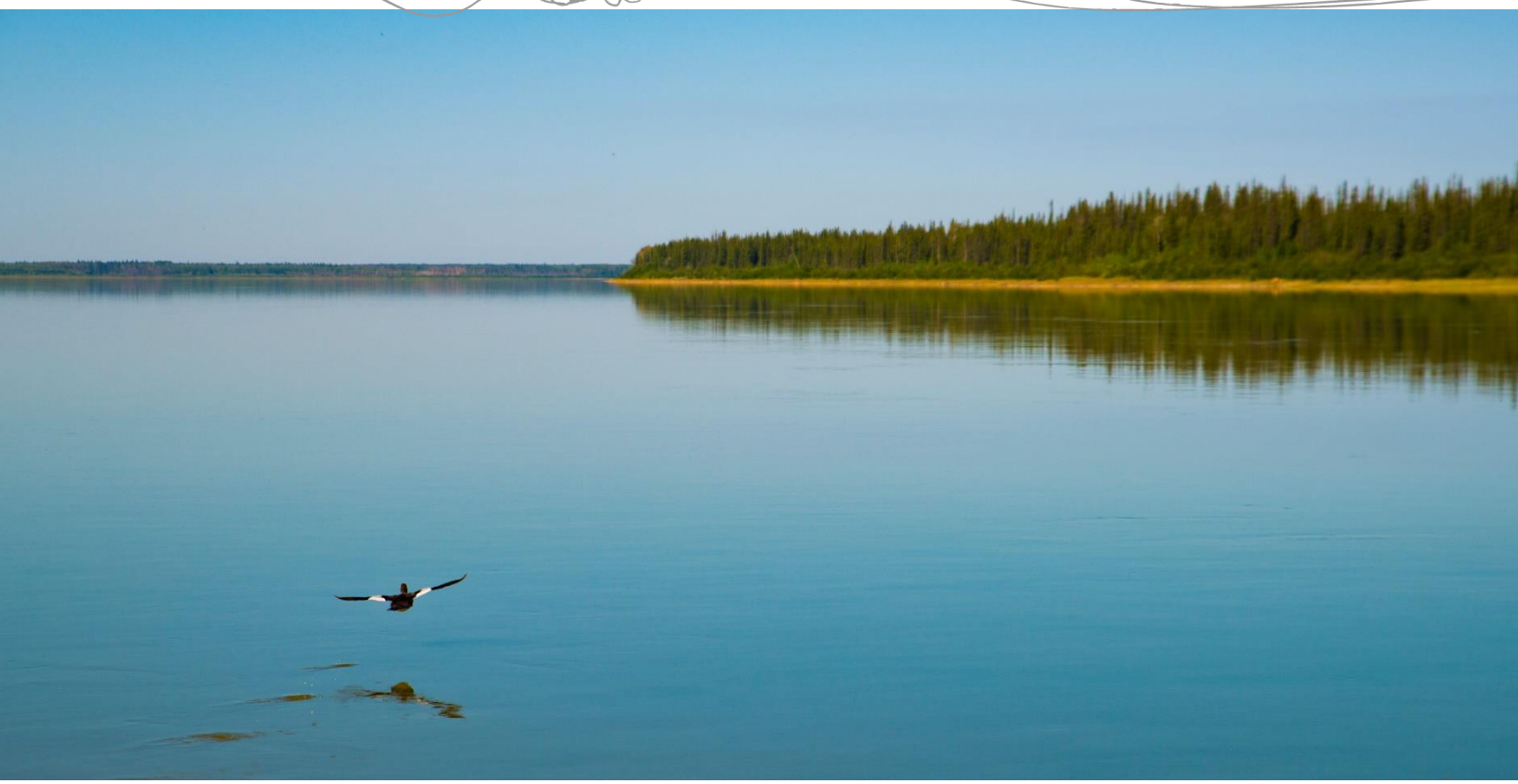


BIOMONITORING OF AB-NWT TRANSBOUNDARY RIVERS USING INVERTEBRATES

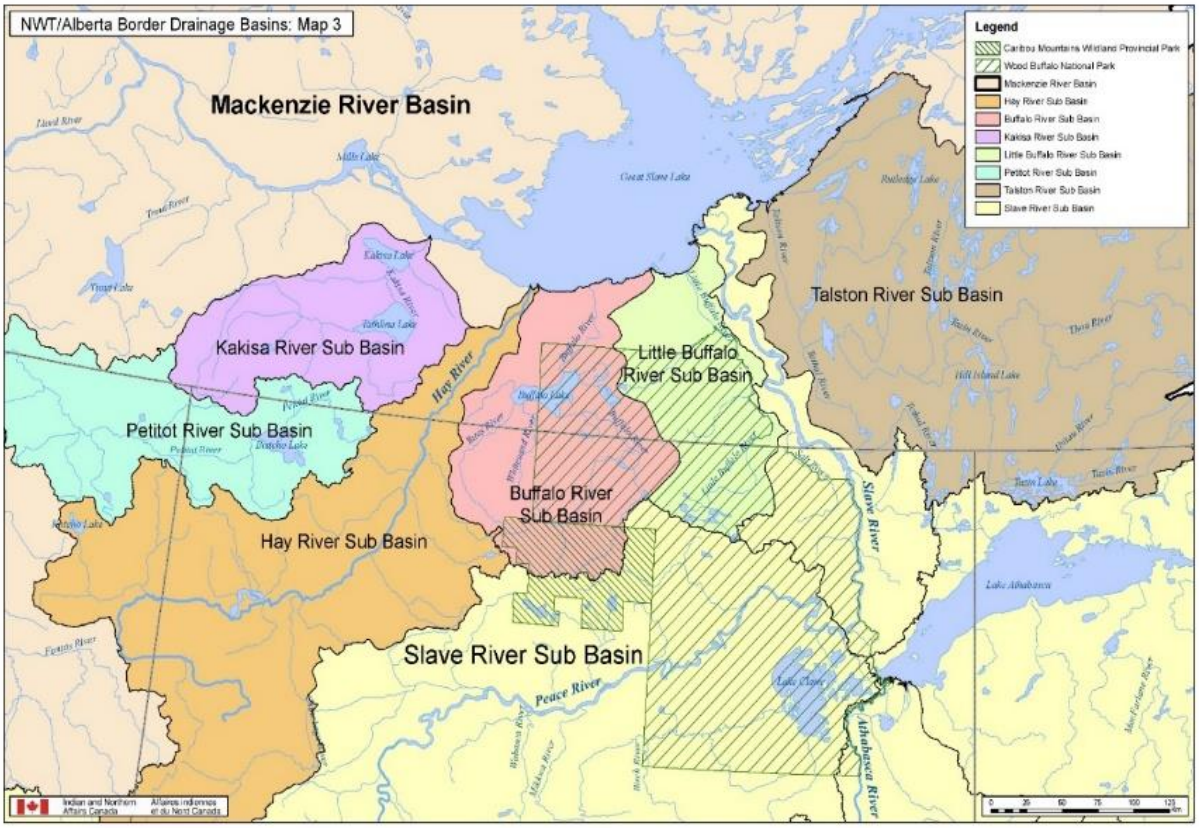
PROGRAM SUMMARY 2017-2020

Government of Northwest Territories

Alberta Government

Biomonitoring of Alberta-Northwest Territories Large Transboundary Rivers Using Invertebrates

In freshwater systems that cross multiple jurisdictions, such as large rivers that flow across provincial or territorial boundaries, there is a shared requirement to manage and monitor the aquatic ecosystem. Any changes to water quality and water quantity that occur in the upriver portion of the watershed in one jurisdiction have implications for the downriver portion of the watershed in the other jurisdiction. For this reason, there is a strong incentive for cooperation between jurisdictions to monitor different aspects of the aquatic ecosystem.



Alberta and the Northwest Territories have an inter-provincial/territorial agreement to monitor the aquatic ecosystem of large transboundary rivers such as the Hay River and the Slave River, both of which flow north from Alberta towards Great Slave Lake in the Northwest Territories. As part of this agreement, biological indicators were identified and monitoring programs were developed and initiated to begin coordinated monitoring of the health of the waters near the shared provincial/territorial border.

Monitoring water quality using aquatic invertebrates

Water quality grab samples provide a direct way to assess freshwater quality, but such samples represent a snapshot in time, only telling us about the water quality at the time that the sample was collected. In contrast, the organisms that live in a body of water are subjected to all conditions in the system over their lifespan and feel the effects of all stressors (including changes to flow, temperature, and the physical habitat), not just changes to the chemical habitat. The composition of organisms (the taxonomic groups that are found there and the relative abundance of all taxonomic groups) can tell us more about water quality conditions over a longer time period than water quality grab samples, giving us a complementary, time-integrated picture of changes to water quality and aquatic habitat.

Mayfly nymph (Photo: Bob Henricks from Charlottesville, USA, CC BY-SA 2.0 <https://creativecommons.org/licenses/by-sa/2.0>, via Wikimedia Commons)

Aquatic invertebrates, also known as benthic macroinvertebrates, are commonly used to assess water quality in rivers and lakes. Their name means that they are insects and other creatures without a backbone (*invertebrates*) that live on the bottom of a river or lake (*benthic*) and are large enough to see with the naked eye (*macro*). Most aquatic invertebrates in lakes and rivers are larvae or nymphs (young life stages) of terrestrial insects such as midges, mosquitos, black flies, and mayflies. Many of the insect species live for only a short time as terrestrial adults (some for as little as one day) but live for years as larvae or nymphs in freshwater. Non-insect invertebrates in freshwater include worms, clams, and snails.

Stonefly nymph (Photo: Dave Huth, CC BY-SA 2.0, via Flickr)

Benthic macroinvertebrates are relatively immobile, which means they can't easily move away from sources of stress (unlike fish), and different taxonomic groups have differing tolerance levels to a variety of stressors. Some invertebrates require clean water and high oxygen levels, while others are capable of living in extremely poor water quality or harsh environmental conditions.

Midge larva (Photo: Mélissa69770, CC BY-SA 4.0, via Wikimedia Commons)

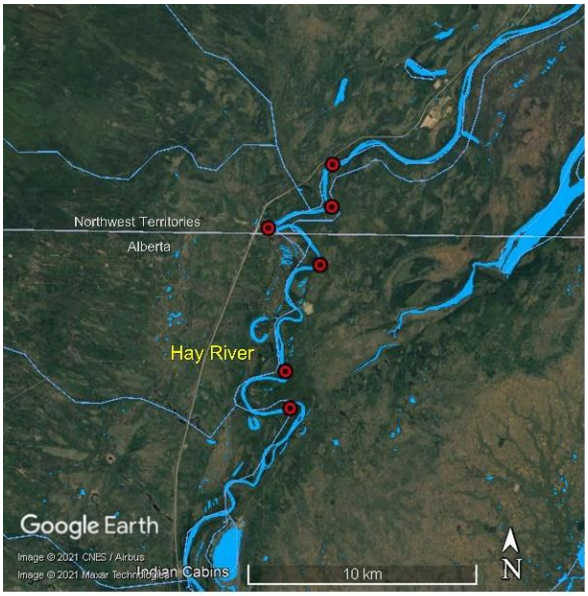
For all these reasons, benthic macroinvertebrates are an excellent indicator of water quality, and were chosen as a biological indicator for the Alberta-Northwest Territories transboundary water monitoring program.

Sampling method

Sampling methods for benthic macroinvertebrates in streams are well established, but fewer protocols exist for sampling large rivers. The establishment of the Alberta-Northwest Territories transboundary monitoring program offered an opportunity to expand the large river study design and sampling protocols in two very different rivers. Near the Alberta-Northwest Territories border, the Hay River is a moderately wide, shallow, relatively slow-flowing meandering river, whereas the Slave River is a very wide, deep, fast-flowing braided river with islands.

The sampling methods for the transboundary monitoring program were developed based on examples of large river sampling protocols from programs elsewhere in Canada and the United States. Within each river, reaches were identified as 250-500 metre (m) lengths of the shoreline along which there was a primarily rocky substrate (cobble and pebble) where benthic macroinvertebrates could be sampled with a kicknet. Five sites were selected within each reach, with sites located 50-100m apart along the shoreline of the river, and at each site, samples of the benthic macroinvertebrate community, water quality, sediment quality, and habitat descriptions were collected.

Macroinvertebrate sample collection followed a modification of the national Canadian Aquatic Biomonitoring Network (CABIN) protocols for streams. The operator held a kicknet downstream while kicking and disturbing the substrate with their boots for three minutes to cause organisms to float downstream into the net. While kicking, the operator moved in a zig-zag pattern upstream through the wadeable portion of the river near the shoreline to sample as much of the habitat as possible during the sampling time. After three minutes, macroinvertebrate samples were collected from the net, preserved, and sent to a lab for identification.



Hay River sample reaches (red points)

Slave River sample reaches (red points)

Sampling of the Hay and Slave Rivers began with five reaches in 2017. A sixth reach was added to each river in subsequent years. Sampling is repeated each year initially with the goal of describing natural variability from year to year in the macroinvertebrate community. Once the natural range of variability is described, routine sampling can occur less frequently (for example, every two or three years) to monitor any changes from expected conditions. Sampling takes place in late summer or early fall, but timing depends on water levels and site accessibility.

Hay River

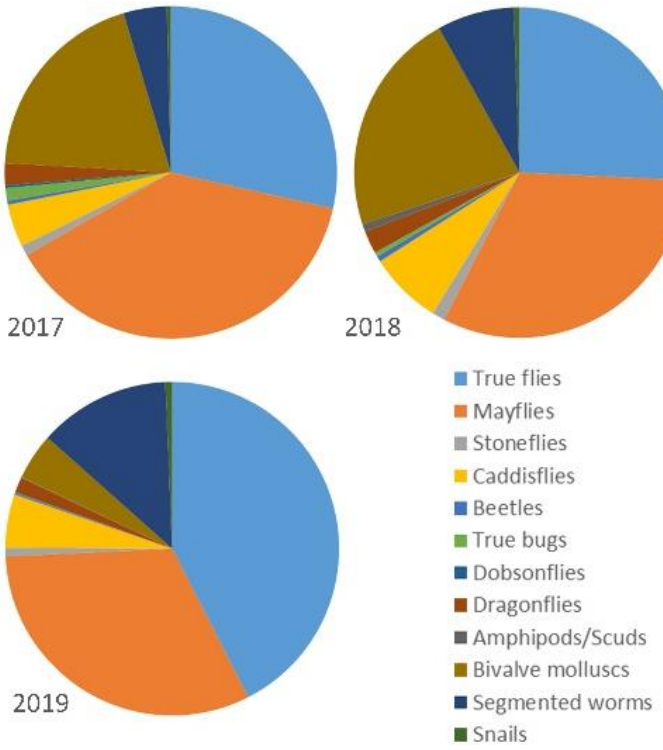
The Hay River was sampled each year from 2017 to 2019 but could not be sampled in 2020 due to high water levels. Variability in water levels among sampling years led to some differences in the abundance of taxonomic groups, but community composition was generally similar among years.

Hay River communities were dominated by true flies (mostly midges) and mayflies, which are both common in river communities. Bivalve molluscs were found in fairly high abundance in 2017 and 2018 when water levels were low, but they were replaced by segmented worms in 2019 when water levels were high. The macroinvertebrate community of Hay River was diverse from 2017-2019, with an average of 27-37 different taxa found at a site. The community was not overly dominated by a single taxonomic group, which would be an indicator of poor water quality. The moderate to high abundance and diversity of taxa, which was fairly evenly spread across many taxonomic groups, indicated good water quality.

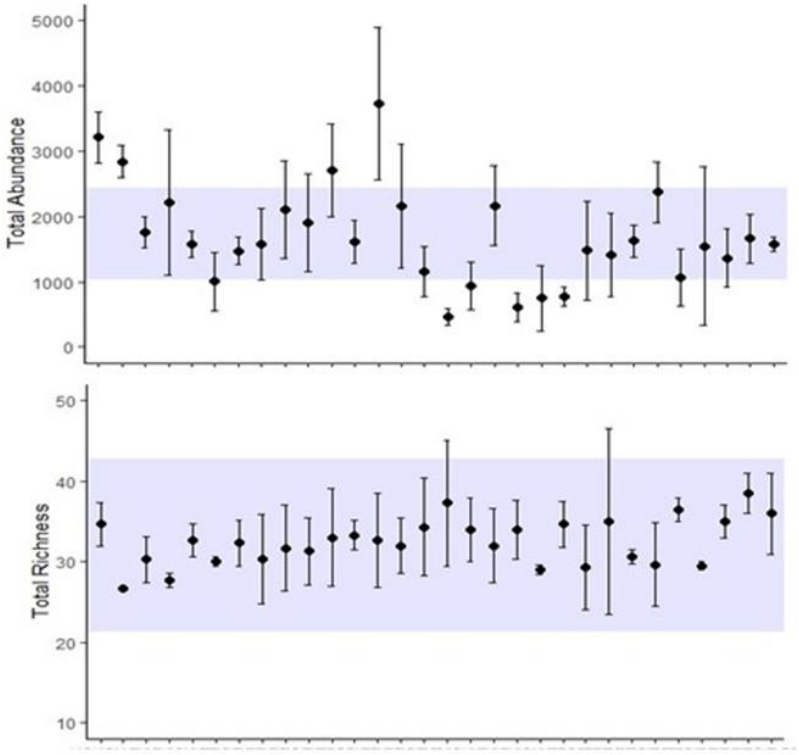
Data from the first three years of sampling on the Hay River were used to estimate the normal range of variability for the benthic macroinvertebrate community. Average values for each site across the three sampling years were compared with the normal range to evaluate the amount of variability captured. Total abundance of macroinvertebrates was quite variable across sites, and many sites were above or below the normal range for the either river. The annual variability in abundance of different taxonomic groups is due to weather and flow conditions. Taxonomic richness, which is a measure of the number of unique taxa found at a site, was less variable over time, indicating that the taxonomic composition of macroinvertebrates remained fairly stable, even if abundance fluctuated.

Sample research in the Hay River

Hay River



Relative abundance of macroinvertebrate groups in Hay River samples



Average (points) and standard deviation (lines) total abundance and taxonomic richness from 2017-2019 at Hay River sites. Shaded area is normal range of variability among all sites.

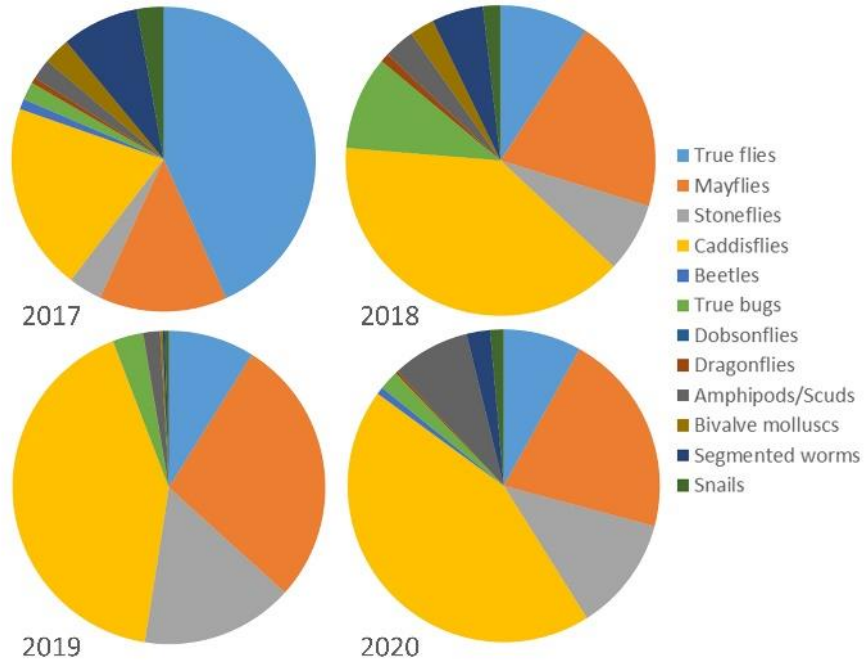
Slave River

The Slave River was sampled in 2017-2020, but sampling in 2020 was limited due to high water levels. Water levels were quite different in 2017 compared to later years of sampling, and this appeared to have a strong effect on the composition of benthic invertebrate samples. In particular, samples in 2017 were dominated by true flies (primarily midges), which made up nearly 50% of the community on average, but samples in 2018-2020 had extremely low abundance of midges, which may have reflected the much higher water levels and different flow conditions prior to sampling in those later years. Composition of major benthic macroinvertebrate groups was similar from 2018 to 2020, with very high abundance of caddisflies (case-making insect larvae) and higher abundances of mayflies and stoneflies than were observed in 2017. Many caddisfly, mayfly, and stonefly taxa are tolerant of fast flowing water, or have a preference for fast flows, which may explain their dominance in the later years of sampling.

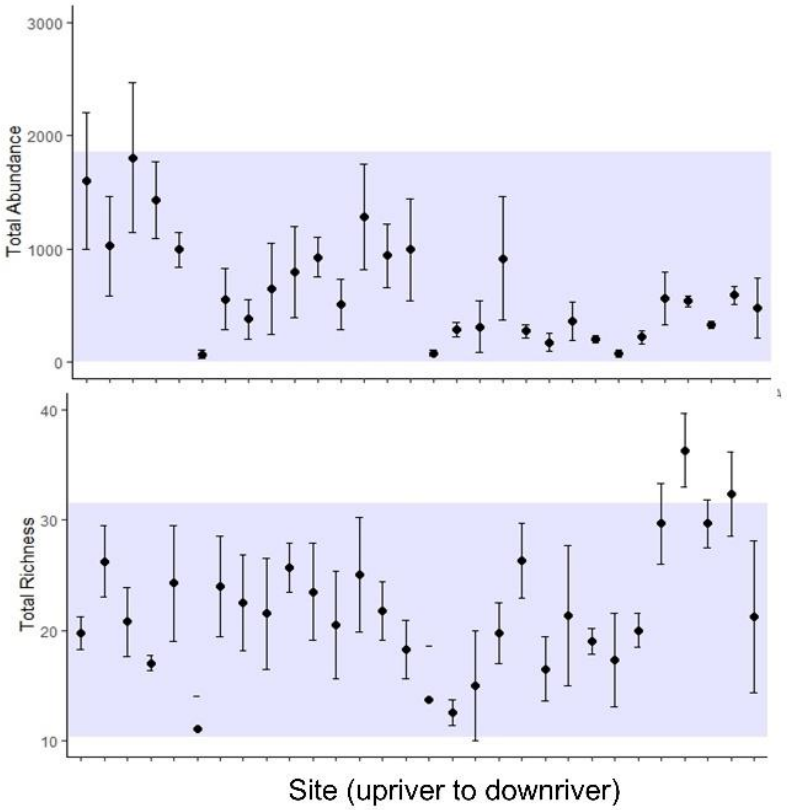
The strong differences in community composition among years in Slave River samples led to some difficulty in defining the normal range of variability for the river, particularly with respect to taxonomic groups like the midges (which shifted from strong dominance to extremely low abundance) and the mayflies, stoneflies, and caddisflies (which became more dominant after 2017). Variation in total abundance of macroinvertebrates was large across all sites, but average abundance for most sites was within the defined normal range for the river. Total richness (total number of taxa) was more variable among years, due in part to the obvious shifts in composition after 2017. There was an average of 20-29 different taxa found at a site from 2017-2019, and though composition was variable among sampling years, the variety and abundance of taxa was fairly typical of a large river and did not indicate any potential water quality impacts. Richness and abundance of macroinvertebrates were both reduced in 2020, but this was a result of higher than average water levels prior to sampling. Overall, the results indicated good water quality for the Slave River, and a strong effect of water level on macroinvertebrate sample results.

Benthic macroinvertebrate kick sampling in the Slave River 2017

Slave River



Relative abundance of macroinvertebrate groups in Slave River samples



Average (points) and standard deviation (lines) total abundance and taxonomic richness from 2017-2020 at Slave River sites. Shaded area is normal range of variability among all sites.

Future work

Data from the first three years of sampling in the Hay River and the first four years of sampling in the Slave River have contributed to defining the normal range of variability in community composition. Defining the normal range will be vital as monitoring becomes routine and new data are assessed to detect signs of change. As more data are collected, the normal range will be refined, and boundaries will likely get narrower, allowing for better diagnostic capability. The relationship between water level and community composition in the Slave River will be explored to determine whether estimates of natural variability can be adjusted for flow conditions.