LIFE AND DEATH OF BELUGA WHALES, St Lawrence River, Canada

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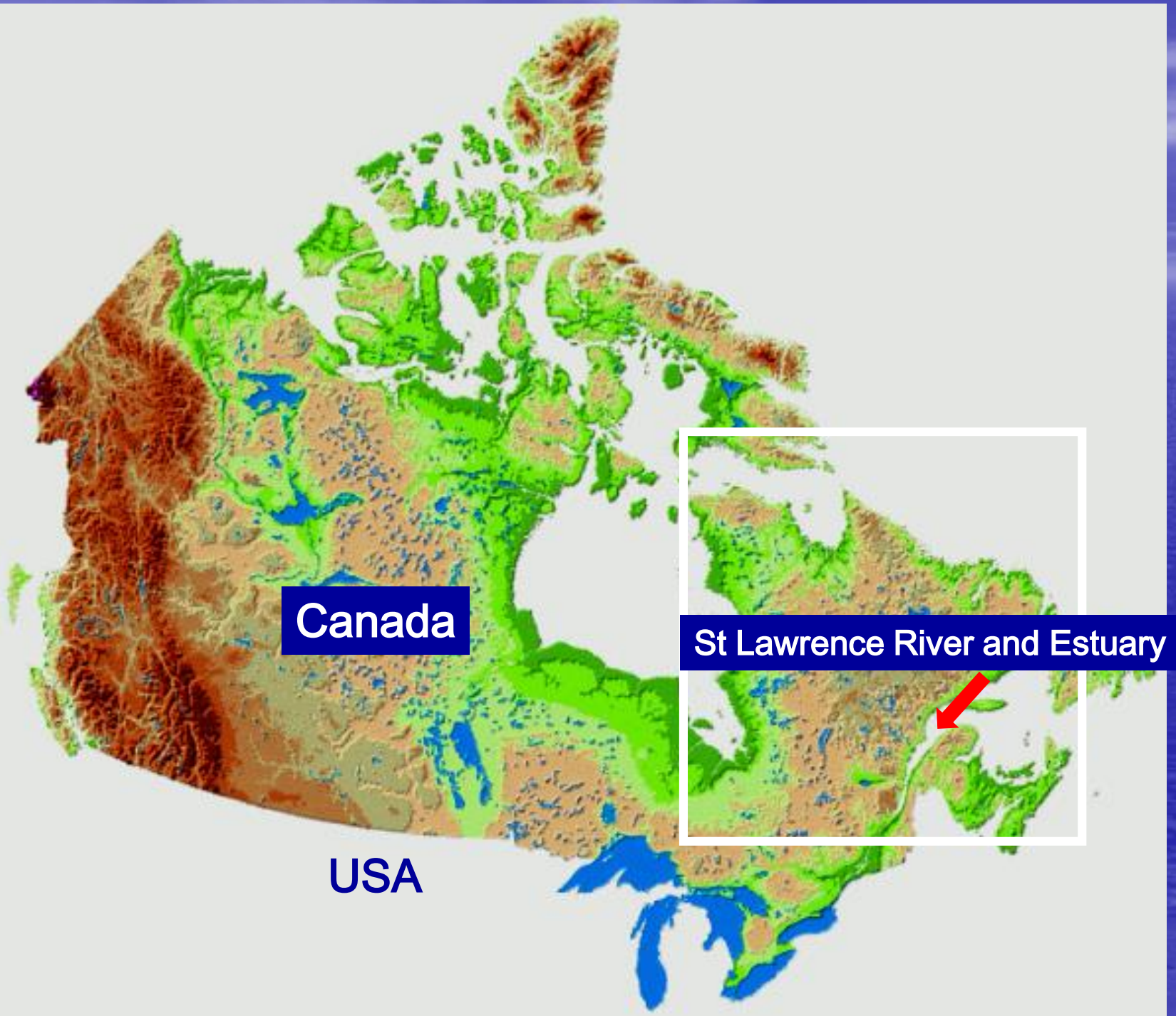
One Health One Planet™

2018 One Health One Planet Symposium
Health Impacts: Chemicals of Concern in the Environment


Canada
St Lawrence River and Estuary
USA

July 1978

WHY STUDYING DISEASES OF BELUGA WHALES ?

Who takes care of wildlife ?

…a veterinarian's point of view…

Who pays for it?

Why conserve it ?

Who treats it?

- 5448 species of mammals
- 37 species of felids
- all are threatened

except….

Who would study it ? Why ?

Who studies it ?

« *We share the same biology*

regardless of ideology»

- «*Russians* » Sting

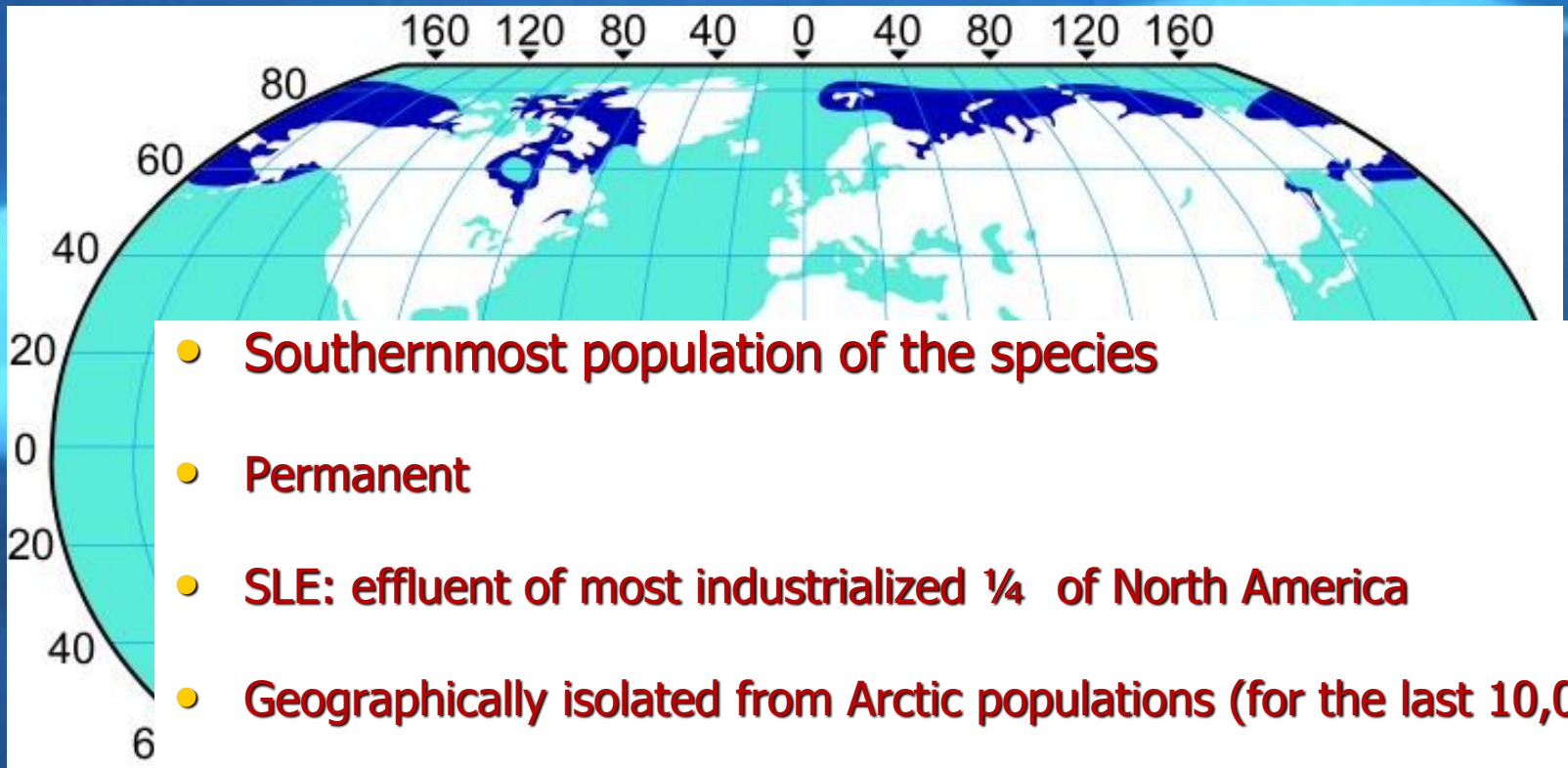
The beluga whale population living in the Saint Lawrence Estuary:
An autopsy program, from 1982 to now

Conclusion: contaminants equally affect beluga and people living nearby

One Medicine, One Health, One Planet

… before its time

Beluga from the St Lawrence River, Canada



- Southernmost population of the species
- Permanent
- SLE: effluent of most industrialized ¼ of North America
- Geographically isolated from Arctic populations (for the last 10,000 y)
- Accessible to research (relatively)
- Size:
  - 527 beluga, using a x 1.15 correction factor (2000)
  - 952 beluga, using a x 2.09 correction factor (2001)
  - *(851: maximum number ever counted directly (2007))*
  - 889: mathematical model (2012)

Like people !

BELUGA

(*Delphinapterus leucas*)

Accumulation of distantly produced stable lipophilic (« fat loving ») contaminants

- **Long lifespan: 75-80 y**
- **Lipids: 40-50 % of body weight**
- **Top predators: feed on fish**

Transfer of stable lipophilic contaminants (ex.: PCB) from mother to newborn

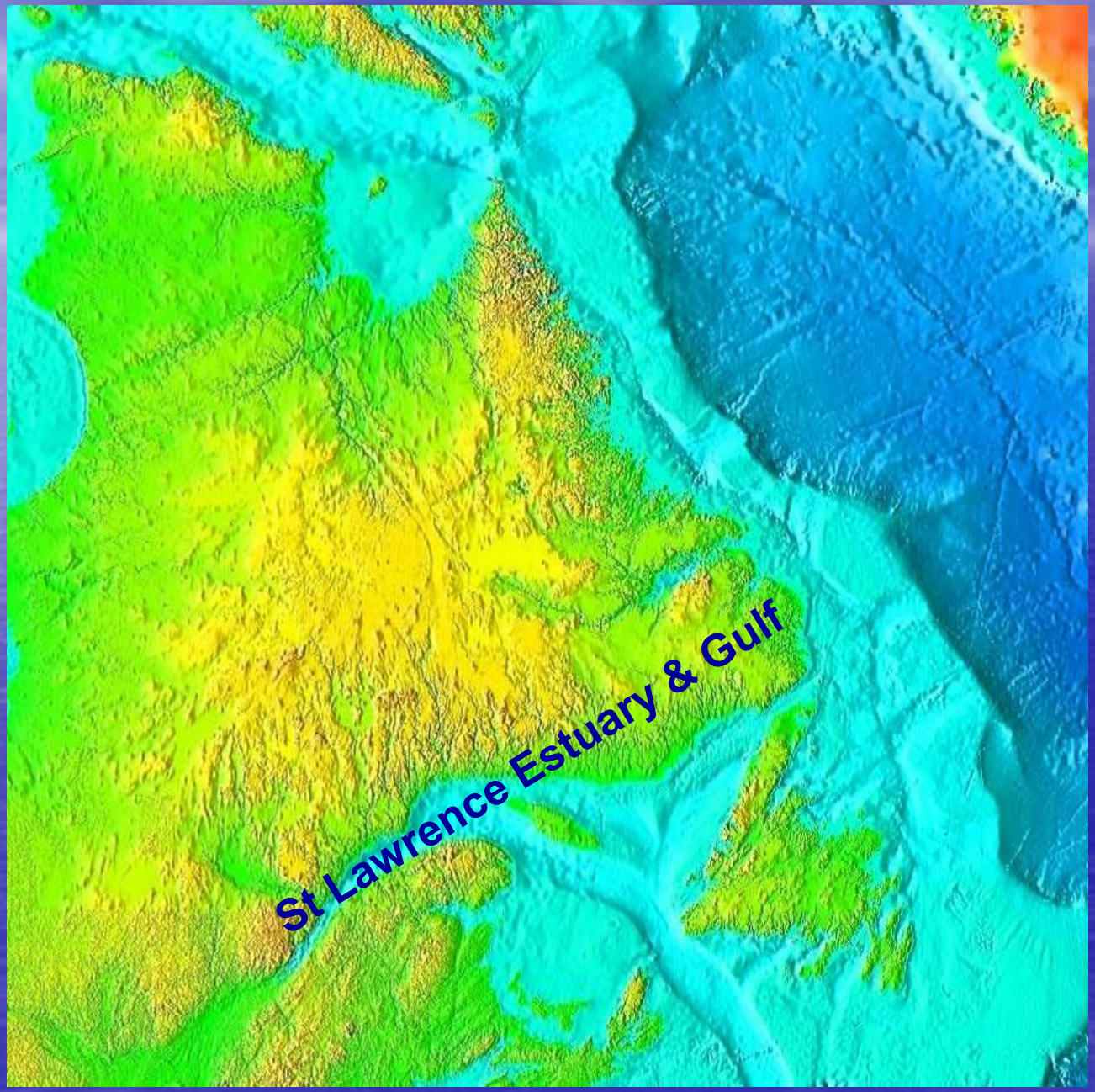
- **Mammal: milk (40 % lipid)**

Ingestion of less stable, locally produced contaminants (ex.: PAHs) accumulated in worms

Deep diver (> 1 km)

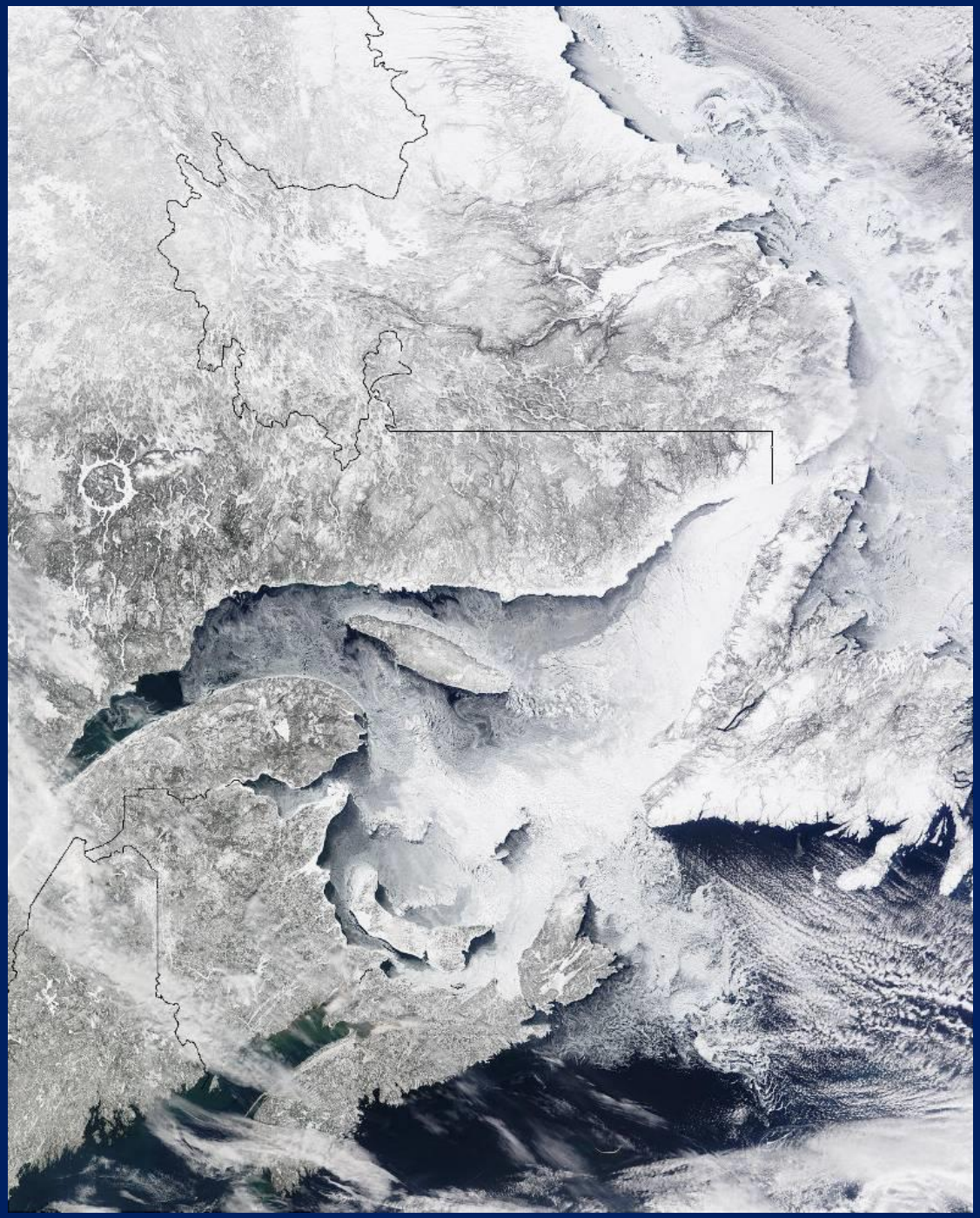
«mud grazer »: feed on worms

- Martineau et al 1987, Arch Environ Contam



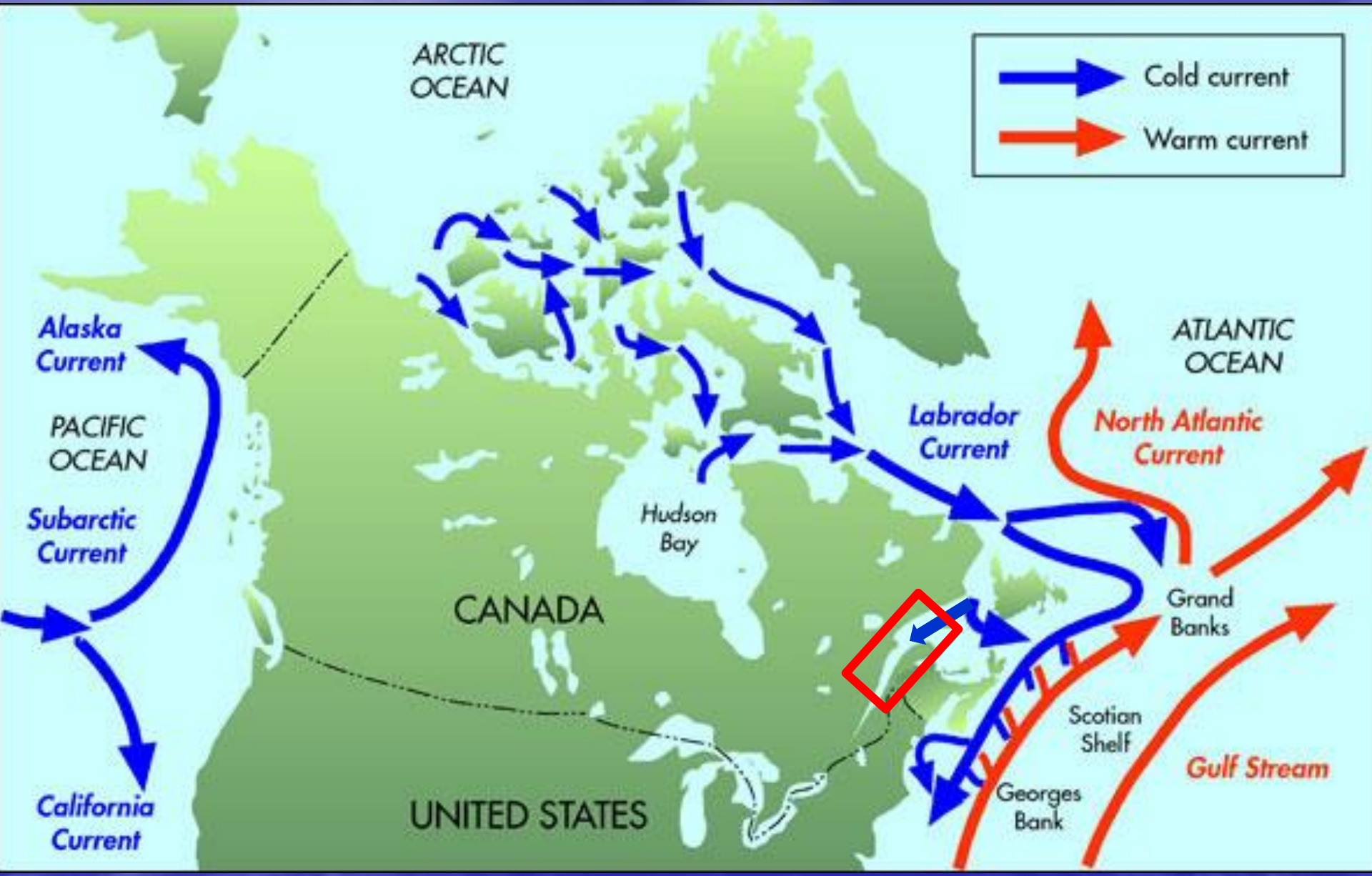
NOAA

Winter



WHY ARE THERE BELUGA IN THE ST LAWRENCE ESTUARY ?

Part 1



http://www.qc.ec.gc.ca/csl/inf/inf069_e.html

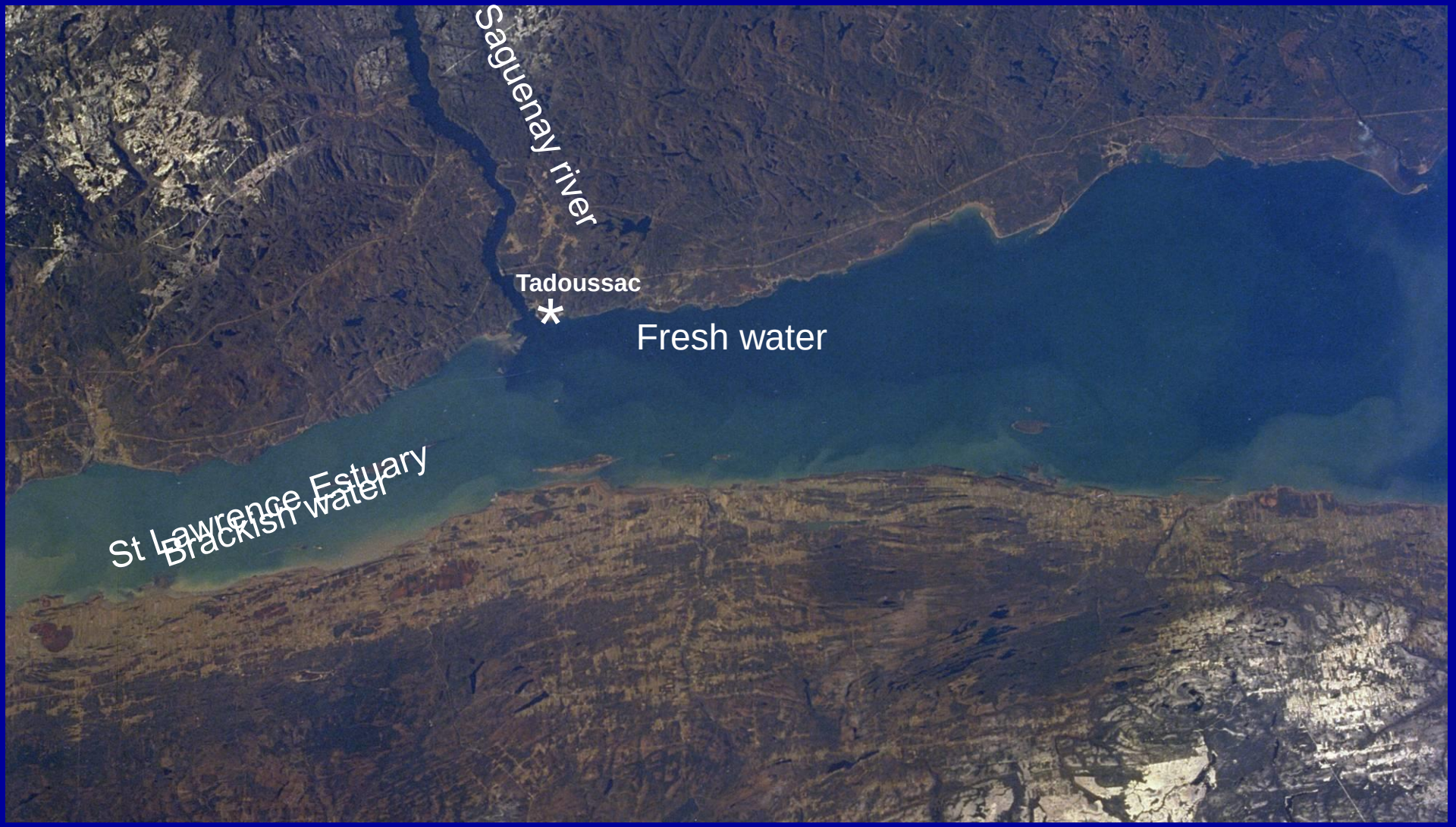
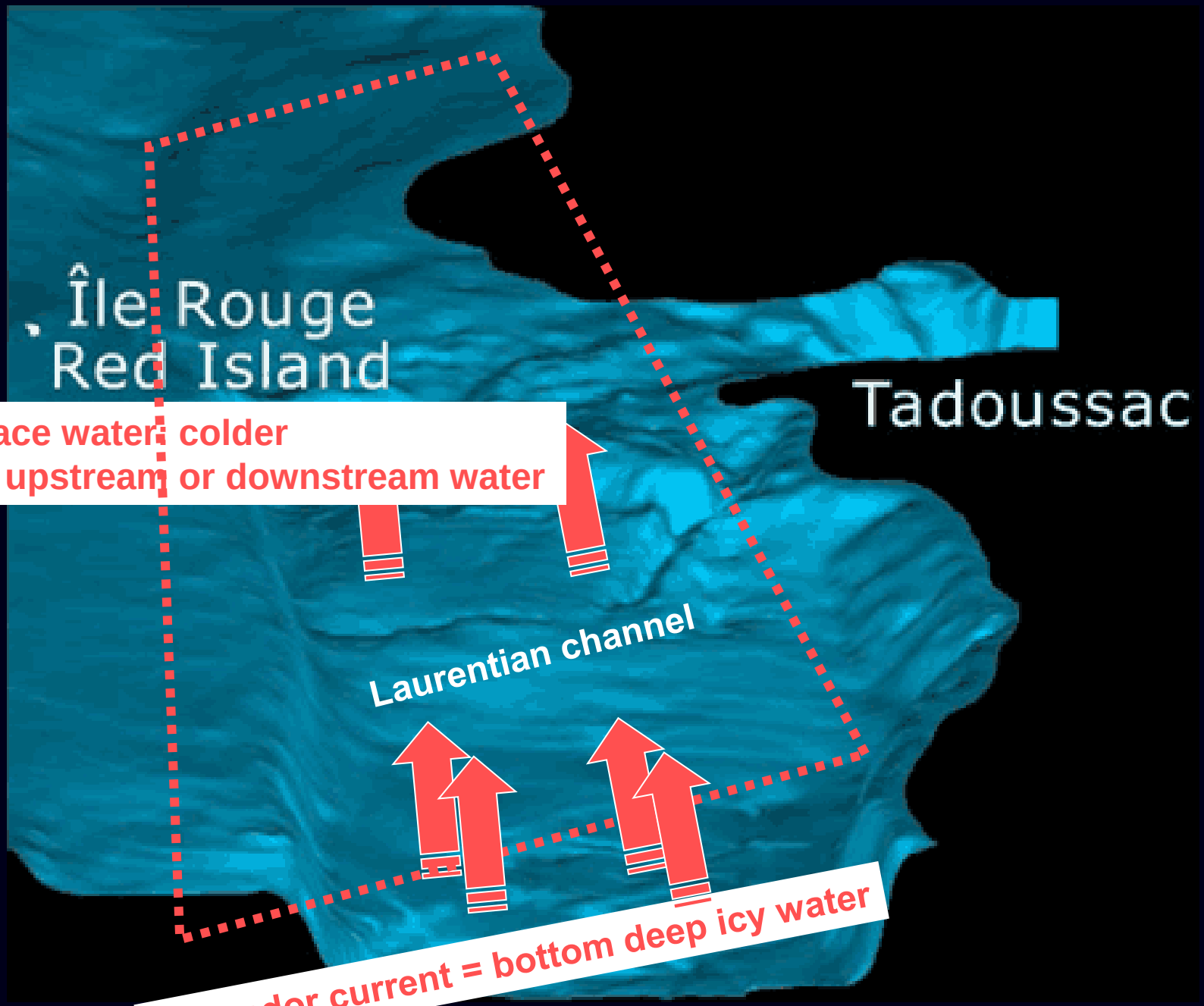

Saguenay river
Tadoussac
Fresh water
St Lawrence Estuary
Brackish water

Photo NASA

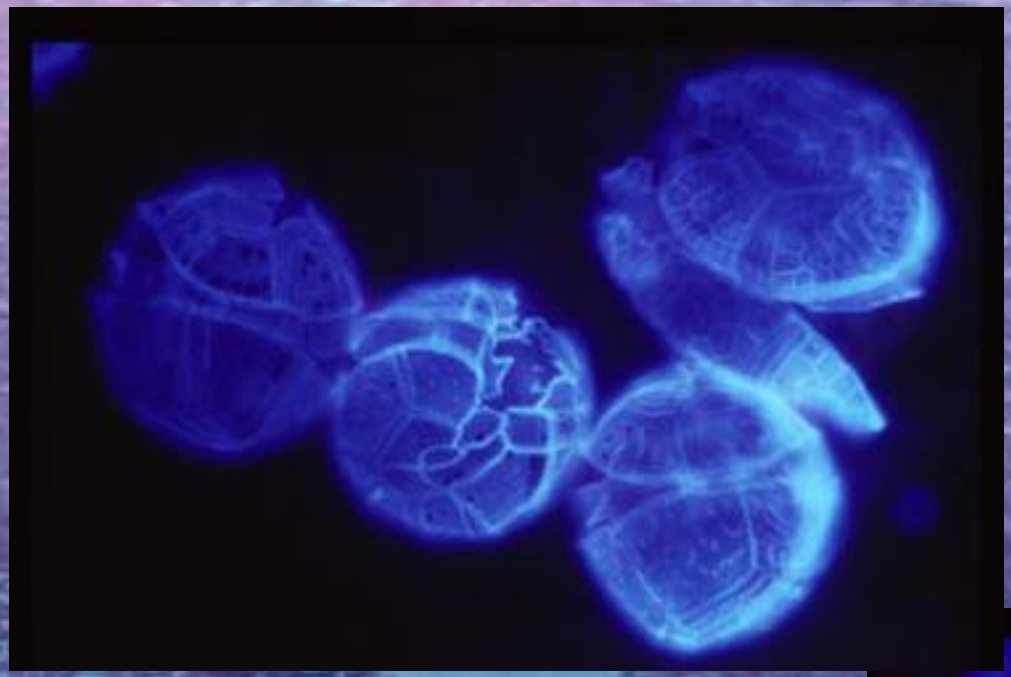
Photo NASA

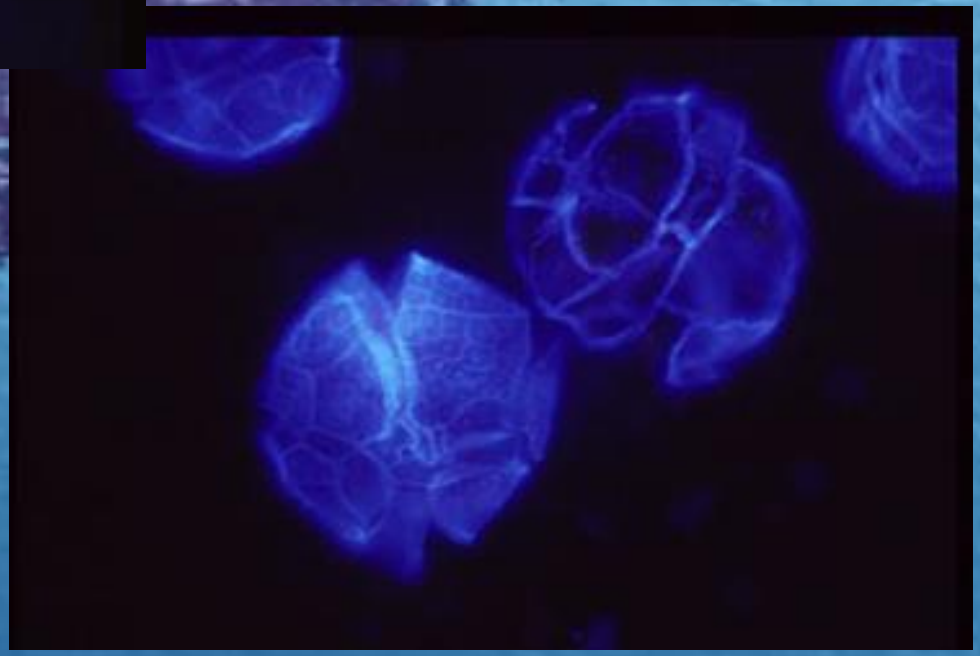

Île Rouge
Red Island
Tadoussac
Surface water: colder
than upstream or downstream water
Laurentian channel
Labrador current = bottom deep icy water

ST LAWRENCE ESTUARY AND BALTIC SEA. A COMPARISON.

	St Lawrence Estuary	Baltic Sea
Biological diversity	**Low (100 fish species)**	
Cod	**Endangered**	
Marine mammal populations. Contamination, lesions	**Severe**	
Invasions by foreign animal species (mostly ponto-caspian)	+	
Red tides	+	
Eutrophication	+	
Hypoxia	+	

RED TIDES

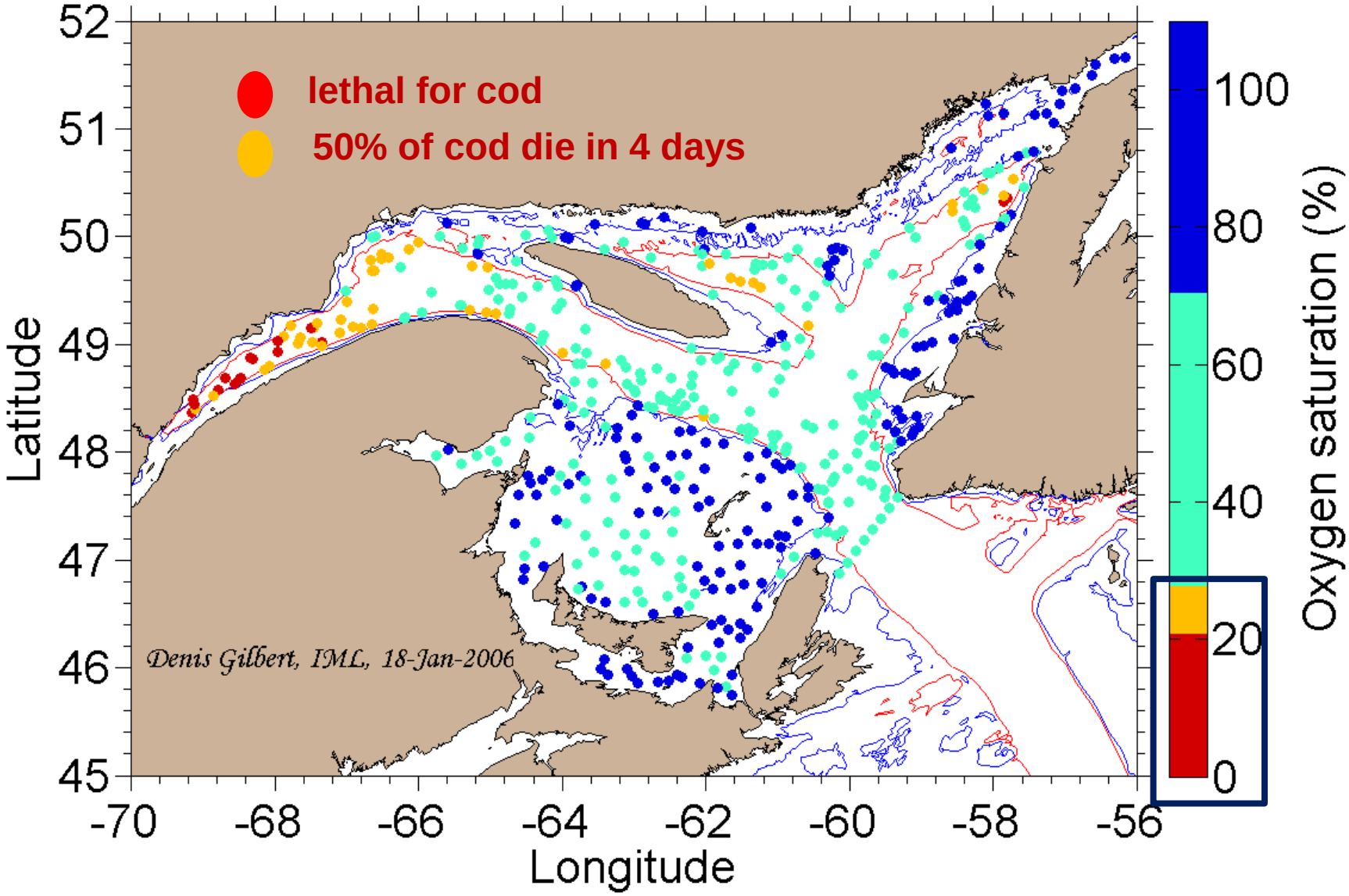




Dinoflagellate:
Alexandrium tamarense: saxitoxin

HYPOXIA

2003: 1300 km^2 of deep waters found hypoxic



WHY ARE THERE BELUGA IN THE ST LAWRENCE ESTUARY ?

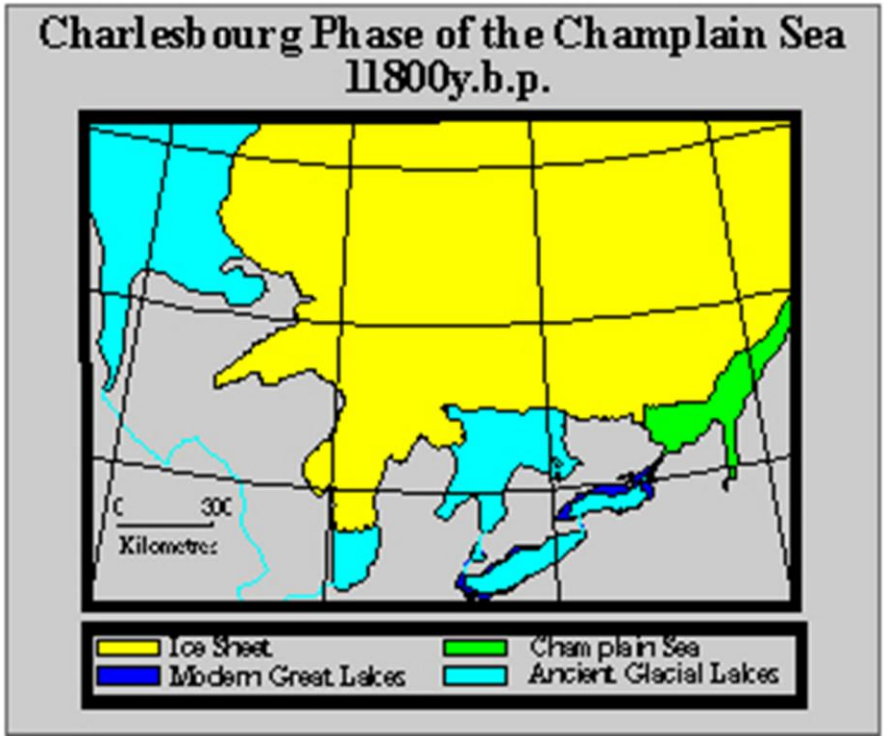
Part 2

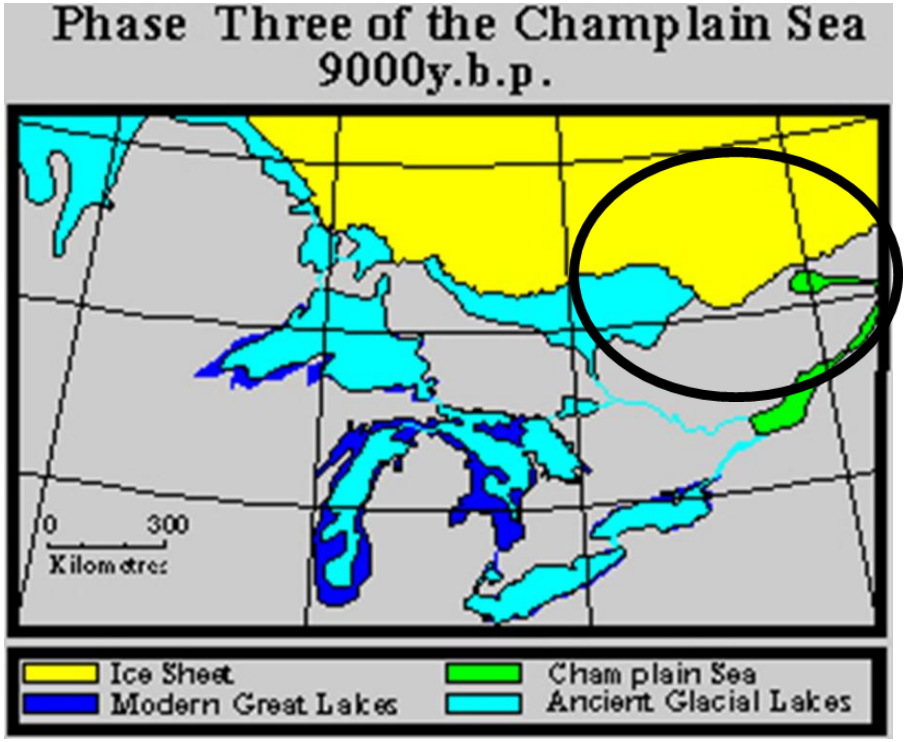
North America

Last glaciation (8,000 to 12,000 years)

http://eas.unl.edu/~tfrank/History%20on%20the%20Rocks/Nebraska%20Geology/Cenozoic/cenozoic%20web/2/Timescale.html

Last ice age: 18,000 ans ago





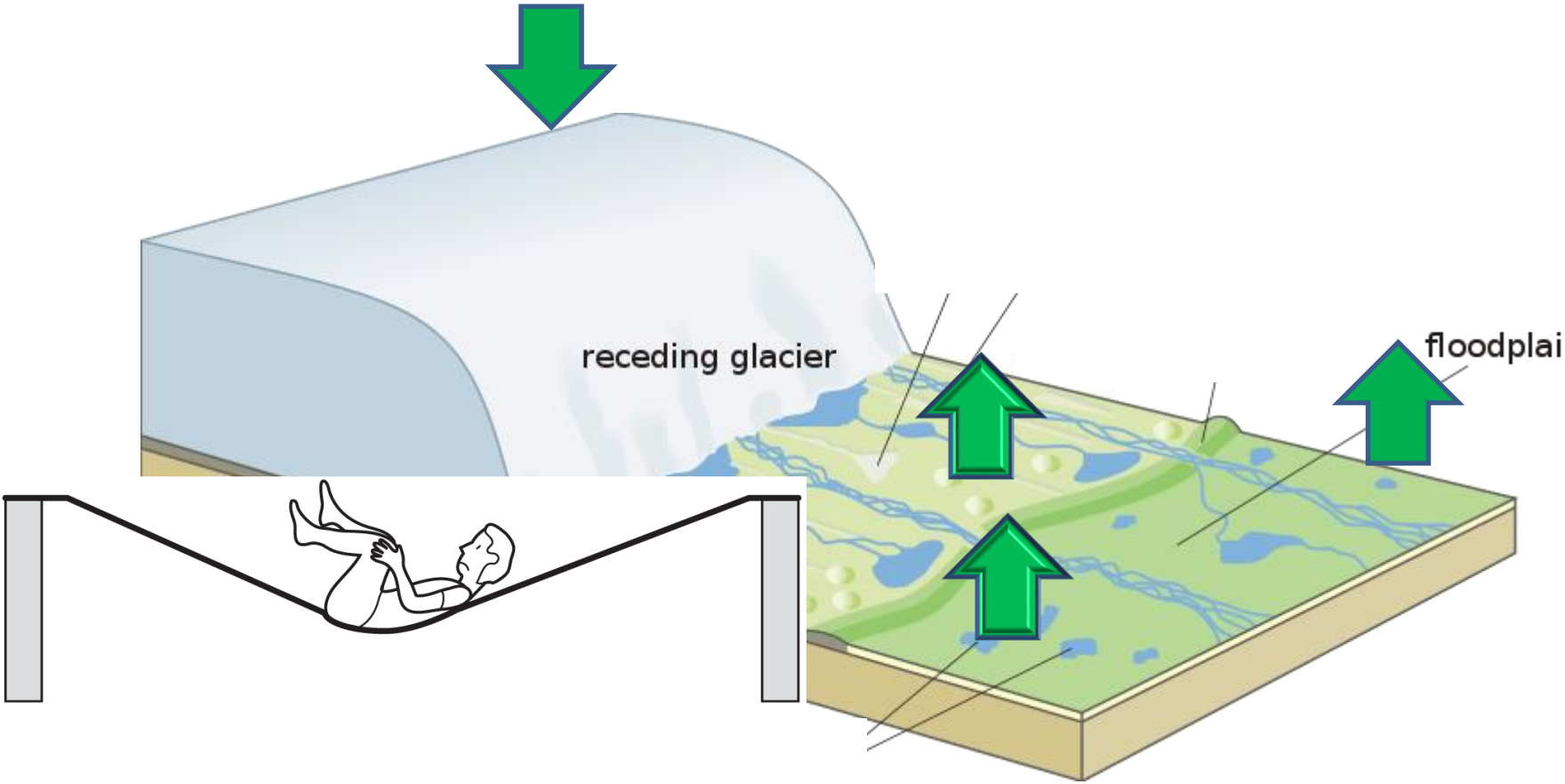
All « déjà vu » again:

GLOBAL WARMING

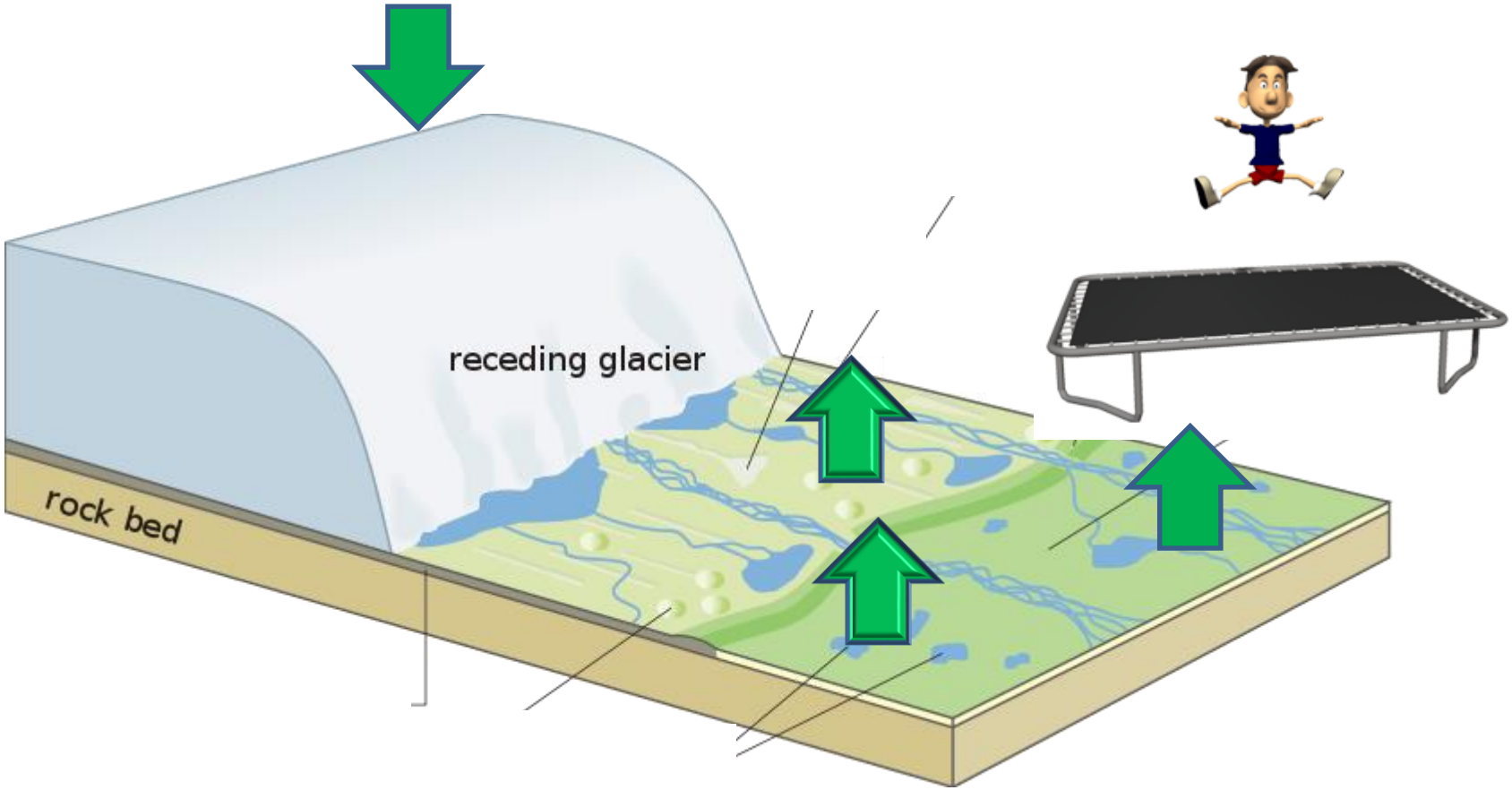
- Ice melts -> oceans fill up

- Sea of Champlain empties

SEA OF CHAMPLAIN: 13,000 to about 10,000 years ago


receding glacier
floodplai

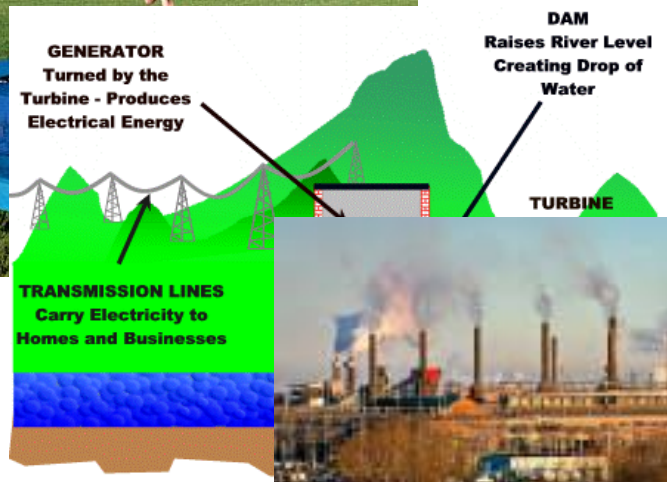
NOWADAYS, LOTS OF LAKES AND RIVERS ABOVE SEA LEVEL



- Glaciers formation -> earth crust caves in

- Glaciers melt -> earth crust rebounces

Water higher than sea level

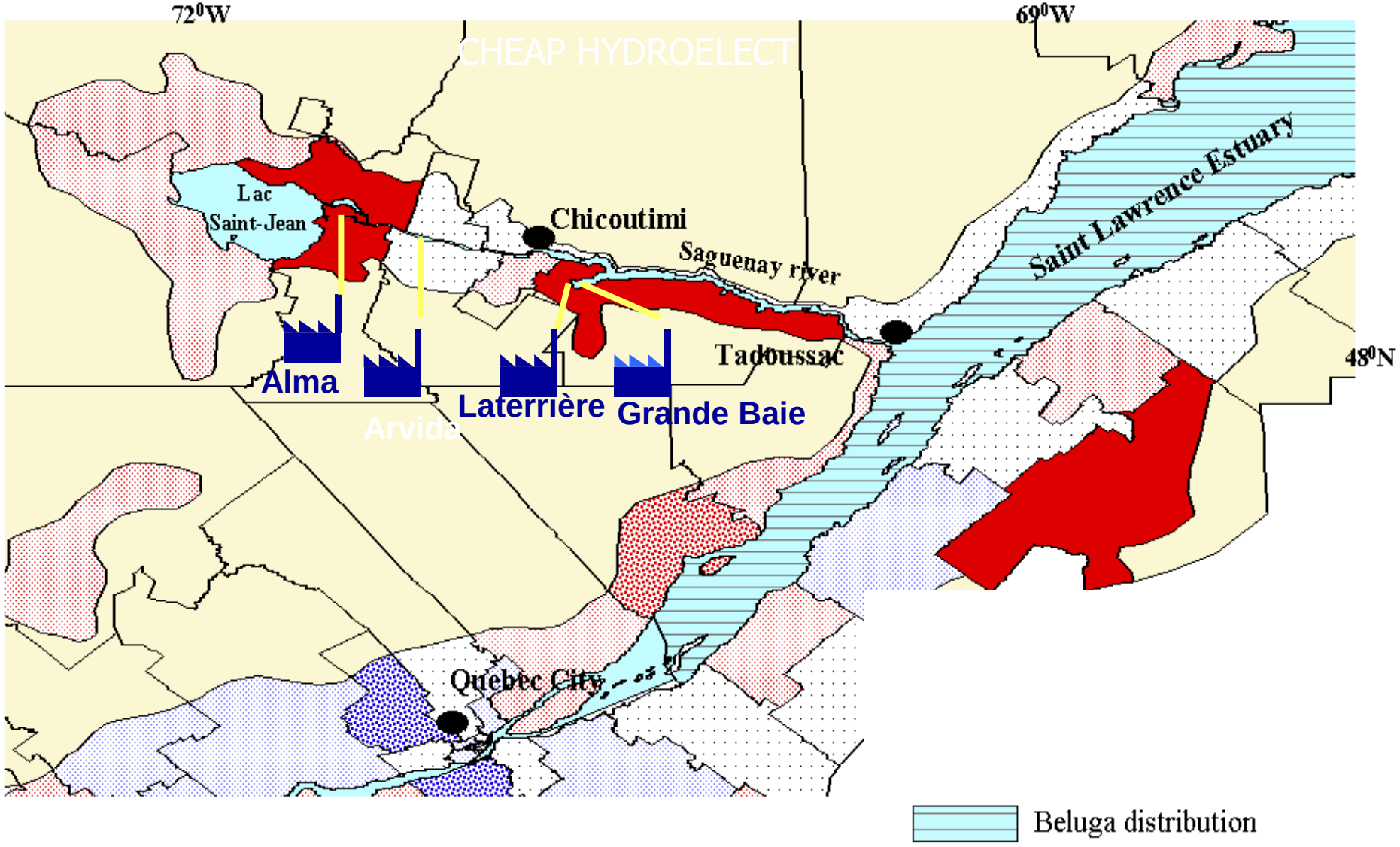


(cheap) HYDROELECTRICITY !!!

METALLURGY , SMELTERS

Aluminum = « frozen electricity »

Release of PAHs into environment



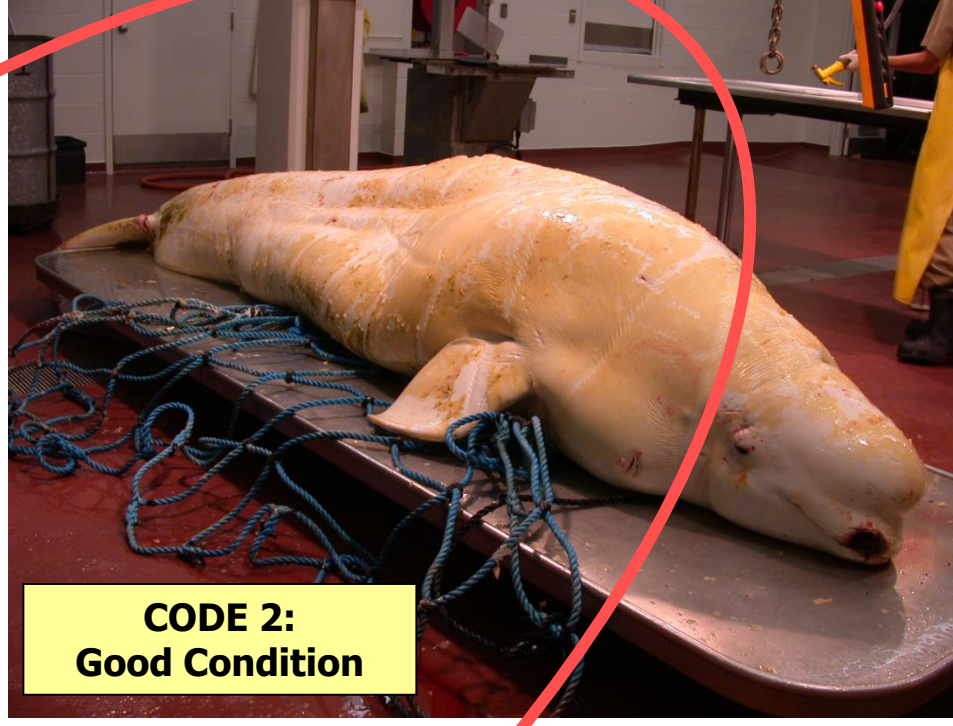
CHEAP HYDROLELECTRICITY -> METALLURGY

(recently read in the financial news: « aluminum is frozen electricity ») (March 5th, 2018)

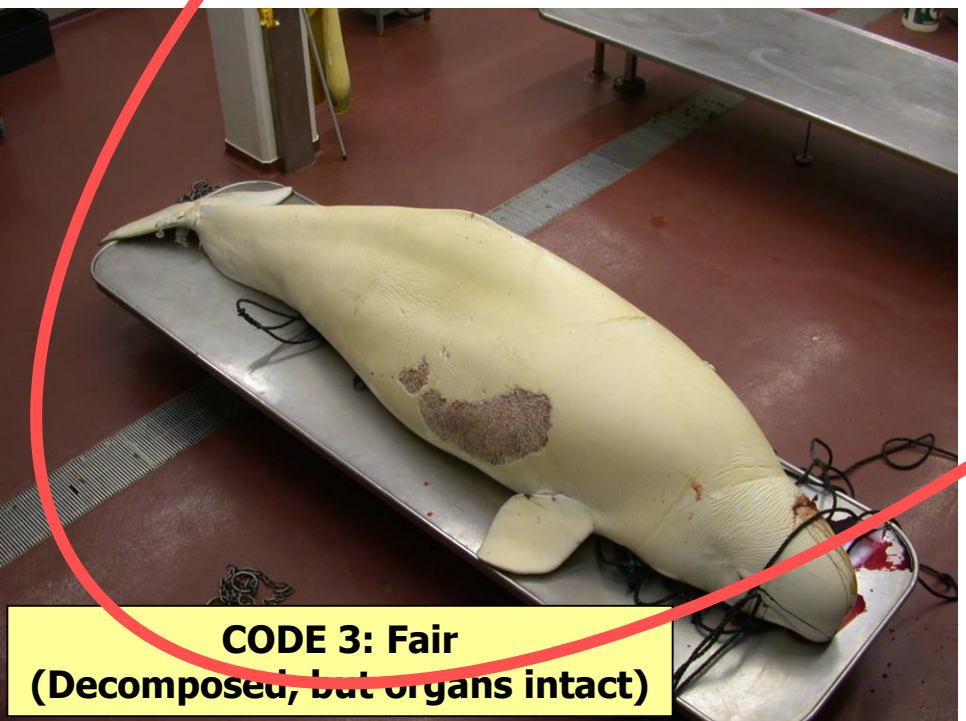
POST MORTEM EXAMINATIONS OF BELUGA WHALES STRANDED (DEAD) ALONG THE SAINT LAWRENCE ESTUARY SHORELINE

1983- 2012

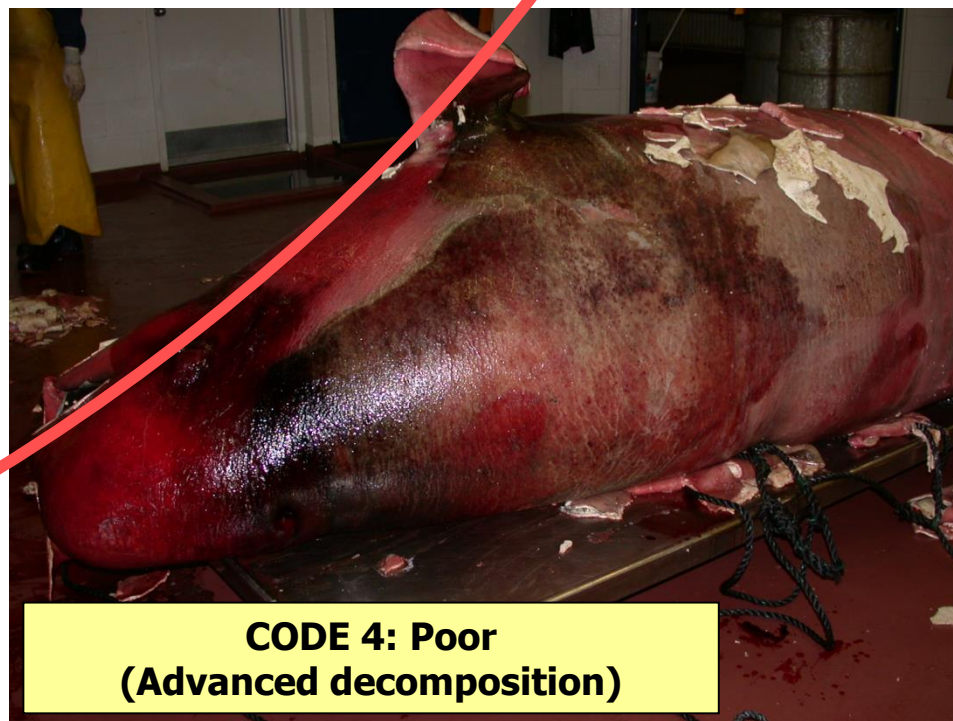
CODE 1:
Stranded alive!



CODE 2:
Good Condition



CODE 3: Fair
(Decomposed, but organs intact)



CODE 4: Poor
(Advanced decomposition)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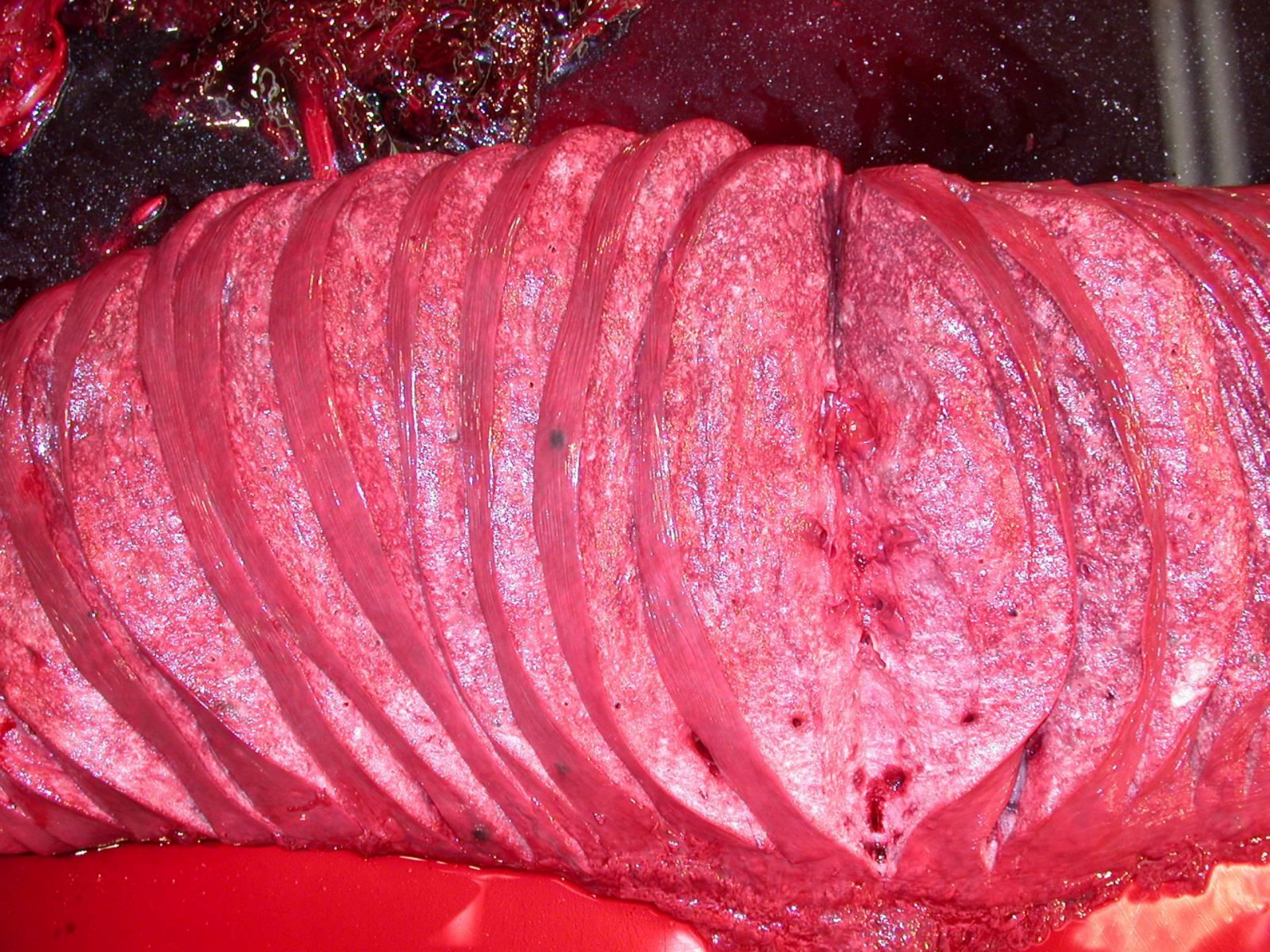
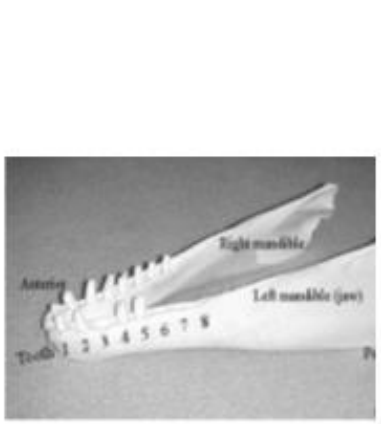


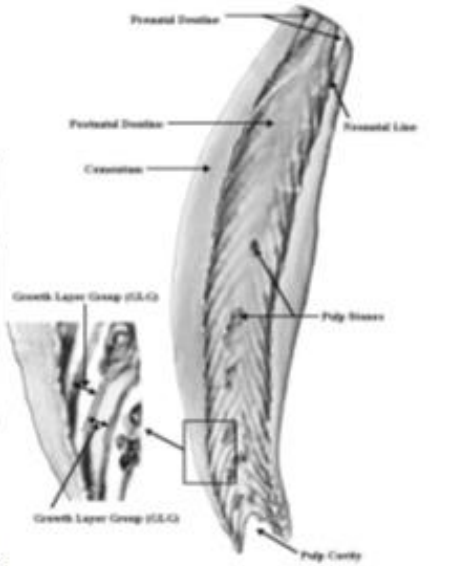

Mammary glands

Post mortem exams
SLE belugas,
1983-2012

- 472 reported carcasses (median: 15/year):
-222 (or 47 %) examined
- 2 intersexes

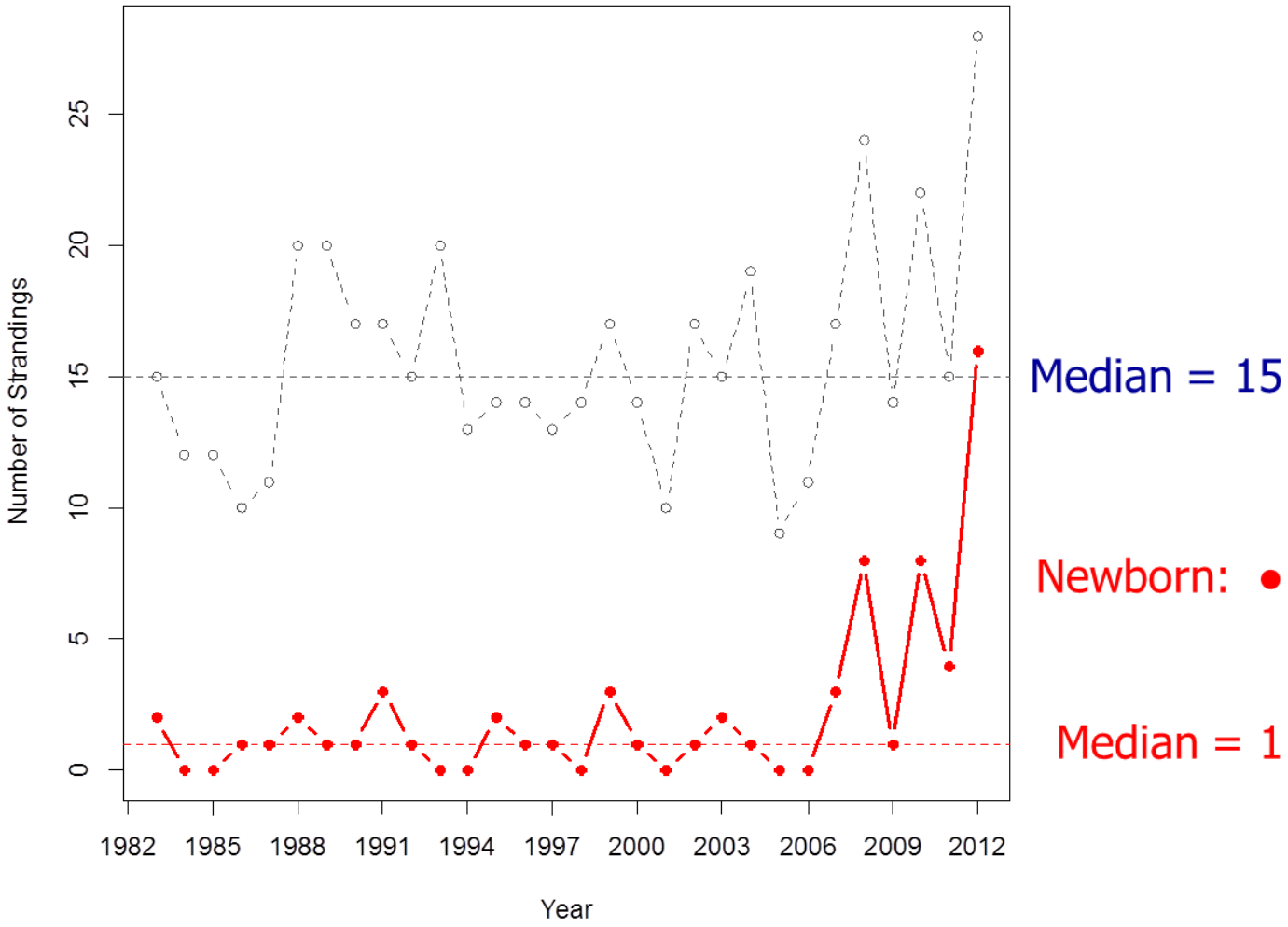
Age: estimated by counting dentine growth layers on longitudinal sections of teeth…





Brodie, P. F. 1982. Rep Int Whal Comm 32: 445
Vos DJ. 2003. MSc thesis

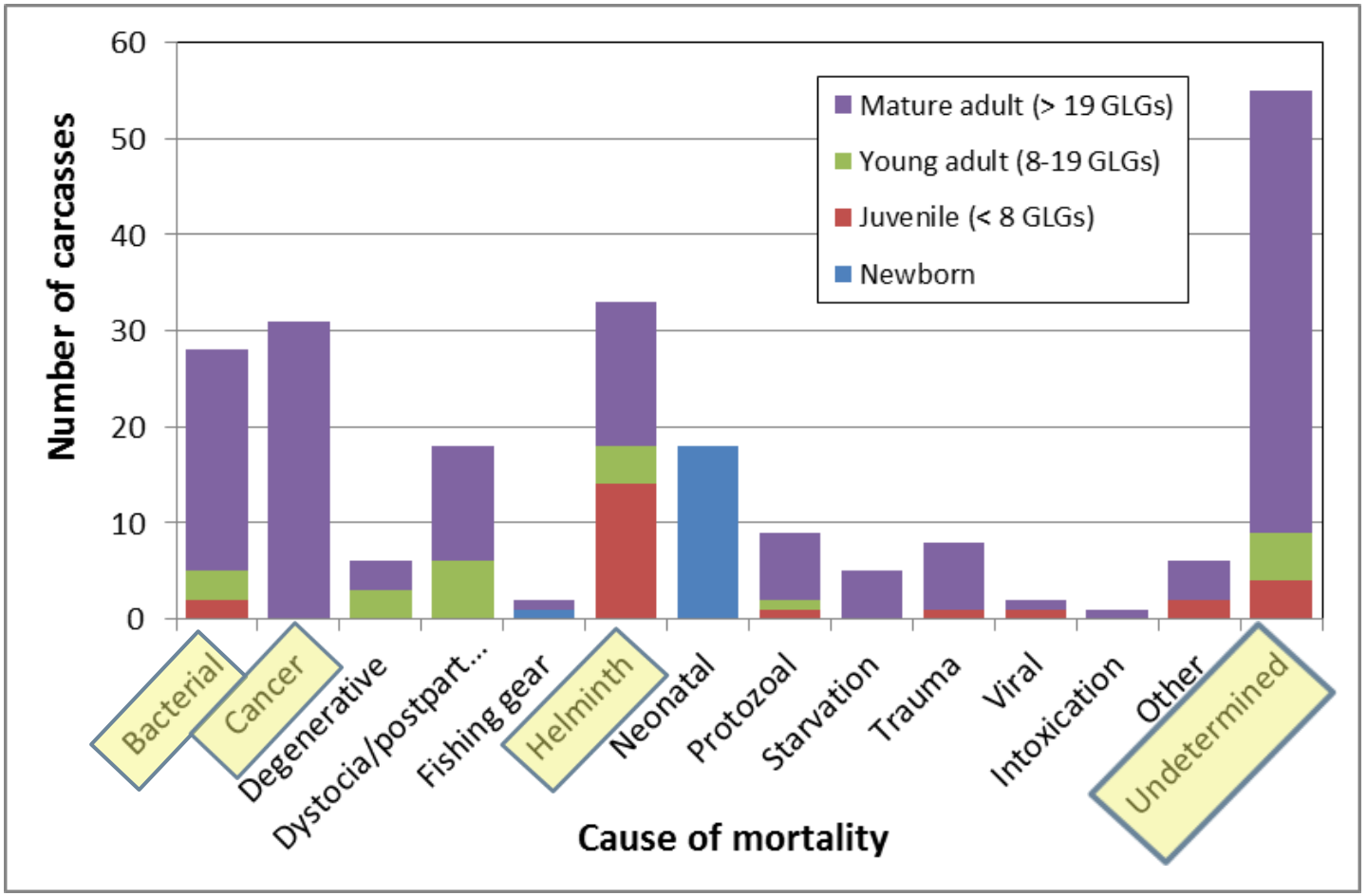
Total number of dead SLE beluga reported (with and without post mortem) in the SL Estuary over 30 years (1983-2012; n= 472)



Post mortem – «success» rate

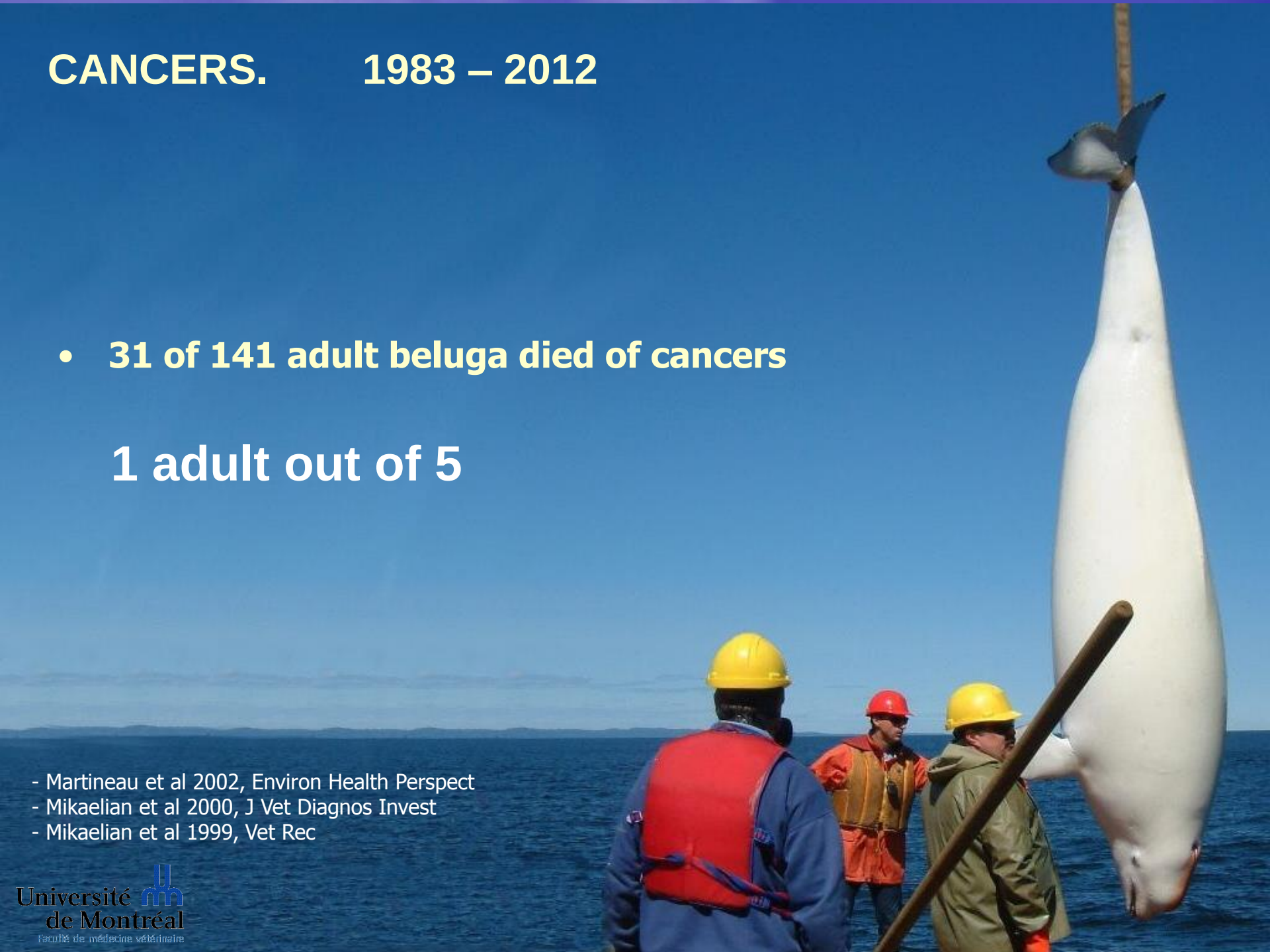
Likely cause of death	
Determined	75% (166)
Not determined	25% (56)
Total number of mortalities investigated	**222**

SLE beluga. Causes of death and age classes. n =222 (1983-2012)



CANCER

CANCERS. 1983 – 2012



- **31 of 141 adult beluga died of cancers**

1 adult out of 5

- Martineau et al 2002, Environ Health Perspect
- Mikaelian et al 2000, J Vet Diagnos Invest
- Mikaelian et al 1999, Vet Rec

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31 Cancers (1983 – 2012)

Female reproductive (8)

Mammary adenocarcinoma (8)

(also:
Granulosa cell tumor (1)
Dysgerminoma (1))

Digestive system (13)

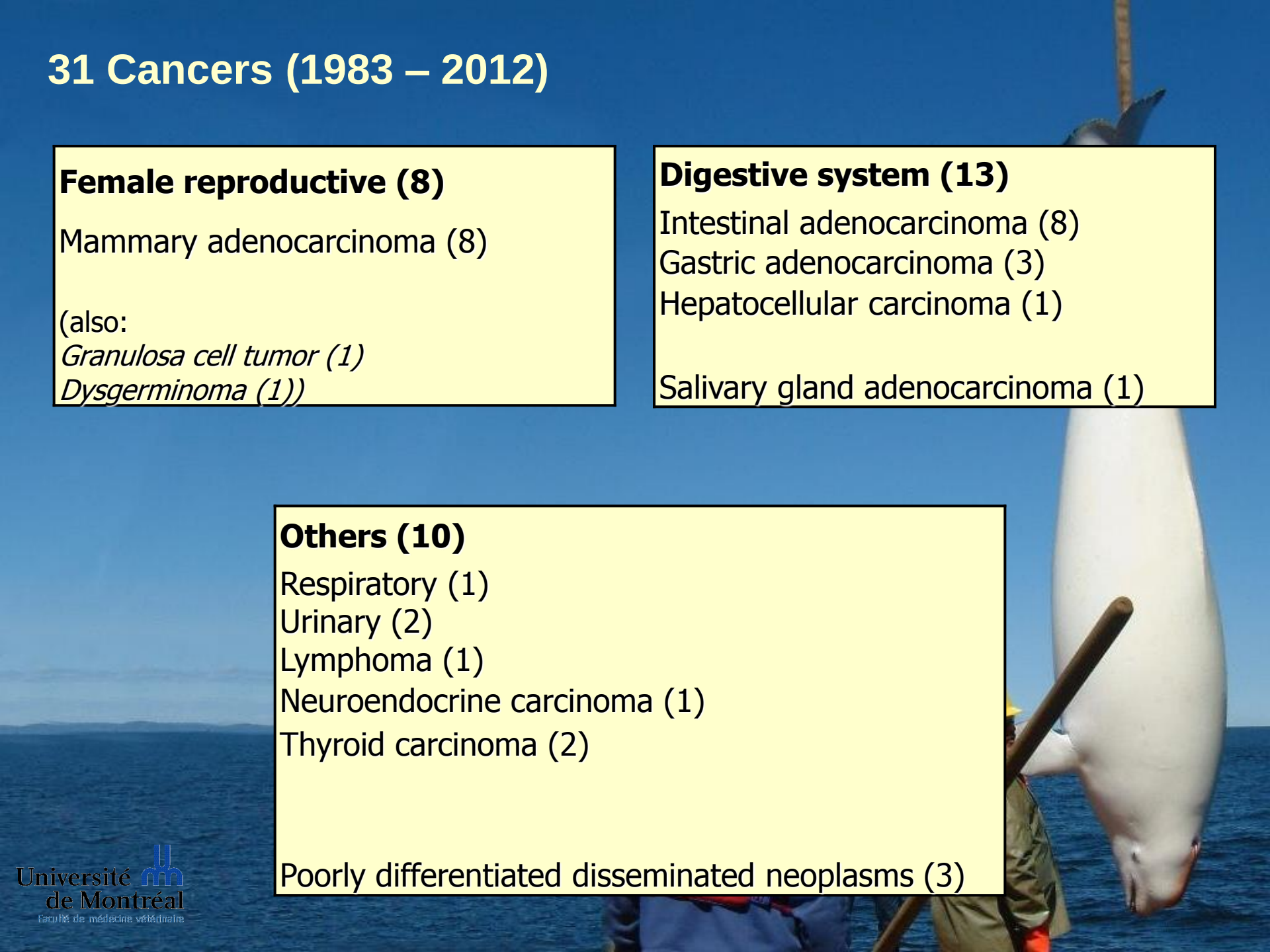
Intestinal adenocarcinoma (8)
Gastric adenocarcinoma (3)
Hepatocellular carcinoma (1)

Salivary gland adenocarcinoma (1)

Others (10)

Respiratory (1)
Urinary (2)
Lymphoma (1)
Neuroendocrine carcinoma (1)
Thyroid carcinoma (2)

Poorly differentiated disseminated neoplasms (3)



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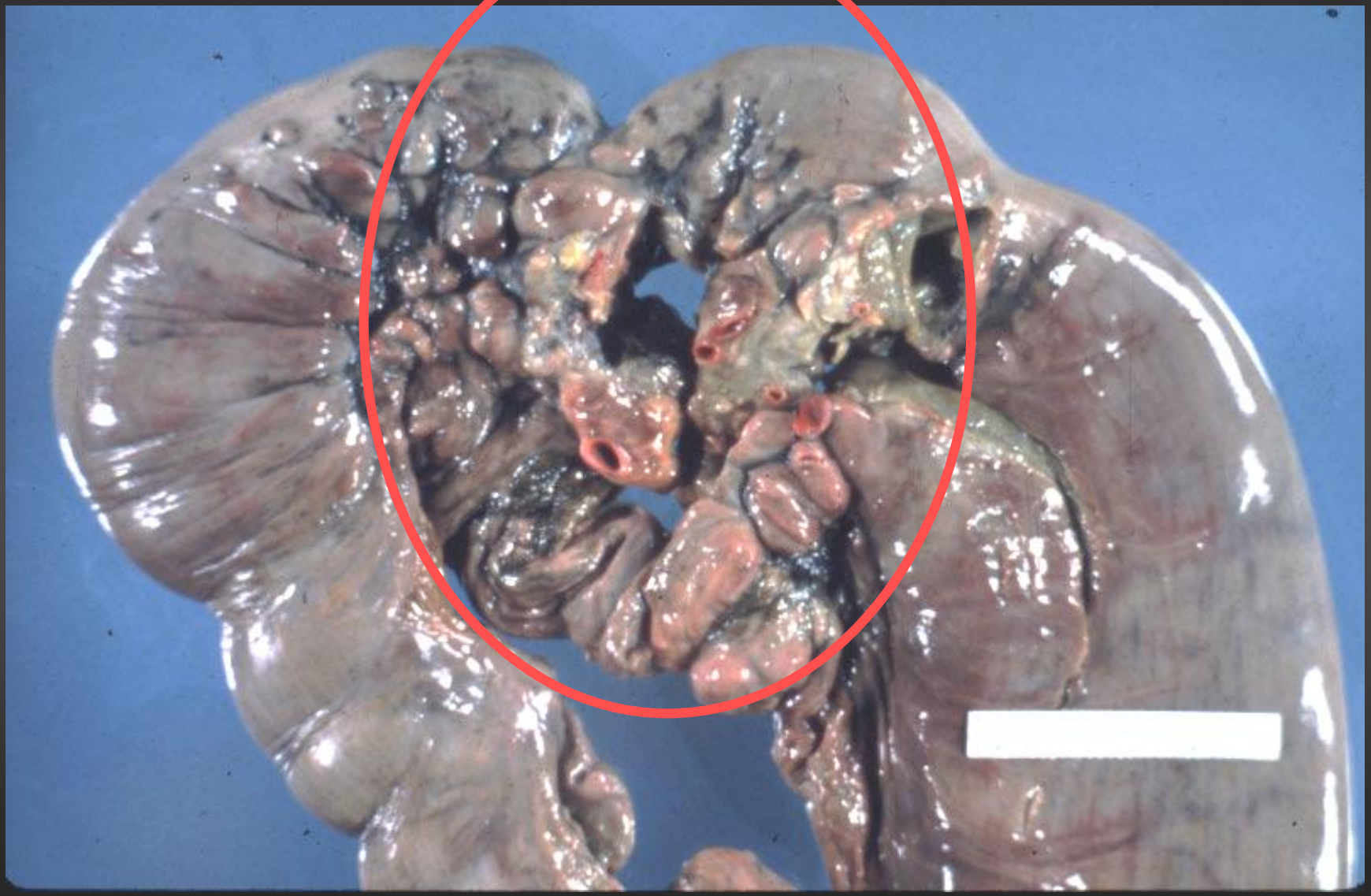
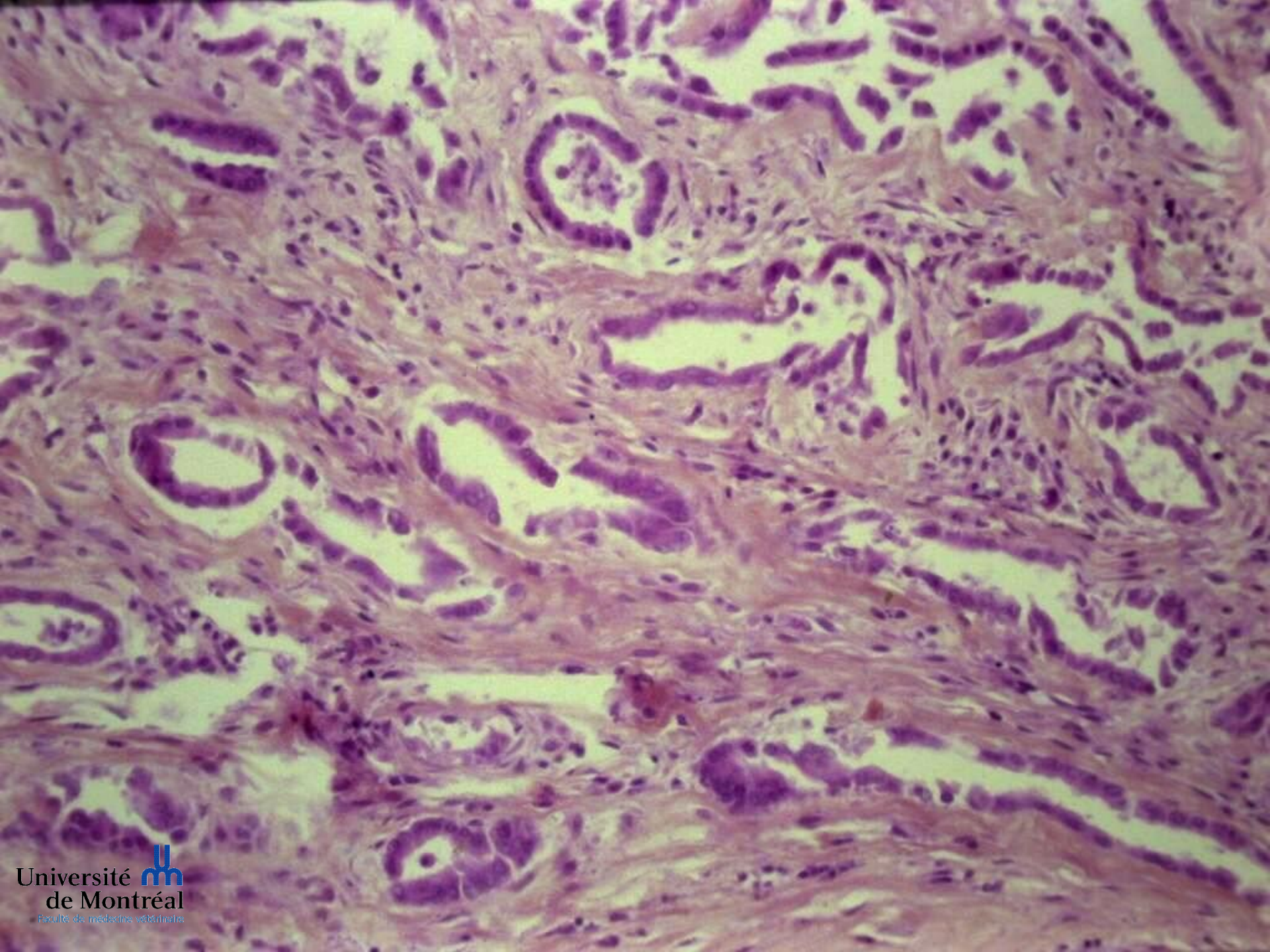
Beluga. Cancer, proximal intestine.
Adenocarcinoma.

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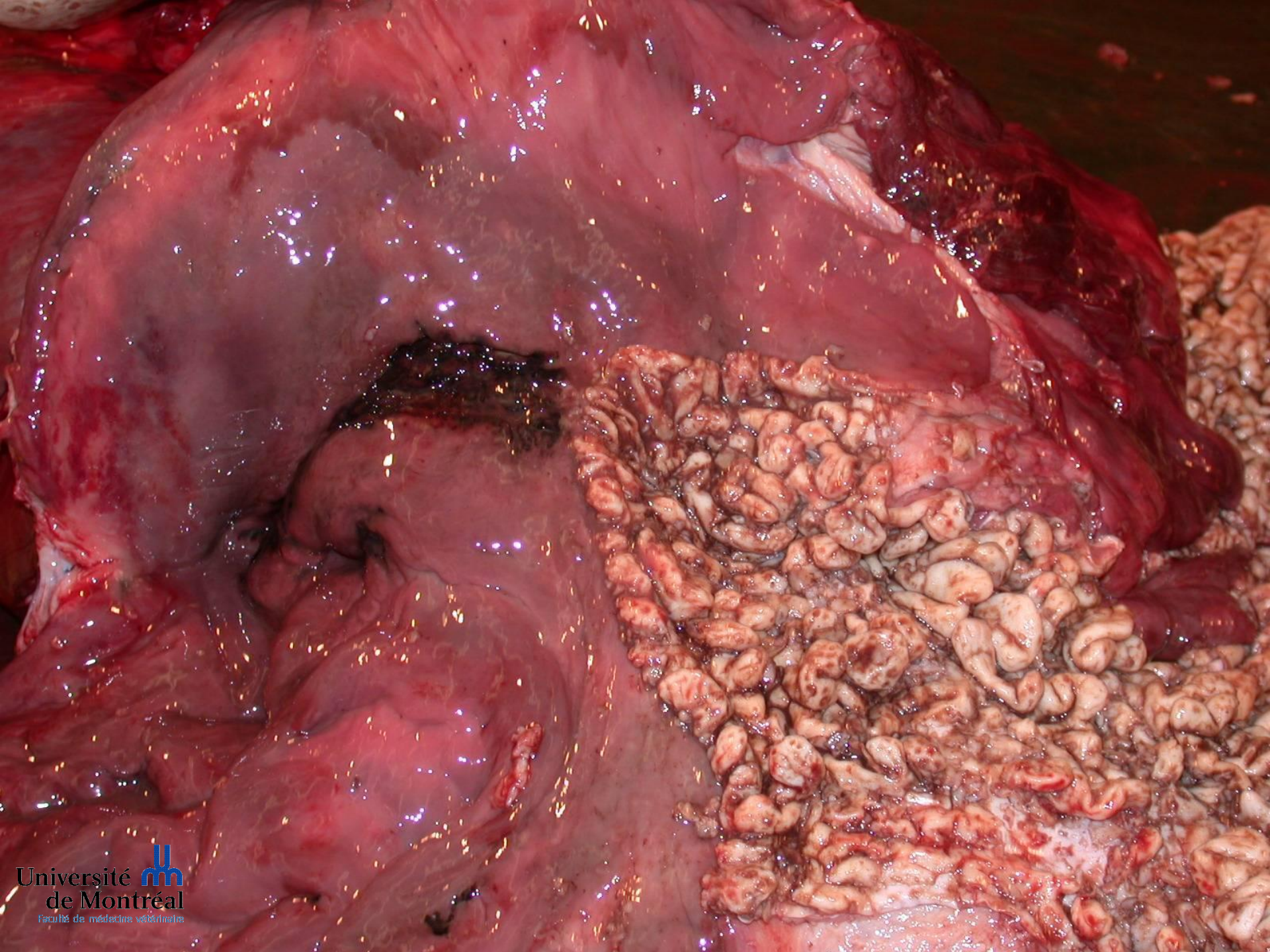
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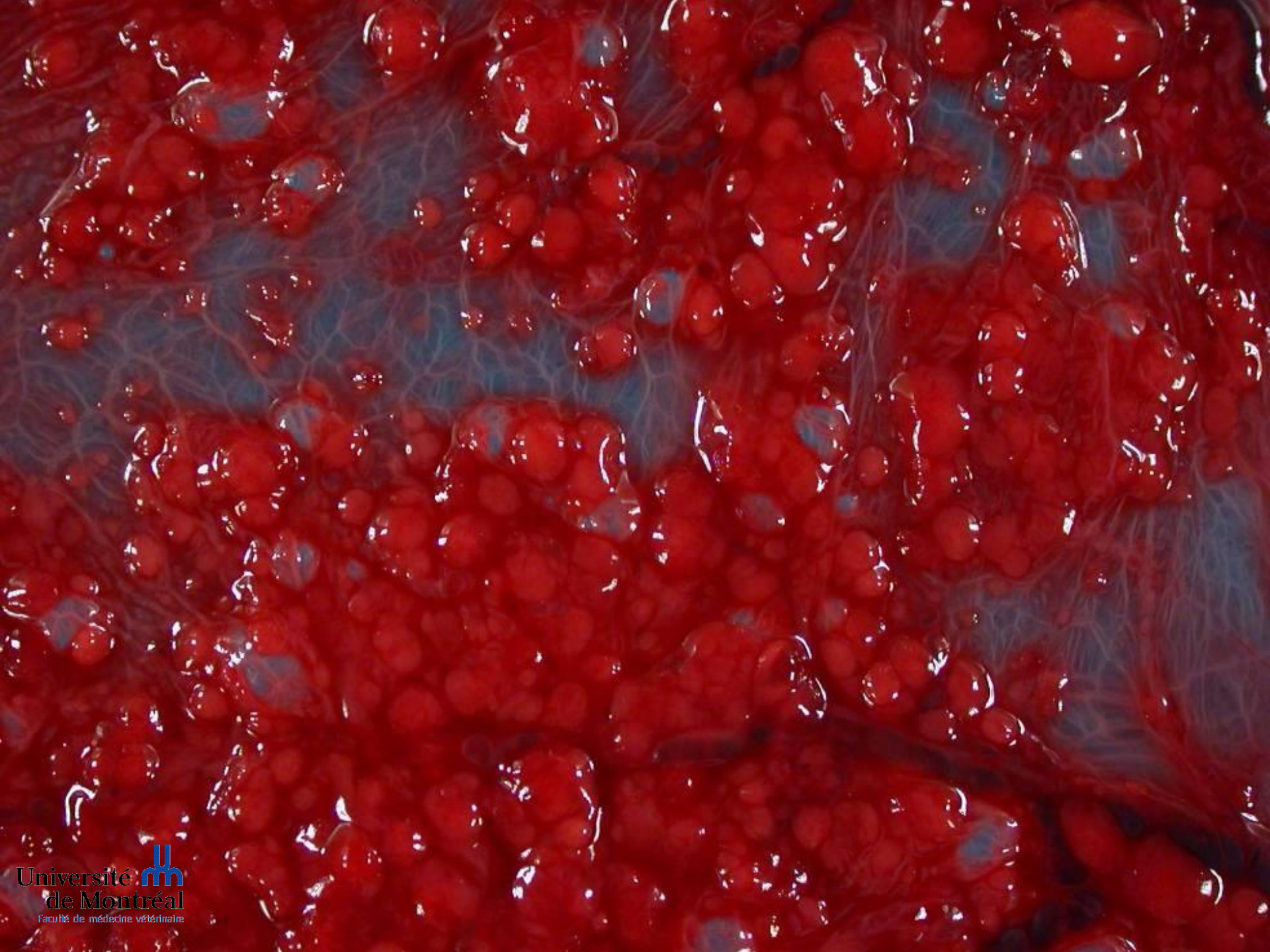
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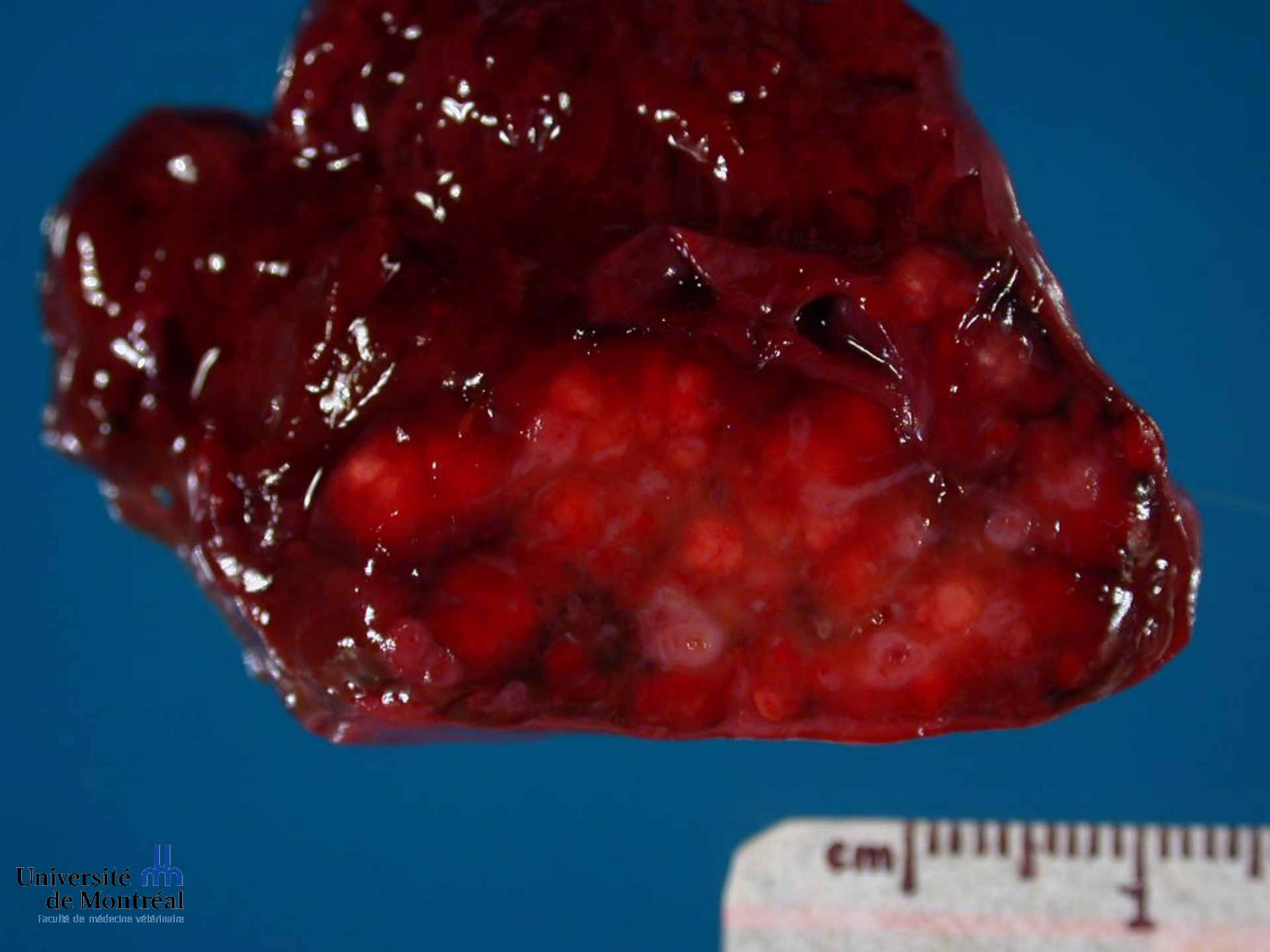
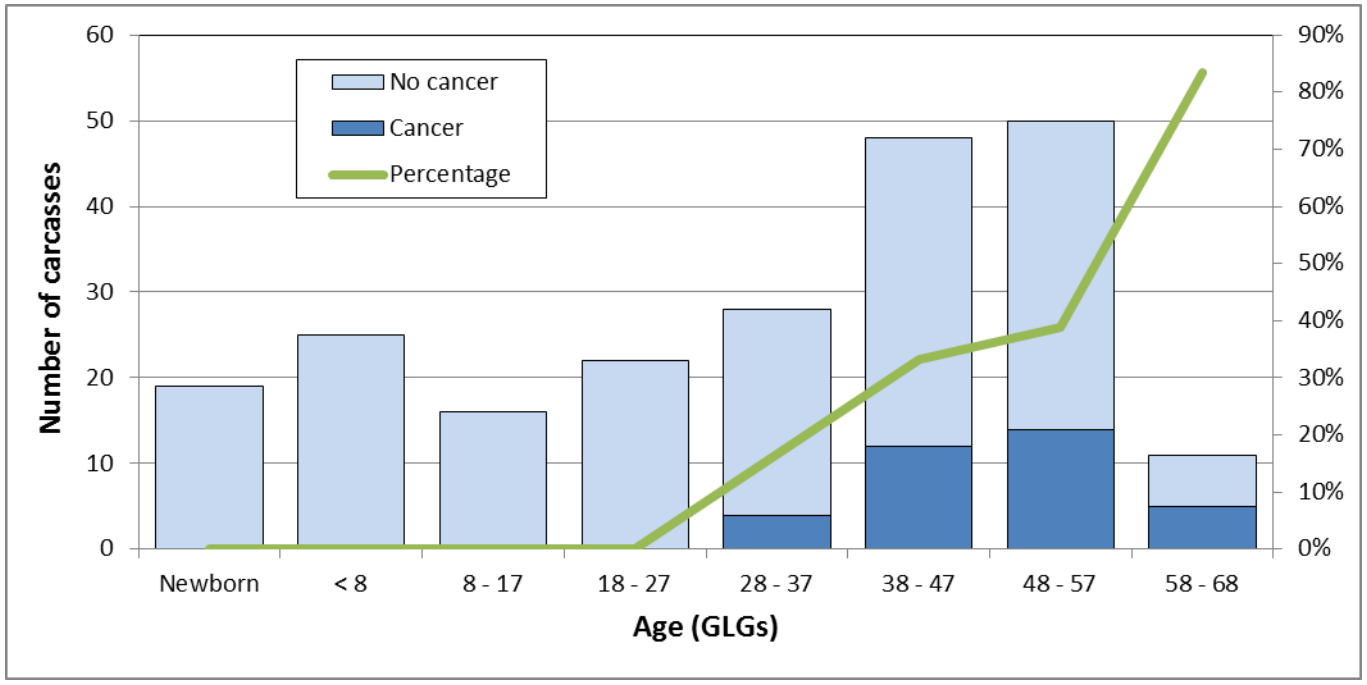
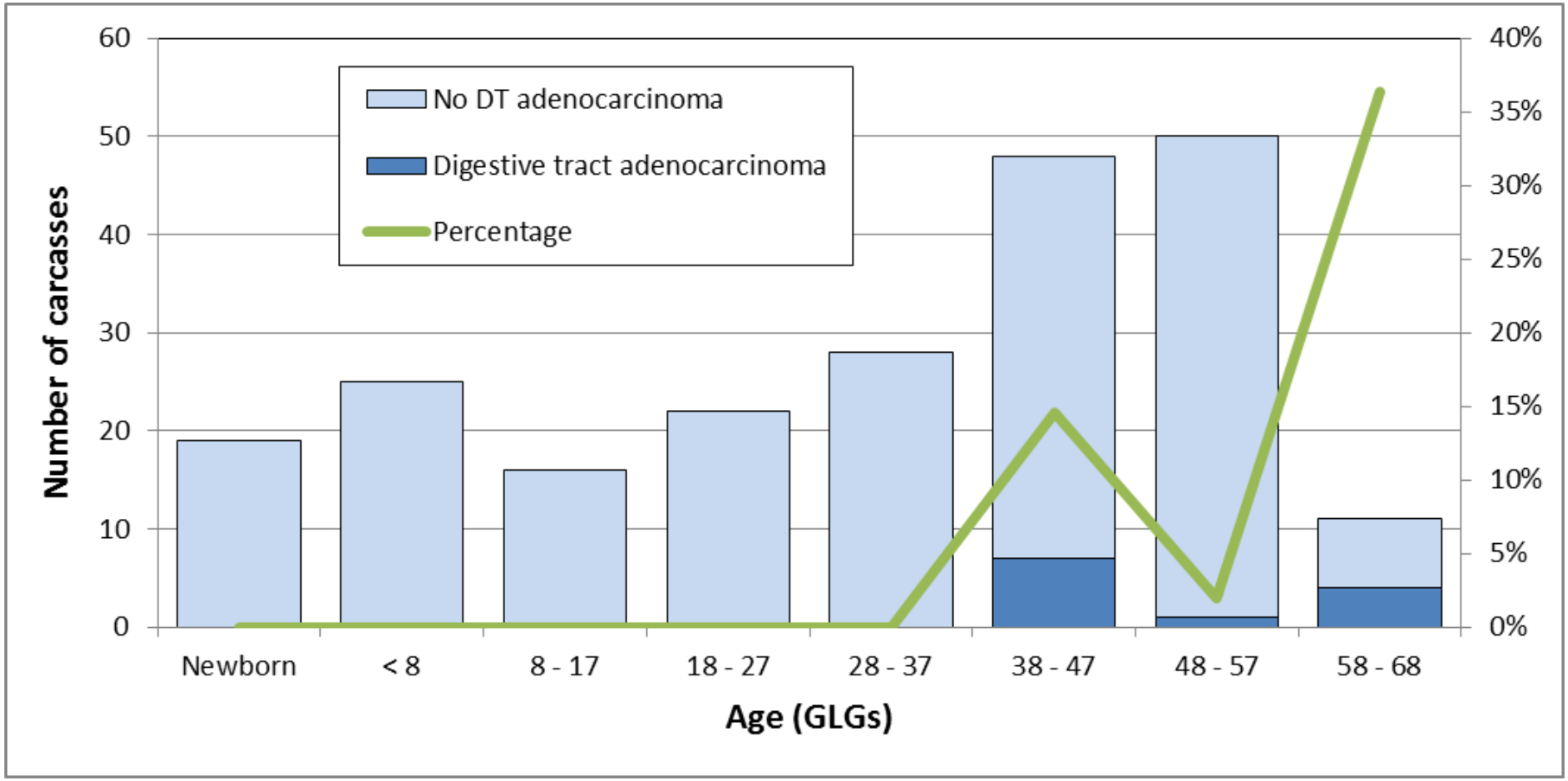


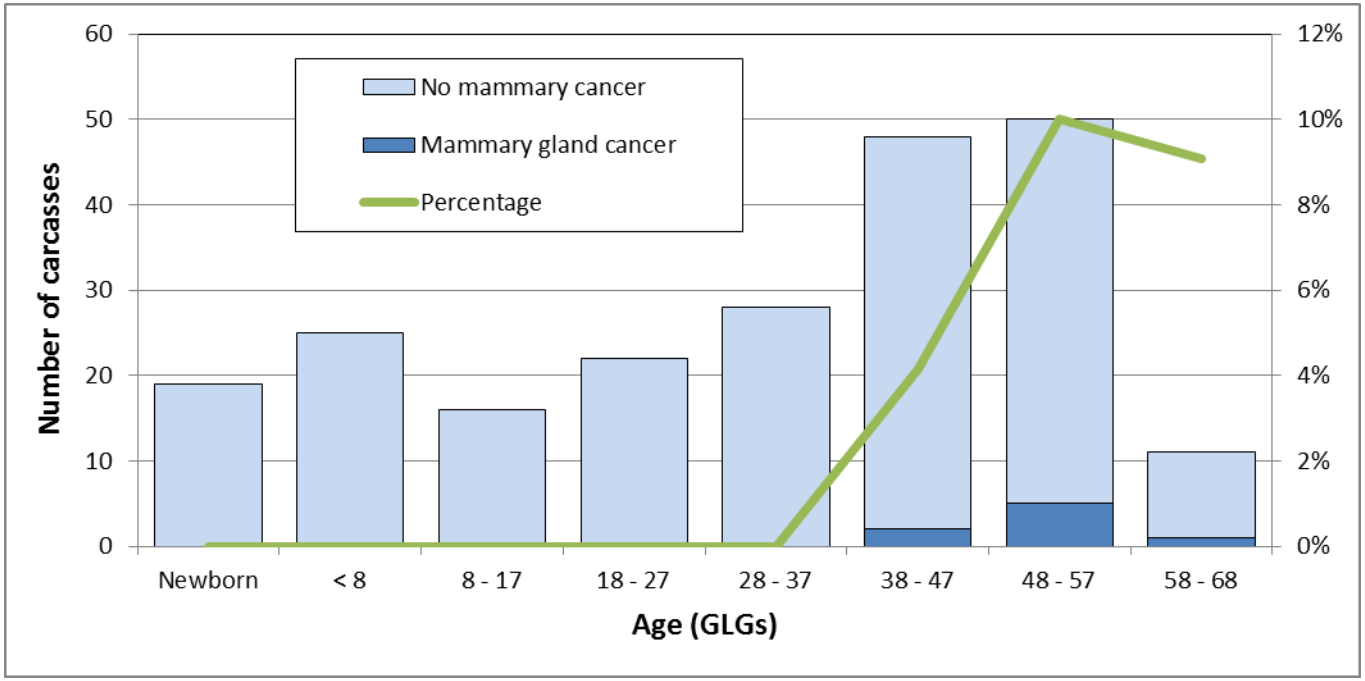
Number of SLE beluga with at least one cancer (all types) (n=35) vs age distribution. N = 219 (3 not aged)

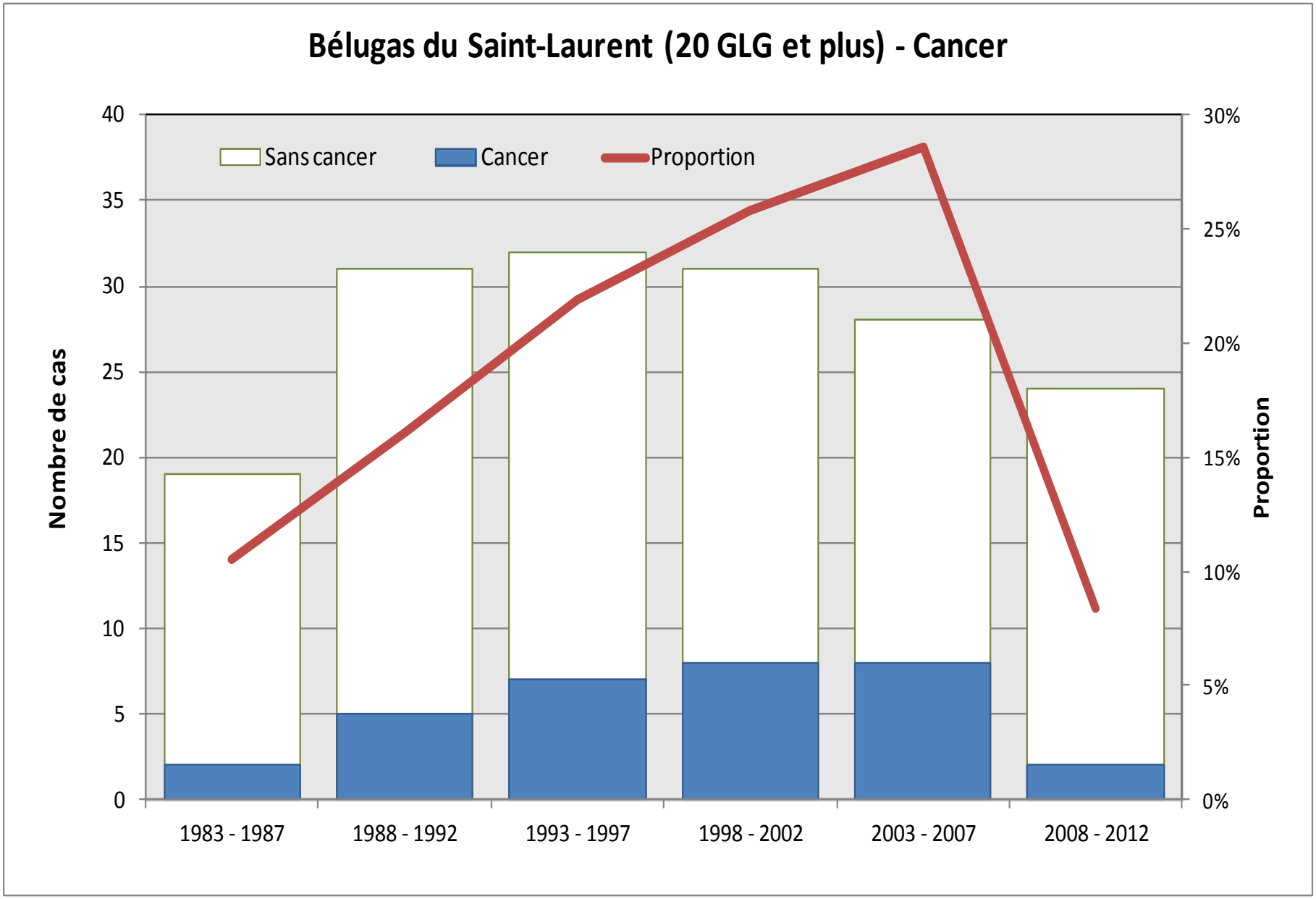


Gastrointestinal tract cancers (n= 11) + salivary gland adenocarcinoma (n=1) VS age distribution.
n= 219 (3 not aged)

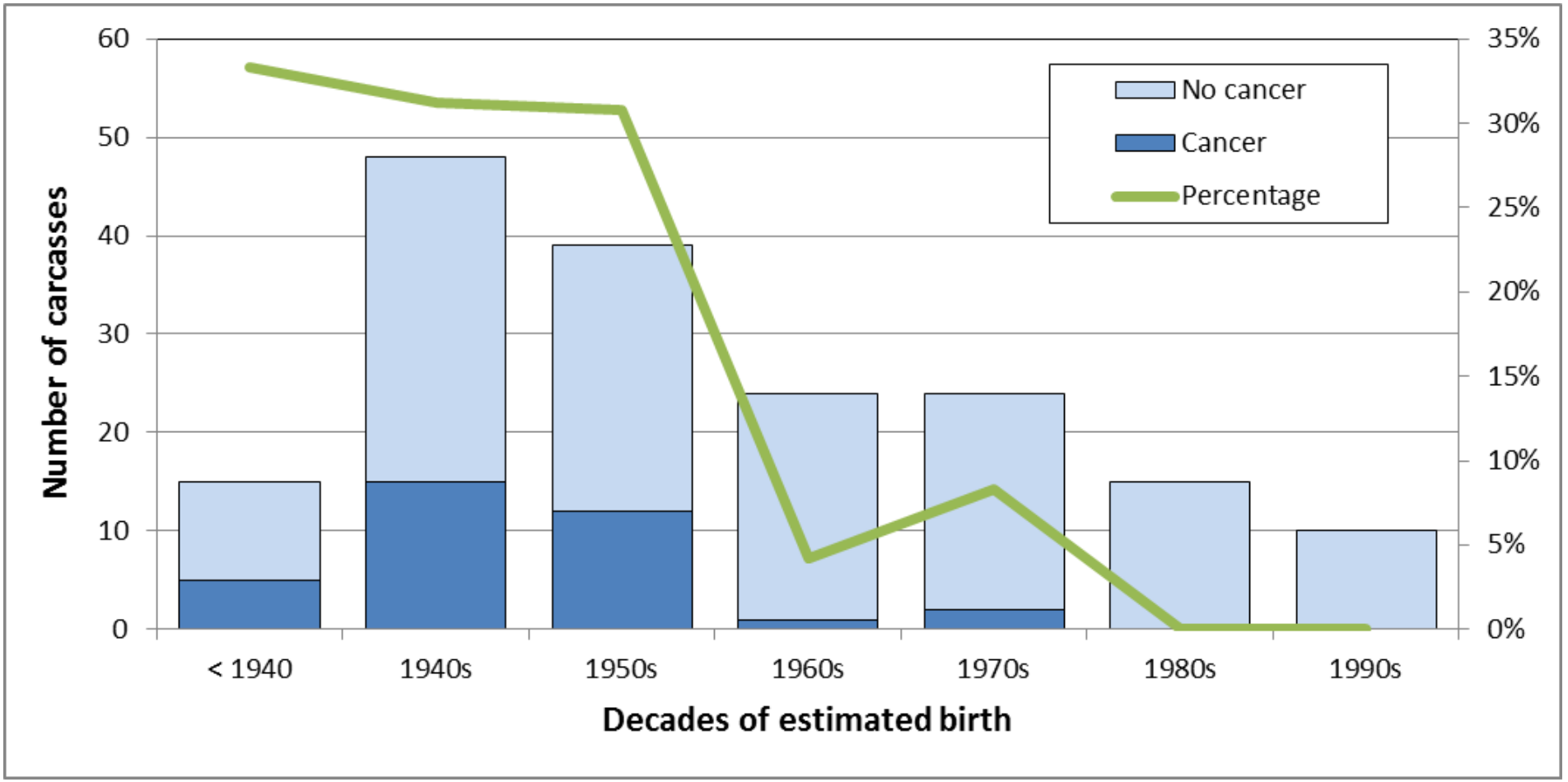


Mammary gland cancer (n=8) VS age distribution. n= 219 (3 not aged)

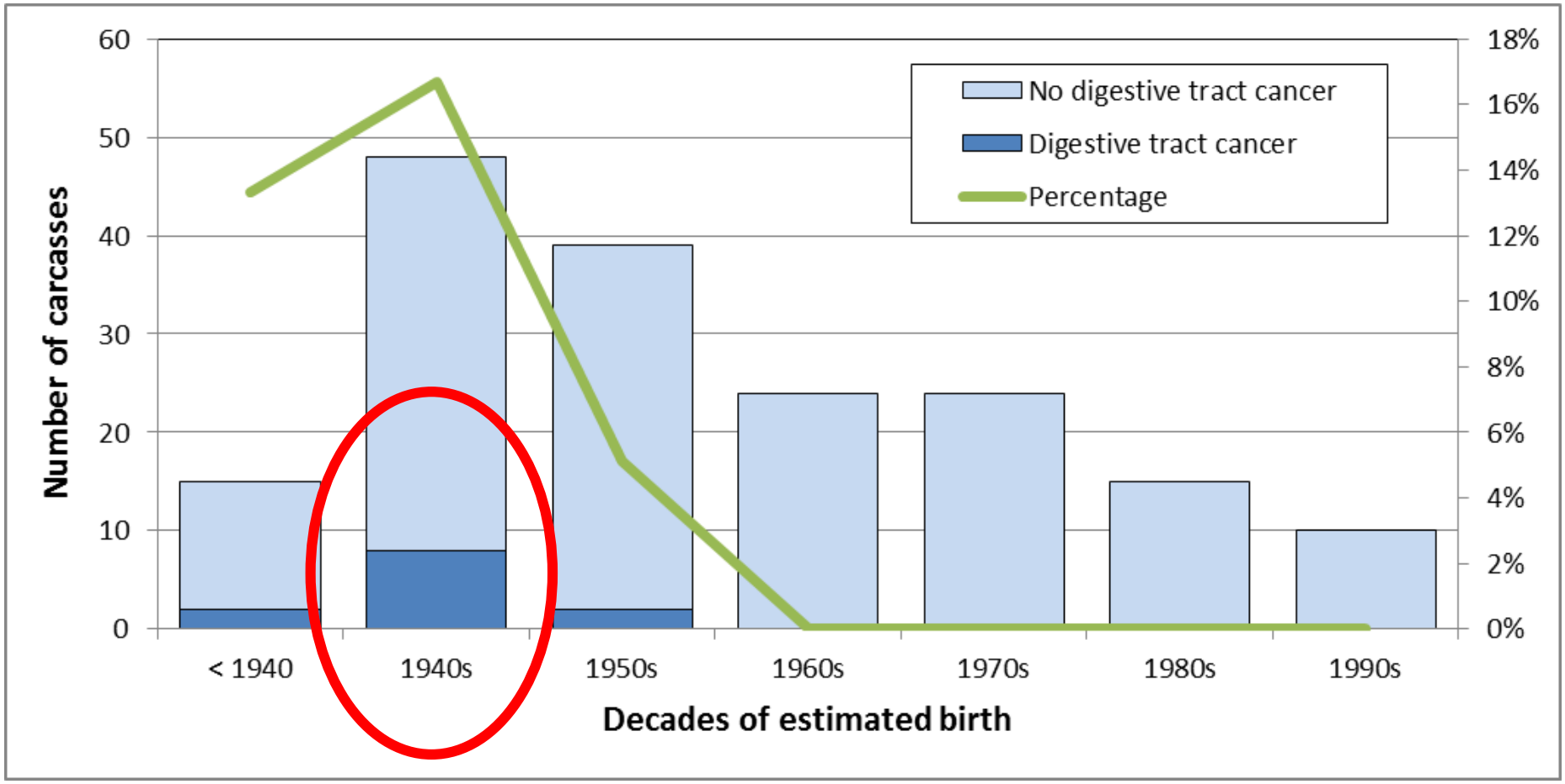



Bélugas du Saint-Laurent (20 GLG et plus) - Cancer
Sans cancer
Cancer
Proportion
Nombre de cas
Proportion
40
35
30
25
20
15
10
5
0
30%
25%
20%
15%
10%
5%
0%
1983 - 1987
1988 - 1992
1993 - 1997
1998 - 2002
2003 - 2007
2008 - 2012

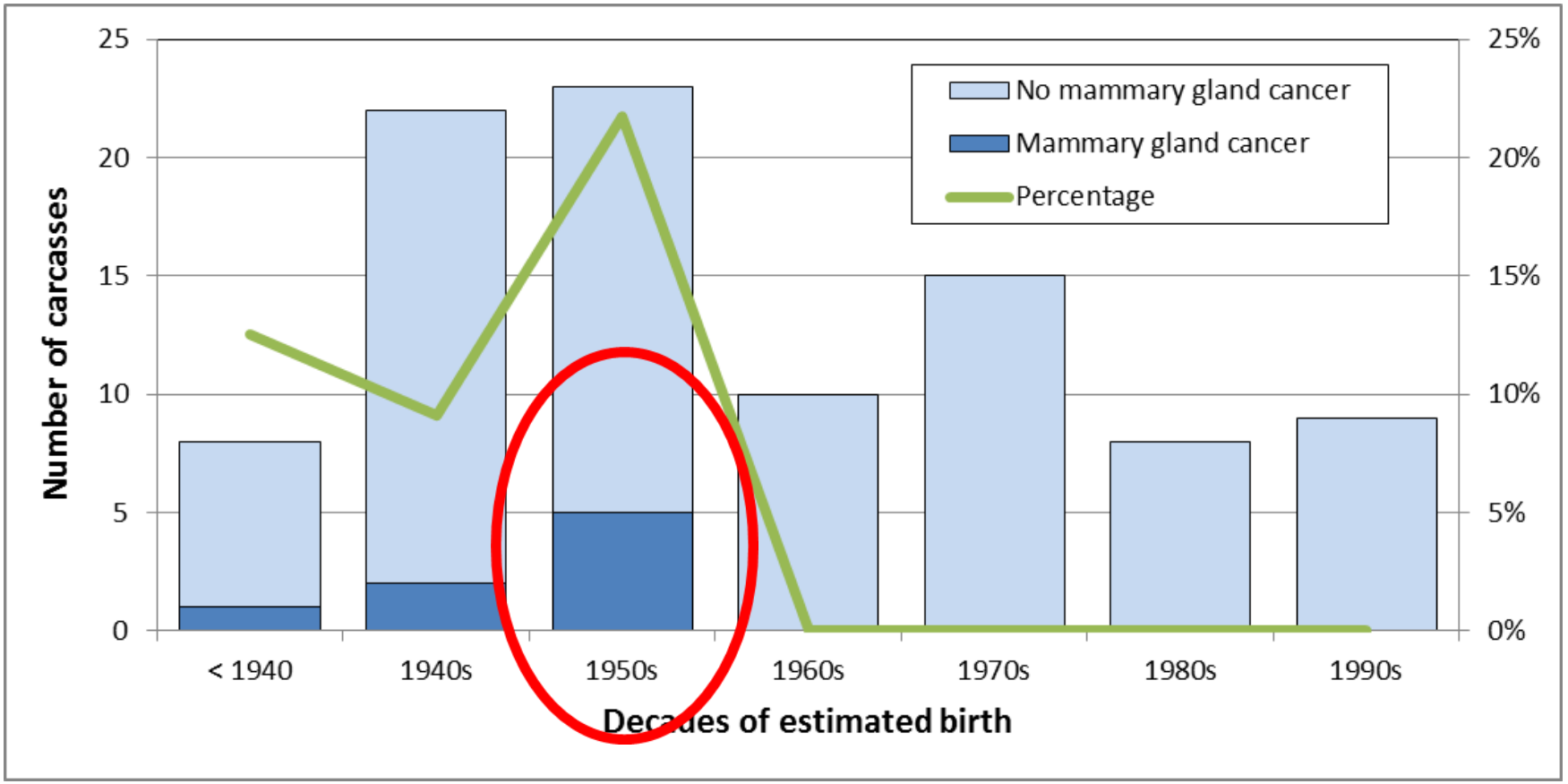
Adult SLE beluga with cancer VS estimated decade of birth (n=175)



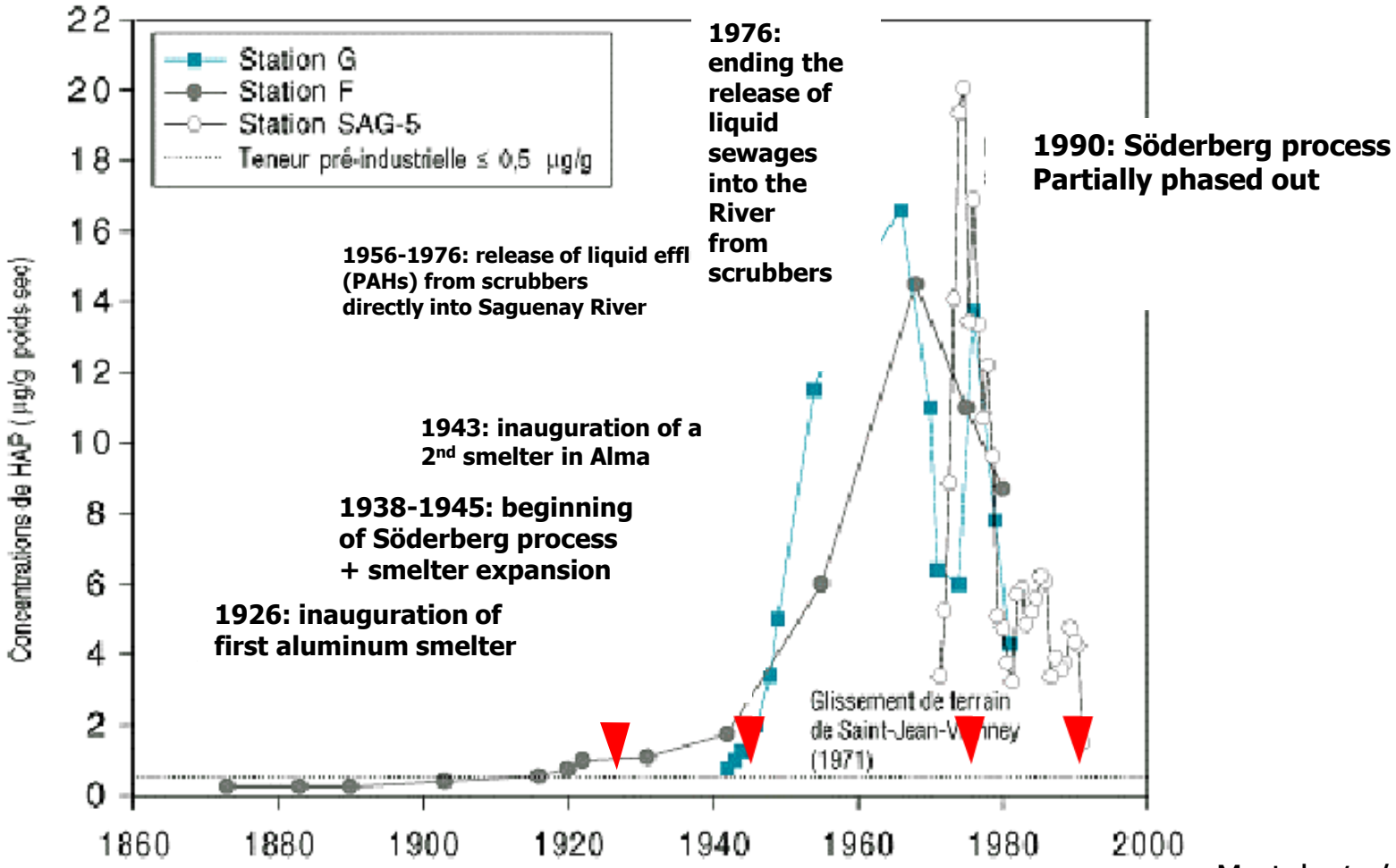
SLE beluga with GI tract cancer VS estimated decade of birth (12 / 175)



Adult SLE female beluga with mammary gland cancer VS estimated decade of birth (8 / 95)

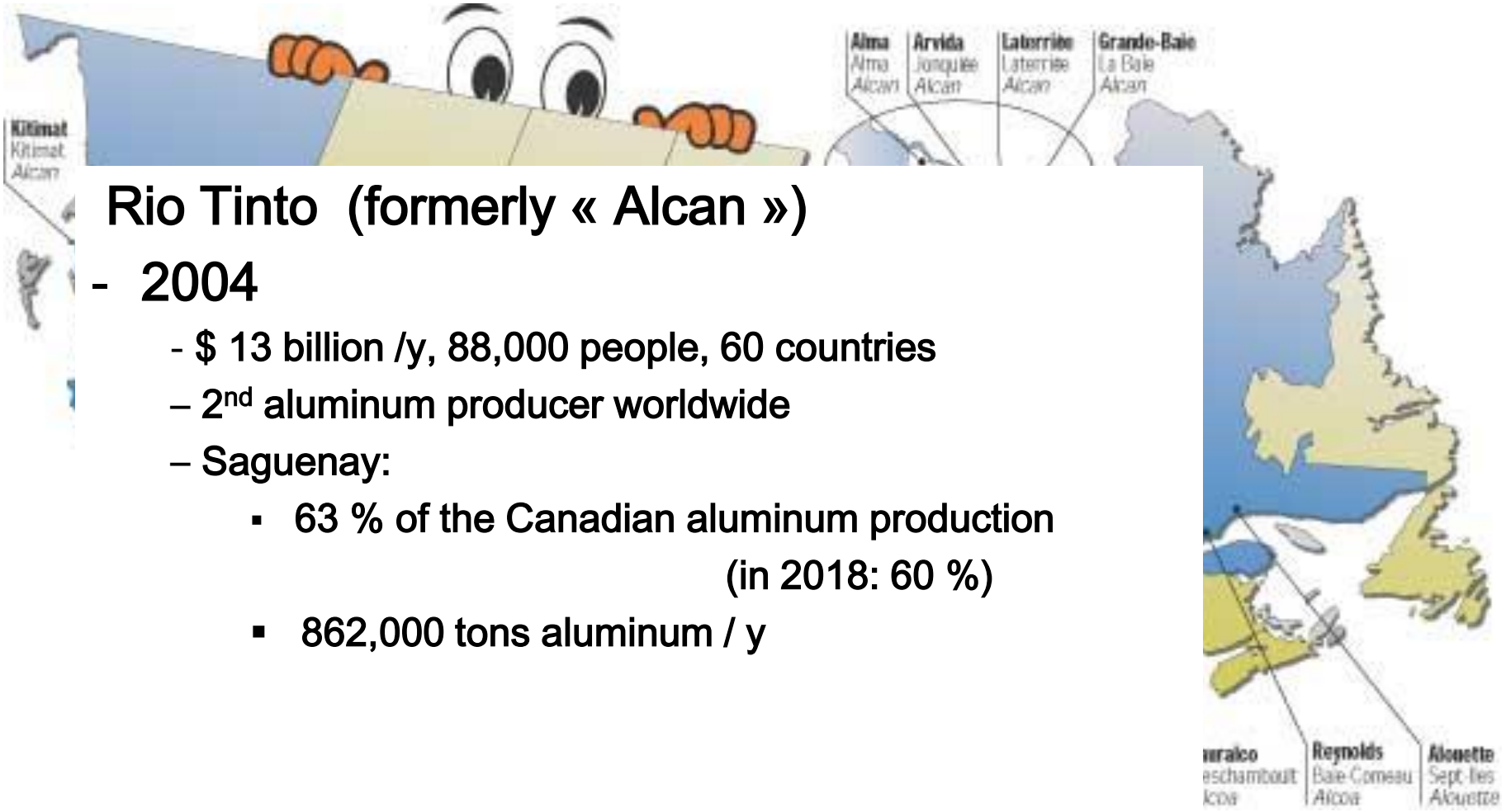


PAHs in the Saguenay river sediments



Martel *et al.* 1986

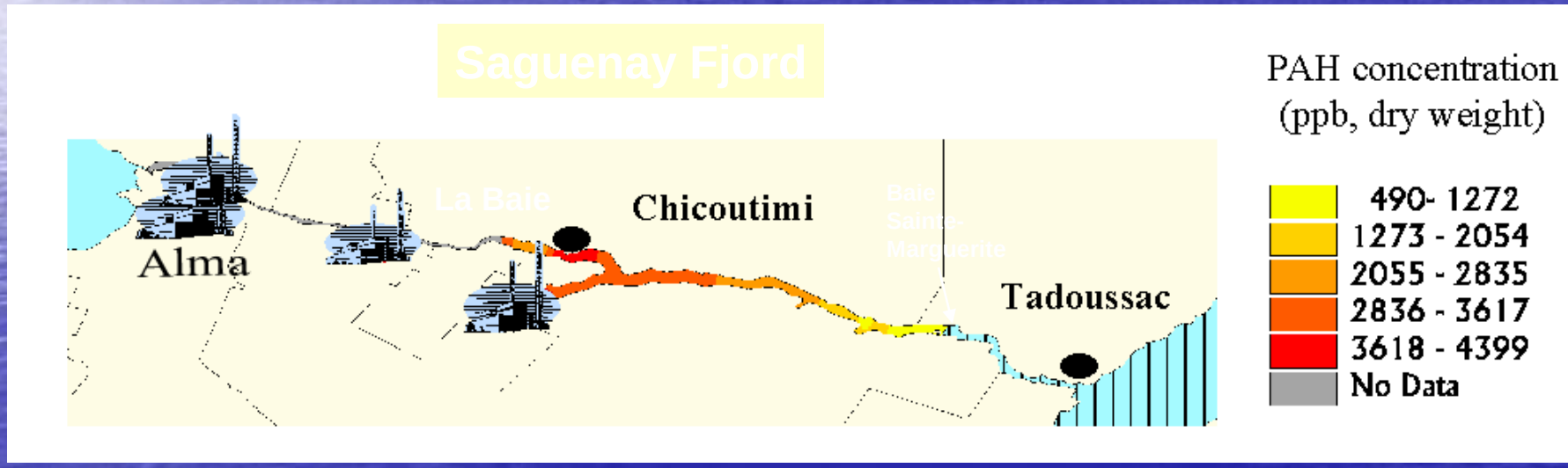
ALUMINUM PRODUCTION, PAHs AND THE SAGUENAY-LAC SAINT-JEAN AREA



Rio Tinto (formerly « Alcan »)

- 2004
  - $ 13 billion /y, 88,000 people, 60 countries
  - 2nd aluminum producer worldwide
  - Saguenay:
    - 63 % of the Canadian aluminum production
      (in 2018: 60 %)
    - 862,000 tons aluminum / y

PAHs in sediments of the Saguenay River. A spatio-temporal gradient



Martel et al., 1986, in: Martineau et al, 2002, Env Health Perspect

Saguenay River,
Baie Éternité

PAHs in the Saguenay River

- Aluminium industry present in the Saguenay region since 1926
- 40,000 tons of PAHs released in the Saguenay watershed

« …*serious chronic hazard to this environment and its inhabitants* »

- Smith and Levy 1990 (from Fisheries and Oceans Canada)

PAHs in beluga

- BaP adducts detected in St Lawrence beluga
- none detectable in Arctic beluga -

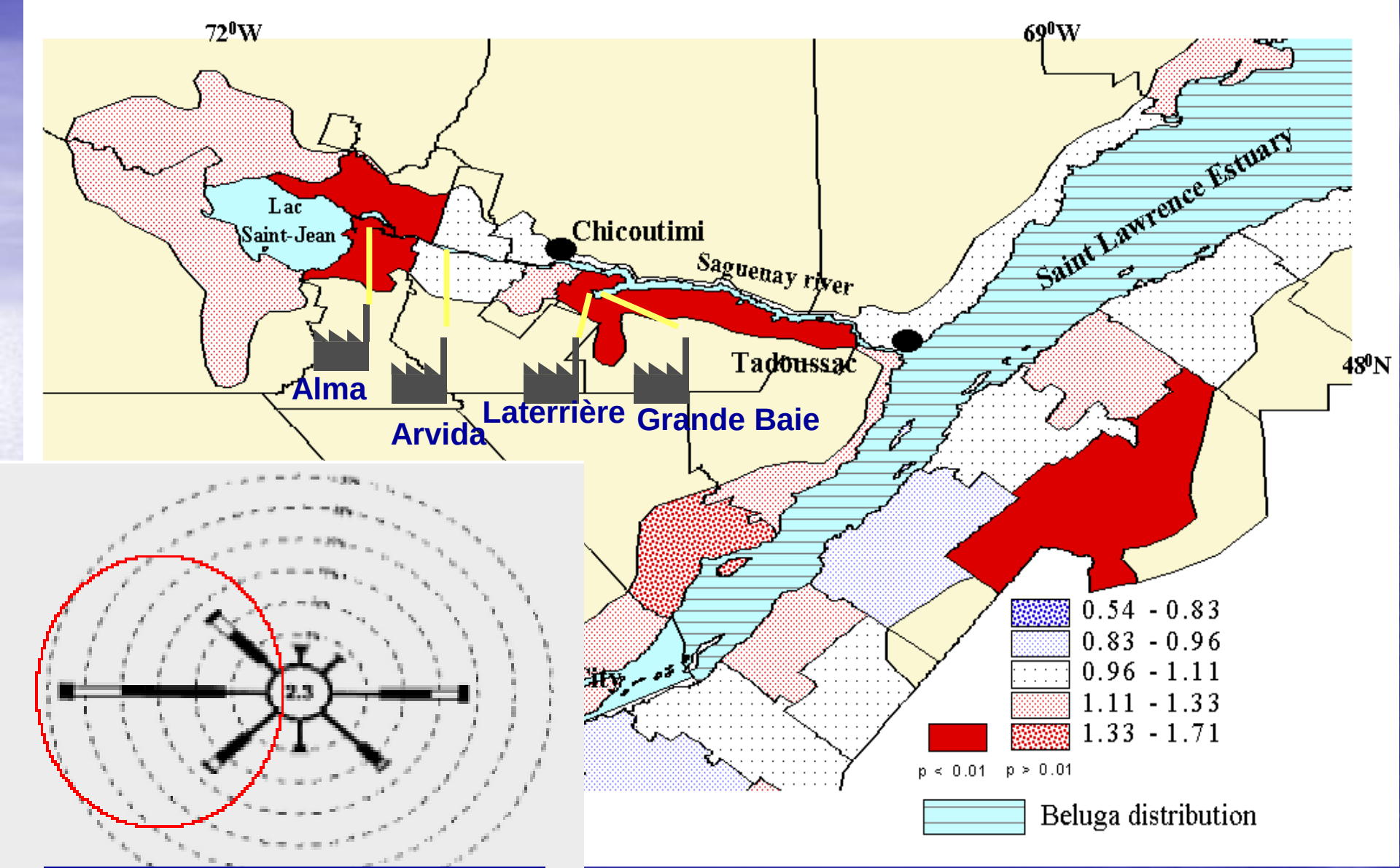
Martineau et al 1988, J Comp Pathol
Martineau et al 2002, Env Health Perspect

Cancer in people, Saguenay River region

- Aluminum workers
  - Urinary bladder and lung cancers:
    - high incidence
    - compensated by Quebec Health and Workers Compensation Board because strongly associated with PAH exposure

      - Armstrong and Theriault 1996

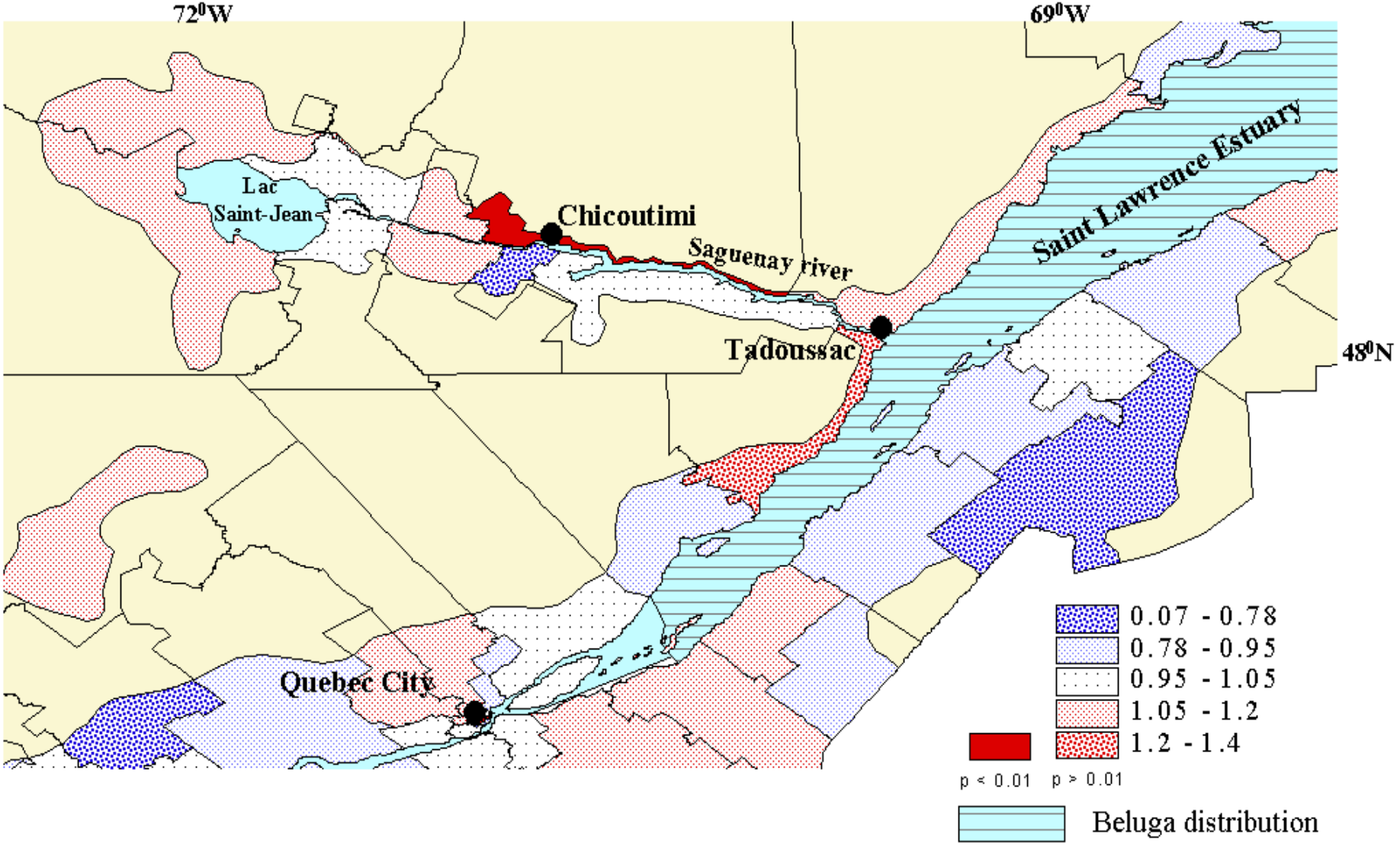
- Other inhabitants of that region



Wind directions. Frequency. 1993-1999

Women. Standardized rate ratio

Martineau et al. 2002. Env Health Perspect



GI tract Cancer. Men. Standardized rate ratio

Martineau et al. Env Health Perspect.: 110:285-292 (2002)

If PAHs cause digestive cancers in the Saguenay Lac Saint-Jean population:

- 1) why are aluminum workers not also affected by digestive cancers, like the rest of the local population?
- 2) why are digestive cancers more frequent in woman than in man ?

Drinking water in the Saguenay region

- 79 % surface water (rivers, lakes)
  - Saint-Laurent Vision 2000. Rapport En40-216/17F, 1995

- Contamination of surface water by PAHs
  - higher than EPA standards: (analyses 1997-1999)

EPA: 4.4 ng/L.
Rivière à Mars: 19.7 ng/L
Rivière Chicoutimi: 83 ng/L

- MEQ 2002

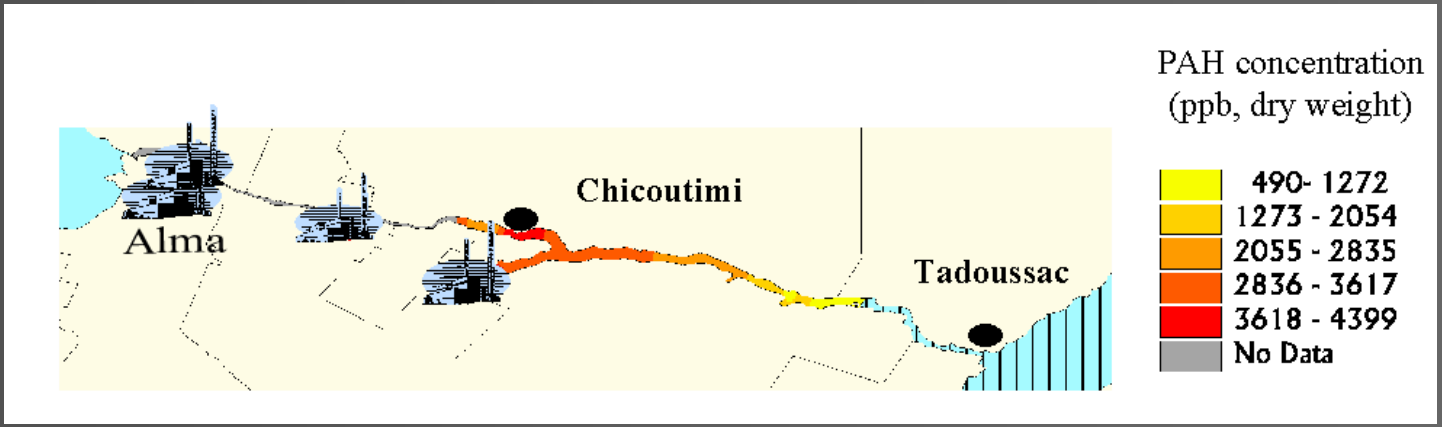
The industry claims that in 2002,
PAH emissions had decreased 8 times compared to 1983. Thus, in 1983….

– « Workers in the plants have drunk bottled water for as long as I can remember »

- Director, environmental affairs, Alcan
September 9, 2003

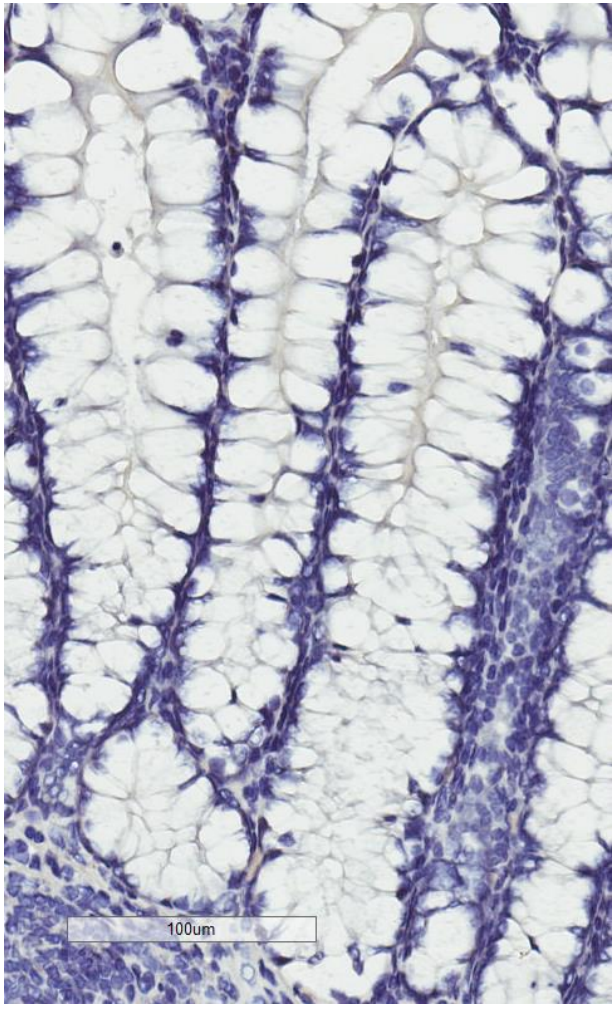
- Are beluga with GI tract cancer exposed to PAHs ?
  - PAH adducts have been detected in SLE beluga tissues
    - Martineau et al 1988, JCP
    - Shugart and Theodorakis, 1994, EHP
  - Saguenay River sediments are contaminated with PAHs

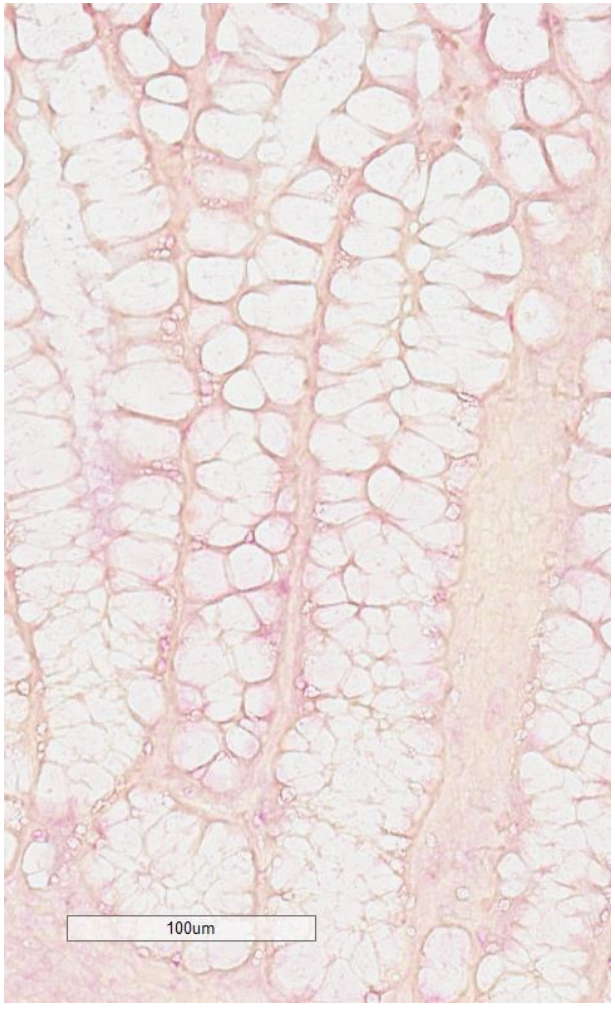
- Do beluga whales with GI tract cancer feed on the Saguenay River sediments ?



CANADIAN ARCTIC.
Adult beluga, Age: 42 y. Intestine.

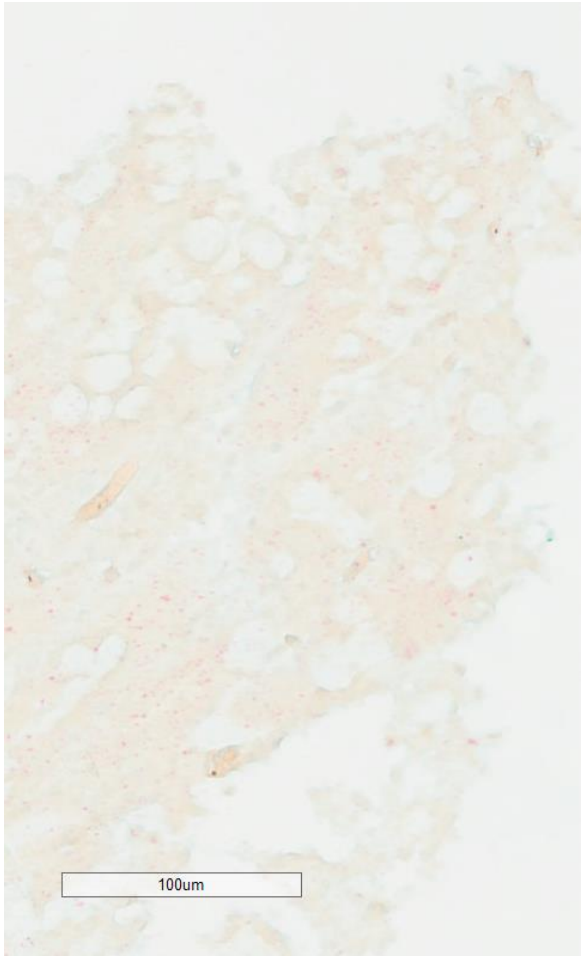
Absorbed | **Absorbed + Hematoxylin** | **Specific**

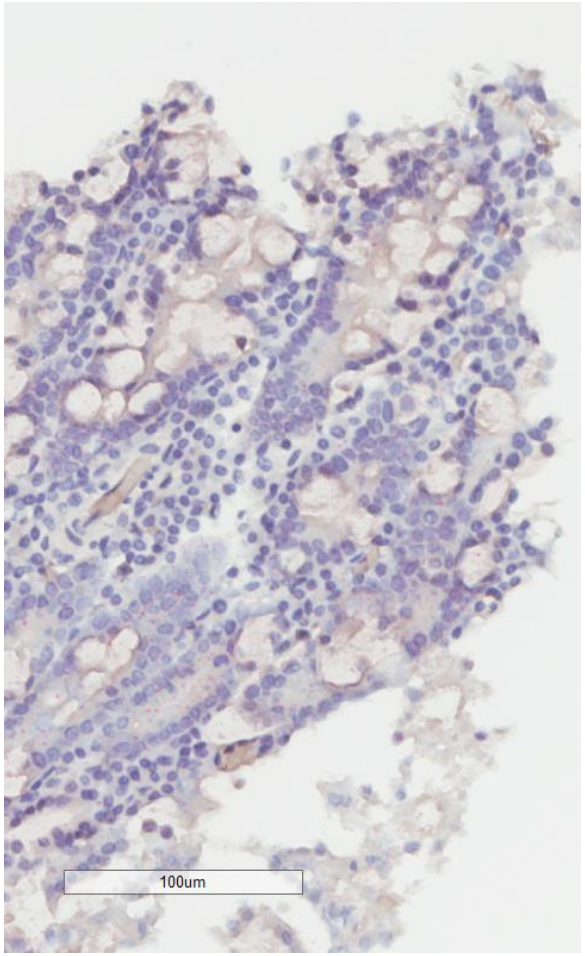


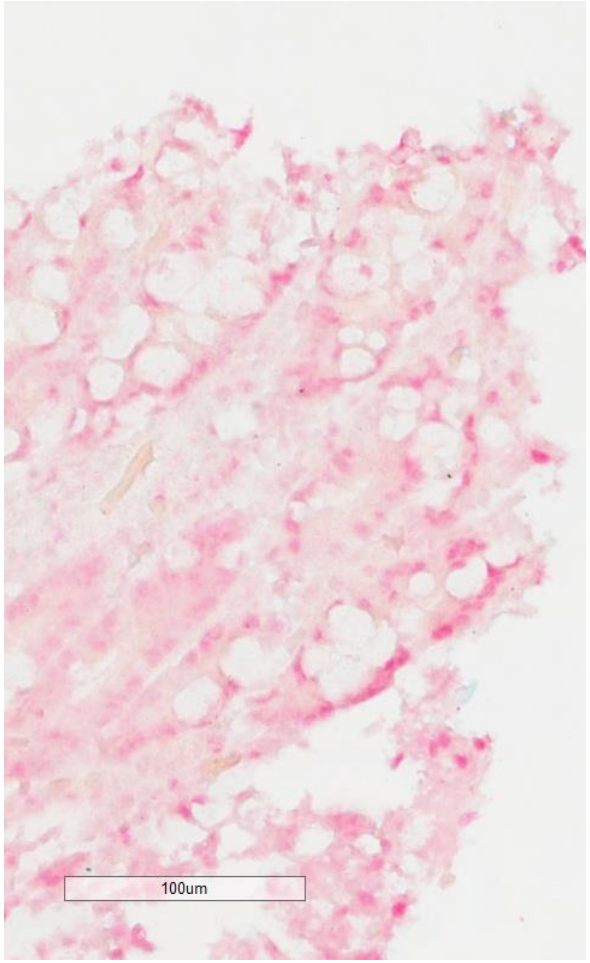


COOK INLET, ALASKA
Newborn beluga. Intestine

Absorbed antiserum **Absorbed + Hematoxylin** **Specific antiserum**

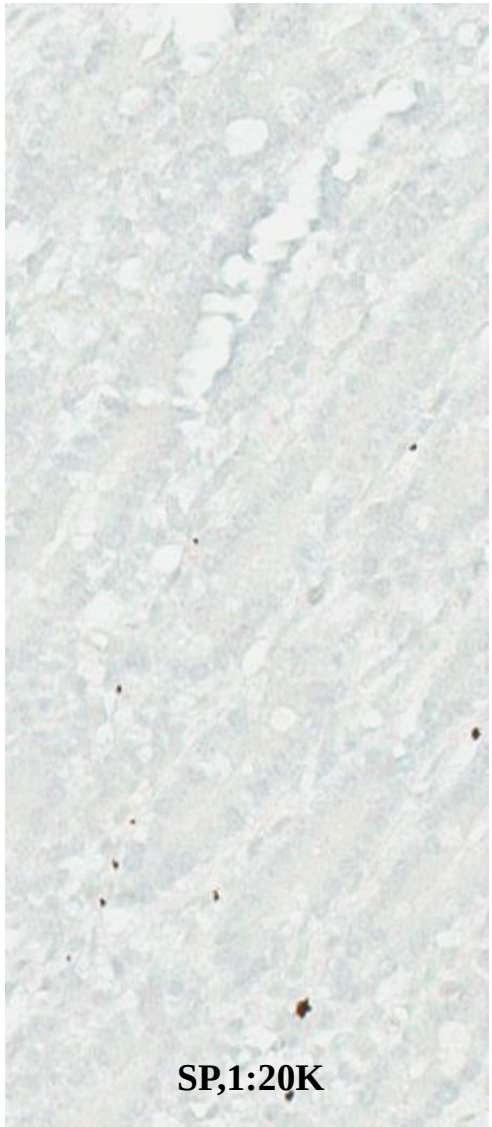






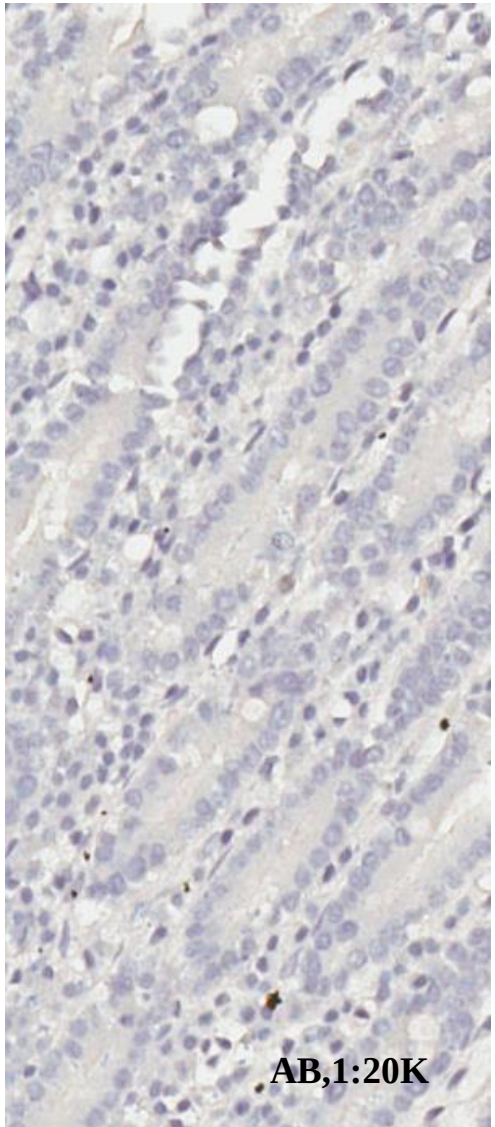
St LAWRENCE ESTUARY.
Adult beluga, Age: 55 y. Intestine.

Absorbed antiserum



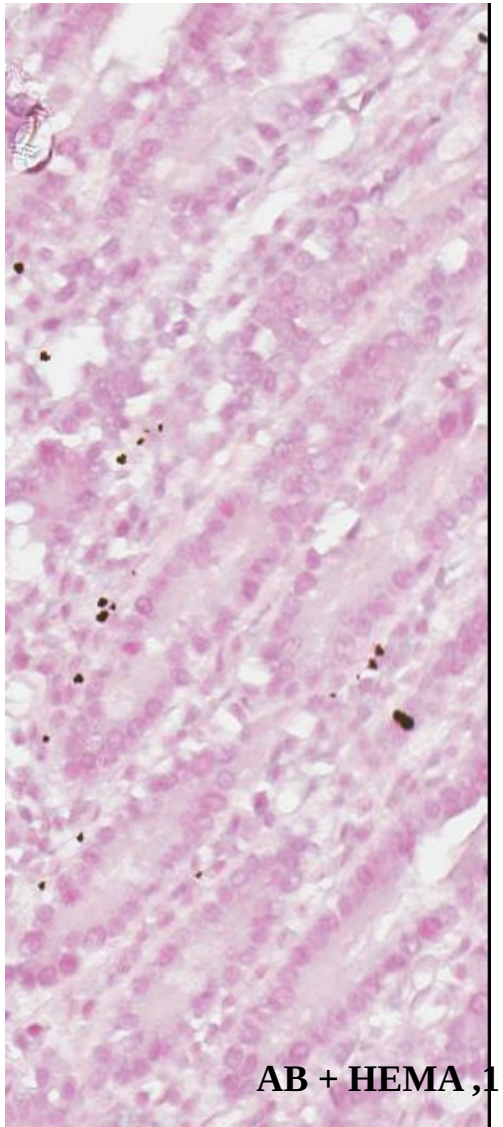
SP,1:20K

Absorbed + Hematoxylin



AB,1:20K

Specific antiserum



AB + HEMA ,1:20K

PRELIMINARY RESULTS - SUMMARY

IMMUNOHISTOCHEMISTRY (anti PAH-DNA adducts)

SLE > Cook Inlet> > Canadian Arctic > aquarium

IMMUNOHISTOCHEMISTRY
(anti PAH-DNA adducts)

RESULTS - SUMMARY

SLE > **Cook Inlet ??!! ALASKA ?!** > Canadian Arctic

Cancer in Wildlife, a Case Study: Beluga from the St. Lawrence Estuary, Québec, Canada

Daniel Martineau,[1] Karin Lemberger,[1] André Dallaire,[1] Philippe Labelle,[1] Thomas P. Lipscomb,[2] Pascal Michel,[3] and Igor Mikaelian[4]

[1]Département de Pathologie et Microbiologie, Faculté de Médecine Vétérinaire, Université de Montréal, St. Hyacinthe, Québec, Canada; [2]Department of Veterinary Pathology, Armed Forces Institute of Pathology, Washington, DC, USA; [3]Faculté de Médecine Vétérinaire, Université de Montréal, St. Hyacinthe, Québec Canada; [4]Idexx Veterinary Sciences, West Sacramento, California, USA

- Env Health Perspect 2002 110: 285

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Le 5 mars 2002

Dr Daniel Martineau
Faculté de médecine vétérinaire
Université de Montréal
3200, rue Sicotte
Saint-Hyacinthe (Québec) J2S 2M2

Objet : Votre article à paraître concernant les bélugas du Saint-Laurent

Monsieur,

Par la présente, nous désirons vous remercier de nous avoir transmis une copie de votre article à paraître dans la publication Environmental Health Perspectives (édition mars 2002) concernant votre étude sur les bélugas du Saint-Laurent. Toutefois, nous exprimons notre surprise et notre déception concernant la diffusion et le contenu du communiqué de presse du 25 février portant sur la parution prochaine de votre article.

La rencontre que vous avez eue avec des représentants d'Alcan le jeudi 21 février dernier nous a laissés sur l'impression que des collaborations dans les programmes de recherche de la faculté de médecine vétérinaire méritaient d'être approfondies. Ainsi, nous déplorons vivement ne pas avoir été informés lors de cette rencontre de la diffusion prochaine de ce communiqué de presse. Le cas échéant, nous aurions pu commenter le communiqué avant sa publication (toujours dans un esprit de collaboration) et éviter la diffusion d'informations erronées quant aux émissions de HAP * relatées, qui n'ont aucune mesure avec la réalité tant passée que présente.

Dans l'optique de clarifier la situation à l'égard des émissions de HAP provenant des activités d'Alcan au Saguenay-Lac-Saint-Jean, nous souhaitons apporter à votre attention les informations suivantes :

- Contrairement à vos affirmations, il n'y a jamais eu d'émissions de 300 000 t/an de HAP dans la région du Saguenay. Environnement Canada a publié en 1990 que l'ensemble de l'industrie de l'aluminium au Canada émettait à l'atmosphère 925 t/an de HAP. D'autre part, depuis le milieu des années 1970, les rejets liquides de HAP provenant d'Alcan dans les émissaires ont été réduits de façon continue et drastique, grâce à des pratiques soucieuses de protéger l'environnement et à la mise en place d'équipements de traitement des eaux.

* Hydrocarbures aromatiques polycycliques générés, entre autres, par les alumineries de type Söderberg

Ces efforts d'Alcan ont d'ailleurs été reconnus dans le cadre du Plan d'action Saint-Laurent. Les rejets liquides démontrent maintenant une quasi-élimination de la présence des HAP dans les émissaires (Martel 1986, Cossa 1990). Selon Cossa, les plus hauts flux de HAP dans les sédiments du Saguenay ont été observés vers les années 1968 et, depuis, ils n'ont cessé de diminuer.

- Les émissions atmosphériques au Saguenay Lac Saint-Jean de HAP issues des activités d'Alcan ne sont plus qu'une fraction de ce qu'elles étaient avant 1970, soit plus de 80% plus faibles, et en l'an 2000, elles étaient d'environ 235 t/an; les efforts de réduction se poursuivent. En 2001, l'implantation dans toutes les usines utilisant l'ancien procédé Söderberg d'un nouveau brai à faible teneur en HAP, qui sert à la fabrication des anodes, permet d'estimer que les émissions dans la région diminueront encore d'au moins 50%. Les mesures sont en cours et seront disponibles en début 2003 ou avant.

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- Le
de 1996 seront publiées l'an prochain par les nombreux chercheurs impliqués et que vous connaissez bien pour la plupart. Les résultats préliminaires font état d'une «encapsulation» stable des sédiments contenant des HAP, depuis quatre ans.

- Les études épidémiologiques réalisées chez les travailleurs d'Alcan n'ont pas révélé un

n'étaient utilisés que comme indicateurs et non comme agent causal.

Cela précisé, il importe d'ajouter que des améliorations considérables ont été réalisées par Alcan sur le plan des émissions des HAP au cours des 25 dernières années. Ces résultats tangibles et démontrés sont nettement significatifs et à l'opposé de vos propos à l'effet que la situation se détériore au lieu de s'améliorer.

Quant aux affirmations reliant les cancers des bélugas à un excès semblable dans la population

The atmospheric release of PAHs is only a fraction (20%) of what it was before 1970...

... and in 2000, it was about 235 tons per year

Since 2001, a new (electrolytic) process releasing less PAHs has been used in all smelters...

(well... Wrong!)

Copy to:

- President (U de M)
- Vice President (U de M Research)
- Dean (College of Veterinary Medicine. U de M)
- Vice Dean (Vet Med, Research, U de M)
- Director, Pathology Department, Veterinary Medicine, U de M

Pour ce qui est du domaine de la santé publique, les Dr Kennedy et Larouche de la Régie régionale de la Santé et des Services sociaux ont émis un communiqué (ci-joint) indiquant « qu'aucune étude scientifique n'a pu mettre en évidence de façon concluante un lien entre des excès de cancers dans une population avoisinant une aluminerie et les rejets de HAP par cette industrie ». Ils ajoutent que « l'exposition via l'eau potable est négligeable, qu'on ne peut en tenir compte ».

En terminant, nous réitérons notre volonté d'entretenir des communications transparentes et continues avec l'Université de Montréal, dans un climat de franche collaboration, ceci afin d'éviter que des informations erronées soient véhiculées auprès de la population.

Veuillez agréer, Monsieur, l'expression de nos meilleurs sentiments.

André Chevalier
Directeur, Affaires générales - Québec

p.j.

c.c.:

Université de Montréal :

Monsieur Robert Lacroix, recteur

Monsieur Alain Caillé, vice-recteur à la recherche

Monsieur Raymond S. Roy, doyen, Faculté de médecine vétérinaire

Monsieur Youssef El Azhary, vice-doyen à la recherche et au développement, Faculté de médecine vétérinaire

Monsieur Roger Ruppanner, directeur du département de pathologie et de microbiologie, Faculté de médecine vétérinaire

Alcan to
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The final blow to the facility e of
the Canadian dollar. Alcan sa e in
the value of the loonie has bee than the
recent rise in the market price o inum.
Alcan said "normal employee turn er" in the
next two years will provide it with "a window of
opportunity" to reduce the impact of the closure.
Alcan vice president Jean Simon said the
company will do everything it can to prevent
layoffs and said a number of jobs will be cut
through attrition.
But the announcement is still a major blow to the
town of Arvida, which was founded back in 1925
for the sole purpose of giving Alcan workers a
home in the Saguenay.
Alcan plans to begin closing the facility next
month, with the final shutdown slated for April.
Alcan said the smelter accounts for 3 per cent of
Alcan's global production capacity.
Alcan is the world's biggest aluminum producer in
the world. It has 88,000 employees in 60
countries.

"Closing a plant is never an easy decision, but as a corporation dedicated to economic and environmental sustainability, we must make the decisions that are required to be both environmentally responsible and protect Alcan's competitive position globally,"

– Alcan CEO Travis Engen. (January 2004)

Web Posted | Jan 22 2004 05:42 PM EST

Alcan to shut Arvida smelter

MONTREAL - Alcan has an[illegible] the closing of its aluminum smelter in Arvid[illegible] jeopardy in the Saguenay[illegible]

The head of the company[illegible] primary metal group, Cyn[illegible] Carroll, said the 60-year-[illegible] smelter uses outdated technology and produces[illegible] much pollution.

« The head of the company ..said the 60-year-old smelter uses outdated technology and produces too much pollution » - January 22, 2004

Alcan's Saguenay smelter

The closure will be a blow to workers in the region, but Carroll said the company can't afford to keep the plant open, saying the smelter's technology has reached the end of its lifespan.

Conclusions

- Diseases contributing to the lack of recovery of that population:

Cancers

- PAHs: environmental carcinogens
- Aluminum workers: **urinary bladder, lung, gastric cancers**
- People living in the Saguenay area: digestive cancer
- **Smelter closed in 2004 instead of 2016**
- **NO MORE CANCERS IN BELUGA WHALES**
- **Decrease of CANCER IN PEOPLE**

PCB-induced immunosuppression

Parasites

Dystocie / mother-calf separation

Future research

1) **Biomarkers:**

PAH adducts in fish

PAH adducts in wild animals (woodchucks)

PAH metabolites in urine, of animals, of people,

of aluminum workers (??!!)

2) Molecular epidemiology of cancer

Nucleotide sequence of the p53 cDNA of beluga whale

3) Transgenic mice

cDNA Cloning and Characterization of a High Affinity Aryl Hydrocarbon Receptor in a Cetacean, the Beluga, *Delphinapterus leucas*

- BA Jensen and ME Hahn. Toxicol Sci. 2001 64(1):41-56

- Xu N, Shiraki et al. Gene 2002 288(1-2):159-166

Future research

4) Microarrays to measure gene expression:

- **Toxicogenomics**
- **Stress genes**

Future research

OTHER ASPECTS of ENVIRONMENTAL DEGRADATION

POLLUTION ?

NOISE: marine traffic, wind farms, military sonars

STRESS: Ex.:

EASTERN PACIFIC DOLPHINS CHASED IN TUNA FISHERIES

COMMERCIAL WHALE OBSERVATION

THE END