Results of a Marine Mammal Disease Investigation Project in the Inuvialuit Settlement Region 2000-2004

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ABSTRACT

Marine mammals have always been an integral part of the culture and identity of northern peoples. Both ringed seals (*Phoca hispida*) and beluga whales (*Delphinapterus leucas*) are routinely hunted and used for food by the people of the Inuvialuit Settlement Region (ISR) while Bowhead whales (*Balaena mysticetus*) are hunted occasionally. Over the last few years, hunters have become increasingly concerned about the health of these animals. As a result of these concerns, the Department of Fisheries and Oceans Canada (DFO) has been asked by the Fisheries Joint Management Committee (FJMC) of the Inuvialuit Settlement Region to determine what possible infectious disease threats are present in the marine mammal populations of the ISR as well as to identify any possible human health hazards associated with contact and or consumption of diseased animals.

PREFACE

The results reported here were based on work carried out and funded by the FJMC, Canadian Food Inspection Agency, Department of Fisheries and Oceans Canada, United States Department of Agriculture and the British Columbia Ministry of Agriculture Food and Fisheries, in the years 2000-2004. The work is part of a larger infectious disease survey of marine mammals carried out in arctic Canada seeking to identify infectious diseases circulating in various species, to determine threats to long term survival of specific stocks of animals and to identify possible zoonotic disease threats. This report was prepared for the Fisheries Joint Management Committee (FJMC), Joint Secretariat – Inuvialuit Renewable Resources Committees, P. O. Box 2120, Inuvik, NT, X0E 0T0. Burton Ayles, Member of the FJMC, reviewed the draft document.

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The Fisheries Joint Management Committee (FJMC) Report Series was initiated in 1986 and reports were published sporadically in a variety of formats until 1998. Information on the earlier publications can be obtained directly from the FJMC office. The series was re-initiated in 2003 and a common format established with concurrent publication on the FJMC website (www.fjmc.ca).

INTRODUCTION

The 'Canada Oceans Act' was enacted into federal law in 1997. The need for such legislation was in large part due to the public's perception that oceans are under increasing pressure from human activity and must be protected and monitored. With this increase in mandate the Department of Fisheries and Oceans (DFO) was tasked with providing information and advice on the health and sustainability of Canada's ocean resources to stakeholders and users of these resources. In arctic Canada generally, and the Inuvialuit Settlement Region (ISR) specifically two reasons were identified to investigate marine mammal diseases. First, infectious diseases have been shown to cause severe epizootics in populations of marine mammal species world wide and mortalities can approach 60% of the total population (Jensen et al., 2002). In cases where marine mammal species were endangered or threatened, the risk to individual stocks or populations was even greater. Up to the early 1990's little was known concerning the infectious diseases circulating among marine mammal species in Canadian waters or whether epizootics which had affected populations of marine mammals in other parts of the world could appear in Canada. Secondly, the hunters and their families in the ISR continue to use marine mammals as a source of food, some of which is consumed raw, and they were becoming increasingly aware of zoonotic disease threats from the butchering and consumption of these animals. Delivering a program to address these concerns within the region presented some challenges due primarily to the large geographical area of the ISR, the remoteness of the locations where hunting took place and a limited budget.

Prior to 1995 DFO personnel within the Central and Arctic Region responded to strandings of marine mammals on an *ad hoc* basis. There were no experts designated to deal with such events and records of the results of any investigations or analyses (if they were done at all) were not usually kept. However, it became obvious to marine mammal scientists working with the endangered bowhead whale (*Balaena mysticetus*) stocks both in the eastern and western Canadian arctic that a more comprehensive and science based investigation was necessary to determine sources of natural mortality and provide management authorities [FJMC in the ISR and the Nunavut Wildlife Management Board (NWMB) in Nunavut] with risk assessments of the threats that they pose to long term survival of the two stocks.

In 1995 DFO started to monitor the strandings of these animals more closely and an effort was made to determine the cause of death in cases where fresh carcasses were available. Hunters were also becoming concerned about abnormalities and obvious cases of diseases in other species of marine mammals that were harvested. In the ISR Inuvialuit are allowed to harvest a number of species of marine mammals including beluga, (*Delphinapterus leucas),* ringed seal (*Phoca hispida)* and occasionally Bowhead whales (*Balaena mysticetus*). The "Marine Mammal Disease Investigation Program" was started to allow hunters to submit tissues and in some cases whole animals for diagnosis of the underlying causes of these abnormalities. A similar program was also being conducted by territorial game officials to address similar concerns in terrestrial wildlife (caribou). In 2003, the program evolved from a passive sampling program to an active one when

posters advertising the program were sent to the six main communities in the ISR where marine mammal hunting was known to occur (Inuvik, Aklavik, Holman, Sachs Harbour, Paulatuk and Tuktoyaktuk).

DFO in conjunction with FJMC also had in place a scientific sampling program which collected tissues from hunter-killed and supposedly healthy animals. Blubber, kidney and liver were collected routinely for chemical contaminant analysis including mercury and persistent organic pollutants. Skin samples were collected for DNA analysis and subsequent stock identification while reproductive organs were sampled and examined in order to establish recruitment and productivity rates. With the additional need to collect samples for the disease investigation program a formal coordinated community based sampling program has evolved which included the collection of blood for serological analysis to a suite of infectious disease agents.

METHODS

Between 2000 and 2004 six ringed seals and four belugas were found dead or had been recently harvested by hunters with obvious signs of disease or abnormalities. In addition, samples and/or information from sixteen bowhead whales that had stranded dead in the Northwest Territories between 1987 and 2004 were also collected in an attempt to establish the cause of death. In cases where fresh tissues were available they were forwarded (frozen) to a veterinary pathologist for diagnosis. Blood samples from hunter killed animals were harvested as soon as possible after death and held at -20^{o}C in the various communities and were then held at -80^{o}C upon arrival to the lab in Winnipeg. Serological tests were done in a number of laboratories against a number of viral and bacterial pathogens. Antibody to *Brucella spp*. was determined for 204 beluga and 322 ringed seal samples of whole blood collected by hunters from eight camps in the ISR between 2000 and 2004. Serological analyses were done as previously described (Nielsen et al., 1996, Nielsen et al., 2001 and Nielsen et al., 2005). Additionally, attempts to isolate the *Brucella spp*. responsible for the positive serological reactions were carried out according to methods described in Forbes et al., 2000 using lymph nodes collected at the time of harvest and held at -20^{o}C until testing. Isolation attempts were carried out in a certified Biocontainment level three facility at the United States Department of Agriculture (USDA) laboratories in Ames, Iowa, USA. Biochemical characterization of *Brucella* isolates was done according to the standard methods used for characterizing terrestrial *Brucella spp*. (Alton et al., 1988). Serological testing of antibodies to influenza A was done with whole blood samples from 107 ringed seals harvested in the ISR using a competitive enzyme linked immunoassay (C-ELISA) (Zhou et al., 1998) as part of a larger study to determine evidence of infection in marine mammals in arctic Canada (Nielsen et al., 2001). Blood samples from 107 ringed seals harvested from Paulatuk and Holman in 1994 and 94 were tested for the presence of distemper virus antibodies using a plaque reduction serology test using canine distemper virus (CDV) and phocine distemper virus (PDV). This was also a part of a larger study to determine the prevalence of distemper among seal species from Atlantic and arctic Canadian waters (Duignan et al., 1997). Finally, 108 beluga blood samples from the ISR obtained between 1984 and

1995 were also tested for exposure to DMV using the plaque neutralization method (Nielsen et al., 2000). It should be noted that some samples from some animals were run in more than one test and against more than one pathogen.

RESULTS

A final diagnosis was made in all ten cases involving the belugas and seals submitted for testing (Table 1). Overall, emaciation was the leading cause for submission, accounting for all six of the seal cases. Muktuk of poor quality accounted for two cases among the beluga, another was probably a very old animal at the end of its life, while another was a "struck and lost" hunted animal. Bacterial and parasitic pneumonia was the most common finding upon necropsy (detected in two belugas and in one seal). A perforated stomach and an abscess on the stomach contributed to emaciation in two of the seal pups and incidentally both of these animals were serology positive for brucellosis. Adrenal necrosis consistent with a herpes virus etiology was identified as the major cause of emaciation in a seal pup while no underlying cause could be detected in the under sized pup submitted in 2000. This animal had no blubber reserves and was assumed to be starving.

Determining the cause of death and stranding in the bowhead whales that were identified was less successful (Table 2). The meager results that were obtained were based largely on the information gathered at the site at the time of investigation. No other diagnoses were made based on testing done on post mortem samples submitted for analysis by veterinary pathologists.

Brucellosis serology testing of hunter harvested beluga and ringed seals revealed that both species are enzootically infected within the ISR. A total of 10.3% (21/204) belugas tested were positive (Table 3) and 6.5% (21/322) of the seals were positive (Table 4). *Brucella* isolates were recovered from lymph nodes from 14.2% of the serologically positive belugas (3/21) (Table 3) and from 9.5% of the serologically positive seals (2/21) (Table 4). Biochemical characterization of all five isolates revealed that they belonged within the genus *Brucella* and were all the same biotype (Table 5). Hunters did not report seeing any signs of sickness or abnormality in any of the animals from which *Brucella* was isolated.

Eight ringed seals were identified as serologically positive for influenza A antibodies among the 31 ringed seals harvested and submitted for analysis from Holman in 1993. The remaining 47 samples from seals harvested from Paulatuk, and Sachs Harbour in 1993 and 1994 and the 29 from Holman harvested in 1994 were all negative (Table 7). Since samples consisted of whole frozen hemolysed blood, determination of the hemagglutinin subtype by the hemagglutinin inhibition (HI) test was not attempted. No sign of any symptoms associated with influenza A infection were detected in any of the serologically positive animals.

No evidence of distemper infection found in any of the 108 beluga blood samples obtained between 1989 and 1995 (Nielsen et al., 2000). However, 37/107 or 34.6% of the ringed seals blood samples obtained from Holman and Paulatuk in 1993-94 were positive for distemper antibodies suggesting that distemper is circulating in the ringed seal population but not among beluga.

The finding of serological evidence of dolphin rhabdovirus and canine adenovirus exposure in beluga in the ISR as reported in Phillipa et al., 2004 would indicate that these viruses are also circulating in Canadian beluga populations. It is also reasonable to conclude that these two viruses may be contributing to morbidity and mortality among infected animals.

Table 1. Results of Beluga and Ringed Seal Necropsy Results 2000-2004.				
Location	**Date**	**Species**	**Reason for Submission**	**Final Diagnosis**
Holman	2000	Ringed Seal	Skinny pup	Emaciation
Kendall Island	2000	Beluga	Brown spots in blubber	Subcutaneous fibrosis (healed over wound)
Kendall Island	2001	Beluga	Muktuk of poor quality	Parasitic pneumonia – animal in poor body condition
Holman	2001	Ringed Seal	Skinny pup	Perforated stomach, *Brucella* serology positive
Holman	2001	Ringed Seal	Skinny pup	Stomach abscess, *Brucella* serology positive
Holman	2001	Ringed Seal	Skinny pup	Congenital spinal malformation
Holman	2002	Ringed Seal	Skinny pup	Bacterial pneumonia
Inuvik	2003	Beluga	Older animal found in poor condition	Bacterial pneumonia, *Brucella* serology positive
Holman	2004	Ringed Seal	Skinny pup	Adrenal necrosis of herpes virus etiology
Inuvik	2004	Beluga	Tagged animal found dead	Hunter killed animal “struck and lost”

Table 2. Summary of Bowhead Whale (*Balaena mysticetus*) Strandings in the ISR, 1987-2004.				
Location	**Date**	**Approximate length (meters)**	**Sex**	**Remarks**
Nunaluk Spit	September 1987	9	ND	Dead for 3-4 months
Komakuk Beach	ND	ND	ND	Scavenged by bears
Cape Parry	July 1989	7	ND	Floating in the sea and could not land
Sachs Harbour	August 1993	ND	ND	
Horton River	April 1995	16	ND	Dead from previous year, scavenged by bears
Stokes Point	August 1996	9	ND	
Horton River	September 2000	8.0	ND	Carcass in good condition, scavenged by bears
Tom Cod Bay	September 2000	14	ND	Could not land, visited in winter, scavenged by bears
Nelson Head	April 2003	ND	ND	
Sachs Harbour	July 2003	13	F	
Prince Albert Sound	August 2003	14	ND	Mostly bones
Mashooyak	September 2003	ND	ND	Floating in current
Pearce Point	August 2004	14	ND	Very deteriorated
Pearce Point	August 2004	9.5	ND	Very deteriorated
Mouth of Hornaday River	August 2004	14	ND	Lodged on sand bar
Atkinson Point	December 2004	ND	ND	Found frozen

Table 3. *Brucella* Serology and Bacterial Isolation Results for Beluga (*Delphinapterus leucas*) in the ISR, 2000-2004.				
Location	**Year**	**Number Tested**	**Number Serologically Positive (%)**	**Bacterial Isolations**
Kendall Island	2000	15	1	0
Hendrickson Island	2000	22	1	1
Total	*2000*	*37*	*2 (5.4)*	*1*
Kendall Island	2001	17	1	1
Hendrickson Island	2001	25	2	0
Total	*2001*	*42*	*3 (7.1)*	*1*
Kendall Island	2002	16	1	0
Hendrickson Island	2002	25	3	1
Total	*2002*	*41*	*4 (9.7)*	*1*
Kendall Island	2003	13	2	0
Hendrickson Island	2003	27	4	0
East Whitefish	2003	1	0	[b]ND
[a]Ya Ya Lake	2003	1	1	0
Total	*2003*	*42*	*7 (16.6)*	*0*
Kendall Island	2004	18	3	ND
Hendrickson Island	2004	24	2	ND
Grand Total		**204**	**21 (10.3%)**	**3(14.2%)**

[a]Sick animal
[b]Not Done

Table 4. *Brucella* Serology and Bacterial Isolation Results for Ringed Seals (*Phoca hispida*) in the ISR, 1993-2004.				
Location	**Year**	**Number Tested**	**Number Serologically Positive (%)**	**Number of Bacterial Isolations**
Holman	1993	31	0	ND
Sachs Harbour	1993	3	0	0
Paulatuk	1993	9	0	ND
Total	*1993*	*43*	*0*	*0*
Holman	1994	29	1 (3.4)	0
Paulatuk	1994	38	0	ND
Total	*1994*	*67*	*1(1.5)*	*0*
Holman	2000	56	3 (5.3)	2
	2001	35	4 (11.4)	0
	2002	31	4 (12.9)	0
	2003	30	1 (3.3)	0
	2004	32	4 (12.5)	0
Sachs Harbour	2004	17	4 (23.5)	ND
Tuktoyaktuk	2004	11	0	ND
Grand Total		**322**	**21 (6.5%)**	**2 (9.5%)**

Table 5. Biochemical Characterization of Five *Brucella* Isolates Recovered from Hunter Harvested Ringed Seals (*Phoca hispida*) and Belugas (*Delphinapterus leucas*) in the ISR.	
Characteristic	**Result**
General	
Carbon dioxide required for growth	Yes
Hydrogen sulphide produced	No
Catalase produced	Yes
Urease produced	Yes
Serum required for growth	No
Growth in Medium Containing	
Thionin 1:25,000	Yes
Basic Fuschin 1:25,000	Yes
Thionin Blue 1:50,000	Yes
Safranin O 1:5,000	Yes
Penicillin 5.0 µg/ml	Yes
Erythritol 1.0 µg/ml	Yes
Erythritol 2.0 µg/ml	Yes
Lysis by Brucella Bacteriophages	
Tbilisi	No
Firenze	No
S708	No
Weybridge	Inconclusive
Berkley 2	Variable
Rough	No
Rough ovis	No
Rough canis	No
Delta	No
Me75	No
Surface Antigens	
A antigen	Yes
M antigen	No
R antigen	No

Table 6. Evidence of Infectious Agents in Marine Mammals in the ISR.		
Agent	**Species Tested**	**Test, (Method) and [Reference]**
Brucella spp.	Ringed seal and beluga	Serology (C-ELISA) [Nielsen et al., 1996 and Nielsen et al., 2001]
Brucella spp.	Ringed seal	Bacterial isolation [Forbes et al., 2000]
Canine and Phocine Morbillivirus	Beluga and ringed seal	Serology (virus neutralization) [Duignan et al., 1997 and Nielsen et al., 2000]
Canine, Phocine and Dolphin Morbillivirus	Beluga	Serology (C-ELISA) [Phillipa et al., 2004]
Influenza A	Beluga, ringed seal and bowhead whale	Serology (C-ELISA) [Nielsen et al., 2001]
Phocine Herpes	Beluga	Serology (C-ELISA) [Phillipa et al., 2004]
Dolphin Rhabdovirus	Beluga	Serology (C-ELISA) [Phillipa et al., 2004]
Canine Adenovirus	Beluga	Serology (C-ELISA) [Phillipa et al., 2004]

Table 7. Sampling locations and serum antibody prevalence of ringed seals (*Phoca hispida*) and beluga (*Delphinapterus leucas*) to influenza A antibodies.				
Location and approximate co-ordinates	**Year**	**Species**	**Number Tested**	**Number Positive**
Holman, 71°N, 118°W	1993	Ringed seal	31	8 (25.8)
Holman	1994	Ringed seal	29	0
Paulatuk**,** 68ºN, 123ºW	1993	Ringed seal	10	0
Paulatuk	1994	Ringed seal	34	0
Sachs Harbour,72ºN, 125ºW	1993	Ringed seal	3	0
Sachs Harbour	1993	Beluga	1	0
Hendrickson Island, 69ºN, 133ºW	1993	Beluga	8	0
Hendrickson Island	1994	Beluga	31	0
East Whitefish, 69ºN, 133ºW	1993	Beluga	11	0
East Whitefish	1994	Beluga	13	0
Shingle Point, 60°N, 137°W	1993	Beluga	4	0
Husky Lakes, 69ºN, 132ºW	1989	Beluga	27	0

DISCUSSION

Assessing the health of populations of wildlife including marine mammals by serological screening of individuals against a panel of known pathogens and by investigation of the cause(s) of so-called natural mortality is not a new concept. Wildlife species are known reservoirs of numerous bacterial, viral, and parasitic pathogens and they are thought to account for more than 70% of the world's emerging infectious diseases (Taylor et al., 2001). The importance of pathogen surveillance in wildlife has been recognised both here in Canada and abroad as an important means of determining the risk to wildlife, the domestic animal industry and even to human health. Examples of important emerging diseases originating in wildlife abound in both the scientific literature and the nightly news i.e. the near extinction of the Mediterranean monk seal by distemper in 1997 (Osterhaus et al., 1997), the so called avian flu (H5N1) outbreak that has crippled the poultry industry in Asia and Europe from 2003 till the present, and HIV/AIDS epidemic globally since the mid 1980's that has killed approximately 20 million people, are all good examples. The long term effects of these infections can be threefold, environmental with the loss of biodiversity due to extinction, economic loss due to closure of live stock markets because of imposed quarantine measures, and lastly the real threat to human health globally and to the future of individual countries and even whole continents.

Pathogen surveillance in Canadian domestic animals is the responsibility of the Canadian Food Inspection Agency (CFIA) as mandated by the Animal Health Act while human health issues are the responsibility of Health Canada (HC). The responsibilities for wildlife health issues are not so clearly defined but certainly the responsibly for marine mammals comes under the jurisdiction of DFO while terrestrial species and birds falls under the jurisdiction of Environment Canada (EC) as well as provincial and territorial governments. Recently, all Canadian federal departments with wildlife responsibilities have endorsed a plan by the Canadian Co-operative Wildlife Health Center (CCWHC) to co-ordinate and carry out pathogen surveillance on all wildlife species nationally (Environment Canada, 2004). Though far from an operational reality in Canada there is a growing impetus to develop this strategy further so that wildlife disease surveillance programs can be implemented in other countries and a central reporting system can be developed internationally through the auspices of the World Health Organisation (WHO), United Nations Food and Agriculture Organisation (FAO), World Organisation for Animal Health (OIE) to monitor emerging disease threats from wildlife and Canada is seen as a world leader in this initiative (Kuiken et al., 2005). While little work has been done on marine mammal diseases in Canada and even less has been done in arctic Canada the ability to obtain and study tissues from freshly killed and therefore "good quality samples" gives researchers a unique opportunity to investigate what infectious agents are present in those populations and species of marine mammals.

In the present study, evidence has been presented that a number of infectious agents are circulating among the marine mammal species of the ISR including brucellosis (bacterial), influenza A (virus), distemper (virus) and herpes (virus). Though their role in negatively impacting the populations of animals is largely unknown at this time these agents have been shown to cause considerable mortality in other terrestrial species and in

the case of marine mammal brucellosis evidence is accumulating that in some cetacean species, reproduction is being negatively affected (Ohishi et al., 2003). *Brucella* spp. isolations made from both beluga and ringed seals from the ISR would indicate that the same species of bacteria is infecting both marine mammal species (Table 5) but is different from the species that is infecting caribou and occasionally humans (*B. suis* biovar 4) (Forbes, 1991). Since the marine mammal form can infect both seals and belugas it is also likely that the infection is being spread, both through inter and intra species contact. This may have significance to the long term survival of the species most affected since infection will be constantly introduced into these animals by the species that is harbouring it but may be more resistant to its deleterious effects (so called "spill over") which could eventually cause a decline in the more susceptible species (Dazak et al., 2000). Serological findings from the ISR reveal that seroprevalence to brucellosis in beluga has gradually increased from 5.4% in 2000 to 16.6% in 2003 and 11.9% in 2004 (Table 3). The situation is similar in ringed seals where the prevalence of *Brucella* positive animals in Holman in 1993 is zero but rises over the next decade to a high in 2004 to 12.5% (Table 4). Brucellosis in both beluga and ringed seals is therefore increasing in the ISR as is the risk for hunters for being exposed to infected tissues. Two seal pups from Holman and one beluga from Inuvik were found to be serologically positive for brucellosis, however it is not known if this was the underlying or contributing cause for them to be under sized in the case of the seals, or to strand dead in the case of the beluga (Table 1).

Influenza, distemper and herpes have immediate and sometimes catastrophic impacts by causing acute disease and death within a short period of time (months) in susceptible hosts while brucellosis is known to decrease fecundity in infected populations thereby causing a decline in population over a longer period of time (years and decades). Brucellosis and influenza A infections can also cause significant disease in humans (Sohn et al., 2003 and Webster et al., 1992) however no reports of human disease related to the handling and consumption of marine mammals has been reported in the Northwest Territories or in Nunavut. Territorial Health Boards in both jurisdictions have been made aware of the findings in marine mammals but so far no sero-epidemiological studies in humans is being contemplated. Since the risk of human exposure to zoonotic diseases (especially brucellosis) in infected tissues from hunted animals is thought to be significant by occupational safety officers in DFO, protocols to handle and transport marine mammal samples in order to protect DFO employees from exposure to these agents are being adopted by DFO nationally and should be operational by the end of 2006. These protocols will be quite extensive and will guide employees on every aspect of handling the samples i.e. what level of containment is required, what barrier clothing, and eyewear that must be worn etc. The paradox regarding the way that hunters and their families handle, butcher and consume these same tissues versus the way that DFO employees handle the same tissues from the same animals will no doubt raise questions among hunters in the ISR and Nunavut regarding their safety. Indeed the animals from which bacterial isolations of *Brucella* have been made were used for human food (Table 3 and 4). More work is required to establish what the actual risks are for marine mammal hunters, especially in view of the apparent rise in prevalence of brucellosis in marine mammals of the ISR but this work is outside the scope of the present study.

Brucellosis was not the only pathogen with zoonotic potential identified as circulating in the marine mammals of the ISR. Antibodies to influenza A were also detected in the blood of hunter killed ringed seals from Holman in 1993 indicating that at least sporadic outbreaks of influenza A are occurring in these animals. Evidence of influenza A infection in Alaskan ringed seals would also support this finding (Danner and McGregor, 1998). Influenza A infections are known to cause significant die-offs in seals and have also been isolated from stranded/dead whales (Geraci et al., 1982 and Geraci et al., 1984) but human infections from contact with influenza infected seals have also been reported (Webster et al., 1981). Birds are known to be the reservoir host for all influenza A viruses and marine mammals are thought to be infected by incidental contact with infected waterfowl who are capable of shedding large numbers of virus in their feces. Recent work with Caspian seals (*Phoca caspica*) would also suggest that transmission of human viruses to seals is also possible and may occur frequently where humans and seals share the same habitat (Ohishi et al., 2002). A separate study would be needed to confirm whether human influenza strains are circulating in seals in the ISR as well as what if any effect that is having on ringed seal stocks. The present outbreak of H5N1 avian influenza in Asia and Europe also presents the ISR, as well as Canada, with some serious challenges should it ever become established here. This strain is notorious for its ability to infect and cause serious disease in animals other than birds. It is known to be the direct cause of death in over 70 people and can also cause death in other species including tigers (*Panthera tigris*) and leopards (*Panthera pardus*) (Keawcharoen et al., 2004). In the future it may become necessary to determine whether H5N1 or related strains are circulating in Canadian marine mammals.

Distemper viruses are important wildlife pathogens capable of causing large scale periodic die-offs in susceptible animals such as the seal epizootics reported in Europe in 1988 and again in 2002 (Jensen et al., 2002). They are so potent a threat to marine mammal populations that they present the greatest single danger of extinction to some vulnerable species (Osterhaus et al., 1997). Distemper is enzootic in many seal species in the Atlantic and arctic regions of North America but not in the Pacific region (Duignan et al., 1997). No large scale mass mortalities on the scale of those reported in Europe have ever been reported in Canadian waters but occasional reports of distemper causing stranding and death of infected animals has been reported in Canada (Daoust et al., 1993). Thirty seven of 107 ringed seal blood samples collected in 1993 and 94 from Holman and Paulatuk had detectable levels of distemper antibodies in their blood indicating that a distemper virus is circulating in that population of seals. If distemper is circulating in the seal population enzootically at the present time then the risk of a large scale sudden mass mortality is decreased. The European situation is different from the ISR in that the population of young animals without immunity must reach a threshold level before an epizootic can be re-ignited by the introduction of the virus presumably from infected migrating harp seals (Duignan et al., 1997). Distemper viruses are also capable of causing disease and mortality in cetaceans (Reiderson et al., 1998). No evidence of antibodies to distemper viruses was found in any of the blood samples analysed in Canadian cetaceans in the years 1989-1997, including the 108 beluga from the ISR (Nielsen et al., 2000). The absence of protective “herd immunity” to distemper would suggest that Canadian cetacean species, including the ISR belugas, are at risk of

infection and a major die off should the virus be introduced into northern waters. Evidence of infection has been demonstrated in stranded common dolphins (*Phocenae phocenae*) from the Pacific (Reiderson et al., 1998) and presumably other susceptible cetacean species whose range extends northward could bring the virus into arctic waters. Both periodic serological surveys for distemper antibodies in hunted whales as well testing of tissues from dead stranded whales would provide early warning of an epizootic.

The investigation of sick, stranded and abnormal animals in both the ISR and Nunavut remains a high priority in most communities. The present study reports success in investigations involving seals and beluga but the results from Bowhead whale investigations are less encouraging. Seal and beluga samples have usually been recovered from recently killed animals in good condition while dead Bowheads are usually reported by hunters who see them floating or washed up on the beach in various stages of decay. Large whales deteriorate much quicker than smaller animals after death, sampling trips must be organised to go to the site where the whale has stranded and that can further delay of obtaining good quality samples. Butchering a large whale to access the tissues required for analyses also requires equipment and expertise that is not always available in communities closest to the stranding. In spite of these obstacles, there seems to be a greater will by the communities themselves, FJMC as well as DFO to provide sufficient funding and manpower to investigate these events in recent years. This is in part due to apparent rise in stranding events in the ISR as well as it's listing by COSEWIC as being endangered (DFO, 1999). Bowheads are not the only large whales to strand dead and present obstacles for investigation. Of the 29 emaciated carcasses of gray whales (*Eschrichtius robustus*) investigated in San Francisco Bay area in 1999-2000 no clear cut cause of death could be established. Again, the lack of fresh carcasses hampered the investigations (Moore et al., 2001). The only way to obtain any insight into the periodic strandings of Bowhead whales is to make every effort to investigate only those animals that have recently died. Data regarding those animals that are decomposed is also valuable in terms of identifying how many animals have stranded and where. In some cases, it is possible to ascertain an approximate age of the animal by measuring the length of the carcass, while skin samples can sometimes be used to determine sex through DNA analysis. All this data provides investigators with additional clues that will eventually lead researchers the underlying causes of these strandings.

In the future, no doubt other pathogens will be identified and studied and they too will add to our knowledge about marine mammal diseases and their role in the ecology of their hosts as well as the their effect on the people who rely on them for their food.

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