Spatial variation in ringed seal tooth morphology and its relationship to diet

by

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Abstract

The degree of multi-cusped dentition has been associated with dietary differences among seal species. However, little research has focused on intraspecific variation in dentition in relation to diet. Ringed seals are opportunistic feeders whose diet varies with geographic location and season. Their trophic position increases with latitude, suggesting that high Arctic individuals occupy a higher trophic level than those in lower latitudes. This spatial trophic position shift is likely due to a higher consumption of fish in the high Arctic ringed seals than at lower latitudes, where relatively more invertebrates may be consumed. As opportunistic feeders, ringed seal tooth morphology may vary depending on their diet across the circumpolar Arctic. We compared postcanine tooth morphology of ringed seals from high latitudes (Grise Fiord) and lower latitudes (Sanikiluaq), in relation to their diet, which was analyzed through their muscle $\delta^{15}N$ values, reflecting trophic level. We examined four tooth characteristics: height, gap width, jaggy index and width-height ratio. Most showed no significant relationships with location or diet. Tooth height was the only variable affected, with shorter teeth at the southern location and tooth height increasing with $\delta^{15}N$. As seals aged, tooth height decreased, the width-height ratio increased, and teeth became less jagged (lower jaggy index). Gap width showed no relationships with location, diet or age. These results suggest that tooth size, rather than shape, may play a more important role in dietary adaptation for ringed seals. In particular, increased tooth height in high Arctic ringed seals may enhance their ability to retain fish prey, consistent with a higher reliance on fish relative to the low Arctic ringed seals. These results provide insights into how Arctic mammals adapt to differences in prey availability as the Arctic warms over time.

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Introduction

The ability to generate heat as a byproduct of cellular activity, known as endothermy, has existed for at least 160 mya (Ruben and Jones 2000; Seebacher 2003; Grigg et al. 2004). The basal aerobic metabolic rates of mammals and birds, both endotherms, are 5 to 8 times greater than those of ectotherms, which regulate their body temperature using external sources like the sun (Koteja 2000; Seebacher et al. 2006). High energetic demands of endotherms require efficient food consumption, in which teeth are used as tools that allow the mechanical breakdown of food (Lucas et al. 2008; Martin et al. 2016).

In many cases, the teeth morphology of an organism is related to their type of diet (Ishihara et al. 2024). Teeth exhibit a variety of different characteristics that vary according to the size, shape, texture and hardness of the type of prey consumed (Van Valkenburgh 1989). For example, in some terrestrial animals, rounded postcanine teeth are more common in species that feed primarily on nonvertebrate prey (Van Valkenburgh 1989). As another example, extant carnivore lepidosaurs and crocodylians, which feed on vertebrate prey, have a simple, sharp tooth morphology that can be useful for cutting through tissue (Schwenk 2000; Melstrom 2017). In contrast, insectivore lepidosaurs and crocodylians, who rely on arthropod prey, show a range of tooth complexities, typically bearing one to three cusps, that likely aid in breaking down insect cuticles (Melstrom 2017).

The degree of multi-cusped dentition has been associated with dietary differences among seals, whether their diet consists of fish, zooplankton, or both (Ishihara et al. 2024). For example, the teeth morphology of Antarctic leopard seals (*Hydrurga leptonyx*) and Crabeater seals (*Lobodon carcinophaga*), particularly their postcanine teeth, function as a sieving mechanism that facilitates feeding on small prey such as krill (Hückstädt et al. 2012; Hocking et al. 2013).

Additionally, out of five northern seal species, including harbour seal (*Phoca vitulina)*, spotted seal (*Phoca largha)*, Baikal seal (*Pusa sibirica)*, ringed seal (*Pusa hispida)* and Caspian seal (*Pusa caspica)*, Baikal seals exhibited the highest level of multi-cusped postcanine teeth (Ishihara et al. 2024) (Fig. 1a & b) and were the seal species that also consumed relatively more zooplankton than the other four species (Ishihara et al. 2024). Multi-cusped teeth allow seals to capture pelagic amphipods and aid in expelling excess water to avoid ingestion (Ishihara et al. 2024; Kienle and Berta, 2016). In contrast, the two *Phoca* species (harbour seal and spotted seal) analyzed were primarily fish consumers (Boveng et al. 2013; Härkönen 1987), with a shorter gap width between their teeth as well as wider teeth, traits thought to enhance their ability to puncture and consume fish (Ishihara et al. 2024). Additionally, increased tooth height facilitates the fracture of vertebral tissue (Popowics 2003), while a narrower gap width has been associated with pierce feeders (Churchill and Clementz 2015). The research on the five northern seal species focused on interspecific differences in dietary habits, but there is little research focused on intraspecific variation in dentition related to diet, despite there being a large amount of literature documenting spatial variation in the diet of a species in relation to resource availability (Parker et al. 2022; Walker et al. 2023).

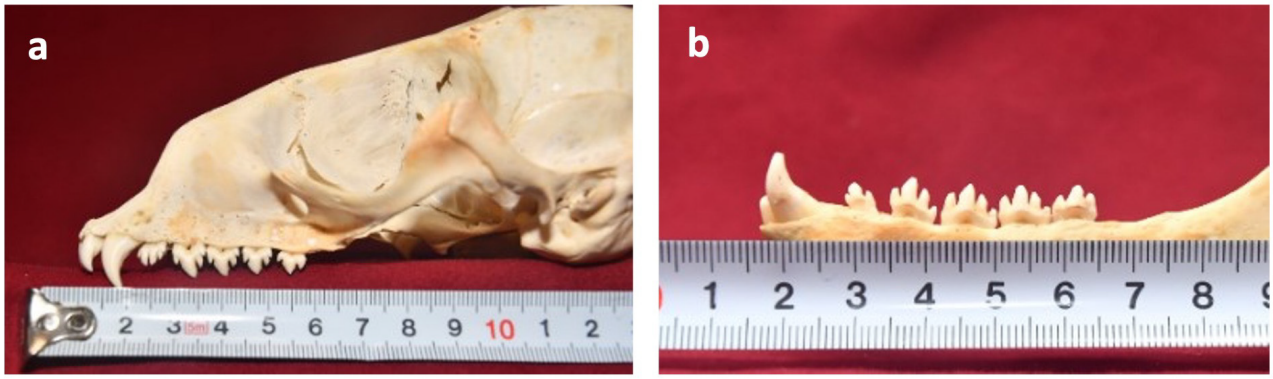


Figure 4. Baikal seal (a) maxilla and (b) mandible with multi-cusped teeth. Adapted from Ishihara et al. (2024).

Ringed seals have a circumpolar distribution and inhabit Arctic waters of Canada, Russia, Alaska, Svalbard, and Greenland (Labansen et al. 2007; Reeves 1998). Ringed seals are an important resource for northern communities and Inuit culture and are also the primary prey item of polar bears (Reeves 1998). Ringed seals are opportunistic feeders whose diet varies depending on geographic location and season (Lowry et al. 1980), suggesting that their diet varies with resource availability. In Alaska, ringed seals consume a variety of organisms throughout the year, including saffron cod (*Eleginus gracilis*), Arctic cod (*Boreogadus saida*), shrimp, hyperiid amphipods and euphausiids (krill) (Lowry et al. 1980). Ringed seals from Norway primarily feed on Arctic cod, fish from the *Stichaeidae* family and the *Cottidae* family (Labansen et al. 2007). Northeast Greenland ringed seals mainly feed on the *Parathemisto libellula* amphipod and Arctic cod (Labansen et al. 2011). In Canada, near Resolute Bay, ringed seals primarily consume Arctic cod (Matley et al. 2015). In addition, polar cod (*Arctogadus glacialis*) and Arctic cod were the primary resources of ringed seals in Grise Fiord and Qaanaaq, Greenland (Holst et al. 2001).

Ringed seal trophic levels increase with latitude, suggesting that high Arctic ringed seals, inhabiting locations such as Grise Fiord, have a higher trophic position than low Arctic ringed seals, inhabiting locations like Arviat (Carlyle et al. 2022). This spatial trophic position shift is likely due to a higher consumption of fish in the high Arctic ringed seals than at lower latitudes, where relatively more invertebrates may be consumed (Yurkowski et al. 2016; Carlyle et al. 2022). Ringed seals exhibit multi-cusped dentition with typically four cusps per tooth. Since ringed seals are opportunistic feeders, their tooth morphology may be slightly different depending on their diet across the circumpolar Arctic. Teeth with more defined cusps could be beneficial used as a sieve (Ishihara et al. 2024), while taller teeth may be advantageous for the fracture of vertebrae tissue (Popowics 2003), which may be beneficial for high Arctic seals that have been observed to consume more fish than low Arctic seals (Carlyle et al. 2022).

The objective of this research was to examine whether postcanine tooth morphology in ringed seals varied with latitude in relation to their diet. We compared postcanine tooth morphology of ringed seals from high-latitudes (Grise Fiord) and lower-latitudes (Sanikiluaq), in relation to the δ^{15}N, where lower δ^{15}N values would indicate more invertebrate consumption and a higher δ^{15}N would indicate more fish consumption. We hypothesized that variation in tooth morphology across latitudes reflects the diet of ringed seals. We formulated separate predictions for the two study locations. Each prediction corresponds to morphological characteristics that may be advantageous depending on the habitat. We predicted that high Arctic ringed seals, which primarily consume fish, would have a significantly greater width-height ratio and tooth height, since narrow, pointed teeth would efficiently puncture fish, preventing them from escaping. We further predicted that lower Arctic ringed seals would exhibit a significantly higher jaggy index and a smaller gap width. These predictions were based on the following considerations. First, the jaggy index quantifies tooth cusp definition and indicates tooth complexity. Low Arctic ringed seals may exhibit higher jaggy indices associated with their relatively lower level of fish consumption (Carlyle et al. 2022). Second, a smaller gap width should prevent zooplankton from escaping between the teeth. Overall, gap width and height will quantify tooth size, whereas jaggy index and width-height ratio will represent the tooth shape. We also examined bearded seal teeth, but a limited sample size precluded statistical analysis, so we have merely included a description of their teeth (Appendix A).

Methods

Study area and sample collection

Ringed seal samples were collected from Sanikiluaq (low Arctic) and Grise Fiord (high Arctic) in Nunavut, Canada, spanning latitudes 56.51°N to 76.50°N (Fig. 2). Ringed seals were harvested from Sanikiluaq between 2022 and 2024 (n=26) and from Grise Fiord between 2023 and 2024 (n=14).



Figure 2. Locations where ringed seals were harvested by community members between 2022 and 2024.

Community members from Sanikiluaq and Grise Fiord collected the samples during their subsistence harvests in accordance with a community-based monitoring program that is coordinated by Fisheries and Oceans Canada. The selection of which seal to hunt depended on the hunter. Seals are hunted year-round, but most hunting occurs in the spring and fall. Muscle tissue, along with other tissues, such as liver, blubber and claws, were collected, stored frozen

and shipped to the Freshwater Institute in Winnipeg for laboratory analysis. Seal age was determined using the lower right canine extracted from each mandible. Canines were aged by the Matson's Laboratory (Manhattan, MT, USA) by counting the cementum annuli from each tooth. The ringed seal mandibles analyzed in this project ranged from 1 to 45 years of age.

Photography Setup and Mandible Processing

Jaws were simmered in water to remove muscle tissue prior to photographing each mandible. We used forceps and a spatula to prepare the third postcanine tooth (PC3) by exposing the tooth's junction with the mandible, the cusps and the gap between the third and the fourth postcanine teeth (PC4) (Fig. 3a). Among the five postcanine teeth, PC3 and PC4 were among the least affected by age, sex, season and intra-individual variation, making them ideal for dietary analysis (Bethune et al. 2021). Photos for each mandible were taken using an iPhone 14, a photography light box, labels, a ruler, and a spatula (Fig. 3b). The work surface was cleaned with bleach before and after every photo session.

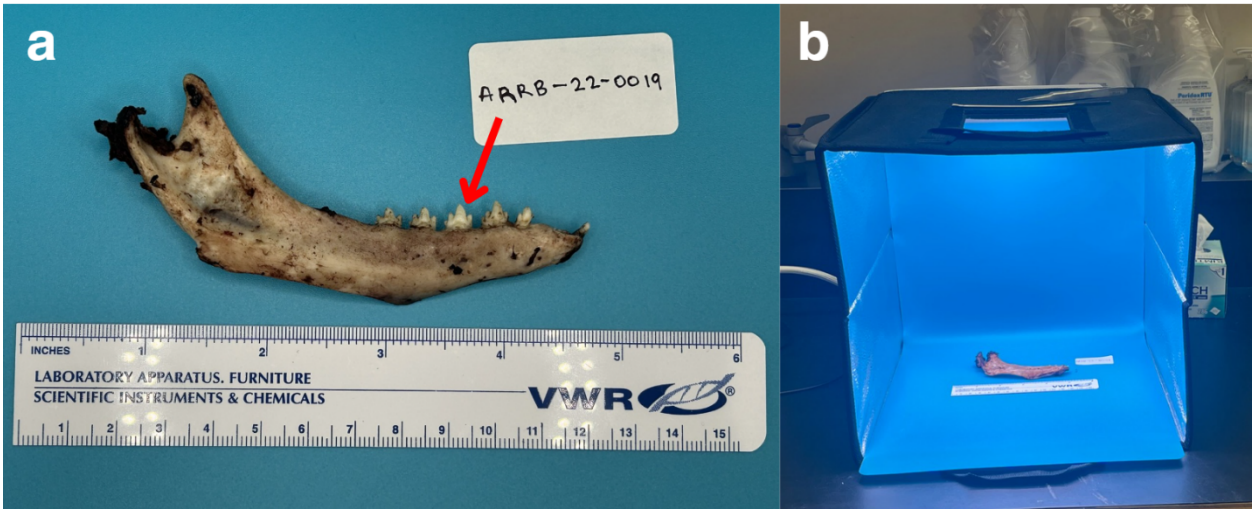


Figure 5. (a) Seal mandible with the cleaned PC3 (pointed out by the red arrow) and (b) equipment set up for mandible photography.

Tooth measurement description

Four variables were measured on the PC3, including the tooth width, tooth height, perimeter of the smallest bounding rectangle, and perimeter of the tooth. PC3 and PC4 teeth were chosen to measure the gap width between them (fifth variable). To provide unbiased measurements, two different readers (my coworker Abby and I) independently measured the same teeth. The tooth measuring methods were based on methods described in Ishihara et al. (2024). The ImageJ program (Rasband 1997) was used for measurement. As a first step, a reference line was drawn at the junction of PC3 and the mandible. All measurements were taken either perpendicular or parallel to this line to ensure consistent orientation of the measurements, as well as to reduce variability between the two individuals taking the measurements. Tooth width was measured with a straight line drawn parallel to the tooth-mandible junction line, measuring the distance between the two farthest tooth points (Fig. 4a). Another straight line perpendicular to the tooth-mandible junction line was drawn to measure the height of the tooth from the tallest cusp point to the base of the tooth (Fig. 4a). Using the freehand line tool, the perimeter of the tooth was outlined (Fig. 4b). The base of the tooth perimeter was the same as the tooth-mandible junction line. The smallest bounding rectangle was measured using the rotated rectangle tool, which included all the parts of the tooth (Fig. 4c). The last measurement was calculated by drawing a line between the PC3 and PC4 to calculate the gap width (Fig. 4d).

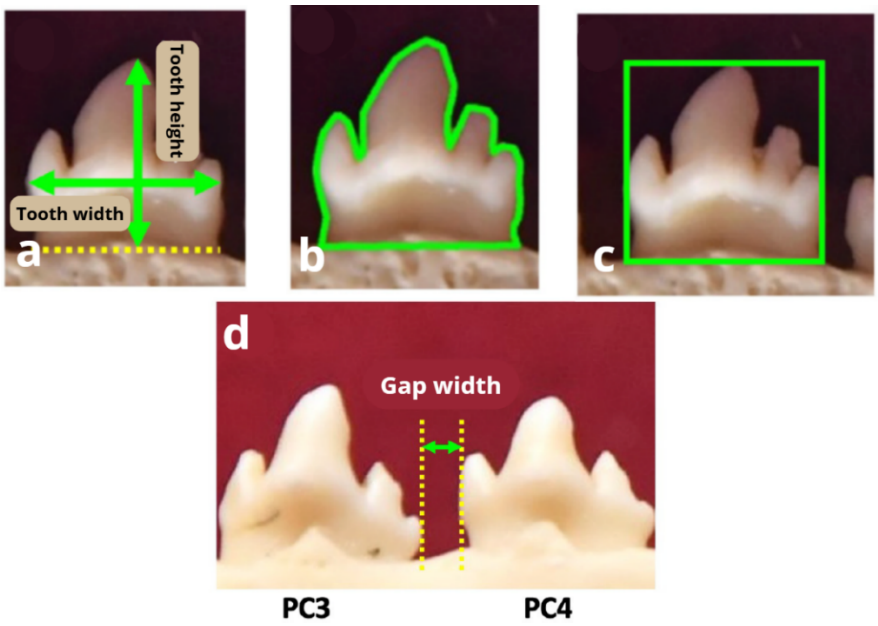


Figure 4. Example of tooth measurements. (a) Green arrows show the tooth height and tooth width. The yellow dotted line represents the tooth-mandible junction line. (b) The green line represents the tooth perimeter. (c) The green rectangle shows the perimeter of the smallest bounding rectangle. (d) The green arrow represents the gap width between PC3 and PC4. Adapted from Ishihara et al. (2024).

To reduce the variability of the measurements caused by using multiple tools, the freehand line tool was used to calculate the perimeter, width, and height of the tooth, as it also provided both the distance between the two farthest points for width and height. These measurements were used to calculate the smallest bounding rectangle: (width x 2) + (height x 2), limiting the methods to the freehand line and straight-line tools to calculate the gap width.

Two indices were calculated with the five variables taken, following the methods described in Ishihara et al. (2024). Jaggy index was calculated by dividing the perimeter of the tooth by the smallest bounding rectangle of the tooth measurement. This parameter represents the degree of cusp definition. The width-height ratio was calculated by dividing tooth width by tooth height. This parameter corresponds to the relative width of the tooth. These parameters allowed me to compare data between ringed seals from the two locations (Ishihara et al. 2024).

After taking the measurements and calculating the indices of 40 teeth by the two readers, we examined the percentage differences between measurements from both readers, which were minor, with an average difference of 2.46 %. Since differences were minimal across all variables, we calculated the average of all tooth variables and indices from both readers' data sets.

Stable Isotope Analysis

To investigate variation in the diet of ringed seals, we used stable isotope analysis. Isotopes are atoms of the same element that differ in the number of neutrons, where heavier isotopes have more neutrons in the nucleus, compared with lighter isotopes (Fry 2006). Stable isotopes do not decay over time, in contrast to radioactive isotopes, which do decay over time and may release energy that can be either harmful or beneficial (Fry 2006). The $\delta^{15}N$ of consumers' tissue reflects that of their prey (Caut et al. 2013), where $\delta^{15}N$ typically increases up the food web due to protein metabolism. Trophic position refers to an organism's level within a food web based on energy transfer from primary producers to top predators, and can be estimated by analyzing $\delta^{15}N$ in different tissues relative to the primary producers of its food web (Caut et al. 2013; Lesage et al. 2001; Levine 1980).

Muscle subsamples from ringed seals were obtained from frozen samples and put into 2ml plastic vials, then freeze-dried for 48 hours. Samples were then homogenized and lipid extracted using a 2:1 chloroform : methanol solvent. The samples were then weighed into tin capsules at 400 – 600 μg (Ogloff et al. 2019). Different tissues in an organism have different turnover rates, meaning that each type of tissue provides stable isotope information that reflects a specific time window in the organism's dietary history (Ogloff et al. 2019). Muscle isotopic half-life can range from 100 to 130 days, meaning that it takes this amount of time for muscle tissue to

reflect half of the isotopic shift resulting from a dietary change (Vander Zanden et al. 2015). Therefore, δ^{15}N values from the muscle of ringed seals represent diet over several months.

Statistical analysis

All data analysis, visualization and statistical tests were conducted using the R software version 2025.09.2. Four separate general linear models were conducted in which tooth length, gap width, jaggy index and width-height ratio were the dependent variables. Age, location, δ^{15}N and an interaction between location and δ^{15}N were the independent variables for each model. Age was included as a covariate to account for and explain ontogenetic variation in tooth morphology. The interaction between the location and diet was also considered as a variable since the δ^{15}N baseline of the primary producers may be different at each location (Como et al. 2012; Carlyle et al. 2022). Body length was initially considered as an additional variable, but it was not evaluated because of the limited sample size, and preliminary tests showed it was not significant. Thus we decided to continue with the age variable instead. We expected that these models would reflect the relationships between tooth morphology and diet in these two populations. The residuals for each model were analyzed to satisfy the assumptions of normality, variance homogeneity, linearity and independence of the general linear model. The Benjamini-Hochberg procedure (Haynes 2013) was used to calculate the threshold for the p-values since multiple models were conducted, to prevent Type 1 errors.

Results

Summary statistics, including mean and standard error for ringed seal tooth variables, δ^{15}N, age and body length are presented in Table 1.

Table 1. Mean (± SE) of tooth variables, $\delta^{15}N$, age and body length in ringed seals from the high Arctic (Grise Fiord, n=14) and low Arctic (Sanikiluaq, n=26).

Ringed seal variables	Grise Fiord	Sanikiluaq
Width (mm)	7.33 ± 0.22	6.49 ± 0.09
Height (mm)	6.03 ± 0.16	5.46 ± 0.13
Tooth perimeter (mm)	26.9 ± 0.8	23.8 ± 0.5
Smallest bounding rectangle (mm)	26.7 ± 0.7	23.9 ± 0.4
Width-height ratio	1.22 ± 0.03	1.20 ± 0.03
Gap width (mm)	1.06 ± 0.15	1.30 ± 0.10
Jaggy index	1.01 ± 0.02	0.993 ± 0.012
$\delta^{15}N$ (‰)	17.70 ± 0.15	15.4 ± 0.2
Age (years)	7.71 ± 3.21	10.0 ± 1.6
Body length (cm)	132 ± 3	124 ± 2

Tooth height decreased significantly with age ($t_{35} = -2.365$, $p = 0.024$) (Fig. 5a), was higher in high Arctic ringed seals than low Arctic ringed seals ($t_{35} = 2.530$, $p = 0.016$) (Fig. 5b), and increased with higher $\delta^{15}N$ values ($t_{35} = 2.662$, $p = 0.012$) (Fig. 5c), particularly in the high Arctic, as reflected in the significant interaction between $\delta^{15}N$ and location ($t_{35} = -2.590$, $p = 0.014$) (Fig. 5d). Width-height ratio was only significantly influenced by age ($t_{35} = 3.064$, $p = 0.004$) (Fig. 6), where tooth shape decreased with age; the effects of the location, diet and their interaction were all non-significant ($p > 0.1$). Jaggy index was also only significantly associated

with age (t_{35} = -4.817, p <0.0001) (Fig. 7) in that it decreased with age; the other variables showed non-significant effects (p > 0.3). Gap width was not significant with any of the four variables (p > 0.023).

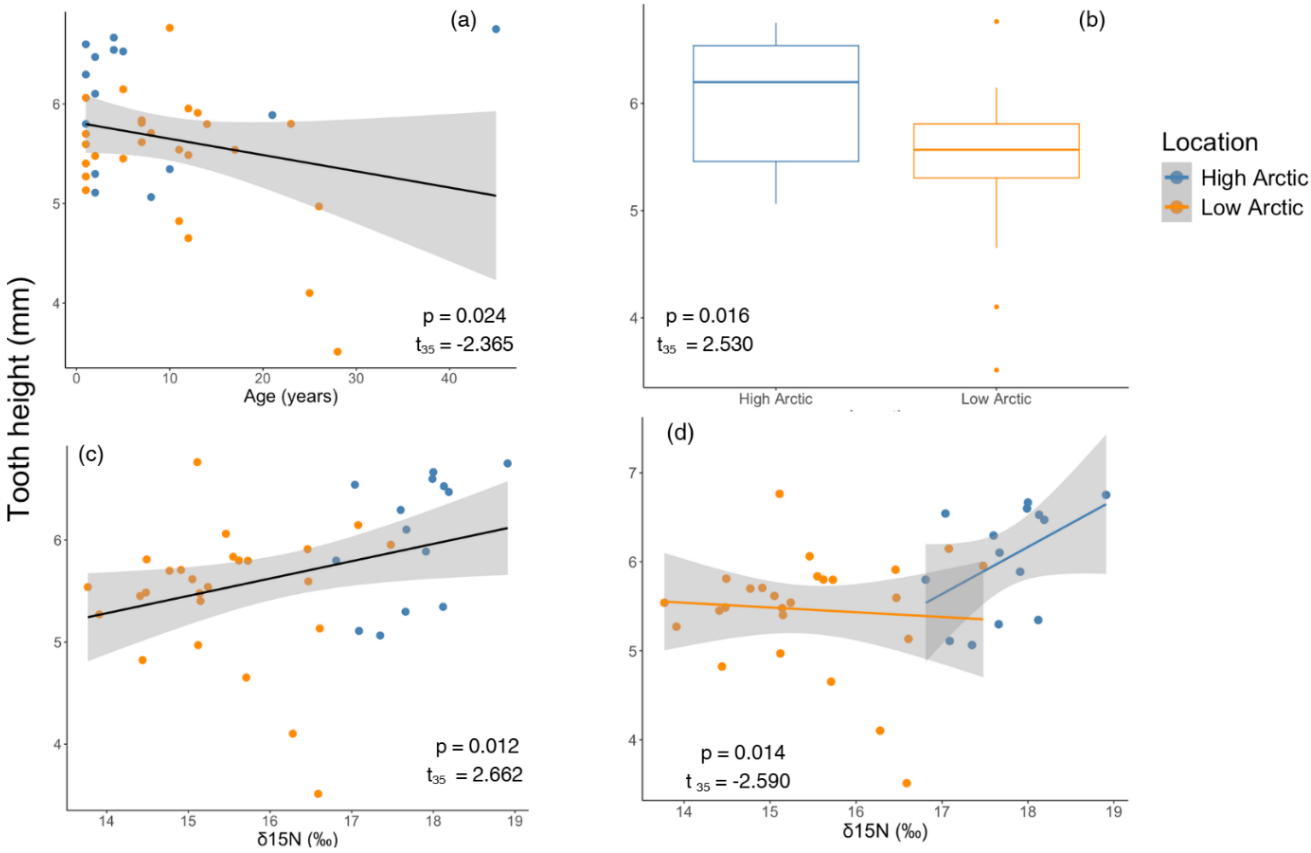


Figure 5. Tooth height compared with (a) age, (b) location, and (c) diet (δ^{15}N), with an illustration of (d) the interaction between diet and location.

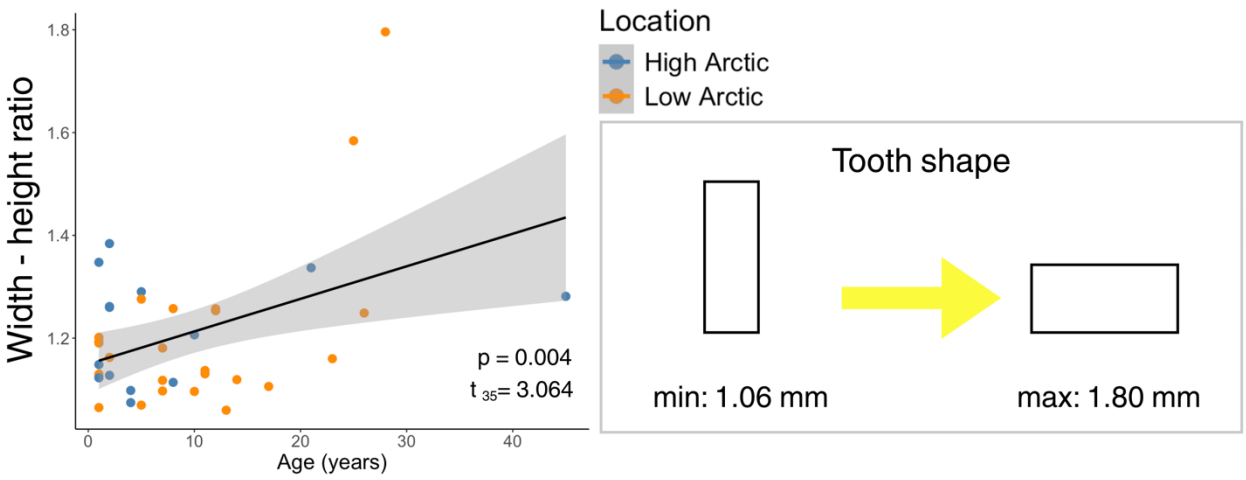


Figure 6. Width - height ratio compared with age (left panel), with an example of tooth shape variation (right panel).

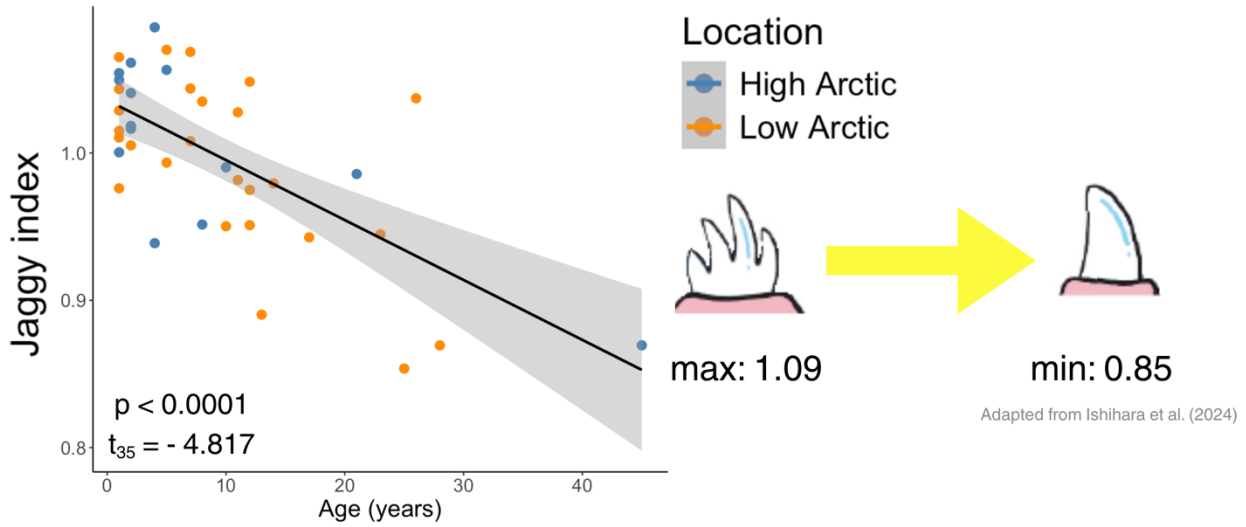


Figure 7. Jaggy index compared with age (left panel), with an example of tooth shape variation (right panel).

Discussion

This project is the first to examine latitudinal variation in ringed seal tooth morphology in relation to diet. Tooth height was greater in high Arctic ringed seals, suggesting increased fish consumption, which aligns with ringed seal feeding ecology research (Yurkowski et al. 2016; Carlyle et al. 2022; Laing et al. 2025) and decreased with age, suggesting teeth wear over time

(Berthaume et al. 2010; Galbany et al. 2014; Kim et al. 2018). Similarly, changes in tooth width-height ratio and jaggy index with age may also reflect progressive tooth wear, which suggests that tooth shape becomes more flattened and conical with age. Tooth height was significantly associated with diet, location and age, while width-height ratio, jaggy index were only influenced by age.

In this project, high Arctic ringed seals had greater tooth height compared with low Arctic individuals. Since diet varies across latitudes, this morphological difference may reflect an advantage of increased tooth height for efficiently capturing and puncturing larger or tougher prey, such as fish (Churchill and Clementz 2015). Taller teeth may improve the retention of the prey by increasing the ability to pierce and hold slippery fish while preventing them from escaping (Adam and Berta 2001; Kienle and Berta 2016). Increased tooth height may also enhance efficient prey handling. Variation in tooth morphology can influence feeding mode and puncture ability (Churchill and Clementz 2015; Peredo et al. 2022). Consistent with this interpretation, tooth height showed a positive relationship with $\delta^{15}N$ values, particularly in high Arctic seals, which exhibited higher $\delta^{15}N$ values compared with low Arctic seals, indicative of occupying a higher trophic position (Yurkowski et al. 2016; Carlyle et al. 2022; Laing et al. 2025). This latitudinal increase in trophic position is consistent with previous research (Yurkowski et al. 2016; Carlyle et al. 2022; Laing et al. 2025) and is commonly attributed to a greater reliance of fish in high Arctic ringed seal populations relative to low Arctic seals (Yurkowski et al. 2016; Carlyle et al. 2022). However, it may also be due to structural differences in Arctic food webs (Carlyle et al. 2022). Low Arctic food webs tend to have shorter food chains and lower zooplankton complexity, whereas high Arctic food webs are characterized by longer food chains and more complex zooplankton communities (Young and Ferguson 2014; Yurkowski et al. 2016). These structural differences suggest a greater prevalence of carnivory near the base of the high Arctic food web, whereas low

Arctic food webs may be more dominated by omnivorous or herbivorous consumers near the base of the food chain (Møller and Nielsen 2020; Lerner et al. 2022; Carlyle et al. 2022).

The relationship between tooth height and age may be explained by changes in diet composition across age classes and seasons in pinnipeds (Behrends 1985; Wilson et al. 2015). Additionally, Bethune et al. (2021) reported that PC3 was one of the least affected by age, although some variation in height may still occur, particularly since the ringed seal diet differs with latitude (Carlyle et al. 2022; Laing et al. 2025). Canine morphology has been previously used to estimate age in ringed seals, but postcanine teeth have also been used for this purpose and show a positive correlation with canine age esimations (Chambellant and Ferguson 2009). This correlation likely reflects progressive tooth wear over time, where continuous teeth use and physical food properties lead to a gradual reduction of tooth height (Berthaume et al. 2010; Galbany et al. 2014). Such wear-related changes suggest that both tooth types (canine and postcanine) undergo morphological modifications as individuals age. Although tooth characteristics vary among species, tooth height has also been identified as a useful trait to estimate age in other animals, such as horses, deer, red foxes, and racoons (Thomé and Geiger 1997; Nussey et al. 2007; Gaillard et al. 2015). Future studies should include a larger sample of ringed seals, especially individuals aged 20 years and older, to have a better insight into older seals' patterns, since the sample size for this project was mostly composed of seals between 0 and 20 years old and ringed seals may live up to 45 years in the wild (Hammill 2009).

The width-height ratio had a positive relationship with age, going from a narrow and pointy tooth shape to a wider and smaller shape. In contrast, there was a negative relationship between the jaggy index and age, suggesting a shift from a multi-cusped shape to a simpler conical shape. Both relationships are consistent with previous research (Ishihara et al. 2024). However, having a

positive relationship between the width-height ratio and age may not mean that teeth are getting wider, progressive tooth wear reduces tooth height over time as cusps are gradually worn down, resulting in shorter teeth with relatively larger width, reflecting the increase in width-height ratio over time (Kim et al. 2018). Most pinnipeds do not masticate their prey (Jones et al. 2013), which could indicate that tooth shape change may be driven by tooth wear during occlusion movements, rather than mastication, which supports the idea that teeth are used more for capturing prey rather than processing it (Loch and Simões-Lopes 2013; Peredo et al. 2022). This are-related change may influence their capture efficiency overtime, since worn teeth could be less efficient at piercing and retaining prey.

Although the jaggy index was not significantly different between locations, this lack of relationship may reflect limited dietary divergence between populations. While low Arctic ringed seals showed lower $\delta^{15}N$ values than high Arctic individuals, suggesting a relatively reduced reliance on fish, they likely still consume fish prey. However, these dietary differences may not be pronounced enough to drive a detectable morphological variation in tooth cusp structure. Since tooth height showed significant results between locations, it suggests that this variable may be more prone to dietary differences selection than the other variables.

Gap width did not show significant relationships for any independent variables, despite it being strongly correlated with prey acquisition techniques among previous studies. Churchill and Clementz (2015) suggested that gap width increases when teeth are less involved in prey capture. Gap width was also negatively correlated with tooth size (Churchill and Clementz 2015), indicating that smaller teeth would present larger spacings between them. Gap width has been associated with different feeding strategies, where piercing feeders tend to exhibit small gap widths, whereas large gap widths have been associated with filter feeders (Hocking et al. 2013; Churchill and Clementz 2015; Ishihara et al. 2024). Similar to the jaggy index, the lack of a significant

relationship between gap width and location suggests that dietary variation is not sufficiently pronounced to produce a detectable variation in gap width among individuals from these two populations.

In conclusion, we provided insights into the spatial variation of tooth morphology in relation to ringed seals' diet and location, with tooth height being the most relevant trait. These findings suggest that tooth size, rather than shape, may play a more important role in dietary adaptation in ringed seals. This study also provides insights into how Arctic predators may respond to spatial variation in prey availability. As environmental conditions continue to change in the Arctic, being able to understand how organisms interact with the environment is critical to predict how species may adapt to environmental shifts.

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Appendix A

Bearded seals (*Erignathus barbatus*) are typically found in shallow coastal waters and prefer drifting pack ice over land-fast ice. Their distribution includes waters from Alaska, Canada, Greenland and Russia (Fuirst et al. 2023), and they mainly feed on benthic organisms such as shrimp, crabs, clams and squid (Antonelis et al. 1994; Kovacs 2018; Young et al. 2010). Although fish appears to have minor importance in their diet (Lowry et al. 1980), fish such as capelin (*Mallotus villosus*), members of the cod family (*Gadidae*), members of the sculpin family (*Cottidae*) and flatfish are also common prey species of bearded seals in the Chukchi sea (67.91 N, -169.85 W) and Bering Sea (60.90 N, -171.99 W) (Antonelis et al. 1994; Quakenbush et al. 2011). During summer, prey species such as Arctic cod, sculpin and polar cod (*Arctogadus glacialis*) as well as anemones and sea cucumbers, were common for bearded seals in Grise Fiord (76.41 N, -82.89 W), Pond Inlet (72.69 N, -77.96 W) and Clyde River (70.45 N, -68.48 W) (Finley and Evans 1983). Spatial variation in their diet has not been extensively investigated, but given their broad diet as a species, bearded seals are considered opportunistic predators (Antonelis et al. 1994; Young et al. 2010).

Bearded seal samples were collected from Sanikiluaq and Kugaaruk, all within Nunavut, spanning latitudes from 56.51° N to 68.76° N (Fig. A1). Bearded seals were harvested from Sanikiluaq between 2022 and 2024 (n=7) and from Kugaaruk between 2023 and 2024 (n=6) with ages ranging from 0 to 18 years.



Figure A1. Locations where bearded seals were harvested by community members between 2022 and 2024.

When the bearded seal mandible photographs were being taken, 6 mandibles out of 13 were missing the PC3 to be measured (Fig. A2). Two additional bearded seal mandibles had incomplete PC3s but were enough to have two measurements taken (gap width and tooth width) (Fig. A2). In general, bearded seal teeth were very worn down, especially when compared with ringed seal teeth, which is likely due to their benthic diet. Therefore, we only had 5 out of 13 bearded seal mandibles with complete data (Table A1).

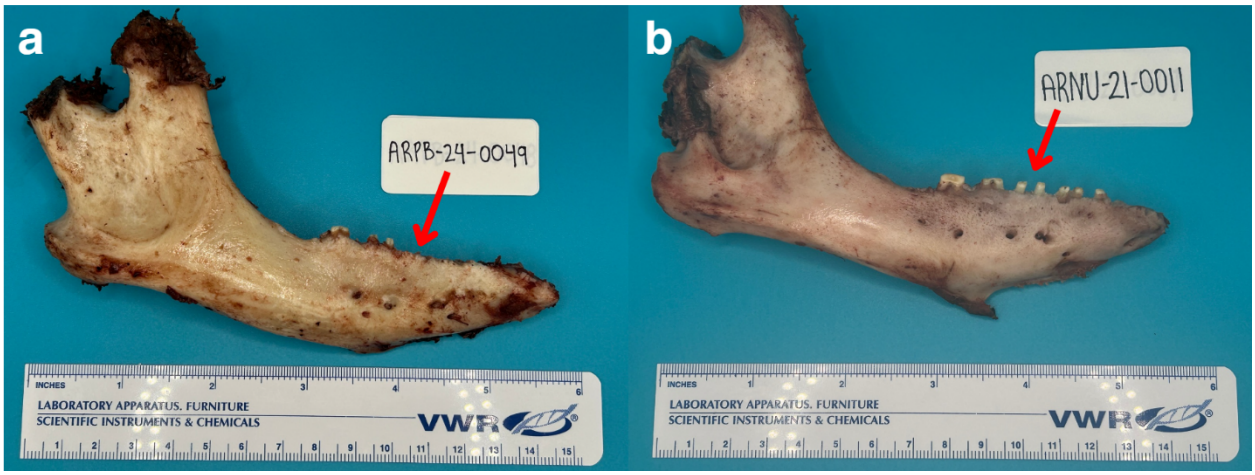


Figure A2. Bearded seal mandible with PC3 (indicated by red arrows) either (a) missing or (b) worn down.

Table A1. Mean (± SE) of tooth variables, $\delta^{15}N$, age, and body length in bearded seals from the high Arctic (Kugaaruk) and low Arctic (Sanikiluaq).

Bearded seal variables	Kugaaruk	Sanikiluaq
Width (mm)	7.86 ± 0.05	7.42 ± 0.29
Height (mm)	5.40 ± 0.03	6.07 ± 0.77
Tooth perimeter (mm)	24.00 ± 0.01	24.5 ± 2.3
Smallest bounding rectangle (mm)	26.6 ± 0.2	27.3 ± 2.2
Gap width (mm)	3.17 ± 0.32	2.37 ± 0.49
Jaggy index	0.905 ± 0.006	0.892 ± 0.014
Width-height ratio	1.470 ± 0.004	1.31 ± 0.10
$\delta^{15}N$ ($^{0}/_{00}$)	16.1 ± 0.3	15.4 ± 0.2
Age (years)	8.4 ± 2.8	4 ± 2
Body length (cm)	217 ± 15	179 ± 18