BriGHT - Bridging Global Change, Inuit Health and the Transforming Arctic Ocean

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BriGHT PROJECT

UNIVERSITÉ LAVAL

Sentinel North

What we wanted to do: Study the effects of climate change, such as shorter ice seasons or ocean acidification, on nutrients and contaminants in the marine food web, and how this impacts Inuit health and food security.

Québec Océan · ArcticNet · CHU de Québec Centre de recherche · Forêts, Faune et Parcs Québec · Littoral · Société Makivik / Makivik Corporation · Nunavik Marine Region Wildlife Board · Takuvik · Institut national de santé publique Québec · Pêches et Océans Canada · Régie régionale de la santé et des services sociaux du Nunavik / Nunavik Regional Board of Health and Social Services

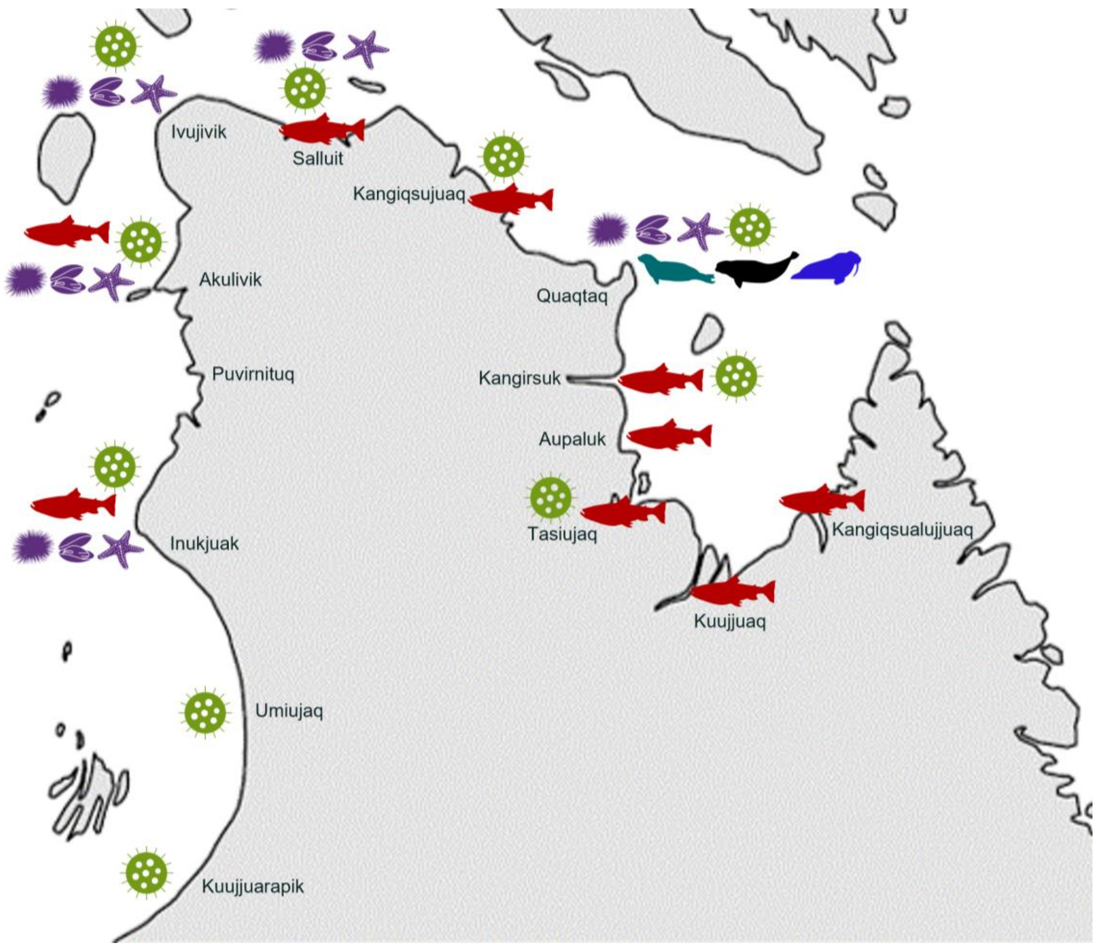
WHAT DID WE SAMPLE?

Which species?
We sampled microalgae, seafloor organisms (urchins, sea stars, mussels, scallops), Arctic Char, and marine mammals (seals, belugas, walruses).

Where?
We sampled marine organisms in the three marine regions of Nunavik (Hudson Bay, Hudson Strait and Ungava Bay).

When?
Marine organisms were sampled during the summer from 2017 to 2019.

Which molecules?
Back at our lab, we studied omega-3 fatty acids, pigments, vitamin A, selenoneine and mercury.



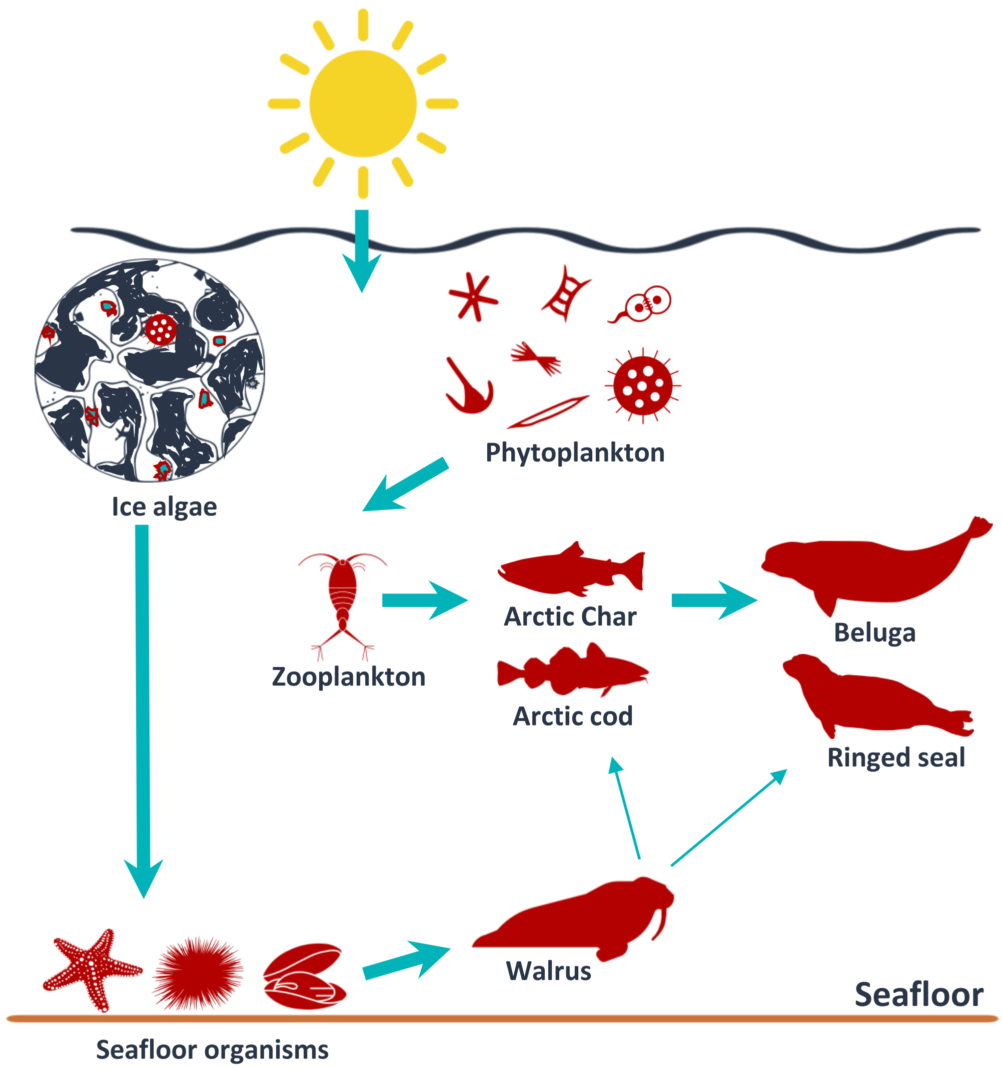

Canada
C-GCOB

THE MARINE FOOD WEB

Nunavimmiut choose local marine foods according to their preferences, accessibility, abundance, appearance and quality.

The amount and quality of marine foods depend on how much sunlight and nutrients are available.

The image on the right shows a simplified version of the marine food web in Nunavik.



Microalgae are the “engine” of the marine food web because they are key sources of food for seafloor species, fish and marine mammals – and us humans. Like other plant species on the land, they use light and natural elements in the ocean to carry out photosynthesis and produce biomass, on which other species can feed.

In this process, microalgae produce **nutrients**, such as omega-3 fatty acids (good fats), carotenoid pigments (antioxidants), and vitamins. Changes in the availability of sunlight or ocean acidification due to climate change can affect the amount of nutrients produced and thereby, modify the nutritional quality of marine foods. Microalgae also slightly absorb contaminants, which accumulate in some top predator species.

NUTRIENTS & CONTAMINANTS

What are omega-3 fatty acids?

Omega-3s (EPA and DHA) are good fats produced by microalgae. Fish, marine mammals and humans absorb omega-3s through their food. These fats are important for fish and marine mammals' development. In humans, they are crucial for the brain development of the baby during pregnancy and are important for a healthy heart.

What are carotenoid pigments?

Carotenoid pigments are also produced by microalgae and ingested by fish, marine mammals and humans through their diet. These pigments can colour an animal's flesh. For example, the pigment *Astaxanthin* is responsible for the red colour of Arctic Char flesh while other pigments are responsible for the orange color of the flesh. In humans, these pigments can help the body fight against cellular damage (antioxidant properties).

What is vitamin A?

Vitamin A is synthetized from some carotenoid pigments. Fish, marine mammals and humans acquire vitamin A through their diet. Vitamin A is associated with a good vision (particularly at night), it helps the body fight against infections, and is important for reproduction and communication between body cells.

What are selenium and selenoneine?

Selenium is an element naturally found in sea water. Selenoneine is a molecule made of selenium and produced by bacteria and fungi in the marine environment.
We are currently studying if marine animals obtain selenoneine from their diet or if it is directly produced by organisms colonizing their skin. In humans, selenoneine is known as a powerful antioxidant that could eventually contribute to reduce the harmful effects of mercury. More studies to come!

Check out our video to learn more about selenoneine!

What is mercury?

Mercury is naturally found in the soil but recirculated into the environment by human activities, such as burning of coal, oil and wood, and artisanal gold mining activities in other parts of the world. Although there is no major source of mercury in the Arctic, it is transported to the poles by long-range atmospheric and marine currents. It accumulates in the aquatic food chain, primarily in predatory fish and marine mammals. People accumulate mercury when eating these species. Mercury is a contaminant which is harmful for the brain development of the baby and child.

* Note that our results are always presented in wet weight and when we mention mercury, we refer to methylmercury.

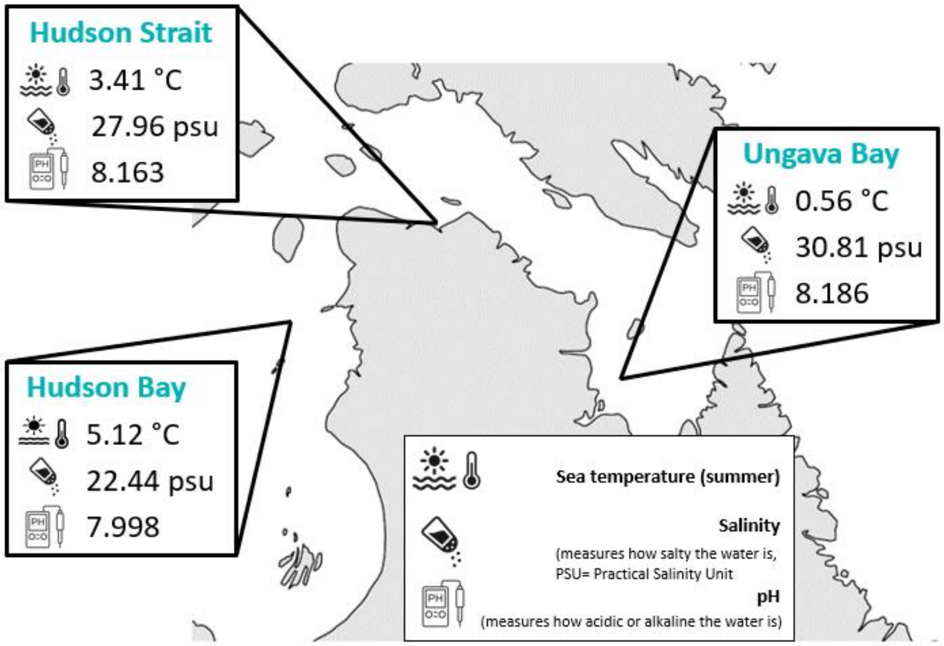
OCEAN WATER PROPERTIES & NUTRITIONAL QUALITY OF MICROALGAE

KEY MESSAGES

Sea surface temperature during the summer was highest in Hudson Bay (5.12°C) and got colder following the coast to Ungava Bay (0.56°C). The **salinity** levels also followed this gradient from the lowest level in Hudson Bay to the highest in Ungava Bay. The **pH** values were similar in all three regions following the trend from low (Hudson Bay) to high (Ungava Bay) (*see map on the right*).

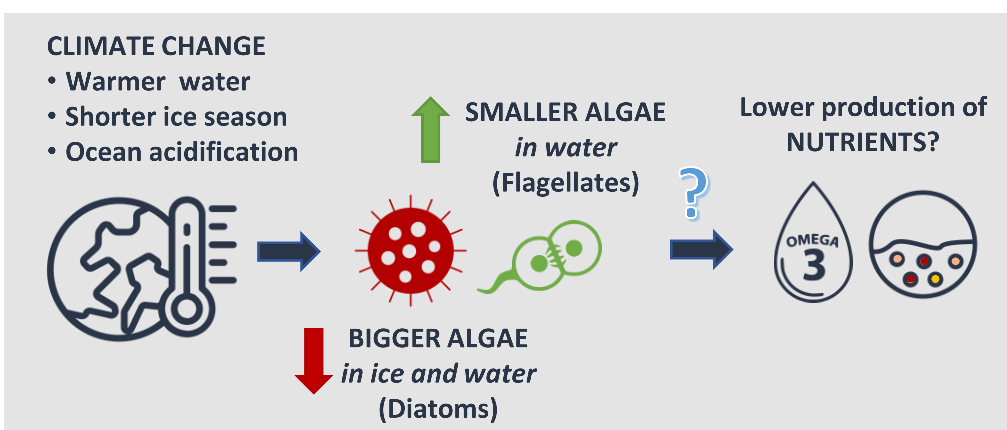
We found that levels of **omega-3 fatty acids** and **pigments** were higher in microalgae when there was a higher proportion of bigger microalgae (*see figure on the bottom right*).The levels of nutrients were lower at warmer temperatures.

Our results suggest that **climate change** may lead to a lower production of organic nutrients for the whole marine food web due to a progressive shift from bigger to smaller microalgae in the water.



WATER PROPERTIES & CLIMATE CHANGE

Microalgae (ice algae and phytoplankton) are the only organisms in the marine food web which can produce nutrients like omega-3 fatty acids or pigments. Climate change affects the ocean's temperature (warmer), salinity (less salty), pH (more acidic) and nutrients. This could alter the ***composition and nutritional quality of microalgae*** *and thereby affect the whole food web, including humans who eat marine species.*



NUTRITIONAL QUALITY OF SEAFLOOR ORGANISMS

KEY MESSAGES

Seafloor organisms like mussels, scallops, urchins and sea stars have different nutritional values depending on whether they are carnivorous or filter feeding (*see explanation on the right*).

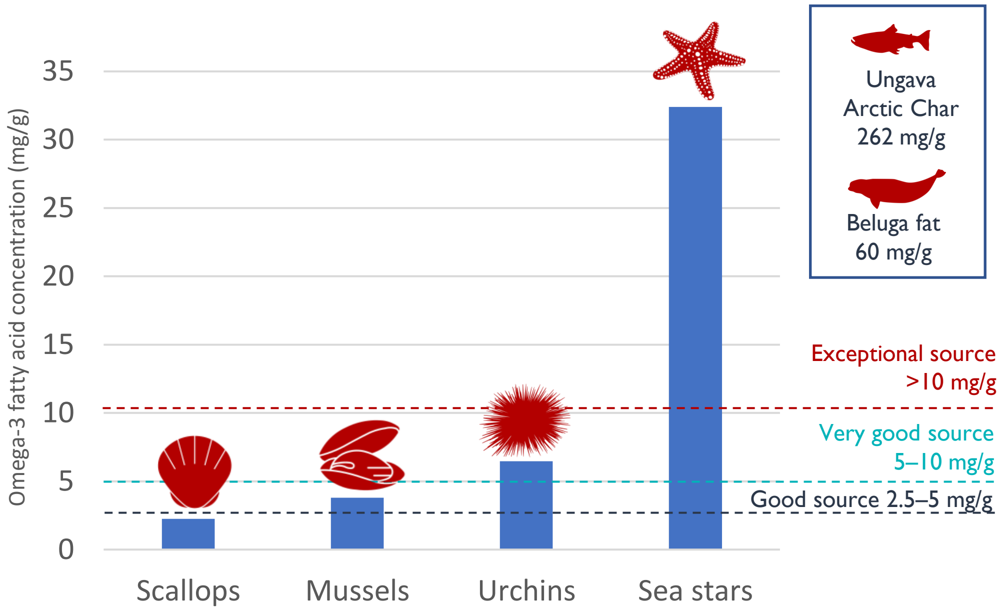
Sea stars are carnivorous and are exceptionally high in **omega-3 fatty acids**. All other species also have good or very good omega-3 levels.

Mussels and sea stars have very good levels of **selenium** but beluga mattaaq levels are even higher. Scallops and urchins are also good sources.

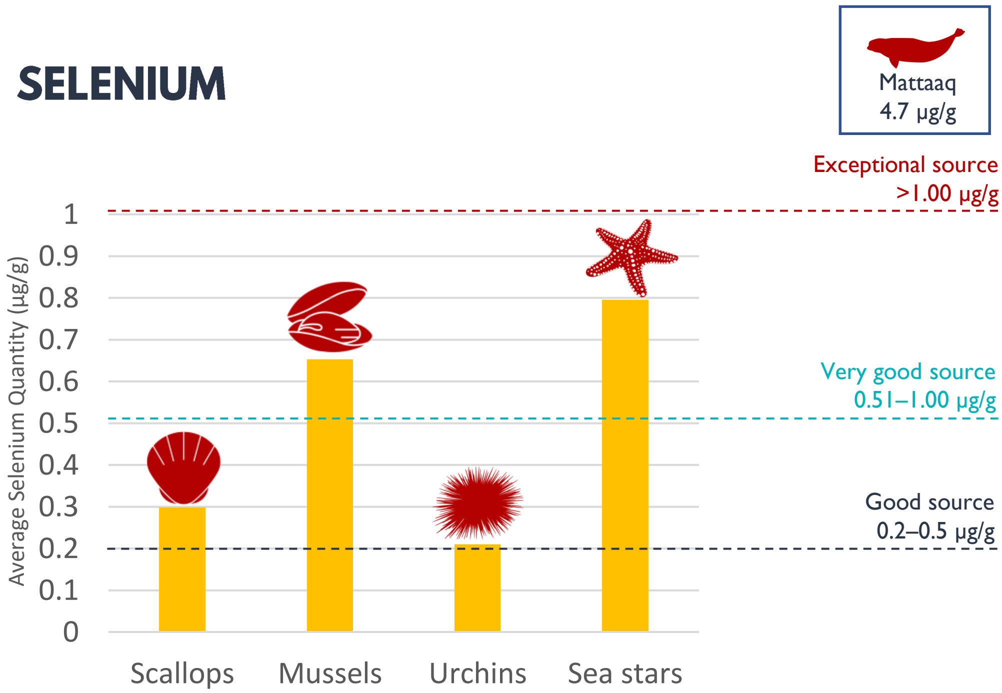
Nutrient levels in filter-feeding seafloor organisms don't seem to change according to the algae on which they feed (ice algae or open-water phytoplankton). Good news! This means that a decline in ice algae due to **climate change** may not impact the nutrient content in seafloor organisms.

Seafloor organisms live on the seafloor. They are called ***filter feeding*** *if they feed on microalgae that fall from above by filtering the water, or* ***carnivorous*** *if they feed on other seafloor organisms. These species are directly consumed by Nunavimmiut and by animals that are part of the traditional diet such as walruses and ducks.*

OMEGA-3 FATTY ACIDS



SELENIUM



DIET & NUTRITIONAL QUALITY OF ARCTIC CHAR

KEY MESSAGES

Our results show that the **diet** of Arctic Char and its nutrient content differ between Nunavik regions but are similar in nearby rivers. They also highlight that small Char mostly feed on zooplankton, while bigger Char eat more fish.

Flesh and liver are both excellent sources of **omega-3 fatty acids**. Although the level is lower in Hudson Bay, it is still an excellent source. In addition, bigger fish accumulate higher total fat reserves.

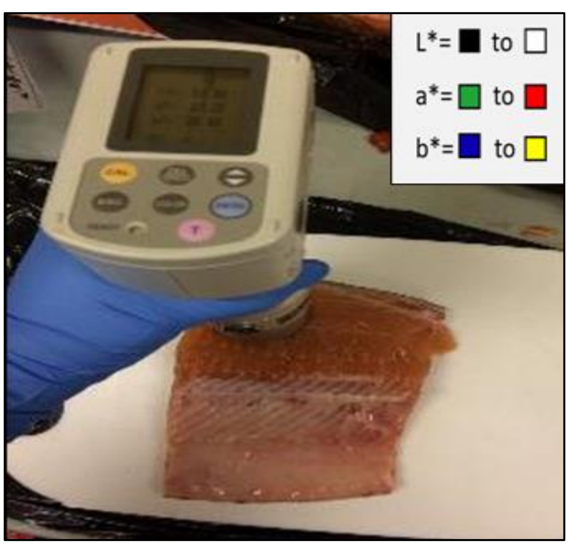
Char in Ungava Bay are higher in **Astaxanthin** (red pigment). Therefore, these fish have a redder flesh colour than elsewhere in Nunavik. Moreover, Char with a lot of water in their flesh (soft meat) have a lighter colour.

No **vitamin A** was found in the flesh of Arctic Char, but low levels were found in its liver.

Arctic Char (Iqalukpiq) acquires its nutrients (omega-3 and pigments) mostly during the summer from its prey in the ocean. Since microalgae and zooplankton differ in Hudson Bay, Hudson Strait and Ungava Bay, we tested if there are regional differences in Arctic Char diet and in the nutrients in its flesh and liver.

Inuit know that Arctic Char in Ungava Bay is redder than elsewhere. Although its colour changes from region to region, our results show that **Arctic Char is an excellent source of omega-3, no matter the colour**!

	Hudson Bay	Hudson Strait	Ungava Bay
DIET	Mostly fish	Fish, seafloor organisms & zooplankton	Seafloor organisms & zooplankton
OMEGA-3			
PIGMENTS			
COLOUR			



Colorimetry measures flesh colour

Next steps:
How will climate change impact the diet and nutritional quality of Arctic Char?

GENETICS OF ARCTIC CHAR

KEY MESSAGES

Regional adaptation

Arctic Char from different regions can be viewed as separate populations. They are genetically distinct in Hudson Bay, Hudson Strait, Ungava Bay and Labrador, and adapted to their environment (temperature, precipitation salinity, etc.).

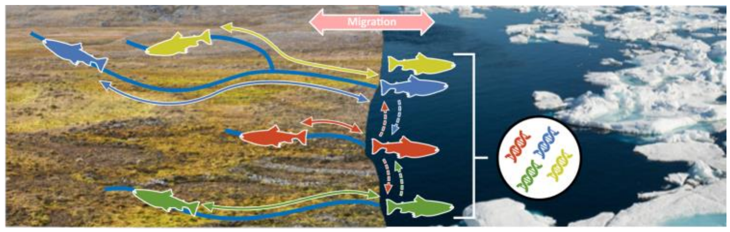
Rivers

In some adjacent rivers, populations cannot be distinguished (pie charts of the same colour in one region). This may indicate that more fish travel between those rivers. In other words, fish in nearby rivers are generally more similar.

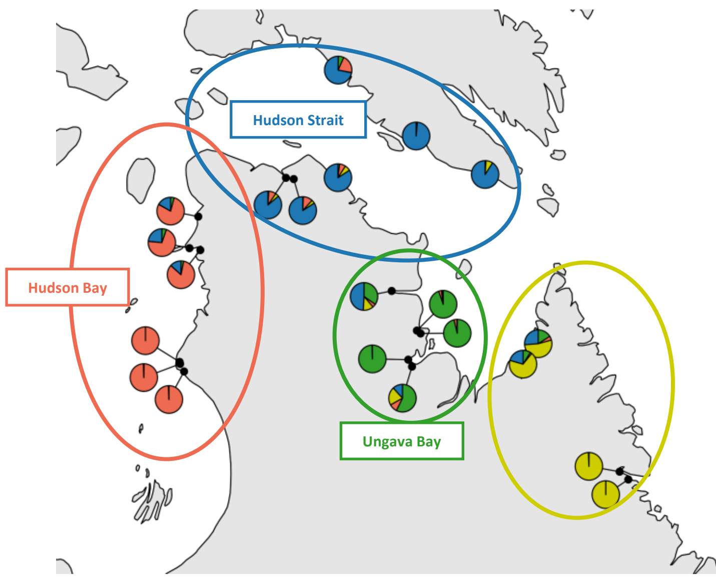
Implications for hatcheries

Fishing in one river could have impacts on nearby fish populations. Our results also confirm that fish source populations for hatchery and stocking projects should be chosen from a nearby river to make sure that stocked fish are as similar as possible to nearby populations to increase their chances of survival.

Arctic Char (Iqalukpiq) is a searun species. These fish spend the summer in the sea to feed and grow accumulating good nutrients. At the end of the summer, they migrate to rivers to spend the winter and to spawn. They mostly return to the same river where they were born. Therefore, Arctic Char from different rivers will form different populations which can be more or less isolated from each other.

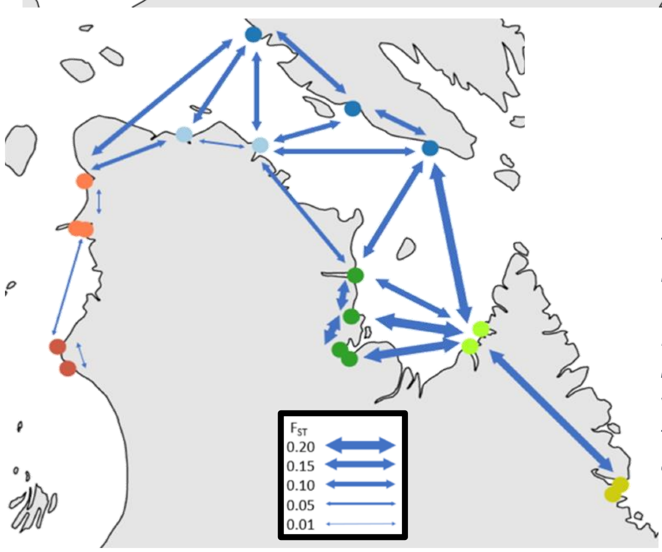


***Genetics** help us understand how Arctic Char from different rivers are related to one another. Higher genetic differences imply that they rarely breed together and that they may be adapted to different conditions, eat different things and respond to climate change in a different way.*



Separate populations

Arctic Char can be divided by region into separate populations (pie charts of different colours), which are genetically distinct.



Regional genetic differences

The bigger the arrow (higher F_{ST}), the higher the genetic differences between two populations.

E.g., Arctic Char populations are more different from each other within Ungava Bay (big arrows) than within Hudson Bay (small arrows).

NUTRIENTS & CONTAMINANTS IN MARINE MAMMALS

KEY MESSAGES

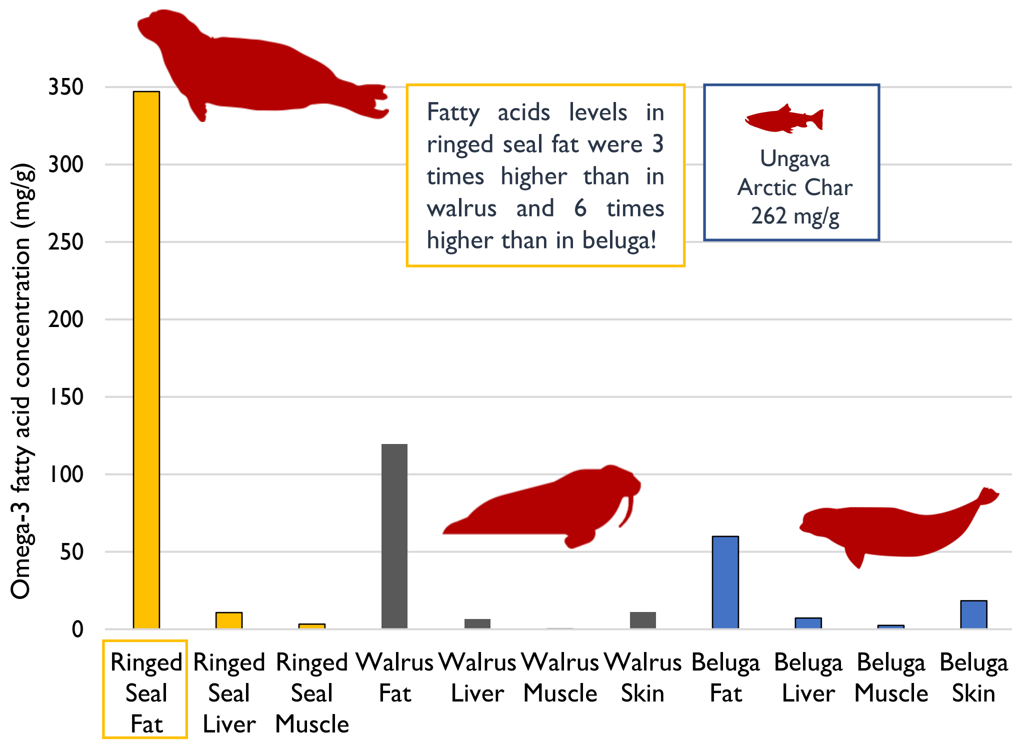
Our results show what Inuit communities already know: Marine mammals have distinct **diets**. These diets play an important role in the nutrient and contaminant levels of marine mammals.

The fat of marine mammals is exceptionally high in **omega-3 fatty acids**, especially the fat of ringed seals.

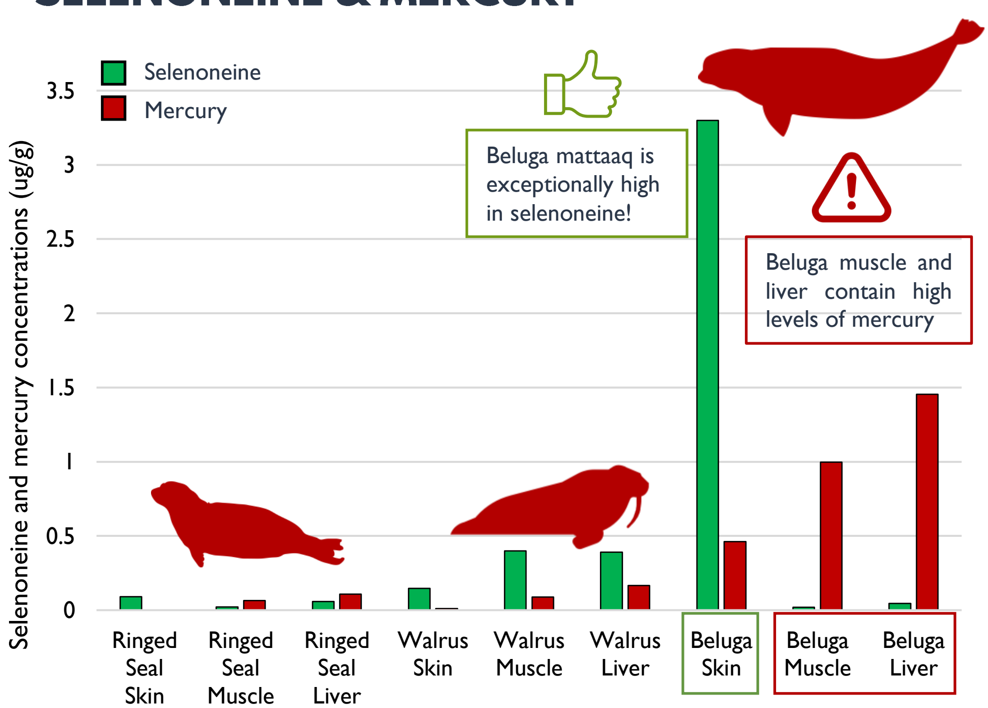
Selenoneine levels in beluga skin were incredibly high. Selenoneine in walrus was intermediate and the highest levels were found in muscle and liver. Selenoneine in ringed seal was relatively low, with the highest values found in the skin.

Pigments in the liver vary between species, which can indicate differences in their diet and/or habitat. Alloxanthin in beluga liver, a pigment primarily produced by small algae in estuaries, shows that belugas probably use estuaries as feeding grounds.

OMEGA-3 FATTY ACIDS



SELENONEINE & MERCURY



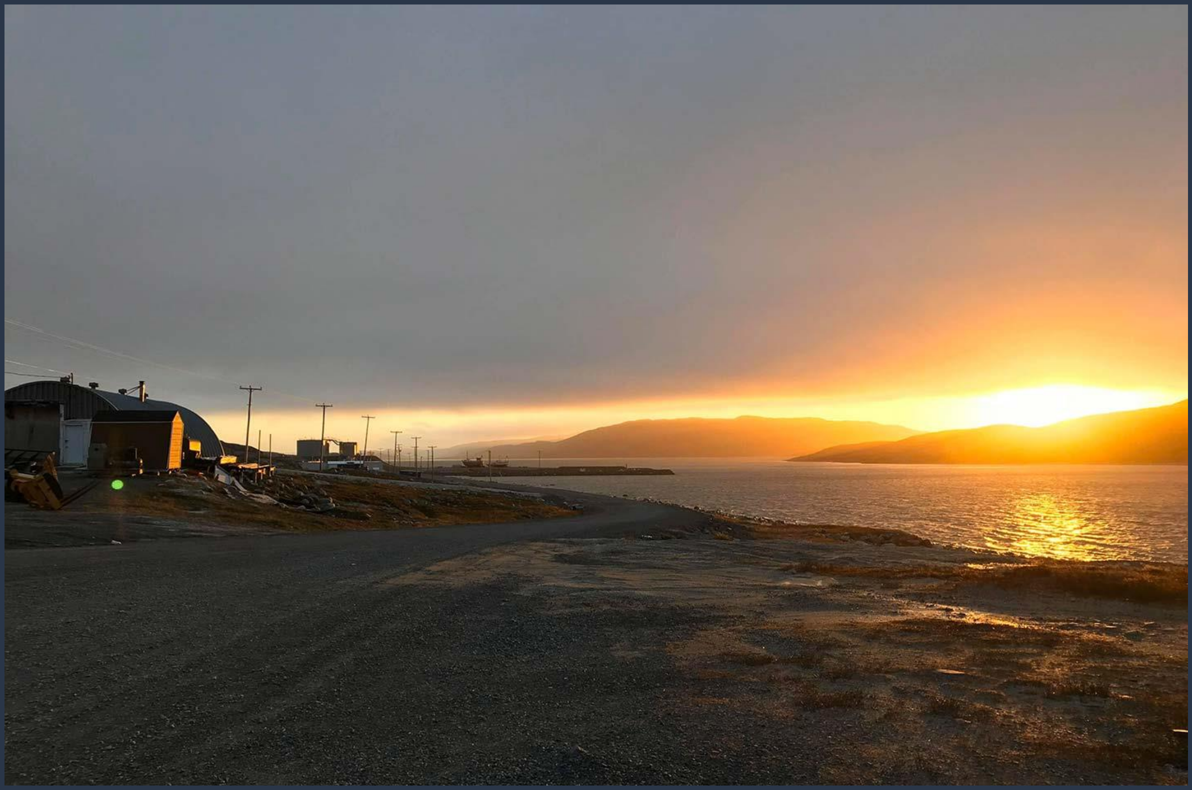
WHAT'S NEXT?

With the BriGHT team and Nunavik colleagues we now aim to bring all these findings together to better understand the potential impacts of climate change on the different species in the marine food web, their nutrient content, and eventually Inuit nutrition and health. Stay tuned!

If you want our team to present these findings and talk about the links between environmental changes and health in your community or at your school or organization, please let us know!

Several related projects related have just started.
Don't hesitate to contact us if you have any questions or wish to join our project teams!

- *Food system modelling: Sustainable and resilient country food systems for future generations of Nunavimmiut - promoting food security while adapting to changing northern environments*
- *Selenoneine in bivalves and beluga in Quaqtaq*
- *FISHES (Fostering Indigenous Small-scale Fisheries for Health, Economy, and Food Security)*
- *Tininnimiutait: Assessing the potential of local marine foods accessible from the shore to increase food security and sovereignty in Nunavik*



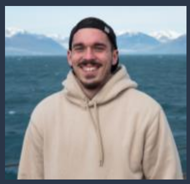
TEAM BriGHT




The BriGHT project was led by the following researchers at Laval University:
Mélanie Lemire, Jean-Éric Tremblay, Jean-Sébastien Moore and Philippe Archambault





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Catherine van Doorn – Seafloor organisms
Sara Bolduc – Arctic Char
Xavier Dallaire – Arctic Char
Guillaume Cinq-Mars – Marine mammals
Francis Dufour – Food web

Other team members: Frédéric Maps, Sara Pedro, Louis Bernatchez, Pierre Ayotte, Pierre Dumas, Adel Achouba, Adriano Magesky, Johann Lavaud, Guillaume Massé, Rebecca Hennigs

Questions? Want to know more? Contact us!

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NAKURMIK

to all the community members who were involved in this project for their time, knowledge and hospitality!