Polar Biology
https://doi.org/10.1007/s00300-021-02979-1

SHORT NOTE

# Occurrence of Slimy Sculpin (*Cottus cognatus*) on southern Victoria Island, Nunavut

**Michael Power[1] · Graham Power[1] · Guillaume Grosbois[2] · Milla Rautio[3]**

Received: 14 September 2021 / Revised: 24 November 2021 / Accepted: 26 November 2021


**Abstract**
During an icthyofaunal survey of lakes on southern Victoria Island in the Canadian Arctic Archipelago Slimy Sculpin (*Cottus cognatus*) were found in Lake Ferguson. The finding is the first recorded instance of the species north of the Dease Strait that separates the continental mainland of North America from the Canadian Arctic Archipelago. Captured specimens were bio-chemically analysed and compared to published data for other Arctic populations. Comparison of the weight–length relationship to other Arctic populations indicate the Ferguson Lake population is generally in poorer condition, a conclusion supported by fatty acid data. Comparative stable isotope data also suggest Ferguson Lake Slimy Sculpin display a similar degree of niche diversification as other Arctic populations of the species, but are considerably more limited in terms of their trophic diversity. Together the data provide an important initial baseline against which to compare future samplings for understanding the possible impacts of climate change.

**Keywords** Slimy Sculpin range · Victoria Island · Arctic freshwater fish species distributions · Trophic ecology

## Introduction

The distribution of freshwater fish species in the Canadian Arctic Archipelago is thought to be limited to eight species (Power et al. 2008), with the lack of freshwater connectivity being primarily responsible for limiting colonization opportunities to anadromous species (Christiansen et al. 2013). Increasingly climate change is being seen as a possible means by which freshwater fish diversity in the region will increase (e.g. Reist et al. 2006), with climate change induced relaxation of thermal constraints predicted to facilitate enhanced freshwater colonization (e.g. Campana et al. 2020). And while colonization will invariably change the fish diversity within the region, existing information gaps in space and time for a number of taxonomic groups remain and have hampered full understanding of the existing diversity in many parts of the Arctic, including the Canadian Arctic Archipelago (Laske et al. 2022). This is particularly true of the smaller bodied fishes that are typically not included in subsistence or commercial fisheries (Tyler et al. 2012).

Thus formal cataloguing of species assemblages have often missed species that broader observational programmes have recorded. For example, the Laske et al. (2022) circumpolar biodiversity monitoring analysis of fish used formal survey data that failed to record 17 fish species noted using a survey of indigenous knowledge, in part because of the broader spatial coverage resulting from the use of indigenous knowledge (Knopp et al. 2022) and the effect of the well-known species–area relationship (e.g. Rosenweig 1995; Turner and Tjørve 2005). If we are to understand the impacts of climate change on fish assemblages in Arctic freshwater ecosystems, it is important that all knowledge regarding the range and biology of resident species be accurately catalogued over as large an area as possible. Here we report on a range extension and trophic data for a sample of Slimy Sculpin (*Cottus cognatus*) recently obtained during scientific sampling on southern Victoria Island, Nunavut. We then compare relevant dietary and biological characteristics of the sample with similar data reported for other Arctic populations.

✉ Michael Power
m3power@uwaterloo.ca

[1] Department of Biology, University of Waterloo, 200 University Ave. West, Waterloo, ON N2L 3G1, Canada

[2] Institut de Recherche Sur les Forêts, Université du Québec en Abitibi-Témiscamingue, Amos, QC, Canada

[3] Département des Sciences Fondamentales, Université du Québec à Chicoutimi, Chicoutimi, QC, Canada

Published online: 10 January 2022

## Methods

Sampling occurred in Lake Ferguson, the largest lake on Victoria Island (740km$^2$), elevated approximately 11 m above sea level (Kristofferson 2002). The watershed is underlain by permafrost with a variable active layer typically < 1 m deep and the surrounding topography is low relief, consisting mainly of low, gently sloping hills (Ponomarenko et al. 2019).

During a littoral sampling survey for juvenile Arctic charr (*Salvelinus alpinus*) in Ferguson Lake, August 13, 2017, Slimy Sculpin ($n = 7$) were obtained as by-catch along an expanse of sandy beach (69.315°N, 104.793°W) in waters 20–50 cm in depth. Fish were generally captured from among a series of discontinuous rocky outcrops and patches of small boulders (typically < 50 cm across). Sampling was completed using an electro-fisher (Smith-Root LR-24, Smith-Root Inc, Vancouver, WA) and dip-nets (6 mm mesh). Specimens were identified using descriptions of the species provided by McPhail and Lindsey (1970), Scott and Crossman (1973) and Arcisewski et al. (2015). Length (mm) and mass (g) were measured immediately on return to the laboratory, approximately 3 h after capture. Sacculus otoliths were removed for aging, with age determined by examination of the otolith under a microscope (Van Vliet 1964). Fish were then frozen at − 20 °C for shipment south where they were stored at − 80 °C until further analysed. For analyses, samples of dorsal muscle tissue were removed and freeze-dried for stable isotope and fatty acid analyses. Stable isotope analyses ($\delta^{13}C$, $\delta^{15}N$) were completed following methods described in Davidsen et al. (2020) and Eldøy et al. (2021) at the University of Waterloo Environmental Isotope Lab using a Delta Plus Continuous Flow Stable Isotope Ratio Mass Spectrometer (Thermo Finnigan, Bremen, Germany) coupled to a 4010 Elemental Analyser (CNSO 4010, Costech Analytical Technologies Inc., Valencia, USA). Machine analytical accuracy was ± 0.2% ($\delta^{13}C$) and ± 0.3% ($\delta^{15}N$). As tissue C:N ratios did not exceed 4, lipid extraction or correction was not required (Jardine et al. 2013). Fatty acids were extracted and methylated using methods described in Grosbois et al. (2017) at the University of Quebec in Chicoutimi where trans-esterified fatty acids were extracted with hexane and submitted to gas chromatography-mass spectrometry (GC–MS) for identification and quantification using calibration curves (e.g. Grosbois et al. 2017).

## Results and discussion

The capture of Slimy Sculpin in Ferguson Lake occurred north of the current known continental coastal limit for the distribution of the species in Canada (Fig. 1). Captured fish ranged in length from 23 to 101 mm, in weight from 0.05 to 6.40 g and in age from 1 to 7 years. Spot temperatures at time of capture ranged from 11 to 13 °C. When compared to other Arctic populations, the weight–length relationship for Ferguson Lake Slimy Sculpin showed them to be in poorer condition across the range of sizes captured (Fig. 2). Fulton's K at 60 mm (K = 0.58) was one half to one third of similar values implied by the weight–length relationships reported for other Arctic populations (e.g. 1.11, 1.02 and 1.52, respectively, for the Chandler River (Craig and Wells 1976), Stewart (Power et al. 2002) and Toolik (McDonald et al. 1982) lakes).

Stable isotope values, mean ± standard deviation for $\delta^{13}C$ and $\delta^{15}N$, respectively, were − 25.8 ± 1.8‰ and 7.6 ± 0.3‰. Values were generally clustered about the mean with the exception of the $\delta^{13}C$ for the smallest individual ($\delta^{13}C = -29.7$‰), which tested as a significant outlier (Dixon's test $p < 0.05$). When compared to other Arctic populations for which data were available, Ferguson Lake Slimy Sculpin displayed a range in resource use of 1.6‰ (± $\delta^{13}C$ Std Dev), i.e. niche diversification (Layman et al. 2007), within the lake food web that approximated the average (1.8‰) reported for other Arctic populations (Fig. 3). In contrast, the trophic diversity (±$\delta^{15}N$ Std Dev) in the diet of 0.3‰ was considerably lower than the mean of 0.9‰ seen in other Arctic populations (e.g. Power et al. 2002; Jones 2010; Arciszewski et al. 2015; Rohonczy et al. 2020).

Total fatty acid concentration (± Std Dev) in Slimy Sculpin muscle was 75.4 ± 28.7 μg×mg$^{-1}$ dry weight. The largest (101 mm) individual had the lowest fatty acid concentration, with 49.1 μg×mg$^{-1}$ dry weight. In contrast, the smallest (23 mm) individual had the second highest concentration of fatty acids, with 116.3 μg×mg$^{-1}$ dry weight. There are no data for comparison from other Arctic Slimy Sculpin, but when compared to Slimy Sculpin sampled in Lake Ontario (158.1 ± 39.1 μg×mg$^{-1}$ dry weight, $n = 22$) (Honeyfield et al. 2012) fatty acid concentrations for Ferguson Lake fish were only half as high. Thus, as evidenced by both condition factor and fatty acids Slimy Sculpin at the northern limit of their distribution are in poorer condition than those found further south.

At all latitudes Slimy Sculpin have been found to rely heavily on benthic invertebrates, particularly Chironomids, with Chironomidae being a major prey for Slimy Sculpin in Alaskan rivers (Craig and Wells 1976) and lakes (Hershey and McDonald 1985) and in the lakes studied

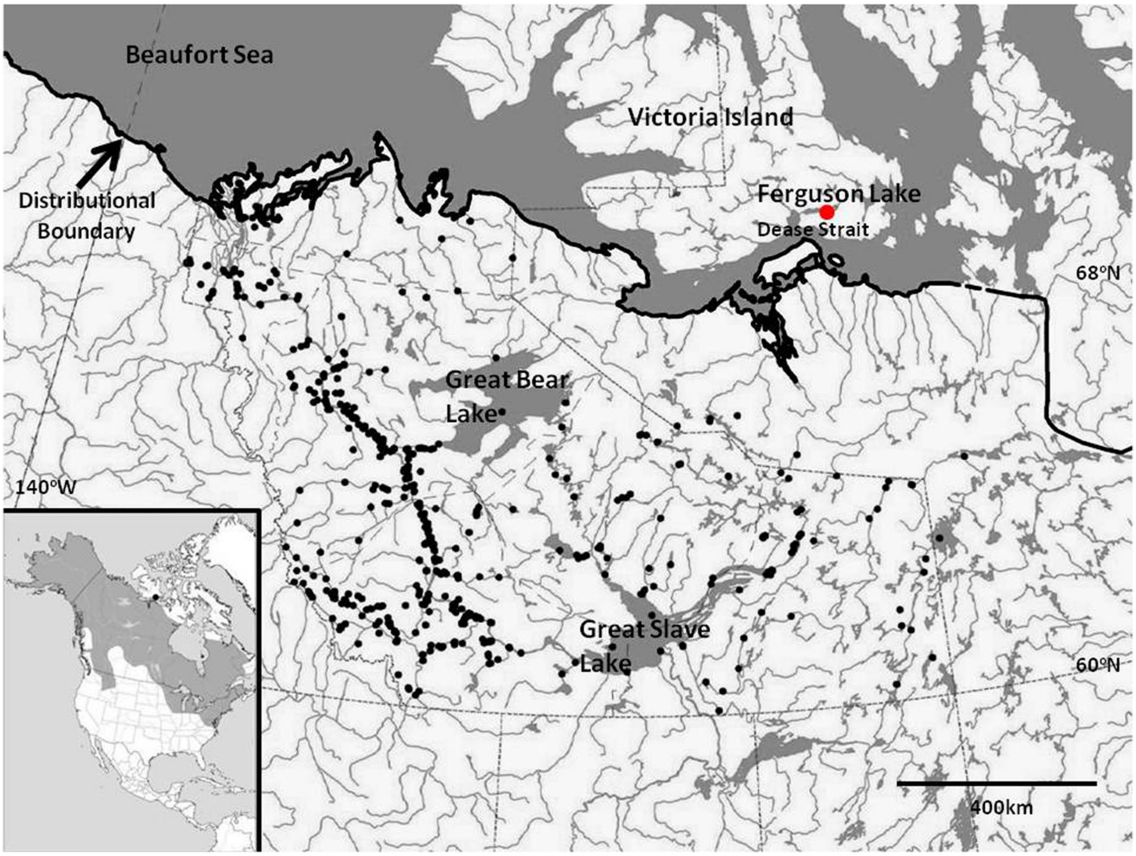


**Fig. 1** Distributional map for Slimy Sculpin (*Cottus cognatus*) in the central Canadian Arctic as revised by Sawatzky et al. (2007) based on reported locational sampling data (small black circles). The heavy line towards the top of the map denotes the inferred distributional limit of the species based on the location of confirmed samples. The range as defined includes areas where the species is thought to exist but where its presence has not been confirmed by sampling. Inset denotes the North American distribution of Slimy Sculpin (shaded grey area). The red dot on the south shore of Ferguson Lake denotes the reported capture location for this study and the new northern distributional limit for the species. The black dot on the inset denotes the location of Ferguson Lake relative to North America. Figure adapted from Sawatzky et al. (2007)

within the Great Lakes basin (Walsh et al. 2008; French et al. 2010; Chalupnicki and Johnson 2016). Cladocerans and other microcrustaceans may also account for a high proportion of the diet, consisting of up to 23% of the diet (Cuker et al. 1992). Previously reported diets are consistent with the stable isotope values reported here which suggest lower trophic level feeding. Feeding on planktonic microcrustaceans, however, appears limited to the early juvenile ages as evidenced by the outlying $\delta^{13}C$ found for the 23 mm fish.

Widely distributed throughout the Northwest Territories in Canada, Slimy Sculpin have been recorded at sites proximate to the Arctic coastline only west of Darnley Bay (Sawatzky et al. 2007). Most of the locational records for the species in the Canadian Arctic occur in the Mackenzie River drainage (Sawatzky et al. 2007), a fact reflective of the significant amounts of resource development related survey work that has been conducted in that drainage. Accordingly, the current documented distribution probably does not represent the actual distribution of the species. As Slimy Sculpin are not a valued subsistence or popular recreational angling species, and because of their size are typically selected against in scientific surveys using multimesh gillnets (e.g. Portt et al. 2006; Hershey et al. 2006), their occurrence in many localities in all likelihood remains undocumented. Indeed as noted by Hershey et al. (2006) detection of Slimy Sculpin often requires special purpose sampling trips.

The current distributional boundaries for Slimy Sculpin in the Canadian Arctic include the Kent Peninsula located approximately 63 km to the southwest of the capture site across the Dease Strait, a marine body of water varying in width from 20 to 25 km that borders southern Victoria Island and lies immediately to the south of Ferguson Lake. Although Slimy Sculpin have a wide North American distribution, they are generally not considered migratory. For example, combined stable isotope and PIT-tagging studies have provided little evidence of within season movement

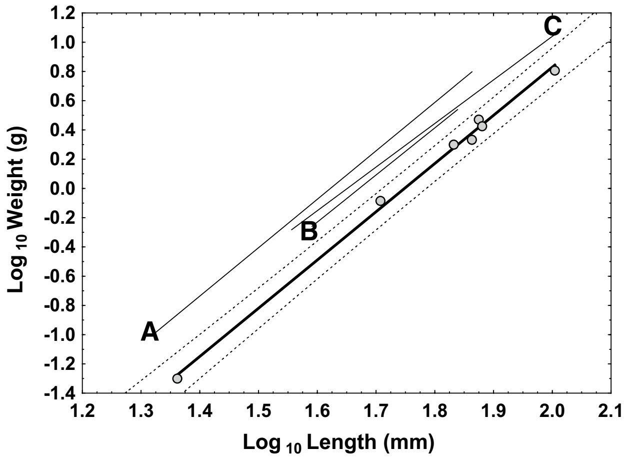


**Fig. 2** Weight–length regressions for Slimy Sculpin sampled from Arctic environments as compared to fish sampled from Ferguson Lake (grey dots). The heavy dark line defines the weight–length regression based on the Ferguson Lake sample ($r^2=0.996$, $P=0.019$) and the dashed lines plot the associated 95% prediction intervals. Literature reported weight–length relationships are reported for: **A** Toolik Lake, Alaska (McDonald et al. 1982); **B** Stewart Lake, Ungava (Power et al. 2002); and **C** Chandler River, Alaska (Craig & Wells, 1976)

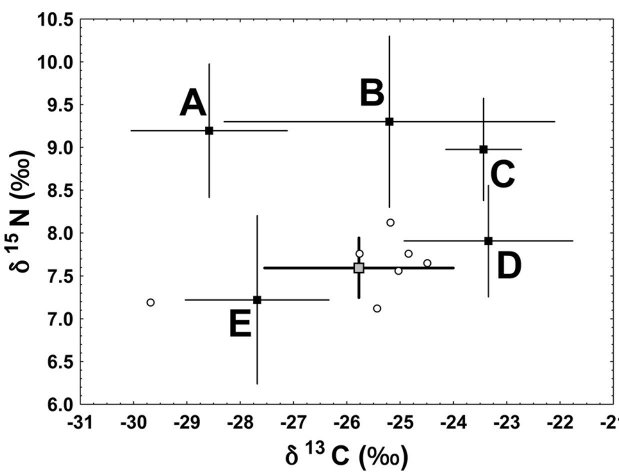


**Fig. 3** Bi-variate staple isotope plot of mean ± standard deviation for Slimy Sculpin sampled in Ferguson Lake and other literature reported Arctic environments. Ferguson Lake samples are plotted with the heavy black lines and grey square. Individual values for Ferguson Lake Slimy Sculpin are plotted with open circles. Literature values are plotted with the thin black lines and black squares as: **A** the mean of Alaskan lakes with co-occurring Lake Trout, *S. namaycush* (Jones 2010); **B** the mean of Alaskan lakes with co-occurring Arctic Charr, *S. alpinus* (Jones 2010); **C** Great Slave Lake, NWT (Rohonczy et al. 2020); **D** Stewart Lake, Ungava (Power et al. 2002); and **E** Alexie Lake, NWT (Arciszewski et al. 2015)

(e.g. Cunjak et al. 2005). More recent work with otolith microchemistry, however, has demonstrated a dispersal phase during early life for many fish (Clarke et al. 2015), which may explain their successful post-glacial dispersal across large parts of North America. And while Slimy Sculpin are classified as a freshwater fish, the Cottidae evolved from marine sculpins that invaded freshwater habitats (Yokoyama and Goto 2005). Furthermore, early reports of Slimy Sculpin in the eastern Arctic (southern Ungava Bay) noted Slimy Sculpin were a common and abundant resident of brackish water tidal pools in the estuary of the Koksoak River (Dunbar and Hildebrand 1952) where salinities vary between 15 and 23ppt (Mohammadain et al. 2019). The salinity of such ponds approximates that of the Dease Strait and Wellington Bay (18–27ppt, Moore et al. 2016), water bodies that Slimy Sculpin would need to cross to gain access to Ferguson Lake. Furthermore, patterns of lake occupancy on the Arctic Coastal Plain of Alaska point to a distribution indicative of the marine origin of Slimy Sculpin with the probability of lake occupancy decreasing as distance from the coast increases (Haynes et al. 2014). Thus dispersal across short stretches of marine habitat are not out of the question as Gormley et al. (2005) recently noted in discussing the colonization of Prince Edward Island off Canada's eastcoast.

**Acknowledgements** The study was funded by Polar Knowledge Canada (MP, MR), the Canada Research Chairs Program (MR), the Natural Sciences and Engineering Research Council of Canada Discovery Strategic Projects Grants Programs (MP, MR). We thank the reviewers (K. Teather and an anonymous reviewer) for their helpful suggestions to improve the manuscript, Ekaluktutiak Hunters and Trappers Association for their support, the UW Environmental Isotope Lab and P. Carrier-Corbeil, and B. Sylla for assistance with fatty acid analyses.

**Author contributions** GP and MP completed sampling with GP being the first to identify Slimy Sculpin. MP, MR and GG completed all relevant laboratory analysis. MP completed statistical analysis and all authors contributed to drafting and finalizing the written text.

## References

Arciszewski T, Gray MA, Hrenchuk C, Cott PA, Mochnacz NJ, Reist JD (2015) Fish life history, diets, and habitat use in the Northwest Territories: freshwater sculpin species. Canadian Manuscript Report Fisheries and Aquatic Sciences 3306

Campana SE, Casselman JM, Jones CM, Black G, Barker O, Evans M, Guzzo MM, Kilada R, Muir AM, Perry R (2020) Arctic freshwater fish productivity and colonization increase with climate warming. Nat Clim Change. https://doi.org/10.1038/s41558-020-0744-x

Chalupnicki MA, Johnson JH (2016) Diel feeding ecology of slimy sculpin in a tributary to Skaneateles Lake, New York. Am Midl Nat 175:37–46

Christiansen JS, Reist JD, Brown RJ, Brykov VA, Christensen G, Christoffersen K, Cott P, Crane P, Dempson JB, Docker M, Dunmall K, Finstad A, Gallucci VF, Hammar J, Harris LS, Heino J, Ivanov E, Karamushko OV, Kirillov A, Kucheryavyy A, Lehtonen H, Lynghammar A, Mecklenburg CW, Møller PDR, Mustonen T, Oleinik AG, Power M, Reshetnikov YS, Romanov VI, Sandlund O-T, Sawatzky CD, Svenning M, Swanson HK, Wrona FJ (2013)

Fishes. Pages 192–245 in Meltofte, H. Arctic Biodiversity Assessment: Status and Trends in Arctic Biodiversity. Conservation of Arctic Flora and Fauna, Iceland

Clarke AD, Telmer KH, Shrimpton JM (2015) Movement patterns of fish revealed by otolithmicrochemistry: a comparison of putative migratory and resident species. Environ Biol Fish 98:1583–1597

Craig PC, Wells J (1976) Life history notes for a population of slimy sculpin (*Cottus cognatus*) in an Alaskan arctic stream. J Fish Res Board Can 33:1639–1642

Cuker BE, McDonald ME, Mozley SC (1992) Influences of slimy sculpin (*Cottus cognatus*) predation on the rocky littoral invertebrate community in an Arctic lake. Hydrobiologia 240:83–90

Cunjak RA, Roussel J-M, Gray MA, Dietrich JP, Cartwright DF, Munkittrick KR, Jardine TD (2005) Using stable isotope analysis with telemetry or mark-recapture data to identify fish movement and foraging. Oecologia 144:636–646

Davidsen JG, Power M, Knudsen R, Sjursen AD, Kjærstad G, Rønning L, Arnekleiv JV (2020) Marine trophic niche-use and life history diversity among Arctic charr *Salvelinus alpinus* in southwestern Greenland. J Fish Biol 96:681–692

Dunbar MJ, Hildrebrand HH (1952) Contributions to the study of the fishes of Ungava Bay. J Fish Res Board Can 9:83–128

Eldøy SH, Davidsen JG, Vignon M, Power M (2021) The Biology and feeding ecology of Arctic charr in the Kerguelen Islands. J Fish Biol 98:526–536

French JRP, Stickel RG, Stockdale BA, Black MG (2010) A short-term look at potential changes in Lake Michigan slimy sculpin diets. J Great Lakes Res 36:376–379

Gormley K, Guignion D, Teather K (2005) Distribution and abundance of slimy sculpin (*Cottus cognatus*) on Prince Edward Island, Canada. Am Midl Nat 153:192–194

Grosbois G, Mariash H, Schneider T, Rautio M (2017) Under-ice availability of phytoplankton lipids is key to freshwater zooplankton winter survival. Sci Rep-UK 7:11543

Haynes TB, Rosenberger AE, Lindberg MS, Whitman M, Schmutz JE (2014) Patterns of lake occupancy by fish indicate different adaptations to life in a harsh Arctic environment. Freshwater Biol 59:1884–1896

Hershey AE, McDonald ME (1985) Diet and digestion rates of slimy sculpin, *Cottus cognatus*, in an Arctic lake. Can J Fish Aquat Sci 42:482–487

Hershey AE, Beaty S, Fortino K, Keyse M, Mou PP, O'Brien WJ, Ulseth AJ, Gettel GA, Lienesch PW, Lueke C, McDonald ME, Mayer CH, Miller MC, Richards C, Schuldt JA, Whalen SC (2006) Effect of landscape factors on fish distribution in arctic Alaskan lakes. Freshwater Biol 51:39–55

Honeyfield DC, Daniels ME, Brown LR, Arts ME, Walsh MG, Brown SB (2012) Survey of four essential nutrients and thiaminase in five Lake Ontario prey fish species. J Great Lakes Res 38:11–17

Jardine TD, Hunt RJ, Faggotter SJ, Valdez D, Burford MA, Bunn SE (2013) Carbon from periphyton supports fish biomass in waterholes of a wet-dry tropical river. River Res Appl 29:560–573

Jones CM (2010) Piscivore Effect on size distribution and planktivorous behavior of slimy sculpin in Arctic Alaskan lakes. MSc Thesis, University of North Carlin at Greensboro, Greensboro, NC

Knopp JA, Levenstein B, Watson A, Ivanova I, Lento J (2022) Systematic review of documented Indigenous knowledge of freshwater biodiversity in the circumpolar Arctic. Freshwater Biol. https://doi.org/10.1111/fwb.13570

Kristofferson AH (2002) Identification of Arctic char stocks in the Cambridge Bay Area, Nunavut Territory, and evidence of stock mixing during overwintering. PhD Thesis, University of Manitoba, Winnipeg, Manitoba, Canada

Laske SM, Amundsen P-A, Christoffersen KS, Erkinaro J, Guðbergsson G, Hayden B, Heino J, Holmgren K, Kahilainen KK, Lento J, Orell P, Ostergren J, Power M, Rafikov R, Romakkaniem A, Svenning M-A, Swanson H, Whitman M, Zimmerman CE (2022) Circumpolar patterns of Arctic freshwater fish biodiversity: A baseline for monitoring. Freshwater Biol. https://doi.org/10.1111/fwb.13405

Layman CA, Arrington DA, Montaa CG, Post DM (2007) Can stable isotope ratios provide for community-wide measures of trophic structure. Ecology 88:42–48

McDonald ME, Cuker BE, Mozley SC (1982) Distribution, production and age structure of slimy sculpin in an Arctic lake. Environ Biol Fish 7:171–176

McPhail JD, Lindsey CC (1970) Freshwater fishes of northwestern Canada and Alaska. Fisheries Research Board of Canada Bulletin 173. Ottawa, ON, Canada

Mohammadian A, Morse B, Robert J-L (2019) Assessment of tidal stream energy resources in a hypertidal estuary with highly irregular bathymetry using 3D numerical modelling. J Ocean Eng Mar Energy 5:267–281

Moore JS, Harris LN, Kessel ST, Bernatchez L, Tallman RF, Fisk AT (2016) Preference for nearshore and estuarine habitats in anadromous Arctic char (*Salvelinus alpinus*) from the Canadian high Arctic (Victoria Island, Nunavut) revealed by acoustic telemetry. Can J Fish Aquat Sci 73:1434–1445

Ponomarenko S, McLennan D, Pouliot D, Wagner J (2019) High resolution mapping of tundra ecosystems on Victoria Island, Nunavut - Application of a standardized terrestrial ecosystem classification. Can J Remote Sens 45:551–571

Portt CB, Coker GA, Ming DL, Randall RG (2006) A review of fish sampling methods commonly used in Canadian freshwater habitats. Canadian Technical Report Fisheries and Aquatic Sciences. 2604

Power M, Klein GM, Guiguer KRRA, Kwan MKH (2002) Mercury accumulation in the fish community of a sub-Arctic lake in relation to trophic position and carbon sources. J Appl Ecol 39:819–830

Power M, Reist JD, Dempson JB (2008) Fish in high latitude Arctic lakes. In: Vincent WF, Laybourn-Parry J (eds) Polar Lakes and Rivers: Limnology of Arctic and Antarctic Aquatic Ecosystems. Oxford University Press, Oxford, UK, pp 249–268

Reist JD, Wrona F, Prowse TD, Power M, Dempson JB, King JR, Beamish RJ (2006) An overview of the effects of climate change on selected Arctic freshwater and anadromous fishes. Ambio 35:381–387

Rohonczy J, Cott PA, Benwell A, Forbes MR, Robinson SA, Rosabal M, Amyot M, Chtelat J (2020) Trophic structure and mercury transfer in the subarctic fish community of Great Slave Lake, Northwest Territories, Canada. J Great Lakes Res 46:402–413

Rosenzweig ML (1995) Species diversity in space and time. Cambridge University Press, Cambridge, UK

Sawatzky CD, Michalak D, Reist JD, Carmichael TJ, Mandrak NE, Heuring LG (2007) Distributions of freshwater and anadromous fishes from the mainland Northwest Territories, Canada. Canadian Manuscript Report Fisheries and Aquatic Sciences. 2793

Scott WB, Crossman EJ (1973) Freshwater Fishes of Canada. Fisheries Research Board of Canada Bulletin 184. . Ottawa, ON, Canada

Turner WR, Tjørve E (2005) Scale-dependence in species-area relationships. Ecography 28:721–730

Tyler EHM, Somerfield PJ, Vanden Berghe E, Bremner J, Jackson E, Langmead O, Palomares MLD, Webb TJ (2012) Extensive gaps and biases in our knowledge of a well-known fauna: implications for integrating biological traits into macroecology. Global Ecol Biogeogr 21:922–934

Van Vliet WH (1964) An ecological study of *Cottus cognatus* Richardson in Northern Saskatchewan. Masters Thesis. University of Saskatchewan, Saskatoon, Saskatchewan, Canada

Walsh M, O'Gorman R, Strang T, Edwards W, Rudstam L (2008) Fall diets of alewife, rainbow smelt, and slimy sculpin in the profundal zone of southern Lake Ontario during 1994–2005 with an emphasis on occurrence of *Mysis relicta*. Aquat Ecosyst Health 11:368–376

Yokoyama R, Goto A (2005) Evolutionary history of freshwater sculpins, genus *Cottus* (Teleostei; Cottidae) and related taxa, as inferred from mitochondrial DNA phylogeny. Mol Phylogenet Evol 36:654–668