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Authors: Nielsen, Ole, Stewart, Robert E. A., Measures, Lena, Duignan, Padraig, and House, Carol

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A MORBILLIVIRUS ANTIBODY SURVEY OF ATLANTIC WALRUS, NARWHAL AND BELUGA IN CANADA

Ole Nielsen,[1,5] Robert E. A. Stewart,[1] Lena Measures,[2] Padraig Duignan[3] and Carol House[4]

[1] Department of Fisheries and Oceans, Central and Arctic Region, 501 University Crescent, Winnipeg, Manitoba R3T 2N6, Canada
[2] Department of Fisheries and Oceans, Maurice Lamontagne Institute, P.O. Box 1000, Mont-Joli, Quebec G5H 3Z4, Canada
[3] Massey University Cetacean Investigation Center, Department of Veterinary Pathology and Public Health, Massey University, Private Bag 11-22, Palmerston North, New Zealand
[4] National Veterinary Services Laboratories, Foreign Animal Diseases Diagnostic Laboratory, Greenport, New York 11946, USA
[5] Corresponding author: e-mail (NielsenO@DFO-MPO.GC.CA)

ABSTRACT: A longitudinal serologic survey was conducted for morbillivirus antibodies in Atlantic walruses (*Odobenus rosmarus rosmarus*), narwhal (*Monodon monoceros*), and beluga (*Delphinapterus leucas*) from the Northwest Territories, Nunavut and the St. Lawrence estuary (Canada). Sixty-five of 131 (50%) walruses sampled between 1984 and 1993 had detectable morbillivirus neutralizing antibodies. Positive walrus were identified from four of five Arctic sampling sites, to as far back as 1984. Prevalence of morbillivirus neutralizing antibodies in walruses from Foxe Basin ranged from a high of 76% (n = 21) in 1993 to a low of 22% (n = 28) in 1984. Limitations in sample acquisition may have produced underestimates for the 1984 data. There are no reports of clinical morbillivirus infection in walruses. Our results are consistent with the hypothesis that a morbillivirus similar or identical to phocine distemper virus (PDV) has circulated among walrus populations of the eastern Canadian Arctic, at least since the early 1980s. No narwhal (n = 79) or beluga (n = 445) from Arctic waters were identified as having antibodies to dolphin morbillivirus (DMV) above the threshold serum dilution of $\log_2$ 4. Also, none of the beach-cast cetacean carcasses (n = 28) from the Gulf of St. Lawrence and the St. Lawrence estuary were positive for antibodies to DMV. This indicates that Gulf of St. Lawrence, St. Lawrence estuary, and Arctic cetaceans either have not been exposed to DMV or an antigenically related morbillivirus, or are not susceptible to infection.

Key words: Atlantic walrus, beluga, *Delphinapterus leucas,* dolphin morbillivirus, *Monodon monoceros,* morbillivirus, narwhal, *Odobenus rosmarus rosmarus,* phocine distemper virus, plaque neutralization assay, virus neutralization test.

INTRODUCTION

Inuit hunters harvest marine mammals throughout their ranges for food and income (Anderson and Garlich-Miller, 1994; Brody, 1976). All species require careful monitoring of removal to ensure sustainable harvests. In addition to mortality from exploitation there is the recently recognized phenomenon among marine mammals of mass mortality attributable to hitherto unknown viral pathogens (Young, 1994). The largest and best reported incident occurred among harbor seals (*Phoca vitulina*) in northern European waters during the breeding season of 1988 when an epizootic killed thousands of animals (Harwood, 1989). The virus responsible, phocine distemper virus (PDV), was identified as a new member of the morbillivirus group, related, but not identical, to canine distemper virus (CDV) (Kennedy, 1990).

Although PDV has not been isolated from pinnipeds in North American waters, there is considerable evidence that it, or a similar morbillivirus, has been enzootic there for some time. Retrospective serologic surveys of a number of seal populations indicate exposure throughout the western Atlantic range of harbor and gray seals (*Halichoerus grypus*) (Duignan et al., 1995c) as well as harp (*Phoca groenlandica*), hooded (*Cystophora cristata*) and ringed seals (*Phoca hispida*) (Duignan et al., 1997). The presence of morbillivirus antibodies in phocid seals from Arctic Canada indicates that sympatric Atlantic walruses (*Odobenus rosmarus rosmarus*)

may have been exposed to the virus. A preliminary serologic survey of three walruses from Nottingham Island (Nunavut, Canada) suggested this hypothesis (Duignan et al., 1994). However, a similar survey conducted on Pacific walruses (*Odobenus rosmarus divergens*) sampled between 1984 and 1988 (Osterhaus et al., 1988) found no evidence of exposure in Alaskan waters. Here, we show that morbillivirus antibodies are present in the Atlantic walrus populations of the eastern and high Canadian Arctic from four locations sampled between 1984 and 1996.

Morbilliviruses have also caused disease in European harbor porpoises (*Phocoena phocoena*), Mediterranean striped dolphins (*Stenella coeruleoalba*), Atlantic bottlenose dolphins (*Tursiops truncatus*) (Kennedy et al., 1988; Duignan et al., 1992; Lipscomb et al., 1994), pilot whales (*Globicephala melas* and *Globicephala macrorhynchus*) from the western Atlantic (Duignan et al., 1995b) and common dolphins (*Delphinus delphis ponticus*) from the Black Sea (Birkun et al., 1999). Some epizootics have been quite severe. It has been estimated that more than 50% of the in-shore population of Atlantic bottlenose dolphins died along the eastern coast of the United States between June 1987 and May 1989 in one such event (Federal Register, 1993). Investigations on the dolphin and porpoise isolates revealed only subtle differences between them but confirmed they are genetically distinct from PDV and other morbilliviruses; they have been named dolphin morbillivirus (DMV) and porpoise morbillivirus (PMV), respectively (Barrett et al., 1993; Visser et al., 1993). Based on serology, exposure to DMV and PMV appears to be widespread among odontocetes of the western Atlantic and the Gulf of Mexico as well (Duignan et al., 1995a, b). However, there was no evidence of morbillivirus exposure in the 35 beluga examined between 1985 and 1992 in Hudson Bay and Hudson Strait (Canada; Duignan et al., 1995a). Antibodies to morbillivirus have been identified from stranded common dolphins recovered from beaches in southern California, USA, though no histological evidence of distemper was found. This was the first reported occurrence of morbillivirus exposure in the Northern Hemisphere of the Pacific Ocean (Reidarson et al., 1998).

Here, we report the results of an extensive serologic survey for morbillivirus antibodies in Atlantic walrus from the eastern Canadian Arctic, narwhal and beluga from 17 sampling sites across the Canadian Arctic and five species of cetaceans from the St. Lawrence Estuary and Gulf of St. Lawrence.

MATERIALS AND METHODS

Walruses

Liver, lower canine teeth and blood samples were obtained from hunter-killed Atlantic walruses (n = 114) from Foxe Basin (approximately 69°N, 80°W) (Nunavut, Canada) during the summer hunt (July–August), between 1984 and 1993. Samples were also obtained during various seasons from hunter killed walruses at Loks Land (63°N, 65°W) (n = 5), Resolute Bay (75°N, 95°W) (n = 4), Nottingham Island (63°N, 78°W) (n = 3) and Grise Fjord (76°N, 83°W) (n = 5), all in Nunavut. Blood or serum was collected from walruses in 1987–96 and held at −20C. No blood was collected from the 28 walruses sampled in 1984, so it was necessary to subsample liver specimens stored at −20C for blood after thawing. All samples were centrifuged at 1,000 × g to remove cellular debris prior to serologic testing. Information on body morphometrics and sex of walruses was recorded (Garlich-Miller, 1994; Garlich-Miller and Stewart, 1998, 1999). Age was determined by counting dental annuli in the teeth (Garlich-Miller et al., 1993). Females less than six, and males less than ten years of age, were considered to be juveniles (Garlich-Miller and Stewart, 1999).

Cetaceans

Liver and lower jaw samples were obtained from 79 hunter-killed narwhal between 1986 and 1994 at communities in Nunavut. Samples were obtained from Repulse Bay (66°N, 86°W) (n = 6), Arctic Bay (73°N, 85°W) (n = 3), Iqaluit (63°N, 68°W) (n = 27), Pond Inlet (72°N, 77°W) (n = 25), and Igloolik (68°N, 81°W) (n = 18). No blood was collected so it was necessary to subsample frozen livers for Repulse

Bay, Iqaluit, and Pond Inlet samples and frozen jaws for Arctic Bay and to obtain whole blood for testing. Serum, whole blood and liver samples also were obtained from 445 hunter-killed beluga between 1984 and 1995. They were obtained from the Nunavik (56°N, 76°W to 58°N, 65°W to 63°N, 77°W) (n = 12); the Nunavut communities of Arviat (61°N, 94°W) (n = 68), Coral Harbour (64°N, 83°W) (n = 11), Sanikiluaq (56°N, 79°W) (n = 35), Cape Dorset (64°N, 76°W) (n = 4), Lake Harbour (65°N, 69°W) (n = 46), Iqaluit (63°N, 68°W), (n = 47), Pangnirtung (66°N, 65°W) (n = 87), Grise Fjord (76°N, 82°W) (n = 27), East Whitefish (69°N, 133°W) (n = 24), Hendrickson Island (69°N, 133°W) (n = 52), Husky Lakes (69°N, 132°W) (n = 28), and Shingle Point (60°N, 137°W) (n = 4). Subsampling of livers for blood was necessary in most cases. However, whole blood was available from the 28 whales taken in Husky Lakes in 1989 and serum was available from 52 samples from Hendrickson Island (1993–95), 28 samples from Arviat in 1986, and the eight samples from Grise Fjord in 1987. Both the narwhal and beluga blood and serum samples were handled the same way as the walrus samples prior to serologic testing.

Blood and serum samples were also obtained from 28 beach-cast cetacean carcasses from the Gulf of St. Lawrence (46°N, 59°W to 49°N, 67°W), *Hyperdoon ampullatus* (n = 1) and the St. Lawrence estuary (47°N, 71°W to 49°N, 67°W) *Balaenoptera acutorostrata* (n = 1), *Hyperdoon ampullatus* (n = 2), *Phocoena phocoena* (n = 2), *Lagenorhynchus acutus* (n = 4), and *Delphinapterus leucas* (n = 18) between 1991 and 1997. These samples were stored and processed in the same way as the walrus samples.

Sample analysis

Plaque neutralization assays (PN) were performed on the walrus samples using PDV and canine distemper virus (CDV) (Duignan et al., 1997). Whale samples were assayed using the same method except that dolphin morbillivirus was used and the incubation time was eight days instead of 14. Titers were expressed as the reciprocal of the highest dilution of sample that gave an 80% reduction in the number of plaques compared to the control plates (virus alone) (Habel, 1969). Antibody titers of 16, or greater, were considered positive.

Frequencies of seropositive animals, as well as statistical comparisons of antibody titers between age classes, were compared by Fisher's exact test and 95% confidence intervals (C.I.) were calculated for antibody prevalence according to Conover (1971). Statistical analyses were carried out using SAS software (SAS Institute Inc., 1989).

A comparison of the virus neutralization test (VN) and PN tests was undertaken using the three walrus sera from Nottingham Island (Nunavut, Canada) described in Duignan et al. (1994) and a serum sample from a bearded seal (*Erignathus barbatus*). Validation of the use of the PN test in determining antibody titers used both CDV and PDV. The PN test was further validated by comparing VN and PN values obtained from 11 pilot whale (*Globicephala* sp.) sera previously tested for anti-DMV antibodies (Duignan et al., 1995b).

RESULTS

In all years, more walrus were seropositive for PDV than CDV (Table 1). CDV neutralizing antibodies were present in 21 (16%) of the 131 walrus tested while 65 (50%) had detectable PDV neutralizing activity. The PDV antibody titers were also higher, ranging from the threshold of 16 to a high of 256 while CDV titers peaked at 128. In only six cases did the CDV titer equal or exceed the PDV titer. There were no significant differences in seroprevalence to PDV between sexes or ages (juveniles vs. adults) (Fisher's exact test, $P > 0.05$) among Atlantic walruses (Table 2). Detailed inter-year comparisons were not made. However, values for 1984 appeared low and because the methods for obtaining the 1984 samples were different, they were omitted from further calculations.

The prevalence of PDV neutralizing antibodies in walruses from Foxes Basin was 53% (n = 114, 95% C.I. = 44 to 62%) (Table 1). Seropositive walruses were identified from all years tested, ranging from a low of 22% in 1984 to a high of 76% in 1993. The overall seroprevalence for the years 1987 to 1993 was 60% (n = 91, 95% C.I. = 50 to 70%) and no temporal trend was apparent. Antibody positive walruses were also identified from the sampling sites outside of the Foxe Basin. Although the sample number was low (n = 17), seropositive walrus were recovered from every location except Nottingham Island (Table 2). One walrus from the 1984 sample

TABLE 1. Prevalence of Canine Distemper Virus (CDV) and Phocine Distemper Virus (PDV) neutralizing antibody in Atlantic walruses from Arctic Canada.

	CDV		PDV	
Location	Positive/tested	Prevalence (95% confidence interval)	Positive/tested	Prevalence (95% confidence interval)
Foxe Basin				
1984	1/23	4% (1–22)	5/23	22% (10–44)
1987	2/16	13% (4–38)	12/16	75% (54–93)
1988	4/36	11% (5–26)	18/36	50% (35–67)
1992	1/18	6% (1–27)	9/18	50% (31–74)
1993	8/21	38% (22–62)	16/21	76% (58–92)
Total	16/114	14% (9–22)	60/114	53% (44–62)
Grise Fjord				
1996	1/5	20% (5–72)	1/5	20% (5–72)
Resolute Bay				
1996	3/4	75% (40–99)	3/4	75% (40–99)
Loks Land				
1984	1/5	20% (5–72)	1/5	20% (5–72)
Nottingham Island				
1995	0/3	0%	0/3	0%
Grand Total	21/131	16% (11–23)	65/131	50% (41–58)

TABLE 2. Prevalence[a] of Phocine Distemper Virus neutralizing antibodies in Atlantic walruses (*Odobenus rosmarus rosmarus*).

	Age class			Sex			
Year	Juvenile	Adult	UK[c]	Female	Male	UK[1]	Total
Foxe Basin[b]							
1984	0/2	0/3	5/18 (28)	0/4	5/17 (29)	0/2	5/23 (22)
1987	1/2 (50)	11/14 (79)	—	5/8 (63)	7/8 (88)	—	12/16 (75)
1988	2/7 (29)	12/21 (57)	4/8 (50)	9/19 (47)	9/16 (56)	0/1	18/36 (50)
1992	2/7 (29)	7/11 (64)	—	3/6 (50)	6/12 (50)	—	9/18 (50)
1993	0/2	16/19 (84)	—	3/5 (60)	13/16 (81)	—	16/21 (76)
Total	5/20 (25)	48/68 (68)	9/26 (35)	20/42 (48)	40/69 (58)	0/3	60/114 (53)
Grise Fjord							
1996	0/1	0/3	1/1 (100)	0/2	1/2 (50)	0/1	1/5 (20)
Resolute Bay							
1996	0/0	3/4 (75)	—	1/1 (100)	2/3 (66)	—	3/4 (75)
Loks Land							
1984	—	—	1/5 (20)	—	—	1/5 (20)	1/5 (20)
Nottingham Island							
1995	0/2	0/1	—	—	0/3	—	0/3
Grand Total	5/23 (22)	49/76 (64)	11/32 (34)	21/45 (47)	43/77 (56)	1/9 (11)	65/131 (50)

[a] Number positive/number tested (percent positive).
[b] 1984 data excluded from overall calculation. See text for details.
[c] Unknown sex and/or age.

TABLE 3. A comparison of the virus neutralizing (VN) and plaque neutralizing (PN) in determining morbillivirus antibody titers in pinniped sera.

Host	CDV titer		PDV titer	
	VN	PN	VN	PN
Bearded seal	Toxic	<16	Toxic	<16
Walrus (Or N90-13)	32	<16	64	32
Walrus (Or N90-15)	16	<16	64	16
Walrus (Or N90-16)	32	32	64	32

having antibody titer to both PDV and CDV was identified (Loks Land) (Table 1).

No evidence of antibodies to DMV, above the threshold dilution, was found in any of the 552 cetacean samples.

When sera from three seropositive Atlantic walruses and a bearded seal were compared for detectable antibodies, it was apparent that the VN test was more sensitive and gave higher titers to both PDV and CDV than the PN test (Table 3). However, the PN test was useful in the screening of the bearded seal sample at the threshold dilution at which the sera was toxic in the VN test. The PN test detected antibodies to DMV in 10 of the 11 pilot whale sera. Among seropositive animals, titers ranged from a low of 32 to a high of 1024 (Table 4). Pilot whale MH 90 614, although negative in the PN (titer < 1:16) test, was seropositive in the VN test at the threshold dilution of 1:20. Quantitatively, the anti-DMV titers were all greater using the VN test than the PN test, sometimes by as much as a 10 fold dilution.

TABLE 4. A comparison of the virus neutralizing (VN) and plaque neutralizing assay (PN) in determining anti-DMV titers in pilot whale (*Globicephalas* sp.) sera.

Code	VN	PN
NYGM9H-1	120	64
MH 86 267	640	32
MH 90 614	20	<16
MH 86 207	320	256
MH 86 251	320	128
MH 86 241	320	64
MH 86 244	160	64
MH 90 583	640	512
MH 90 592	2,560	1,024
MH 90 591	2,560	256
MH 90 584	640	256

DISCUSSION

We found serologic evidence of morbillivirus infection in Atlantic walruses from four samples sites in the Canadian Arctic. Although we found no seropositive walrus from Nottingham Island in 1995 (n = 3), our overall results corroborate findings on Atlantic walruses from Nottingham Island sampled in 1990 (Duignan et al., 1994) which suggested that PDV or a PDV-like virus was present in Atlantic walruses of Arctic Canada. Titration of the walrus sera was performed against PDV and CDV while titration of the cetacean sera was performed against DMV in this study. Though all the viruses cross-react serologically, titers are highest against the homologous virus (Visser et al., 1990).

There is serologic evidence that this infection was present in the walrus populations of the Loks Land region of southeastern Baffin Island and Foxe Basin in 1984. The moderate to high antibody prevalence in Atlantic walruses from Foxe Basin, and the consistency of results over a ten year period suggest that a morbillivirus is either enzootic in the population or is being frequently re-introduced from other host species. Enzootic infection in Atlantic walruses is unlikely for two reasons. First, the population is small consisting of approximately 10,000 individuals (Richard and Campbell, 1988) and it is

fragmented into discrete subpopulations or stocks (Born et al., 1995) that are likely too small to sustain infection over a long period. It is estimated that measles infection in man requires a population of at least 300,000 to maintain itself (Bartlett, 1957). Second, walruses are long-lived and have a low rate of reproduction (Garlich-Miller and Stewart, 1999; Born et al., 1995; Mansfield, 1958); hence, a low annual recruitment of susceptible hosts into the population.

It is thought that the walruses of Arctic Canada are comprised of four major stocks, Foxe Basin, southern and eastern Hudson Bay, northern Hudson Bay–Hudson Strait–southeastern Baffin Island–Northern Labrador and North Water (Baffin Bay–eastern Canadian Arctic) (Born et al., 1995). The Foxe Basin and northern Hudson Bay walrus appear to be separate on the basis of body size (Garlich-Miller and Stewart, 1998), PCB concentrations (Muir et al., 1995), and isotope profiles in teeth (Outridge et al., 1997), therefore contact between these stocks is considered unlikely. Walruses occur year-round along the southeastern coast of Baffin Island (including Loks Land) and Hudson Strait. Although these walruses may undertake long migrations (Born et al., 1995) it appears from their discontinuous distribution and reduced stock size (Born et al., 1995) that exchange among groups is small or nonexistent.

Walruses of the North Water probably belong to a single population that summers in Jones and Lancaster Sounds, and winters in Baffin Bay as far west as Greenland (Born et al., 1995). Contact with the other Canadian stocks is considered unlikely; however, there is a chance that some animals migrate down the east coast of Baffin Island coming in contact with animals from the Southeastern Baffin Island population. Isotope profiles suggest that there may be movement among sites and on occasion, walruses make relatively long migrations (Outridge et al., 1997).

The present study has identified morbillivirus exposure among walruses from all but the Southern and Eastern Hudson Bay stock from which samples were not available. Though not impossible, it is improbable that infected individuals spread infection between stocks. Even with some exchange among stocks, a more likely explanation of exposure to morbillivirus, is infection by sympatric seals which are known to carry PDV and manifest clinical signs of disease (Duignan et al., 1994, 1997). Walrus are known to eat seals (Fisher and Stewart, 1997) and this may be one method by which the disease is spread. Once a walrus becomes infected, it is also likely that a limited infection would occur in that group of animals until the supply of susceptible animals becomes exhausted.

It is unlikely that we will ever know how or when morbillivirus was introduced into these four distinct populations of walrus unless the causative virus or viruses can be more completely analyzed. But it does appear that either PDV or a PDV-like virus has been present in the three walrus populations tested since the early 1980's. Inuit hunters or researchers working with Canadian walruses have reported neither gross lesions nor clinical signs consistent with morbillivirus infection. This morbillivirus infection may cause little mortality but produces persistent and high serum antibody levels in some individuals. This is in agreement with what is known about morbillivirus infections in other animals where morbillivirus antibody titers rise, stabilize, and then decline steadily over a number of years (Appel et al., 1981).

Morbillivirus antibodies were not detected in samples collected from beluga whales or narwhals from Arctic waters. This is consistent with the absence of antibodies in a survey of 35 beluga whales sampled contemporaneously in Hudson Bay and the Hudson Strait (Duignan et al., 1995a). The large number of animals tested over a span of 11 yr would suggest either that these populations have not been exposed to a morbillivirus or that they are

not susceptible to infection. The former is possible in that Arctic stocks probably have limited contact with enzootically infected hosts such as the longfinned pilot whale, found mainly in temperate or sub-polar waters (Duignan et al., 1995b). More intriguing is the absence of antibodies from the relict St. Lawrence beluga population. These animals are more likely to associate with a variety of other odontocete species, many of which are known to have morbillivirus infection (Duignan et al., 1995a, b). Assuming that the St. Lawrence beluga population is indeed naïve through lack of exposure, the risk of an epizootic could be considerable and could have devastating consequences on an already threatened stock.

We have no evidence by which to assess the susceptibility of beluga and narwhal to morbillivirus infection. Other susceptible whales, where significant mortality has been reported, are all members of the families Phocoenidae and Delphinidae (Duignan et al., 1992; Lipscomb et al., 1994) closely related to Monodontidae (Milinkovitch et al., 1993). It seems possible, on the basis of relatedness, that beluga and narwhal too would be susceptible, though the extent of the mortality caused would be problematic.

Indeed, the potential lethal impact of a morbillivirus epizootic on belugas or narwhals could have considerable effect on threatened or endangered populations in the Canadian Arctic. At present, Inuit hunters take a sustainable harvest of narwhal and a mass mortality among narwhal, although traumatic in the near term, would probably not adversely impact the long-term survival of the various stocks. For beluga the situation is more grave. The St. Lawrence estuary, Ungava Bay and the southeast Baffin Island stocks of beluga are considered endangered. The population estimate is as low as 600 to 700 animals for the St. Lawrence estuary (Kingsley, 1998) and less than 500 were counted in Cumberland Sound (Richard, 1991). A population estimate could not be determined for the Ungava Bay stock since so few animals were seen during the last survey (Smith and Hamill, 1986). If belugas are susceptible to infection and mortality is high, as it was in some dolphins, an infection could be catastrophic for these depleted stocks. Monitoring of antibody levels in hunter killed beluga and narwhal is ongoing. If and when signs of infection are detected, population surveys will be necessary to determine the effect on the allowable catch of each species within the affected stock.

The PN test, in comparison to the VN test, has been shown to be an acceptable method for detecting morbillivirus antibodies in hemolyzed blood (Duignan et al., 1997). Although the PN method appears to be less sensitive than the VN test, particularly for anti-CDV antibodies, it does provide a means of detecting antibodies in samples otherwise unsuitable for the VN assay. The PN assay used confluent cells and is not as affected by serum hemolysis and contamination as the VN assay. The VN uses freshly seeded cells that are more fragile and therefore susceptible to these deleterious effects, especially at low serum dilutions. The PN test also seems to be useful in detecting anti-DMV antibodies in cetacean serum and hemolyzed blood. Although the VN test gave quantitatively higher final titers, the ability of the two tests was essentially the same in the detection of seropositive pilot whales. Adjusting the cut-off threshold from an 80% reduction to a 50% reduction in the number of plaques per unit of inoculum can increase the sensitivity of the PN test but the more conservative threshold was adopted in this study to reduce the risk of identifying false-positive reactions.

The 1984 sample from Foxe Basin consisted of subsamples of liver tissue collected for contaminant analysis, are probably only suitable for a qualitative assessment of morbillivirus antibody. Markussen and Have (1992) also used frozen liver samples to detect anti-PDV antibodies in harp seals

using an immunoperoxidase test. They also reported a lower seroprevalence compared to the VN test utilizing sera, probably due to the lower concentration of antibodies in the liver tissues. This would explain the lower number of seropositives identified from the 1984 walrus samples.

We report serologic evidence of morbillivirus infection in the Atlantic walrus from three sites in Arctic Canada. PDV or a PDV-like virus has been present in these populations since the early 1980s probably causing little or no mortality but inducing persistent virus neutralizing titers in affected animals. Prevalence among animals varied regionally but was not associated with sex or age. Whether this level of herd immunity is sufficient to prevent an epizootic remains to be seen, however a similar equilibrium seems to be in effect in grey seals in Maritime Canada (Duignan et al., 1995c). Isolation and characterization of the causative virus, as well as a comprehensive investigation of walrus mortalities are needed before the impact of morbillivirus infection in Atlantic walrus can be assessed. No morbillivirus positive cetaceans were identified from several sites in Arctic Canada and the St. Lawrence River. If already threatened populations are indeed immunologically naïve the possibility for mass mortality should be factored into species management plans and estimates of sustainable harvest.

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