MITIGATION BUFFER ZONES FOR ATLANTIC WALRUS (*ODOBENUS ROSMARUS ROSMARUS*) IN THE NUNAVUT SETTLEMENT AREA

Context

The Nunavut Planning Commission (NPC) is responsible for developing, implementing and monitoring land use plans to guide and direct resource use and development in the Nunavut Settlement Area (NSA). The NPC, with input from government, Inuit organizations and other stakeholders, has been developing a Draft Nunavut Land Use Plan (Plan) that, when finalized, will apply to the entire NSA, with the exception of National Marine Conservation Areas and some parks and historic sites. The Plan will be the entry point for impact assessments and regulatory approval processes for proposed projects, both of industry and government. In accordance with the Nunavut Agreement, any vessel or aerial setbacks that may be included in an approved Plan would not restrict the Inuit right to subsistence land use or harvest of wildlife.

To date, Fisheries and Oceans Canada (DFO) has provided the NPC with some information on Atlantic walrus presence and sensitive walrus habitat in the NSA and Outer Land Fast Ice Zone. DFO has not provided information that might guide measures to avoid and/or mitigate disturbance of walrus and their important habitat from project activities, including shipping. Such information would inform land use planning designations and conditions of use for those areas and/or other mitigation measures outside of the land use plan.

As a first step to providing this information, the Policy and Economics Branch, which leads departmental input into the draft Plan, has requested science advice to identify important walrus habitat and areas of aggregation in the NSA, including the Outer Land Fast Ice Zone; provide information about acceptable noise levels to walrus at haul-out sites and identify mitigation measures, including buffer zone recommendations, to minimize disturbance of walrus from ships, small watercraft and aircraft.

The objectives of this Science Advisory Process are to:

1. identify important ice habitat for walrus and any known walrus terrestrial haul-out sites (occupied, abandoned, and abandoned/reoccupied) within the NSA;
2. provide information about walrus responses to disturbances and if possible, provide information from the literature on acceptable noise levels for walrus at haul-out locations;
3. identify recommendations for buffer zones at haul-out sites to minimize disturbance of walrus from a) large ships (e.g., cargo, re-supply, cruise and research ships); b) ice-breakers; and c) smaller watercraft (e.g., zodiacs, kayaks, launch vessels);
4. recommend a minimum vertical setback for aircraft from haul-out sites; and,
5. identify whether there are seasonal considerations for the recommended mitigations.

This Science Response Report results from the Science Response Process held July 24, 2018 on the Mitigation Buffer Zones for Atlantic Walrus (*Odobenus rosmarus rosmarus*) in the Nunavut Settlement Area.

Background

Decline in sea ice extent and duration has been accompanied by an increase in vessel traffic in Canada's North (e.g., Dawson et al. 2016, Johnston et al. 2016). Current and forecasted growth in shipping, tourism, and port development has the potential to impact Arctic marine mammals directly (e.g., mortality from ship strikes) and indirectly via disturbance and habitat alteration or destruction. Such indirect impacts can be biologically significant if important behaviours such as mating, nursing, or feeding are disrupted, or if animals are displaced from critical habitat over long periods of time (Erbe and Farmer 2000).

Vessel and aircraft-based traffic and their associated stressors may impact Atlantic walruses (*Odobenus rosmarus rosmarus*) in the eastern Canadian Arctic, where two genetically distinct populations of Atlantic walrus occur (Shafer et al. 2014). These populations, which are harvested primarily by Inuit for food and other products, are subdivided into six management stocks (Figure 1). Walrus in Hudson Bay, Foxe Basin and Hudson Strait belong to the Central Arctic population, and are managed as three largely discrete stocks based on distribution, growth patterns, and stable lead isotope ratios: Foxe Basin, Hudson Bay-Davis Strait, and South and East Hudson Bay (Stewart 2008; Figure 1). Three stocks are recognized in the High Arctic population: Baffin Bay, West Jones Sound, and the Penny Strait-Lancaster Sound stocks (NAMMCO 2011, Stewart 2008; Figure 1).

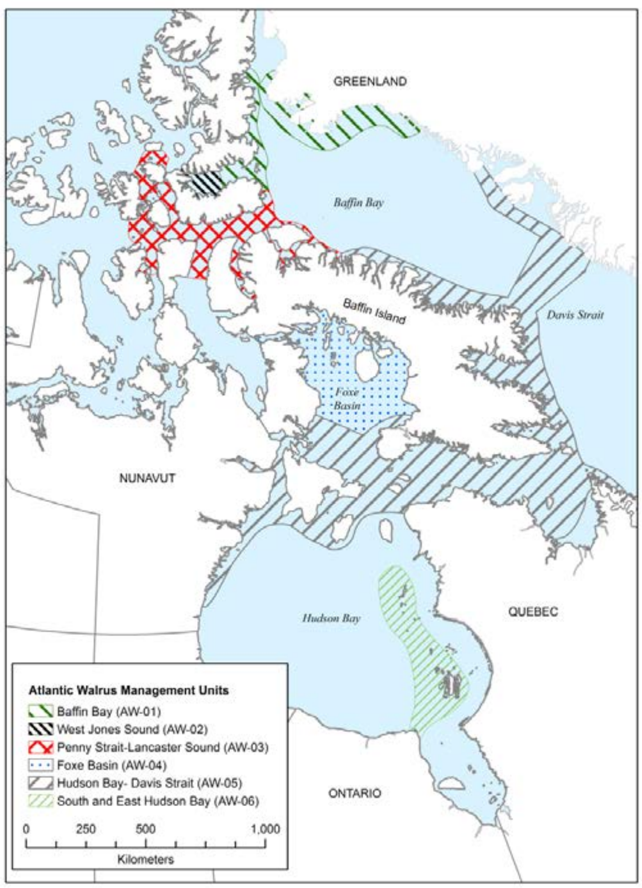

Figure 1. Atlantic Walrus management units in the Canadian Arctic. The High-Arctic population includes the Baffin Bay (AW-01), West Jones Sound (AW-02), and Penny Strait-Lancaster Sound (AW-03) units. The Central Arctic population includes the Foxe Basin (AW-04), Hudson Bay-Davis Strait (AW-05), and South and East Hudson Bay (AW-06) units.

The NPC has identified the need for research on disturbance of walrus at haul-outs, including how to minimize disturbance and any cumulative impacts of shipping and related projects on walrus behavior and habitat. Vessel traffic in the Canadian Arctic is projected to increase over the upcoming decades to meet demand for mineral resources and tourism (e.g., Dawson et al. 2016, Johnston et al. 2016, Stewart et al. 2018), likely with temporal and spatial expansion of existing shipping routes. The disturbance of walrus along shipping routes is of concern given documented shifts in walrus distribution away from human communities after the introduction of motorized technology (Born et al. 1995). To date, DFO has conducted regular surveys of the populations and stocks to provide advice on population estimates and sustainable harvest; however, little research has been conducted on the impact of disturbance on Atlantic walrus.

This Science Response reports on the most recent research by DFO on Atlantic walruses in Canada, including an updated list of haul-out site locations, as well as a brief synthesis of research on Pacific walrus (*Odobenus rosmarus divergens*), primarily by the U.S. Federal and Alaskan governments, to inform appropriate buffer zones to reduce impacts of vessel and aircraft-based disturbance on walrus in Canadian waters.

Analysis and Response

There is limited data and research on the responses of Atlantic walrus to vessel and aircraft disturbances in the Canadian Arctic. To date, DFO has focused on conducting aerial surveys of both walrus populations in the Canadian Arctic to update haul-out locations and status (active, uncertain, abandoned). A summary of existing literature on walrus disturbance and responses was compiled, primarily from long-term studies of Pacific walrus by U.S. Federal and Alaskan government researchers in Bristol Bay, Alaska, as well as other sources. Existing guidelines and regulations restricting vessel and aircraft traffic around walrus haul-out sites in other jurisdictions are provided and form the basis of similar guideline recommendations in the absence of relevant data on Atlantic walrus in Canada.

Important Habitat

Walruses associate with pack ice for much of the year, but when suitable sea ice is unavailable, both sexes and all age classes haul out in herds of several to thousands of animals at terrestrial sites. Walrus haul-outs are typically situated on low shores with easy access to water for feeding and escape from predators or other disturbances (Mansfield 1973). Atlantic walruses feed primarily on bivalve molluscs (Fisher and Stewart 1997) in shallow water (< 80 m), and require nearby ice or land for hauling out (Born et al. 1995). This restricts habitat options; walruses therefore show strong site fidelity to established haul-out sites (Born and Knutsen 1997, Born et al. 2005, Jay and Hills 2005). Foraging habitat may extend from 40-45 km (estimated daily swimming distance; Stewart 2008; Stewart et al. 2013, 2014b,c) up to ~100 km (95 % kernel range; Dietz et al. 2013, Stewart et al. 2014c) from the haul-out site. Both male-only and mixed herds comprising all age classes have been reported at haul-out sites in the Canadian Arctic (Salter 1979, Stewart et al 2014a).

Haul-out Sites

DFO conducts periodic aerial surveys of Atlantic walrus to estimate abundance. Since counts are conducted at haul-out sites, the DFO survey database is the primary data source of identified walrus haul-out sites throughout the eastern Canadian Arctic (Stewart et al. 2013, 2014a-c, Hammill et al. 2016; Figure 2 (panel A), Appendix 1). Higdon (2016) recently augmented DFO's haul-out site database with additional locations identified in other sources, bringing the total number of sites to 196 (Figure 2 (panel B), Appendix 1). The latitude and longitude of all DFO-identified haul-out sites were measured using GPS, but not all of the locations compiled from non-DFO sources have accurate location data (i.e., reported latitude and longitude values). Higdon (2016) estimated latitude and longitude values for these locations from maps, and subjectively classified them as having either moderate accuracy (reasonable certainty to within 5 km) or uncertain accuracy (insufficient resolution to have reasonable certainty of location within 5 km; Appendix 1). Haul-out sites with reported latitude and longitude values were classified as high accuracy.

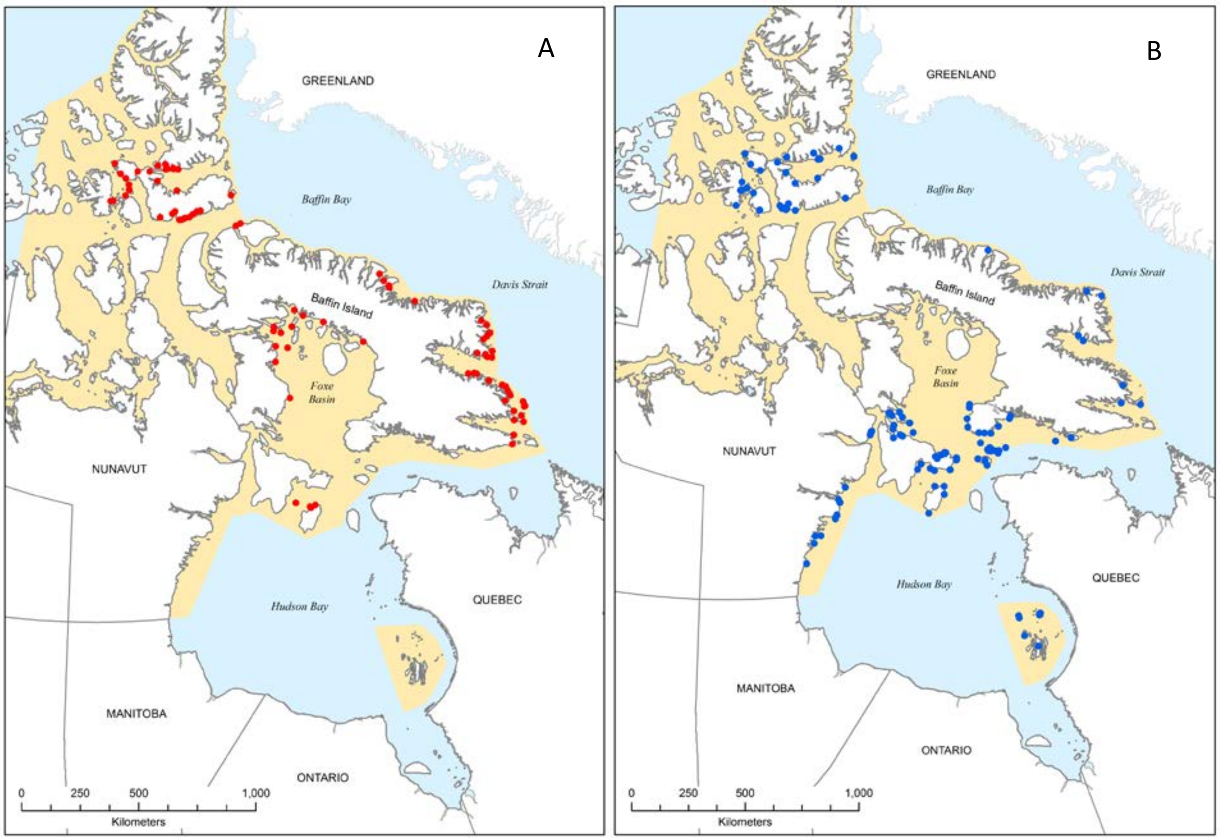

Figure 2. Known terrestrial haul-out sites for Atlantic walrus in the Nunavut Settlement Area (shaded) compiled from the Fisheries and Oceans Canada Central and Arctic Region survey database (red points; Panel A) and other sources identified in Higdon (2016) (blue points; Panel B).

DFO surveys covered former, current, and potential terrestrial haul-out sites based on traditional knowledge and the scientific literature (e.g., Born et al. 1995). The status of previously identified haul-out sites was updated, while newly discovered haul-out sites along intervening coastlines were recorded. Stewart et al. (2014a) summarized surveys of terrestrial haul-out sites of the Penny Strait-Lancaster Sound and West Jones Sound stocks conducted in 1977 and 1998-2009 (with the exception of 2002). Stewart et al. (2014b) summarized surveys of the Baffin Bay stock along eastern Ellesmere and Devon Islands conducted in 1999, 2008, and 2009. Stewart et al. (2014c) report findings of coastline surveys along the southeastern half of Baffin Island in 2005-2008, which included the 37 haul-out sites identified in Born et al. (1995). Foxe Basin was surveyed in 2010 and 2011, where 10 terrestrial haul-out sites were visited repeatedly each year (Stewart et al. 2013). Aerial surveys of the coastline of Hudson Strait and east and south Hudson Bay were conducted in 2014, when 81 of 85 haul-out sites for the Hudson Bay-Davis

Strait stock and 21 of 27 identified sites for the South and East Hudson Bay stock were surveyed (Hammill et al. 2016).

All sites where walruses were observed during the DFO surveys, or otherwise reported within the past 10 years (Higdon 2016), are classified as 'active'. Following Higdon (2016), sites were classified as 'uncertain' if they were used historically, but data on current use is lacking (e.g., the sites have not been recently surveyed or have been surveyed but walruses were not observed). 'Abandoned' sites are those that were previously reported as such with no subsequent evidence of recolonization (Appendix 1). During DFO surveys, any sightings of walrus on land have been recorded as a haul-out location; repeated surveys over at least several years indicate long-term use of most sites.

In 2014, DFO commissioned a study to examine overlaps between suitable walrus habitat and shipping traffic in the Hudson Bay biogeographic region in summer and winter (Stewart et al. 2018). Using a geographic information system (GIS) approach, Stewart et al. (2018) mapped potential overlap between walrus distribution and shipping traffic in northwest Hudson Bay, Foxe Basin, and Hudson Strait. Walrus distribution was modeled based on four variables: distance to a terrestrial haul-out, water depth, seasonal ice cover, and distances to the coast or ice (Stewart et al. 2018). Characteristics for each of these variables that were considered as 'high' suitability as walrus habitat were: within 100 km of a haul-out site, 10 to < 50 m water depth, polynya or persistent flaw lead, and < 20 km from ice or coast (Stewart et al. 2018). Habitat suitability was modeled with grid cells at a spatial resolution of 0.25 by 0.25 degree (matching that of the bathymetric data used) for the periods of least, and greatest ice cover (September, or 'summer', and March, or 'winter', respectively). The winter model excluded distance to haul-out. Shipping intensity was modelled using 2010 vessel traffic data from Transport Canada (A model for 2020 was also developed based on projected future shipping levels, but some of the projects that these projections were based on are no longer planned).

Winter and summer habitat models had a similar number of high/very high quality cells, and there was significant spatial overlap in the highest quality cells between the two seasons (Stewart et al. 2018). High quality habitat in both seasons occurred in northern Foxe Basin and around Southampton and Coats islands in northern Hudson Bay, while areas in western Hudson Strait and Southampton Island with terrestrial haul-outs and areas of Foxe Basin that are covered in land-fast ice in winter were scored as high quality habitat in summer only (Stewart et al. 2018). Of 1655 cells covering water, 527 scored high to very high habitat suitability scores in summer, with 525 in winter (an additional 382 and 283 scored 'moderate' in summer and winter, respectively).

Overlap between high quality walrus habitat and industrial activity was high, with 384 of the high quality habitat cells transited by at least one vessel (Stewart et al. 2018). The spatial extent of vessel traffic was similar between 2010 and that projected for 2020, although vessel intensity was greater in 2020 (While some of the specific projections were based on projects that are no longer planned in the study area, it is likely shipping will generally increase.) Ninety-seven percent of the 92 vessel transits through Hudson Strait in 2010 occurred between July to November, indicating summer habitat is the more important focus in terms of potential impacts on walrus (Stewart et al. 2018). This may change if future projects include winter shipping with ice-breaking vessels. Identified limitations of this study include the coarse resolution of the ice data used, in terms of both ice type and spatial variation. The authors recommended inclusion of finer-grained ice data in future models. The 0.25 x 0.25 degree grid cells, based on the resolution of bathymetric data, may have led to the apparent underestimation of habitat suitability in Hudson Strait, where the analysis did not identify high quality habitat despite the high numbers of walrus known to occupy the middle north side of the strait (4675-6020 animals;

Elliott et al. 2013, Stewart et al. 2018). There are also few data (e.g., survey results or tagging studies) with which to validate model results, although the habitat models agree well with known walrus hotspots (Stewart et al. 2018).

Disturbances

Responses

Disturbance is defined as any change in one or more walrus' behavior due to an event, and includes head raises, reorientation of bodies, and dispersal (Cody 2003). Stampedes of alarmed walruses into the water have been associated with mortality due to trampling, particularly of young walruses and those in poor condition, as well as abortion of fetuses and separation of cow-calf pairs (Loughrey 1959, Born et al. 1995, COSEWIC 2017, Garlich-Miller et al. 2011). Demographic studies of Pacific walrus have shown population-level impacts of disturbance-related mortality (Udevitz et al. 2013). Indirect impacts of disturbance include foraging and social disruptions (e.g., masking or interference of acoustic mother-offspring communications, insufficient nursing of calves), increased stress and energy expenditure, and impaired thermoregulation in calves that spend too much time in water (Born et al. 1995). Studies in Hudson Bay show walruses can abandon haul-out sites for up to three or four days after being disturbed by human activities like boating and surveying via aircraft (Mansfield and St. Aubin 1991), while prolonged or repeated disturbances can lead to long-term abandonment of haul-out sites and distribution shifts away from preferred feeding areas (Johnson et al. 1989, Born et al. 1995).

Walrus reactions to disturbance are presumably triggered by auditory, olfactory, and visual cues (Loughrey 1959, Born 1995). There have been no quantitative studies of sound levels that elicit disturbance response in walrus, and so thresholds likely to elicit any of the three types of disturbance reactions are unknown. A study of Atlantic walruses hauled out on a beach indicated they are sensitive to sounds between 250 Hz and 4 kHz that were 10 to 20 dB above ambient noise levels (Kastelein et al.1993a). Tests on a captive Pacific walrus indicated similar sensitivity in the 250 Hz to 4 kHz range, with responses 3 to 13 dB above background noise levels (Kastelein et al. 1996). Underwater hearing sensitivity tests showed the range of best hearing of a captive 18-yr old male Pacific walrus was 1 to 12 kHz, beyond which sensitivity dropped off sharply (Kastelein et al. 2002). Walruses are therefore sensitive to most anthropogenic noise in both air and underwater (Kastelein et al. 1996, 2002).

While their sense of smell is acute, there have been no conclusive tests on the olfactory sensitivity of walruses (Kastelein 2009). Detailed analysis of eye anatomy and retina histology suggest visual acuity in walruses is less than that of other pinnipeds, and is likely specialized for short ranges in air and underwater (Kastelein et al. 1993b).

Vessel-based

Little is published about Atlantic walrus reactions to vessels. Most sources regarding either Atlantic or Pacific walruses do not report vessel sizes, which makes it difficult to classify disturbance responses according to categories defined by Transport Canada. Inuit have indicated walrus are frightened by large ships, although their reactions are variable (Stewart et al. 2011). Ice breakers have the greatest potential for disturbance given their frequent accelerations, turns, and reversals of direction (Garlich-Miller et al. 2011). Fay et al. (1984) found Pacific walruses on ice reacted to an icebreaking ship when it was within 2 km. Females with young went into the water when the ship was 500–1000 m away, while males did not enter the water until the ship was 100–300 m away (Fay et al. 1984). Brueggeman et al. (1990) found most groups of walruses hauled out on ice showed little reaction to ice breaker activities beyond

800 m. McFarland and Aerts (2015) recorded the behavior of walruses in water and on ice at various distances from their survey vessel. Diving and changing course or speed occurred primarily within 500 m of the vessel.

Walruses typically do not respond to small boats with outboard motors until they are less than 400 m away (Born et al. 1995 and references therein). In the eastern Canadian Arctic, Salter (1979) observed no detectable response by walruses to any of six boat approaches within 1.8 to 7.7 km of their terrestrial haul-out. Using automated cameras, Øren et al. (2018) examined the effects of small boats (as well as tourist and polar bear presence) on walrus behavior at five haul-out sites. No significant effects of boats were detected on the number of walruses present at haul-out sites; however, on one occasion a zodiac caused a large and rapid reduction in walrus numbers (images were taken hourly, which limited ability to assess the exact nature of both the disturbance and the response; Øren et al. 2018).

Reactions of Pacific walruses to vessel-based disturbances have been recorded as part of a long-term monitoring study of all-male bachelor herds at Round Island, Bristol Bay, Alaska. Round Island is part of the Walrus Islands State Game Sanctuary, and is monitored by the Alaska Department of Fish and Game (ADFG) and the United States Fish & Wildlife Service (USFWS). During the summer haul-out period, the ADFG and USFWS conduct daily walrus counts and record responses to disturbances, which are compiled in annual reports. Appendix 2 summarizes walrus disturbances from vessel and aircraft activity at Round Island from 1995-2016. The vast majority of documented disturbances are small boats used to ferry staff and visitors to and from the islands (e.g., zodiacs and skiffs). Dispersal of walruses generally occurred when small boats were within 800 m of haul-out sites, although the majority of such close approaches elicited either no or minor reactions (i.e., head raises; Appendix 2). Walrus are highly sensitive to exhaust fumes and will abandon ice pans and terrestrial haul-outs when downwind of boat motors, which may account for some of the variability in response to small boat disturbance. Generally, larger ships that remained outside of the 3 miles (~4.8 km) restriction zone (see below) did not cause noticeable reactions by walruses (Appendix 2). Anecdotally, mixed herds with females and calves seem to be more prone to disperse from a haul-out when disturbed.

Aircraft

Studies have shown walrus reactions to aircrafts vary widely with type, range, and flight pattern (Garlich-Miller et al. 2011). Although escape responses (i.e., stampeding into water) are usually only observed when the aircraft is within horizontal distances of 1 to 2 km (Born et al. 1995 and references therein), jets flying overhead at 30 000 ft (~ 9140 m) have also caused dispersals into water (Appendix 2). There have only been a handful of studies investigating impacts of aircraft disturbance on behavior of hauled out walruses in the eastern Canadian Arctic. Salter (1979) monitored impacts of helicopter, fixed-wing aircraft, and boats on the behavior of walruses at one terrestrial haul-out on Bathurst Island, Nunavut, over a 1-mo period. Walruses reacted to 30, 30, and 67 % of all disturbances within 10, 5, and 2.5 km of the haul-out site, respectively. However, the only disturbances that elicited a reaction beyond head raising (i.e., orientation towards water and escaping into water) occurred within a horizontal distance of 2.5 km and altitude of 1500 m (Salter 1979). There was also evidence that sudden changes in pitch impacted walrus behavior, as a helicopter 1.3 km away caused 26 walruses to rush into the water when it veered suddenly (Salter 1979). Adult females, calves, and immature walruses were more likely to enter the water in response to disturbance than males were (Salter 1979).

The long-term monitoring study of Pacific walruses at Round Island provides the best documentation of aircraft-based disturbances of walrus (Appendix 2). Walruses typically dispersed when aircraft (helicopters and propeller planes) were 165 to 2500 m above ground level (AGL) either flying directly overhead or within several km of haul-out sites. However, there have been several instances of dispersal from overflights at higher altitudes, including a propeller plane at ~ 6100 mAGL and several commercial jets at ~ 9000 mAGL (Appendix 2). The long-term datasets suggest walrus at Round Island have not habituated to disturbance by either boats or aircraft, as reactions to both types of disturbances have been similar over the 20+ yr monitoring period (Appendix 2).

Guidelines in Canada

The federal government of Canada regulates approaches of marine mammals through the Marine Mammal Regulations (MMR), which prohibit the disturbance of marine mammals. Disturbance includes, for example, ‘approaching or attempting to approach a marine mammal to feed it, swim or interact with it, move it or entice or cause it to move from the immediate vicinity in which it is found, separate it from its group or go between it and a calf, trap it or its group between a vessel and the shore or between a vessel and other vessels, or tag or mark it.’ The MMR state the following minimum approach distances for walrus: 100 m in water (January 1 to December 1), 200 m on ice (June 1 to October 31), and 300 m on shore (June 1 to October 31). The MMR also ‘prohibit flight manoeuvres, including taking off, landing or altering the course or altitude of the aircraft for the purpose of bringing the aircraft closer to a marine mammal or otherwise disturbing it. This prohibition is applicable when the aircraft is being operated at an altitude of less than 304.8 m (1 000 ft.) within a radius of one-half nautical mile from the marine mammal.’ Commercial aircraft operating on a scheduled flight plan are exempt from this provision.

Guidelines in other jurisdictions

The USFWS has developed regulations for five terrestrial haul-out sites used by Pacific walrus in Bristol Bay, Alaska (including the Walrus Islands discussed above). The USFWS Guidelines are under the auspices of the Marine Mammal Protection Act, which prohibits the ‘take’ of all marine mammal species in US waters, which includes harassment or attempted harassment, defined as ‘any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal stock in the wild’ or has the potential to ‘disturb … by causing disruption of behavioral patterns …”. The USFWS Guidelines (2012) are as follows: marine vessels ≤ 50 ft (~ 15.2 m) in length should remain at least a 0.5 nautical mile (~ 0.9 km) away from hauled out walruses; those 50–100 ft (~ 15.2 to 30.5 m) should remain at least 1 nautical mile (~ 1.9 km) away; and those greater than 100 ft (30.5 m) should remain at least 3 nautical miles (~ 5.6 km) away. Further, all vessels are to refrain from anchoring and other activities within 3 miles (~ 4.8 km) of hauled out walrus. Vessels are also to maintain a 0.5 nautical mile (~0.9 km) exclusion zone around feeding walruses. At the state level, Alaska restricts all access within state waters (0 to 3 miles; ~ 4.8 km) around Round Island without prior authorization (Rice 2000). The United States National Marine Fisheries Service (NMFS) prohibits groundfish operations within 22 km of walrus haul-outs on Round Island and other locations in Bristol Bay.

The United States Federal Aviation Administration (FAA) recommends that all aircraft maintain a minimum altitude of 5000 feet (~ 1524 m) above ground level within a 3-mile (~ 4.8 km) radius of Round Island. The FAA also has guidelines of 2000 feet (~ 610 m) above ground level within a 0.5 mile (800 m) of walrus haul-outs within the Togiak National Wildlife Refuge and the Alaska Peninsula. Guidelines also recommend pilots of single engine aircraft should not knowingly fly over or fly within 1/2 mile (~ 0.8 km) of walruses hauled out on land or ice to avoid causing a disturbance. If weather or aircraft safety require flight operations within 1/2 mile (~ 0.8 km) of walruses, small single engine aircraft should maintain a minimum altitude of 2000 ft (~ 610 m).

Pilots of helicopters and multi-engine aircraft should not knowingly fly over or fly within 1 mile (~ 1.6 km) of walruses hauled out on land or ice to avoid causing a disturbance. If aircraft safety requires flight operations within 1 mile (~ 1.6 km) of walruses, helicopters and multi-engine aircraft should maintain a 3000 ft (~ 914 m) minimum altitude. Guidelines for both vessel and air traffic have been developed through an adaptive management approach by which adjustments are made to ensure disturbance to walrus is minimal.

In Russia, federal law prohibits vessels from passing within 3 to 5 km of walrus haul-outs and restricts aircrafts from flying below 2000 m over walrus haul-outs (Viasman et al. 2009, cited in Shadbolt et al. 2014).

Cumulative Impacts

Potential for cumulative impacts exists as climate change-induced reductions in sea ice drive more walruses onto terrestrial haul-outs for longer periods of time and likely in greater numbers. At the same time, climate change driven increases in vessel traffic will intensify disturbance along coastal areas that are both important shipping routes and walrus habitat (Stewart et al. 2018). Cumulative impacts on walrus may therefore arise if loss of ice-habitat drives greater occupancy of coastal terrestrial haul-out zones where shipping-based disturbances are greater. Climate change could also drive a shift to more pelagic food webs at the expense of the tight link between ice algae production and benthic communities that walrus rely on (Grebmeier and Barry 1991). Potential for cumulative impacts therefore also exists with anticipated shipping increases coupled with reduced benthic prey populations, as walrus could abandon current haul-out sites if they are too close to shipping zones or no longer close enough to productive bivalve communities.

Conclusions

- Little information about walrus response to disturbance is published in the scientific literature, and most available data is for Pacific walrus. We assume disturbance reactions are similar in Pacific and Atlantic walrus.
- Further, available information is almost exclusively from adult male bachelor herds. Females and dependent young are likely to have greater sensitivity to disturbances.
- Walruses hauled out on ice enter water when ice breaking ships are within 1000 m.
- Observations at Round Island, Alaska indicate vessels that remain outside the 3 mile (4.8 km) restricted zone do not cause disturbances at terrestrial walrus haul-outs.
- A larger body of research on small vessel (e.g. zodiac or skiff) disturbance indicates that walruses disperse and enter water when boats are within 800 m, with the bulk of dispersals occurring when boats are within 400 m (including landings).
- Responses to aircraft are variable, and dispersal into water is not uncommon even for jet overflights at 9000+ mAGL. Excluding jets, propeller planes and helicopters flying at ~1370 to 6100 mAGL at horizontal distances of up to 2.8 km have caused dispersal of walruses at haul-outs. Disturbance is more severe as distances decrease (including helicopter landings).
- In the absence of dedicated research on this topic in the Canadian Arctic, the information summarized above may be used as a guideline for developing buffer zones that restrict vessel and aircraft-based activity around Atlantic walrus haul-out sites. Alternatively, interim adoption of existing regulations and guidelines by the USFWS, FAA, and the ADFG for Pacific walrus in Alaska is another option.

- The USFWS Guidelines (2012) are as follows: marine vessels ≤ 50 ft (~ 15.2 m) in length should remain at least a 0.5 nautical mile (~ 0.9 km) away from hauled out walruses; those 50-100 ft (~ 15.2 to 30.5 m) should remain at least 1 nautical mile (~ 1.9 km) away; and those greater than 100 ft (30.5 m) should remain at least 3 nautical miles (~ 5.6 km) away. All vessels are to refrain from anchoring and other activities within 3 miles (~ 4.8 km) of hauled out walrus, and to maintain a 0.5 nautical mile (~0.9 km) exclusion zone around feeding walruses. Alaska restricts all access within 3 miles (~ 4.8 km) around Round Island. The United States National Marine Fisheries Service (NMFS) prohibits groundfish operations within 22 km of walrus haul-outs on Round Island and other locations in Bristol Bay.
- The FAA recommends that all aircraft maintain a minimum altitude of 5000 feet (~ 1524 m) above ground level within a 3-mile (~ 4.8 km) radius of Round Island and 2000 feet (~ 610 m) above ground level within a 0.5 mile (800 m) of walrus haul-outs within the Togiak National Wildlife Refuge and the Alaska Peninsula. Guidelines recommend single engine aircraft fly over or fly within 1/2 mile (~ 0.8 km) of walruses hauled out on land or ice, and when weather or aircraft safety require flight operations within 1/2 mile (~ 0.8 km) of walruses, a 2000’ (~ 610 m) minimum altitude should be maintained.
- Corresponding FAA guidelines for helicopters and multi-engine aircraft restrict flying within 1 mile of walruses hauled out on land or ice. If flying within 1 mile (~1.6 km) of walruses is required for safety, helicopters and multi-engine aircraft should maintain a minimum altitude of 3000’ (~914 m).
- Guidelines in place for haul-outs in Alaska may not be appropriate for other regions with different levels of vessel or aircraft traffic.
- Buffer zones centered around walrus haul-outs would not protect their larger habitat requirements. For example, ships could still impact walrus foraging behavior outside any designated restricted zone around haul-outs.
- It is recommended that the same guidelines be considered for all haul-out sites (active, uncertain, and abandoned), since the ability of walrus to recolonize abandoned sites is unknown.
- A conservative approach would be to assign larger buffer zones around sites with low and moderate spatial accuracy until more accurate location data become available.
- Currently most vessel traffic is during the open water season, therefore disturbance is likely to have a greater impact on terrestrial haul-outs in summer. However, this could change if ice breaking activities become a more important component of overall Arctic shipping.
- Studies measuring reactions of walrus to various disturbance stimuli at terrestrial and ice haul-outs are needed to fill current data gaps. These should include walruses of both sexes and different age classes.
- Future work should also include satellite telemetry studies to better understand walrus habitat use around haul-out sites, which might identify high-use foraging areas that could be spatially delineated and afforded similar levels of protection as haul-out sites.

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APPENDIX 1

Table A1. Known terrestrial walrus haul-out locations within the Canadian Arctic compiled from DFO and other sources (as cited in Higdon 2016). Populations are the High Arctic (HA) and Central Arctic (CA), and management stocks are Baffin Bay (BB), West Jones Sound (WJS), Penny Strait-Lancaster Sound (PS-LS), Foxe Basin (FB), Hudson Bay-Davis Strait (HB-DS), and South and East Hudson Bay (SEHB).

Haul-out Name	Population	Stock	Latitude	Longitude	Spatial Accuracy	Source
Sturges Bourne Island	CA	FB	66.0903	-83.6666	Moderate	Born et al. 1995
Cape Wilson	CA	FB	67.0013	-81.4618	Moderate	Stewart et al. (2013)
Imiliq Island	CA	FB	69.6619	-77.2576	Moderate	Stewart et al. (2013)
Imiliq Island	CA	FB	69.6894	-77.3171		
Jens Munk Island	CA	FB	69.6724	-80.6697	Moderate	Stewart et al. (2013)
Manning Islands	CA	FB	68.7785	-80.0419	Moderate	Stewart et al. (2013)
North Ooglit Island	CA	FB	68.9861	-81.1429	Moderate	Stewart et al. (2013)
South Ooglit Island	CA	FB	68.4322	-81.683	Moderate	Stewart et al. (2013)
Ullit Island	CA	FB	69.1702	-75.6199	Moderate	Stewart et al. (2013)
Tangle Island	CA	FB	69.3908	-80.1655		
Weeks Bay	CA	FB	67.8726	-72.8591	Moderate	Stewart et al. (2013)
Bushnan Rock	CA	FB	69.4664	-78.8419	Moderate	Stewart et al. (2013)
Tern Island	CA	FB	69.5513	-80.8435	Moderate	Stewart et al. (2013)
Foxe Basin Haulout 2	CA	FB	70.0025	-77.9534		
Walrus Island	CA	HB-DS	63.2739	-83.6875		
Walrus Island 1	CA	HB-DS	63.2736	-83.6875	High	Hammil et al. 2016
Walrus Island 2	CA	HB-DS	63.2698	-83.6606	Moderate	Fisher 1962
Walrus Island IQ1	CA	HB-DS	63.2561	-83.697	Moderate	Brody 1976b
Walrus Island IQ2	CA	HB-DS	63.2785	-83.6681	Moderate	Brody 1976b
Walrus Island IQ3	CA	HB-DS	63.289	-83.6665	Moderate	Brody 1976b
Bencas Island Main	CA	HB-DS	62.9932	-82.6778	Moderate	Fisher 1962
Bencas Island	CA	HB-DS	62.9941	-82.6909		
Bencas Island IQ	CA	HB-DS	63.0261	-82.6204	Moderate	Brody 1976b
Cape Prefontaine	CA	HB-DS	62.9848	-82.2641	Moderate	Fisher 1962
Coats Island 1	CA	HB-DS	62.9442	-82.6474		
Coats Island 2	CA	HB-DS	62.9923	-82.2500		
East Coats ugli	CA	HB-DS	62.6333	-82.0784	Moderate	Fisher 1962
Cape Pembroke (NE Coats Is.)	CA	HB-DS	62.9176	-81.8927	Moderate	Fisher 1962
Coats Island IQ (S Coats Is.)	CA	HB-DS	62.1299	-83.7074	Moderate	Brody 1976b

Haul-out Name	Population	Stock	Latitude	Longitude	Spatial Accuracy	Source
Sentry Island	CA	HB-DS	61.1667	-93.85	High	COSEWIC 2006
Little Walrus Island	CA	HB-DS	62.15	-92.917	High	COSEWIC 2006
Bibby Island	CA	HB-DS	61.8834	-93.0834	High	COSEWIC 2006
Tern Point	CA	HB-DS	62.1333	-92.4667	High	COSEWIC 2006
Marble Island	CA	HB-DS	62.6833	-91.1333	High	COSEWIC 2006
Hazy Islet	CA	HB-DS	62.8062	-90.9575	Moderate	Born et al. 1995
Fairway Island	CA	HB-DS	63.2586	-90.55	High	COSEWIC 2006
Wag Island	CA	HB-DS	63.3834	-90.6334	High	COSEWIC 2006
Depot Island	CA	HB-DS	63.791	-89.8987	Moderate	Born et al. 1995
Belcher Islands (proper)	CA	SEHB	56.2064	-79.2964	High	Hammill et al. 2016
Split Island (South)	CA	SEHB	56.7407	-79.9123	High	J.W. Higdon, pers. obs.
Driftwood Island (proper)	CA	SEHB	57.3044	-78.395	High	Hammill et al. 2016
King George Island	CA	SEHB	57.2499	-78.4999	Moderate	Born et al. 1995
Kidney Island (proper)	CA	SEHB	57.4125	-79.8329	Moderate	Manning 1976
Sleeper Island (proper)	CA	SEHB	57.4931	-79.8194	High	Hammill et al. 2016
Renny Point	CA	HB-DS	63.8208	-83.5831	High	Orr and Rebizant 1987
Prairie Point	CA	HB-DS	63.9744	-83.1601	High	Orr and Rebizant 1987
Native Point	CA	HB-DS	63.7212	-82.5406	Moderate	Orr and Rebizant 1987
Native Pt offshore	CA	HB-DS	63.5982	-82.2547	Moderate	Brody 1976b
Leyson Point	CA	HB-DS	63.4362	-80.9823	Moderate	Orr and Rebizant 1987
Back Peninsula	CA	HB-DS	63.7089	-80.2142	High	Fisher 1962
Back Peninsula IQ1	CA	HB-DS	63.7135	-80.1936	Moderate	Brody 1976b
Back Peninsula IQ2	CA	HB-DS	63.717	-80.1626	Moderate	Brody 1976b
Seahorse Point	CA	HB-DS	63.7714	-80.1336	High	Fisher 1962
Seahorse Point IQ	CA	HB-DS	63.7796	-80.1581	Moderate	Brody 1976b
Terror Point IQ1	CA	HB-DS	64.1216	-80.9467	Moderate	Brody 1976b
Terror Point IQ2	CA	HB-DS	64.0636	-80.9617	Moderate	Brody 1976b
Terror Point	CA	HB-DS	64.1019	-80.8569	Moderate	Fisher 1962
SI IQ	CA	HB-DS	64.0715	-81.2827	Moderate	Brody 1976b
East Bay West	CA	HB-DS	64.0865	-81.7937	Moderate	Brody 1976b
East Bay East	CA	HB-DS	63.9926	-81.718	Moderate	Brody 1976b
SI North-1	CA	HB-DS	65.1822	-84.015	High	Hammill et al. 2016
SI North-2	CA	HB-DS	65.2	-83.0161	High	Hammill et al. 2016
SI North-3	CA	HB-DS	65.25	-84.2	High	Hammill et al. 2016
Duke of York Bay	CA	HB-DS	65.2121	-84.8525	Moderate	Born et al. 1995
Nias Island	CA	HB-DS	65.5286	-84.6802	Moderate	Brody 1976b

Haul-out Name	Population	Stock	Latitude	Longitude	Spatial Accuracy	Source
Seekoo Island	CA	HB-DS	65.6642	-84.5211	High	Brody 1976b
N of Seekoo Is	CA	HB-DS	65.6642	-84.5213	Moderate	Brody 1976b
RWS IQ4 Offshore	CA	HB-DS	65.5322	-86.8183	Moderate	Brody 1976b
RWS IQ3	CA	HB-DS	65.6217	-86.6944	Moderate	Brody 1976b
RWS IQ2	CA	HB-DS	65.6456	-86.6679	Moderate	Brody 1976b
RWS IQ1	CA	HB-DS	65.6589	-86.5901	Moderate	Brody 1976b
Vansitart Island	CA	HB-DS	66.0353	-84.4361	High	Born et al. 1995
Bushnan Island	CA	HB-DS	66.1567	-84.5947	High	Hammill et al. 2016
Bushnan Island 5	CA	HB-DS	66.1619	-84.677	Moderate	Brody 1976b
Bushnan Island 4	CA	HB-DS	66.1323	-84.6256	Moderate	Brody 1976b
Bushnan Island 3	CA	HB-DS	66.132	-84.563	Moderate	Brody 1976b
Bushnan Island 2	CA	HB-DS	66.1631	-84.5861	Moderate	Brody 1976b
Danish Island	CA	HB-DS	65.8722	-83.5607	Moderate	Brody 1976b
Sanderson Island	CA	HB-DS	65.5808	-83.0635	Moderate	Brody 1976b
Fraser Island	CA	Overlap	63.4589	-78.4903	High	Hammill et al. 2016
Nottingham Isl. 1	CA	Overlap	63.3089	-77.9789	High	Hammill et al. 2016
Nottingham Isl. 2	CA	Overlap	63.1093	-77.9752	Moderate	Reeves 1995
Salisbury Isl. 1	CA	Overlap	63.6441	-77.4279	Moderate	Born et al. 1995
Salisbury Isl. 2	CA	Overlap	63.5942	-77.4042	Moderate	Born et al. 1995
Salisbury Isl. 3	CA	Overlap	63.5416	-77.2366	Moderate	Born et al. 1995
Salisbury Isl. 4	CA	Overlap	63.5433	-77.0006	High	Hammill et al. 2016
Salisbury Isl. 5	CA	Overlap	63.3699	-76.7505	Moderate	Born et al. 1995
Salisbury Isl. 6	CA	Overlap	63.444	-76.5971	Moderate	Born et al. 1995
Salisbury Isl. 7	CA	Overlap	63.6858	-77.201	Moderate	Born et al. 1995
Nooshwetuk	CA	Overlap	63.4485	-75.9759	Moderate	Russell 1966
Mill Island	CA	HB-DS	63.9772	-77.7692	High	Hammill et al. 2016
Cape Dorchester	CA	HB-DS	65.4775	-77.3817	High	Hammill et al. 2016
Cape Weston	CA	HB-DS	65.3703	-77.4989	Moderate	Born et al. 1995
Wildbird Island	CA	HB-DS	65.0141	-78.0707	Moderate	Born et al. 1995
Cape Queen	CA	HB-DS	64.7083	-78.2789	High	Hammill et al. 2016
Okolli Island	CA	HB-DS	64.1667	-76.6419	High	Hammill et al. 2016
Lona Bay	CA	HB-DS	64.3594	-77.5778	High	Orr and Rebizant 1987
Shuke Islands	CA	HB-DS	64.2664	-77.1336	High	Orr and Rebizant 1987
West Fox Island	CA	HB-DS	64.29	-75.7942	High	Hammill et al. 2016
Chorbak Inlet 1	CA	HB-DS	64.379	-74.6572	Moderate	Born et al. 1995
Chorbak Inlet 2	CA	HB-DS	64.4003	-74.6297	Moderate	Born et al. 1995

Haul-out Name	Population	Stock	Latitude	Longitude	Spatial Accuracy	Source
Chorbak Inlet 3	CA	HB-DS	64.4558	-74.4586	High	Born et al. 1995
Wales Island	CA	HB-DS	62.85	-72.05	Moderate	Born et al. 1995
Big Island	CA	HB-DS	62.6851	-70.7974	High	Hammill et al. 2016
Wollaston Island	HA	PS-LS	73.7167	-80.9167	High	Stewart et al. 2014a
Cape Hay	HA	PS-LS	73.7437	-80.2916		
Philpots Island	HA	PS-LS	74.872	-80.1974	Moderate	Stewart et al. 2014a
Dundas Harbour	HA	PS-LS	74.5476	-82.4626	Moderate	Stewart et al. 2014a
Cuming Inlet	HA	PS-LS	74.6504	-85.0066	Moderate	Stewart et al. 2014a
Powell Inlet	HA	PS-LS	74.6602	-85.5711	Moderate	Stewart et al. 2014a
Burnett Inlet	HA	PS-LS	74.595	-86.1951	Moderate	Stewart et al. 2014a
Stratton Inlet	HA	PS-LS	74.5192	-86.7324	Moderate	Stewart et al. 2014a
Blanley Bay	HA	PS-LS	74.5216	-87.3997	Moderate	Stewart et al. 2014a
No Name Bay	HA	PS-LS	74.5205	-87.8093	Moderate	Stewart et al. 2014a
Graham Inlet	HA	PS-LS	74.5189	-88.1819	Moderate	Stewart et al. 2014a
Ryder Inlet	HA	PS-LS	74.9074	-88.586	Moderate	Stewart et al. 2014a
Custance Inlet	HA	PS-LS	74.8228	-89.1172	Uncertain	Stewart et al. 2014a
Cape Hurd	HA	PS-LS	74.5519	-89.9695	Moderate	Riewe 1992
Kearney Cove	HA	PS-LS	74.8526	-90.7825	Moderate	Stewart et al. 2014a
Cape Ricketts	HA	PS-LS	74.6415	-91.2887	Moderate	Riewe 1992
Radstock Bay	HA	PS-LS	74.6592	-91.1753	Moderate	Stewart et al. 2014a
Gascoyne Inlet	HA	PS-LS	74.721	-91.3646	Moderate	Stewart et al. 2014a
Beechey Island	HA	PS-LS	74.7114	-91.8485	Moderate	Riewe 1992
Union Bay	HA	PS-LS	74.7554	-91.8807	Moderate	Stewart et al. 2014a
Innes Point	HA	PS-LS	74.8282	-92.0915	Moderate	Riewe 1992
Allen Bay	HA	PS-LS	74.7449	-95.1111	Uncertain	Riewe 1976
Marshall Penn	HA	PS-LS	75.4215	-95.8565	Moderate	Stewart et al. 2014a
Moore Island	HA	PS-LS	74.9723	-98.5652	Uncertain	Born et al. 1995
Milne Island	HA	PS-LS	75.6362	-96.7802	Moderate	Riewe 1992
Markham Point	HA	PS-LS	75.5585	-97.6651	Moderate	Stewart et al. 2014a
Markham West	HA	PS-LS	75.5533	-97.8382	Moderate	Stewart et al. 2014a
Brooman Point	HA	PS-LS	75.5167	-97.4	High	Stewart et al. 2014a
Rapid Point	HA	PS-LS	75.874	-97.5442	Moderate	Riewe 1976
Houston-Stewart Island	HA	PS-LS	75.7204	-95.5026	Moderate	Stewart et al. 2014a
Baillie Hamilton Island	HA	PS-LS	75.9101	-94.8473	Moderate	Stewart et al. 2014a
Margaret Island	HA	PS-LS	76.0912	-94.8164	Moderate	Stewart et al. 2014a
Cape Hornby	HA	PS-LS	76.2742	-94.4635	Uncertain	Stewart et al. 2014a

Haul-out Name	Population	Stock	Latitude	Longitude	Spatial Accuracy	Source
Inglis Bay/Dyer Island	HA	PS-LS	76.3489	-95.2231	Moderate	Stewart et al. 2014a
Barrow Harbour	HA	PS-LS	76.5483	-95.9792	Moderate	Stewart et al. 2014a
Village Bay	HA	PS-LS	76.9747	-96.8175	Uncertain	Stewart et al. 2014a
Coburg Island	HA	BB	75.976	-79.1401	Uncertain	Riewe 1992
Jakeman Glacier (base)	HA	BB	76.4643	-80.9485	Uncertain	Riewe 1992
South Cape	HA	BB	76.2934	-84.4428	Moderate	Riewe 1992
West of South Cape	HA	BB	76.2955	-84.8123	Uncertain	Riewe 1976
Sannialuit ("place with bones")	HA	BB	76.5833	-85.25	High	Born et al. 1995
Baad Fiord	HA	WJS	76.3564	-86.6947	Moderate	Stewart et al. 2014a
Musk Ox Fiord - spit	HA	WJS	76.459	-87.4324	Moderate	Stewart et al. 2014a
Musk Ox Fiord – west	HA	WJS	76.4147	-87.4586	Moderate	Stewart et al. 2014a
Clement Uglit	HA	WJS	76.4662	-88.398	Moderate	Stewart et al. 2014a
Borgen Mount	HA	WJS	76.6314	-88.476	Moderate	Stewart et al. 2014a
Walrus Fiord	HA	WJS	76.4718	-88.646	Moderate	Stewart et al. 2014a
Goose Fiord	HA	WJS	76.6602	-88.5932	High	
Blubber Point	HA	WJS	76.65	-89.8333	High	Stewart et al. 2014a
Norfolk Island	HA	WJS	76.5113	-91.4965	Moderate	Stewart et al. 2014a
Arthur Fiord	HA	WJS	76.5527	-93.2043	Moderate	Stewart et al. 2014a
West Fiord	HA	WJS	76.0698	-90.3748	Moderate	Stewart et al. 2014a
Thomas Lee Inlet	HA	WJS	75.5885	-89.2434	Uncertain	Davis et al. 1978
Nookap/Saukuse Island	HA	WJS	75.5712	-87.75	Moderate	Stewart et al. 2014a
Cape Newman Smith	HA	WJS	75.5943	-85.631	Uncertain	Born et al. 1995
Gabriel Strait	CA	HB-DS	61.8673	-66.2801	Moderate	Stewart et al. 2014c
Kendall Strait	CA	HB-DS	62.1226	-65.8297	Moderate	Stewart et al. 2014c
Sumner Island	CA	HB-DS	62.8111	-65.8401	Uncertain	Riewe 1992
Frobisher Bay	CA	HB-DS	62.56	-65.1252	Moderate	Stewart et al. 2014c
Lupton Channel	CA	HB-DS	62.3524	-64.6264	Moderate	Stewart et al. 2014c
Loks Land	CA	HB-DS	62.5469	-64.4802	Moderate	Stewart et al. 2014c
Cape Farrington	CA	HB-DS	62.8354	-64.7337	Moderate	Stewart et al. 2014c
Monumental Island	CA	HB-DS	62.7555	-63.854	Moderate	Stewart et al. 2014c
Lady Franklin Island	CA	HB-DS	62.9214	-63.708	Moderate	Stewart et al. 2014c
Corelius Grinnell Bay	CA	HB-DS	63.3216	-64.906	Moderate	Stewart et al. 2014c
Brevoort Island	CA	HB-DS	63.3714	-64.279	Moderate	Stewart et al. 2014c
Null	CA	HB-DS	63.5508	-64.1760	Uncertain	
Lemieux Islands	CA	HB-DS	63.707	-64.1282	Moderate	Stewart et al. 2014c
Null2	CA	HB-DS	63.8596	-64.2760	Uncertain	

Haul-out Name	Population	Stock	Latitude	Longitude	Spatial Accuracy	Source
Leybourne Islands	CA	HB-DS	64.245	-64.9552	Moderate	Stewart et al. 2014c
Cumberland Sound	CA	HB-DS	64.7268	-65.4878	Uncertain	Born et al. 1995
Ptarmigan Fiord	CA	HB-DS	64.9004	-66.1054	Moderate	Stewart et al. 2014c
Sulut Bay	CA	HB-DS	64.7969	-65.6515	Moderate	Stewart et al. 2014c
Kekertukdjuak	CA	HB-DS	65.8111	-65.6024	Uncertain	Born et al. 1995
Miliakdjuin Island	CA	HB-DS	65.5455	-65.5075	Moderate	Born et al. 1995
Ujuktuk Fiord (Abraham Bay)	CA	HB-DS	65.3331	-64.4208	Moderate	Stewart et al. 2014c
Aktijartukan Fiord	CA	HB-DS	65.1201	-63.8978	Moderate	Stewart et al. 2014c
Cumberland Sound2	CA	HB-DS	65.00	-63.9	Uncertain	Born et al. 1995
Cape Mercy	CA	HB-DS	64.894	-63.6007	Moderate	Stewart et al. 2014c
Anna's Skerries	CA	HB-DS	65.061	-63.265	Moderate	Stewart et al. 2014c
Touak Fiord	CA	HB-DS	65.6008	-63.2387	Moderate	Stewart et al. 2014c
Gordon’s Rock	CA	HB-DS	65.6147	-62.8481	Moderate	Stewart et al. 2014c
Angijak Island	CA	HB-DS	65.6488	-62.4786	Moderate	Stewart et al. 2014c
Clephane Skerries	CA	HB-DS	65.9479	-62.2549	Moderate	Stewart et al. 2014c
Exeter Sound	CA	HB-DS	66.2095	-62.3982	Moderate	Stewart et al. 2014c
Moonshine Fiord	CA	HB-DS	66.5082	-61.6414	Moderate	Stewart et al. 2014c
Padlei	CA	HB-DS	66.9863	-62.4947	Uncertain	Mansfield 1958
Kertaluk Island	CA	HB-DS	68.2092	-66.5163	Moderate	Stewart et al. 2014c
Alexander Bay	CA	HB-DS	69.1368	-67.8747	Moderate	Stewart et al. 2014c
Isabella Bay South	CA	HB-DS	69.4649	-67.9642	Moderate	Stewart et al. 2014c
Isabella Bay North	CA	HB-DS	69.7752	-67.9834	Moderate	Stewart et al. 2014c
Clyde Inlet	CA	HB-DS	70.4122	-68.5775	Uncertain	Freuchen 1935

APPENDIX 2

Table A2. Summary of walrus disturbances during annual monitoring of boat vessel and aircraft activity at Round Island, Alaska, by the Alaska Department of Fish and Game and the United States Fish and Wildlife Service. Some annual reports contained more details than others about the distance of the potential disturbance to walrus and the nature of the walrus response (e.g., 'dispersal' vs. 'dispersal into water').

Activity	Disturbance/walrus response	Reference
11 stated anthropogenic activities	9 vessels within the 3-mile restricted access zone; only a fishing vessel within 75 m of the coast caused disturbance (> 50 walruses of > 1200 present left the beach) 2 airspace violations; no disturbance	Van Daele (1995)
40 anthropogenic activities	Of 39 authorized boat activities (transporting visitors and staff), 11 approaching or anchoring within 75-400 m caused dispersal of 2-125 walruses 5 chartered USFWS flights flying a minimum of 762 m above ground level; walrus responses observed for 2 of them, 1 of which caused a disturbance of ~ 800 of 900 walruses hauled out on the beach, with ~ 250 dispersing into the water A commercial jet flying overhead at ~ 6500 or 7000 m disturbed 15 walruses; at least two animals dispersed 3 occasions of unauthorized boats or groups of boats within restricted area, but ≥ 1.5 km from shore. Walrus behavior was not observed during these events	Rice (2000)
74 anthropogenic activities	Of 71 mostly authorized boat trips by park staff, 51 caused no disturbance, while 20 boats within 75-300 m caused dispersal of 1-24 walruses 3 occurrences of unauthorized boats within restricted area; 1 approach within 10-50 m of beach caused 1000 walruses to leave the beach Floatplane transporting staff caused dispersal of 50-80 walruses 1 unauthorized plane at unknown altitude but within the sanctuary airspace; no disturbance noted	Rice (2001)

Activity	Disturbance/walrus response	Reference
49 boat vessel or aircraft disturbances	9 airplanes flew over the island on 6 occasions that all resulted in dispersals; a single airplane flying at 1650 mAGL caused 8 of 150 walruses to leave the beach, while the other flights at 165-660 mAGL caused several hundred walruses to leave the beach Of 42 authorized boat activities, 20 within 2-300 m of caused dispersal of 1-75 walruses 2 unauthorized visits by boats at least 2 miles (3.2 km) offshore; no disturbance	Rice (2002)
39 boat vessel or aircraft disturbances	17 of 35 occasions where large boats caused disturbance – details not provided 2 of 2 occasions where small boats caused disturbance – details not provided 1 of 2 confirmed disturbances caused by airplane – details not provided	Cody (2003)
38 anthropogenic activities, mostly authorized boat traffic to and from the islands	Most disturbances were considered minor: head raises and body orientation Helicopter landed on Round Island caused 11 of 22 walruses to enter water Unauthorized vessel approach to within 0.25 mile; no disturbance Low-flying airplane heard overhead on overcast day, well above recommended altitude, caused 33 walruses to disperse from haul-out High-flying jet flew overhead, well above recommended altitude, caused 28 walruses to disperse from haul-out	Helfrich and Meehan (2004)
47 anthropogenic activities, 41 of which were boat traffic	Of 41 boat approaches and departures, 3 caused dispersal, 9 caused head raising, and 19 had no visible effect on the walruses 3 jets flew overhead at altitude of at least 30,000 ft (9140 m) caused disturbance of entire herd, with 134 dispersals and 40 head raises	Okonek and Snively (2005)
42 anthropogenic activities, 39 of which were boat traffic	Of the 39 boating activities (approaches and departures of visitors and researchers), 8 caused dispersal, 2 caused head raises, and 25 caused no discernible changes in behavior 2 air traffic violations had unknown effects on walrus	Okonek and Snively (2006)

Activity	Disturbance/walrus response	Reference
74 anthropogenic activities, 71 of which were boat traffic	Of 71 boat traffic incidents, 13 at distances of 600-2400 ft (180- 730 m) caused dispersal of 2-210 walruses, 4 caused head raises, 21 caused no discernable changes in behavior, and 20 occurred when no walruses were present Plane at 1700 ft (520 m) caused no disturbance	Okonek et al. (2007)
62 anthropogenic activities were observed	No reaction occurred during 30 of the 62 activities (including 28 boat approaches/ departures within 0.5 mile (0.8 km) and 1 helicopter that landed on the island) Boat approaches and departures within 0.5 mile (0.8 km) of walruses caused dispersal of 1-10 walruses on four occasions and of 10-50 on four other occasions. Commercial jet flight at 30,000 ft (9140 m) caused dispersal of 48 walruses	Okonek et al. (2008)
27 anthropogenic activities were observed	4 disturbances occurred when boats approached or departed the island 1 airplane in sanctuary airspace within a 0.5 mile of the island caused dispersal of ~150 walruses 2 aircrafts elicited head raises and reorientation	Okonek et al. (2009)
21 anthropogenic events with disturbances resulting from 6 of these	5 disturbances occurred when boats or staff helicopters approached or departed the island, causing dispersals of 5-20 walruses. A turbo prop aircraft thought to be flying at high altitude caused reorientation of ~100-150 walruses.	Sell and Weiss (2010)
29 anthropogenic events within the 3 nautical mile restricted zone; 56 outside the restricted zone	8 disturbances occurred when boats or helicopters approached or departed the island, causing dispersals of 1-14 animals. 4 of the 56 events outside the restricted limit were audible planes at unknown altitudes that caused disturbances. No reactions were observed for 16 events, which included large vessels and high flying jets, and walruses were either not present or not observed for the remainder.	Sell and Weiss (2011)

Activity	Disturbance/walrus response	Reference
330 documented anthropogenic events; 222 inside the restricted area and 108 (mainly vessel or plane transits) outside but clearly audible or visible from the island	Of the 222 events within the 3 nautical mile restricted zone, 43 dispersals occurred during thr 142 disturbances for which the walrus herd was observed 67 anthropogenic events involved visitor transport boats or staff helicopters, 16 of which caused dispersals of 1-11 walruses 2 dispersals of >25 walruses occurred when a high altitude (9,144 mAGL) jet dispersed 32 walruses and a large prop plane flying overhead at 1,372 mAGL dispersed ~ 500 walruses	Weiss and Sell (2012)
102 anthropogenic events, 75 inside the 3 nautical mile restricted area	2 of 20 authorized visitor transport boats or staff transfers via helicopter caused dispersals; a helicopter landing caused dispersal of 1 walrus, while a commercial charter boat caused dispersal of 10 walruses A small prop plane at medium altitudes (2500 mAGL) and a distance of 2778 m dispersed about 300 animals and caused reorientation or head raises from over 1000 animals A skiff attempting to land on a beach caused dispersal of 200 walruses, 1 into the water An idling skiff ~ 1 mile away may have caused dispersal of 80 walruses into the water None of 20 large vessel observed outside of the 3 mile (4.8 km) restricted zone caused any disturbances	Weiss and Morrill (2013)
59 anthropogenic disturbance events, 58 within the 3 nautical mile restricted area; dispersal occurred during 26 of the 59 events	22 of the events were authorized visitor transport boats or staff transfer helicopters. One helicopter landing caused dispersal of 5 walruses and 3 boat arrivals delivering campers caused dispersal of 1-2 walruses Of 13 trips made with an Achilles inflatable, 3 approaches within 10-50 m caused dispersal of 20, 2, and 18 walruses (from 2,320 animals) A high altitude jet (9144 mAGL) caused dispersal 68 walruses on one occasion	Weiss and Morrill (2015)

Activity	Disturbance/walrus response	Reference
128 anthropogenic events; 71 inside the 3 nautical mile restricted area; disturbance (dispersal) occurred during 9 of the 128 events	5 of 19 helicopter flights approaching within 75-600 m caused dispersal of 20-92 animals into water Of 12 authorized transportations of visitors or staff, 2 helicopter flights caused dispersal of 12 and 24 walruses and 1 commercial boat charter caused dispersal of 6 walruses Of 29 high altitude jet overflights, none caused dispersal 2 of 3 high altitude (>20 000 ft, or ~6100 m) propeller commuter planes (Cessnas) caused 100-200 walruses to reorient and disperse towards the sea, with 59 and 10 dispersing into the sea. 1 float plane flying at ~ 1000 feet (~ 305 m) caused dispersal of 9-11 walruses into the water Of 25 large vessels present outside of the 3 nautical mile exclusion zone, none caused disturbances	Weiss and Morrill (2016)

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