Committees to implement local regulations that limit the number of adult/sub-adult walrus that can be killed per hunting trip. Another example is the harvesting rules set up in the Walrus Island-State Game Sanctuary (Garlich-Miller et al. 2011) (also see below re: Habitat Protection).

The USFWS administers two programs to monitor walrus hunting activities: the Marking Tagging and Reporting Program (MTRP) and the Walrus Harvest Monitoring Program (WHMP) (Garlich-Miller and Burn 1999; Shadbolt et al. 2014). The MTRP is a Federally mandated, year-round program that requires hunters to present walrus tusks to USFWS representatives for tagging (Garlich-Miller and Burn 1999). The ADFG conducted a harvest monitoring program in the 1960s and 70s, which was taken over by the USFWS in 1980 (MMC 2003). The WHMP is a co-management effort between the EWC and the USFWS, which was initially run in four communities and currently operates in two (Garlich-Miller and Burn 1999; Shadbolt et al. 2014). Village residents are compensated by the USFWS for collecting walrus harvest data from hunters after they return from hunting trips (Garlich-Miller and Burn 1999). Harvest estimates are derived by the USFWS, which integrates data from the MTRP and WHMP (MMC 2003). The two sources of data are combined to calculate annual reporting compliance, correct for any unreported harvest, and estimate total harvest. The USFWS uses the average annual harvest over the past five years as an estimate of current harvest levels in the USA and Russia (USFWS 2014 - also see Table 3). The Russian harvest data have been collected through an observer program and a reporting program instituted by the Russian Federation, however, this program is no longer active (J. MacCracken, USFWS, pers. comm.).

Under the MMPA, Alaska Natives are permitted to hunt walrus at any time of the year, except at Round Island (Walrus Island-State Game Sanctuary) where

a shorter autumn season is in place (USFWS 1994; Okonek and Snively 2005). Most hunting in Alaska takes place in spring, when walruses are hunted on and amongst ice floes in small boats (Garlich-Miller et al. 2011; Shadbolt et al. 2014).

## Habitat Protection

The MMPA emphasizes habitat and ecosystem protection, with goals that include protection of essential habitats, including rookeries, mating grounds, and areas of similar significance (Garlich-Miller et al. 2011). The typical seasonal distribution pattern, primary breeding areas, and locations of coastal haulouts in the Bering and Chukchi seas are generally well known (e.g., see maps in Smith 2010; USFWS 2014), but changes have been occurring in the past decade in response to loss of sea ice (Jay et al. 2012; Demer 2016; C. Jay, United States Geological Survey (USGS) pers. comm.) that require tracking.

Several important haulouts in Alaska are protected through private, state or Federal land use designations. The State of Alaska created the Walrus Island State Game Sanctuary in 1960, which includes Round Island (Garlich-Miller et al. 2011). Round Island is managed by the ADFG, and regulations are in place to protect the haulout there (Garlich-Miller et al. 2011). Access to the sanctuary is tightly controlled and boat access within a three-mile radius of the island is prohibited, although direct access to the island is authorized by permit and restricted to a designated travel corridor. Pilots are also requested to avoid flights below 5,000 feet above ground level. The creation of the Walrus Island State Game Sanctuary prohibited walrus hunting in the Round Island area (Garlich-Miller et al. 2011). In the early 1990s hunters from Bristol Bay petitioned to reinstate subsistence access, which was granted, and in 1995 the Qayassiq Walrus Commission (QWC) was formed. In September 1995, the USFWS entered into a cooperative agreement with the ADFG, the QWC and the EWC to co-manage a limited subsistence walrus hunt on Round Island (Okonek and Snively 2005). Limited harvests are allowed, but the haulout site is otherwise protected in the manner described above.

In 1980, the *Alaska National Interest Lands Conservation Act* created or expanded National Parks and National Wildlife Refuges in Alaska, which included the expansion of the Togiak National Wildlife Refuge (TNWR) (Garlich-Miller et al. 2011). The TNWR protects walrus haulouts at Cape Peirce and Cape Newenham. Access to Cape Peirce is tightly controlled through a permitted visitor program, which requires that visitors remain out of sight, downwind, and at least 100 yards from walruses (Garlich-Miller et al. 2011). Cape Newenham has no visitor program, as public access is extremely limited because of its proximity to Department of Defense land and facilities.

In recent years, the number of walruses coming ashore in summer and fall along the coastline of the Chukchi Sea in both Alaska and Russia has increased, and mortalities have occurred from disturbance events in both countries (Garlich-Miller et al. 2011; Garlich-Miller (ed.) 2012; USFWS 2014). Walruses are expected to become increasingly dependent on these coastal haulouts, and efficient management efforts to mitigate anthropogenic disturbances and associated mortality at these sites will be an important factor in walrus conservation.

Disturbances are expected to be greater at terrestrial haulouts than in offshore pack ice habitats, since the level of human activity (e.g., hunting, fishing, boating, air traffic) is much greater along the coast (Kochnev 2004; WWF 2010). Growing awareness of walrus sensitivity to disturbance at coastal haulouts has prompted the development of proactive local conservation and management initiatives (EWC 2008; Kavry et al. 2008; WWF 2010; Garlich-Miller et al. 2011; Garlich-Miller (ed.) 2012). In some cases, mortalities have been kept to a minimum through efforts of local villagers to reduce disturbance (Garlich-Miller et al. 2011). Modelling suggests that effective mitigation of potential stressors such as disturbance related mortalities at coastal haulouts could influence future population outcomes (Garlich-Miller et al. 2011).

The USFWS has also developed guidelines in conjunction with the Federal Aviation Administration to reduce human caused disturbances at terrestrial haulouts in Bristol Bay and along the Northwest coast of Alaska (Garlich-Miller et al. 2011). Similar coordination has occurred with the United States Coast Guard, the North Pacific Fisheries Management Council, and the State of Alaska to develop a notice to mariners requesting that marine vessel operators avoid transiting, fishing, tending, or anchoring within 0.5 – 1.0 mile (depending on vessel size) of walrus haulouts (J. MacCracken, USFWS, pers. comm.).

Oil and gas exploration and development, commercial fishing, and commercial shipping are currently limited in scope, intensity, and extent and are not a substantial concern with respect to walrus habitat impacts (Garlich-Miller et al. 2011). In recent years, there have been a number of seismic surveys conducted in the oil and gas lease sale area in the northeastern Chukchi Sea (USFWS 2014; NOAA NMFS 2016a). In summer, a large portion of the walrus population migrates into this region, which is considered particularly important habitat for female walrus with dependent young - especially the Hanna Shoal area. The USFWS monitors and mitigates potential impacts of oil and gas activities on walrus through Incidental Take Regulations (ITR) as authorized under the MMPA (in the MMPA, “Take” is defined to include the harassment of marine mammals, which is defined very broadly) (Garlich-Miller et al. 2011; USFWS 2014; NOAA NMFS 2016a). Companies must adopt measures to ensure that impacts to walrus and their habitats are minimized and that there are no unmitigable adverse impacts on walrus availability for subsistence use (USFWS 2014; NOAA NMFS 2016a). Oil and gas exploration is considered to pose a relatively minor threat to the Pacific walrus population, although a large oil spill could have significant impacts (Garlich-Miller et al. 2011). Current ITR also provided special considerations to limit potential impacts to walrus using the Hanna Shoal area. Oil and gas lease permits in state managed waters also contain specific requirements designed to protect walrus and their habitats (USFWS 2014).

In the United States there are numerous acts and regulations applicable to walrus management and conservation, such as the *Marine Protection, Research and Sanctuaries Act*, which is designed to protect coastal marine habitats (Garlich-Miller et al. 2011). These acts are not discussed in detail here, but are summarized elsewhere (Garlich-Miller et al. 2011; Shadbolt et al. 2014).



## INTERNATIONAL AGREEMENTS

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Regulations governing international trade identify illegally obtained products and encourage member countries to have a sustainable quota system (Wiig et al. 2014). Scientists in Canada and Greenland cooperate regarding assessments of shared stocks in the CHA-NWG and CCA-WG populations (Figure 3) but there is no formal agreement between the countries for the management of these stocks (Wiig et al. 2014). Brief summaries of some of the key international agreements that affect walrus conservation follow.

### Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention)

The Bern Convention is an international agreement between governments for nature conservation that covers most of the European Continent and parts of Africa (Council of Europe 1979). It lists the walrus on Appendix II, which identifies “Strictly protected fauna species”, and under Article 6 requires signatories to “*take appropriate and necessary legislative and administrative measures to ensure the special protection of the wild fauna species specified in Appendix II*”. Norway is the only signatory country that normally has walrus within its jurisdiction, and the waters of Svalbard and Jan Mayen where they occur are not included under the convention (Wiig et al. 2014). Norway has committed to a nature protection policy that is consistent with the Convention for these areas but what this means for walrus management is unclear. Russia and Greenland are not signatories to the Convention.

### Convention on the International Trade in Endangered Species (CITES) (Washington Convention)

CITES is an international agreement between most governments worldwide that aims to ensure that international trade in specimens of wild animals and plants does not threaten their survival (Anon. 1973). It lists walrus in Canada on CITES Appendix III, which requires that a CITES export permit verifying their origin be issued before walrus parts and derivatives can be exported between countries. A CITES review in 1987 concluded that increasing the level of protection for walrus in Canada by listing them on Appendix II was not justified (Hall 2003).

CITES reviews by Greenland in 2011 (GINR 2011; Wigg et al. 2014), 2015 (Ugarte 2015), and 2016 (F. Ugarte, GINR, pers. comm.) concluded that the exploitation of walrus in Greenland and export of walrus products from Greenland are not detrimental to the walrus stocks in East Greenland and West Greenland. The reviews also concluded that current exploitation from the latter, which is shared with Canada, is sustainable because total removals have not exceeded the estimated annual replacement yield. The same conclusion was reached for the Northwest Greenland stock in 2011 and 2015. This changed in 2016 when the Greenland review found that total removals from this shared population by Greenland and Canada (CCA-WG population) might not be sustainable (F. Ugarte, GINR, pers. comm.).



The effectiveness of CITES for regulating and monitoring international trade in walrus products is limited (Shadbolt et al. 2014). The data collected do not, for example, provide a useful estimate of how many walruses are represented in international trade. A single permit can cover one or many pieces, and the products from a single animal may be included in one or many permits. Countries do not have to prove that international trade is not detrimental to walruses in the wild before issuing export permits. This makes it difficult to determine the impact of international trade on the walruses, and whether items are sustainably sourced. Modern ivory can be difficult to distinguish from fossil ivory, so it is sometimes passed off as fossil ivory to circumvent the regulations. Few cases of illegal trade have been recorded, making it difficult to assess the extent of the problem and to target enforcement actions.

## The European Union Wildlife Trade Regulations

CITES is implemented in the European Union (EU) through a set of Regulations known as the EU Wildlife Trade Regulations, which came into effect in 1997 (EC 2014). These regulations are designed to ensure that the provisions of CITES are implemented uniformly in all EU member states. This measure was needed to reduce opportunities for illegal wildlife trade in the absence of systematic internal border controls within the EU (Taylor et al. 2012).

These regulations are more restrictive than those of CITES, as they allow trade to be regulated by quotas or other restrictions (Witting et al. 2014). For example, walruses are listed in Appendix B of the regulations, which means their products require an import permit for the EU. In 2008 the Scientific Review Group, which determines whether imports meet conservation conditions of the regulations, decided that these conditions were not met by commercially caught walruses from Greenland. This led to the suspension of imports of Atlantic walrus products from these hunts into the EU from Greenland.

## Eurasian Customs Union (ECU)

In 2007, Belarus, Kazakhstan and Russia established the Eurasian Customs Union (ECU), which removed border controls between these countries, creating an integrated customs area (Taylor et al. 2012; Vaisman et al. 2013). It allows CITES listed species to be traded freely between the ECU countries. These countries are all parties to CITES but they have not established regulations to develop a coordinated approach to controlling legal and illegal wildlife trade within the ECU, as the EU has done with its European Union Wildlife Trade Regulations. Other countries, including some that are not CITES signatories have expressed interest in joining the ECU. While the ECU is not meant to affect CITES implementation and enforcement, removal of these internal border controls does reduce opportunities for border control and enforcement, with implications for wildlife trade.

## North Atlantic Marine Mammal Commission (NAMMCO)

NAMMCO is an international body that was formed by agreement among Faroe Islands, Greenland, Iceland, and Norway in 1992 to foster cooperation on the conservation, management, and study of marine mammals in the North Atlantic (NAMMCO 1992). Many of the marine mammals in this region had not hitherto been covered by such an international agreement. A Working Group on Walrus provides advice on the species to the Scientific Committee, which responds to requests from the Council, which is the decision-making body of the Commission (Wiig et al. 2014). Specialists from both member and non-member countries (e.g., Canada, Russia, US) are invited to Working Group meetings to address the topics under discussion.

Canada is not a member of NAMMCO but has been invited to participate in meetings at all levels of the organization because it shares stocks of walruses and other marine mammals with Greenland (Wiig et al. 2014). In 2010 NAMMCO made recommendations to improve the management of these shared walrus stocks, including that “*A common management regime be established between Greenland and Canada on shared stocks of walruses.*” (NAMMCO 2011: 408-409). Canada has also been encouraged to join NAMMCO to facilitate the management of shared stocks.

## The Norwegian-Soviet Sealing Agreement of 1958

This bilateral agreement between Norway and Russia applies to waters of the North Atlantic east of Kap Farvel, Greenland, in which nationals of the two countries hunt seals, namely the Greenland and Norwegian seas, Denmark Strait and the area of Jan Mayen Island, and the Barents Sea (Article I) (UN 1958). It forbade the taking of walruses except under special licences that could be issued for the taking of a limited number of adult male walruses, exclusively for the needs of the local population and for expeditions, with the express proviso that the raw materials thus obtained shall be used for food, animal feed and other local domestic purposes. This Agreement confirmed the 1934 Soviet prohibition of ship-based hunting, the 1952 Norwegian prohibition of all walrus hunting, and the 1956 Soviet prohibition of all walrus hunting in the western Soviet Arctic (Øritsland 1973).

## The International Union for the Conservation of Nature (IUCN)

The IUCN is an international organization comprised of both governmental and non-governmental members that was established in 1948. Its mission is “*to influence, encourage and assist societies throughout the world to conserve the integrity and diversity of nature and to ensure that any use of natural resources is equitable and ecologically sustainable.*” ([www.iucn.org/about/](http://www.iucn.org/about/)). The IUCN has observer and consultative status at the United Nations, and plays a role in the implementation of several international conventions on nature conservation and biodiversity. One of its important products is the IUCN Red List of Threatened Species, which uses a scientific approach to evaluate risk of extinction. While the IUCN’s assessment of a species’ status may influence management decisions within member states, there is no mechanism for their enforcement on member states.

The IUCN Pinniped Specialist Group recently assessed the status of the Atlantic and Pacific walrus subspecies separately (Lowry 2015; Kovacs 2016), and the species-level assessment (Lowry 2016) combines those two analyses to assess the global status. Atlantic walrus was listed as Near Threatened (Kovacs 2016) and Pacific walrus (including those in the Laptev Sea) as Data Deficient (Lowry 2015). IUCN considered that all reasonable climate change scenarios predict drastic changes to walrus habitats that will lead to population declines, and this, combined with the limitations of the available abundance and trend data, supported the listing of the species as Vulnerable under criterion A3c (Lowry 2016). This criterion specifies a projected population size reduction of 30% suspected within the next three generations, based on a decline in quality of habitat. This is a change in the species status from the previous assessment in 2008, when it was assessed as “Data Deficient” (Lowry et al. 2008). The national Greenland IUCN red list has not been reviewed since 2007 (K.W. Hansen, WWF Denmark, pers. comm.).



In 2014, roughly 35,000 Pacific walrus hauled out near Point Lay, Alaska.

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# THREATS TO WALRUS CONSERVATION

*Walrus are gregarious, provide valuable products (meat, ivory), and have a narrow trophic niche and restricted seasonal distribution. These factors combine to make them vulnerable to overharvest and environmental changes (Born et al. 1995).*

Hunting continues to be an important limiting factor for some walrus populations but industrial development and climate change may become increasingly important. For example, shipping on a massive scale from iron mine development may soon disrupt Atlantic walrus habitats in Hudson Strait and Foxe Basin (Canada) year-round (NIRB 2012, 2014). Hydrocarbon exploration and development has the potential to affect Atlantic walruses east and west of Greenland (Mosbech et al. 2007; Boertmann et al. 2009a, 2013; Frederiksen et al. 2012; Merkel et al. 2012) and in the Barents Sea (Boltunov et al. 2010; Lydersen et al. 2012; Semyonova et al. 2015). Loss of sea ice is helping to enable these activities and others such as ship-based tourism (e.g., Stewart and Dawson 2011; Wiig et al. 2014).

The status review compiled for the Pacific walrus in response to a petition to list the subspecies under the U.S. *Endangered Species Act*, provides a comprehensive analysis of stressors affecting the Pacific walrus at that time and stressors that are anticipated to become more important in the future (Garlich-Miller et al. 2011). The primary current and emerging conservation threats identified by Garlich-Miller et al. (2011) and USFWS (2014) were (in order of importance) sea ice loss, hunting, haulout mortalities, shipping, and disease. Ocean acidification was too uncertain to rank at the time of the review. In 2017 the USFWS revised the assessment, which was the basis for its determination that the Pacific walrus does not warrant listing as threatened or endangered under the ESA (MacCracken et al. 2017; USFWS 2017). Stressors associated with oil and gas development are not currently a factor; hunting removals and haulout disturbances have declined; and shipping is greater than in the past but has also declined since 2013–2014. The magnitude of ice loss and resiliency of Pacific walruses to this change remain uncertain.

The conservation threats to walruses from human activities stem primarily from hunting, chemical releases, physical alteration of habitat, disturbances, and non-indigenous species introductions. Each of these stressors can also interact with climate change, which human activities also contribute to (IPCC 2014), and some may combine to have cumulative effects. Some can cause direct mortality, others may reduce fitness through contaminant loading, social disruption, displacement or confinement, injury, parasites or diseases, or nutritional changes stemming from food chain alteration. In combination, these effects can reduce walrus abundance, thereby having ecological impacts on predator and prey species, and have socio-economic costs by affecting hunting, tourism, and trade in handicrafts.

Protection of walruses from anthropogenic impacts other than hunting generally focuses on large-scale industrial activity (Wiig et al. 2014). In many areas the level of protection afforded walrus habitat depends entirely on the rigor with which Environmental Impact Assessments for these activities are conducted. The effectiveness of environmental protection regulations depends on industry compliance and the management authorities' ability to enforce compliance, which can be challenging in the remote areas occupied by walruses.

The discussion that follows is organized by threat, beginning with subsistence hunting for Atlantic and Pacific walruses, then research and live capture, industrial development, interactions with fisheries, habitat alteration, disturbances, ship strikes, pollution, species introductions, and climate change.

## SUBSISTENCE HUNTING

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Walrus hunts have traditionally provided important staples in the subsistence economies of the regions they occupy. These hunts are still of great social and cultural significance to indigenous peoples in Canada, Greenland, Alaska (USA) and Russia, and the economic value of the meat (in terms of replacement with store-bought foods) and ivory is substantial. In Canada, for example, the high cost of replacing country (traditional local) foods with those purchased from the store, the market for fermented walrus meat (igunak), the wish to obtain ivory to sell or carve, and the perceived benefits of traditional hunting activities are factors acting to maintain walrus harvests despite the high costs of hunting (Anderson and Garlich-Miller 1994; Loring 1996; Gustavson et al. 2008; D.B. Stewart et al. 2014a).

### Atlantic Walruses

In Canada, there has been a general shift in Atlantic walrus distribution away from human communities to areas that are less accessible (Kopaq 1987; Born et al. 1995; Kuppaq 1996; Immaroitok 1996; Paniaq 2005). This is not a new phenomenon and is related to changes in technology (Brody 1976), beginning with the introduction of whaleboats in the 1920s, which extended hunting ranges and enabled open-water hunting; accelerating with the introduction of motorized technology ca. 1940-60; and continuing as the range and speed of boats increases (see also Crowe 1969; Beaubier 1970; Orr et al. 1986). The extent to which distributional changes reflect declines as opposed to shifts is not always clear (DFO 2002). Changes in socio-economic conditions in Arctic Canada and Greenland (and the use of snowmobiles instead of dog teams in Canada) since the 1960s have led to reduced walrus harvests, despite increasing human population growth (D.B. Stewart et al. 2014a; Wiig et al. 2014).

Data on the historical harvests of Atlantic Walruses from Canadian waters are incomplete and vary widely in quality (see D.B. Stewart et al. 2014a, which elaborates on their sources and quality). The Walrus Protection Regulations under the *Fisheries Act* (Canada Privy Council 1980: P.C. 1980 -1216) enacted in 1980 reduced the number of walruses “an Indian or Inuk” could hunt and kill in one year from seven to four, except where annual community quotas were scheduled instead (Coral Harbour: 60, Sanikiluaq: 10, Arctic Bay: 10, and Clyde River: 20, all in Nunavut). Canadian harvest data summarized in Table 3 were gathered mostly by DFO and by Makivik Corporation’s Nunavik Research Centre. The data were not corrected for hunting losses and do not include information on the age or sex composition of the catch (D.B. Stewart et al. 2014a).

When the removal rates of walruses are determined, uncertainties in the reported landed harvest are compounded by uncertainty in loss rates (animals injured or killed but not secured) (D.B. Stewart et al. 2014a). Few estimates of loss rates exist for subsistence hunts and none for sport hunts. The existing loss rate data (Perey 1961; Freeman 1969-70, 1974-75; Beaubier 1970; Orr et al. 1986) are over 25 years old and may not reflect current hunting practices. Lower loss rates were observed at open water hunts in the Avanersuaq (Thule) area of northwest



Greenland (15-25%; Born and Kristensen 1981 cited in Born et al. 1995). Canadian Inuit hunters believe loss rates to be much lower (~5%) (DFO 2013a).

The hunting mortality that Atlantic walrus populations can sustain is not known. Estimates of sustainable yield range from 3 to 5% for a population that is between 59 and 91% of carrying capacity (DeMaster 1984). DFO uses the potential biological removal (PBR) method to estimate Canadian total allowable removals (TAR) as a step to estimating sustainable harvest levels. It is not known where Canadian stocks stand in relation to their carrying capacities so DFO has been using a conservative recovery factor ( $Fr$ ) of 0.5 for most management stocks when calculating PBRs, which by definition include all human-caused mortality (Stewart and Hamilton 2013). A recovery factor of 1.0 has also been used to calculate PBRs for walruses in Foxe Basin (Hammill et al. 2016a). In the absence of sustainable yield information specific to Atlantic walruses, DFO has been using a maximum replacement rate ( $R_{max}$ ) of 0.07, based on the instantaneous growth rate of 0.067 from a fast-growing Pacific Walrus population in the Russian Chukchi Sea (Sease and Chapman 1988:23). A replacement rate of 0.08 has been used to study the demography of Pacific walruses (Taylor and Udevitz 2015), to model the population dynamics of Atlantic walrus populations in Greenland (Witting and Born 2014), and to estimate total allowable removals of walruses in Foxe Basin (Hammill et al. 2016a). Predictions of sustainable removal for Atlantic walruses in the eastern Canadian Arctic are tentative as the population estimates they rely upon are incomplete, hunting pressures and loss rates are uncertain, other sources of mortality (e.g., ship strikes or net entanglements) are unknown, and the  $R_{max}$  may not be appropriate.

Using the PBR method, DFO has estimated TARs for six walrus stocks (DFO 2013b; Stewart and Hamilton 2013; Hammill et al. 2016b). The Canadian High Arctic - Northwest Greenland population (three stocks) appears able to sustain current Canadian removal rates but is also hunted in Greenland, where the 2016 CITES review found total removals may not be sustainable (F. Ugarte, GINR, pers. comm.). A better understanding of walrus movement patterns and total hunting mortality (i.e., including animals that are stuck and lost) is needed to assess the sustainability of the combined harvests (DFO 2013b). Removals may not be evenly partitioned among the three putative stocks. The ability of the Canadian Central Arctic - West Greenland population to sustain current hunting removal rates is uncertain, due to uncertainty in the abundance and survival estimates. Some walruses that summer in Canada winter in Greenland waters and may be hunted in both jurisdictions. The Greenland 2016 CITES review found that total removals from the shared South and East Baffin-West Greenland stock (of the CCA-WG population) are sustainable (F. Ugarte, GINR, pers. comm.). Estimates of the total allowable removals for walruses in Foxe Basin vary widely depending upon how the abundance and PBR are calculated (DFO 2013b; Hammill et al. 2016a). Again, the partitioning of harvests among management stocks is unknown (DFO 2013b). The ability to sustain current hunting removal rates from the Canadian Low Arctic population is also uncertain. It is unknown whether this population is homogeneous, consists of discrete stocks, or is part of the CCA-WG population (see also Hammill et al. 2016b; COSEWIC in press).

The subsistence hunting of walruses in east Greenland was considered sustainable by the 2016 Greenland CITES review (F. Ugarte, GINR, pers. comm.). The



Stretching of walrus hide at Savoonga St. Lawrence Island, Alaska.  
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Svalbard-Franz Josef Land walrus population (Wolkers et al. 2006) and Atlantic walrus in the Kara Sea-Barents Sea-Novaya Zemlya population (Anon. 1982; Shadbolt et al. 2014) are completely protected from hunting.

## Pacific walrus

The primary source of human-caused mortality for Pacific walrus is subsistence hunting, in both the United States (Alaska) and Russia (Chukotka); hunting of walrus in the Laptev Sea has been prohibited since 1982 (Anon. 1982; Shadbolt et al. 2014). Over the past 60 years the Pacific walrus population has sustained estimated annual harvest removals ranging from 3,184 to 16,127 animals (mean = 6,440) (USFWS 2014: Fig. 2). Harvest levels since 2006 are 5 to 68% lower than the long-term average. Recent reductions in harvest levels largely reflect changes in walrus distribution and access by hunters (USFWS 2014; Allen and Angliss 2015; J. MacCracken, USFWS, pers. comm.). Factors affecting harvest levels include the cessation of Russian commercial walrus harvests after 1991, changes in political, economic, and social conditions of subsistence hunters in Alaska and Chukotka; and effects of variable weather and ice conditions on hunting success (Allen and Angliss 2015). Hunters state that more frequent and severe storms are affecting hunting effort (EWC 2003; Oozeva et al. 2004; USFWS 2014). For example, the 2013, 2014, and 2015 walrus hunts at St. Lawrence Island (AK) was hampered by unusually windy, cold, wet weather coupled with sea ice that was packed tightly around the island (Caldwell 2013; J. MacCracken, USFWS, pers. comm.). Only about 340 walrus were caught in 2013, down from an annual average of about 1,200 over the previous decade, resulting in the State of Alaska declaring a subsistence economic disaster for St. Lawrence Island, which was expanded to Diomedede and Wales in 2015.

The USFWS uses the average annual harvest over the past five years as a representative estimate of current harvest levels. The U.S. annual harvest is estimated using data collected by direct observation and through a statewide regulatory and reporting program (USFWS 2014; Allen and Angliss 2015). These two data sources are combined to calculate annual reporting compliance and correct for unreported harvests. The total U.S. subsistence harvest is the sum of reported and estimated unreported harvests. Harvest estimates in Russia were collected through an observer program and a government-sponsored reporting program. To estimate total removals the estimated number harvested is multiplied by 1.72 to adjust for struck and lost walrus (i.e., those killed or wounded but not retrieved) (USFWS 2014). This factor is based on data collected from 1952 to 1972, when 440 (58%) of the walrus struck with one or more bullets were retrieved and 318 (42%) were lost (Fay et al. (1994). While equipment and hunting techniques have improved since then, this estimate remains the best available for Pacific walrus (USFWS 2014). About 55% of the animals struck and lost in Alaska died immediately and most of the wounded died shortly after being struck (Fay et al. 1994), so all walrus that have been shot with a firearm are assumed to have been mortally wounded. The current accuracy of this struck and lost correction factor is unknown (USFWS 2014; Allen and Angliss 2015).

Harvests from 2003 to 2007 are summarized in Allen and Angliss (2015), and 2006-2010 harvests are summarized in USFWS (2014) (the two source tables

provide slightly different data formats). Estimated harvest mortality for the 2003-2007 five-year period ranged from 4,960 to 5,457 walrus per year (Allen and Angliss 2015). Estimates for the 2006-2010 period, as reported in USFWS (2014), show a wider range, from 3,828 to 6,119 walrus per year. The 2010-2015 range is 1,708-2,126 (J. MacCracken, USFWS, pers. comm.). Sex ratios of the harvest have been 1.55:1 or 1.3:1 males to females for the U.S. component, depending on 5-year period, and 3.76:1 or 3.5:1 for the Russian walrus harvest (Allen and Angliss 2015; USFWS 2014). Overall, population-level removals are biased to males at a ratio of ca. 2.5:1.

Despite the extensive data on Pacific walrus harvests, estimates of absolute population size and population trend are uncertain due to the bias and imprecision in estimated population sizes over time (Hills and Gilbert 1994; Taylor and Udevitz 2015). Largely because of unreliable abundance estimates, the proportion of the population that is being harvested each year is not known with certainty, although based on the 2006 estimate of 129,000, as a minimum population estimate, harvest is at <4% of the population. Walrus have a  $\geq 15$  month gestation that extends through the following breeding season, precluding a full-term calf from being born more frequently than once every 2 years (Fay 1982). Because of their low reproductive rate and a long life span the natural survival of walrus is believed to be high, but it has not been directly estimated (Taylor and Udevitz 2015). If the population declines in response to other factors, such as sea ice loss, harvesting the same number of walrus annually could increase the effective harvest rate and exacerbate population declines (Jay et al. 2011).



Researchers test walrus biopsy sampling equipment.

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## RESEARCH AND LIVE-CAPTURE

No mortalities or serious injuries were associated with research activities on Pacific walrus (satellite-tagging, biopsy sampling) conducted from 2003 to 2015, but one calf died in 2011 when walrus at the Point Lay, Alaska haulout cleared the beach as USGS researchers and local guides boated past (USFWS 2014; Allen and Angliss 2015; J. MacCracken, USFWS, pers. comm.). Four orphaned calves were rescued from the wild and placed on public display between 2003 and 2007 (Allan and Angliss 2015). Up to 52 calves were captured in Russia and placed on public display from 2006 to 2010, and another 3 calves were found on a beach in Alaska in 2012 and taken into captivity (USFWS 2014).

## INDUSTRIAL DEVELOPMENT

Atlantic walrus in Canada will be exposed to new industrial activities (DFO 2013b), including greatly increased shipping associated with reduced ice and increased exploration and extraction of minerals and hydrocarbons in the Canadian Arctic (Smith and Stephenson 2013). For example, the Baffinland Iron Mine project, which the Nunavut Impact Review Board's environmental impact assessment concluded could proceed (see NIRB 2012), would greatly increase shipping traffic, both in frequency of passages and seasonal extent (12 months) through Hudson Strait and Foxe Basin (BIMC 2012). It has begun shipping up to 4.2 mil-

lion tonnes of iron ore through Davis Strait, Baffin Bay, Pond Inlet, and Eclipse Sound annually during the open water period, and has proposed to increase iron ore shipping via Milne Port from to 12 million tonnes per year (NIRB 2015). Many other mineral deposits that require shipping are also in various stages of exploration and/or development in the Canadian Arctic (Gavrillchuk and Lesage 2014; NIRB 2014).

Inuit in the Belcher Islands of southeastern Hudson Bay, Canada have expressed concern that hydroelectric developments are reducing winter currents, and contributing to heavier ice conditions that harm overwintering marine birds and mammals (Federal Review Panel for the Eastmain-1-A Diversion Project 2006:346; Stewart and Hamilton 2007). Fresh water released to meet winter power demands may be diluting the offshore surface waters, enabling ice to form more rapidly and entrap wildlife (J. Heath cited in George 2013). Such formation might reduce wintering success of the Canadian Low Arctic walrus population.

Future large-scale exploration for hydrocarbons is probable west and east of Greenland. Exploration activities in eastern Baffin Bay, offshore northwestern Greenland, have the potential to adversely impact the Baffin Bay walrus stock (Boertmann et al. 2009a); in southeastern Baffin Bay, Davis Strait and the northern Labrador Sea offshore Greenland have the potential to adversely impact the South and East Baffin-West Greenland walrus stock (Mosbech et al. 2007; Frederiksen et al. 2012; Merkel et al. 2012; Boertmann et al. 2013); and offshore northeastern Greenland have the potential to adversely impact the East Greenland walrus population (Boertmann et al. 2009a). There is also interest in lead-zinc mine development in East Greenland that would involve shipping (M. Frost, WWF Greenland, pers. comm.). Svalbard and the northern part of the Barents Sea (north of Bear Island) currently have little industrial activity and petroleum related activities are still not allowed (Wiig et al. 2014).

Threats to Atlantic walruses in Russian waters are currently related mostly to development of oil and gas fields. In Franz Josef Land, most of the walrus range is protected within the Franz Josef Land Federal State Zakaznik (Wildlife Reserve) but the area immediately south of the zakaznik may soon be exposed to hydrocarbon development (M. Gavrilov, RANP, pers. comm.). In the southeastern Barents Sea (or Pechora Sea) and southwestern Kara Sea extensive petroleum exploration, development, production, and transport are ongoing (Boltunov et al. 2010; Chernook et al. 2012; Lydersen et al. 2012:1555; Semyonova et al. 2015; M. Gavrilov, RANP, pers. comm.). Shelf areas of both seas are being prospected for petroleum deposits and licenses have been issued in areas next to or overlapping important walrus habitats (M. Gavrilov, RANP, pers. comm.). Shipping along the Northern Sea Route is increasing to support these activities and to transport oil, gas and other mineral resources from Siberia to Western Europe. Risks to walruses and their prey from these industrial activities are not well understood and require more thorough research and monitoring of these animals. Lydersen et al. 2012:1555). A 15-mile exclusion zone on the development of onshore and offshore infrastructure, applying to the haulouts and surrounding water and shoreline, has been recommended to protect walruses on the Vaigach (Lyamchin Peninsula), Matveyev, Britvin, and Pukhovoy islands (southern Novaya Zemlya); and on the Oranskiye islands, and Cape Konstantin (northern Novaya Zemlya) which, as part of the National Park, already have a 12-mile protected zone (Semyonova et al. 2015; M. Gavrilov, RANP, pers. comm.).

Shelf regions of the Laptev Sea are polluted by a number of inland industries and activities (Tsyban et al. 2005). River run-off and atmospheric transport play an important role in marine pollution. Sources of pollution include oil and gas exploration and production, inland water and sea transport, ore mining and processing, accidental oil spills and discharges, and effluent from towns and settlements situated on the coast and along rivers such as the Lena River (Tsyban et al. 2005). With the extended ice navigation season ships tend to use polynyas, which are vitally important habitat for walrus that overwinter in the Laptev Sea (M. Gavriilo, RANP, pers. comm.).

Oil and gas exploration blocks in the Chukchi Sea overlap with shallow, productive, ice covered habitat used by a significant proportion of the Pacific walrus population each summer (Garlich-Miller et al. 2011). The waters of the eastern Chukchi Sea are considered particularly important habitat for female walrus and their dependent young. In 2009, 2010, and 2011 a number of seismic surveys were conducted in the lease sale area (USFWS 2014). The USFWS monitors and mitigates potential impacts of oil and gas activities on walrus through incidental take regulations (ITR) as authorized under the MMPA (USFWS 2014; Allen and Angliss 2015). These regulations require measures to ensure that impacts to walrus remain negligible, minimize habitat impacts, and eliminate adverse impacts on walrus availability for subsistence use. The current ITRs were renewed in 2013 for another five years (USFWS 2014). The Hanna Shoal area seems to be particularly attractive to walrus summering in the Chukchi Sea, and the current ITRs also provide special considerations to limit potential impacts to walrus utilizing this area (USFWS 2014). Current levels of oil and gas exploration are considered to pose a relatively minor threat to the Pacific walrus population (USFWS 2011), but a large oil spill could significantly impact the population depending on timing, location, amount and type of oil, efficacy of response efforts, etc. (USFWS 2014).

Decreases in summer sea ice extent may lead to increased opportunities for commercial shipping through the Arctic, leading to increased risk of disturbance, habitat modification (e.g., through ice-breaking), and increased risk of spills and discharge of pollutants (Tynan and Demaster 1997; Moore 2005; Laidre et al. 2008; Garlich-Miller et al. 2011). Transits through the Bering Strait have increased significantly in recent years and are currently outpacing regulatory efforts to define shipping channels, seasons of use, and mitigation measures (USFWS 2014). Commercial shipping is expected to increase in the future, but shipping is not currently impacting the Pacific walrus population to any great degree and is not expected to be a major source of mortality in the future (Garlich-Miller et al. 2011; USFWS 2014).

## INTERACTIONS WITH FISHERIES

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Direct conflicts of Pacific walrus with fisheries for other species are uncommon, and mortality and serious injury from these interactions is considered insignificant (< 2 mortalities/year in Alaskan fisheries) (Lowry et al. 2008; USFWS 2011, 2014; Allen and Angliss 2015). However, disturbances caused by fisheries that overlap walrus habitats could displace walrus from their preferred feeding

habitats, cause them to abandon haulouts, and interfere with their communications (COSEWIC in press). At present, this is unlikely to be a significant problem. Arctic fisheries are also unlikely to compete directly with walrus for food or to cause significant damage to their feeding habitats due to a variety of economic and environmental factors. Fish stocks in the Laptev Sea are not large enough to support the establishment of a large industrial fishery (Tsyban et al. 2005). There are no known interactions of the Svalbard-Franz Josef Land walrus population with commercial fisheries (Wolkers et al. 2006).

## HABITAT ALTERATION

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Walrus are vulnerable to the loss of both terrestrial and ice habitats. They require access to suitable terrestrial haulouts when suitable ice platforms are absent, and vice versa. Human activities, such as port construction that alter shorelines in the vicinity of terrestrial haulouts or shipping that changes the quality or presence of sea ice, risk driving walrus from an area. Fragmentation of sea ice can have ecological consequences (Sahanatian and Derocher 2012). It could affect habitat use by walrus during low ice years when pack ice for hauling out is limited, or alter breeding habitat. There may also be a risk of walrus mortalities from following ship tracks through the ice if these tracks then freeze, or of mortalities or injuries from crushing by shifting ice. Walrus may not be able to penetrate refrozen ship tracks and these tracks can provide rough ice in which polar bears may hide more easily.

The potential effects on walrus of long-term exposure to year-round shipping that has been approved to support iron ore development on Baffin Island are unknown. This vessel traffic could disrupt ice environments in Hudson Strait and Foxe Basin and affect the Canadian Central Arctic - West Greenland population. Shipping for non-renewable resource development projects that are in various stages of exploration and development could impact other populations in the future.

## DISTURBANCES (NOISE, SMELL, SIGHT)

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Walrus are sensitive to disturbances caused by human activities and other sources. Their response to disturbance may affect population dynamics by causing stampedes, interfering with feeding and increasing energy expenditures—particularly on the part of calves, and by masking communications, impairing thermoregulation and increasing stress levels (Stewart et al. (ed.) 1993). Walrus have poor eyesight but fairly acute hearing and an acute sense of smell (Loughrey 1959). They can probably distinguish large moving objects such as boats visually at a distance of ~60 m but were unable to identify a stationary person within 6 m unless they were silhouetted. Atlantic walrus will reply to hunters imitating their vocalizations from a distance of ca. 1 km (Loughrey 1959). They detected the sound of a Bell 206 helicopter up to 8 km away, oriented toward the sea when it was within 1.3 km and sometimes escaped into the water immediately thereafter (Salter 1979a). Pacific walrus dispersed when a jet air-

Research helicopter, Svalbard.

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craft passed overhead at an altitude of about 9000 m (Okonek et al. 2009), and when a plane flew within 800 m (Okonek et al. 2010). Walruses seem to rely on their sense of smell to warn of danger (Loughrey 1959). When approached from upwind they will stampede into the water before the threat (e.g., person) can be seen.

Reactions to vessel noise vary depending upon the animals' previous experiences (Born et al. 1995). Those from hunted populations tend to be skittish when approached by boats but when asleep can sometimes be approached within 10-20 m. Ice breaking activities caused Pacific walruses to enter the water: females and calves when the ship was within 500–1000 m and males when it was within 100–300 m. They moved 20–25 km away from the disturbance if it continued, but returned after it stopped. The effects, if any, of pulsed noise from seismic exploration are unknown, as is the ability of walruses to habituate to noise. Underwater noise might disrupt the transmission of important sounds made by walruses, such as vocalizations during the breeding season and mother-calf communications (Moore et al. 2012; Stewart et al. 2012).

Walruses at dense coastal haulouts are particularly vulnerable to disturbances, including low-level aircraft overflights and near-shore passage of vessels that can cause mortality from stampedes (Fay and Kelly 1980; Ovsyanikov et al. 1994; Kavry et al. 2006, 2008). Such mortalities also occur from natural sources (poor condition, old age, injuries, predation, thunder storms, etc.) at an unknown background level (USFWS 2014). Mortalities due to human-caused stampedes are hard to quantify, as most events are observed after the fact or go undetected (Fay and Kelley 1980; Fischbach et al. 2009). Haulout mortalities have been documented in both Russia and Alaska in recent years (Fischbach et al. 2009; USFWS 2014). Haulout protection programs in Russia and Alaska may be a successful management tool for reducing disturbance-related mortalities (USFWS 2014).

Young animals and those in poor condition are particularly vulnerable to trampling if herds are stampeded onshore or offshore (Kavry et al. 2006, 2008). Pacific walruses sometimes haul out in very large numbers along the Chukotka coast on Cape Vankarem (30,000 walruses) and Cape Kozhenikov (40,000), and nearby on Karkapko Islet (1,000). The majority of these animals are females and calves. In autumn 2007, disturbance by humans who approached too close was a major contributor to unprecedented high mortality of walruses in the vicinity of capes Kozhenikov (577 carcasses) and Venkarem (>200) (Kavry et al. 2006, 2008; Arnbom 2009; T. Arnbom, WWF Sweden, pers. comm.). A similar mortality event occurred in 2008 (Arnbom 2009). At St. Lawrence Island in the Bering Sea where at least 537 Pacific walruses died in October-November 1978, trampling may have been one cause of the mortality (Fay and Kelly 1980). Some of the animals examined had been attacked by killer whales (*Orcinus orca*), which may have stampeded the large herd ashore, resulting in death by trampling of smaller or weaker individuals. About 400 carcasses also washed ashore from various sources and about 15% of the total mortality consisted of aborted fetuses. The latter likely resulted from physical trauma but an infectious or toxic agent could not be ruled out. Mortality on such a scale has not been reported for Atlantic walruses, but stampedes do cause some mortality (Loughrey 1959). Prolonged or repeated disturbances may cause walruses to abandon a haulout (Salter 1979a). Haulout disturbances are a particular concern in areas where ship-based tourism



is occurring, such as Svalbard and Canada (Wiig et al. 2014).

Ship-based tourism is relatively recent in Franz Josef Land and in Severnaya Zemlya where it is less common (M. Gavrilov, RANP, pers. comm.). In 2015, a marine border checkpoint was established in Franz Josef Land, enabling direct passage of cruise ships from Svalbard and increasing traffic. Cruise ships bring thousands of visitors to the coastal areas, and walrus watching is one of the main attractions. Disturbance by tourism may have serious negative impacts on walrus using the haulouts, especially in Franz Josef Land, at Victoria Island, and in northern Novaya Zemlya where many females and calves are present.



Ship, Svalbard.

© WWF / Sindre Kinnerød

## SHIP STRIKES

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The threat of mortality or injury from ship strikes is uncertain (D.B. Stewart et al. 2014b). Walrus are quick and maneuverable in the water and should be able to detect and avoid vessels approaching in open water. Icebreaking may represent a bigger threat, especially during the breeding season when animals may be clustered, males are aggressively defending territories, and escape options are limited by ice. The species' gregarious nature and vigorous defense of calves may cause individuals or groups to challenge ships, which could lead to injury or possibly mortality if they are struck, trapped by ice, or entrained by propeller suction. In many areas, walrus will have limited experience with ship passage, particularly in winter. Whether this unfamiliarity will make them more or less apt to avoid ships is unknown. Marine mammal observations from Arctic shipping as part of environmental impact assessment and monitoring may provide the data needed to properly assess this threat.

## POLLUTION

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The effects of chemical contaminants on walrus are largely unknown because the animals are large, isolated, and difficult to study experimentally (e.g., Wage-mann and Stewart 1994; de March et al. 1998; Fisk et al. (ed.) 2003). Because walrus excavate much of their food from the bottom sediment, they can accumulate naturally occurring cadmium and lead in their tissues at elevated concentrations relative to other marine mammals in the same region (Outridge et al. 1997, 2002). Levels of organochlorines in walrus tissues are generally low because they primarily feed low in the food web (Norstrom and Muir 2000). Their levels are typically 4–10 times lower than those of beluga whales (*Delphinapterus leucas*) from the same area, but with a similar pattern of residues. The highest levels are found in individuals that are thought to eat seals, which accumulate these contaminants in their blubber (Muir et al. 1995).

Pollution levels are too low to cause mortality or any impediment to reproduction in the Svalbard-Franz Josef Land walrus population (Wolkers et al. 2006). In contrast, the remains of a walrus from the Kolguev Island area of the Bar-ents Sea contained 7 to 70 times the total polychlorinated biphenyls ( $\Sigma$ PCBs, 62 congeners; 1597.4 ng/g of lipid cf. 28.9–236 ng/g of lipid) found in fat tissue of Pacific walrus from the Chukchi Sea (Semyonova et al. 2012). Further research

is needed to assess the risk from persistent organic pollutants to walrus in the Barents Sea.

The direct and indirect effects of petroleum on walrus have not been studied. Born et al. (1995) believed that several aspects of the species' ecology may make it vulnerable to oil pollution, in particular, its gregariousness, which may spread oil from animal to animal, its preference for coastal areas and loose pack ice where oil may be more likely to accumulate, and its reliance on benthic molluscs which may accumulate petroleum hydrocarbons or succumb to the oil. Oil fouling is unlikely to cause hypothermia due to their thick blubber but, like seals, walrus may continue to use haulouts that have been fouled (Isaksen et al. 1998). This could lead to irritation and damage to the eyes and skin and increased exposure to the deleterious effects of inhaling aromatic hydrocarbons (neuronal damage). They would also be vulnerable to disturbance and possibly stampedes during clean-up activities. Walrus populations may be most vulnerable to harm from oil spills during the calving period, and calves may be the most vulnerable component of the population (Born et al. 1995). Contamination due to increased shipping traffic is likely to increase as a stressor of walrus in the Chukchi Sea (Jay et al. 2011), and elsewhere, as ice reductions make areas occupied by walrus more accessible to human activities. Oil and gas exploration and development, discussed earlier under "Industrial Development", also has the potential to expose some walrus from most populations to hydrocarbon contamination in the future.

## SPECIES INTRODUCTIONS

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As circumpolar shipping increases, the risk of introducing non-indigenous species into walrus habitats on fouled ships hulls or in discharged ballast water also increases. Little is known about what non-indigenous species might be introduced, their ability to establish, or potential impacts to indigenous species such as the Atlantic walrus (Stewart and Howland 2009; Chan et al. 2012; Stewart et al. 2015). It is important that there be a better understanding of this pathway, given that shipping is likely to increase substantially over the next decade and vessels involved in resource extraction from mines and wells in the circumpolar Arctic will arrive empty and in ballast. Vulnerability of walrus to changes in the species composition, abundance, and growth of benthic invertebrates is unknown but potentially serious. Walrus eat a wide variety of organisms (e.g., Fay et al. 1986; Fisher and Stewart 1997; Seymour et al. 2014a, 2014b) and may be able to shift their foraging patterns to compensate for changes, but they also eat a lot and thus would be vulnerable to declines in the abundance and/or size of key prey species. The introduction of a non-indigenous disease that causes shellfish die-off could therefore be serious. Little is known about diseases of walrus or the potential for harm from parasites or diseases that might be introduced via biota carried in ballast water or on ships hulls.



Walrus resting on drift ice,  
Svalbard.

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Liodden / WWF

## CLIMATE CHANGE

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The effects of climate change on walrus habitat will be very complex. The directions and magnitudes of these changes will vary seasonally and regionally, making prediction of their impacts on walruses very difficult. All aspects of the species ecology are likely to be affected by a combination of changes in the ice platform, foraging opportunities, and other factors.

Major changes in sea ice conditions are occurring throughout the circumpolar region (Parkinson and Cavalieri 2008; Sahanatien and Derocher 2012; Parkinson 2014; Frey et al. 2015). The effects of a decrease in the extent and duration of Arctic sea ice in response to warming will depend upon the geographical location. Quality of the ice cover, water depth, bottom substrate, and availability of suitable terrestrial haulouts will be particularly important. Loss of ice cover in areas with terrestrial haulouts may increase food availability for walruses by improving access to feeding areas in shallow inshore waters that are currently covered in winter by landfast ice (Born et al. 2003; Born and Wiig 2005; Laidre et al. 2008). This effect will be greatest in areas with extensive landfast ice that extends offshore over waters deeper than ca. 100 m. On the other hand, loss of ice cover in shallow feeding areas that are situated offshore, far from suitable terrestrial haulouts, may greatly reduce the seasonal feeding distribution, leading to crowding at haulouts and reduced abundance (Kovacs et al. 2011; Taylor and Udevitz 2015).

Warming and loss of ice cover could alter the benthic biomass of key prey for walruses (Piepenburg 2005; Grebmeier et al. 2006, 2015; Bluhm and Gradinger 2008; Kovacs et al. 2014). The direction and magnitude of the change is uncertain and likely to vary over time and space. Initially increases in water temperature and incident light might stimulate primary production, enhancing export production of phytodetritus to benthic macrinvertebrate species, and thereby increasing food for the walruses (Grebmeier et al. 2015). Continued warming and freshening of the surface waters could have the opposite effect, by strength-

ening stratification of the water column and thereby limiting the availability of nutrients required for photosynthesis and primary production. Warming and freshening of the surface water inflow earlier in the season could have complex and regionally variable impacts on phytoplankton production, on the timing and development of zooplankton communities, and consequently on the strength of pelagic-benthic coupling and the benthic biomass of key prey for walrus (Grebmeier et al. 2006, 2015). Piepenburg (2005) has hypothesized that increased fluvial runoff and reduced ice cover could lead to a shift in the relative importance of sea-ice, pelagic and benthic biota in the overall carbon and energy flux, ultimately resulting in a switch from a 'sea-ice algae–benthos' to a 'phytoplankton– zooplankton' dominance; which could reduce benthic production and thereby food for walrus (Bluhm and Gradinger 2008; Kovacs et al. 2014).

Ocean acidification related to increased atmospheric CO<sub>2</sub> may also alter trophic dynamics by reducing the availability of calcium to marine invertebrates, and by altering host-pathogen relationships in favour of pathogens (Azetsu and Scott et al. 2010; Garlich-Miller et al. 2011; AMAP 2013; Kroeker et al. 2013; Asplund et al. 2014; USFWS 2014; Yamamoto-Kawai et al. 2016; Qi et al. 2017). The likelihood of such trophic changes, their time horizon, and possible effects on the abundance and composition of walrus prey and thereby walrus are unknown. This threat is an issue of concern because lower pH levels can interfere with invertebrate shell formation and erode existing shells (Garlich-Miller et al. 2011; USFWS 2014). Walrus have a wide prey base that includes >100 benthic invertebrate taxa from all major phyla (Fay et al. 1986; Fisher and Stewart 1997; Sheffield and Grebmeier 2009; Seymour et al. 2014a). Walrus are highly adapted for obtaining bivalves, but they also have the potential to switch to other prey items if bivalves and other calcifying invertebrate populations decline (USFWS 2014). Whether other prey items would meet their nutritional needs is not known (Sheffield and Grebmeier 2009). There is also uncertainty about the extent to which other suitable non-bivalve prey might be available, mainly due to uncertainty about the effects of ocean acidification (USFWS 2014).

The impacts of changes in Arctic and subarctic ice dynamics on Pacific walrus are not well understood (Garlich-Miller et al. 2011). Walrus use sea ice as a substrate for birthing, nursing, and resting between foraging trips. Declines in sea ice extent have been documented, and are predicted to continue, in both summer and winter habitats (Meier et al. 2007; Overland and Wang 2007; Stroeve et al. 2008; Douglas 2010; NSIDC 2012). In recent years, summer sea ice extent in the Chukchi Sea has retreated off the shallow continental shelf to over deep Arctic Ocean waters, where walrus cannot forage effectively (USFWS 2014). Females with dependent young are the animals most likely to be affected by changes in energy expenditure or competition (Garlich-Miller et al. 2011). They require a platform upon which to haulout and rest between foraging trips, so they must remain closer to ice or shore than the males, which can remain at sea for extended periods (Taylor and Udevitz 2015). These impacts of summer sea ice declines have been documented but ice loss may also impact walrus directly during other seasons via declines in their sea-ice breeding habitat (Kovacs et al. 2014).

In the Bering and Chukchi seas, the effect of diminished sea ice on walrus behavior is already evidenced by their increased use of land haul-outs (Kavry et

al. 2006, 2008; Jay and Fischbach 2008), and by foraging in September and October in nearshore rather than offshore areas as in the past (Jay et al. 2012). Numbers of walrus coming ashore along Chukchi Sea coast in both Alaska and Russia have increased over the past decade (Kavry et al. 2006, 2008; Boltunov and Nikiforov 2008; Garlich-Miller et al. 2011; Jay et al. 2011). Female and young walrus are arriving earlier and staying longer at coastal haulouts as summer ice disappears, with numbers in the tens of thousands at some haulouts in both Russia and Alaska (Kavry et al. 2006, 2008; USFWS 2014; Allen and Angliss 2015).

Demographic changes related to ice loss have not yet been detected in the Bering and Chukchi population (Taylor and Udevitz 2015). It is not known whether the food supply within foraging range of coastal haulouts is able to support such large numbers of walrus over the long term (Garlich-Miller et al. 2011; USFWS 2014). Thin animals that appear to be physiologically stressed have been reported from Chukotka and Alaska (Ovsyanikov and Menyushina 2008; Ovsyanikov et al. 2008; Garlich-Miller et al. 2011), but the majority of walrus observed at fall haulouts in Alaska in 2010 and 2011 were in good physical condition (USFWS 2014). If benthic communities near coastal haul-outs are unable to provide sufficient food (Jay and Hills 2005) nutritional stress may result in reduced reproduction, juvenile survival, and possibly adult female survival (Jay et al. 2011). Trampling and mass mortality of calves may be more likely when disturbances stampede these very large concentrations of walrus that are hauled out on land (Udevitz et al. 2013).

When sea ice is not available walrus must haul out on land. The fossil record suggests that 9,000 to 1,000 years ago, when walrus occupied areas along the east coast of Canada, summer surface water temperatures there may have ranged between 12 and 15°C (Miller 1997). Whether these animals summered in these warm waters or moved north into cooler waters is unknown. Within the last few hundred years they thrived in the Gulf of St Lawrence and on the Scotian Shelf (Shuldham 1775; Stewart 1806; Perley 1850; Gilpin 1869; Allen 1880). Clearly, walrus are capable of thriving on boreal bivalves if there is a northward movement of these species in response to warming, although such a prey shift might not be without problems.

The Pacific walrus also persisted in the geologic past, apparently during periods when ice was absent or at least more limited (Jay et al. 2011). Behavioural and physiological responses to changes in air temperature suggest that Pacific walrus calves can maintain their body temperature at an air temperature of 18°C in still air and shade (Fay and Ray 1968; Ray and Fay 1968). Above this temperature, they go into the water to avoid overheating. Air temperatures at or above this level for an extended period of time might disrupt normal feeding, moulting, and calving schedules.

Some populations of Atlantic walrus may be less vulnerable to ice loss than Pacific walrus (Jay et al. 2011; Kovacs et al. 2011). Fischbach et al. (2009) have postulated that the mortality of 131 young Pacific walrus along the Chukchi Sea coast near Icy Cape, Alaska, in mid-September 2009 was related to loss of sea ice cover over the continental shelf, but this cannot be confirmed. A large mortality event involving Pacific walrus at Wrangel Island in 2007 was also coincident

with light ice conditions and polar bear predation (Ovsyanikov and Menyushina 2008; Ovsyanikov et al. 2008). Evidence of similar mortality events is lacking for Atlantic walrus. In the event of ice loss, fewer Atlantic walrus populations may need to increase energy expenditure to access distant foraging areas. This may apply in particular to the Canadian eastern Arctic where there are large shallow areas near shore, many islands, and a high degree of shoreline complexity that afford haulouts within range of feeding areas. Atlantic walrus in Russian waters are highly dependent on sea ice and show little evidence of adaptation to ice-free environments (M. Gavilo, RANP, pers. comm.). Atlantic walrus are unlikely to congregate at haulouts in the very large numbers for protracted periods reported for Pacific walrus, or to experience the same intraspecific competition for limited food resources near the haulouts.

Indirect effects of climate change may pose a greater threat to walrus than the change itself. Sea ice loss that increases interactions with humans may impact walrus more than other environmental factors (COSEWIC in press). In Canada, winter hunting pressure on walrus may decrease as ice conditions become less predictable (Laidler 2007). The duration of open-water access to walrus may increase in response to ice loss, and walrus may also become more concentrated at terrestrial haulouts (Born and Wiig 2005; NAMMCO 2006), but whether the overall hunting pressure will increase in response is unknown. In Canada, careful regulation of Inuit hunting may be required to prevent walrus disappearing from haulouts as they did in West and Northwest Greenland during the 20th century (Born and Wiig 2005). Earlier loss of sea ice could prompt Arctic marine fisheries to expand into areas that have not hitherto been fished commercially (Christiansen et al. 2014), increasing the potential for interactions between walrus and fisheries.

The impacts of climate change on future subsistence harvests of Pacific walrus are difficult to predict (Hovelrsrud 2008). Subsistence harvests have declined in recent years, due to a faster spring migration and more frequent severe storms that have limited hunting opportunities during the spring migration (Kapsch et al. 2010; USFWS 2014). Animals are being harvested earlier in the spring and earlier in the winter than during previous decades, demonstrating hunter adaptations to changing environmental conditions (USFWS 2014; Allen and Angliss 2015). Garlich-Miller et al. (2011) assumed that summer sea ice loss would result in a walrus population decline over time, and that subsistence harvests could become unsustainable if not reduced in concert with any population declines. The Native Villages of Gambell and Savoonga (Alaska) have recently adopted trip limit ordinances, and a Tribal Wildlife Grant was acquired to ensure administration (USFWS 2014; Allen and Angliss 2015). These are positive developments for the continued management of subsistence harvests. The USFWS, in cooperation with the Russian Federation, had established a comprehensive monitoring program to gather detailed information on harvest trends and characteristics (Allen and Angliss 2015), but this may no longer be active (J. MacCracken, USFWS, pers. comm.). The USFWS has developed Cooperative Agreements with the Eskimo Walrus Commission annually since 1997 to facilitate local participation in walrus conservation and management activities in Alaska (USFWS 2014). This co-management process is ongoing.

Predation by polar bears and killer whales may also increase as walrus are forced to make greater use of terrestrial sites and spend more time in open water

(Garlich-Miller et al. 2011). Young walrus will be most at risk from predation by these species. Walrus are consumed most often by older male polar bears, and there is spatial variation in the importance of walrus as a prey item (Thiemann et al. 2007, 2008; Galicia et al. 2015). Killer whales prey on Pacific walrus (Kryukova et al. 2012) but Inuit indicate that killer whales in the eastern Canadian Arctic rarely if ever feed on Atlantic walrus (Ferguson et al. 2012). If the availability of their other prey declines they may learn to successfully hunt walrus.

Disease and parasite transmission could increase in response to increased terrestrial haulout use (Burek et al. 2008; Sonsthagen et al. 2012). Walrus might also be exposed to novel pathogens and parasites as vector species expand their distributions northward. In September 2011, 6% of the walrus at the Point Lay haulout had skin lesions that were similar to those observed on ringed seals that summer and fall and suggestive of a viral infection (Garlich-Miller et al. 2011; USFWS 2014). Nearly half of the seals were dead and the rest were lethargic, but the walrus were in good physical condition other than the lesions. Most of affected walrus were subadults and some had healed lesions, which would indicate that the disorder is not necessarily fatal (Garlich-Miller et al. 2011; USFWS 2014). A number of dead calves at the haulout had both skin lesions and signs of trampling trauma however, and the ultimate cause of death is not known. In December 2011, the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NOAA NMFS) declared the seal mortalities an unusual mortality event (UME) and with USFWS concurrence, included walrus in the UME due to the similarities of the lesions (Garlich-Miller et al. 2011; USFWS 2014; NOAA NMFS 2011). No causative agent has been identified and it is unknown whether or not the same agent is infecting both species (symptoms appear to be less severe in walrus). Tissue sampling and laboratory analyses are ongoing (Garlich-Miller et al. 2011; USFWS 2014; NOAA NMFS 2016b).

Climatic warming could also have unanticipated impacts. For example, an increase in the occurrence of thunderstorms could disturb walrus and result in stampede-related mortality (Okonek and Snively 2005). If primary prey species become limited, walrus might eat more seals and thereby increase the incidence of *Trichinella* infection (Garlich-Miller et al. 2011) although the life history of *T. nativa* is not well known.

### **Potential for future habitat projections**

Predictions of future conditions can be an important tool for identifying conservation priorities for circumpolar walrus populations. We therefore explored the possibility of projecting future habitat based on two Representative Concentration Pathways (RCPs) - 8.5 and 4.5 - as identified by the Intergovernmental Panel on Climate Change (IPCC).

Representative Concentration Pathways (RCPs) are four greenhouse gas concentration trajectories adopted by the IPCC for its fifth Assessment Report (AR5) in 2014 (Moss et al. 2008, 2010). The pathways are used for climate modelling and research and describe four possible climate futures that depend on the quantity of greenhouse gas emissions in future years. The four RCPs are RCP 2.6, RCP 4.5, RCP 6, and RCP 8.5, which are named after a possible range of radiative forcing values in the year 2100 relative to pre-industrial values (+2.6, +4.5, +6.0, and



+8.5 W/m<sup>2</sup>, respectively) (Weyant et al. 2009). The RCPs are consistent with a wide range of possible changes in future anthropogenic greenhouse gas (GHG) emissions (van Vuuren et al. 2011; Collins et al. 2013). The different scenarios have the following assumptions on global annual GHG emissions (Meinshausen et al. 2011): RCP 2.6 assumes that emissions peak between 2010-2020 and decline substantially thereafter; emissions in RCP 4.5 peak around 2040 and then decline; compared to RCP 6 where emissions peak around 2080, then decline; and RCP 8.5, where emissions continue to rise throughout the 21st century (i.e., a worst-case scenario). Each RCP was developed by a different modelling group.

Two of the four scenarios are being considered. RCP 4.5 is an intermediate emissions scenario developed by the Pacific Northwest National Laboratory in the US. In this scenario, radiative forcing is stabilized by 2100, consistent with a future with relatively ambitious emissions reductions, stringent climate policies, stable methane emissions, and CO<sub>2</sub> emissions that continue to increase only slightly before a decline commences ca. 2040 (Thomson et al. 2011). In contrast, RCP 8.5 is a high emission scenario developed by the International Institute for Applied System Analysis in Austria. It is consistent with a future with no policy changes to reduce emissions and is characterized by increasing greenhouse gas emissions that lead to high greenhouse gas concentrations over time (Riahi et al. 2011).

Hamilton et al. (2014) assessed future polar bear habitat conditions in the Canadian Arctic Archipelago using a Coupled Model Intercomparison Project Phase 5 (CMIP5) simulation from the Geophysical Fluid Dynamics Laboratory Coupled Physical Model (GFDL-CM3) driven by radiative scenario RCP8.5 to pilot a regional model. The simulation includes a realistic spatial distribution of sea ice extent and thickness and simulates the observed trend in minimum sea ice extent during the 1979–2013 period. This pilot simulation was dynamically downscaled using the ice-ocean Massachusetts Institute of Technology General Circulation Model (MITgcm) simulation in regional mode over the Arctic at a resolution of 18km.

To study changes in polar bear sea ice habitat, each pixel was classified as multiyear ice, annual ice, or ice-free based on the sea ice concentration of the pixel location over a given year (ice types defined as per Comiso 2012). Numerous studies have linked changes in the seasonal ice cycle, particularly changes to the ice-free period, to effects on polar bear population size, survival, and reproduction (e.g., Stirling et al. 1999; Durner et al. 2009; Rode et al. 2010, 2013; Robbins et al. 2012; Cherry et al. 2013). Given this information, Hamilton et al. (2014) were able to link sea ice concentration to polar bear habitat quality via well established relationships between sea ice and polar bear foraging success (chiefly predation on ringed seals). Furthermore, Hamilton et al. (2014) examined polar bear habitat in a relatively small geographic area, the Canadian Arctic Archipelago. As such, it was a relatively simple process to define polar bear habitat based solely on sea ice concentration.

In contrast, sufficient data to develop similar sea ice models for walruses, across both subspecies and all populations in the circumpolar range, do not exist. There are some data from some populations, for example satellite-tagging studies in Alaska (Jay and Garner 2002; Jay and Hills 2005; Jay et al. 2006, 2010, 2012, 2014) and Svalbard (Lydersen et al. 2008; Freitas et al. 2009; Lydersen and Ko-

vac 2014), but there is a paucity of data on species-habitat relationships in other areas. Walrus habitat and ecological relationships also vary across subspecies and populations. For example, Pacific walruses generally follow seasonal patterns of ice advance and retreat, whereas Atlantic walruses generally feed in coastal areas because of the narrow continental shelf over much of its range (Garlich-Miler et al. 2011). The distribution of many Atlantic walrus stocks is restricted to relatively small areas by natural barriers such as land masses (Born et al. 1995), which can be contrasted with the habitat and ecological conditions of the northern Bering and Chukchi Seas, namely broken pack-ice habitat juxtaposed over large areas of shallow continental shelf waters with high benthic production (Garlich-Miler et al. 2011). There have been attempts to model walrus range based on habitat requirements at the species level (e.g., AquaMaps), but such “one size fits all” models may bear little resemblance to reality. In comparison to polar bears, other habitat variables would also be required, including depth, which limits walrus access to benthic prey; substrate, which influences prey availability; and distance to shore, which influences seasonal access to prey and thereby feeding energetics.

For these reasons, we suggest that it is premature to attempt to model future walrus habitat conditions across the species range. It may be possible to model specific populations, but data will still be lacking, to varying degrees (e.g., D.B. Stewart et al. 2014b; MacCracken et al. 2017).



Researchers prepare to collect biopsy samples. Laptev Sea, Russia.

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# KNOWLEDGE GAPS AND RESEARCH NEEDS

*Active research is being conducted on all walrus populations, but numerous research gaps and sources of uncertainty remain.*

In some cases, gaps are population-specific, for others, research is needed for all or most populations (e.g., recent estimates of population-specific growth rates; struck and lost rates for hunted populations). Knowledge gaps are summarized by five main categories (Table 5).

We have not ranked knowledge gaps with respect to research priorities, as these decisions are better left to the specific research teams, management authorities and funding agencies. In many cases, there will be a logical sequence of gaps that need filling to address information needs - for example, data on walrus distribution and seasonal movements will inform the design of surveys for abundance, and all these data are needed for comprehensive assessments of potential threats (e.g., industrial development, harvest rates, climate change).

Responsible management jurisdictions could plan research agendas based on established research needs, with input from co-management partners and NGOs, as is currently being done by DFO in Canada (Stewart et al. 2017). International cooperation in the establishment of research goals and priorities is also important, and this type of cooperation is ongoing in many cases (e.g., harvest management for stocks shared between Canada and West Greenland, NAMMCO 2006; USA-Russia working groups, Meek et al. 2008; Schuessler 2016).

**Table 5.** Summary of identified knowledge gaps and research needs for walrus populations (see text for details). Both general (all populations) and specific (each population) research needs are identified. Blank cells should not be considered as an indication that no knowledge gaps exist, but they do indicate lower priority as identified by the authors of this report. Priorities are not ranked by importance, as any prioritization should be done by research and funding organizations.

Sub-species	Population <sup>1</sup>	Knowledge gaps and research needs				
		Abundance, distribution, and movements	Genetic relationships	Mortality (including natural)	Life history and ecology	Climate change impacts/response
Both	All	<p>Increase precision and accuracy of survey estimates/methods.</p> <p>Conduct regular surveys for trend assessment.</p>	<p>Research on circumpolar population genetic patterns, historic diversity and abundance, evolution.</p>	<p>Improve catch reporting and update data on struck and lost rates (all legally harvested populations).</p> <p>Data on illegal removals (non-legally harvested populations).</p> <p>Survival and mortality rates.</p> <p>Effects of predation, disturbance, parasites, diseases, contaminants.</p> <p>Sex and age composition of walrus catches.</p>	<p>Habitat requirements - multiple spatial scales, all seasons.</p> <p>Life-history data: age at senescence, generation time, replacement rates, demography.</p> <p>Diet and energy requirements.</p> <p>Population-specific growth rate estimate (needed for all populations).</p> <p>Rate of recolonization.</p>	<p>Climate change linkages with other stressors.</p> <p>Sea ice stability and breeding behaviour, reproduction.</p> <p>Haulout occupancy and dynamics, disturbance events. Tracking changes (e.g., new haulouts)</p> <p>Diet requirements and flexibility in response to trophic shifts.</p> <p>Energetic thresholds (Atlantic subspecies).</p>
Atlantic	CHA-NWG	<p>Information on movements between Canada and Greenland and within parts of range.</p>	<p>Relationships between animals in different areas (e.g., Baffin Bay, Jones Sound, Lancaster Sound).</p>	<p>Partitioning of hunt mortality among management stocks.</p>		

Sub-species	Population <sup>1</sup>	Knowledge gaps and research needs				
		Abundance, distribution, and movements	Genetic relationships	Mortality (including natural)	Life history and ecology	Climate change impacts/response
	CCA-WG	Information on movements between Canada and Greenland and within parts of range.  Large-scale systematic survey of entire population range.	Relationships between animals in different areas (e.g., Foxe Basin and northwest Hudson Bay), relationship to animals in CLA population.	Partitioning of hunt mortality among management stocks.		
	CLA	Movements (if any) to Hudson Strait. No movement (e.g., tagging) data available. Additional abundance estimates needed.	Relationship to animals in CCA-WG population.		Location of wintering habitats	
	EG					
	S-FJL	Research on movements between S and FJL.	Relationship to animals in KS-SBS-NZ population and LVS (Pacific walrus) population.		Basic biology and life history data (FJL).	
	KS-SBS-NZ	Systematic surveys needed.  Research on movements between S-FJL and KS-SBS-NZ.	Relationship to animals in S-FJL population and LVS (Pacific walrus) population.	Research on persistent organic contaminant levels.	Basic biology and life history data.	
Pacific	LVS	Systematic surveys needed.	Relationship to Atlantic walruses in S-FJL and KS-SBS-NZ populations.		Basic biology and life history data.	
	BCS		Further research on stock structure.	Causal factors for mass die-offs.		Monitoring climate-related changes.

## ABUNDANCE, DISTRIBUTION, AND MOVEMENTS

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There have been considerable recent advances in understanding of movements and seasonal distribution patterns for some walrus populations (e.g., satellite-tagging research in the Bering and Chukchi seas and at Svalbard (Lydersen et al. 2008; Freitas et al. 2009; Jay et al. 2010, 2012, 2014; Lydersen and Kovacs 2014)), but additional data would be beneficial in many cases.

Among Atlantic walrus populations, recent (2015) satellite tracking of animals tagged in northwest Greenland suggests that the three stocks identified in the Canadian High Arctic - Northwest Greenland (CHA-NWG) population are not as discrete as previously assumed (NAMMCO 2015). Additional research is needed to inform harvest management. For the Canadian Central Arctic - West Greenland (CCA-WG) population, an increased understanding of the seasonal movements between the two countries will improve inter-jurisdictional management of harvesting and other population stressors (e.g., oil and gas development). Seasonal movements within and between different areas occupied by this population (e.g., movements, if any, between Foxe Basin or South and East Hudson Bay and northwest Hudson Bay/Hudson Strait) could also be studied via tagging. The Canadian Low Arctic (CLA) population in southeast Hudson Bay is considered a separate population, but this is tentative as there are no data to confirm. Research on movement patterns of these animals (e.g., via satellite-tagging), particularly whether they move into Hudson Strait, is needed (also see Genetics, below).

For the Kara Sea - Southern Barents Sea – Novaya Zemlya (KS-SBS-NZ) population, data on the distribution of walruses during the spring breeding season and on seasonal movements are needed. The relationship of Atlantic walruses in the Svalbard – Franz Josef Land Population (S-FJL) population to those in the KS-SBS-NZ population is uncertain (Born et al. 1995; NAMMCO 2006; Boltunov et al. 2010; Shitova et al. 2014b). There is extensive oil exploration, development and production currently taking place in the Pechora Sea and southwest Kara Sea. Data on walrus distribution and movements are needed to assess the risks posed by these industrial activities to walruses and their prey.

For Pacific walruses, data on Laptev Sea walrus movements and distribution are needed. Movements of animals in the Bering and Chukchi Seas (BCS) population of Pacific walruses have been extensively studied through the use of satellite-telemetry (Jay and Garner 2002; Jay and Hills 2005; Jay et al. 2006, 2010, 2012, 2014), providing critical information for assessing impacts from industrial development and climate change. Continuing this work could provide valuable early information on the direction and extent of changes in walrus distribution and abundance in response to climate change and other stressors, and thereby benefit population management. Genetic data will also assist in understanding walrus movement patterns (see below).

Abundance estimates are available for most populations, but with considerable uncertainty. Bias and imprecision in estimated population sizes over time leads to uncertainty in understanding trends in absolute population size (e.g., Taylor and Udevitz 2015). Population estimates are generally negatively biased due to incomplete survey coverage and methodological issues. Research on ways to increase

the precision and accuracy of survey estimates using different methods (e.g., genetic capture-mark-recapture as an potential alternative to aerial surveys) and study designs (e.g., aerial line surveys versus aerial haulout count surveys) would benefit walrus conservation and management across the species' range. All populations would also benefit from regular systematic surveys for trend assessment.

Amongst Atlantic walruses, abundance trends for the Kara Sea - Southern Barents Sea – Novaya Zemlya (KS-SBS-NZ) population are considered positive (M. Gavrilov, pers. comm.), but no systematic surveys have been conducted. This should be a priority going forward. Recent surveys have been conducted for various parts of the range of the Canadian Central Arctic - West Greenland (CCA-WG) population (Elliott et al. 2013; Heide-Jørgensen et al. 2014; R.E.A. Stewart et al. 2014c; Hammill et al. 2016b), but a lack of understanding of seasonal distribution and potential movements between sub-areas (see above) leads to uncertainty in estimates of population size. Surveys of the entire range could be conducted, using multiple crews to reduce potential biases introduced by animal movement. For Pacific walruses, data on abundance from the Laptev Sea are needed, so trends can be monitored in relation to industrial development, pollution, and climate change.

The ability of walruses to re-colonize areas where populations have been depleted or extirpated is not known. Large-scale studies of walrus movements (e.g., satellite-tagging) and population genetics (see below) could provide relevant information. The rarity of Atlantic walruses along the Atlantic coast of Canada since the Nova Scotia-Newfoundland-Gulf of St Lawrence population was extirpated in the 1850s suggests that re-colonization would be exceedingly slow at best, however.

## GENETIC RELATIONSHIPS

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Genetic research can help answer numerous research questions, including those of relevance to other identified categories (e.g., Abundance, distribution, and movements, above). At the species level, research on circumpolar population genetic patterns can provide valuable information on historic diversity, abundance (e.g., effective population size), and the evolution of subspecies- and population-level differentiation.

Among Atlantic walruses, there is a lack of genetic data from the Canadian Low Arctic (CLA) population, an important knowledge gap. If these animals are genetically distinct it will be important to retain their genetic adaptive potential as they represent the most southerly remaining population in a period of climatic change (see below). Genetic relationships between walruses in the Svalbard-Franz Josef Land (S-FJL) population and those in Novaya Zemlya and the Pechora and Kara seas in the southeastern Barents Sea (KS-SBS-NZ population) are unknown (Boltunov et al. 2010; Lydersen et al. 2012; Lydersen and Kovacs 2014; Shitova et al. 2014a, b; Lindqvist et al. 2016). The genetic placement of these walruses in relation to other Atlantic walruses should be a top research priority. These data should be used to delineate where in the Russian Arctic the separation between the Atlantic and Pacific walrus subspecies occurs. Further research on stock structure in the BCS population of Pacific walruses is also needed (Garlich-Miller et al. 2011; USFWS 2014).



## MORTALITY (ANTHROPOGENIC AND NATURAL)

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Hunting by humans is the greatest known cause of mortality in most areas of walrus range within Canada, Greenland, Russia and the United States. The hunting mortality that the different Atlantic walrus and Pacific walrus populations can sustain is not known. In all areas where walrus are legally harvested, removal rates are uncertain due to uncertainties in the reported harvest. This is due to factors such as reporting bias and lack of systematic data collection effort. Even where extensive data on harvests are available, the proportion of the population being harvested is typically uncertain due to biased population estimates. These uncertainties are further compounded by significant uncertainty in struck and loss rates (animals injured or killed but not secured) (D.B. Stewart et al. 2014a). There are few estimates for loss rates in subsistence hunts, and none are recent. Accurate seasonal and habitat specific (e.g., land-based, and over deep and shallow water) data on struck and lost rates are needed for all hunted populations.

For populations that are not legally harvested (e.g., KS-SBS-NZ population of Atlantic walrus; LVS population of Pacific walrus), data on illegal removals (poaching) would be of value. However, the collection of data needed to understand abundance and distribution should take precedence.

The natural survival rate of walrus is thought to be high, due to their low reproductive rate and long life span, but this has not been directly estimated (Taylor and Udevitz 2015). Rigorous survival rate estimates do not exist for any population. Lack of this information increases uncertainty in important population management tools used to predict demography, estimate abundance, and calculate total allowable removals.

Rates of walrus predation by polar bears and killer whales are not well known, nor are rates of natural mortality from sources such as disturbance, which can stampede walrus causing trampling mortality. Efforts to study and monitor walrus behaviour at haulouts (see below) can provide important data on disturbances. Mortality rates from pathogens and parasites are generally unknown. The susceptibility of walrus to viral and bacterial diseases is poorly understood for both subspecies (e.g., Nielsen et al. 2000, 2001a, 2001b, 2004; Calle et al. 2002; Phillipa et al. 2004). Research could improve understanding of potential risk to populations from disease exposure that could change in response to factors such as climate change that alter population and species distributions and increase crowding at haulouts. Data on contaminant loading has been collected for some populations (e.g., Muir et al. 1995, 2000; de March et al. 1998; Fisk et al. (ed.) 2003; Wolkers et al. 2006; Semyonova et al. 2012), but more information is needed on the persistent organic contaminant levels of walrus in the Barents Sea (Semyonova et al. 2015).

The cause(s) of recent mass die-offs among Pacific walrus should be investigated since these mortality levels may affect population conservation and management. Starvation, disturbance, and disease have contributed to these large mortality events (e.g., Fay and Kelly 1980; Kavry et al. 2006, 2008; Arnbom 2009; Fischbach et al. 2009; Udevitz et al. 2013). Better understanding is needed of the linkages between these causes of mortality and climate change, which is likely to be a key stressor for the species over the next century.

## LIFE HISTORY AND ECOLOGY

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A better understanding of walrus habitat requirements, at multiple spatial scales (i.e., from local to circumpolar) and in all seasons, is needed to better inform conservation and management. Habitat use information can be gathered using a variety of methods, including satellite-tagging studies (e.g., Freitas et al. 2009; Jay et al. 2014) and aerial or ship-based surveys (e.g., Elliott et al. 2013), and via traditional knowledge from local resource users (e.g., EWC 2003; Laidler et al. 2009; Garlich-Miller (ed.) 2012; DFO 2013a; Bering Strait experts in Kawerak, Inc. 2013). Information on habitat use is needed for assessing impacts of industrial development and other disturbances as well as assessment of potential distribution shifts with climate change. At present, the level of detail of habitat use information varies widely across populations but is perhaps best understood in the Alaskan Chukchi Sea. An analysis of knowledge gaps could provide guidance on priorities for research, to bring habitat knowledge for all populations to a sufficient level for preliminary assessments of potential range shifts due to global climate change (see “Potential for future habitat projections” section of this report). Habitat-based research should consider both sea ice and terrestrial haulouts sites, and the composition and relative abundance of suitable prey species in relation to seasonal foraging activities.

For all populations, additional data on basic biology and life history would be useful. Obtaining these data should be a higher priority for some populations than others. For example, Lydersen et al. (2012: 1555) note that basic knowledge of the population biology of Atlantic walrus throughout the eastern parts of their range (i.e., Russia) is scarce or nonexistent. The generation time of Atlantic walrus is uncertain due to gaps in knowledge of population demographics, reproduction and survival rates, and length of the reproductive period (COSEWIC 2006). The relative numbers of adult females of a given age are unknown, as is age at senescence. These gaps increase the uncertainty in any estimates of sustainable yield for harvested populations and can have a substantial influence on conservation and management. For example, modelling suggests the Eastern Greenland (EG) population has recovered from its historical depletion, but the trajectory of this recovery is uncertain due to lack of a population-specific growth rate estimate (Witting and Born 2014). An understanding of whether or not populations have recovered is critical to effective harvest management.

## CLIMATE CHANGE IMPACTS/RESPONSE

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Many potential impacts from climate change are secondary, due to linkages with other stressors. For example, the potential for population displacement by increasing Arctic shipping is unknown. This could be of real concern for many walrus populations and merits proactive scientific study. These studies will need to establish strong baselines against which changes can be measured, followed by careful long term monitoring to establish trends, identify cause and effect, and inform potential mitigation responses. The effects of climate change will need to be considered in all of the various research needs identified above.

The mating system of Atlantic walrus in fast-ice (Sjare and Stirling 1996) differs from that of Pacific walrus in pack ice (Fay et al. 1986). This suggests that sea ice stability may be an important determinant of walrus breeding behaviour, and sea ice declines could therefore have pronounced effect on reproduction and population. Research on walrus behaviour (and movements and habitat use, see above) in pack ice environments is necessary. Reductions in sea ice will increase walrus reliance on terrestrial haulout sites, and research on haulout occupancy and dynamics will inform efforts to mitigate disturbance. Trail cameras could be used for monitoring and to provide information on disturbance events.

Walrus are highly adapted for obtaining bivalves, but they also have the potential to switch to other prey items if bivalves and other calcifying invertebrate populations decline (USFWS 2014). Whether other prey items would meet their nutritional needs is not known (Sheffield and Grebmeier 2009). There is also uncertainty about the extent to which other suitable non-bivalve prey might be available, mainly due to uncertainty about the effects of ocean acidification (USFWS 2014). Climate change impacts on walrus food sources are an important research avenue. Research on diet requirements and flexibility in response to trophic shifts is needed, as is research on energetic thresholds in Atlantic walrus (see Noren et al. 2012, 2014, 2015, 2016 for relevant research on Pacific walrus).

1. International cooperation in the management of shared populations
2. A proactive approach to the assessment of potential impacts from human activities on walrus and their habitats.

# CONSERVATION AND MANAGEMENT RECOMMENDATIONS

International jurisdictions with walrus populations have already identified many of the gaps discussed above and detailed possible approaches to addressing them (e.g., see Boltunov et al. 2010; Garlich-Miller et al. 2011; Wiig et al. 2014; Semyonova et al. 2015; Stewart et al. 2017).

These details will not be repeated here but two overarching conservation and management measures bear mention. The first is the need for international cooperation in the management of shared populations, and the second is the need for a proactive approach to the assessment of potential impacts from human activities on walrus and their habitats. Both measures are increasing in importance as human activity expands and increases in response to changes in the distribution and quality of Arctic sea ice, and will pose new threats to walrus if not well regulated (Wiig et al. 2014).

International information sharing has benefited walrus management and if maintained and expanded will improve the management of both Atlantic and Pacific walrus in the future (Garlich-Miller et al. 2011; Shadbolt et al. 2014; Wiig et al. 2014). This is particularly important between Canada and Greenland, Norway and Russia, and Russia and the United States, which share walrus populations and regularly cooperate on research and management. Because walrus populations do not respect international boundaries it will become increasingly important in the face of climate change for the countries that share them to coordinate these activities. Canada and Greenland, for example, cooperate informally at a scientific level on walrus research and management. This has worked well but they should consider formalizing their shared management of these stocks as they have for belugas and narwhals, *Monodon monoceros* (Canada/Greenland Joint Commission on the Conservation and Management of Narwhal and Beluga, JCNB).

Climate change is already increasing the effects of human activities on circumpolar walrus populations by improving access to mineral and hydrocarbon resources (e.g., BIMC 2012). Many new developments are planned in the Canadian Arctic, Greenland, and elsewhere over the next several decades. Shipping will be a major component of these remote developments since other transportation infrastructure is lacking or inadequate to resupply them and transport their products to market. In the case of iron mines, which generate massive quantities of ore that is smelted elsewhere, vessel transits may occur at intervals of a few days, year-round. These vessels will venture into areas where

the animals have not hitherto been exposed to shipping or icebreaking. The effects of vessel disturbance on these walrus populations are uncertain and of concern to the scientific community, resource users, and others (e.g., Stewart et al. 2012; DFO 2014).

Jurisdictions with walrus populations must take a proactive approach to the assessment of potential impacts to walruses from proposed developments. Substantial lead-time is required to gather the baseline information needed for predicting, assessing and monitoring impacts since basic information on walruses such as numbers and stock discreteness is often lacking (Wiig et al. 2014). In Canada the task of establishing a strong baseline against which to measure the impact of project activities has been largely devolved to the proponent of each project. The resultant baselines tend to be short-term, local, and draw heavily on existing literature as the baseline research is expensive and must be undertaken before the project is approved and revenue is generated. These baselines are seldom robust enough to detect anything but a very large impact and even then may not be able to differentiate between effects caused by project activities, natural variation, and the effects of climate change. By the time effects have been identified and their causes argued, it may be too late for effective impact mitigation. While most environmental protection legislation requires consideration of 'cumulative impacts', the practical application of this concept remains problematic (Wiig et al. 2014).

Governments with walrus populations need to establish robust baselines and long term monitoring programs that enable the detection of changes in the animals' distribution, abundance, and health and the identification of causative factors. They also need to support the basic research needed to establish appropriate regulatory thresholds that are needed to assess potential impacts of development. Understanding the behavioural responses of walruses to disturbances that occur in the air and water is vitally important for good assessment of shipping impacts on walrus populations. For example, regulators and industry need to know with reasonable certainty what level of noise will mask cow-calf communications or mating songs, cause animals to stampede, or cause them to leave their preferred habitat. Otherwise walruses may be essentially unprotected from the effects of increasing northern industrial development.

# ANNEX: TABLE 4

Hunt management	Habitat Protection
Canada - Atlantic	
<p>Populations were over-exploited historically. Regulations established in 1928 restricted harvests to Aboriginal hunters, ending commercial hunting by whalers and traders. More explicit regulations in 1931 forbade export of hides and uncarved tusks and limited Aboriginal catch to seven walrus per family.</p> <p>In 1980, Walrus Protection Regulations were enacted under the <i>Fisheries Act</i> - only “an Indian or Inuk” was allowed to “hunt and kill walrus without a licence”, each individual limited to a maximum of four walrus per year except where annual community quotas were scheduled. In 1993, these regulations were consolidated with those for other marine mammals in the Marine Mammal Regulations of the <i>Fisheries Act</i>.</p> <p>Hunts in Nunavut and Nunavik are co-managed by regional wildlife management boards under the applicable sections of their respective land claims agreements, with scientific advice from DFO. Community and Aboriginal traditional knowledge are also used to manage walrus, and co-management working groups are drafting a fisheries management plan.</p> <p>A limited sports hunt has been open for non-resident hunters since 1994 to benefit communities located near walrus populations. Most are conducted in northern Foxe Basin with some in northern Hudson Bay.</p>	<p>Walrus habitat is protected under sections 34-37 of the <i>Fisheries Act</i> (under the Act, “fish” are broadly defined to include walrus and other marine mammals).</p> <p>Existing Federally-managed lands (e.g., National Parks, National Wildlife Areas) offer temporary protection to small numbers of walrus. Inuit have the right to hunt in National Parks and other conservation areas in Nunavut and Nunatsiavut.</p> <p>In Nunavut, the North Baffin Regional Land Use Plan and Keewatin Regional Land Use Plan mention protection of walrus haulouts but the level of protection is vague. A Nunavut-wide land use plan is currently being drafted.</p>
Greenland - Atlantic	
<p>Walrus in Greenland have been hunted for the past millennium. Commercial hunting was prohibited in 1956 but licensed hunts continue for subsistence. Parliament Act No 12 of 29 October 1999 on harvest and hunting is a framework act that regulates hunting and is supplemented by a long list of ministerial orders issued by government to regulate details on harvest and hunting of specific species.</p> <p>Until 2005 walrus hunting in West Greenland was regulated by limiting hunting seasons and methods. There were no quotas in place. Northeast Greenland walrus received complete protection from harvesting in 1951.</p> <p>In 2006, a quota system was established. Quotas are based on the recommendations of scientific assessments, using recent population estimates to allow population growth from a depleted population, and taking into account Nunavut catches in shared populations and struck and lost estimates. Quota decisions are made with regard to international agreements and in consultation with local hunting committees.</p> <p>Adult females are protected except in Northwest Greenland where walrus hunting is of great importance to the hunting community, walrus hauled out on land are completely protected, and animals must be harpooned with floats attached before receiving the finishing shot to reduce losses from sinking (there is concern however that struck and lost walrus are not being reported).</p>	<p>In 2003 a new <i>Nature Protection Act</i> was adopted to protect biological diversity, ensure that exploitation is sustainable, and implement international agreements on the conservation of nature under Greenlandic law. A ministerial order on protection and harvest of walrus was announced in 2006. The Greenland <i>Mineral Resources Act</i> and other rules, regulations, and guidelines also stipulate a range of measures for protecting nature and the environment.</p> <p>Future large-scale hydrocarbon exploration might include activities that affect walrus habitat. Applications to conduct hydrocarbon exploration must include an environmental impact assessment. Before opening new areas for exploration and initiating a licensing process the Greenland Government has been conducting its own Strategic Environmental Impact Assessments. There are licenses for exploration and exploitation of hydrocarbons in the Greenland Sea but so far only seismic testing is taking place.</p> <p>The Melville Bay Nature Reserve was created in 1980 in northwestern Greenland, and Grønlands Nationalpark was established in 1974 in northeastern Greenland. Both offer some protection for terrestrial haulouts but their boundaries do not extend to offshore waters. Hunting by local residents is allowed. The parks also do not offer strict protection, as extensive exploration for minerals is occurring within the Nationalpark. In 1951 the island of Sandøen, in East Greenland, was named a game preserve, prohibiting access to protect a well-known haulout.</p>



Hunt management	Habitat Protection
Norway (Svalbard) - Atlantic	
<p>Norway (Jan Mayen and Svalbard) does not allow walrus hunting. Commercial hunting was banned in 1952 in response to very large catches by Norwegians in Northwest Greenland. Denmark and Norway concluded that walruses were so depleted that they could not sustain the Norwegian harvest and a Royal Decree gave complete protection to walruses.</p>	<p>Walrus haulouts at Svalbard are well documented and most are within protected areas. In 2008 regulations protecting the Northeast Svalbard and Southeast Svalbard nature reserves in eastern Svalbard were strengthened to reduce the impacts of ship traffic. These protected areas serve as reference areas for research. Access by tourist ships with over 200 passengers was prohibited, as was ship use and transport of fuels other than light diesel fuel. The objectives were to reduce direct disturbances and the risk of oil fouling at haulouts.</p>
Russia - Atlantic	
<p>Commercial hunters took many walruses from the KS-SBS-NZ population over many centuries, and the population had declined considerably by the 1930s.</p> <p>Hunting was first regulated in 1921; followed in 1935 by cessation of the state harvest from sealing vessels; and in 1949 by the prohibition of killing walruses by any fishing and sealing industry.</p> <p>In 1956, hunting was banned for all Soviet citizens, except for subsistence. In 1975, regulations prohibited sport hunting and any landing on or the littering of shore haulouts at any time. It also prohibited possession, manufacture, buying, selling, storage, and transportation of hides and tusks. Subsistence hunting of Atlantic walruses has been prohibited since 1982.</p>	<p>Atlantic walruses are classified as Category II in the Red Data Book of the Russian Federation 2001, Federal Law requires activities that alter walrus habitat, breeding and feeding conditions, and migration routes to meet requirements that ensure walrus conservation.</p> <p>Atlantic walrus habitats on land and at sea are protected in the following specially protected areas: Franz-Josef Land Federal State Zakaznik (Wildlife Reserve), Russian Arctic National Park (northern Novaya Zemlya), Nenetskiy Strict Nature Reserve in the Pechora Sea, Great Arctic Reserve in the Kara Sea, Gydansky Strict Nature Reserve, and regional wildlife reserves Vaigach and Yamalsky.</p> <p>A National Strategy for the Atlantic walrus is currently under development in Russia.</p>
Russia - Pacific	
<p>Commercial hunting of Pacific walruses ended in 1991 due to the economic collapse of the industry. Russian legislation still allows commercial hunting, but would require an annual decree from the Russian Fisheries Ministry to be resumed.</p> <p>Indigenous people in Chukotka are permitted to hunt Pacific walruses for subsistence. There are no restrictions on possession or sale of Pacific walrus parts provided the harvest was legal and there is proper documentation.</p> <p>Hunting in the Laptev Sea area has been banned since 1956 for all Soviet citizens, except for subsistence.</p>	<p>Laptev Sea walruses are included in the Red Book of the USSR as a rare endemic subspecies that is potentially vulnerable because of its low numbers, limited range, and increasing anthropogenic stress (<i>i.e.</i>, considered a distinct subspecies).</p> <p>Laptev Sea walrus habitats are protected in Taimyr Strict Nature Reserve (NE Taimyr) and will get formal protection in New Siberian Islands Zakaznik (Wildlife reserve) which is currently in the approval stage.</p>

Hunt management	Habitat Protection
United States - Pacific	
<p>Large-scale harvesting prior to the 1960s reduced the population, which then increased rapidly in the 1960s and 1970s in response to management actions. The population has since declined; it is currently below carrying capacity and likely limited primarily by subsistence harvest. Recent harvest levels are much lower than the long-term average.</p> <p>USFWS is responsible for management and conservation, via authority transferred from the State of Alaska in 1972 under the <i>Marine Mammal Protection Act</i> (MMPA). Walrus are protected by the MMPA and only qualified coastal-dwelling Alaskan Natives are permitted to hunt them for subsistence and craft purposes. The MMPA also has provisions for cooperative management agreements to provide for co-management of subsistence use. A conservation plan was developed in 1994.</p> <p>Prior to the MMPA walrus were managed via state regulations, including quotas on females. The MMPA has more liberal regulations, and Natives can take walrus at any time of the year, without restrictions on sex, age, and number provided the population is not considered depleted. The Native harvest cannot be restricted if the population size is above the size providing the maximum net productivity level and the harvest is non-wasteful. If the population is considered depleted, then actions can be taken to regulate the harvest. At present there are no quotas, but some local management programs have been developed and local regulations implemented. Walrus hunting activities are monitored via the Marking Tagging and Reporting Program (MTRP) and the Walrus Harvest Monitoring Program (WHMP).</p>	<p>MMPA emphasizes habitat and ecosystem protection, such as the protection of essential habitats including rookeries and mating grounds.</p> <p>Several important haulouts are protected through state or Federal parks and protected areas. The State of Alaska created the Walrus Island State Game Sanctuary in 1960, which includes Round Island. Round Island is managed by the Alaska Department of Fish and Game and regulations are in place to protect the haulout there. Access is tightly controlled. A limited subsistence hunt is co-managed on Round Island. In 1980 the Togiak National Wildlife Refuge (TNWR) was expanded. The TNWR protects walrus haulouts at Cape Peirce and Cape Newenham. The USFWS has developed guideline to reduce human caused disturbances at terrestrial haulouts in Bristol Bay and along the Northwest coast of Alaska.</p> <p>In recent years the number of walrus coming to shore in summer and fall has increased, and mortalities have occurred from disturbance events. Walrus are expected to become increasingly dependent on coastal haulouts, and efficient management efforts to mitigate anthropogenic disturbances and associated mortality will be an important factor. Local conservation and management initiatives have been developed, and in some cases mortalities have been minimized through efforts of local villagers to reduce disturbances.</p> <p>Seismic surveys in the eastern Chukchi Sea occur in important habitat for females with dependent young. The USFWS monitors and mitigates potential impacts of oil and gas activities on walrus through Incidental Take Regulations (ITR). Companies must adopt measures to ensure that impacts to walrus remain negligible and minimize impacts to their habitat.</p>

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