Final Research and Budget Report for Fisheries and Wildlife Enhancement Trust project
Phenology of aquatic vegetation near Old Crow, Yukon

Prepared by

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The project *Phenology of aquatic vegetation near Old Crow, Yukon* focused on two research questions, related to a larger IPY research project on the seasonal use of the Old Crow Flats by moose. The key questions we sought to answer with funding from the Fisheries and Wildlife Enhancement Trust were whether 1) over-wintering or new under-ice growth of macrophytes are sufficiently abundant and nutrient rich in early spring to explain the arrival of moose into OCF shortly after ice-off and 2) late summer decreases in macrophyte abundance or nutrient composition account for the departure of moose from OCF well before freeze-up.

Background

Moose are known to use aquatic habitats extensively in summer, but how aquatic vegetation phenology affects moose habitat selection and food habits throughout the ice free season is poorly understood. Old Crow Flats (OCF) in North Yukon is an internationally-renowned wetland complex containing probably more than 2,000 lakes. Research by Fran Mauer (Arctic National Wildlife Refuge) in the 1990's showed that moose collared in north-eastern Alaska in winter traveled long distances in early spring to spend the summer in OCF then left again in late summer to return to the winter range occupied in the previous year. Satellite download GPS collaring of 19 moose in OCF during the summer of 2007, as part of the International Polar Year (IPY) project *YNNK: Environmental change and traditional use of the Old Crow Flats*, has confirmed this late summer moose emigration from OCF. This research has also shown that moose summering in OCF travel to winter ranges in Ivavvik National Park and along the Porcupine River upriver of the village of Old Crow, in addition to north-eastern Alaska. The spring migration of moose into the OCF wetland complex from distant and distinct winter ranges (that will again be documented with satellite download GPS collars in the coming months) represents one of North America's most dramatic examples of aquatic habitat selection by moose. Better understanding of the seasonal migration of moose to and from OCF requires resolving why they come and why they leave.

At the onset of this project, our working hypothesis was that moose are attracted to OCF in spring because of abundant, nutrient-rich food growing in lakes and/or shrubs concentrated in drained lake basins. However, we were and are puzzled about the timing of the moose migration. It is unknown why moose leave OCF in late summer, well before the rut and lake freeze-up, but we speculated that late summer declines in the abundance and nutrient value of preferred macrophytes (large, aquatic plant life) play an important role. Within the broader YNNK IPY project, we are using 1) satellite images, aerial photos, and ground truthing to map the distribution of aquatic and terrestrial vegetation across OCF, 2) satellite/GPS telemetry to examine the timing of seasonal movements of moose into and out of OCF as well as their finescale aquatic and terrestrial habitat within OCF, and 3) stable isotopes to assess the proportion of aquatic and terrestrial plants in moose diets within OCF.

We requested funding from the Yukon Fish and Wildlife Enhancement Trust to conduct an additional, detailed study of the phenology (timing of growth and reproduction) of aquatic vegetation in the Old Crow region that formed an important complement to the associated YNNK IPY moose research project. The key questions to be answered by this additional project were whether 1) over-wintering aquatic macrophytes are sufficiently abundant and nutrient rich in early spring to explain the arrival of moose into OCF shortly after ice-off and 2) late summer decreases in macrophyte abundance or nutrient composition account for the departure of moose from OCF well before freeze-up. This latter question is especially important to North Yukon moose management because the pre-rut departure of bulls and cows from OCF creates the potential for distinct breeding populations with overlapping summer ranges. Thus, it is important to establish the ecological drivers of the pre-rut migration out of OCF and the potential annual variability of these drivers.

Methods

We accomplished this research by visiting three study lakes close to the village of Old Crow and accessible via the Porcupine River (Fig. 1).

Figure 1. Three study lakes located south of the village of Old Crow and the Porcupine River at 67.535°N / 139.856°W, 67.557°N / 139.784°W and 67.555°N / 139.796°W

Field work was conducted primarily by Ann Balasubramaniam (PhD Student in Limnology and Aquatic Ecology, University of Waterloo) and Robert Kaye (Game Guardian, Vuntut Gwitchin Government) , with additional assistance from Lance Nukon (Vuntut Gwitchin First Nation) and Martin Kienzler (Yukon Environment). Lakes were visited up to seven times during the ice free season of 2008, including sampling dates on June 19, June 26, July 4, July 11, July 26, August 30, and September 9. During these sampling dates we estimated the percent cover of major genera of aquatic vegetation on the lakes and collected representative samples of any aquatic vegetation present. Adjacent to these lakes, we also collected samples of leaves and twigs from terrestrial shrubs that moose are known to consume. We also collected some willow samples during late winter 2008, to establish a winter baseline. Vegetation samples were air dried prior to shipping and the completion of analysis at commercial laboratories. Samples were analysed by Agri-Food Laboratories (Guelph, ON) for nutrient composition (e.g., energy, protein, fiber, lignin, and various micronutrients) and by SINLAB (Fredericton, New Brunswick) and by EMDW (Victoria, British Columbia) for stable isotope composition. Stable isotopes were analysed to determine if isotopic enrichment varied seasonally or according to nutrient composition, since we are using isotope approaches to assess moose diet selection in the larger IPY project.

Results

The three lakes remained ice covered until early June. There was no to very little aquatic vegetation visible in the lakes in mid-June, when they were first visited. Aquatic vegetation did not become widespread until mid-July, but then remained abundant until the last visit on September 9.

The major species of vascular aquatic vegetation encountered, in order of abundance and seasonal extent of occurrence, were *Carex aquatilis* (water sedge), *Potamogeton praelongus* (white-stemmed pondweed), *Equisetum fluviatile* (water horsetail), *Potamogeton richardsonii* (Richardson’s pondweed) and *Nuphar variegatum* (yellow pond lily). The main terrestrial shrubs that were encountered and identified to be browsed by moose were, in order of relative abundance, *Salix* sp. (willow), *Alnus crispa* (green alder) and *Betula* sp. (birch).

The net energy content of the three most abundant genera of aquatic vegetation was similar to each other and to terrestrial shrubs (Fig. 2). Seasonal variation in the energy content of aquatic plants and terrestrial shrubs was minimal, except that shrubs collected in winter and autumn had lower energy content than shrubs with green leaves (Fig. 2).

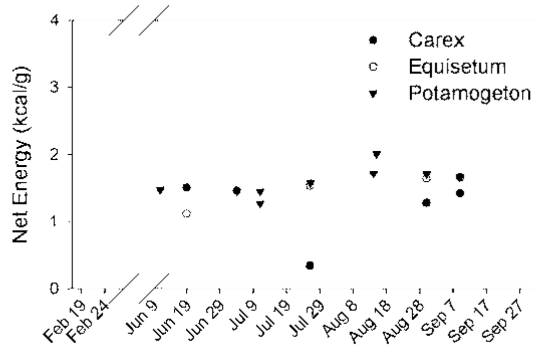

Figure 2a. Seasonal trends in net energy content of the aquatic plants *Carex aquatilus*, *Equisetum fluviatile*, and *Potamogeton praelongus*.

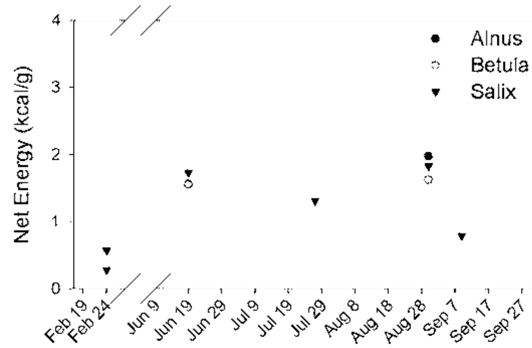

Figure 2b. Seasonal trends in net energy content of the terrestrial shrubs. *Alnus crispa*, *Betula sp.*, and *Salix sp.*

The protein content of *Carex* and *Equisetum* exceeded that of *Potamogeton*, particularly early in the season (Fig. 3a). The protein content of all three terrestrial shrubs was similar and declined consistently from spring (ca. 15%) through summer to autumn and winter (ca. 5%; Fig. 3b). Thus, terrestrial shrubs contained more protein than aquatic vegetation in spring, whereas protein levels in the two groups were similar in late summer and fall.

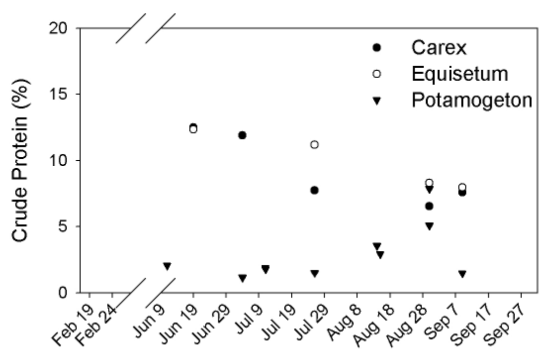

Figure 3a. Seasonal trends in protein content of aquatic plants.

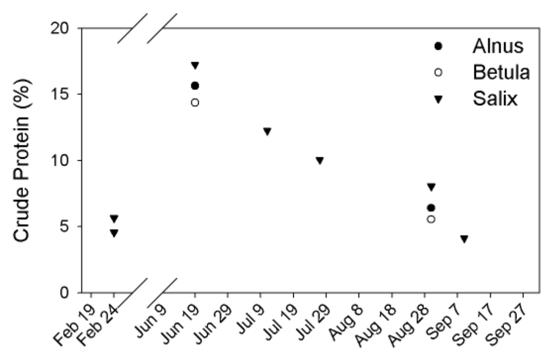

Figure 3b. Seasonal trends in protein content of terrestrial shrubs.

The sodium content of aquatic plants was much higher than terrestrial plants and within aquatic plants *Potamogeton* had much more sodium than *Carex* or *Equisetum* (Fig. 4).

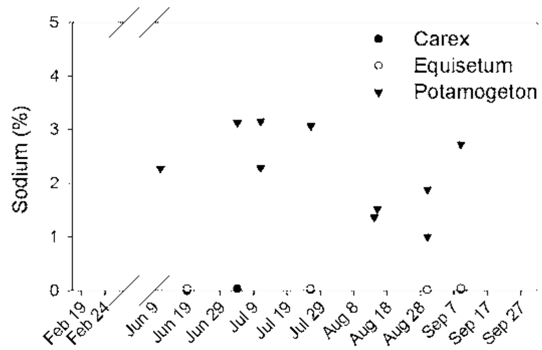

Figure 4a. Seasonal trends in sodium content of aquatic plants.

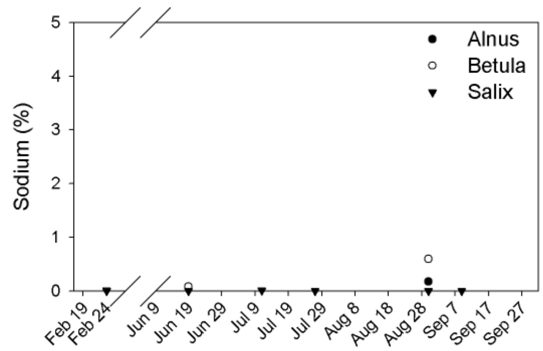

Figure 4b. Seasonal trends in sodium content of terrestrial shrubs.

Other components of nutritional composition are compared seasonally and between *Salix* and *Potamogeton* in Table 1. In addition to differences in sodium content, *Potamogeton* also contained much more calcium and marginally more phosphorous than *Salix*.

Table 1. Seasonal variation in nutrient composition of *Potamogeton* sp. (pondweed) and *Salix* sp. (willow) near Old Crow, Yukon. All values are percentages, except for net energy content, which is in kcal/g. No *Potamogeton* was present to be sampled on June 19, but all other missing values reflect missing samples rather than the plant not being present.

Date	Crude Protein		Calcium		Phosphorous		Sodium		Potassium		Magnesium		Acid Detergent Fiber		Lignin		Total Digestible Nutrient		Net Energy (kcal/g)	
	Potam.	Salix	Potam.	Salix	Potam.	Salix	Potam.	Salix	Potam.	Salix	Potam.	Salix	Potam.	Salix	Potam.	Salix	Potam.	Salix	Potam.	Salix
19-Jun		17.25		0.70		0.28		0.00		1.27		0.38		29.10		15.83		69.37		1.73
4-Jul	17.09		1.15		0.31		0.04		3.13		0.37		37.00		15.86		62.17		1.45	
11-Jul	13.71	12.26	1.78	0.38	0.32	0.20	0.19	0.01	2.29	0.79	0.51	0.14	41.80		14.82		57.80		1.27	
26-Jul	18.80	10.06	1.52	0.65	0.32	0.13	0.03	0.00	3.07	0.53	0.30	0.19	33.30	40.60	13.20	19.96	65.54	58.89	1.58	1.31
30-Aug	16.32	8.06	5.10	0.95	0.21	0.10	0.05	0.00	1.88	0.46	0.31	0.27	29.60	26.00	14.21	13.17	68.91	72.19	1.71	1.83
9-Sep	12.91	4.13	1.48	0.60	0.19	0.11	0.08	0.00	2.73	0.30	0.38	0.15	31.10	54.00	12.11	14.32	67.54	46.68	1.66	0.79

Although there was some spatial variability in C13 and N15 isotopic signatures, we detected no consistent seasonal trends in these signatures (Fig. 5), which provides an important validation of the feasibility of using isotopic approaches to track seasonal changes in moose diets.

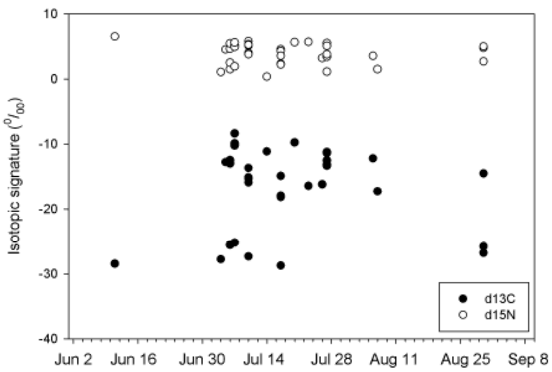

Figure 5a. Seasonal trends in d13C and d15N composition of *Potamogeton sp.*

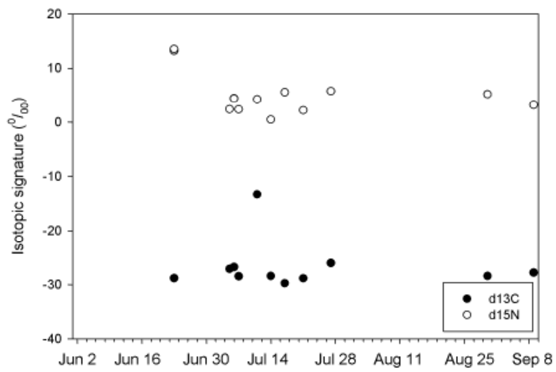

Figure 5b. Seasonal trends in d13C and d15N composition of *Salix sp.*

Intepretation

Spring Nutrients

Our results provide no support, at least at a macronutrient level, for the hypothesis that moose return to Crow Flats in early spring to access aquatic vegetation that is more nutritious than terrestrial shrubs. In fact, in early spring, both the energy and protein content of terrestrial shrubs equals or exceeds that of aquatic vegetation. Furthermore, very little aquatic vegetation is present at this time of year, whereas as shrubs are ubiquitous. However, aquatic plants may be more nutritious at a micronutrient level than terrestrial shrubs. In particular, sodium, calcium, and to a lesser extent potassium all are more prevalent in *Potamogeton* than *Salix* (Table 1), If any or all of these nutrients are limiting in moose diets, then it remains possible that the nutritional benefits of aquatic vegetation are at least partly responsible for moose returning to Crow Flats in spring.

Fall Nutrients

Our results provide no support for the hypothesis that moose leave Crow Flats in late summer because of a decline in the abundance and nutritional quality of aquatic vegetation. In fact, because the nutritional value of terrestrial shrubs declines seasonally much more strongly and consistently than aquatic vegetation, the opportunity cost of switching from aquatic to terrestrial vegetation is higher in late summer than during any other ice free period.

Isotopic Tracing of Moose Diets

Elsewhere we have shown that the freshwater and terrestrial vascular plants commonly found in the diets of subarctic herbivores can be discriminated using a combination of $\delta13C$ and $\delta15N$ stable isotope analysis (Milligan et al. conditional accepted, Ecoscience). This means that isotopic analysis of hair, muscle of fecal samples from herbivores can be used to infer the importance of aquatic and terrestrial sources in their diet. However, an important assumption of this approach is the isotopic signatures of aquatic and terrestrial plants do not vary seasonally, so that isotopic shifts in herbivore tissues can be attributed to seasonal changes in diet rather than seasonal changes in the isotopic composition of the same food sources. The analyses presented here and funded by Fisheries and Wildlife Enhancement Trust of phenological variation in the isotopic composition of willow, the most abundant terrestrial forage for moose, and pondweed, the most abundant aquatic forage for moose, provides an important validation for application of stable isotope techniques for identifying the seasonal use of aquatic and terrestrial plants by herbivores.

Budget Report

Budget

We received seeking **$18,720** from the Yukon Fish and Wildlife Enhancement Trust to complete this project. The original submitted budget is presented in Table 3 and an updated and revised budget is presented in Table 4. We have

Table 3. Original, submitted budget for the project *Phenology of aquatic vegetation near Old Crow, Yukon.*

Category	Budget item	Projected cost	Other funding sources (all confirmed)	Funds requested from Trust
1. Capital	None	0		0
2. Wages, contract	Game Guardian 18 days (additonal half day in the office for each of 12 days in field)	3,600	VGG	0
	Student field assistant 18 days	3,600	VGG	0
	Field training 5 days @ 200	1,000	McGill (IPY project)	0
	Field training 5 days @ 200	1,000	U Waterloo (IPY project)	0
3. Office and admin	None	0		0
4. Travel	Travel for field training	1,200	McGill (IPY project)	0
5. Materials supplies	Gas 40 liters @ $1.75 X 12 days for VGG boat transport to field sites	840		840
	Sample bags and related material for plant samples	100		100
	Portable dehydrator to dry plant samples	300		300
	Water sample supplies	100	U Waterloo: coordinate with lab	0
6. Facility	None	0		0
7. Other	Plant sample shipping costs	200		200
	Nutrient analysis (5 samples of 3 species at 5 lakes sampled 6 times @ $20)	7,200		7,200
	Isotope analysis (5 samples of 3 species at 5 lakes sampled 6 times @ $20)	7,200		7,200
	Water chemistry analysis (1 sample at 4 lakes sampled 6 times @ $120)	2,880		2,880
	Aerial photography, 2 additional plane hours * 3 flights	3,000	U Vic (IPY prject), YG (IPY)	0
	Canoe for 12 days @ $50 per day	800	CWS	0
		$29,220		**$18,720**