NUNAVUT WILDIFE MANAGEMENT BOARD FINAL REPORT

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Project Number: #4-10-03

Project Title: Avian Cholera: Examining the Geographic Spread and Population Impact of the Disease among Northern Common Eider Ducks Nesting in Nunavut

Project Leaders: Dr. Grant Gilchrist, Environment Canada, National Wildlife Research Centre, 1125 Colonel By Drive, Carleton University, Ottawa, Ontario K1A 0H3 Phone: (613) 998-7364 Fax:(613) 998-0458, E-mail: grant.gilchrist@ec.gc.ca

Dr. Catherine Soos, Environment Canada, 115 Perimeter Rd, Saskatoon, Saskatchewan, S7N 0X4. Phone: (306) 975-5357 Fax: (306) 975-4087, E-mail: catherine.soos@ec.gc.ca

Summary:

Mass-mortality events have been reported at several common eider breeding colonies in the Hudson Strait region of Nunavut and Nunavik. Laboratory testing has confirmed the presence of avian cholera, which is a disease affecting birds caused by infection with the bacterium *Pasteurella multocida.* Avian cholera does not cause serious illness in humans; however it is a major disease for waterfowl and its recent emergence in Nunavut poses a significant conservation concern.

Working with multiple partners, we compiled information about past outbreaks and conducted coastal surveys to examine the geographic extent and severity of outbreaks in Nunavut during the summers of 2010, 2011 and 2012. We supplemented these data with information gathered at a long-term research station where common eiders have been studied since 1996, encompassing a period before, during and after a severe epidemic (Mitivik Island, East Bay Migratory Bird Sanctuary, Nunavut). Our results indicate that avian cholera is spreading within bird populations in the north and the presence of multiple serotypes of *Pasteurella multocida*, suggest that there have been multiple sources of introduction. Our surveys in Nunavut did not identify any new outbreak locations, however, surveys conducted in Nunavik (funded separately by Environment Canada and the Nunavik Marine Region Wildlife Management Board), indicate several recent outbreaks. Data from our long-term study site indicate that mortality can be severe. A 44% decline in the number of nesting females was documented over a 3-year period (2006-2008), but since 2009 the population has stabilized and the number of females dying from avian cholera has steadily declined.

During our study several Inuit partners identified polar bear predation as an additional conservation concern to breeding eiders in Nunavut. In response, we also evaluated nest predation by polar bears on common eiders during the coastal surveys, and at Mitivik Island. Our results indicate that combined predation of polar bears and gulls resulted in near complete reproductive failure in some colonies. Bears were more likely to visit larger, dense colonies, and after 2003, were more prevalent in years with poor ice conditions.

Cholera outbreaks appear to be cyclical and there is some evidence that previously affected populations have stabilized. However, it is not clear how populations will respond to multiple threats, including both cholera outbreaks and bear predation. Our results indicate that in order to better understand the population dynamics of common eiders in Nunavut, the combined effects of cholera and bear predation must be considered in addition to more traditional population stressors such as hunting. Currently, there are few interventions possible to reduce the impacts of avian cholera outbreaks and bear predation on eider populations. Inuit harvesters are our best asset for monitoring disease emergence and bear predation and should be incorporated into future monitoring strategies. We also recommend that down picking and egging be avoided on colonies where there is evidence of high bear predation or significant die-offs and to allow a minimum of 5 years for numbers to rebuild following a significant outbreak event.

Introduction:

Our project investigated recent disease outbreaks affecting common eiders in Nunavut. Common eiders are sea ducks of considerable economic and cultural importance. They are a source of food, eggs and down for subsistence hunters and are among the most numerous bird species in Nunavut. Common eiders concentrate in large numbers on breeding colonies during summer, which makes them vulnerable to disturbance, environmental catastrophes and disease.

Avian cholera was first reported in the Arctic-breeding common eider population near Ivujivik, Nunavik in 2004. Die-offs were subsequently reported in the vicinity of several other Nunavik communities in western Ungava Bay and Hudson Strait in 2006 and 2007. The most severe outbreaks were observed near Coral Harbour, Nunavut, at Mitivik Island in the East Bay Migratory Bird Sanctuary. Mitivik Island is the largest known common eider breeding colony in the Canadian Arctic (up to 8500 breeding pairs). Mitivik Island is also the site of a long-term research station administered by Environment Canada. Biologists have been stationed on Mitivik Island every summer since 1996. Avian cholera was first confirmed on Mitivik Island in 2005, allowing disease dynamics and population impact to be studied in detail.

Avian cholera outbreaks have been documented at several breeding colonies in the Hudson Strait region of Nunavut and northern Quebec (Nunavik). This disease has been documented further south in the past, but appears to be new in northern common eiders. It is caused by infection with the bacterium *Pasteurella multocida*. Avian cholera is suspected when large numbers of dead ducks or geese are found in a short time, when few sick birds are seen, and when the dead birds look otherwise healthy.

We examined the geographic extent and population impacts of avian cholera for eiders and other bird species, as well as the implications of theses outbreaks for wildlife management and subsistence use in Nunavut.

Project Objectives:

Our project has four main objectives:

(1) Use Inuit Ecological Knowledge to understand the current and historical prevalence of avian cholera in Nunavut's bird populations.

(2) Evaluate the impact of avian cholera on common eiders nesting at Mitivik Island in the East Bay Migratory Bird Sanctuary, where a marked population was being studied before outbreaks began and the course of an epidemic could be directly monitored.

(3) Conduct community-based research with the help of Inuit guides to sample common eiders for disease and parasites and estimate disease distribution and prevalence in the vicinity of Coral Harbour, Cape Dorset and Iqaluit.

(4) Communicate our results to local communities and provide wildlife management organizations with the information necessary to make management decisions concerning eiders.

Based on the input of Inuit and the results of our first year we added a fifth objective:

(5) Evaluate nest predation by polar bears on common eiders using long-term data from Mitivik Island, Nunavut and colony surveys throughout Hudson Strait.

Materials and Methods:

Our methods for the long-term research program on Mitivik Island in the East Bay Migratory Bird Sanctuary and the use of Inuit Ecological Knowledge have not changed from previous reports (Project 4-07-01). Briefly, the long-term program at Mitivik Island annually documents the size of the breeding colony, the degree of mortality due to disease, and the impact of disease exposure on the breeding success and survival of individual eiders. PhD student Dominique Henri (Oxford University) complemented this research by conducting interviews of northern residents in the communities of Kimmirut, Cape Dorset and Coral Harbour in 2007-2009. For the this project, PhD student Sam Iverson used the information gathered in these interviews to implement field surveys in the vicinity of Cape Dorset in 2010, 2011, and 2012 and Iqaluit in 2012. Our initial proposal included summer surveys in the vicinity of Coral Harbour in 2011, but given budget constraints and the success we had in Cape Dorset in 2010 we chose to focus on obtaining a solid 3-year data set from Cape Dorset. In 2012 we expanded our survey region to include Frobisher Bay due to recently obtained Inuit Ecological Knowledge suggesting increased polar bear activity on eider breeding colonies and potential cholera outbreaks in the area.

Our surveys were designed in collaboration with the Cape Dorset Hunters and Trapper Organization (HTO) and Canadian Wildlife Service biologists in Iqaluit. Advice from the HTO boards was given as to the optimal time to conduct summer surveys considering ice conditions and eider breeding chronology. Common eiders in Nunavut typically breed in colonies that number from a few individuals to thousands of birds. Their clutches average 3-5 eggs and nests are initiated in mid-June to early July. Nesting occurs predominately on small (0.1 km^2 to 5.0 km^2) near shore islands. Locations where significant numbers of eiders are known to occur were identified and agreement was made about costs for hiring guides and leasing boats or snow machines. The HTO directors volunteered to advertise for guides and make preliminary selections on the basis of guide experience and equipment, subject to approval by EC.

Table 1: Participating Inuit guides and assistants during field work in 2012

Name	Community Nearest to Survey	Role	Dates of involvement
Qabaroak Qatsiya	Cape Dorset	Boat Captain	July 7-14, 2012
Numa Ottokie	Cape Dorset	Boat Captain	July 7-14, 2012
Kooyoo Buuku Pudlat	Cape Dorset	Guide	July 7-13, 2012
Mosha Ragee	Cape Dorset	Guide	July 7-14, 2012
Tutuya Qatsiya	Cape Dorset	Guide	July 14, 2012
Terry Noah	Cape Dorset	Research Assistant	July 5-16, 2012
Loasie Anilnilaq	Iqaluit	Boat Captain	July 18-23, 2012
Nancy Anilnilaq	Iqaluit	Guide	July 18-23, 2012

The data collected during summer surveys included GPS coordinates of colony locations, estimates for the number of common eider breeding females and nest status, the biophysical characteristics of the colonies, other wildlife present, and disease samples. After landing on an island, a search was made on foot by 3-6 people walking 10-25 m apart in successive linear sweeps until the entire colony was investigated. Nests are easily identified because there is little vegetation and current year breeding attempts can be reliably distinguished from previous years' attempts by the presence of fresh feather down, which eiders pluck to line their nest bowls (Goudie et al. 2000). The disease samples included potentially infected pond water, fecal samples from nests, and salvaged carcasses of dead birds. Samples collected in 2010 and 2011 have been processed by the laboratory of Dr. Catherine Soos, Western Veterinary College, Saskatoon. Results for the 2012 samples are pending.

Figure 1. Surveys of eider colonies in the vicinity of Cape Dorset, Nunavut

Disease sampling was also conducted each year on Mitivik Island in the East Bay Migratory Bird Sanctuary. Avian cholera was first confirmed at Mitivik Island in 2005. We expanded our field research in 2005 to track disease prevalence and better understand the influence of disease outbreaks on colony wide reproduction and survival. We collected samples (such as feathers, blood, saliva and feces) from live eiders , as well as water and pond sediments to assess whether the disease is being carried by apparently healthy birds, whether birds have been previously exposed to the disease, and whether the disease can over-winter on an eider colony in the Arctic.

To evaluate temporal variation in bear presence we used a 15-year dataset (1997-2011) collected by Environment Canada biologists stationed on the island. Encounters with bears are recorded in daily log books, which we used to determine the number of days that one or more bears were present between 10 June and 1 August (hereafter bear days) each year. Estimates of sea ice coverage were obtained from the Canadian Ice Service, IceGraph Tool 2.0 database (http://dynaweb.cis.ec.gc.ca/IceGraph20/). We queried the database to determine the percentage of the sea surface that was covered by ice in Northern Hudson Bay Narrows on 25 June of each year. We used 25 June as a reference date because it is the approximate date of 50% ice clearance in our study area over the past 40 years (Hochheim, Lukovich and Barber 2011). Following Stirling and Parkinson (2006), we considered this threshold as biologically relevant indicator of bears' seal hunting opportunity and the timing of bears' arrival on shore.

Figure 2. Common eider breeding habitat and polar bear sign. Clockwise from top left: polar bears on Mitivik Island; an active eider nest; polar bear feces containing egg shell fragments; and a depredated eider nest.

To examine the extent and severity of nest predation by polar bears, we utilized data collected in our boat-based surveys. When a nest was encountered, we recorded its status as active—a nest containing an incubating hen, eggs, or newly hatched ducklings, or empty—a nest in which fresh down was present but a hen, eggs, or ducklings were not present. We also noted sign of potential nest predators, including gulls [principally herring or glaucous gulls], polar bears, and foxes. For gulls, the most reliable indicators of presence were seeing birds and finding egg shells that had been cracked open by pecking. For polar bears, the principal signs were seeing animals, finding feces or tracks, and encountering large numbers of nests that had been destroyed in which feather down was strewn widely around the nest bowl and eggs were broken by large bites or blows. For foxes, the principle signs were seeing animals, finding feces or fur, and encountering both destroyed nests and cached eggs.

For our analyses, we used Generalized Linear Models (GLMs), which we parameterized using a logit link and binomial distribution. We examined the prevalence of bear sign and the proportion of nests remaining active in relation to survey area, nest abundance, and date. We also estimated spatial autocorrelation in the distribution of bear sign among colonies to assess the independence of observations (Moran's I; Fortin, Dale and ver Hoef 2006) and we queried the IceGraph Tool 2.0 database for sea ice coverage estimates in Hudson Strait. We conducted our linear regression and GLM analyses using the software program STATISTICA, Version 6 (Systat Software Inc., Richmond, CA, USA). We conducted our analysis of spatial autocorrelation using the Spatial Statistics Tool in ArcGIS Version 9.2 (Environmental Systems Research Institute Inc., Redlands, CA, USA). Parameter estimates are presented (±SE) and statistical significance was judged at the $\alpha < 0.05$ level.

Results

Avian Cholera on Mitivik Island

Mitivik Island is the largest known breeding colony of common eiders in Nunavut. Prior to the appearance of avian cholera the colony had been growing at a rapid rate. From 1997 to 2005 the population more than doubled reaching >8000 nesting females. A total of 203 mortalities were documented in 2005. From 2006 to 2008 mortality was severe. Overall, 5,973 deaths were recorded over a three year period and the colony dropped in size by 44%. Peak mortality was in 2006 when 3,722 female common eiders succumbed from a colony of 8,596. A total of 781 mortalities were documented on the colony in 2007 and 1,470 mortalities were documented in 2008.

Figure 3. Avian cholera mortality on Mitivik Island, Nunavut

By 2009 the most severe effects of avian cholera abated. Laboratory testing has not confirmed that surviving birds have acquired or pre-existing immunity; however susceptibility appears to have declined. The number of documented mortalities declined to 225 in 2009, to 222 in 2010, to 34 in 2011, to just 12 in 2012. However, colony size has remained largely unchanged. The offspring of females that survived outbreaks in 2009 should only now be recruiting into the population and population modeling indicates numbers should rebuild slowly if avian cholera prevalence remains low and new constraints on survival and productivity are not introduced.

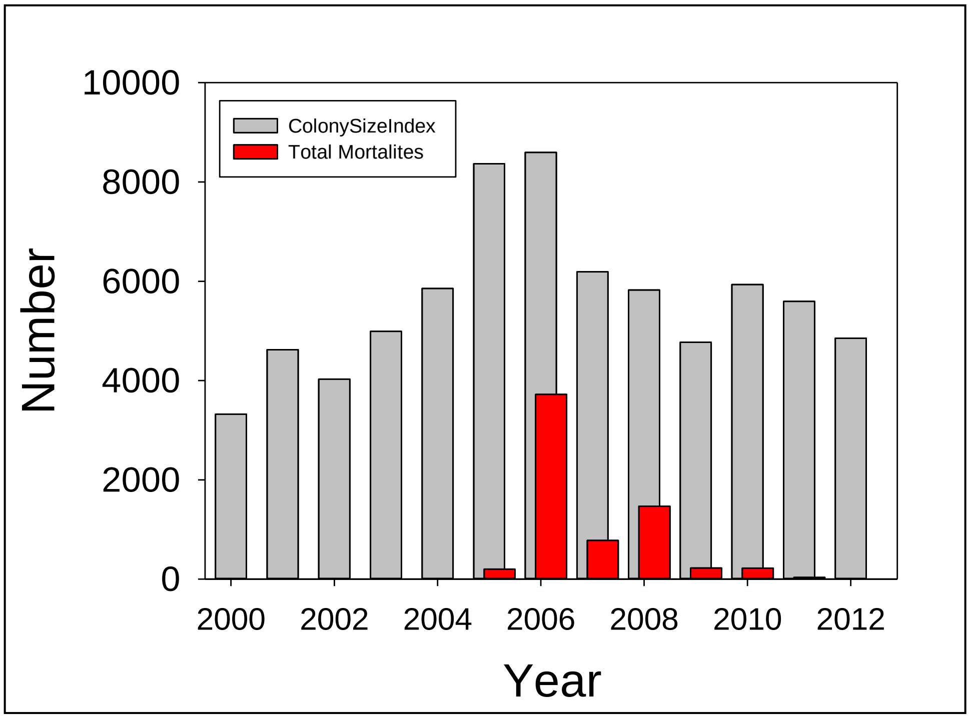

Figure 4. Colony size and total mortality due to avian cholera (2000-2012)

In total, >3000 common eiders have been tested for the presence of *Pasturella multocida* since 2005 using cloacal and/or oral swabs. Results indicate multiple serotypes are circulating in the population. Serotype 1 (confirmed in 2005, 2006, 2008 and 2009) is the serotype most commonly found in the Central and Mississippi Flyway, and Serotypes 3, 4, and 3x4 (confirmed in 2006, 2007, 2008, and 2009) are the serotypes most commonly found on the Atlantic coast. The discovery of Serotype 1 is consistent with the hypothesis that the avian cholera was introduced to northern common eiders by waterfowl (most likely lesser snow geese) on the Arctic breeding grounds. Snow geese are known carriers and avian cholera outbreaks are common and increasing on their wintering and staging areas in the central United States. Atlantic population common eiders, which nest primarily in southern Quebec, the Maritimes and New England, are also affected by avian cholera. The discovery of Serotypes 3, 4 and 3x4 in northern eiders is consistent with the hypothesis that avian cholera was introduced via contact between northern and Atlantic eider populations during the non-breeding season, when there is limited co-mingling off the coasts of Labrador, Newfoundland and Quebec in the Gulf of St Lawrence.

PCR testing of live, apparently healthy females at the time of their arrival at Mitivik Island suggest that up to 10.7% of females were infected with *Pastuerella multocida* at the peak of the outbreak in 2007, compared to 2.0-3.6% from 2009 to 2011. Similar results have been indicated from environmental testing with an estimated 25.0% to 34.2% of pond water samples testing positive for Pasteurella multocida during the nesting period in 2007 and 2008 compared to 9.1% in 2009.

Collectively these results suggest that avian cholera can cause severe mortality in new populations, but that outbreaks appear to be cyclical. This is the case in southern breeding populations in the St. Lawrence and our evidence suggests this is also happening at Mitivik Island. Common eiders do not reach sexual maturity until they reach the age of ≥3 and subadult females do not typically appear at colonies until they reach breeding age. This is significant because it means there is a temporal lag in timing of both population injury and population recovery. Although the breeding adult population suffered severe mortality, a new pool of immunologically naïve females continued to arrive for several years, which helped to bolster numbers but also exposed new birds to the disease. Males largely escape avian cholera outbreaks occurring during the breeding season because they do not help with incubation or brood rearing.

Avian Cholera in Hudson Strait

Surveys in the vicinity of Cape Dorset covered coastal islands extending from Enukso Point on Foxe Peninsula in the west to the Chamberlain Islands and Chorkbak Inlet in the east during July 2010, 2011, and 2012 (Figure 5). Survey effort in the vicinity of Iqaluit was limited by sea ice conditions in Frobisher Bay in 2012. We also conducted surveys in Nunavik, which were separately funded by the Nunavik Marine Region Wildlife Management Board (see Table 2 for synopsis). In total, our surveys in Hudson Strait encompassed ~1200 km of coastline and included 202 islands occupied by nesting eiders.

Our surveys in the vicinity of Cape Dorset and Iqaluit did not indicate that avian cholera outbreaks are affecting common eiders in these areas. Laboratory testing for 2012 is not yet complete; however, we did not encounter significant mortality events in any of the locations that we surveyed. In contrast, outbreaks continue to occur in Nunavik and the geographic range of confirmed outbreak locations has increased considerably since 2004. Confirmed or suspected outbreaks have been documented from Aupaluk in Ungava Bay to Inukjuak in Hudson Bay.

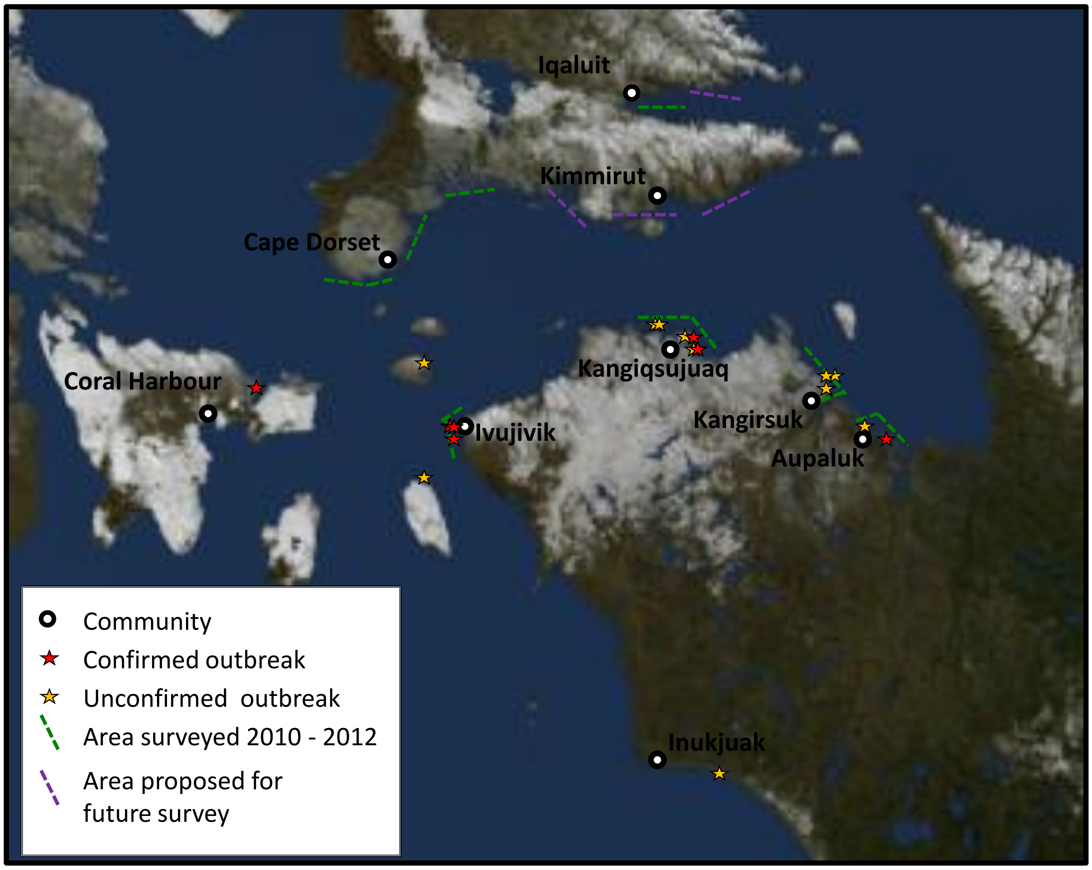

Figure 5. Map depicting survey locations and locations of confirmed or suspected avian cholera outbreaks.

Table 2. Number of colonies surveyed in Nunavut and Nunavik during July 2010-2012.

Year	Community	Number of colonies	Number of breeding pairs
2010	Cape Dorset, NU	93	8,502
2011	Cape Dorset, NU	38	3,819
	Aupaluk, QC	13	1,102
	Kangiqsujuaq, QC	32	3,198
2012	Cape Dorset, NU	34	3,694
	Iqaluit, NU*	22	136
	Ivujivik, QC	22	2,324
	Kangirsuk, QC	32	4,183

* Survey efforts in the vicinity of Iqaluit were limited due to ice conditions in Frobisher Bay during July 2012.

Table 3. Summary of avian cholera outbreak locations in the eastern Canadian Arctic (2004-2012).

ID	Year	Location or Nearest Community	Latitude	Longitude	Species and Estimated Number of Mortalities	Laboratory Testing Results	Information Source
1	2004	Ivujivik	62.43285	-78.17026	COEI: 20-50	Confirmed	Tony Gaston (EC) and Ivujivik HTA members
2	2004	Ivujivik	62.38412	-78.18308	COEI: 20-50	Confirmed	Tony Gaston (EC) and Ivujivik HTA members
3	*2004*	*Ivujivik*	*62.37976*	*-78.20493*	*COEI: 20-50*	*Confirmed*	*Tony Gaston (EC) and Ivujivik HTA members*
4	2004	Mansel Island	Unknown	Unknown	COEI: number unknown	Unconfirmed	Reported to Tony Gaston (EC), but not confirmed
5	2004	Nottingham Island	Unknown	Unknown	COEI: number unknown	Unconfirmed	Reported to Tony Gaston (EC), but not confirmed
6	2006	Aupaluk	59.3839	-69.5400	BLGU: 4; Gull: 1	Unconfirmed	Reported to Nunavik Research Centre by community member
7	2006	Kangiqsujuaq	61.3233	-71.4383	COEI: 250	Confirmed	Reported to Nunavik Research Centre by community member
8	2006	Kangiqsujuaq	61.5757	-71.5500	COEI: 6	Unconfirmed	Reported to Nunavik Research Centre by community member
9	2006	Kangiqsujuaq	61.5700	-71.4700	COEI: 6	Unconfirmed	Reported to Nunavik Research Centre by community member
10	2006	Kangiqsujuaq	61.8700	-72.2000	COEI: 3	Unconfirmed	Reported to Nunavik Research Centre by community member
11	2006	Kangiqsujuaq	61.4200	-71.7000	COEI: 309	Confirmed	Reported to Nunavik Research Centre by community member
12	2006 or 2007	Kangirsuk	60.03241	-69.75114	COEI: 20-50	Unconfirmed	Reported by community member to S. Iverson (Carleton University); site visit conducted in 2012
13	2006 or 2007	Kangirsuk	60.01451	-69.70792	COEI: 20-50	Unconfirmed	Reported by community member to S. Iverson (Carleton University); site visit conducted in 2012
14	2006 or 2007	Kangirsuk	60.04774	-69.61895	COEI: 20-50	Unconfirmed	Reported by community member to S. Iverson (Carleton University); site visit conducted in 2012
15	2011	Aupaluk	59.1550	-69.4660	COEI: 40; HERG: 5; NOPI: 1; BLGU: 2	Confirmed	S. Iverson (Carleton University)
16	2011	Kangiqsujuaq	61.84853	-72.15713	COEI: 16; CAGO: 1; HERG: 1; GLGU: 1; BLGU: 3	Unconfirmed	S. Iverson (Carleton University)
17	2012	Inukjuak	57.7789	-77.0330	Eider: ~2 CAGO: 2 Other ducks: some	Unconfirmed	Reported by Johnny Mina to DFO. Location is Qikkitaluuq (89.2 km S of Inukjuak)
18	2005-2012	Coral Harbour (East Bay Island)	64.0299	-81.7893	COEI: 6669; Other species affected: KIEI, HERG, BLGU, SNBU, CAGO	Confirmed	Site of long-term research by Environment Canada

Many of the locations that we surveyed had been visited by Canadian Wildlife Service biologists assisted by Inuit in the 1950s, 1970s, 1980s and 1990s, which allowed comparison of current nesting female numbers to past numbers. Results indicate that the populations near Cape Dorset in the West Foxe Islands declined from 1956 to 1976 by >60% and from 1976 to 1999 by a further 40%. However, from 1999 to 2010 and 2011 numbers increased to the point that they were above the 1976 level (but still <50% of the 1956 level).

Table 4. Common eider numbers in the West Foxe Islands for locations surveyed repeatedly by Environment Canada biologists and Inuit guides.

	Average Colony Size	Total Number of Nests by Area		
Year	(All Areas)	Southern†	Northern††	Eastern†††
1956	106.5	894	43	86
1976	85.8	215	90	34
1981	96.8	257	65	Not surveyed
1991	39.0	153	23	156
2010	63.1	260	58	89
2011	95.0	352	76	256
2012	62.5	101	67	177

† Southern area: Blades Is., Dunne Is. Luke Is., Tunitjuak Is.; †† Northern area: Bildfell Is. Gudmusson Is., Honting Is. Innuksuk Is., Hume Is., Putaguk Is., Russel Is., and Schioler Is.; ††† Eastern area: Ooglukjuak Is.

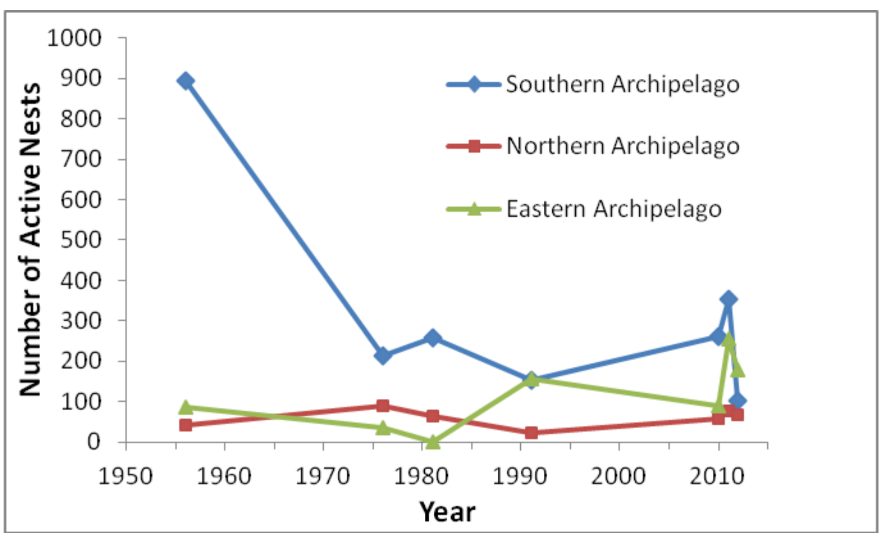

Figure 6. Population trends of nesting common eiders in the West Foxe Islands from 1956 to 2012.

Nest Predation by Polar Bears

Biologists stationed on Mitivik Island observed polar bears on 112 days between 1997 and 2011. A clear increase was evident in bear visits over time (Figure 7a). However, our prediction that the number of bear days would be negatively correlated with sea ice coverage was not met. Post-hoc analysis revealed a large increase in the number of bear visits occurring in 1997-2002 ($\bar{x} = 2.2 \pm 0.5$ bear days*year^{-1}) compared to 2003-2011 ($\bar{x} = 11.2 \pm 1.5$ bear days*year^{-1}). After parsing the data into separate intervals on the basis of this observation, we determined that prior to 2003 bear encounters were unrelated to ice coverage ($F_{1,4} = 0.2$, $P = 0.70$; $r^2 = 0.04$); whereas from 2003 onward a negative correlation was evident in accordance with our *a priori* prediction ($F_{1,7} = 6.2$, $P = 0.04$; $r^2 = 0.47$; Figure 7b).

2010 and 2011 had the lowest early summer ice extents on record in Hudson Strait, with sea surface coverage estimates of 10% and 14%, respectively. We recorded 22 encounters with bears over the course of our surveys, which we estimated to include 19 different individuals (three bears were likely seen on successive days). Bear sign was encountered on 41% of the colonies (Table 5). Sign of gull activity was evident on 84% of the colonies, whereas sign of fox activity was observed on just 5% of colonies. Pair wise comparisons indicated that the presence of predator sign was not correlated among predator species ($r < 0.1$) for bears, gulls and foxes, although we did observe large numbers of gulls converging at locations where recent disturbances had occurred. Bears were observed consuming large numbers of eggs on multiple occasions and the combined effects of bear and gull predation caused near total reproductive failure in many instances. For example, we surveyed an island east of Cape Dorset (64.06° N, 73.53° W) on 11 July 2011 and counted 536 eider nests. Among these, 334 were still active. Fresh bear feces containing egg shell fragments were present on the island and we counted >30 gulls, many of which were actively hunting eider eggs. We returned to the same island two days later and observed a bear consuming eggs and >50 gulls on or above the island. We resurveyed the colony after the bear had left and counted 24 eider nests remaining active.

Our GLM analysis indicated that bear sign was positively associated with nest abundance ($\beta_{NestAbundance} = 0.23 \pm 0.08$). Consistent with this finding, we observed bear sign on 56% of large (≥ 50 nests) colonies, 25% of medium (10-49 nests) colonies, and 19% of small (<10 nests) colonies. The prevalence of colonies with bear sign ranged from 5% to 81% among survey areas and we estimated significant spatial autocorrelation in the data (Moran's I = 0.32, $P < 0.001$), suggesting that nest predation by bears was more likely to occur in locations where neighboring colonies had also been depredated. The probability of encountering bear sign was also positively associated with date ($\beta_{Date} = 0.19 \pm 0.08$), suggesting that our surveys occurred at a time when bears were actively arriving on islands and hunting eider eggs.

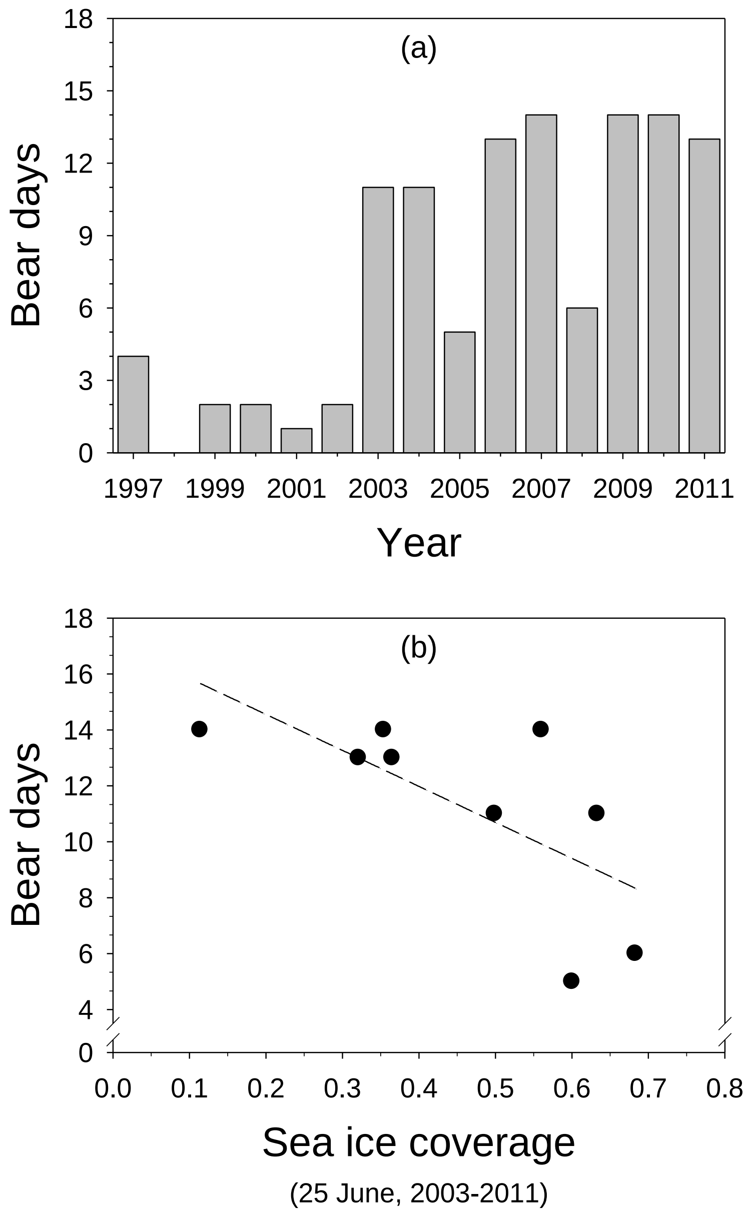

Figure 7. Number of days that bears were present on Mitivik Island during the eider nesting period (1997 to 2011) and relationship between bear days and summer sea ice conditions in Northern Hudson Bay Narrows (2003-2011).

On the colonies where polar bear sign was present, 18% of nests (1635 of 9103) remained active compared to 65% of nests (4831 of 7487) on colonies without bear sign (Table 5). Gull sign was encountered on all but one of the colonies where bear sign was present and 62% of nests (3999 of 6420) remained active when gull sign was present but bear and fox sign were absent. Fox sign was observed on just eight colonies, five of which also had bear sign and all of which had gull sign.

Table 5. Number of common eider colonies surveyed, proportion of colonies on which polar bear sign was encountered, and nest success when bear sign was absent compared to when bear sign was present.

Survey zones[1]	Year	Colonies surveyed		Nest success on colonies without bear sign		Nest success on colonies with bear sign	
		Number	Proportion with bear sign	Nests	Proportion active	Nests	Proportion active
A	2010	9	0.33	154	0.44	362	0.01
B	2010	19	0.05	1985	0.40	362	0.23
B	2011	19	0.11	1528	0.81	729	0.82
C	2010	27	0.81	330	0.26	3336	0.06
D	2010	24	0.63	101	0.79	1872	0.04
D	2011	14	0.36	882	0.79	680	0.61
E	2011	15	0.07	1639	0.76	58	0.02
F	2011	7	0.29	410	0.89	1060	0.24
G	2010	13	0.77	458	0.54	644	0.02
Total		147	0.41	7487	0.65	9103	0.18

[1] A: Cape Dorset; B: West Foxe Islands; C: Chorkbak Inlet; D: Chamberlain Islands E: Kangiqsujuaq; F: Joy Bay; and G: Aupaluk.

Our GLM analysis indicated that the relationship between active nests and the presence of bear sign was negative ($\beta_{BEARSIGN}$= -0.56 ± 0.06), as was the relationship between active nests and date (β_{DATE} = -0.42 ± 0.06). The association between the active nests and nest abundance was positive ($\beta_{NESTABUNDANCE}$= 0.15 ± 0.06), indicating that although larger colonies were visited more frequently by bears these locations remained advantageous in terms of overall nest survival.

Discussion and Management Implications

Our results indicate that avian cholera is spreading within bird populations in the north. Multiple serotypes of *Pasteurella multocida* have circulated in the population since 2005, suggesting that there have been multiple sources of introduction. Our surveys in Nunavut did not identify any new outbreak locations. However, surveys conducted in Nunavik (funded separately by Environment Canada and the Nunavik Marine Region Wildlife Management Board), indicate several recent outbreaks. Mortality attributed to avian cholera has been confirmed or is suspected at a minimum of 18 different locations. Data from our long-term study site indicate that mortality can be severe. A 44% decline in the number of nesting females was documented over a 3-year period (2006-2008). Since 2009 the population has stabilized and the number of females dying from avian cholera has steadily declined.

We also found that polar bear predation is a significant source of reproductive failure at some eider breeding colonies. Of the colonies surveyed, nest success was much higher on islands without bear sign compared to islands with evidence of bears. Further, the combined effects of bear and gull predation resulted in near complete reproductive failure in some instances. Bears were more likely to have visited larger eider colonies than the smaller ones, but larger colonies were also advantageous to eiders in terms of overall nest survival. At Mitivik Island, we found that years with poor ice conditions resulted in higher prevalence of bears on the eider colony. Taken together, these findings indicate that the feeding conditions for polar bears, and more specifically the timing of ice break-up may have important consequences for eider reproduction throughout Nunavut.

Our results indicate that the affect of avian cholera on eider populations can be severe, but that outbreaks are cyclical and mortality levels decrease after the initial outbreak. The combined effects of multiple threats however, such as hunting, polar bear predation, and avian cholera is likely to have a much more pronounced effect on eider populations than any one stressor in isolation. We plan to synthesize the information presented here into demographic models to better understand the combined effects of multiple stressors on eider populations. This will be relevant to multiple aspects of eider management including the assessment of population trends and sustainable harvest levels, the implementation of effective monitoring strategies, and the identification of areas for further investigation and research.

Currently, there are few interventions possible to reduce the impacts of avian cholera outbreaks on eider populations. Large colonies where common eider nesting densities are high appear to be the most susceptible to cholera and population recovery is slow if outbreaks last for multiple years. Inuit harvesters are our best asset for monitoring disease emergence and bear predation and should be incorporated into future monitoring strategies. We also recommend that down picking and egging be avoided on colonies where there is evidence of high bear predation or significant die-offs and to allow a minimum of 5 years for numbers to rebuild following a significant outbreak event.

Reporting to Communities/ Resource Users:

Our project is on schedule. We have modified our work plan to include only surveys near Cape Dorset, but we added surveys to the Frobisher Bay region, as discussed in the Methods section. This is a 3 year project with multi-year funding. Included below is a timeline for the research and community consultation. Community consultation has been in the form of presentations to local HTO, discussion and announcements on the radio, and visits to the community school.

Year	Date	Event	Status
1	March – May 2010	Preliminary planning and consultation (email and telephone)	Complete
	June 2010	Consultation meeting in Cape Dorset with HTO, conservation officer, local community	Complete
	July 2010	Costal surveys in the vicinity of Cape Dorset	Complete
	May – August 2010	Field research camp at Mitivik Island in the East Bay Migratory Bird Sanctuary	Complete
	December 2010 - January 2011	Completion of interim report for year 1	Complete
2	May 2011	Consultation meeting in Coral Harbour with HTO, conservation officer, local community	Complete
	May 2011	Presentation of preliminary results and consultation meeting in Cape Dorset with HTO, conservation officer, local community	Complete
	July 2011	Costal surveys in the vicinity of Cape Dorset	Complete
	May – August 2011	Field research camp at Mitivik Island in the East Bay Migratory Bird Sanctuary	Complete
	December 2011 - January 2012	Completion of interim report for year 2	Complete
3	May 2012	Presentation of preliminary results and consultation meeting in Cape Dorset with HTO, conservation officer, local community	Complete
	July 2012	Costal surveys in the vicinity of Cape Dorset	Complete
	May – August 2012	Field research camp at Mitivik Island	Complete

Year	Date	Event	Status
3	September 2012	Completion of final report for year 2	Complete
	December 2012 - January 2013	Completion of interim report for year 3	Planned
	December 2012 – June 30 2013	Ongoing lab analysis of disease samples, and data analysis	Planned
	July 2013	Presentation of results and consultation meeting in Cape Dorset with HTO, conservation officer, local community	Planned
	September 30 2013	Completion of final Project Report	Planned

References

Pending Manuscripts from this research:

In review: Cascading ecological impacts of climate change: advancing sea ice break-up and increased predation of terrestrial resources by polar bears. By Samuel Iverson, Grant Gilchrist, Paul Smith, Anthony Gaston, and Mark Forbes.

In preparation: Extent and severity of avian cholera outbreaks in the eastern Canadian Arctic. By Samuel Iverson, Grant Gilchrist, Jane Harmes, Catherine Soos, and Mark Forbes.

Avian cholera disease dynamics on Mitivik Island, Nunavut. By Samuel Iverson, Grant Gilchrist, Jane Harmes, Catherine Soos, and Mark Forbes.

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