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Serologic Survey of Alaska Wildlife for Microbial Pathogens

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FINAL REPORT (RESEARCH)

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Study No.: 18.6 Study Title: Serologic Survey of Alaskan Wildlife for Microbial Pathogens

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SUMMARY

A serologic survey of selected wildlife species from Alaska was conducted. There was little or no evidence of most diseases in most host species. Based on serologic test results, some notable exceptions were apparent:

1. Contagious ecthyma virus was common in Dall sheep (*Ovis dalli*) and rare in other ruminant species.

2. Prevalence of parainfluenza 3 (PI3) virus in the Delta Bison (*Bison bison*) Herd remained extremely high.

3. Prevalence of 3 respiratory viruses (infectious bovine rhinotracheitis, bovine viral diarrhea, and parainfluenza 3) was significantly higher in northern caribou (*Rangifer tarandus*) herds as compared with herds in other parts of the state. PI3 also appeared in muskoxen (*Ovibos moschatus*) from the Arctic National Wildlife Refuge for the first time.

4. Brucellosis was common in caribou, grizzly bears (*Ursus arctos*) and wolves (*Canis lupus*) in the northern portions of Alaska and low in other species and other areas.

5. Leptospirosis was more common in southern caribou and grizzly bears compared with other parts of the state.

6. Respiratory syncytial virus was newly added to the survey. There was very little evidence of its presence in any species.

7. There was a widespread outbreak of contagious ecthyma in mountain goats (*Oreamnos americanus*) in southeastern Alaska in 1989-90. Serologic tests provided no advance warning of the epizootic.

8. The South Alaska Peninsula Caribou Herd declined in herd size and productivity. Serologic tests revealed no conclusive evidence that infectious diseases were a factor in the herd's dynamics.

9. The dramatic increase in PI3 in the Delta Bison Herd has raised concerns that this agent may spread to other wildlife species in the vicinity with serious consequences. To date, there is no evidence of spread to either the Macomb Caribou Herd, Dall sheep at Granite Creek, or a small sample of moose (*Alces alces*).

10. During this study, several species were considered for translocation. No evidence of infectious diseases which might preclude translocation was found.

11. Grizzly (*Ursus arctos*) and black (*U. americanus*) bear populations were examined for evidence of 2 agents included in the survey for the first time, namely pseudorabies virus and *Toxoplasma gondii*. Evidence was very low or nonexistent. These agents appear absent from bears in Alaska at this time.

12. Several caribou herds were surveyed for the first time. Results fit established patterns for other herds previously tested in the vicinity.

Key Words: Alaska, disease, serologic survey, wildlife

CONTENTS

BACKGROUND

There have been few documented instances of infectious diseases having a detectable impact on wildlife populations in Alaska. Brucellosis in caribou (*Rangifer tarandus*) and rabies in canids have been notable exceptions. A serologic survey was conducted throughout the state to evaluate the disease status of various Alaskan wildlife populations.

Disease surveys conducted by serologic tests have many advantages:

1. Blood samples are easy to collect.

2. It is not necessary to sacrifice animals to test for evidence of previous exposure to disease(s).

3. Periodic samples can be collected from the same animals(s) over an extended time frame, thus providing information on the timing of exposure.
4. Tests are relatively inexpensive to perform.

5. A single sample can be tested for evidence of many different diseases, rather than requiring a specific tissue or organ for each disease.

6. Sera are stable for a long time (under adequate storage conditions), which provides the basis for a functional archive system that can be analyzed in the future.

7. If the sample size is adequate, the status of an entire population in relation to a disease can be evaluated.

8. If populations are monitored over a period of time, it is possible to determine changes in the disease status of the population.

9. Early warning of such changes in disease status of a population allow for the consideration of human intervention in the disease process at the most opportune time and place.

Within a living animal, antibody molecules are produced in response to invading disease agents. For certain agents, antibody may decay to undetectably low levels over a relatively short period (ca. several months). For other agents, antibody may be more long-lived and may remain at detectable levels for many years. Re-exposure to the same disease agent usually causes an increase in the level of antibody in circulation. These factors all confound attempts to correlate the level of antibody in the serum to the date of exposure of the host to the agent.

Perhaps the most reasonable means of determining the time frame during which an animal has been exposed to an infectious disease agent is to collect serum specimens periodically from a specific animal periodically. However, in most cases such periodic sampling schemes are not practical for free-ranging animals. Thus, determining the time of exposure for specific individuals or populations is difficult.

Test results for samples which were collected during any particular year do not necessarily reflect that year's transmission pattern. For example, animals with evidence of exposure may have been infected previously. However, analyzing such test results based upon the year in which the samples were collected may reveal long-term trends in the frequency of disease transmission. Although this approach of grouping samples according to the year in which they were collected may not be infallible, it serves a practical purpose and is an accepted technique for evaluating data. This sample grouping approach will be used throughout the discussion of the current study.

The Alaska Department of Fish and Game (ADF&G) has conducted serologic surveys since the early 1960s. During the early years such surveys were limited in the scope of disease agents and host species investigated. Over the past decade the survey expanded to include both more potential host species and more disease agents.

Abstracts of formal manuscripts which were produced during the past 5 years as a result of the serologic survey are presented in Appendices A-D.

OBJECTIVE

The objective of this survey was to monitor Alaskan wildlife populations for the occurrence of microbial disease agents which may have a detrimental effect upon the health of both individual animals and entire populations.

METHODS

Most blood samples were collected by ADF&G biologists who captured animals to meet objectives of other studies. Hunters collected and contributed samples from bison (*Bison bison*), caribou, Dall sheep (*Ovis dalli*), and Sitka blacktail deer (*Odocoileus hemionus sitkensis*). General collection areas are indicated in Figures 1-7.

Most blood samples settled at ambient or refrigerated temperatures for 6 to 36 hours and then were centrifuged. Sera were then removed by aspiration and dispensed in vials. Sera were kept frozen until the time of testing. Most serologic tests were performed by personnel of the National Veterinary Services Laboratories (USDA, Ames, Iowa). Disease agents were selected for inclusion in this survey based upon past or potential problems with wildlife species in Alaska or other parts of the world.

Sera were tested for evidence of exposure to:

1. *Brucella* spp., by the buffered acidified plate antigen test (Angus and Barton 1984).

2. *Francisella tularensis*, by the tube agglutination test (Owen 1970).

3. Q fever and contagious ecthyma, by the complement fixation test (Erickson et al. 1975).

4. *Leptospira* spp., by the microscopic agglutination test (Cole et al. 1973). Twelve *Leptospira interrogans* serovarieties were included in the tests: *pomona*, *ballum*, *canicola*, *icterrohemorrhagiae*, *wolffi*, *grippotyphosa*, *hardjo*, *autumnalis*, *bataviae*, *tarassovi*, *australis*, and *pyrogenes*.

5. Infectious bovine rhinotracheitis bovine viral diarrhea, canine distemper virus, infectious canine hepatitis virus, epizootic hemorrhagic disease, and bluetongue, by the serum neutralization test (Thorsen and Henderson 1971).

6. Epizootic hemorrhagic disease, bluetongue, and ovine progressive pneumonia by the immunodiffusion test (Pearson and Jochim 1979).

7. Parainfluenza 3, by the hemagglutination-inhibition test (Thorsen and Henderson 1971).

8. Pseudorabies, by the microimmunodiffusion test (Gutekunst et al. 1978).

9. *Toxoplasma gondii*, by the indirect hemagglutination test (Peterson et al. 1974).

Minimum titers for all tests were based upon natural or experimental infection of the species in question or of a domesticated species. Sera which met or exceeded these titers (plus those designated "positive" in the immunodiffusion test and brucellosis plate test) were considered to contain evidence of past infection by the agent in question. Hereafter, these samples are referred to as "positive." All other samples are referred to as "negative."

Two types of potential qualitative errors should be considered in evaluating the significance of serologic survey results: (1) samples from animals which have been infected by the disease agent in question may be incorrectly categorized as "negative," and (2) samples from animals which were never exposed to an agent may be incorrectly deemed "positive." Explanations for the former include: (1) natural antibody decay over time, (2) antibody degradation due to improper specimen handling, (3) establishment of the threshold titer value at a level too high, (4) improper inspection or evaluation of the test, and (5) inaccurately recorded data. Explanations for the latter include: (1) presence of "nonspecific" reacting substances in the sample, (2) improper inspection or evaluation of the test, and (3) inaccuracies in recording data. With these disclaimers in mind, discussion of the test results may proceed.

RESULTS AND DISCUSSION

In most cases test results provided no evidence of exposure to a particular disease in a particular host species (Table 1-33). This discussion will focus on those situations where evidence of previous exposure was found.

Respiratory Viruses

Four viral diseases, infectious bovine rhinotracheitis (IBR), bovine viral diarrhea (BVD), parainfluenza III (PI3), and respiratory syncytial virus (RSV), are commonly referred to, collectively, as the "bovine respiratory group." As this generic term implies, the viruses often cause upper respiratory infections (Dieterich 1981). Morbidity (rate of illness) may be high in an infected population, but mortality (rate of death) is usually low. Major impacts on individual animals occur via lowered body condition, decreased weight gain, and increased susceptibility to other infectious diseases. Transmission usually occurs via aerosol droplet, but the venereal route may also play a role (Dieterich 1981). Serologic evidence of exposure has been previously reported for various wildlife species (Thorsen and Henderson 1971, Parks and England 1974, Stauber et al. 1980).

IBR, BVD, and PI3 continue to be more prevalent in the northern caribou herds (Western Arctic, Teshekpuk, Central Arctic, Porcupine, and Fortymile) compared with herds in other portions of Alaska (Tables 1-8). Several southern caribou herds were recently added to the survey and helped to further clarify this pattern. There have been few observed cases of pneumonia in any of these herds (R. Zarnke, unpubl. data). Several of the northern herds experienced significant growth during this study. The significance of the higher antibody prevalence of IBR, BVD, and PI3 remains unknown.

Antibody prevalence of PI3 in the Delta Bison Herd rose dramatically from 0% in 1977 to 100% by 1984 (Zarnke and Erickson 1990) and remains near 100% (Table 9). No health-related problems were linked to this increased prevalence of PI3. Domestic livestock were implicated in the introduction of PI3 into the bison herd (Zarnke and Erickson 1990). This situation exemplifies how easily an introduced disease agent can spread through a naive population.

There was no evidence of Dall sheep being exposed to any respiratory viruses (Tables 10 and 11). This observation was especially noteworthy for the population at Granite Creek in Subunit 20D (Table 11). Because of their proximity to the Delta Bison Herd, there is concern that these sheep may be exposed at least to PI3. Similarly, there was no evidence of PI3 in the Macomb Caribou Herd (Table 5), which was newly added to the survey. Additional sampling is necessary to assess the status of these 2 populations adequately.

Serologic evidence of PI3 in muskoxen (*Ovibos moschatus*) from the Arctic National Wildlife Refuge (ANWR) was observed once (Table 12). If the test results are valid, then presumably some conditions which result in higher antibody prevalence of respiratory viruses in northern caribou herds also pertain to muskoxen in the area.

There was little evidence of RSV in any of the species included in the survey (Tables 1-18).

I currently perceive little threat to wildlife populations as a result of BVD.

Leptospirosis

Leptospirosis is caused by 1 or more so-called "serovarieties" of a spirochete known as *Leptospira interrogans* (Busch 1970). Symptoms may include chronic kidney infections (Diesch et al. 1970), hepatitis (Bishop et al. 1979), and/or abortion. Transmission usually occurs via contamination of water by leptospires which are shed in urine (Busch 1970). Also, the disease may be passed along the food chain from prey to predators (Reilly et al. 1970). Exposure to more than 1 serovar is not uncommon.

Antibody prevalence for selected serovars of *Leptospira interrogans* remained higher in several species from the southern portion of the state (Tables 1-33). This pattern was especially evident for grizzly bears (*Ursus arctos*) (Tables 19-26) and caribou (Tables 1-8). As discussed previously (Zarnke 1986), differences in environmental conditions may be responsible for the apparent geographic discrepancy in prevalence.

Contagious Ecthyma

Contagious ecthyma (CE) is a viral disease primarily found in sheep and goats, both wild (Samuel et al. 1975) and domestic (Beck and Taylor 1974). Infection causes crusty, proliferative lesions on exposed skin near the mouth, eyes, udder, anus, and/or hoof line (Beck and Taylor 1974, Dieterich et al. 1981). Anorexia and ataxia are common symptoms (Beck and Taylor 1974). The virus is shed in scabs and remains infective for years (Beck and Taylor 1974). Direct contact transmission also plays a role (Beck and Taylor 1974). The epizootiology of CE in Alaska has been discussed previously (Dieterich et al. 1981, Zarnke et al. 1983).

Serologic evidence of CE in Dall sheep remains common (Tables 10 and 11). Clinical cases are reported by hunters or agency personnel virtually every year. Based on past experience, infection may be fatal in lambs but rarely in otherwise healthy adults.

Clinical cases of CE in mountain goats (*Oreamnos americanus*) were reported from a large portion of southeastern Alaska during 1989-90 (T. McCarthy, pers. commun.). A previous report documented CE in free-ranging coastal mountain goats (Hebbert et al. 1977). Signs of disease in the current outbreak were severe, presumably capable of causing death. No serologic evidence of exposure was detected in

specimens collected a few months before the epizootic began (Table 15). Additional sampling is planned to further assess the outbreak.

Sporadic evidence of CE in moose (*Alces alces*) and caribou continues to be observed (Tables 1-8 and 16-18). These instances are thought to be of little consequence for the populations. There was also evidence of CE in ANWR muskoxen (Table 12). Considering results of previous surveys involving both captive and free-ranging muskoxen, these new data are not surprising.

Bluetongue and Epizootic Hemorrhagic Disease

Bluetongue (BLU) and epizootic hemorrhagic disease (EHD) are viral diseases of wild and domestic ruminants. Symptoms may include anorexia, ataxia, dyspnea, and depression. The 2 diseases are most often recognized postmortem by acute subcutaneous and/or internal hemorrhaging (Hoff and Trainer 1978). The oral route may be important for transmission during enzootic periods, but arthropod vectors play a big role during epizootics (Hoff and Trainer 1978).

The situation surrounding EHD and BLU in Alaskan wildlife is more confusing than for most other diseases. On occasions when positive samples were detected by means of immunodiffusion tests, USDA personnel attempted to determine which of the 2 viruses (EHD or BLU) was responsible. This was done by means of implementing the more specific serum neutralization test. In virtually all cases where this was done, test results were inconclusive and were accompanied by the following comment: "significance of these results is difficult to evaluate in an area where no [overt disease] has ever been reported. The reaction may be due to exposure to an antigenically similar virus." Mention of antigenic variation and overlap are inherent in any discussion of these 2 viruses. Although discernible from each other, EHD and BLU are closely related antigenically. On the other hand, there are at least 19 distinct strains of BLU. It is not inconceivable that there is a distinct relative of EHD and BLU present in Alaskan wildlife. The proper means of addressing such a problem is to isolate and identify the disease agent in question. In the absence of clinical disease, the likelihood of isolating the agent is small.

There is some question regarding the transmission of either EHD or BLU in Alaska. In North America, a midge (*Culicoides variipennis*) is the most common vector of these viruses. There is some debate as to whether this particular gnat species exists in Alaska. Certainly, members of the genus *Culicoides* do occur in Alaska and experience in other parts of the world indicates that in the absence of the preferred vector species, other members of the genus will occupy this ecological niche and serve as vectors.

Based on serologic evidence, exposure of a variety of ungulate species to EHD and BLU continues to occur (Tables 1-18). There have been no clinical cases of hemorrhagic disease reported. In the absence of clinical cases, clarification of the epizootiology of these viruses will be complicated.

Brucellosis

Brucella suis IV is the causative agent of the type of brucellosis found in Alaska. The most well-studied host species include caribou and their associated predators (Neiland et al. 1968, Neiland 1975). Infection usually localizes in joints or reproductive organs, causing arthritis and/or abortion (Neiland et al. 1968). Transmission occurs venereally (Neiland et al. 1968), or via the food chain (Neiland 1970, 1975).

Serum antibody prevalence of *B. suis* IV in northern caribou herds (Tables 1-3), wolf (*Canis lupus*) (Table 27) and grizzly bear populations (Tables 20, 21, and 23) continues to be higher than in other portions of Alaska. Several southern caribou herds (Tables 5-8) were added to the survey in recent years and helped to further clarify this pattern. The absence of detectable evidence of brucellosis in the North Alaska Peninsula Caribou Herd (Table 8) was especially important because animals from this herd were translocated to establish a new herd near Togiak. Evidence of brucellosis was also found in brown bears (*Ursus arctos*) from Kodiak Island (Table 24).

Interpretation of *Brucella* spp. serology in all 3 species of bears (brown/grizzly, black [*U. americanus*], and polar [*U. maritimus*]) (Tables 19-26 and 28-30) and also in wolves (Tables 27, 31, and 32) was complicated by anomalous results of tularemia tests. Evidence of tularemia was found in geographic areas and at levels beyond any previous understanding of this disease. For example, antibody prevalence of tularemia in black bears from Subunit 20A appeared to increase from 0% to nearly 100% over the course of a single year (Table 29). I do not accept the validity of these test results. I suspect that either a third agent or nonspecific substances in the sera are confounding these tests.

No evidence of brucellosis was found in the Delta Bison Herd (Table 9).

Q fever

Q fever is caused by the rickettsium *Coxiella burnetti* (Randhawa et al. 1977). The organism usually localizes in the respiratory tract. Although the disease is usually mild in domestic species, abortions can occur in sheep and goats (Enright et al. 1969). Death is rare (Bell 1981). *Coxiella burnetti* is shed in milk, feces, birth fluids, and placental tissues (Enright et al. 1969).

Serologic evidence of Q fever continues to appear in a variety of species (Tables 1-33). The most well-studied of the state's wildlife hosts for Q fever is the caribou. During a 10-year study, serologic prevalence in the Delta Caribou Herd averaged 10% (Hopla 1975). Prevalence was low in the South Alaska Peninsula Caribou Herd which has experienced a population decline. I doubt there is any causal relationship between the occurrence of Q fever and decreased productivity. Perhaps the biggest surprise was the absence of disease evidence in Dall sheep populations (Tables 10 and 11).

Miscellaneous

Pseudorabies was added to the black bear survey (Table 28 and 29) in response to the death of a captive black bear from this swine-oriented disease (Schulze et al. 1986) and serologic evidence of exposure in a free-ranging bear (Pirtle et al. 1986). The apparent absence of exposure of Alaska's black bears is favorable.

Toxoplasmosis was added to the roster for bears because of previous evidence of exposure of humans (Peterson et al. 1974) and wildlife (Kocan et al. 1986, Van Pelt and Dieterich 1973) in Alaska. Test results provided no strong evidence of exposure of bears to this disease.

The absence of evidence of ovine progressive pneumonia in Dall sheep (Tables 10 and 11) concurred with past surveys and continues to be encouraging.

ACKNOWLEDGMENTS

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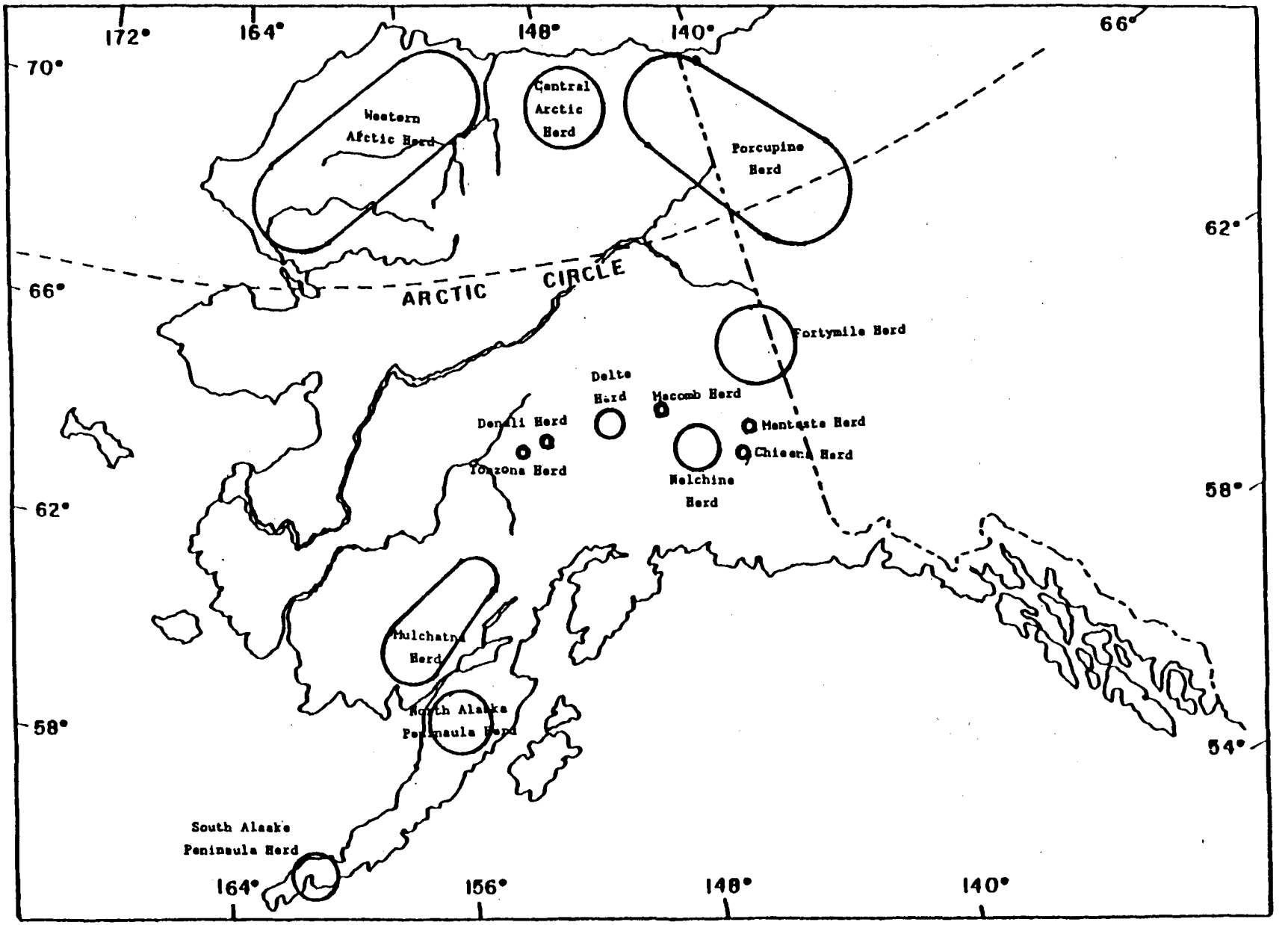

Fig. 1. Approximate home ranges of caribou (Rangifer tarandus) herds from which blood specimens were collected for serologic survey.

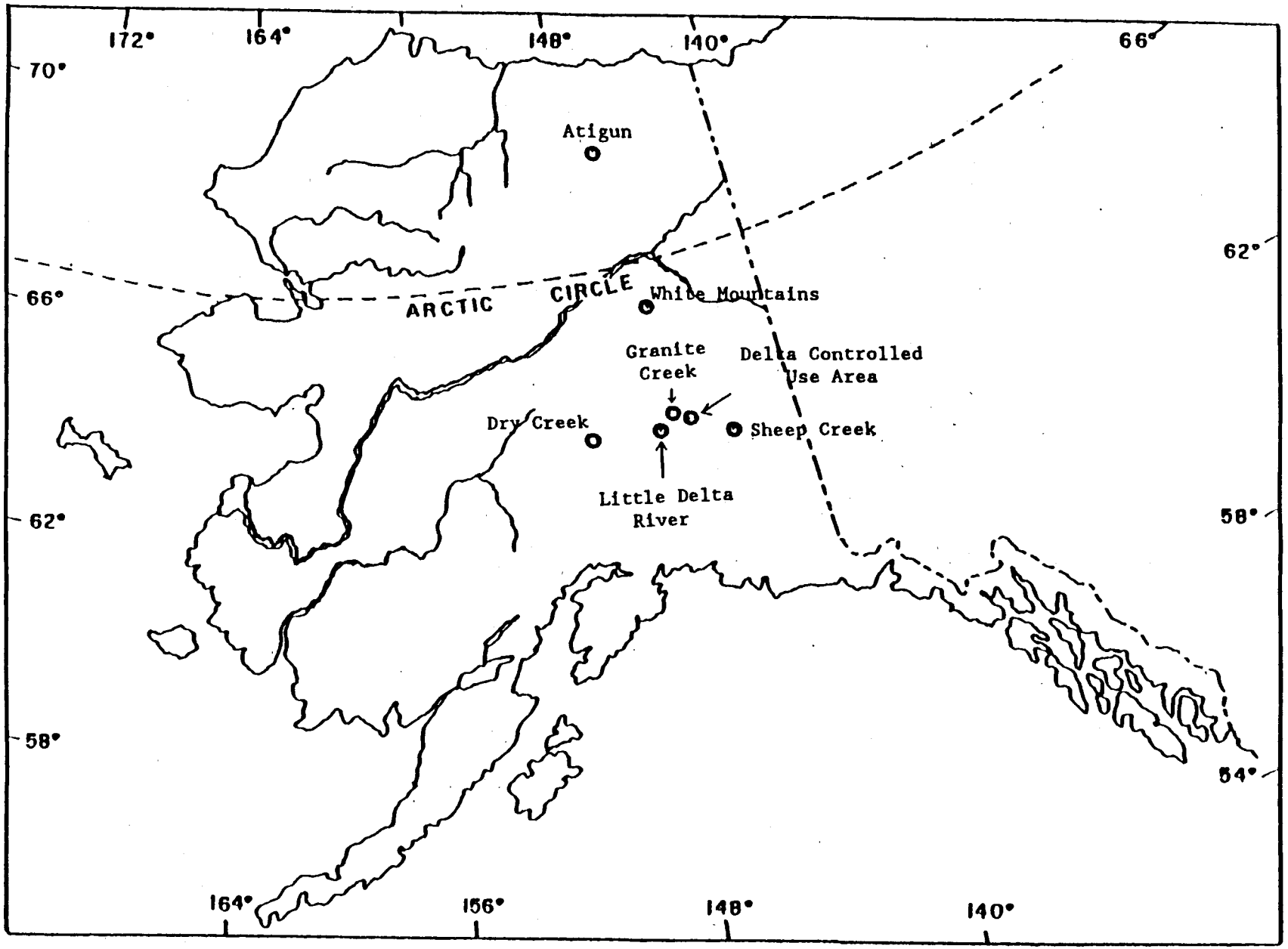

Fig. 2. Locations at which blood specimens were collected from Dall sheep (Ovis dalli) for serologic survey.

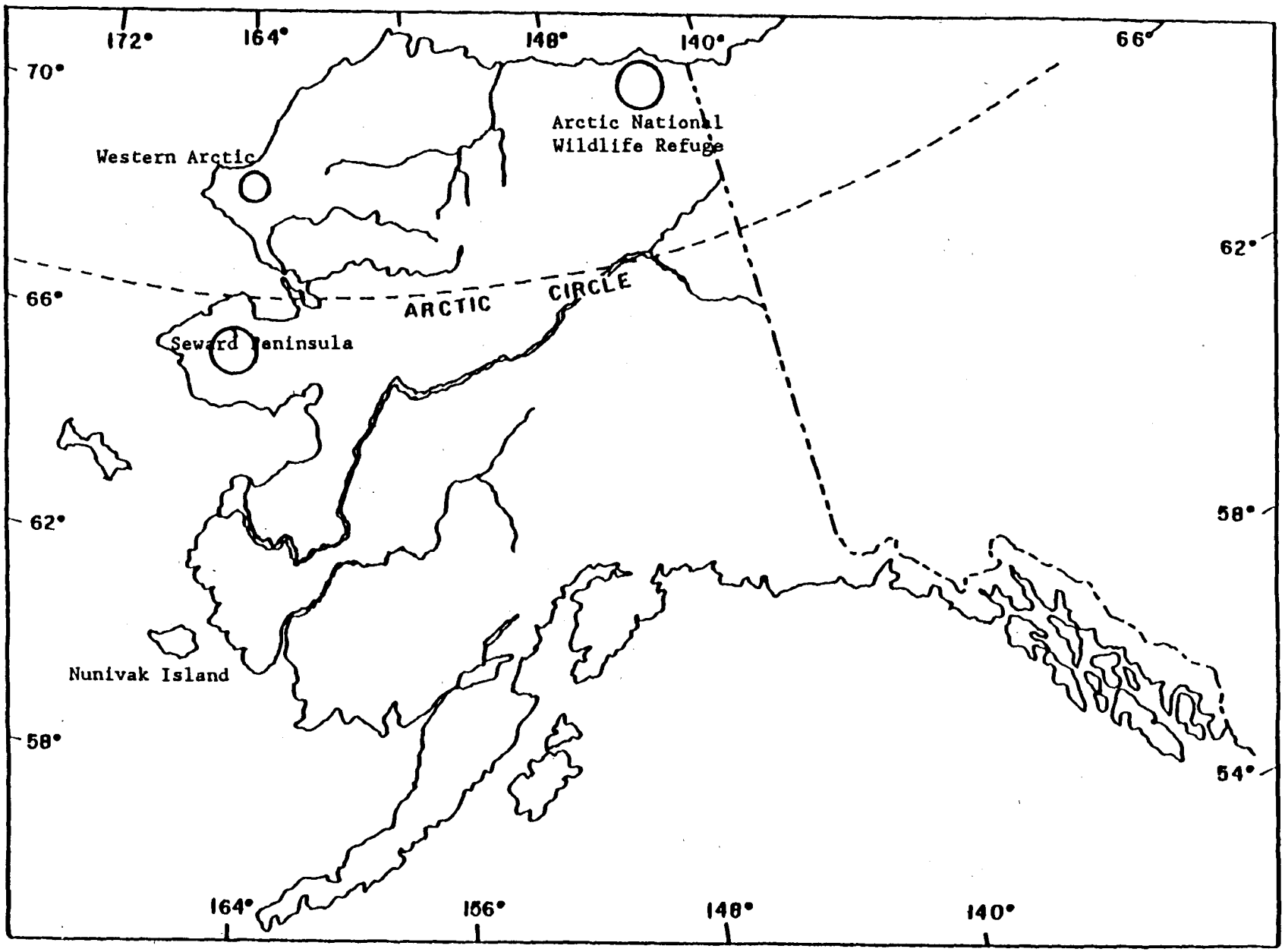

Fig. 3. Locations at which blood specimens were collected from muskoxen (Ovibos moschatus) for serologic survey.

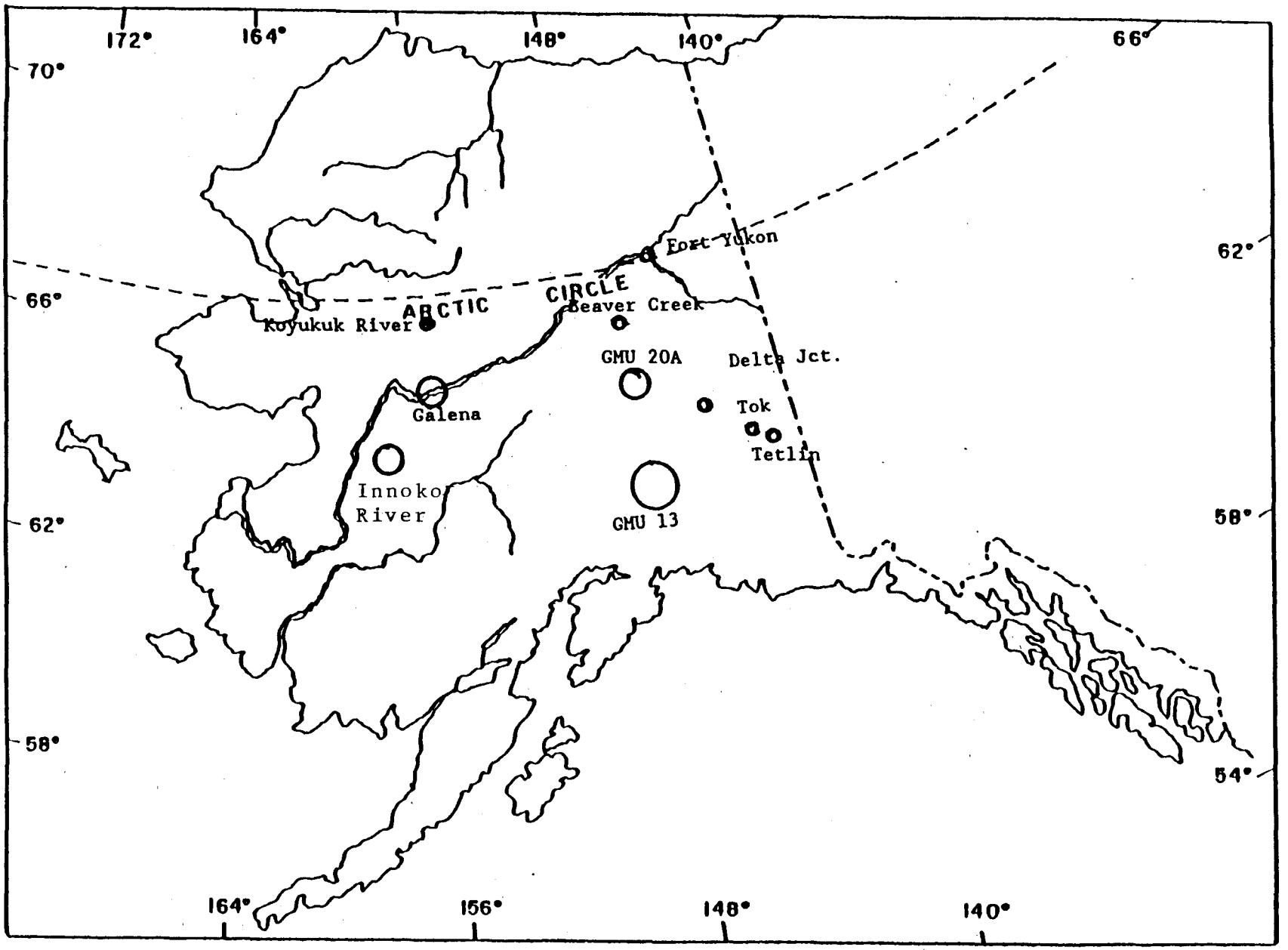

Fig. 4. Locations at which blood specimens were collected from moose (Alces alces) for serologic survey.

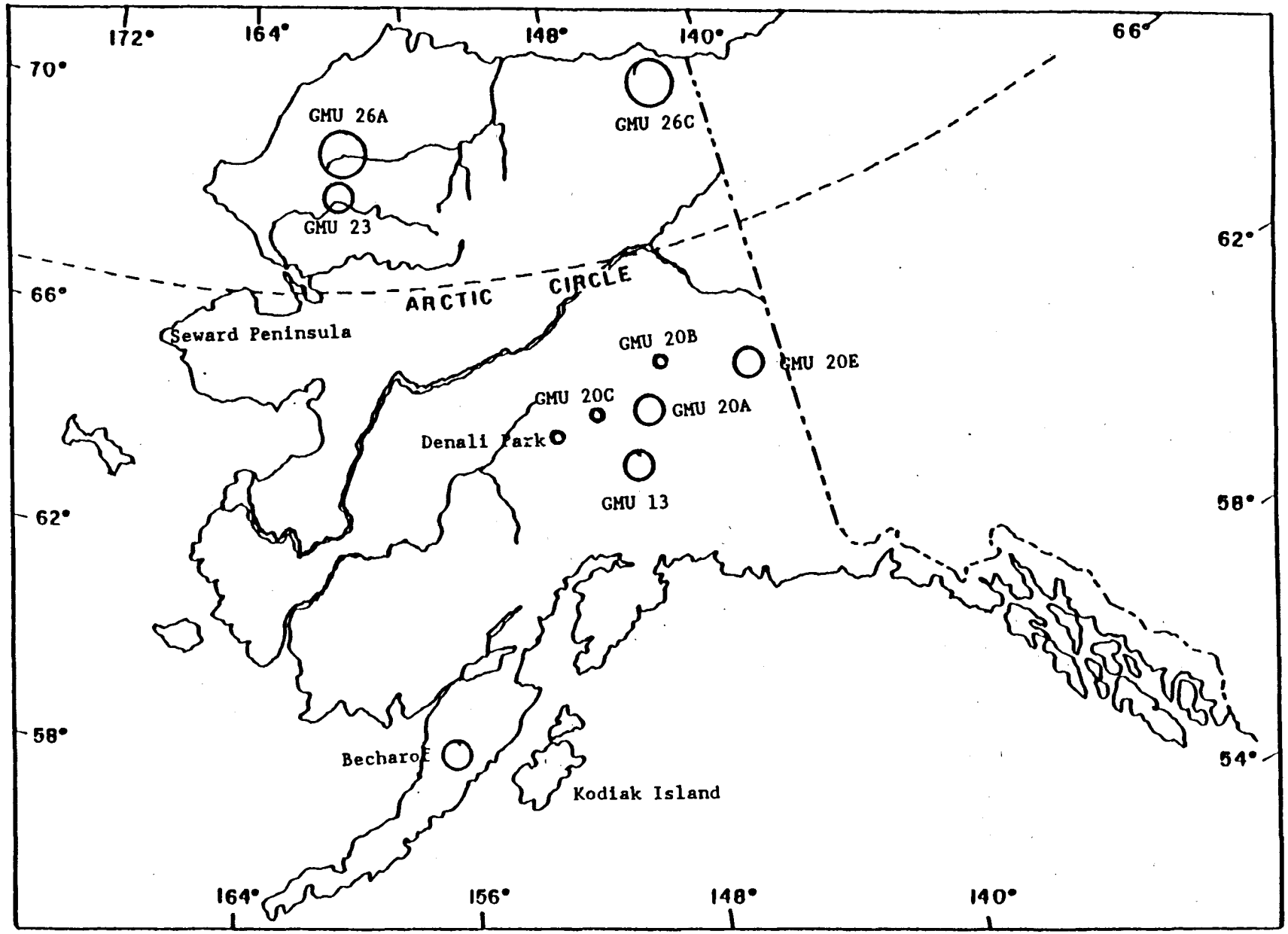

Fig. 5. Locations at which blood specimens were collected from grizzly bears (Ursus arctos) for serologic survey.

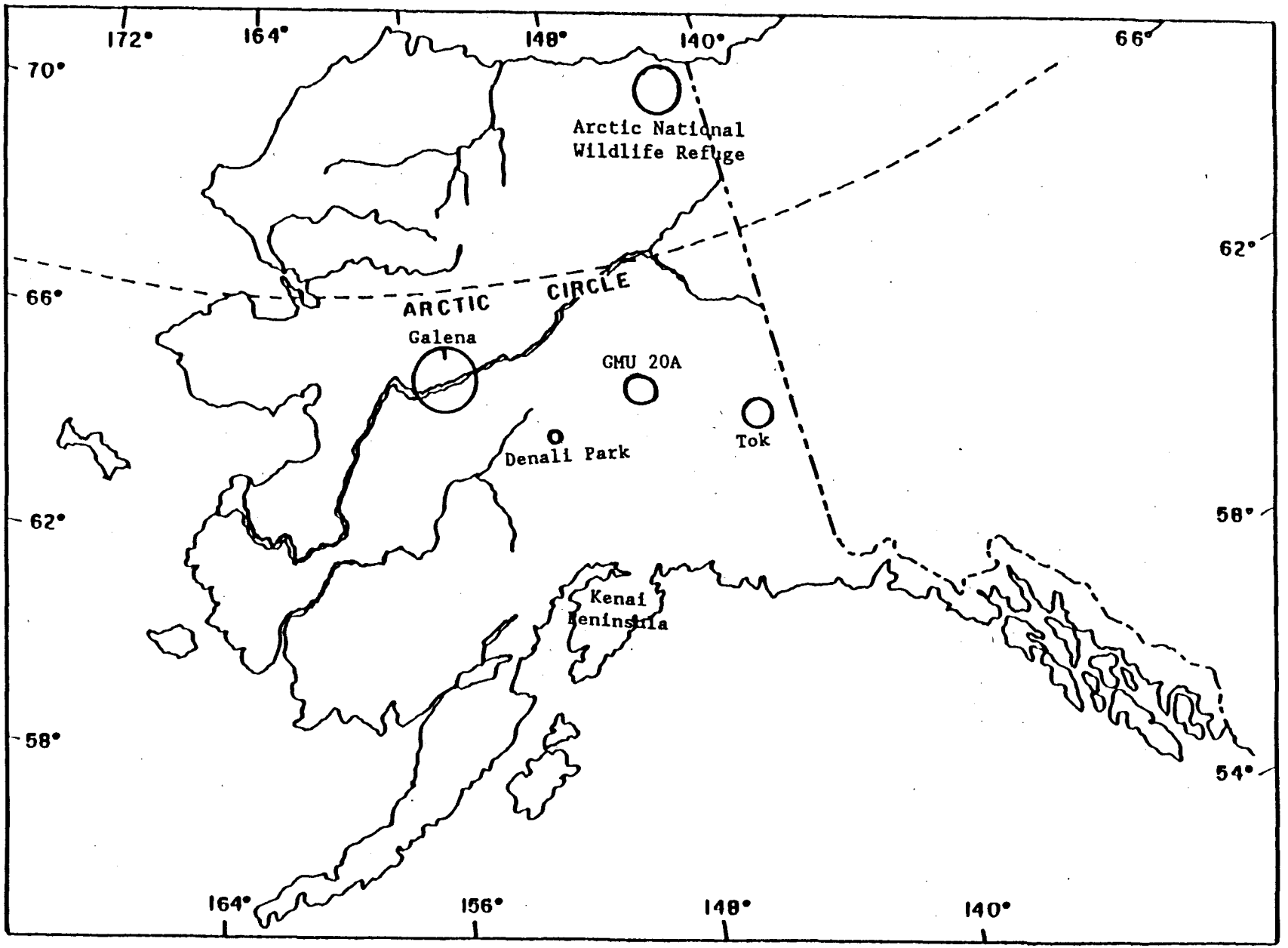

Fig. 6. Locations at which blood specimens were collected from wolves (Canis lupus) for serologic survey.

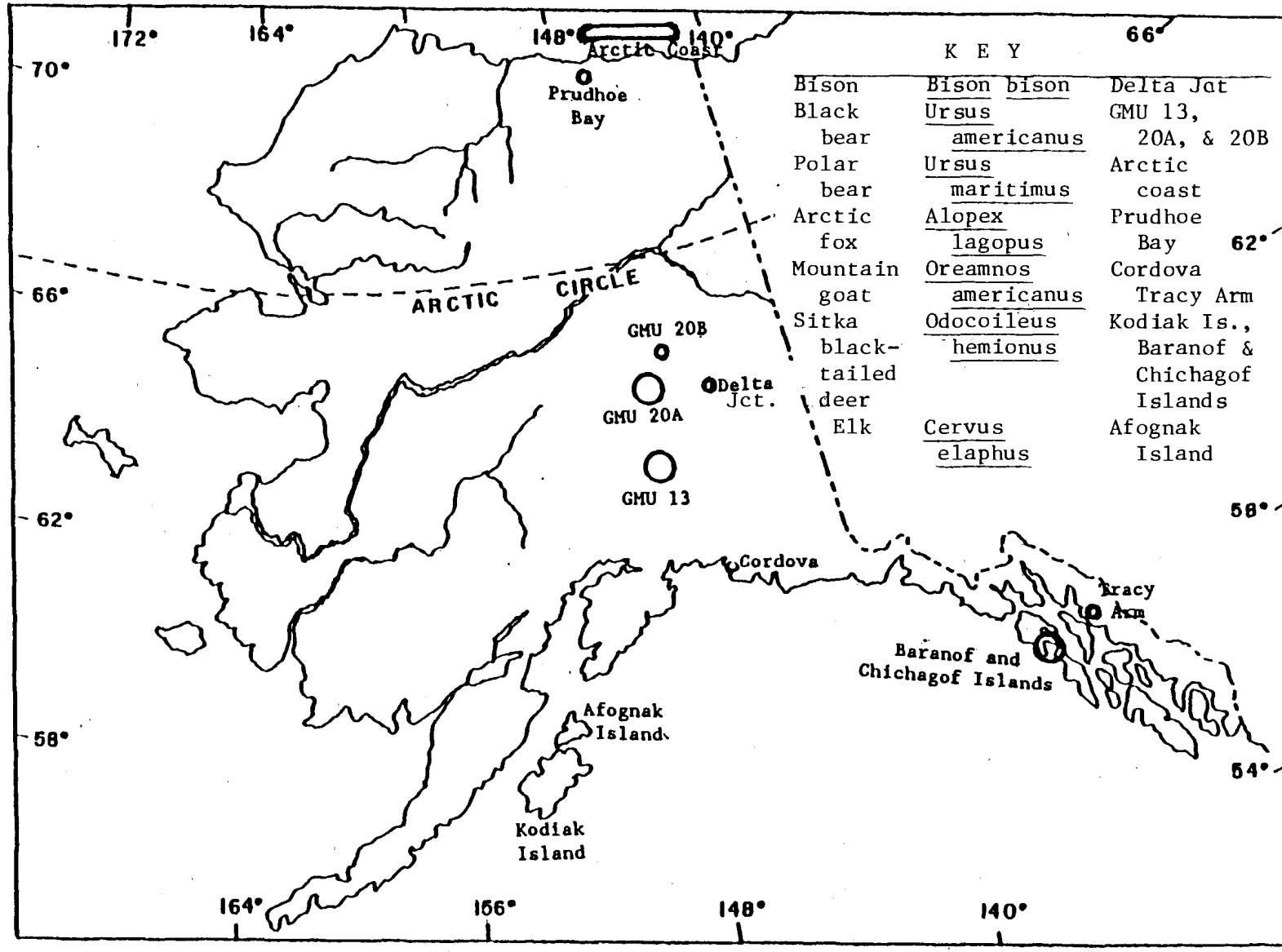

Fig. 7. Locations at which blood specimens were collected from listed species for serologic survey.

Table 1. Serum antibody prevalence of 10 infectious disease agents in caribou from the Western Arctic and Teshekpuk Herds, Alaska, 1986, 1987, and 1989.

Agent	Western Arctic 1986	Western Arctic 1987	Western Arctic 1989	Teshekpuk 1986
Infectious bovine rhinotracheitis virus SN[a] (8)[b]	2/40[c]		0/2	1/16
Bovine viral diarrhea virus SN (8)	1/40		0/2	3/16
Parainfluenza 3 virus HI (8)	10/41		0/2	0/15
Respiratory syncytial virus IFA (20)	0/40		0/2	0/16
Epizootic hemorrhagic disease virus ID (±)	1/41		0/3	0/15
Bluetongue virus ID (±)	0/41		0/3	0/15
Contagious ecthyma virus CF (10)	0/15		0/3	0/14
Brucella suis IV bacterium BAPA (±); STT (50)	7/37	1/4	0/3	0/16
Q fever rickettsium CF (20)	0/41		0/3	0/15
Leptospira interrogans bacterium MAT (100)	0/41			

[a] Test method: SN = serum neutralization test, HI = hemagglutination inhibition test, IFA = indirect fluorescent antibody test, ID = immunodiffusion test, CF = complement fixation test, BAPA = buffered acidified plate antigen test, STT = standard tube test, and MAT = microscopic agglutination test.

[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."

[c] Number positive/number tested.

Table 2. Serum antibody prevalence of 10 infectious disease agents in caribou from the Central Arctic Herd, Alaska, 1984-89.

Agent	1984	1985	1986	1987	1988	1989
Infectious bovine rhinotracheitis virus SN[a] (8)[b]		1/1[c]	4/29	1/30	0/17	0/64
Bovine viral diarrhea virus SN (8)		1/1	2/29	3/30	0/17	3/64
Parainfluenza 3 virus HI (8)		0/1	1/28	0/28	0/17	7/64
Respiratory syncytial virus IFA (20)			0/29	1/30	0/17	0/64
Epizootic hemorrhagic disease virus ID (±)	0/11	0/8	0/27	0/30	0/39 +0/17	0/41
Bluetongue virus ID (±)	0/11	0/8	0/30	0/30	0/39 +0/17	0/41
Contagious ecthyma virus CF (10)		0/1	1/24	0/25	0/32 +0/17	2/40
Brucella suis IV bacterium BAPA (±); STT (50)				6/53	0/17	0/62
Q fever rickettsium CF (20)	0/11	0/8	0/27	0/27	8/35 +0/17	6/41
Leptospira interrogans bacterium MAT (100)			0/28	0/26		

[a] Test method: SN = serum neutralization test, HI = hemagglutination inhibition test, IFA = indirect fluorescent antibody test, ID = immunodiffusion test, CF = complement fixation test, BAPA = buffered acidified plate antigen test, STT = standard tube test, and MAT = microscopic agglutination test.

[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."

[c] Number positive/number tested.

Table 3. Serum antibody prevalence of 10 infectious disease agents in caribou from the Porcupine herd, Alaska, 1984-89.

Agent	1984	1985	1986	1987	1988	1989
Infectious bovine rhinotracheitis virus SN[a] (8)[b]		3/17[c]	2/21	0/42	2/67	0/39
Bovine viral diarrhea virus SN (8)		1/17	1/21	5/42	6/67	2/39
Parainfluenza 3 virus HI (8)		2/19	8/21	0/42	4/67	13/39
Respiratory syncytial virus IFA (20)			0/21	1/42	2/67	0/39
Epizootic hemorrhagic disease virus ID (±)	0/19	0/49	0/23	0/42	0/75	0/39
Bluetongue virus ID (±)	0/19	1/49	0/23	0/42	0/75	0/39
Contagious ecthyma virus CF (10)		0/19	0/22	0/37	1/64	0/38
Brucella suis IV bacterium BAPA (±); STT (50)				5/42	1/75	2/39
Q fever rickettsium CF (20)		0/46	0/23	0/42	4/73	7/33
Leptospira interrogans bacterium MAT (100)			0/21	0/42	0/67	

[a] Test method: SN = serum neutralization test, HI = hemagglutination inhibition test, IFA = indirect fluorescent antibody test, ID = immunodiffusion test, CF = complement fixation test, BAPA = buffered acidified plate antigen test, STT = standard tube test, and MAT = microscopic agglutination test.

[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."

[c] Number positive/number tested.

Table 4. Serum antibody prevalence of 10 infectious disease agents in caribou from the Fortymile herd, Alaska, 1984-87.

Agent	1984	1985	1986	1987
Infectious bovine rhinotracheitis virus SN[a] (8)[b]	0/10[c]	4/6	0/1	4/26
Bovine viral diarrhea virus SN (8)	0/10	1/6	0/1	14/26
Parainfluenza 3 virus HI (8)	0/10	5/6	0/1	1/26
Respiratory syncytial virus IFA (20)			0/1	1/26
Epizootic hemorrhagic disease virus ID (±)	0/11	0/6	0/1	0/26
Bluetongue virus ID (±)	0/11	0/6	0/1	0/25
Contagious ecthyma virus CF (10)		0/5	0/1	0/17
Brucella suis IV bacterium BAPA (±); STT (50)				0/26
Q fever rickettsium CF (20)	0/11	0/5	0/1	0/24
Leptospira interrogans bacterium MAT (100)			0/1	0/24

[a] Test method: SN = serum neutralization test, HI = hemagglutination inhibition test, IFA = indirect fluorescent antibody test, ID = immunodiffusion test, CF = complement fixation test, BAPA = buffered acidified plate antigen test, STT = standard tube test, and MAT = microscopic agglutination test.

[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."

[c] Number positive/number tested.

Table 5. Serum antibody prevalence of 10 infectious disease agents in caribou from the Delta and Macomb herds, Alaska, 1984-86 and 1988-90.

Agent	Delta						Macomb	
	1984	1985	1986	1988	1989	1990	1988	1990
Infectious bovine rhinotracheitis virus SN[a] (8)[b]	0/11[c]	0/13	0/43	0/13	0/9	0/20	0/14	0/18
Bovine viral diarrhea virus SN (8)	0/11	0/13	0/43	0/13	0/9	0/20	0/14	0/18
Parainfluenza 3 virus HI (8)	0/11	0/14	0/47	0/13	0/9	0/20	0/14	0/18
Respiratory syncytial virus IFA (20)			0/44	0/13	0/9	0/20	0/14	0/18
Epizootic hemorrhagic disease virus ID (±)	0/25	0/14	0/44	0/13	0/9	0/20	0/14	0/18
Bluetongue virus ID (±)	0/27	0/14	0/47	0/13	0/9	0/20	0/14	0/18
Contagious ecthyma virus CF (10)		1/11	0/38	0/12	0/9	1/20	0/8	0/15
Brucella suis IV bacterium BAPA (±); STT (50)				0/13	0/9	0/20	0/14	0/17
Q fever rickettsium CF (20)	0/25	0/13	0/40	0/13	0/9	1/20	0/14	2/17
Leptospira interrogans bacterium MAT (100)			0/47	2/11			4/14	

[a] Test method: SN = serum neutralization test, HI = hemagglutination inhibition test, IFA = indirect fluorescent antibody test, ID = immunodiffusion test, CF = complement fixation test, BAPA = buffered acidified plate antigen test, STT = standard tube test, and MAT = microscopic agglutination test.

[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."

[c] Number positive/number tested.

Table 6. Serum antibody prevalence of 10 infectious disease agents in caribou from the Nelchina, Mentasta, and Chisana herds, Alaska, 1986-89.

Agent	Nelchina			Mentasta		Chisana
	1986	1988	1989	1987	1988	1987
Infectious bovine rhinotracheitis virus SN[a] (8)[b]	0/63[c]	0/7	0/1	1/39	0/19	0/16
Bovine viral diarrhea virus SN (8)	0/63	0/7	0/1	0/39	0/19	0/16
Parainfluenza 3 virus HI (8)	0/61	0/7	0/1	0/39	0/19	0/16
Respiratory syncytial virus IFA (20)	0/63	0/7	0/1	0/39	0/19	1/16
Epizootic hemorrhagic disease virus ID (±)	0/61	0/7	0/2	0/39	0/19	0/15
Bluetongue virus ID (±)	0/63	0/7	0/2	0/39	0/19	0/15
Contagious ecthyma virus CF (10)	0/61	0/0	0/2	0/39	1/3	0/13
Brucella suis IV bacterium BAPA (±); STT (50)	1/64	0/7	0/1	0/39	0/19	0/16
Q fever rickettsium CF (20)	0/61	2/5	1/1	1/39	4/12	0/14
Leptospira interrogans bacterium MAT (100)	2/64			0/39		3/13

[a] Test method: SN = serum neutralization test, HI = hemagglutination inhibition test, IFA = indirect fluorescent antibody test, ID = immunodiffusion test, CF = complement fixation test, BAPA = buffered acidified plate antigen test, STT = standard tube test, and MAT = microscopic agglutination test.

[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."

[c] Number positive/number tested.

Table 7. Serum antibody prevalence of 10 infectious disease agents in caribou from the Denali and Tonzona herds, Alaska, 1986-90.

Agent	Denali					Tonzona	
	1986	1987	1988	1989	1990	1988	1989
Infectious bovine rhinotracheitis virus SN[a] (8)[b]	0/26[c]	1/26	0/8	0/17	0/24	0/9	0/3
Bovine viral diarrhea virus SN (8)	0/26	0/26	0/8	0/17	0/24	0/9	0/3
Parainfluenza 3 virus HI (8)	0/18	0/26	0/8	0/17	0/24	0/9	0/3
Respiratory syncytial virus IFA (20)	0/26	0/26	0/8	0/17	0/24	0/9	0/3
Epizootic hemorrhagic disease virus ID (±)	0/22	0/26	0/8	0/17	0/24	0/9	0/3
Bluetongue virus ID (±)	0/25	0/26	0/8	0/17	0/24	0/9	0/3
Contagious ecthyma virus CF (10)	0/15	0/23	0/8	2/15	1/23	0/7	0/2
Brucella suis IV bacterium BAPA (±); STT (50)	0/27	0/26	0/8	0/17	0/23	0/9	0/3
Q fever rickettsium CF (20)	0/16	0/26	0/8	1/15	0/24	4/5	1/3
Leptospira interrogans bacterium MAT (100)		1/25	0/8				

[a] Test method: SN = serum neutralization test, HI = hemagglutination inhibition test, IFA = indirect fluorescent antibody test, ID = immunodiffusion test, CF = complement fixation test, BAPA = buffered acidified plate antigen test, STT = standard tube test, and MAT = microscopic agglutination test.

[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."

[c] Number positive/number tested.

Table 8. Serum antibody prevalence of 10 infectious disease agents in caribou from the South and North Alaska Peninsula and Mulchatna herds, Alaska, 1988-90.

Agent	South Alaska Peninsula 1988	1989	1990	North Alaska Peninsula 1988	Mulchatna 1988
Infectious bovine rhinotracheitis virus SN[a] (8)[b]	0/10[c]	0/13	0/4	0/145	0/8
Bovine viral diarrhea virus SN (8)	0/10	0/13	0/4	0/145	0/8
Parainfluenza 3 virus HI (8)	0/10	0/13	0/4	0/145	0/8
Respiratory syncytial virus IFA (20)	0/10	0/13	0/4	0/145	0/8
Epizootic hemorrhagic disease virus ID (±)	0/10	0/13	0/4	0/145	0/8
Bluetongue virus ID (±)	0/10	0/13	0/4	1/144	0/8
Contagious ecthyma virus CF (10)	0/7	0/11	0/3	1/123	0/1
Brucella suis IV bacterium BAPA (±); STT (50)	0/10	0/13	0/4	0/145	0/8
Q fever rickettsium CF (20)	4/7	2/9	0/4	0/142	4/5
Leptospira interrogans bacterium MAT (100)				2/141	

[a] Test method: SN = serum neutralization test, HI = hemagglutination inhibition test, IFA = indirect fluorescent antibody test, ID = immunodiffusion test, CF = complement fixation test, BAPA = buffered acidified plate antigen test, STT = standard tube test, and MAT = microscopic agglutination test.

[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."

[c] Number positive/number tested.

Table 9. Serum antibody prevalence of 9 infectious disease agents in the Delta bison herd, Alaska, 1984-90.

Agent	1984	1985	1986	1987	1988	1989	1990
Infectious bovine rhinotracheitis virus SN[a] (8)[b]	0/48[c]	0/29	0/52	0/42	0/43	0/38	0/9
Bovine viral diarrhea virus SN (8)	0/48	0/29	3/52	0/43	0/43	0/38	0/9
Parainfluenza 3 virus HI (8)	41/41	28/29	52/52	38/38	42/43	38/38	9/9
Respiratory syncytial virus IFA (20)			0/52	0/43	0/43	0/38	0/9
Epizootic hemorrhagic disease virus ID (±)	0/48	0/29	0/52	0/43	0/10	0/33	0/10
Bluetongue virus ID (±)	0/48	0/29	0/52	0/43	0/10	0/33	0/10
Brucella suis IV bacterium BAPA (±); STT (50)	0/48	0/1	0/52	0/43	0/43	0/41	0/10
Q fever rickettsium CF (20)	1/48	0/29	0/50	0/39	0/6	0/33	0/8
Leptospira interrogans bacterium MAT (100)			5/52	4/42	0/10		

[a] Test method: SN = serum neutralization test, HI = hemagglutination inhibition test, IFA = indirect fluorescent antibody test, ID = immunodiffusion test, BAPA = buffered acidified plate antigen test, STT = standard tube test, CF = complement fixation test, and MAT = microscopic agglutination test.

[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."

[c] Number positive/number tested.

Table 10. Serum antibody prevalence of 10 infectious disease agents in Dall sheep from eastern Game Management Unit 20A and western Game Management Unit 20D, Alaska, 1988-90.

Agent	Little Delta 1988	Granite Creek 1988	Granite Creek 1989	Subunit 20A 1989	Subunit 20A 1990	DCUA[a] 1989
Infectious bovine rhinotracheitis virus SN[b] (8)[c]	0/10[d]	0/14	0/19	0/6	0/4	0/3
Bovine viral diarrhea virus SN (8)	0/10	0/14	0/19	0/6	0/4	0/3
Parainfluenza 3 virus HI (8)	0/10	0/14	0/19	0/6	0/4	0/3
Respiratory syncytial virus IFA (20)	0/10	0/14	0/19	0/6	0/4	0/3
Epizootic hemorrhagic disease virus ID (±)	0/10	0/14	0/19		0/4	0/3
Bluetongue virus ID (±)	1/10	0/14	0/19		0/4	0/3
Contagious ecthyma virus CF (10)	4/10	2/14	4/18		3/4	1/3
Brucella suis IV bacterium BAPA (±); STT (50)	0/10	0/14	0/19	0/6	0/4	0/3
Q fever rickettsium CF (20)	0/9	0/14	0/19		1/4	0/3
Ovine progressive pneumonia virus ID (±)	0/10	0/14	0/19		0/4	0/3

[a] DCUA = Delta Controlled Use Area.

[b] Test method: SN = serum neutralization test, HI = hemagglutination inhibition test, IFA = indirect fluorescent antibody test, ID = immunodiffusion test, CF = complement fixation test, BAPA = buffered acidified plate antigen test, STT = standard tube test, and MAT = microscopic agglutination test.

[c] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."

[d] Number positive/number tested.

Table 11. Serum antibody prevalence of 11 infectious disease agents in Dall sheep from selected areas of Alaska, 1984-86 and 1989.

Agent	Dry Creek 1984	Dry Creek 1985	Dry Creek 1986	Sheep Creek 1984	Sheep Creek 1985	White Mtns. 1985	Atigun 1986	Atigun 1989
Infectious bovine rhinotracheitis virus SN[a] (8)[b]	0/15[c]	0/31	0/12	0/22	0/23	0/7	0/5	0/10
Bovine viral diarrhea virus SN (8)	0/15	0/31	0/12	0/22	0/23	0/7	0/5	0/10
Parainfluenza 3 virus HI (8)	0/15	0/31	0/12	0/22	0/23	0/7	1/5	0/10
Respiratory syncytial virus IFA (20)	0/15		0/12	0/23			0/5	0/10
Epizootic hemorrhagic disease virus ID (±)	0/15	0/31	0/12	0/23	0/23	0/6	0/5	
Bluetongue virus ID (±)	0/15	0/31	0/12	0/23	0/23	0/7	0/5	
Contagious ecthyma virus CF (10)	4/15	3/29	2/12	5/22	0/23	0/4	0/5	
Brucella suis IV bacterium BAPA (±); STT (50)	0/15		0/12	0/22		0/6		0/10
Q fever rickettsium CF (20)	0/14	0/30	0/12	2/22	0/23	0/5	0/5	
Leptospira interrogans bacterium MAT (100)			0/12				0/5	

Table 11. Continued.

Agent	Dry Creek 1984	Dry Creek 1985	Dry Creek 1986	Sheep Creek 1984	Sheep Creek 1985	White Mtns. 1985	Atigun 1986	Atigun 1989
Ovine progressive pneumonia virus ID (±)	0/15			0/22				

[a] Test method: SN = serum neutralization test, HI = hemagglutination inhibition test, IFA = indirect fluorescent antibody test, ID = immunodiffusion test, CF = complement fixation test, BAPA = buffered acidified plate antigen test, STT = standard tube test, and MAT = microscopic agglutination test.

[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."

[c] Number positive/number tested.

Table 12. Serum antibody prevalence of 10 infectious disease agents in muskoxen from Nunivak Island, Seward Peninsula, Arctic National Wildlife Refuge (ANWR), and Western Arctic, Alaska, 1984 and 1986-89.

Agent	Nunivak 1984	Nunivak 1986	Seward Peninsula 1986	Seward Peninsula 1987	Seward Peninsula 1988	Seward Peninsula 1989	ANWR 1988	ANWR 1989	Western Arctic 1989
Infectious bovine rhinotracheitis virus SN[a] (8)[b]	0/12[c]	0/8	0/6	0/4	0/16	0/6	0/10	0/11	0/2
Bovine viral diarrhea virus SN (8)	0/12	0/8	1/6	0/4	0/16	0/6	0/10	0/11	0/2
Parainfluenza 3 virus HI (8)	0/11	0/8	0/6	0/4	0/16	0/6	4/10	0/11	0/2
Respiratory syncytial virus IFA (20)		0/8	0/6	0/4	0/16	0/6	0/10	0/11	0/2
Epizootic hemorrhagic disease virus ID (±)	0/13	0/8	0/6	0/4	0/16	0/6	1/10	0/11	0/2
Bluetongue virus ID (±)	0/13	0/8	0/6	0/4	0/16	0/6	0/10	0/11	0/2
Contagious ecthyma virus CF (10)	0/6	0/8	0/6	0/4	0/16	0/6	0/10	3/11	0/2
Brucella suis IV bacterium BAPA (±); STT (50)		1/8	0/6	0/4	0/16	0/6	0/10	0/11	
Q fever rickettsium CF (20)	0/9	0/8	0/6	0/4	0/16	0/6	0/10	0/11	0/2

Table 12. Continued.

Agent	Nunivak 1984	Nunivak 1986	Seward Peninsula 1986	Seward Peninsula 1987	Seward Peninsula 1988	Seward Peninsula 1989	ANWR 1988	ANWR 1989	Western Arctic 1989
Leptospira interrogans bacterium MAT (100)		0/8	0/6						

[a] Test method: SN = serum neutralization test, HI = hemagglutination inhibition test, IFA = indirect fluorescent antibody test, ID = immunodiffusion test, CF = complement fixation test, BAPA = buffered acidified plate antigen test, STT = standard tube test, and MAT = microscopic agglutination test.

[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."

[c] Number positive/number tested.

Table 13. Serum antibody prevalence of 10 infectious disease agents in deer from Southeast and Kodiak Island, Alaska, 1984-85.

Agent	Southeast 1985	Kodiak 1984	Kodiak 1985
Infectious bovine rhinotracheitis virus SN[a] (8)[b]	0/21[c]	0/2	0/38
Bovine viral diarrhea virus SN (8)	0/21	0/2	0/38
Parainfluenza 3 virus HI (8)	0/21	0/2	0/38
Respiratory syncytial virus IFA (20)			0/38
Epizootic hemorrhagic disease virus ID (±)	0/24	0/2	0/41
Bluetongue virus ID (±)	0/24	0/2	0/41
Contagious ecthyma virus CF (10)	0/24	0/2	0/41
Brucella suis IV bacterium BAPA (±); STT (50)	0/24	0/2	0/41
Q fever rickettsium CF (20)	8/8	2/2	1/41
Leptospira interrogans bacterium MAT (100)	2/24	0/2	

[a] Test method: SN = serum neutralization test, HI = hemagglutination inhibition test, IFA = indirect fluorescent antibody test, ID = immunodiffusion test, CF = complement fixation test, BAPA = buffered acidified plate antigen test, STT = standard tube test, and MAT = microscopic agglutination test.

[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."

[c] Number positive/number tested.

Table 14. Serum antibody prevalence of 9 infectious disease agents in elk from Kodiak Island, Alaska, 1986.

Agent	1986
Brucella suis IV bacterium BAPA[a] (±)[b]; STT (50)	0/7[c]
Infectious bovine rhinotracheitis virus SN (8)	0/7
Bovine viral diarrhea virus SN (8)	0/7
Parainfluenza 3 virus HI (8)	0/7
Respiratory syncytial virus IFA (20)	0/7
Leptospira interrogans bacterium MAT (100)	0/7
Epizootic hemorrhagic disease virus ID (±)	1/7
Bluetongue virus ID (±)	0/7
Q fever rickettsium CF (20)	0/7

[a] Test method: BAPA = buffered acidified plate antigen test, STT = standard tube test, SN = serum neutralization test, HI = hemagglutination inhibition test, IFA = indirect fluorescent antibody test, MAT = microscopic agglutination test, ID = immunodiffusion test, and CF = complement fixation test.

[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."

[c] Number positive/number tested.

Table 15. Serum antibody prevalence of 10 infectious disease agents in mountain goats from Southeast and Cordova, Alaska, 1989.

Agent	Southeast 1989	Cordova 1989
Infectious bovine rhinotracheitis virus SN[a] (8)[b]	0/10[c]	0/14
Bovine viral diarrhea virus SN (8)	0/10	0/14
Parainfluenza 3 virus HI (8)	0/10	0/14
Respiratory syncytial virus IFA (20)	0/10	0/14
Contagious ecthyma virus CF (10)	0/10	0/14
Epizootic hemorrhagic disease virus ID (±)	0/10	0/14
Bluetongue virus ID (±)	0/10	0/14
Q fever rickettsium CF (20)	1/10	3/14
Brucella suis IV bacterium BAPA (±); STT (50)	0/10	0/14
Ovine progressive pneumonia virus ID (±)	0/10	0/14

[a] Test method: SN = serum neutralization test, HI = hemagglutination inhibition test, IFA = indirect fluorescent antibody test, CF = complement fixation test, ID = immunodiffusion test, BAPA = buffered acidified plate antigen test, and STT = standard tube test.

[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."

[c] Number positive/number tested.

Table 16. Serum antibody prevalence of 10 infectious disease agents in moose from Game Management Unit 13, Alaska, 1979-82, 1984-86, and 1988.

Agent	1979	1980	1981	1982	1984	1985	1986	1988
Infectious bovine rhinotracheitis virus SN[a] (8)[b]	0/15[c]	0/10	0/25	1/18		0/21	0/5	0/2
Bovine viral diarrhea virus SN (8)	0/15	0/10	0/25	0/18		2/21	0/5	0/2
Parainfluenza 3 virus HI (8)	0/15	0/10	0/25	0/18		0/21	0/5	0/2
Respiratory syncytial virus IFA (20)						0/17	0/5	0/2
Epizootic hemorrhagic disease virus ID (±)	0/15	0/10	0/25	2/18	0/6	0/21		0/2
Bluetongue virus ID (±)	0/15	0/10	0/25	0/18	0/6	0/21		0/2
Contagious ecthyma virus CF (10)	0/14	0/10	0/17	0/16	0/5	1/21		0/2
Brucella suis IV bacterium BAPA (±); STT (50)	0/15	0/10	0/25	0/18	0/6	0/17	1/5	
Q fever rickettsium CF (20)	0/15	0/10	0/25	0/18	0/6	0/21		0/2
Leptospira interrogans bacterium MAT (100)	0/15	0/10	1/25	0/18	1/6	2/17	0/5	

Table 16. Continued.

[a] Test method: SN = serum neutralization test, HI = hemagglutination inhibition test, IFA = indirect fluorescent antibody test, ID = immunodiffusion test, CF = complement fixation test, BAPA = buffered acidified plate antigen test, STT = standard tube test, and MAT = microscopic agglutination test.

[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."

[c] Number positive/number tested.

Table 17. Serum antibody prevalence of 10 infectious disease agents in moose from Interior Alaska, 1978, 1984-86, and 1988-90.

Agent	Tetlin 1984	Tok 1986	Tok 1988	Delta 1984	Delta 1985	Ft. Yukon 1989	Ft. Yukon 1990	Beaver Creek 1985	20A 1978	20A 1989
Infectious bovine rhinotracheitis virus SN[a] (8)[b]	0/8[c]	0/8	0/37	0/1	0/4	0/7	0/9	0/10	0/7	0/39
Bovine viral diarrhea virus SN (8)	0/8	0/8	0/37	0/1	0/4	0/7	0/9	0/10	0/7	0/39
Parainfluenza 3 virus HI (8)	0/8	0/8	0/37	0/1	0/4	0/7	0/9	0/10	0/7	0/39
Respiratory syncytial virus IFA (20)		0/8	0/37			0/7	0/9		0/7	0/39
Epizootic hemorrhagic disease virus ID (±)	0/10	1/8	0/37	0/3	0/4	0/7	0/9	0/10	0/7	
Bluetongue virus ID (±)	0/10	0/8	10/37	0/3	0/4	0/7	0/9	0/10	0/7	
Contagious ecthyma virus CF (10)	0/10	0/8	1/36	0/3	0/4	1/7	0/9	0/5	0/7	
Brucella suis IV bacterium BAPA (±); STT (50)	0/10	0/8	0/37	0/3		0/7	0/9	0/10	0/7	0/39
Q fever rickettsium CF (20)	0/10	0/8	0/37	0/3	0/4	0/7	0/9	0/10	1/7	
Leptospira interrogans bacterium MAT (100)	0/10	0/8	0/34	0/3				2/10		

Table 17. Continued.

[a] Test method: SN = serum neutralization test, HI = hemagglutination inhibition test, IFA = indirect fluorescent antibody test, ID = immunodiffusion test, CF = complement fixation test, BAPA = buffered acidified plate antigen test, STT = standard tube test, and MAT = microscopic agglutination test.

[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."

[c] Number positive/number tested.

Table 18. Serum antibody prevalence of 10 infectious disease agents in moose from selected areas of Alaska, 1984-86.

Agent	Koyukuk 1984	Koyukuk 1985	Galena 1986	Innoko 1986
Infectious bovine rhinotracheitis virus SN[a] (8)[b]	0/19[c]	0/4	0/4	0/29
Bovine viral diarrhea virus SN (8)	0/19	1/3	0/4	0/29
Parainfluenza 3 virus HI (8)	0/19	2/4	0/4	0/29
Respiratory syncytial virus IFA (20)			0/4	0/29
Epizootic hemorrhagic disease virus ID (±)	0/19	0/4	0/4	
Bluetongue virus ID (±)	0/19	0/4	0/4	
Contagious ecthyma virus CF (10)	0/8	0/4	0/4	
Brucella suis IV bacterium BAPA (±); STT (50)	0/19		0/4	0/30
Q fever rickettsium CF (20)	0/18	0/4	0/4	
Leptospira interrogans bacterium MAT (100)	2/19		0/4	0/29

[a] Test method: SN = serum neutralization test, HI = hemagglutination inhibition test, IFA = indirect fluorescent antibody test, ID = immunodiffusion test, CF = complement fixation test, BAPA = buffered acidified plate antigen test, STT = standard tube test, and MAT = microscopic agglutination test.

[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."

[c] Number positive/number tested.

Table 19. Serum antibody prevalence of 5 infectious disease agents in grizzly bears from Game Management Unit 20A, Alaska, 1984-89.

Agent	1984	1985	1986	1987	1988	1989
Brucella suis IV bacterium BAPA[a] (±)[b]; STT (50)	2/19[c]	0/14		0/10	1/11	0/26
Francisella tularensis bacterium TAT (20)	12/19	7/14			0/2	17/26
Leptospira interrogans bacterium MAT (100)	2/19	0/14	2/14			
Q fever rickettsium CF (20)	0/5	0/13	0/16	0/10	0/9	0/26
Toxoplasma gondii IHA (64)	0/13	0/14				

[a] Test method: BAPA = buffered acidified plate antigen test, STT = standard tube test, TAT = tube agglutination test, MAT = microscopic agglutination test, CF = complement fixation test, and IHA = indirect hemagglutination test.

[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."

[c] Number positive/number tested.

Table 20. Serum antibody prevalence of 5 infectious disease agents in grizzly bears from Game Management Unit 26A, Alaska, 1984-89.

Agent	1984	1985	1986	1987	1988	1989
Brucella suis IV bacterium BAPA[a] (±)[b]; STT (50)	3/19[c]	9/24	12/15	14/26	6/35	5/17
Francisella tularensis bacterium TAT (20)	3/19	10/21			11/35	5/17
Leptospira interrogans bacterium MAT (100)	0/19	2/28	1/14			
Q fever rickettsium CF (20)	0/9	0/28	0/15	0/26		0/17
Toxoplasma gondii IHA (64)	0/15	0/21				

[a] Test method: BAPA = buffered acidified plate antigen test, STT = standard tube test, TAT = tube agglutination test, MAT = microscopic agglutination test, CF = complement fixation test, and IHA = indirect hemagglutination test.

[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."

[c] Number positive/number tested.

Table 21. Serum antibody prevalence of 5 infectious disease agents in grizzly bears from Game Management Unit 26C, Alaska, 1984-89.

Agent	1984	1985	1986	1987	1988	1989
Brucella suis IV bacterium BAPA[a] (±)[b]; STT (50)	1/35[c]	7/52	1/2	16/63	1/35	4/22
Francisella tularensis bacterium TAT (20)	18/35	22/52		3/35		4/22
Leptospira interrogans bacterium MAT (100)	0/34	0/52	1/2			
Q fever rickettsium CF (20)	0/18	0/43	0/2	2/63		0/22
Toxoplasma gondii IHA (64)	0/24	0/52				

[a] Test method: BAPA = buffered acidified plate antigen test, STT = standard tube test, TAT = tube agglutination test, MAT = microscopic agglutination test, CF = complement fixation test, and IHA = indirect hemagglutination test.

[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."

[c] Number positive/number tested.

Table 22. Serum antibody prevalence of 5 infectious disease agents in grizzly bears from Game Management Unit 13, Alaska, 1980 and 1983-87.

Agent	1980	1983	1984	1985	1986	1987
Brucella suis IV bacterium						
BAPA[a] (±)[b]; STT (50)	2/70[c]	3/29	2/12	0/12	1/15	3/15
Francisella tularensis bacterium						
TAT (20)		7/29				
Leptospira interrogans bacterium						
MAT (100)		10/29				
Q fever rickettsium						
CF (20)		0/25	0/12	0/12	0/15	0/14
Toxoplasma gondii						
IHA (64)		0/28				

[a] Test method: BAPA = buffered acidified plate antigen test, STT = standard tube test, TAT = tube agglutination test, MAT = microscopic agglutination test, CF = complement fixation test, and IHA = indirect hemagglutination test.

[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."

[c] Number positive/number tested.

Table 23. Serum antibody prevalence of 2 infectious disease agents in grizzly bears from Noatak, Alaska, 1984-87.

Agent	1984	1985	1986	1987
Brucella suis IV bacterium BAPA[a] (±)[b]; STT (50)	4/10[c]	0/3	10/33	9/26
Q fever rickettsium CF (20)			0/33	0/26

[a] Test method: BAPA = buffered acidified plate antigen test, STT = standard tube test, and CF = complement fixation test.

[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."

[c] Number positive/number tested.

Table 24. Serum antibody prevalence of 5 infectious disease agents in grizzly bears from Kodiak, Alaska, 1982-84, 1986, and 1988.

Agent	1982	1983	1984	1986	1988
Brucella suis IV bacterium BAPA[a] (±)[b]; STT (50)	0/9[c]	0/1	1/40	5/15	4/42
Francisella tularensis bacterium TAT (20)	0/9	0/1	1/40		0/42
Leptospira interrogans bacterium MAT (100)	2/9	0/1	11/40	4/14	
Q fever rickettsium CF (20)	0/8		0/25	0/15	
Toxoplasma gondii IHA (64)	0/9	0/1	0/40		

[a] Test method: BAPA = buffered acidified plate antigen test, STT = standard tube test, TAT = tube agglutination test, MAT = microscopic agglutination test, CF = complement fixation test, and IHA = indirect hemagglutination test.

[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."

[c] Number positive/number tested.

Table 25. Serum antibody prevalence of 2 infectious disease agents in grizzly bears from Admiralty Island, Alaska, 1984-87.

Agent	1984	1985	1986	1987
Brucella suis IV bacterium BAPA[a] (±)[b]; STT (50)	2/9[c]	0/3	1/11	0/3
Q fever rickettsium CF (20)	0/10	0/3	0/11	0/3

[a] Test method: BAPA = buffered acidified plate antigen test, STT = standard tube test, and CF = complement fixation test.

[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."

[c] Number positive/number tested.

Table 26. Serum antibody prevalence of 4 infectious disease agents in grizzly bears from selected areas of Alaska, 1985, 1986, 1988, and 1989.

Agent	1986 Becharof	1985 20E	1988 20B	1988 20C	1989 Denali	1989 Seward Peninsula
Brucella suis IV bacterium						
BAPA[a] (±)[b]; STT (50)	10/19[c]		0/1	0/2	0/3	10/47
Francisella tularensis bacterium						
TAT (20)			0/1	1/2	0/3	19/47
Leptospira interrogans bacterium						
MAT (100)	4/16	1/8				
Q fever rickettsium						
CF (20)	0/19	0/9			0/3	0/44
Toxoplasma gondii						
IHA (64)						

[a] Test method: BAPA = buffered acidified plate antigen test, STT = standard tube test, TAT = tube agglutination test, MAT = microscopic agglutination test, CF = complement fixation test, and IHA = indirect hemagglutination test.

[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."

[c] Number positive/number tested.

Table 27. Serum antibody prevalence of 4 infectious disease agents in wolves from the Arctic National Wildlife Refuge, Alaska, 1984-88.

Agent	1984	1985	1986	1987	1988
Brucella suis IV bacterium BAPA[a] (±)[b]	1/16[c]		0/3	7/14	0/6
Francisella tularensis bacterium TAT (20)	2/16				0/6
Leptospira interrogans bacterium MAT (100)	0/16			0/14	
Q fever rickettsium CF (20)		0/9	0/3	0/14	

[a] Test method: BAPA = buffered acidified plate antigen test, STT = standard tube test, TAT = tube agglutination test, MAT = microscopic agglutination test, and CF = complement fixation test.

[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."

[c] Number positive/number tested.

Table 28. Serum antibody prevalence of 6 infectious disease agents in black bears from Game Management Unit 13, Alaska, 1980-85.

Agent	1980	1981	1982	1983	1984	1985
Brucella suis IV bacterium BAPA[a] (±)[b]; STT (50)		0/2[c]	0/2	0/19		
Francisella tularensis bacterium TAT (20)		0/2	0/2	2/19		
Leptospira interrogans bacterium MAT (100)		0/2	0/2	0/19		
Q fever rickettsium CF (20)					0/6	0/15
Toxoplasma gondii IHA (64)		0/2	1/2	0/19		
Pseudorabies virus MIDT (±)	0/28	0/1	0/1	2/18		

[a] Test method: BAPA = buffered acidified plate antigen test, STT = standard tube test, TAT = tube agglutination test, MAT = microscopic agglutination test, CF = complement fixation test, IHA = indirect hemagglutination test, and MIDT = microimmunodiffusion.

[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."

[c] Number positive/number tested.

Table 29. Serum antibody prevalence of 3 infectious disease agents in black bears from Game Management Unit 20A, Alaska, 1987-90.

Agent	1987	1988	1989	1990
Brucella suis IV bacterium BAPA[a] (±)[b]; STT (50)	0/4[c]	0/9	1/22	0/20
Francisella tularensis bacterium TAT (20)		8/9	21/22	20/20
Q fever rickettsium CF (20)	0/4		0/16	0/20

[a] Test method: BAPA = buffered acidified plate antigen test, STT = standard tube test, TAT = tube agglutination test, and CF = complement fixation test.

[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."

[c] Number positive/number tested.

Table 30. Serum antibody prevalence of 5 infectious disease agents in polar bears from Alaska, 1982-85.

Agent	1982	1983	1984	1985
Brucella suis IV bacterium BAPA[a] (±)[b]; STT (50)	1/13[c]	1/27	2/20	3/32
Francisella tularensis bacterium TAT (20)	3/13	1/27	1/20	2/32
Leptospira interrogans bacterium MAT (100)	0/13	0/27	0/20	0/32
Q fever rickettsium CF (20)	0/12	0/27	0/20	0/32
Toxoplasma gondii IHA (64)	0/13	0/27	1/20	0/32

[a] Test method: BAPA = buffered acidified plate antigen test, STT = standard tube test, TAT = tube agglutination test, MAT = microscopic agglutination test, CF = complement fixation test, and IHA = indirect hemagglutination test.

[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."

[c] Number positive/number tested.

Table 31. Serum antibody prevalence of 4 infectious disease agents in wolves from Game Management Subunit 20A, Alaska, 1984 and 1986-89.

Agent	1984	1986	1987	1988	1989
Brucella suis IV bacterium BAPA[a] (±)[b]; STT (50)	0/7[c]	0/4	0/8	0/11	0/4
Francisella tularensis bacterium TAT (20)	3/7			1/7	1/4
Leptospira interrogans bacterium MAT (100)	0/7	0/4	0/8	0/4	
Q fever rickettsium CF (20)		0/4	0/8	0/4	

[a] Test method: BAPA = buffered acidified plate antigen test, STT = standard tube test, TAT = tube agglutination test, MAT = microscopic agglutination test, and CF = complement fixation test.

[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."

[c] Number positive/number tested.

Table 32. Serum antibody prevalence of 4 infectious disease agents in wolves from selected areas of Alaska and Canada, 1984 and 1986-88.

Agent	Denali 1986	Denali 1987	Denali 1988	Tok 1987	Tok 1988	Galena 1986	Galena 1987	Kenai 1984	Canada 1988
Brucella suis IV bacterium BAPA[a] (±)[b]; STT (50)	0/13[c]	0/13	1/19	0/5	0/5	0/1	0/4	0/2	5/23
Francisella tularensis bacterium TAT (20)					1/5			0/2	
Leptospira interrogans bacterium MAT (100)			0/4	0/5		0/1	0/4	0/2	0/23
Q fever rickettsium CF (20)	0/13	0/13	0/17	0/5		0/1	0/4		0/12

[a] Test method: BAPA = buffered acidified plate antigen test, STT = standard tube test, TAT = tube agglutination test, MAT = microscopic agglutination test, and CF = complement fixation test.

[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."

[c] Number positive/number tested.

Table 33. Serum antibody prevalence of 4 infectious disease agents in arctic and red foxes from Alaska, 1982 and 1984-86.

Agent	Arctic 1982	Red 1982	Red 1984	Red 1985	Red 1986
Canine distemper virus SN (20)	0/12	0/2	0/1		
Infectious canine hepatitis virus SN (20)	11/12	1/2	0/1		
Pseudorabies virus MIDT (±)	0/12	0/2	0/1		
Q fever rickettsium CF (20)				0/2	0/1

[a] Test method: SN = serum neutralization test, MIDT = , and CF = complement fixation test.

[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."

[c] Number positive/number tested.

Appendix A. Serologic Survey for Infectious Canine Hepatitis Virus in Grizzly Bears (*Ursus arctos*) from Alaska, 1973 to 1987.

Randall L. Zarnke and Mary Beth Evans

Journal of Wildlife Diseases 25(4), 1989, pp.568-573

Abstract. Serum antibody prevalence of infectious canine hepatitis virus was 12% (90 of 725) for grizzly bears (*Ursus arctos*) from Alaska (USA) during the period 1973 to 1987. Prevalence was highest on Kodiak Island at 29% (37 of 127). Prevalence of exposure at individual collection areas did not change significantly over time. There were no significant sex-specific differences in prevalence. Prevalence was directly related to age, but it was 0% for bears <2 years old. Young bears which are exposed to the virus may develop clinical disease and die as a result of the infection. This disease may be a factor affecting grizzly bear population dynamics.

Appendix B. Serologic Survey for *Mycoplasma ovipneumoniae* in Free-ranging Dall Sheep (*Ovis dalli*) in Alaska.

Randall L. Zarnke and Soren Rosendal

Journal of Wildlife Diseases, 25(4), 1989, pp.612-613.

Abstract. Indirect hemagglutination tests on sera from 251 Dall sheep (*Ovis dalli*) from interior Alaska collected during the period 1979 to 1987 revealed no evidence of exposure to *Mycoplasma ovipneumoniae*. Apparently, this potentially fatal disease agent has not been introduced into free-ranging Dall sheep populations. In the interest of continued health of such Dall sheep, strict enforcement of domestic animal health regulations and prudent land use practices are clearly indicated.

Appendix C. Serum Antibody Prevalence of Parainfluenza 3 Virus in a Free-ranging Bison (*Bison bison*) Herd from Alaska.

Randall L. Zarnke and G. A. Erickson

Journal of Wildlife Diseases, 26(3), 1990, pp.416-419

Abstract. Serum antibody prevalence of parainfluenza 3 virus in the free-ranging Delta bison (*Bison bison*) herd which is found near Delta Junction, Alaska (USA), increased from 0% to 100% during the period 1977 to 1984. Domestic cattle are hypothesized as the source for the infection. There has been no clinical disease or decrease in productivity in this bison herd since establishment of the infection.

Appendix D. Serologic Survey for *Actinobacillus capsulatus* in Free-ranging Snowshoe Hares (*Lepus americanus*) from Alaska and Alberta.

Randall L. Zarnke, Jamie K. Morton, and Patrick J. Manning

Journal of Wildlife Diseases, 26(4), 1990, pp.518-521

Abstract. A plate agglutination method was developed to test sera from free-ranging snowshoe hares (*Lepus americanus*) captured in Alaska (USA) or Alberta (Canada) for antibody against *Actinobacillus capsulatus*. Antiserum against *A. capsulatus* was prepared in a domestic rabbit. A concentrated suspension of formalin-killed *A. capsulatus* was prepared for use as an antigen. Serum antibody prevalence for hares was 98 of 239 (41%) in Alaska and 51 of 111 (46%) in Alberta. Prevalence in Alaska peaked in 1981 corresponding to a peak in hare population density. Seasonal prevalence peaked in May in Alaska. Prevalence at one capture site in Alaska was significantly higher than at four other sites. There was no difference in sex-specific prevalence for either Alaska or Alberta.