UiT

THE ARCTIC UNIVERSITY OF NORWAY

Zoonotic diseases without pandemic potential, like brucellosis, are in need of innovative One Health approaches

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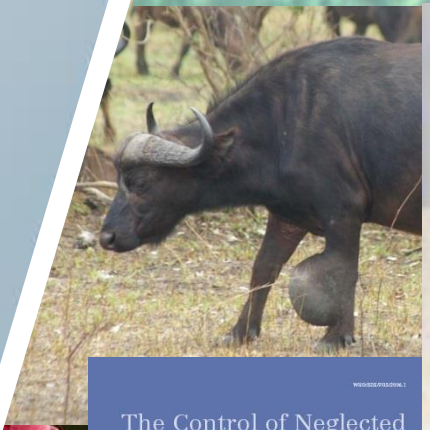
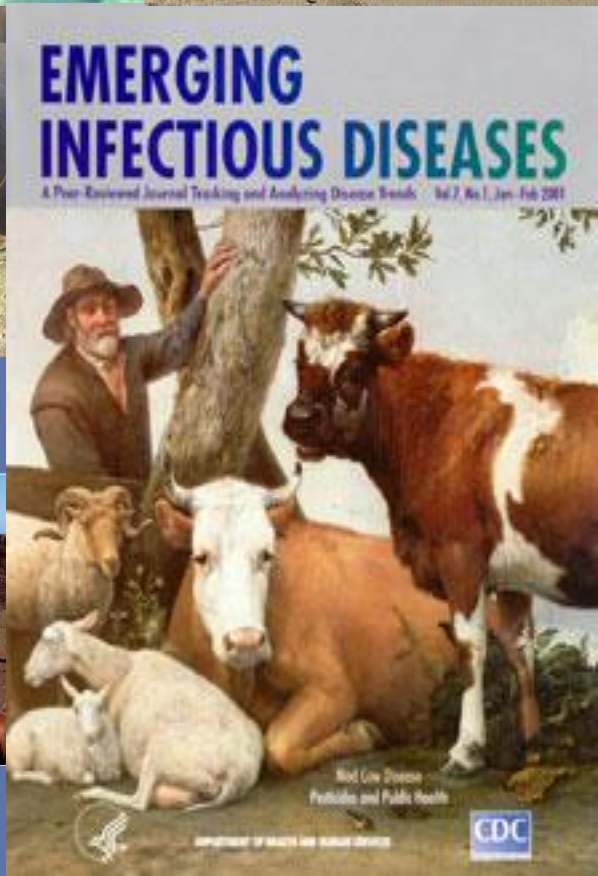
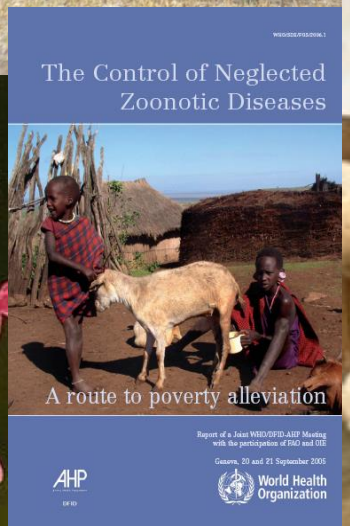
ANTHC's Center for Climate and Health
CDC Arctic Investigations Program in
Anchorage Alaska
April 17, 2018

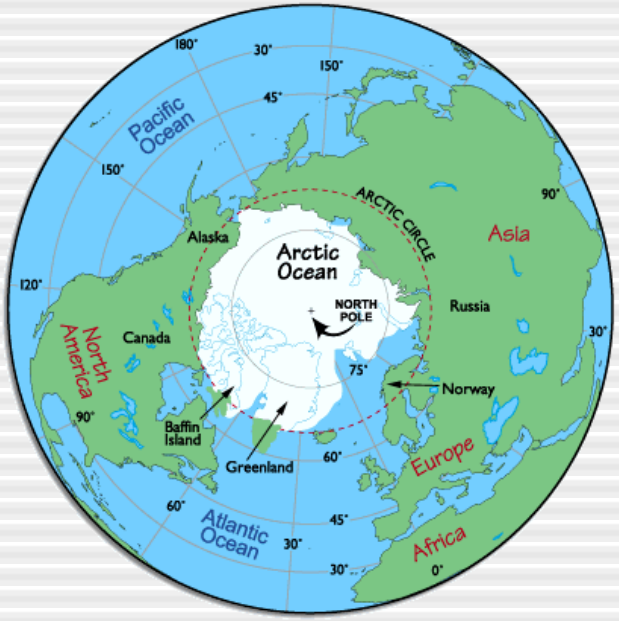






Tromsø

69° 40'58"N - 18° 56'34"E



« Brucellosis is the most common bacterial zoonosis, with over 500 000 new cases globally every year»

Pappas G, Papdimitriou P, Akritidis N, Christou L, Tsianos EV.

The new global map of human brucellosis.
Lancet Infect Dis 2006;6:91-99.

The source of infection is almost always to be found in the animal reservoir

Animal brucellosis in the Arctic

Symptoms in chronic brucellosis – wildlife

Brucella suis…

biovar 4

Symptoms in chronic brucellosis – wildlife

Picture: Kimberlee Beckmen

Brucella suis…

biovar 4

Contagious Ecthyma, Rangiferine Brucellosis, and Lungworm Infection in a Muskox (*Ovibos moschatus*) from the Canadian Arctic, 2014

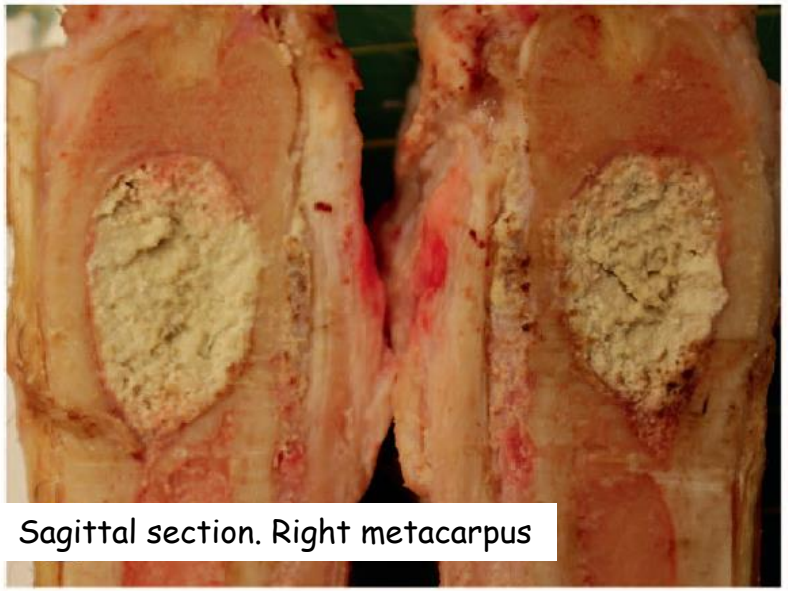
Author(s): Matilde Tomaselli , Chimoné Dalton , Pádraig J. Duignan , Susan Kutz , Frank van der Meer , Pratap Kafle , Om Surujballi , Claude Turcotte , and Sylvia Checkley

Source: Journal of Wildlife Diseases, 52(3):719-724.

Published By: Wildlife Disease Association

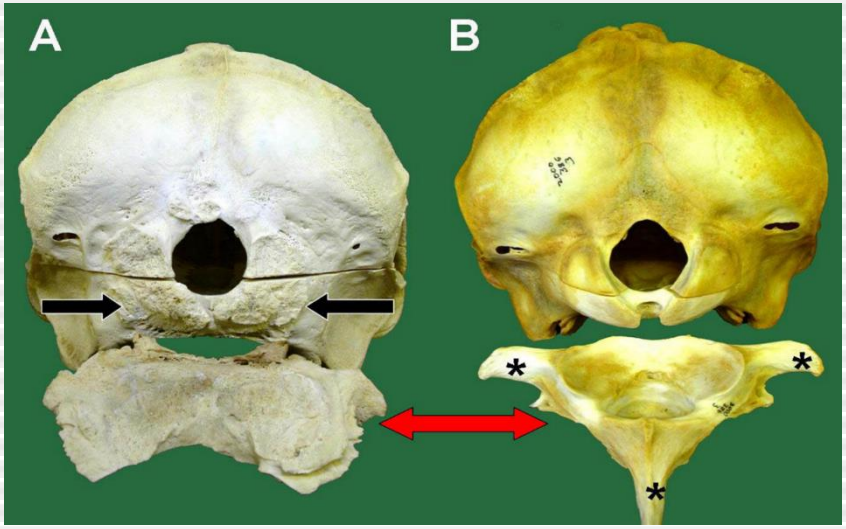
https://doi.org/10.7589/2015-12-327

URL: http://www.bioone.org/doi/full/10.7589/2015-12-327



Sagittal section. Right metacarpus

Symptoms in chronic brucellosis – wildlife



Brucella ceti

Picture: Foster. Testicular abscess, harbour porpoise.

Foster et al., 2002, Gonzalez et al., 2002; Dagleish et al., 2007

Human brucellosis in the Arctic

Brucella suis biovar 4: Confirmed

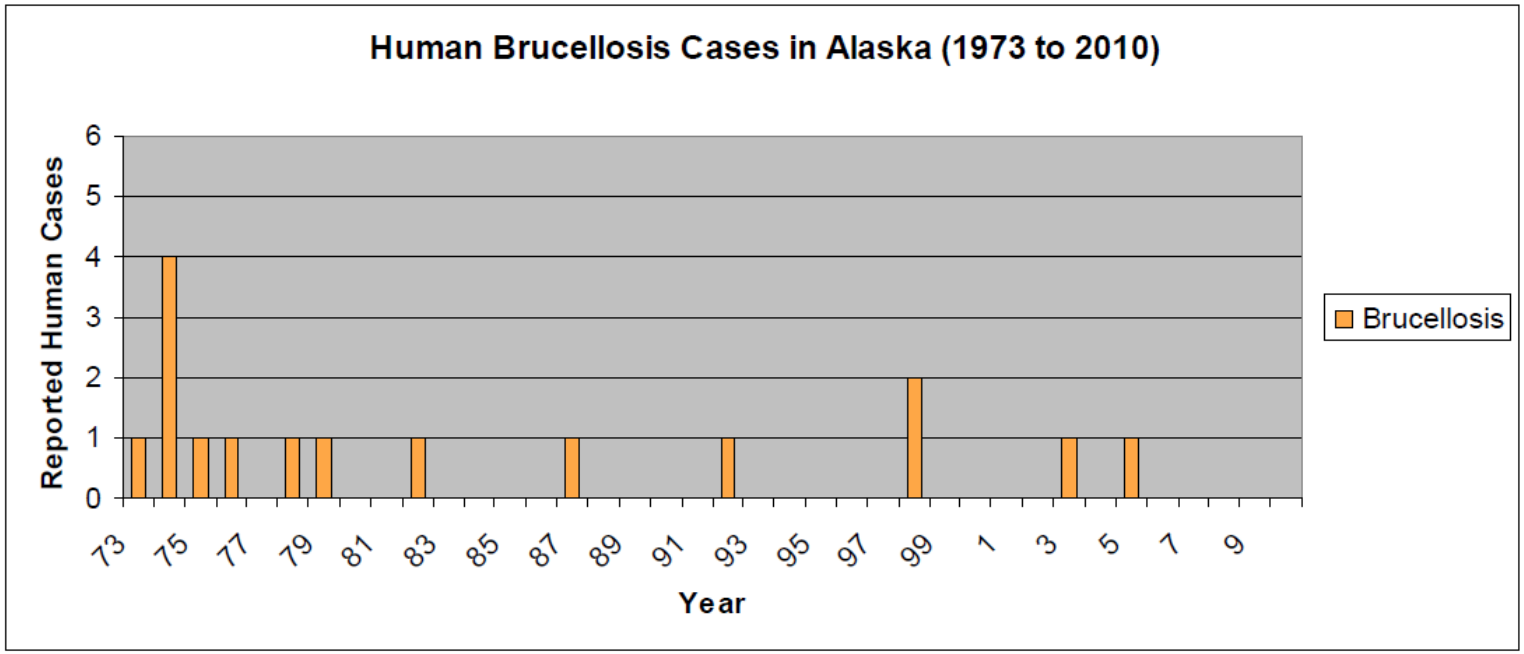
Marine mammal brucellae:
Not described (yet?)

Brucellosis: Understanding an Important Arctic Infectious Disease

Center for Climate and Health

Michael Brubaker MS, James Berner MD, Jay Butler MD, Michael Bradley DVM

CCH Bulletin No. 5, November 30, 2010



Source: State of Alaska Department of Health and Social Services

Isolates of *Brucella suis* biovar 4 from animals and humans in Canada, 1982–1990

Lorry B. Forbes

Can Vet J 1991; 32: 686–688

Table 1. Summary of tissues from which *B. suis* biovar 4 was isolated[a]

Tissue	Gross lesion			Total	Species
	Suppurative[b]	Nonsuppurative	Not described		
Carpal joint	9	12	9	30	29 caribou, 1 muskox
Lymph nodes	2	28		30	7 caribou, 23 reindeer
Testicle	15	1	5	21	18 caribou, 2 reindeer, 1 muskox
Joints other than carpus	7	2	6	15	14 caribou, 1 human
Blood		10		10	All human
Subcutaneous abscess	9			9	All caribou
Mammary gland	4	3		7	6 reindeer, 1 caribou
Epididymis	4		1	5	All caribou
Abscessed muscle	3			3	All caribou
Liver	1		2	3	All caribou
Kidney	1			1	Caribou
Uterus			1	1	Caribou
Placenta		1		1	Caribou
Abscess of rumen wall	1			1	Caribou

[a]One hundred culture-positive cases of caribou, reindeer, muskox, and human origin. Some cases had more than one positive tissue
[b]Classed as suppurative if any of the following terms were used in describing the lesion: abscess, pus, purulent, suppurative

Brucella spp. in Marine Mammals

International Journal of Systematic and Evolutionary Microbiology (2007), **57**, 2688–2693 DOI 10.1099/ijs.0.65269-0

Brucella ceti sp. nov. and *Brucella pinnipedialis* sp. nov. for *Brucella* strains with cetaceans and seals as their preferred hosts

Geoffrey Foster,[1] Bjorn S. Osterman,[2] Jacques Godfroid,[3] Isabelle Jacques[4,5] and Axel Cloeckaert[4]

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[2]Department of Clinical Microbiology, Karolinska University Hospital, MTC, Stockholm SE-17176, Sweden

[3]Faculty of Veterinary Science, Department of Veterinary Tropical Diseases, University of Pretoria, Onderstepoort 0110, South Africa

[4]INRA, UR1282, Infectiologie Animale et Santé Publique, IASP, Nouzilly, F-37380, France

[5]Institut Universitaire de Technologie, Université François Rabelais, 29 rue du Pont-Volant, 37082 Tours cedex 2, France

Small Gram-negative cocco-bacilli resembling *Brucella* strains have been reported from marine mammals since the mid-1990s. Their placement in the genus *Brucella* has been supported by the following characteristics: they are aerobic, non-motile and catalase-positive, do not produce acid from carbohydrates and have a DNA–DNA relatedness value of >77% with the six established members of the genus. Twenty-eight European isolates of the genus *Brucella* from marine mammals were distinguished from the six recognized species by their pattern of utilization of eleven substrates in oxidative metabolism tests and phage lysis. The 28 strains could be further separated into two groups with cetaceans and seals as their respective preferred hosts on the basis of molecular methods and on differences in the metabolism of L-arabinose, D-galactose and D-xylose. The names *Brucella ceti* sp. nov. and *Brucella pinnipedialis* sp. nov. are proposed for the isolates from cetaceans and seals, respectively. The type strain of *Brucella ceti* sp. nov. is NCTC 12891^T (=BCCN 94-74^T) and the type strain of *Brucella pinnipedialis* sp. nov. is NCTC 12890^T (=BCCN 94-73^T).

Atlantic bottlenose dolphin
Atlantic white-sided dolphin
Common dolphin
Harbour porpoise
Hector's dolphin
Striped dolphin
Killer whale
Minke whale
Beluga whale
Bearded seal
Grey seal
Harbour seal
Harp seal
Hooded seal
Ringed seal
California sea lion
Northern fur seal

Novel isolation from marine mammals in 1994

Isolated only on the northern hemisphere

Isolation of marine mammal brucellae from humans

McDonald et al. 2006, Sohn et al. 2003:

- Masses in brain and vertebrae
- All three patents had been in contact with raw products from the sea. No contact with marine mammals.
- **ST27** (Previously isolated from an aborted bottlenose dolphin and placentas from aborting California sea lions)

Brew et al. 1999:

- Laboratory acquired infection in the UK
- ST23 (Previously isolated from porpoises)

Cloeckaert et al. 2011. Whatmore et al. 2008. Whatmore et al. 2007. McDonald et al. 2006. Sohn et al. 2003. Brew et al. 1999. Ewalt et al. 1994.

Brucella infections in cetaceans

Brucellosis!

Brucellosis in cetaceans - Strandings

Neurobrucellosis in Stranded Dolphins, Costa Rica

Gabriela Hernández-Mora, Rocío González-Barrientos, Juan-Alberto Morales, Esteban Chaves-Olarte, Caterina Guzmán-Verri, Elías Baquero-Calvo, María-Jesús De-Miguel, Clara-María Marín, José-María Blasco, and Edgardo Moreno

Ten striped dolphins, *Stenella coeruleoalba*, stranded along the Costa Rican Pacific coast, had meningoencephalitis and antibodies against *Brucella* spp. *Brucella ceti* was isolated from cerebrospinal fluid of 6 dolphins and 1 fetus. *S. coeruleoalba* constitutes a highly susceptible host and a potential reservoir for *B. ceti* transmission.

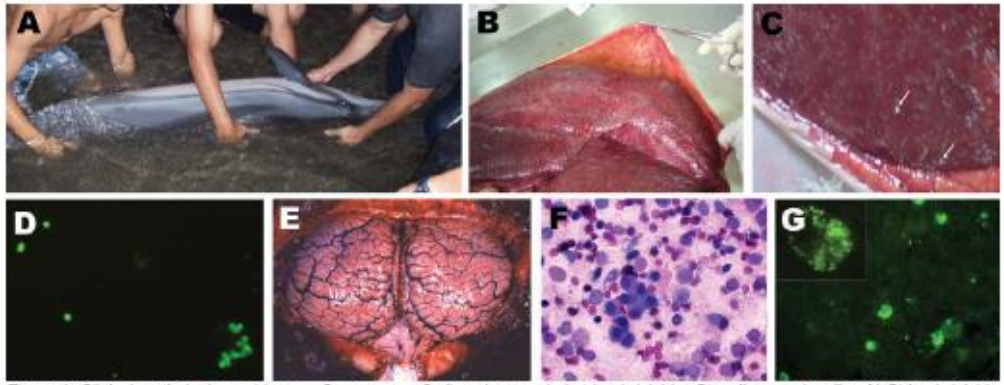

Figure 1. Clinical, pathologic, and immunofluorescence findings in stranded striped dolphin, *Stenella coeruleoalba*. A) Striped dolphin displaying swimming disorders being assisted by local persons; B) dolphin fetus within placenta; C) punctuated placental abscesses (arrows); D) immunofluorescent brucellae in impressions of placenta tissues; E) congested and hyperemic brain and cerebellum; F) Wright-Giemsa–stained mononuclear cell infiltrate in cerebrospinal fluid; G) immunofluorescent green *Brucella* spp. and *Brucella* debris within phagocytic cells infiltrating cerebrospinal fluid; the inset corresponds to an amplified phagocytic cell with fluorescent *Brucella* spp. and debris.

Brucella infections in True Seals

Brucellosis?

Brucellosis in hooded seal (?)

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Veterinary Microbiology 105 (2005) 103–111

veterinary microbiology

www.elsevier.com/locate/vetmic

Prevalence of *Brucella pinnipediae* in healthy hooded seals (*Cystophora cristata*) from the North Atlantic Ocean and ringed seals (*Phoca hispida*) from Svalbard

Morten Tryland[a,*], Karen Kristine Sørensen[b,1], Jacques Godfroid[c,2]

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[b]*National Veterinary Institute Tromsø, NO-9292 Tromsø, Norway*
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Received 6 May 2004; received in revised form 1 October 2004; accepted 22 October 2004

Table 2
Correlation between isolation of *Brucella pinnipediae* from organ samples ($n = 174$) and the presence of anti-*Brucella* antibodies in serum from 29 hooded seals (*Cystophora cristata*) caught between Svalbard and Greenland, autumn 2002 (only seropositive and/or culture positive individuals are presented; open spaces indicate no growth of *Brucella* or seronegative results

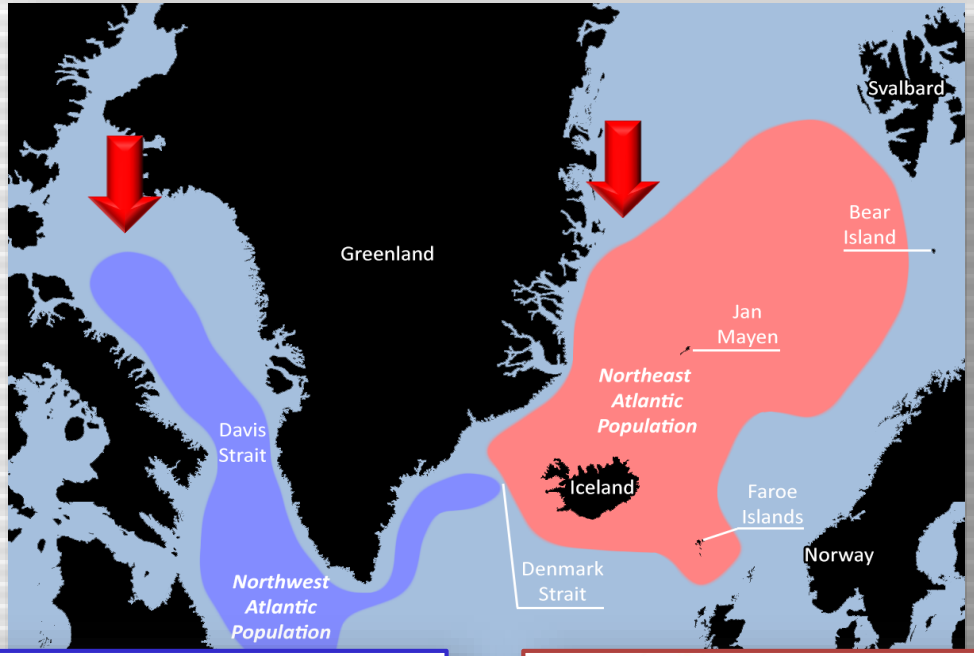
Animal number	Age (months)[a]	Sex	Tonsil	Lung	Lung lymph node	Spleen	Liver	Kidney	Testicle	Serology
1	6	M			NI[b]					+
8	30	F								+
9	6	F			+	+				+
17	30	M	+	+	+	+	+	+	+	+
22	6	M		+	+	+	+			+
23	6	F	+	+	+	+	+			
24	18	M	+			+			+	
25	18	M			+	+				+
30	18	M			+	+	+			+
37	6	M	+	+	+	+	+	+	NI[b]	+
38	6	F						+		
39	18	F			+	+	+			+
53	6	M			+					
Positive/tested			4/26	4/29	9/24	9/29	6/29	3/29	2/9	9/29
(%)			15	14	38	31	21	10	22	31

[a] Since birth takes place in March and the animals were caught in September, ages registered as < 1 year corresponds to 6 months, 1–2 years to 18 months, 2–3 years to 30 months, and 3–4 years to 42 months.
[b] Not investigated.

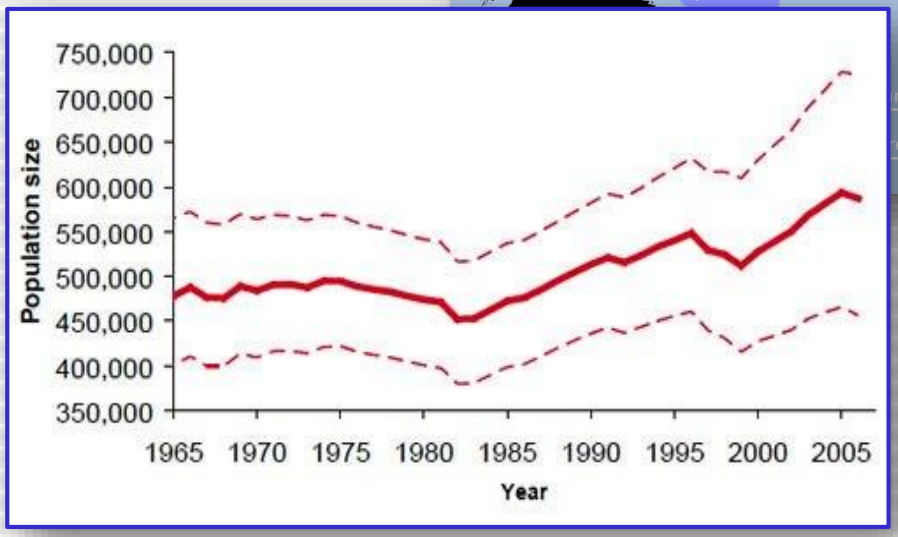
Or
Brucella infection !

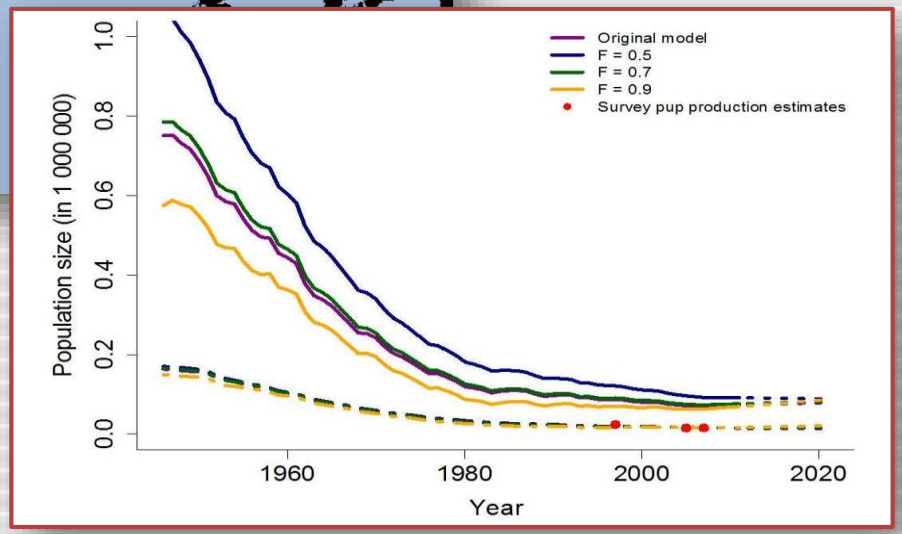
Hooded seal populations

- The Northwest Atlantic population
- Increased since the 1980s
- Estimated population size in 2005: 593 500



- The Northeast Atlantic population
- Estimated population size prior to 1940; 575 000
- Estimated population size in 2011 85 000



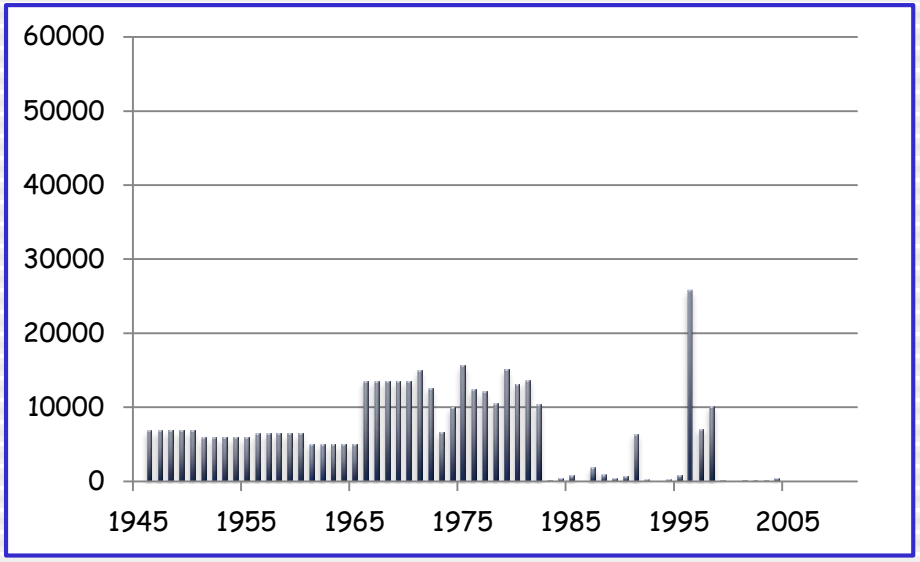


ICES 2011. Øigård et al. 2010. Andersen et al. 2009. Salberg et al. 2008. Coltman et al. 2007. Kovacs 2002. Folkow et al. 1996. Hammill et al. 1993. Sergeant 1974. Rasmussen 1957.

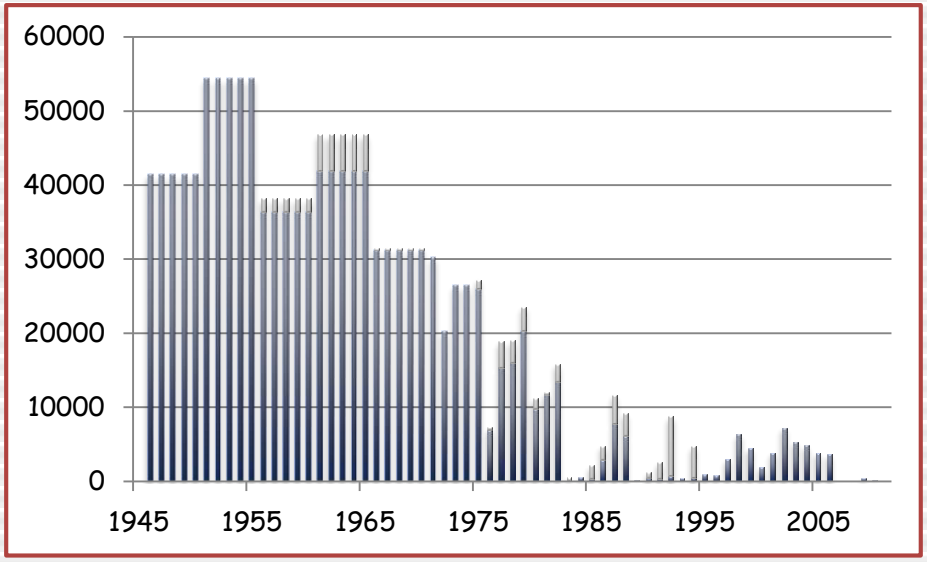
Sealing - Harvest of hooded seals

Large difference in harvest between the two populations

Exploitation of the
Northwest Atlantic population



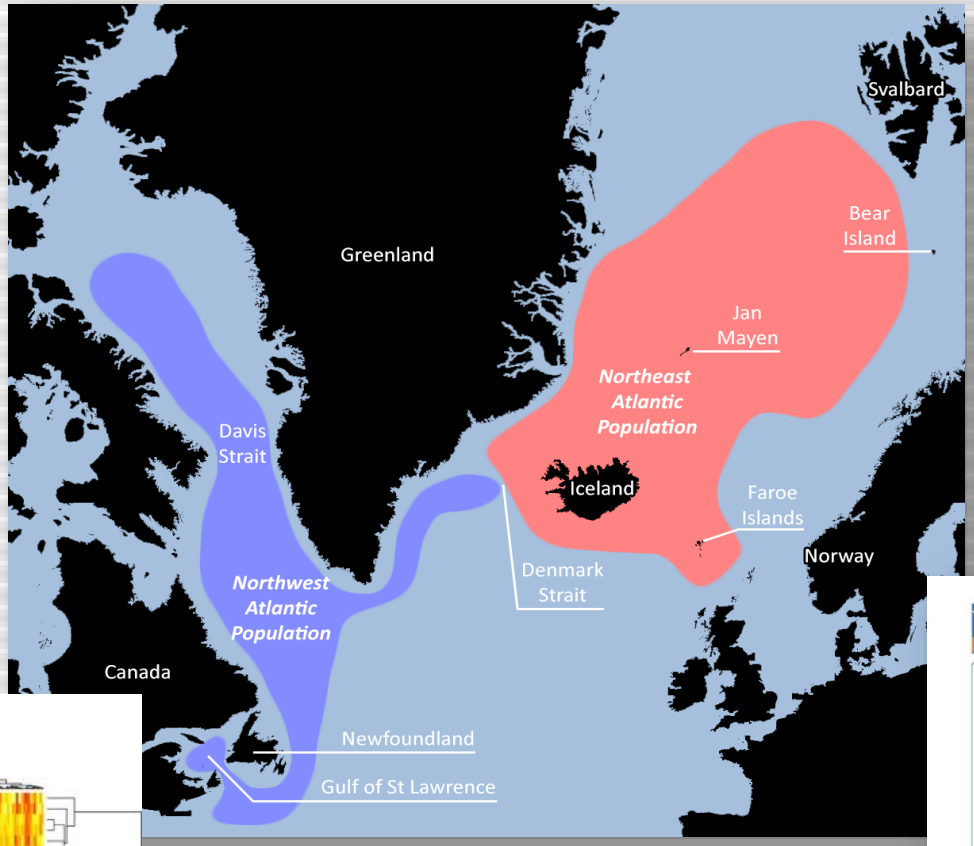
Exploitation of the
Northeast Atlantic population



B. pinnipedialis in hooded seal

- The Northwest Atlantic population

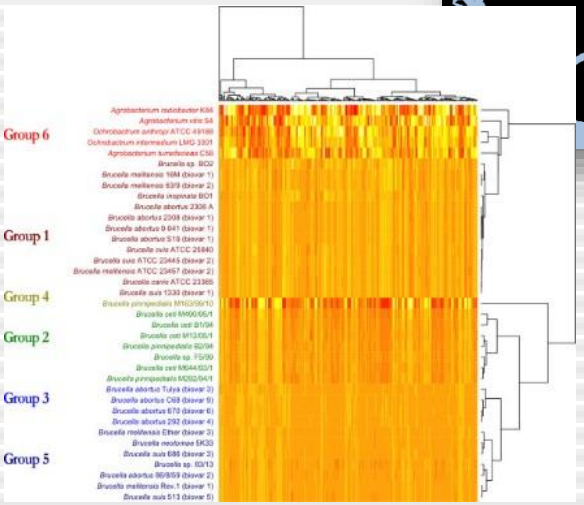
Seroprevalence
5 % (*n* = 10/204)



- The Northeast Atlantic population

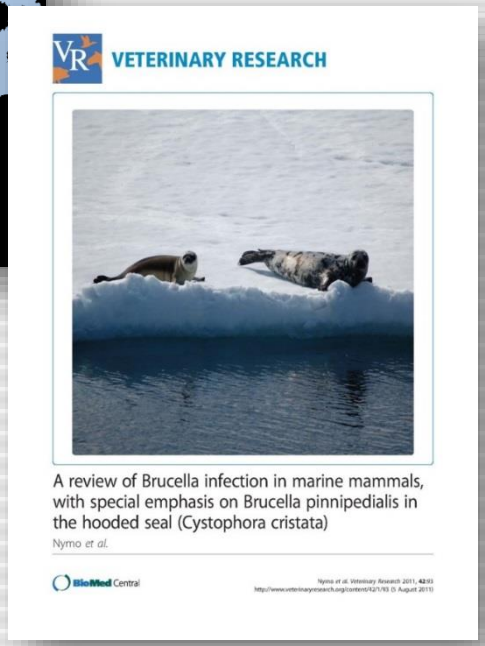
Seroprevalence
- 35 % (*n* = 38/137)
- 31 % (*n* = 9/29)

Bacteriology
- 38 % (*n* = 11/29)



Bohlin et al., 2010

Does Brucella infection contribute to the Northeast population crash?



Vol. 106: 187–196, 2013
doi: 10.3354/dao02659

DISEASES OF AQUATIC ORGANISMS
Dis Aquat Org

Published November 6

Age-dependent prevalence of anti-*Brucella* antibodies in hooded seals *Cystophora cristata*

Ingebjørg H. Nymo[1,*,**], Morten Tryland[1,**], Anne Kirstine Frie[2,**], Tore Haug[2,**], Geoffrey Foster[3], Rolf Rødven[4,**], Jacques Godfroid[1,**]

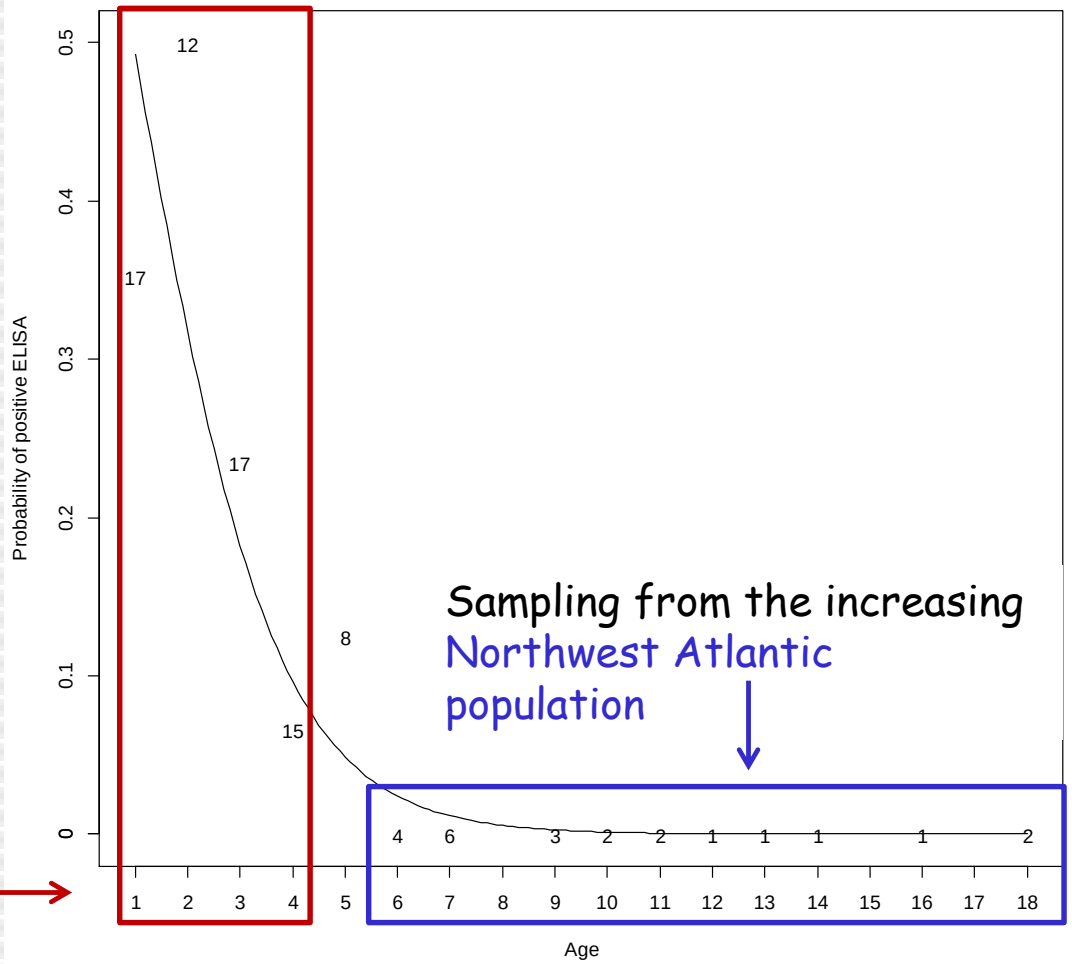
[1]Section of Arctic Veterinary Medicine, Norwegian School of Veterinary Science, Stakkevollveien 23, 9010 Tromsø, Norway
[2]Institute of Marine Research, PO Box 6404, 9294 Tromsø, Norway
[3]SAC Consulting Veterinary Services, Drummondhill, Stratherrick Road, Inverness IV2 4JZ, UK
[4]Bioforsk — Norwegian Institute of Agricultural and Environmental Research, PO Box 2284, 9269 Tromsø, Norway

Seroprevalence in hooded seal

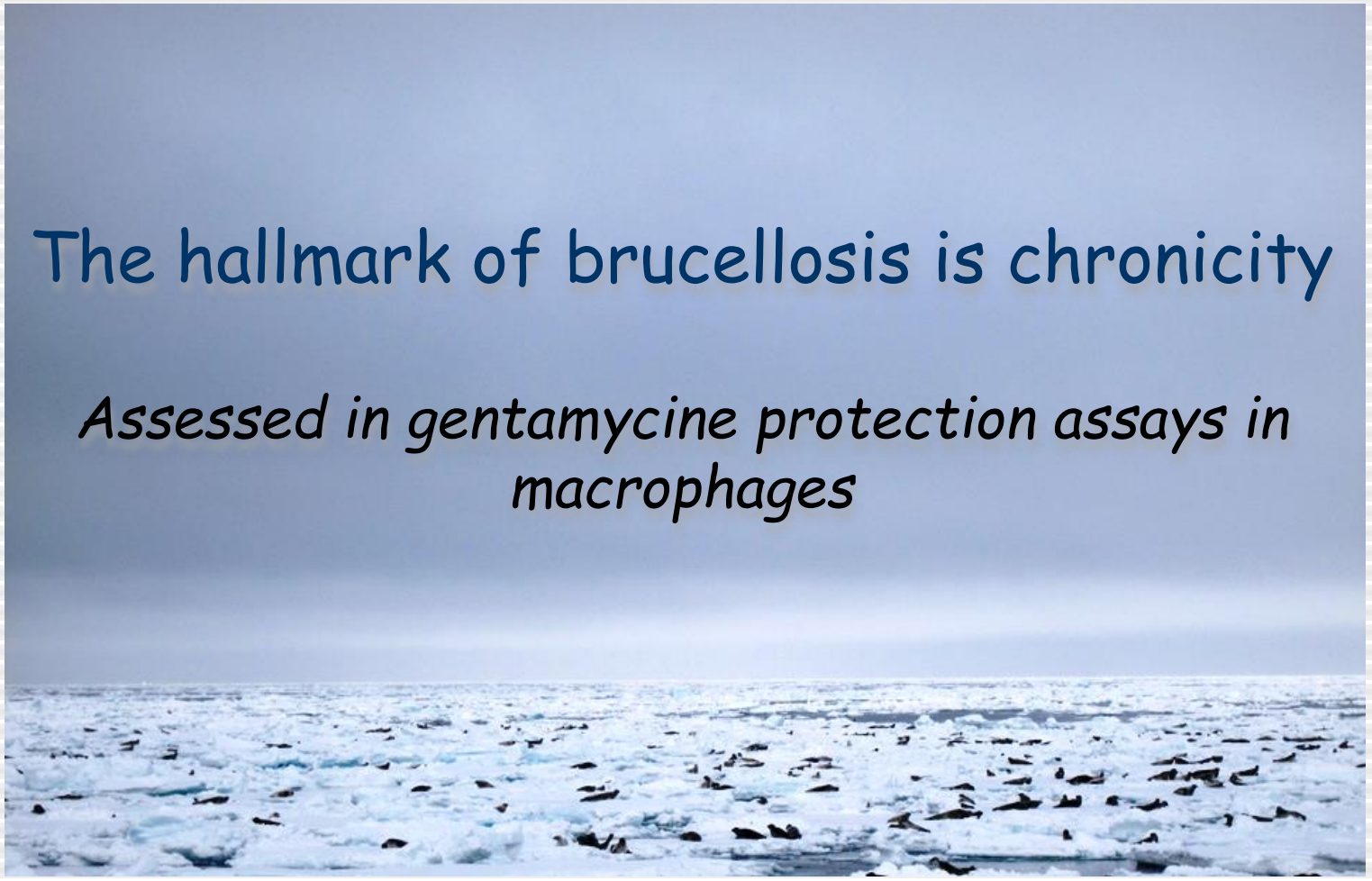
- Age:
  - Pups: 2.5 %
  - Yearlings: 35.3 %
  - The mean probability of being seropositive decreased with age for hooded seals > one year
  - All seropositive ≥ one year were 1-5 years old

- No relation between *Brucella*-serostatus in pups or yearlings and weight, length or dorsal blubber thickness
- No relation between *Brucella*-serostatus and the presence of *corpus luteum* or *corpus albicans*, or the number of *corpus albicans*
- Isolation has never been achieved from a hooded seal > 18 months

Sampling from the declining Northeast Atlantic population



Are hooded seals the preferred hosts for *B. pinnipedialis* HS?

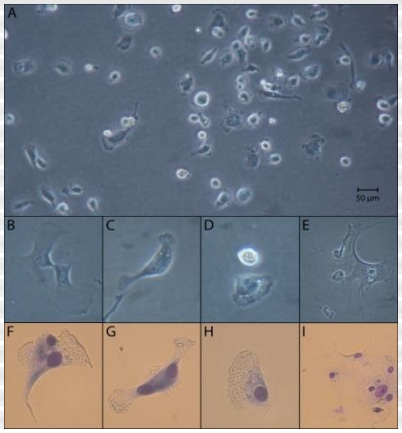


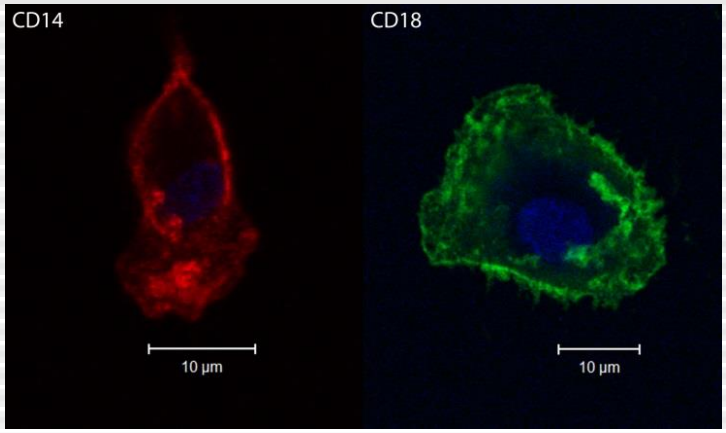
Alveolar macrophages, hooded seal

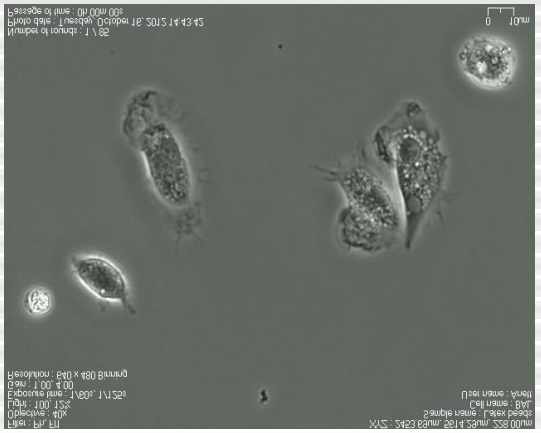
BAL performed on sacrificed hooded seals, 1 – 3 h post mortem

Alveolar macrophages identified by:

- Culture morphology
- Expression of membrane markers assessed by flow cytometry and immuncytochemistry
  - CD14
  - CD18
  - (MHC II, CD11c)
- Phagocytosis

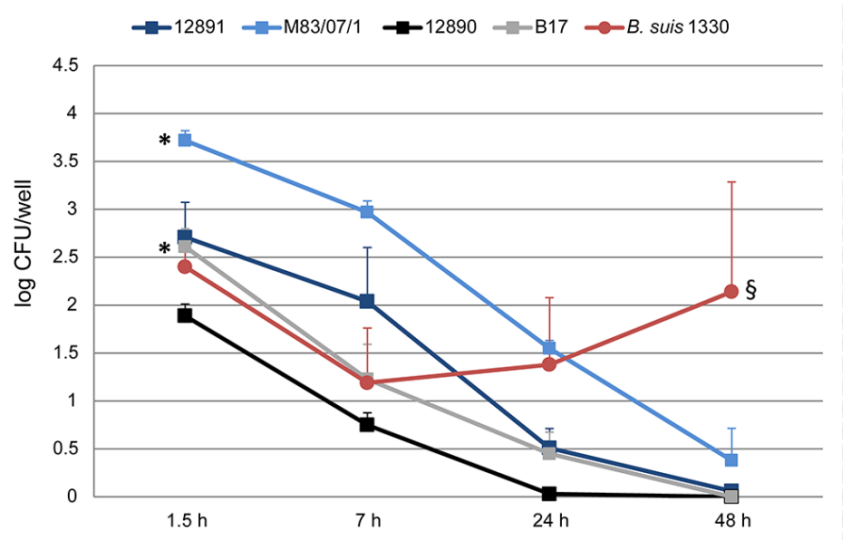


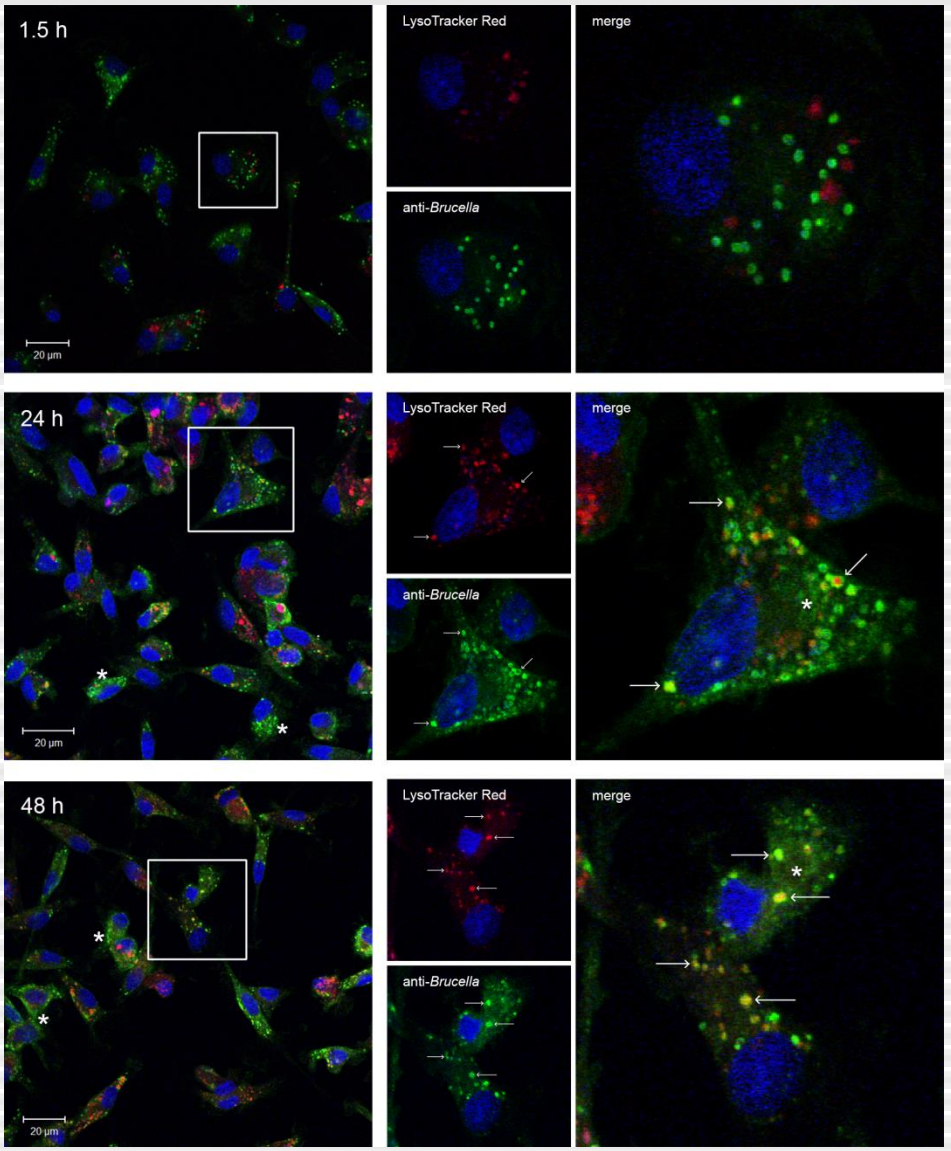




Alveolar macrophages, hooded seal

Alveolar macrophages





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PLOS ONE

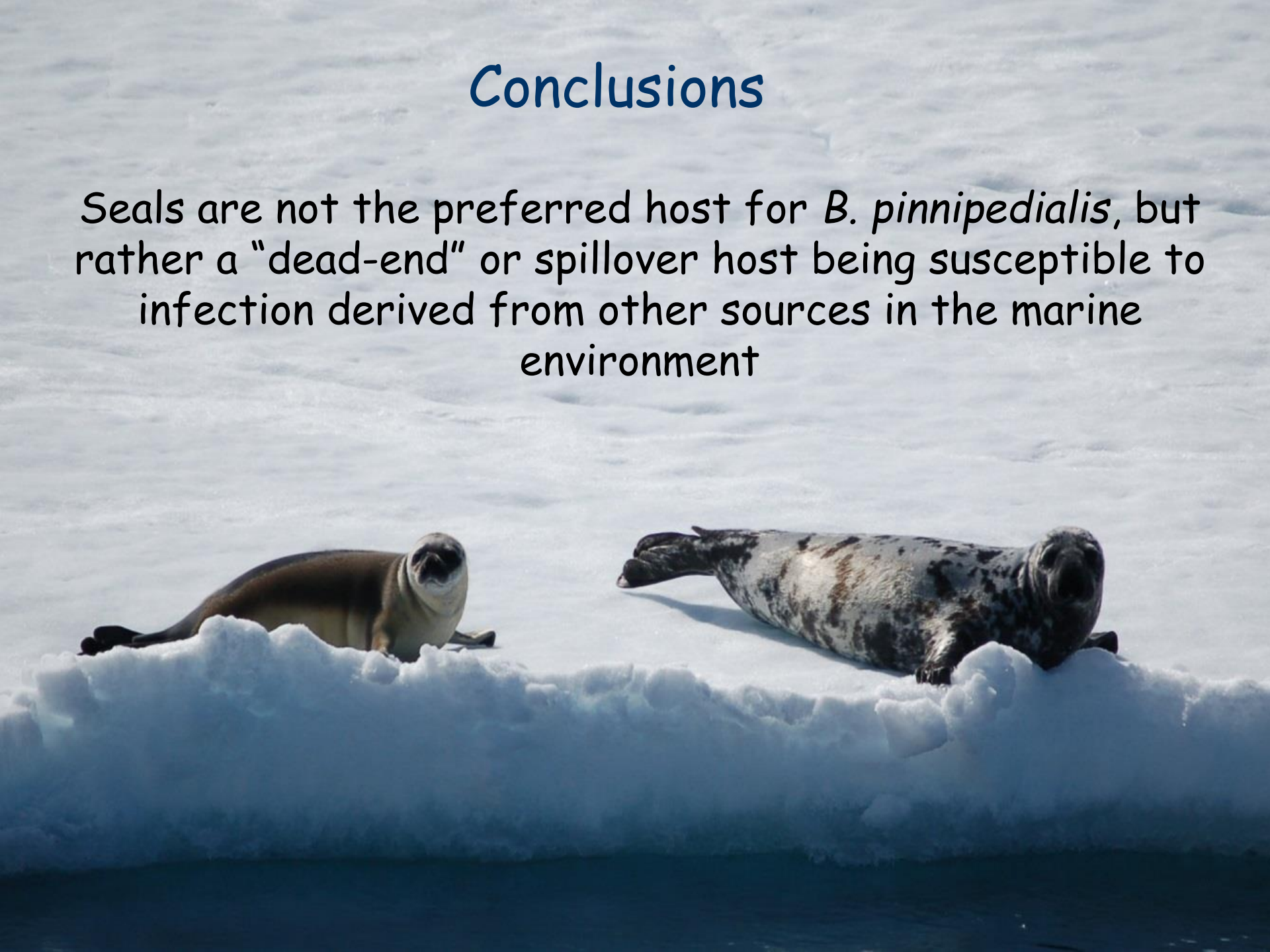
Entry and Elimination of Marine Mammal *Brucella* spp. by Hooded Seal (*Cystophora cristata*) Alveolar Macrophages *In Vitro*

Anett K. Larsen[1,2*], Ingebjørg H. Nymo[1,2], Preben Boysen[3], Morten Tryland[1,2], Jacques Godfroid[1,2]

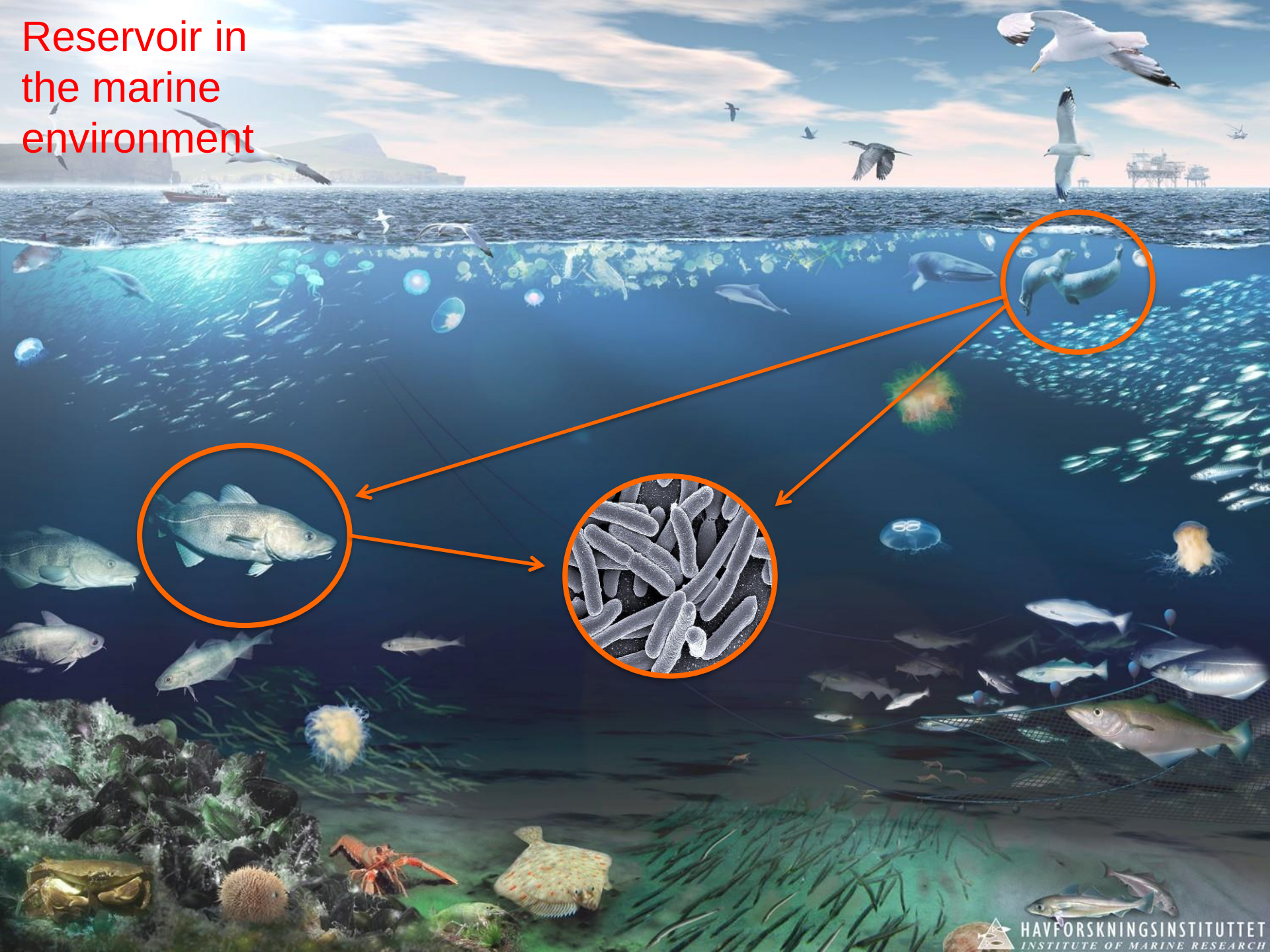
1 Section for Arctic Veterinary Medicine, Department of Food Safety and Infection Biology, Norwegian School of Veterinary Science, Tromsø, Norway, **2** Member of the Fram Centre, High North Research Centre for Climate and the Environment, Tromsø, Norway, **3** Section for Microbiology, Immunology, and Parasitology, Department of Food Safety and Infection Biology, Norwegian School of Veterinary Science, Oslo, Norway

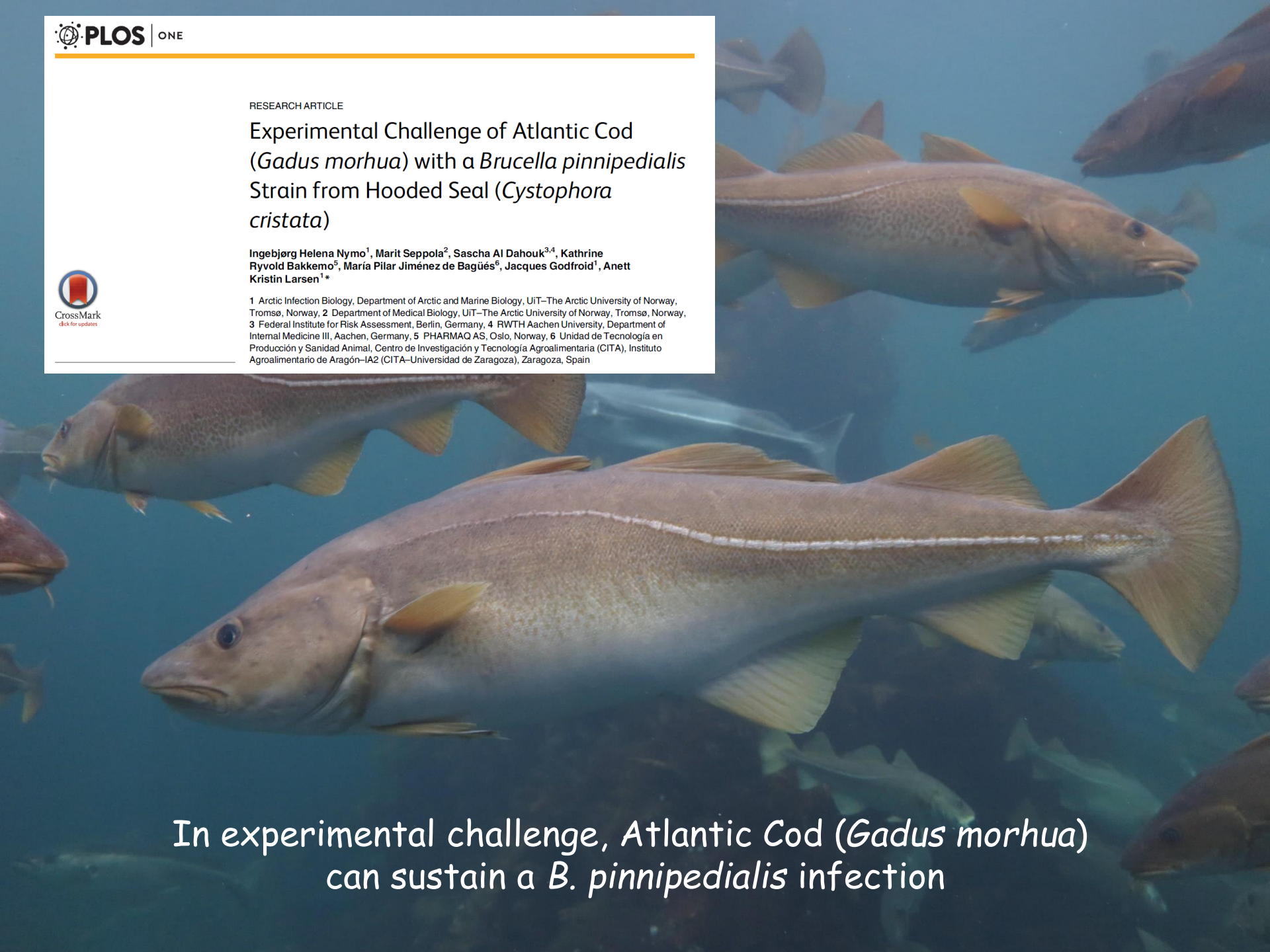
Conclusions

Seals are not the preferred host for *B. pinnipedialis*, but rather a "dead-end" or spillover host being susceptible to infection derived from other sources in the marine environment



Reservoir in the marine environment





PLOS ONE

RESEARCH ARTICLE

Experimental Challenge of Atlantic Cod (*Gadus morhua*) with a *Brucella pinnipedialis* Strain from Hooded Seal (*Cystophora cristata*)

Ingebjørg Helena Nymo[1], Marit Seppola[2], Sascha Al Dahouk[3,4], Kathrine Ryvold Bakkemo[5], María Pilar Jiménez de Bagüés[6], Jacques Godfroid[1], Anett Kristin Larsen[1]*

1 Arctic Infection Biology, Department of Arctic and Marine Biology, UiT–The Arctic University of Norway, Tromsø, Norway, **2** Department of Medical Biology, UiT–The Arctic University of Norway, Tromsø, Norway, **3** Federal Institute for Risk Assessment, Berlin, Germany, **4** RWTH Aachen University, Department of Internal Medicine III, Aachen, Germany, **5** PHARMAQ AS, Oslo, Norway, **6** Unidad de Tecnología en Producción y Sanidad Animal, Centro de Investigación y Tecnología Agroalimentaria (CITA), Instituto Agroalimentario de Aragón–IA2 (CITA–Universidad de Zaragoza), Zaragoza, Spain

CrossMark click for updates

In experimental challenge, Atlantic Cod (*Gadus morhua*) can sustain a *B. pinnipedialis* infection

Brucella infections in True and Eared Seals in North America

Hueffer *et al. Acta Veterinaria Scandinavica* 2013, **55**:2
http://www.actavetscand.com/content/55/1/2

AVS Acta Veterinaria Scandinavica ACTA VETERINARIA SCANDINAVICA

RESEARCH Open Access

Assay dependence of *Brucella* antibody prevalence in a declining Alaskan harbor seal (*Phoca vitulina*) population

Karsten Hueffer[1*], Scott M Gende[2] and Todd M O'Hara[1]

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DISEASES OF AQUATIC ORGANISMS
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Seroprevalence of *Brucella* antibodies in harbor seals in Alaska, USA, with age, regional, and reproductive comparisons

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Brucella placentitis and seroprevalence in northern fur seals (*Callorhinus ursinus*) of the Pribilof Islands, Alaska

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ST25

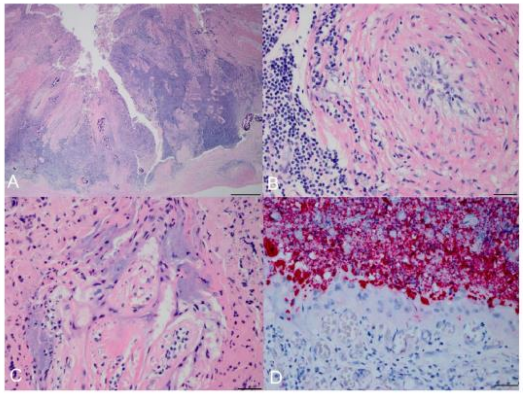

Figure 1.
Northern fur seal (*Callorhinus ursinus*) placenta with histologic lesions associated with *Brucella* infection. **A**, there is a regionally extensive area of inflammation and necrosis. Hematoxylin and eosin (HE). Bar = 500 μm. **B**, centrally within the affected region is a large artery with arteritis. HE. Bar = 20 μm. **C**, rare organisms are identified within the cytoplasm of trophoblasts at the periphery of the lesion. HE. Bar = 40 μm. **D**, *Brucella* immunostaining is present within the cytoplasm of trophoblasts as well as within the necrotic cellular debris. Immunohistochemical staining. Bar = 20 μm.

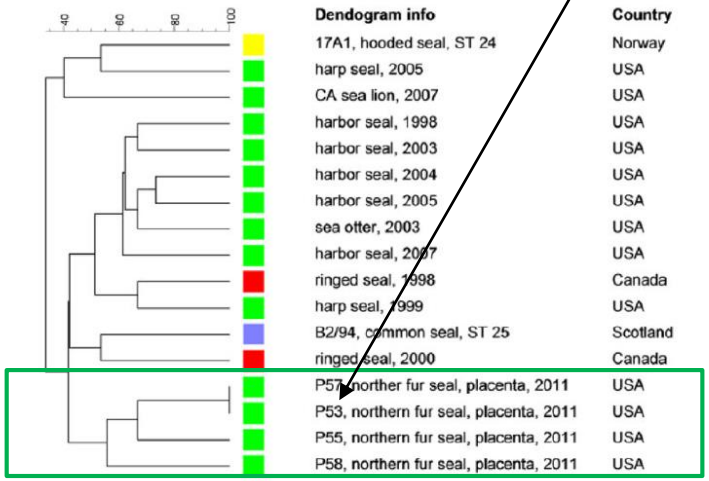

Figure 2.
Clustering analysis of multilocus variable number tandem repeat analysis profiles using the unweighted pair group method with arithmetic averages analysis obtained from northern fur seal (*Callorhinus ursinus*) placenta samples and other *Brucella pinnipedialis* isolates from the United States and Canada.

Journal of Wildlife Diseases, 37(1), 2001, pp. 89–100

SEROLOGIC SURVEY OF *BRUCELLA* SPP. ANTIBODIES IN SOME MARINE MAMMALS OF NORTH AMERICA

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Journal of Wildlife Diseases, 36(3), 2000, pp. 595–598

Brucellosis in Ringed Seals and Harp Seals from Canada

Lorry B. Forbes,[1,5] Ole Nielsen,[2] Lena Measures,[3] and Darla R. Ewalt[4] [1] Centre for Animal Parasitology, Canadian Food Inspection Agency, 116 Veterinary Road, Saskatoon, Saskatchewan, Canada S7N 2R3; [2] Fisheries and Oceans Canada, Central and Arctic Region, 501 University Crescent, Winnipeg, Manitoba, Canada R3T 2N6; [3] Fisheries and Oceans Canada, Maurice Lamontagne Institute, 850 Route de la Mer, Mont-Joli, Quebec, Canada G5H 3Z4; [4] United States Department of Agriculture, Animal and Plant Health Inspection Service, National Veterinary Services Laboratories, 1800 Dayton Road, Ames, Iowa 50010, USA; [5] Corresponding author (e-mail: lforbes@em.agr.ca).

TABLE 3. Prevalence of *Brucella* spp. binding antibodies in fourteen species of North American marine mammals.

Species	Number tested	O-chain	M84	Number positive
Halichoerus grypus	255	1 (0.3)[a]	10 (3.9)	10 (3.9)
Phoca vitulina	163	9 (5.5)	21 (12.9)	21 (12.9)
Cystophora cristata	204	5 (2.4)	9 (4.4)	10 (4.9)
Phoca groenlandica	453	6 (1.3)	7 (1.5)	8 (1.8)
Phoca hispida	628	1 (0.2)	7 (1.1)	7 (1.1)
Odobenus rosmarus	170	5 (2.9)	3 (1.8)	5 (2.9)
Delphinapterus leucas	488	25 (5.1)	26 (5.3)	28 (5.7)
Monodon monoceros	77	5 (6.5)	5 (6.5)	5 (6.5)
Balaena mysticetus	3	0	0	0
Phocoena phocoena	3	0	0	0
Globicephala melas	19	0	0	0
Balaenoptera acutorostrata	1	0	0	0
Lagenorhynchus acutus	4	0	0	0
Hyperdoon ampullatus	2	0	0	0
Total	2,470	57 (2.3)	88 (3.6)	94 (3.8)

[a] Number positive (percent positive).

RESEARCH ARTICLE

Characterisation of North American *Brucella* isolates from marine mammals

Adrian M. Whatmore[1]*, Claire Dawson[1], Jakub Muchowski[1], Lorraine L. Perrett[1], Emma Stubberfield[1], Mark Koylass[1], Geoffrey Foster[2], Nicholas J. Davison[2], Christine Quance[3], Inga F. Sidor[4¤a], Cara L. Field[4¤b], Judy St. Leger[5]

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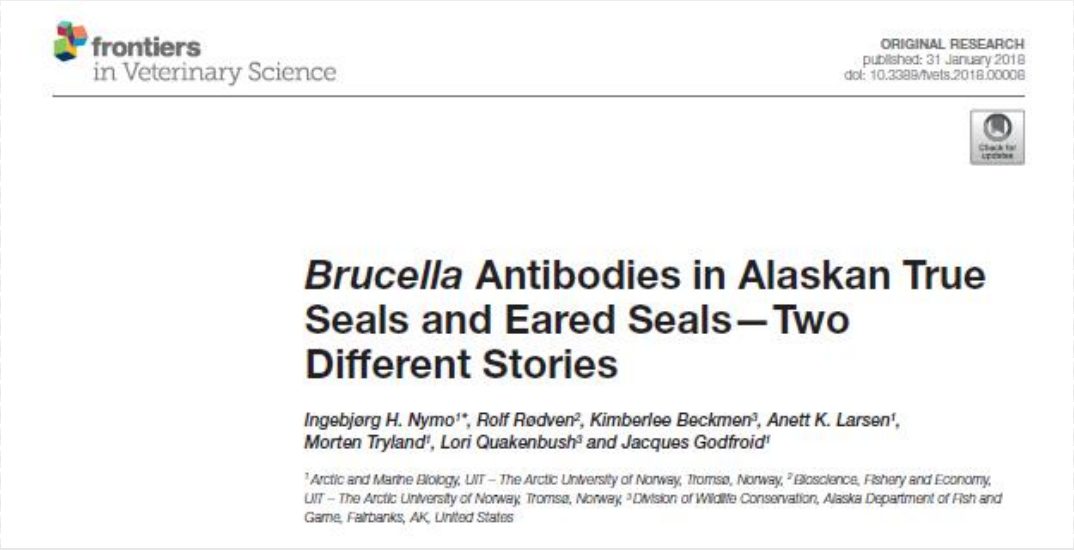
PLoS ONE 2017.12(9): e0184758. https://doi.org/10.1371/journal.pone.0184758

- The majority of isolates represent genotypes previously described in Europe although novel genotypes were identified in both *B. ceti* clades.
- Harp seals were found to carry *B. pinnipedialis* genotypes previously confined to hooded seals.
- Isolates were characterized from beluga whales and found to represent a number of distinct *B. pinnipedialis* genotypes.
- The known host range of ST27 was extended with the identification of this ST from California sea lion samples.



frontiers in Veterinary Science

ORIGINAL RESEARCH
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Brucella Antibodies in Alaskan True Seals and Eared Seals—Two Different Stories

Ingebjørg H. Nymo[1], Rolf Rødven[2], Kimberlee Beckmen[3], Anett K. Larsen[1], Morten Tryland[1], Lori Quakenbush[3] and Jacques Godfroid[1]*

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- In eared seals, *Brucella* antibodies were found in two Steller sea lions (*Eumetopias jubatus*) (2%) and none of the 107 Northern fur seals (*Callorhinus ursinus*).
  - The low seroprevalence in eared seals indicate a low level of exposure or lack of susceptibility to infection. Alternatively, mortality due to the *Brucella* infection may remove seropositive animals from the population.

- *Brucella* antibodies were detected in all true seal species investigated; harbor seals (*Phoca vitulina*) (25%), spotted seals (*Phoca largha*) (19%), ribbon seals (*Histriophoca fasciata*) (16%), and ringed seals (*Pusa hispida hispida*) (14%).
- There was a low seroprevalence among pups, a higher seroprevalence among juveniles, and a subsequent decreasing probability of seropositivity with age in harbor seals.

Transmission of *Brucella* spp. to polar bears

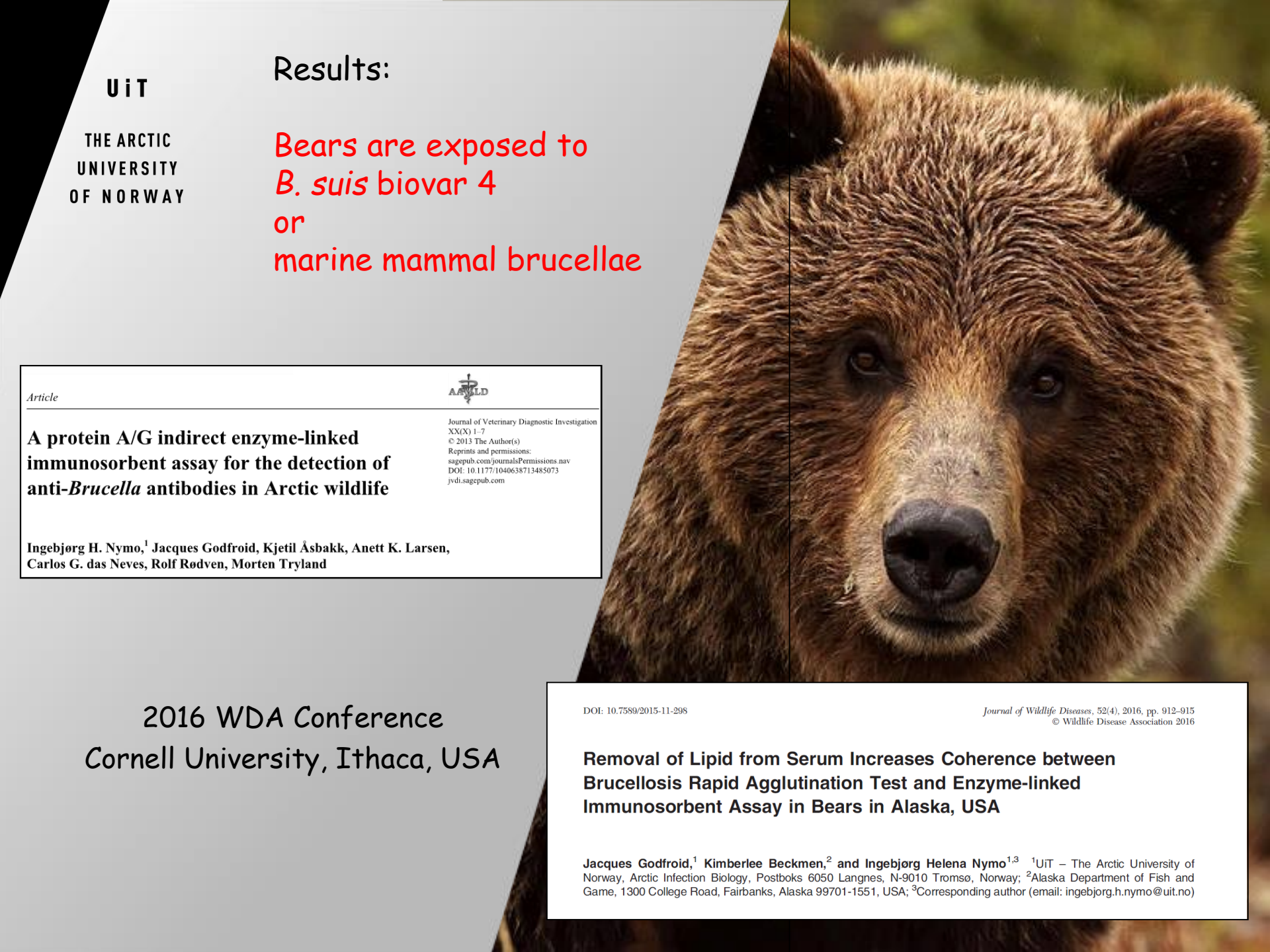
Tryland M., Derocher A. E., Wijg O., Godfroid J., 2001. *Brucella* antibodies in polar bears (*Ursus maritimus*) from Svalbard and the Barents sea. Journal of Wildlife Disease, 37: 523-531.

UiT

THE ARCTIC UNIVERSITY OF NORWAY

Results:

Bears are exposed to
B. suis biovar 4
or
marine mammal brucellae



Article

A protein A/G indirect enzyme-linked immunosorbent assay for the detection of anti-*Brucella* antibodies in Arctic wildlife

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XX(X) 1–7

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Ingebjørg H. Nymo,[1] Jacques Godfroid, Kjetil Åsbakk, Anett K. Larsen, Carlos G. das Neves, Rolf Rødven, Morten Tryland

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DOI: 10.7589/2015-11-298

Journal of Wildlife Diseases, 52(4), 2016, pp. 912–915

Removal of Lipid from Serum Increases Coherence between Brucellosis Rapid Agglutination Test and Enzyme-linked Immunosorbent Assay in Bears in Alaska, USA

Jacques Godfroid,[1] Kimberlee Beckmen,[2] and Ingebjørg Helena Nymo[1,3] [1]UiT – The Arctic University of Norway, Arctic Infection Biology, Postboks 6050 Langnes, N-9010 Tromsø, Norway; [2]Alaska Department of Fish and Game, 1300 College Road, Fairbanks, Alaska 99701-1551, USA; [3]Corresponding author (email: ingebjorg.h.nymo@uit.no)

« Nothing is
permanent,
but change… »

Thank you for your
attention