# Memo

**To:** Peter Madden, Nalcor

**From:** Jim McCarthy

**cc:** Reed Harris, Randy Baker

**Date:** May 10, 2018

**Re.** Summary of Isotope and Stomach Data, Goose Bay / Lake Melville Estuary



## 1. Introduction

As part of the ongoing baseline data collection for the Environmental Effects Monitoring (EEM) Program for the Muskrat Falls portion of the lower Churchill Project, fish have been collected for numerous analyses. Presented below is a brief summary of ongoing stable isotope and stomach content data that provides estimates of downstream habitat use and feeding behaviour to support recent modelling of mercury bioaccumulation and exposure risk due to consumption. The data has been separated by location of capture below Muskrat Falls (e.g., riverine below Muskrat Falls, Goose Bay, inner Lake Melville, and outer Lake Melville). Inner Lake Melville includes all sample locations in the western portion of the lake while outer Lake Melville are those fish sampled near Valley Bight at the eastern end of Lake Melville (Figures 1-1 and 1-2). Additional food web analysis is ongoing as part of PhD research.

Fin clips have been collected from subsets of fish and analyzed for stable isotope ($\delta^{13}C$ and $\delta^{15}N$) ratios by the Stable Isotope in Nature Laboratory (SINLab) at UNB. The ratio of stable isotopes of nitrogen can be used to estimate trophic position because the $\delta^{15}N$ of a consumer is typically enriched by 3-4$^{o/oo}$ relative to its diet (DeNiro and Epstein 1981, Post 2002, Jardine et al 2003, Borga et al. 2011). When comparing among ecosystems (eg. Freshwater to estuary), the $\delta^{15}N$ and $\delta^{13}C$ of an organism alone provides little information about its absolute trophic position or ultimate source of carbon. This is because there is considerable variation among ecosystems in the $\delta^{15}N$ and $\delta^{13}C$ or the base of the food web from which organisms draw their nitrogen and carbon (Post 2002). Without suitable estimates of food web base $\delta^{15}N$ and $\delta^{13}C$, there is no way of knowing if variation reflects changes in food web structure and carbon flow, or just variation in the base nitrogen or carbon values. The simplest model for estimating the trophic position of a secondary consumer is: trophic position = $\lambda + (\delta^{15}N_{secondary\ consumer} - \delta^{15}N_{base})/\Delta_n$, where $\lambda$ is the trophic position of the organism used to estimate $\delta^{15}N_{base}$ (Post 2002, Borga et al. 2011).

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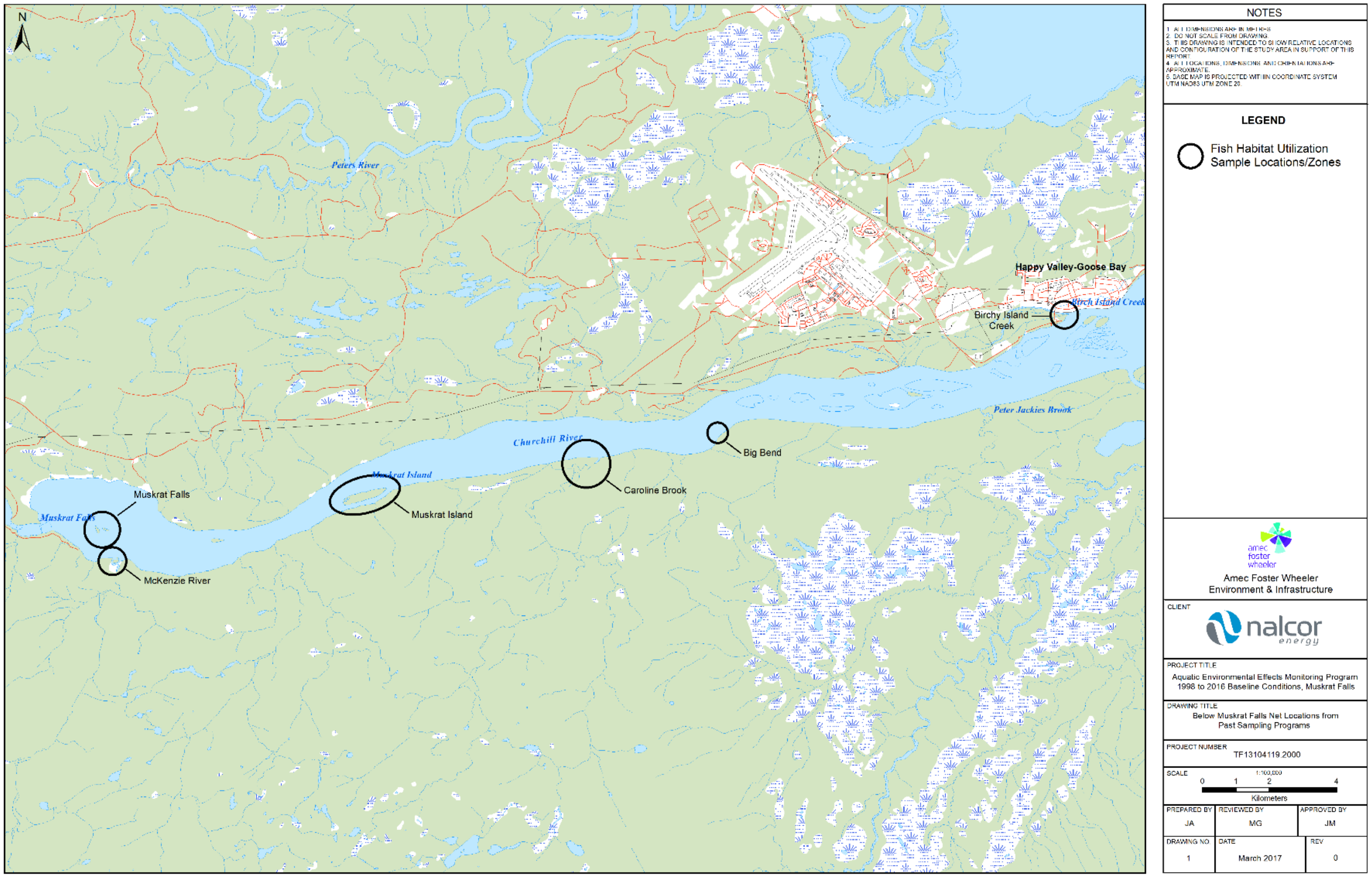


*Figure 1-1: Overall EEM study area: mainstem of the lower Churchill River (AMEC 2013b).*

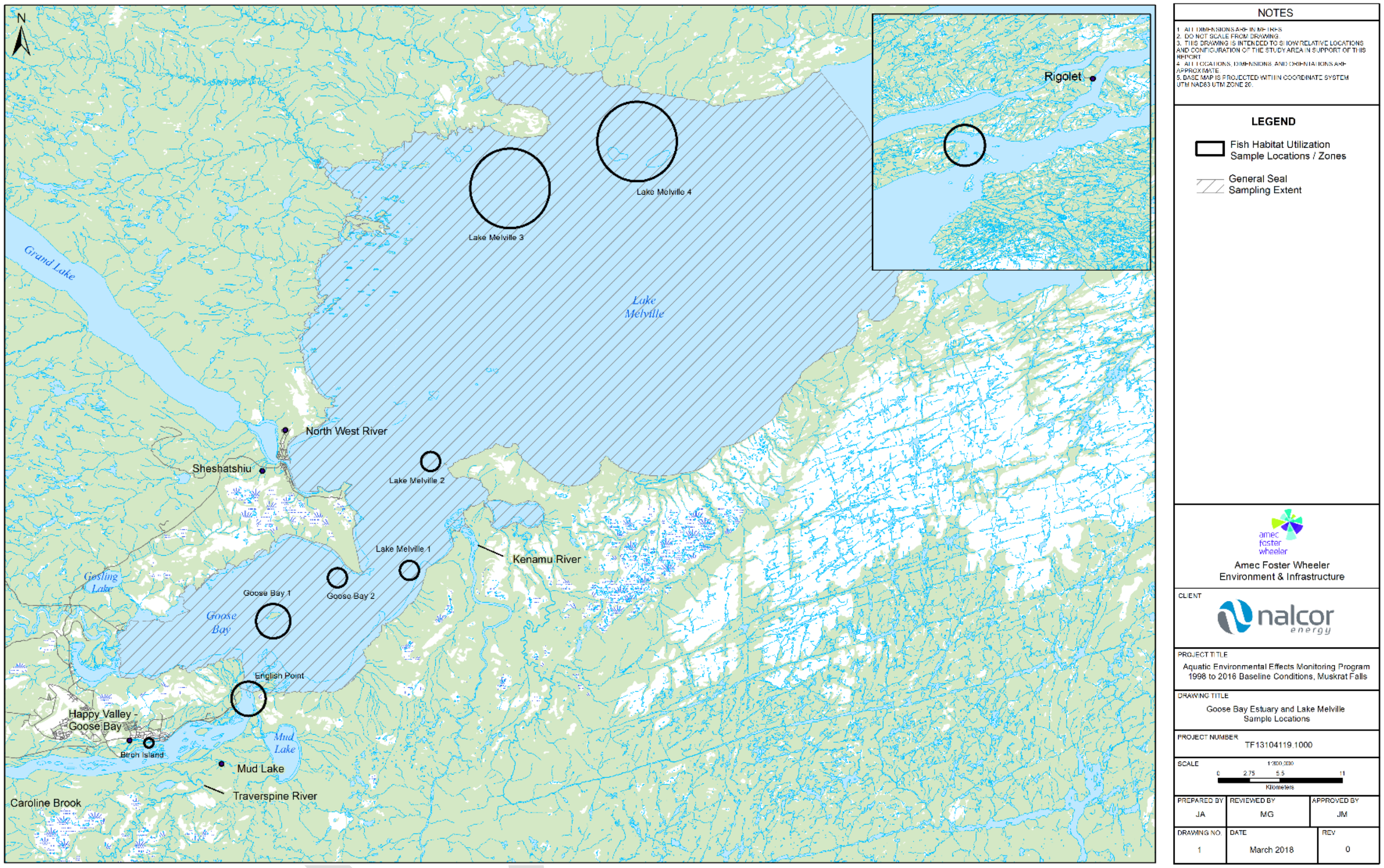


*Figure 1-2: Overall EEM study area: Goose Bay estuary and Lake Melville (AMEC 2013b).*

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Using isotope data from base organisms from the main stem of the Churchill River and estuary (e.g., molluscs, phytoplankton and zooplankton), the trophic position of each fish species was estimated.

In addition to stable isotopes, prey selection by key species has been ongoing via stomach content analysis which can augment isotope data. Stomach content analysis of a subset of samples (focusing on salmonids, northern pike, rainbow smelt and tomcod) was completed from 2017 to augment the trophic results determined by stable isotope ratios. The data presented has been characterized as the percent of all non-empty stomachs analyzed that contained that prey type and does not estimate the quantity within each stomach. Since one fish could have been feeding on multiple prey types, a single stomach sample can be included in multiple categories. Because the number of benthic macroinvertebrate families is high, individual families were consolidated into a larger benthic macroinvertebrate category for ease of presentation.

## 2. General Isotope Trends

To illustrate the general trends in isotope data, Figure 2-1 shows a generalized plot of isotope signatures for fish sampled in the estuarine (Goose Bay and Lake Melville) and freshwater environments of the lower Churchill River and its tributaries below Muskrat Falls in 2017. The graph shows the division of isotope signatures between the two habitats, as shown by variations in the $\delta^{13}C$ values. It also shows that there are fish that have been sampled in the freshwater environment that display isotope signatures similar to estuarine environments; however, the species and numbers are limited. Note that the identification of 'estuarine' and 'freshwater' are not indicative of the life history of the species, rather it identifies the location in which the specimen was captured (i.e. estuarine samples have been collected from Goose Bay and Lake Melville, while freshwater samples are from the mainstem and associated tributaries below Muskrat Falls). For example, species such as brook trout that are captured in the freshwater of the lower Churchill River below Muskrat Falls show an estuarine isotope signature because they are returning from feeding in the estuary and do not spend considerable time in the main stem prior to migrating up tributaries to spawn.

### Freshwater

Figure 2-2 presents the isotope signatures for all species sampled within the mainstem of the Churchill River and tributaries below Muskrat Falls during 2017. Brook trout and Atlantic salmon have the highest $\delta^{15}N$ values and therefore make up the highest trophic levels sampled in 2017.

A general $\delta^{13}C$ ratio greater than -23 can indicate estuarine/marine habitat use (B. Graham, pers. comm. 2011). Several species captured in freshwater in 2017 (i.e. brook trout, northern pike and white sucker) showed $\delta^{13}C$ ranges that could potentially include a marine signature (Figure 2-3). Since netting in Goose Bay and Lake Melville began, brook trout and white sucker have been captured in relatively high abundances in these habitats (see Amec Foster Wheeler 2016). There have been very few northern pike captured within the estuary, however isolated captures of juveniles around Rabbit Island in Goose Bay have occurred. Pike could be preying on fish with estuarine influence (i.e., prey may be feeding near/within the estuary environment).

### Goose Bay and Lake Melville

Samples collected from Goose Bay and Lake Melville also show within species variability. Figure 2-4 presents isotope ranges for each fish captured in Goose Bay and Lake Melville during 2017. Brook trout, rainbow smelt and tomcod occupied the highest trophic levels in 2017, similar to

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past sampling programs. Unlike the freshwater habitats, very few fish captured in the estuary environment showed potential freshwater signatures.

Since isotope analysis of ringed seal muscle samples began, they have consistently been shown to occupy the highest trophic level within Goose Bay and Lake Melville (Figure 2-6), indicating that they are likely relying on fish as a primary food source.

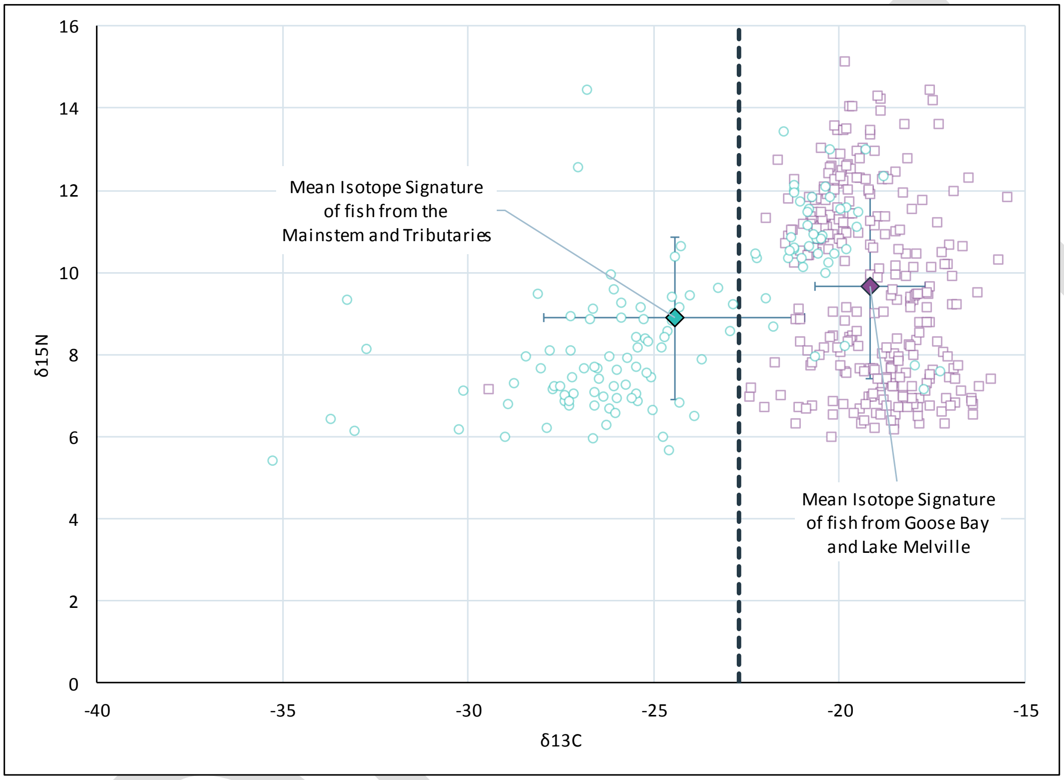


*Figure 2-1: Isotope signatures from fish captured within the mainstem and tributaries below Muskrat Falls, Goose Bay and Lake Melville, 2017*

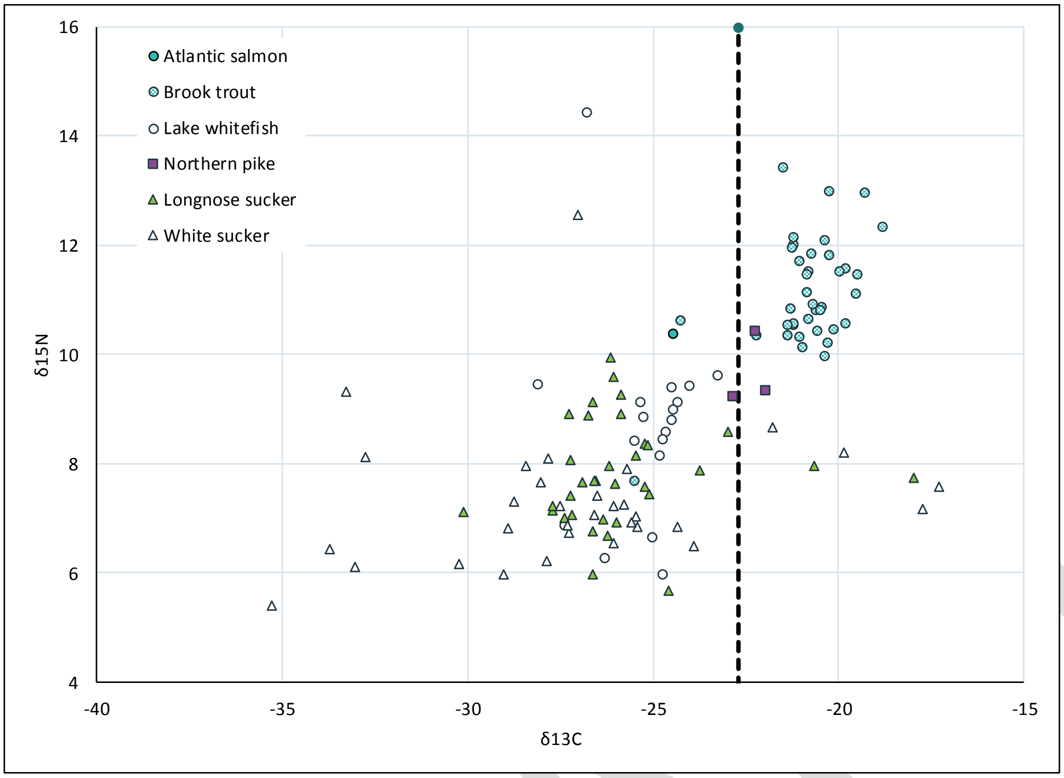


*Figure 2-2: Isotope signatures of fish captured the mainstem and tributaries below Muskrat Falls, 2017*

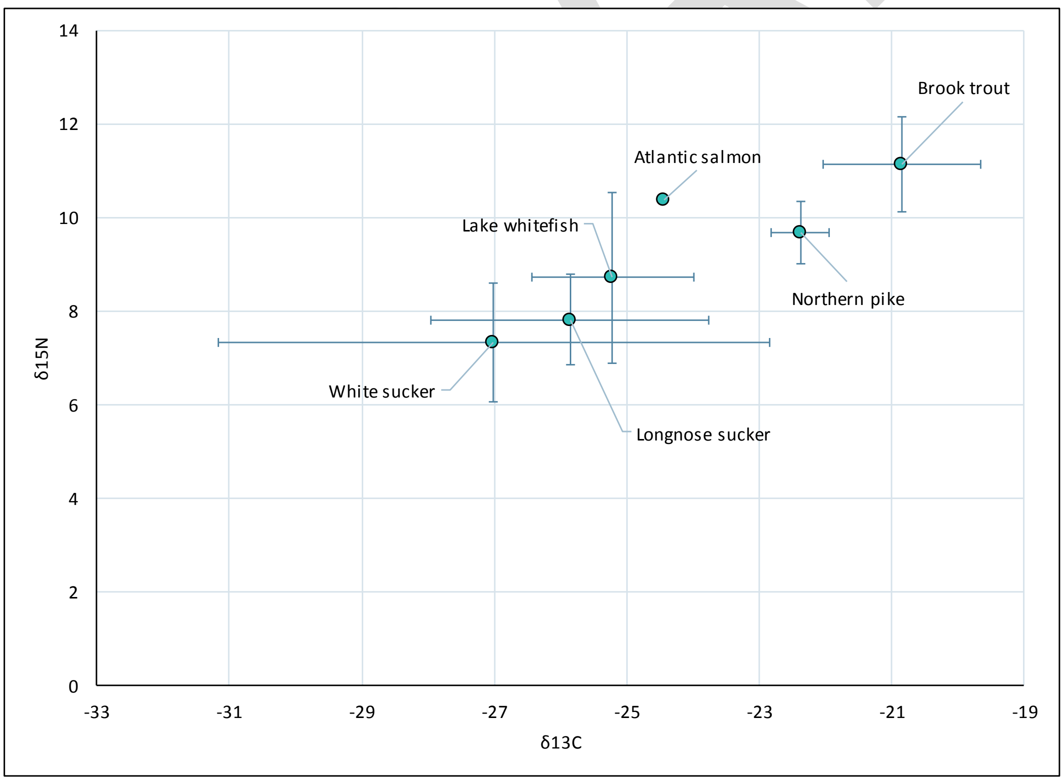


*Figure 2-3: Variability in carbon (habitat usage) and nitrogen (trophic level) signatures in fish captured in the mainstem and tributaries below Muskrat Falls, 2017*

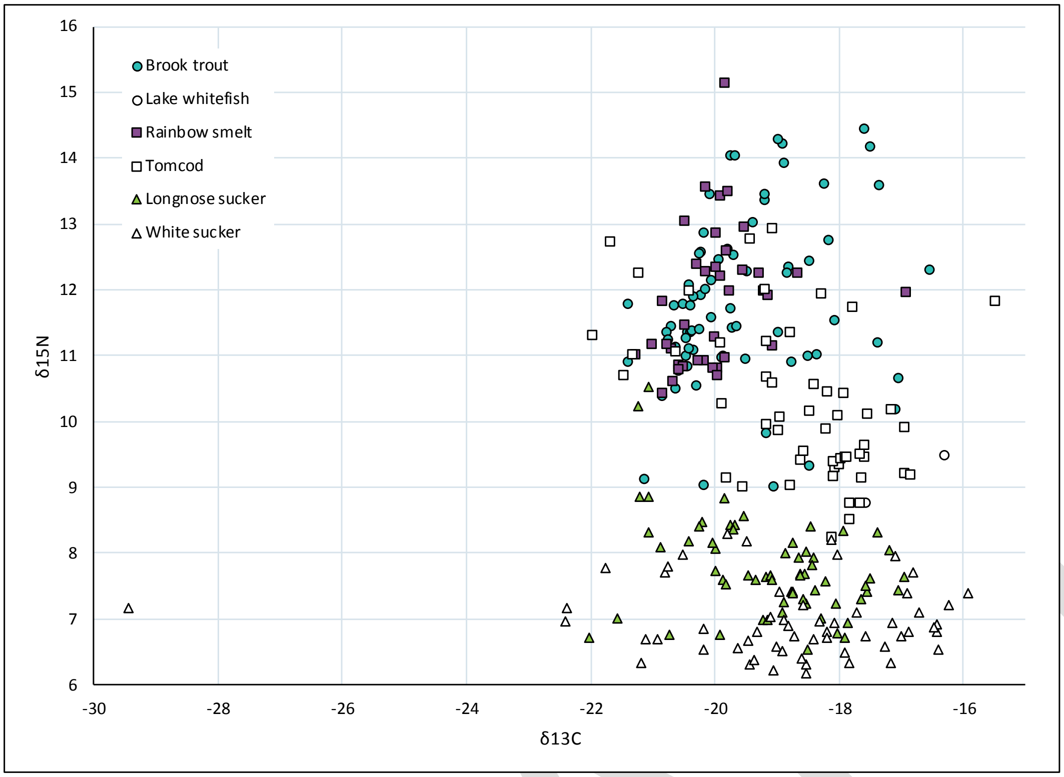


*Figure 2-4: Isotope signatures of fish captured in Goose Bay and Lake Melville, 2017*

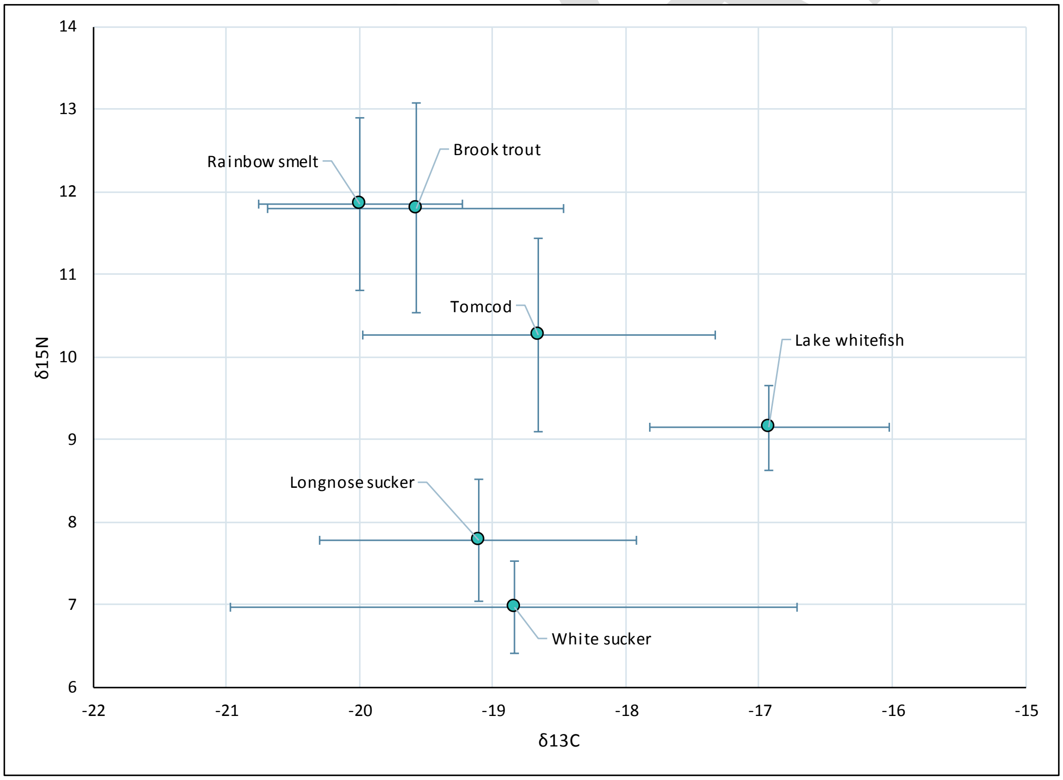


*Figure 2-5: Variability in carbon (habitat usage) and nitrogen (trophic level) signatures in fish captured Goose Bay and Lake Melville, 2017*

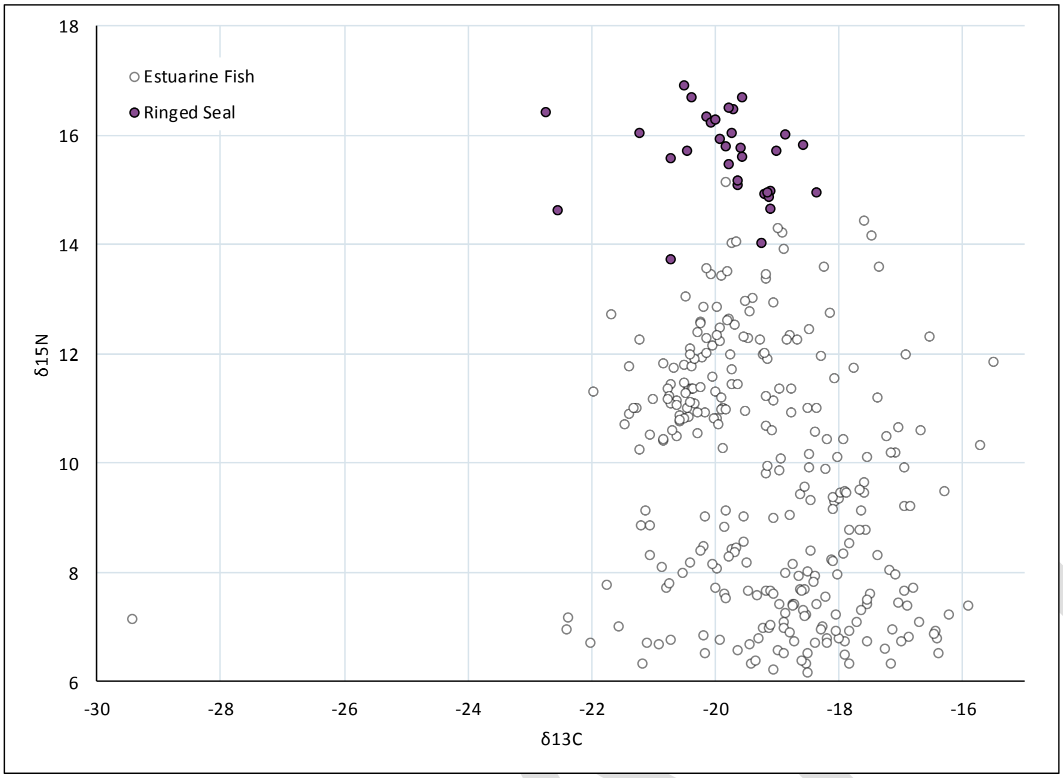


*Figure 2-6: Ringed seal isotope signatures, 2017*

## 3. Food Chain / Species Trophic Position

Table 1-1 provides a summary of mean stable isotope data collected from key fish species included in the EEM program since 2011 separated in the above noted locations. This data was used to estimate trophic position and food chain length for each species. Table 1-2 provides a general summary of stomach contents within each species to assist in feeding habitat characterization (e.g., freshwater or saline) and interpretation of isotope values.

As shown in Table 1-1, most piscivorous fish species are at the highest trophic positions, generally between values of 4-5. These species include Atlantic herring, Atlantic salmon, brook trout, rainbow smelt, and tom cod which all primarily feed in the estuarine environment as adults (Atlantic salmon off the Labrador coast). Species such as lake whitefish show a slightly lower trophic position as they typically rely on benthic invertebrates and larger amphipods/zooplankton and do not consume other fish species. It is noteworthy that northern pike also appear to be at a general trophic range of 2-5-3.5 likely due to their major prey being suckers (a fish also at a lower trophic range of ~1.5-2.5). Ringed seals have the greatest trophic values as they likely feed on a variety of fish and are one of the top predators monitored in Lake Melville.

It should be noted that some of the variability within the trophic ranges of fish could be due to variations in sample sizes between years and varying size classes of fish sampled (e.g., the data were not separated by age-class or size) for this exercise.

*Table 3-1: Summary of mean annual stable isotope data and trophic level estimates, Churchill River, Labrador.*

| Species | Location | Year | Sample Size (n) | Mean Carbon δC13 (o/oo) | Mean Nitrogen δN15 (o/oo) | Estimated Trophic Level & Food Chain Length[1] |
|---|---|---|---|---|---|---|
| Atlantic herring | Goose Bay | 2011 | 1 | -18.4 | 13.2 | 4.7 |
| Atlantic salmon | Inner Lake Melville | 2010 | 6 | -19.8 | 10.7 | 4.0 |
| Atlantic salmon | Inner Lake Melville | 2013 | 2 | -18.7 | 11.9 | 4.3 |
| Atlantic salmon | Inner Lake Melville | 2015 | 22 | -21.0 | 11.9 | 4.3 |
| Brook trout | Goose Bay | 2011 | 43 | -21.3 | 10.9 | 4.0 |
| Brook trout | Goose Bay | 2013 | 26 | -19.7 | 10.7 | 4.0 |
| Brook trout | Goose Bay | 2014 | 30 | -18.9 | 12.8 | 4.6 |
| Brook trout | Goose Bay | 2015 | 6 | -19.1 | 10.9 | 4.0 |
| Brook trout | Goose Bay | 2016 | 6 | -19.5 | 11.1 | 4.1 |
| Brook trout | Goose Bay | 2017 | 11 | -18.5 | 11.0 | 4.1 |
| Brook trout | Inner Lake Melville | 2013 | 35 | -18.5 | 10.7 | 4.0 |
| Brook trout | Inner Lake Melville | 2014 | 30 | -19.7 | 11.9 | 4.3 |
| Brook trout | Inner Lake Melville | 2015 | 29 | -18.9 | 12.6 | 4.5 |
| Brook trout | Inner Lake Melville | 2016 | 30 | -19.6 | 11.8 | 4.3 |
| Brook trout | Inner Lake Melville | 2017 | 32 | -19.7 | 12.2 | 4.4 |
| Brook trout | Outer Lake Melville | 2017 | 29 | -19.8 | 11.7 | 4.3 |
| Brook trout | Below Muskrat Falls | 2010 | 2 | -26.4 | 14.3 | 5.5 |
| Brook trout | Below Muskrat Falls | 2011 | 12 | -23.0 | 11.1 | 4.6 |
| Brook trout | Below Muskrat Falls | 2012 | 18 | -22.3 | 11.9 | 4.8 |
| Brook trout | Below Muskrat Falls | 2013 | 30 | -22.4 | 10.2 | 4.3 |
| Brook trout | Below Muskrat Falls | 2014 | 8 | -24.3 | 9.06 | 4.0 |
| Brook trout | Below Muskrat Falls | 2015 | 11 | -23.9 | 10.4 | 4.4 |
| Brook trout | Below Muskrat Falls | 2016 | 35 | -22.4 | 10.6 | 4.4 |
| Brook trout | Below Muskrat Falls | 2017 | 40 | -20.9 | 11.1 | 4.6 |
| Lake Whitefish | Goose Bay | 2011 | 1 | -19.1 | 10.2 | 3.8 |
| Lake Whitefish | Goose Bay | 2013 | 4 | -20.7 | 9.1 | 3.5 |
| Lake Whitefish | Goose Bay | 2014 | 1 | -18.4 | 11.2 | 4.1 |
| Lake Whitefish | Goose Bay | 2016 | 2 | -21.1 | 9.5 | 3.6 |
| Lake Whitefish | Inner Lake Melville | 2014 | 7 | -19.1 | 9.2 | 3.5 |
| Lake Whitefish | Inner Lake Melville | 2015 | 2 | -20.2 | 9.3 | 3.6 |
| Lake whitefish | Goose Bay | 2017 | 2 | -16.9 | 9.1 | 3.5 |
| Lake whitefish | Below Muskrat Falls | 2010 | 6 | -24.3 | 8.6 | 2.9 |
| Lake whitefish | Below Muskrat Falls | 2011 | 14 | -24.4 | 9.8 | 3.3 |
| Lake whitefish | Below Muskrat Falls | 2012 | 5 | -22.8 | 9.6 | 3.2 |
| Lake whitefish | Below Muskrat Falls | 2014 | 3 | -24.8 | 9.2 | 3.1 |
| Lake whitefish | Below Muskrat Falls | 2015 | 2 | -23.2 | 9.2 | 3.1 |
| Lake whitefish | Below Muskrat Falls | 2016 | 2 | -21.6 | 10.8 | 3.6 |
| Lake whitefish | Below Muskrat Falls | 2017 | 19 | -25.2 | 8.7 | 3.0 |
| Rainbow Smelt | Goose Bay | 2011 | 30 | -20.9 | 12.6 | 4.5 |
| Rainbow Smelt | Goose Bay | 2013 | 21 | -20.4 | 12.7 | 4.6 |
| Rainbow Smelt | Goose Bay | 2014 | 2 | -18.2 | 14.2 | 5.0 |
| Rainbow Smelt | Goose Bay | 2016 | 1 | -19.9 | 9.3 | 3.6 |
| Rainbow Smelt | Inner Lake Melville | 2013 | 21 | -20.3 | 12.7 | 4.6 |
| Rainbow Smelt | Inner Lake Melville | 2014 | 25 | -19.6 | 13.3 | 4.7 |
| Rainbow Smelt | Inner Lake Melville | 2015 | 12 | -20.1 | 12.7 | 4.6 |
| Rainbow Smelt | Inner Lake Melville | 2016 | 6 | -20.2 | 11.3 | 4.1 |
| Rainbow Smelt | Outer Lake Melville | 2016 | 16 | -18.3 | 10.6 | 3.9 |
| Rainbow Smelt | Inner Lake Melville | 2017 | 16 | -20.4 | 11.6 | 4.2 |
| Rainbow Smelt | Outer Lake Melville | 2017 | 22 | -19.7 | 12.1 | 4.4 |
| Rainbow Smelt | Below Muskrat Falls | 2016 | 1 | -21.6 | 10.7 | 3.8 |
| Tom cod | Goose Bay | 2011 | 6 | -20.5 | 12.6 | 4.1 |
| Tom cod | Goose Bay | 2013 | 8 | -20.7 | 11.0 | 4.0 |

| Species | Location | Year | Sample Size (n) | Mean Carbon δC13 (o/oo) | Mean Nitrogen δN15 (o/oo) | Estimated Trophic Level & Food Chain Length[1] |
|---|---|---|---|---|---|---|
| Tom cod | Goose Bay | 2014 | 1 | -19.0 | 10.7 | 4.0 |
| Tom cod | Goose Bay | 2016 | 6 | -20.9 | 10.9 | 4.4 |
| Tom cod | Inner Lake Melville | 2011 | 7 | -20.4 | 13.1 | 4.7 |
| Tom cod | Inner Lake Melville | 2013 | 12 | -17.4 | 10.3 | 3.8 |
| Tom cod | Inner Lake Melville | 2014 | 30 | -18.7 | 11.5 | 4.2 |
| Tom cod | Inner Lake Melville | 2015 | 8 | -17.9 | 11.5 | 4.2 |
| Tom cod | Inner Lake Melville | 2016 | 30 | -18.0 | 10.6 | 3.8 |
| Tom cod | Goose Bay | 2017 | 3 | -19.1 | 12.1 | 4.5 |
| Tom cod | Inner Lake Melville | 2017 | 39 | -18.6 | 10.1 | 3.8 |
| Tom cod | Outer Lake Melville | 2017 | 11 | -18.8 | 10.5 | 3.9 |
| Winter flounder | Inner Lake Melville | 2011 | 10 | -19.6 | 13.5 | 4.8 |
| Longnose sucker | Goose Bay | 2011 | 29 | -18.8 | 7.5 | 1.6 |
| Longnose sucker | Goose Bay | 2013 | 27 | -17.8 | 8.0 | 1.7 |
| Longnose sucker | Goose Bay | 2014 | 29 | -18.4 | 8.5 | 1.9 |
| Longnose sucker | Goose Bay | 2015 | 29 | -17.4 | 8.0 | 1.7 |
| Longnose sucker | Goose Bay | 2016 | 29 | -18.6 | 7.4 | 1.5 |
| Longnose sucker | Inner Lake Melville | 2011 | 15 | -17.7 | 8.6 | 1.9 |
| Longnose sucker | Inner Lake Melville | 2013 | 26 | -18.5 | 8.2 | 1.8 |
| Longnose sucker | Inner Lake Melville | 2014 | 26 | -19.1 | 8.6 | 1.9 |
| Longnose sucker | Inner Lake Melville | 2015 | 30 | -18.3 | 7.8 | 1.7 |
| Longnose sucker | Inner Lake Melville | 2016 | 21 | -18.9 | 7.2 | 1.5 |
| Longnose sucker | Outer Lake Melville | 2016 | 1 | -18.4 | 8.1 | 1.6 |
| Longnose sucker | Inner Lake Melville | 2017 | 32 | -18.9 | 7.7 | 1.7 |
| Longnose sucker | Outer Lake Melville | 2017 | 32 | -19.3 | 7.8 | 1.7 |
| Longnose sucker | Below Muskrat Falls | 2011 | 26 | -26.4 | 8.0 | 2.8 |
| Longnose sucker | Below Muskrat Falls | 2012 | 29 | -26.4 | 7.3 | 2.6 |
| Longnose sucker | Below Muskrat Falls | 2013 | 29 | -23.4 | 8.9 | 3.0 |
| Longnose sucker | Below Muskrat Falls | 2014 | 9 | -25.9 | 9.2 | 3.1 |
| Longnose sucker | Below Muskrat Falls | 2015 | 27 | -26.4 | 7.8 | 2.7 |
| Longnose sucker | Below Muskrat Falls | 2016 | 31 | -26.6 | 7.7 | 2.7 |
| Longnose sucker | Below Muskrat Falls | 2017 | 36 | -25.7 | 7.8 | 2.7 |
| Northern Pike | Goose Bay | 2013 | 1 | -21.0 | 7.7 | 2.7 |
| Northern Pike | Below Muskrat Falls | 2010 | 7 | -25.5 | 8.1 | 2.8 |
| Northern Pike | Below Muskrat Falls | 2011 | 5 | -28.2 | 9.0 | 3.1 |
| Northern Pike | Below Muskrat Falls | 2012 | 7 | -24.6 | 8.9 | 3.0 |
| Northern Pike | Below Muskrat Falls | 2013 | 28 | -24.6 | 9.3 | 3.1 |
| Northern Pike | Below Muskrat Falls | 2014 | 10 | -24.5 | 10.1 | 3.4 |
| Northern Pike | Below Muskrat Falls | 2015 | 5 | -25.9 | 8.8 | 3.0 |
| Northern Pike | Below Muskrat Falls | 2016 | 15 | -25.8 | 9.2 | 3.1 |
| Northern Pike | Below Muskrat Falls | 2017 | 3 | -22.4 | 9.7 | 3.3 |
| Ringed Seal | Inner Lake Melville | 2011 | 14 | -19.5 | 15.5 | 5.4 |
| Ringed Seal | Inner Lake Melville | 2012 | 30 | -19.1 | 16.2 | 5.6 |
| Ringed Seal | Inner Lake Melville | 2013 | 29 | -19.2 | 16.1 | 5.6 |
| Ringed Seal | Inner Lake Melville | 2014 | 28 | -19.5 | 16.0 | 5.5 |
| Ringed Seal | Inner Lake Melville | 2015 | 27 | -19.6 | 15.9 | 5.5 |
| Ringed Seal | Inner Lake Melville | 2016 | 29 | -20.1 | 16.0 | 5.5 |
| Ringed Seal | Inner Lake Melville | 2017 | 30 | -19.9 | 15.6 | 5.4 |

[1] Based on each trophic level accounting for approximately 3.4 o/oo although it is recognized that this can be variable.

*Table 3-2: Summary of prey diversity below Muskrat Falls, 2017*

| Species | Vegetation | Invertebrates | Fish | Plankton |
|---|---|---|---|---|
| **Freshwater** | | | | |
| Brook trout | | Odonata, Ephemerelidae, Daphniidae, Plecoptera, Tipulidae, Chironimidae, Coleoptera, Hydroptilidae, Leptophlebidae, Diptera | Rainbow smelt, Lake Chub, Sculpin | |
| Lake whitefish | Filamentous algae | Daphniidae, Leptoceridae, Chironimidae, Cyelopidae, Chydoridae, Podocopida | | |
| Longnose sucker | Filamentous algae | Chironimid, Hydrachnidia, Bivalves | | |
| Northern pike | | | 3-spine stickleback, Longnose sucker, White sucker | |
| Rainbow smelt | | | | |
| Atlantic salmon | | Pteronacidae | Unidentified fish | |
| **Goose Bay** | | | | |
| Brook trout | | Tricoptera, Chironimidae, Odonata, Formicidae, Hymenoptera | Sculpin, Tomcod, Rainbow smelt, Longnose sucker | |
| Lake whitefish | | Chironimidae, Diptera, Hymenoptera | Sculpin, Unidentified fish | |
| Longnose sucker | | | | |
| Northern pike | | | | |
| Rainbow smelt | | | | Decopod |
| Tomcod | | | Lake chub, Sand lance | |
| **Lake Melville** | | | | |
| Brook trout | | Diptera, Chironimidae, Hydroptilidae, Ichnumonidae, Cicadellidae, Staphylinidae, Hymenoptera, Bivalve | Tomcod, Sand lance, 3-spine stickleback, Winter flounder, Rainbow smelt, Unidentified fish | Amphipod, Decopod |
| Lake whitefish | | | | |
| Longnose sucker | | | | |
| Northern pike | | | | |
| Rainbow smelt | | | Sand lance, Rainbow smelt, Unidentified fish | Decapod, Amphipod |
| Tomcod | | Chironimidae | Sand lance, Sculpin, Rainbow smelt, Lake chub | Amphipod, Decapod, Isopod |



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**Brook trout** were collected in all four habitat areas (below Muskrat Falls, Goose Bay, inner Lake Melville, and outer Lake Melville). Below Muskrat Falls, Brook trout displayed generally greater range in tropic level ($\delta^{15}N$), indicating variation in diet (Figure 2-3). In the estuary environments, brook trout showed one of the greatest ranges in $\delta^{15}N$ signatures (Figure 2-5) and suggests they may be opportunistic feeders and are likely preying on various fish and planktonic species.

Stomach content analysis summary is provided in Figure 3-1. As shown, the influence of benthic macroinvertebrates is greatest in those fish captured within or near (i.e. Goose Bay) the lower Churchill River. Similar to other years, most 2017 brook trout in freshwater were captured in September within tributaries of the lower Churchill River such as Caroline Brook and McKenzie River. The presence of marine prey such as sandlance and rainbow smelt in a percentage of the non-empty stomachs indicates a return from the estuary environment. The presence of benthic invertebrates as prey in samples from inner Lake Melville was much lower, possibly indicating lower influence of freshwater. A general increase in prey diversity can also be seen from samples collected from outer Lake Melville (e.g., Valley Bight area). Brook trout from the more eastern portion of the lake preyed on amphipods and decapods which were not identified in freshwater, Goose Bay or inner Lake Melville samples. Sandlance appeared to be a prevalent prey item within Lake Melville while tomcod seemed to play a greater role as prey in Goose Bay but less so further into Lake Melville.

The brook trout stomach content results support the isotope values recorded in both the freshwater and estuary environment. Brook trout captured and sampled in the freshwater environment are feeding on benthic macroinvertebrates and fish with some of the fish being estuary origin. The estuary samples indicate higher numbers of brook trout preying on fish along with zooplankton in outer Lake Melville. This places them near the higher $\delta^{15}N$ values and would explain the high range of $\delta^{15}N$ values measured as they feed at various trophic levels. A similar trophic level and chain length among freshwater and estuary samples indicates the general movement of brook trout into the estuary from freshwater environments to feed (see Table 1-1).

**Tomcod** were sampled in all estuary environments (i.e., Goose Bay, inner Lake Melville and outer Lake Melville) but not in freshwater. Similar to brook trout and rainbow smelt, tomcod showed one of the greatest ranges in $\delta^{15}N$ signatures (Figure 2-5) and suggest that they may be opportunistic feeders and are likely preying on various fish and planktonic species.

With respect to stomach content analysis, a high proportion of stomachs from Goose Bay were empty in contrast to those from Lake Melville (Figure 3-2). In Goose Bay, fish was the only prey item identified (sandlance and lake chub). In Lake Melville, there seemed to be little freshwater influence in terms of prey items and greater presence of amphipods, isopods and decapods and generally lower predation on fish species in outer Lake Melville. This is also evident in the $\delta^{15}N$ isotope signatures which tended to be lower than those of brook trout and rainbow smelt (see Figure 2-5).

**Rainbow smelt** were also sampled in all estuary environments, similar to tomcod. Also similar to tomcod and brook trout, they showed some of the largest range in $\delta^{15}N$ signatures (Figure 2-5) and may suggest that they are opportunistic feeders and are likely preying on various fish and planktonic species.

However, those rainbow smelt sampled for stomach contents in Goose Bay appeared to rely heavily on decapods (Figure 3-3). Within inner Lake Melville, fish was the most prevalent prey item with fish and zooplankton (amphipods and decapods) preyed upon in outer Lake Melville.

This trend is similar in some ways to tomcod and likely reflects general prey availability for these species within Lake Melville.

Rainbow smelt showed a similar $\delta^{15}N$ isotope signature range to that of brook trout which indicates that the relative proportions of prey items may be similar among these species diet. They both appear to be the two fish species (of those sampled) highest on the estuary food web (see Figure 1-7).

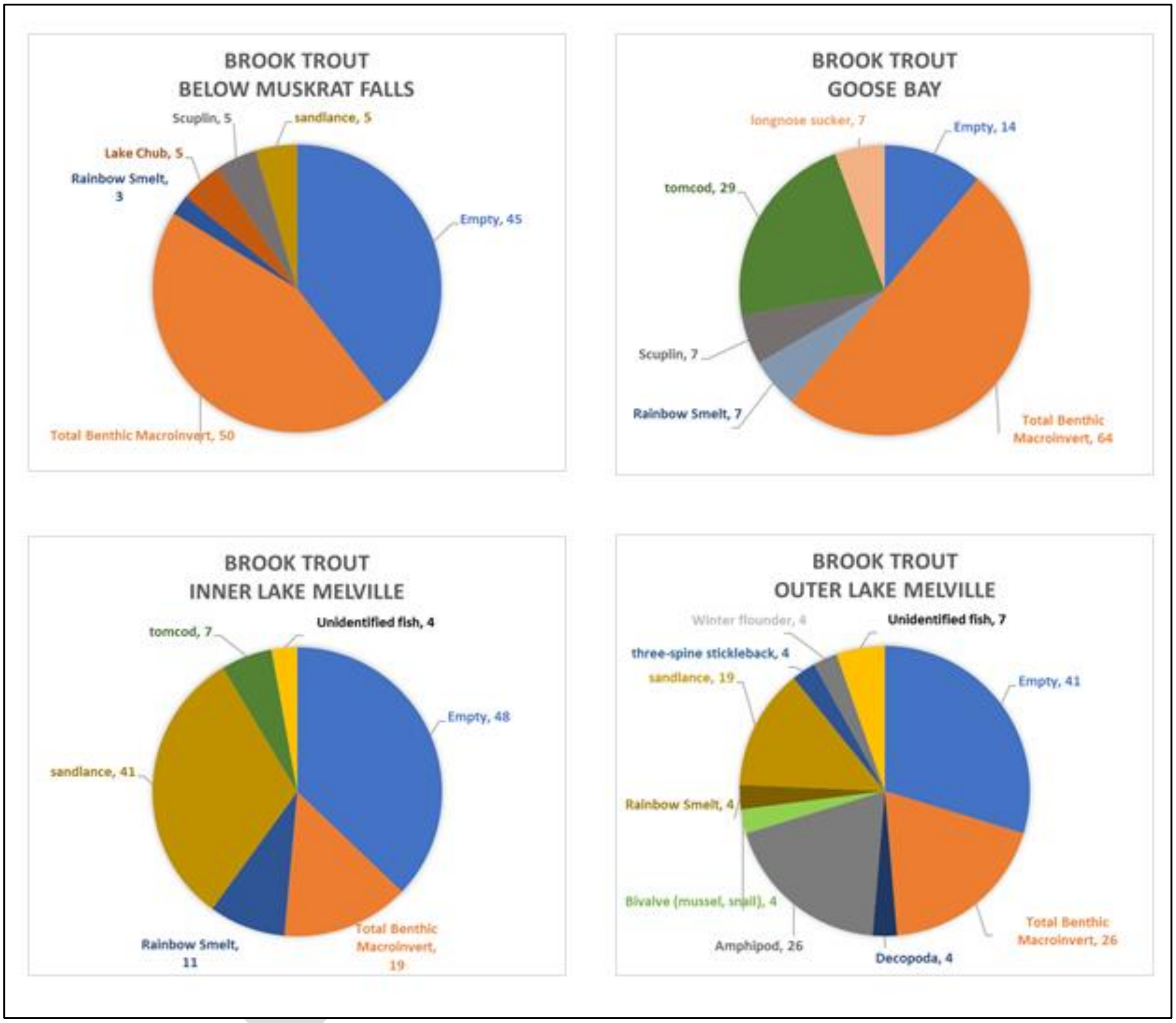


*Figure 3-1: Brook trout stomach content analysis. Numbers presented are the percentage of stomachs which contained that prey item.*

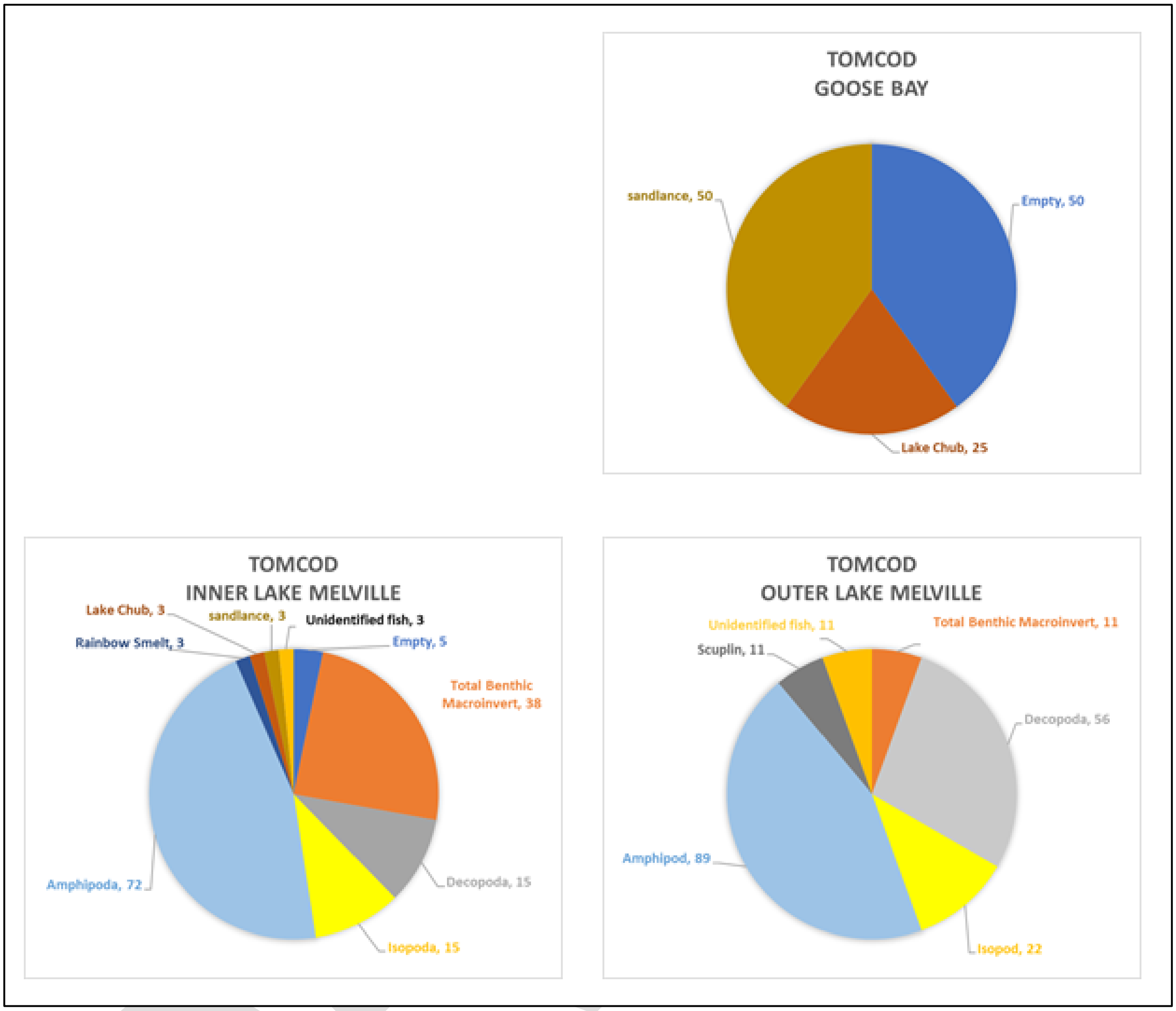


*Figure 3-2: Tomcod stomach content analysis. Numbers presented are the percentage of stomachs which contained that prey item.*

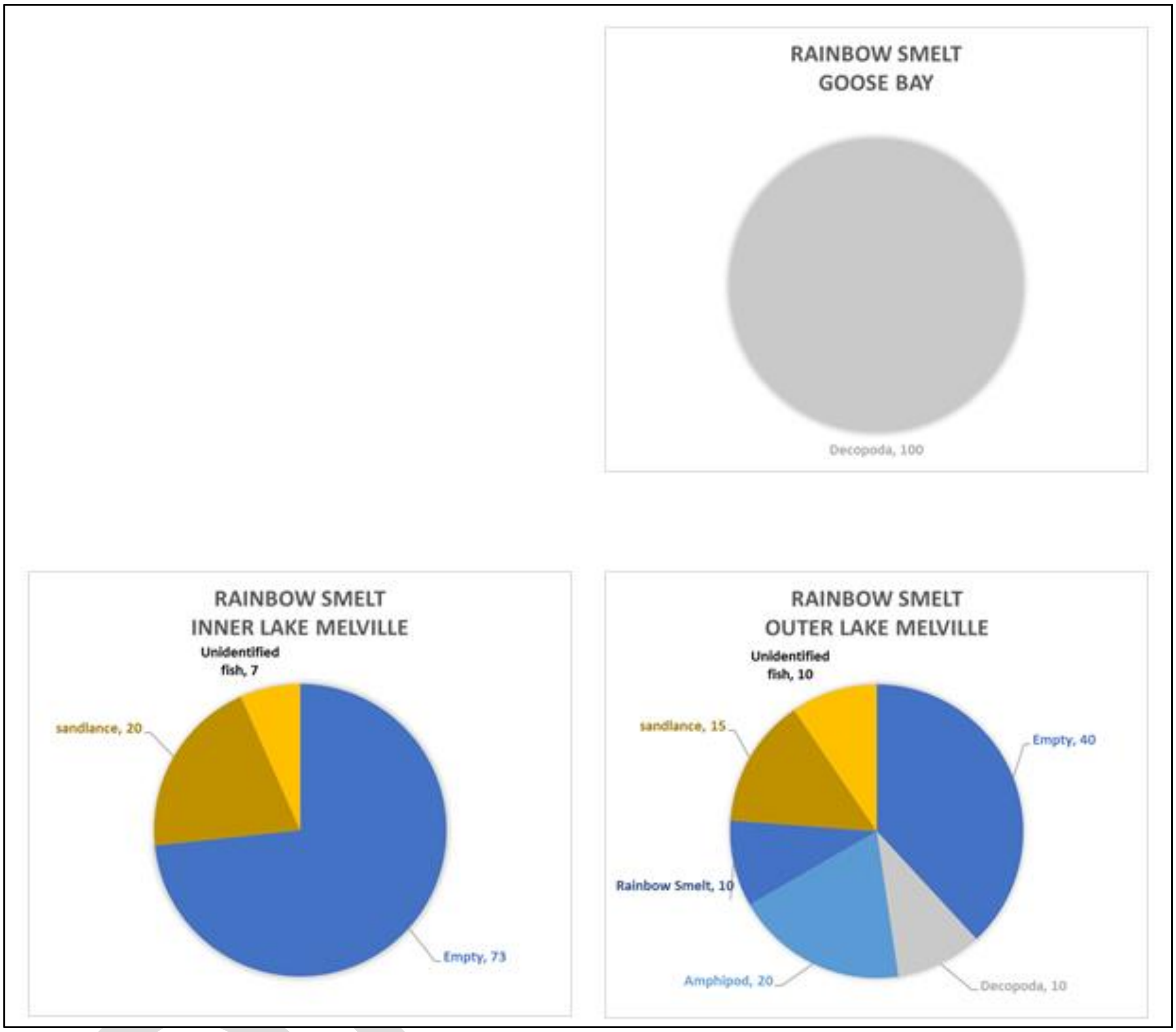


*Figure 3-3: Rainbow smelt stomach content analysis. Numbers presented are the percentage of stomachs which contained that prey item.*

**Lake whitefish** were sampled in and near the freshwater environment (Figure 3-4). Similar to brook trout, lake whitefish displayed generally greater range in tropic level ($\delta^{15}N$), indicating variation in diet (Figure 2-3).

As shown via stomach content analysis, there was a large benthic macroinvertebrate prey influence with some fish predation identified within the freshwater environment. The higher benthic invertebrate prey is also reflected in the $\delta^{15}N$ isotope signature range (see Figures 2-3 and 2-5) which places this species, as expected, lower than brook trout, rainbow smelt, tomcod, and northern pike. The species food chain length is also relatively shorter that these other species with the exception of northern pike (see Table 1-1).

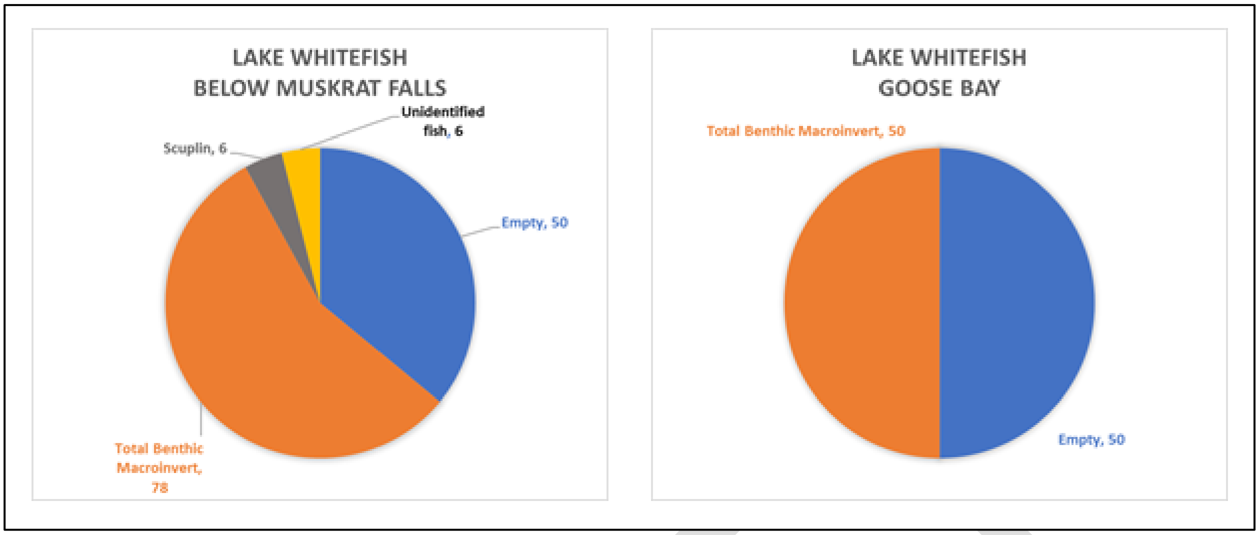


*Figure 3-4: Lake whitefish stomach content analysis. Numbers presented are the percentage of stomachs which contained that prey item.*

**Northern pike** were only sampled from the freshwater environment in 2017 (Figure 3-5). Based on isotope signatures, northern pike displayed the lowest variability of $\delta^{15}N$ isotope signature (Figure 2-3), indicating that northern pike are likely relying on other fish as a food primary source and may be keying in on specific species based on abundance or capture success.

Based on stomach content analysis, northern pike appear to be heavily reliant upon fish as a food source within the mainstem and tributaries such as white sucker, longnose sucker, and stickleback. This information tends to confirm that pike are feeding on lower trophic level fish as shown in their $\delta^{15}N$ isotope signature range as shown in Figure 2-3. While they are feeding on other fish, these prey species have relatively short food chain lengths which is reflected in the pike's lower food chain length as well (see Table 1-1).

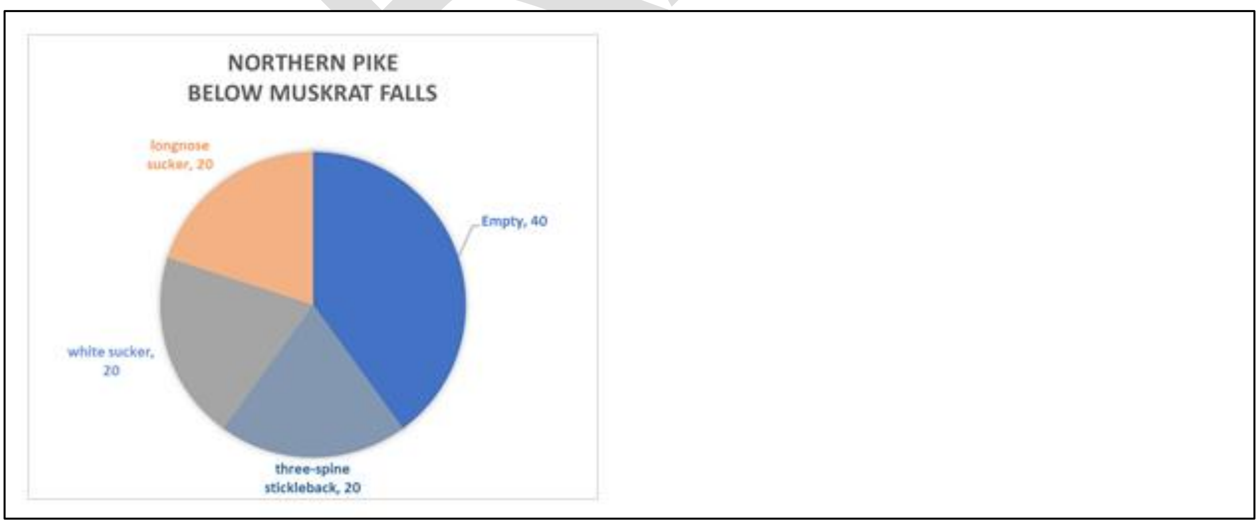


*Figure 3-5: Northern pike stomach content analysis. Numbers presented are the percentage of stomachs which contained that prey item.*

**Longnose sucker** showed the greatest range in $\delta^{13}C$ signatures, indicating that they may be feeding on a wide range of terrestrial, benthic, and pelagic carbon sources that have settled to the substrate (Figure 2-5).

Stomach content analysis from Goose Bay (the only location where stomach content analyssi has been completed) confirms that they appear to feed on benthic organisms such as filamentous algae, benthic macroinvertebrates, and bivalves (mussels and snails) (Figure 3-6). Their overall low trophic level and food chain length in all estuarine habitats seems to indicate that they feed at a similar trophic level throughout (see Table 1-1). It is notable however that the estimated trophic level of longnose sucker sampled within the freshwater environment appear to have a slightly higher trophic level and food chain length, possibly related to greater benthic macroinvertebrate diversity in the tributaries (e.g., predacious benthic inverts such as Odonata), bivalve availability, or pelagic contributions to the bottom substrate such as settling zooplankton.

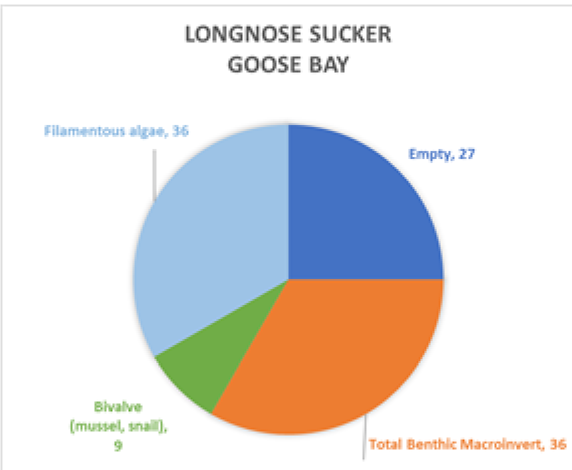


*Figure 3-6: Longnose sucker stomach content analysis. Numbers presented are the percentage of stomachs which contained that prey item.*

## 4. Recommendation on Habitat Utilization and Food web influence

The data on stable isotopes and stomach content analysis suggests that many of the fish species that utilize Lake Melville for feeding are preying on other lower trophic fish and zooplankton that are more marine origin. This would suggest that species spend greater time in the lower more-saline layer of Lake Melville to feed. This information should be considered in terms of the pathway for any predicted increase in methylmercury exposure.