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Monitoring Change using Aklavik (Inuvialuit) Local Ecological Knowledge

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EXECUTIVE SUMMARY

This report represents the outcome of 13 years of community-base monitoring by Inuvialuit harvesters in Aklavik, Northwest Territories. The Arctic Borderland Ecological Knowledge Coop gathered local ecological knowledge from harvesters on topics related to subsistence harvesting and changes on the landscape and climate. Interviewees spent, on average more than one week on the land each year harvesting berry, caribou, and/or fish. In general, berry harvesters saw an increase in the number of *aqpik*, yellowberry (*Rubus chamaemorus*) and *kimmingnaq*, cranberry (*Vaccinium vitis-idaea* ssp. *minus*). Meanwhile, caribou harvesters often reported more *tuttu*, Porcupine caribou (*Rangifer tarandus granti*) being available throughout the season. At the same time, they observed caribou body condition as being good. Both berry and caribou harvesters annually met their subsistence needs. In contrast, harvesters reported a decline in *iqaluqpiq*, Dolly Varden (*Salvelinus malma malma*) numbers. The results of this study in some cases agreed with and other times corrected recent scientific conclusions, demonstrating the value and efficiency of such community based ecological monitoring programs.

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1.0 INTRODUCTION

Community-based monitoring is becoming popular among natural resource managers, particularly in northern Canada where comprehensive claim settlements call for integration of local ecological knowledge (LEK) with other sources of knowledge (Usher 2000). LEK is a multigenerational knowledge accumulated through close and continuous contact with the environment (Usher 2000, Papik et al. 2003). This knowledge (albeit site specific) is a holistic view of the surroundings that takes into account the interactions between people, plants, and animals. LEK as defined above is thus not limited by age or heritage to aboriginal persons.

The integration of LEK into monitoring practices has been difficult due to uncertainty in the steps required to facilitate integration. Recently, several products containing LEK, formerly treated as anecdotal and then overlooked, have been produced that likely affected resource management decisions and policies (e.g., Papik et al. 2003; Wildlife Management Advisory Council (North Slope) and Aklavik Hunters and Trappers Committee 2008, 2009). Conversely, attempts at overcoming the challenges associated with the latter are becoming more widespread (e.g., Usher 2002, Knopp 2010). Yet typically, these studies are short-term with local people being asked to recount what they had observed as needed.

Few community based monitoring programs are long-term, and thus, do not have LEK readily available for integration into research and monitoring. Arctic Borderlands Ecological Knowledge (ABEK) Coop is such an organization whose goals are to (1) monitor and assess ecosystem changes in the range of the Porcupine caribou herd and adjacent coastal and marine areas; (2) encourage use of both science-based studies and studies based on local and traditional knowledge in ecological monitoring and ecosystem management; (3) improve communications and understanding among governments, aboriginal and non-aboriginal communities, and scientists with regard to ecosystem knowledge and management; and (4) foster capacity-building and training opportunities in northern communities in the context of the above-listed goals (Arctic Borderlands Ecological Knowledge Society 2011). Although the Coop has collected and maintained this long-term data, few products have come out of it (e.g., Russell et al. 2008). This left many stakeholders wondering the relevance of the surveys, merit of data collection, and if the results can be integrated with other knowledge. At the same time, Parks Canada Agency is producing a State of the Park Report for Ivvavik National Park to provide a snapshot of the park (Parks Canada Agency 2009). This report provides an opportunity for the Inuvialuit to document their LEK, and further advance their vision of LEK in natural resource management.

In response to these needs, this report quantitatively summarizes LEK provided by Inuvialuit harvesters in Aklavik, Northwest Territories since 1996. Using the Coop's data, the overall objective is to identify any trends in the responses provided by local harvesters on topics related to subsistence harvesting (e.g., berries, caribou, and fish) and life on the land (e.g., weather). These results should facilitate governments, aboriginal and non-aboriginal communities, and scientists to access and integrate with other types of knowledge for decision making purposes, as well as work towards improving the lack of understanding and/or capacity to use local ecological knowledge.

2.0 METHODS

2.1 Survey design

Since 1996, Arctic Borderland Ecological Knowledge (ABEK) Coop has gathered local ecological knowledge by interviewing harvesters in different Arctic communities across the range of the Porcupine caribou herd, Mackenzie Delta, and adjacent marine areas (Figure 1). In the beginning, interviews focused on the communities of Aklavik and Fort McPherson, Northwest Territories and Old Crow, Yukon Territory. Today, standardized interviews are conducted across eight communities spanning the Northwest Territories, Yukon Territory, and Alaska.

Each community had a locally trained monitor who administered the survey to harvesters (typically $n \leq 20$). The Coop trained the monitor, typically an individual recommended by the Renewable Resource Council and/or Hunters and Trappers Committee, to standardize data collection across the Arctic communities for spatial and temporal comparison. The selection of interviewees was deliberately nonrandom to focus on harvesters who had the most experience on the land during different seasons. Although details of all candidates are recorded in a database, interviewees remain anonymous when accessing this data to ensure confidentiality and reduce the response bias of the surveys.

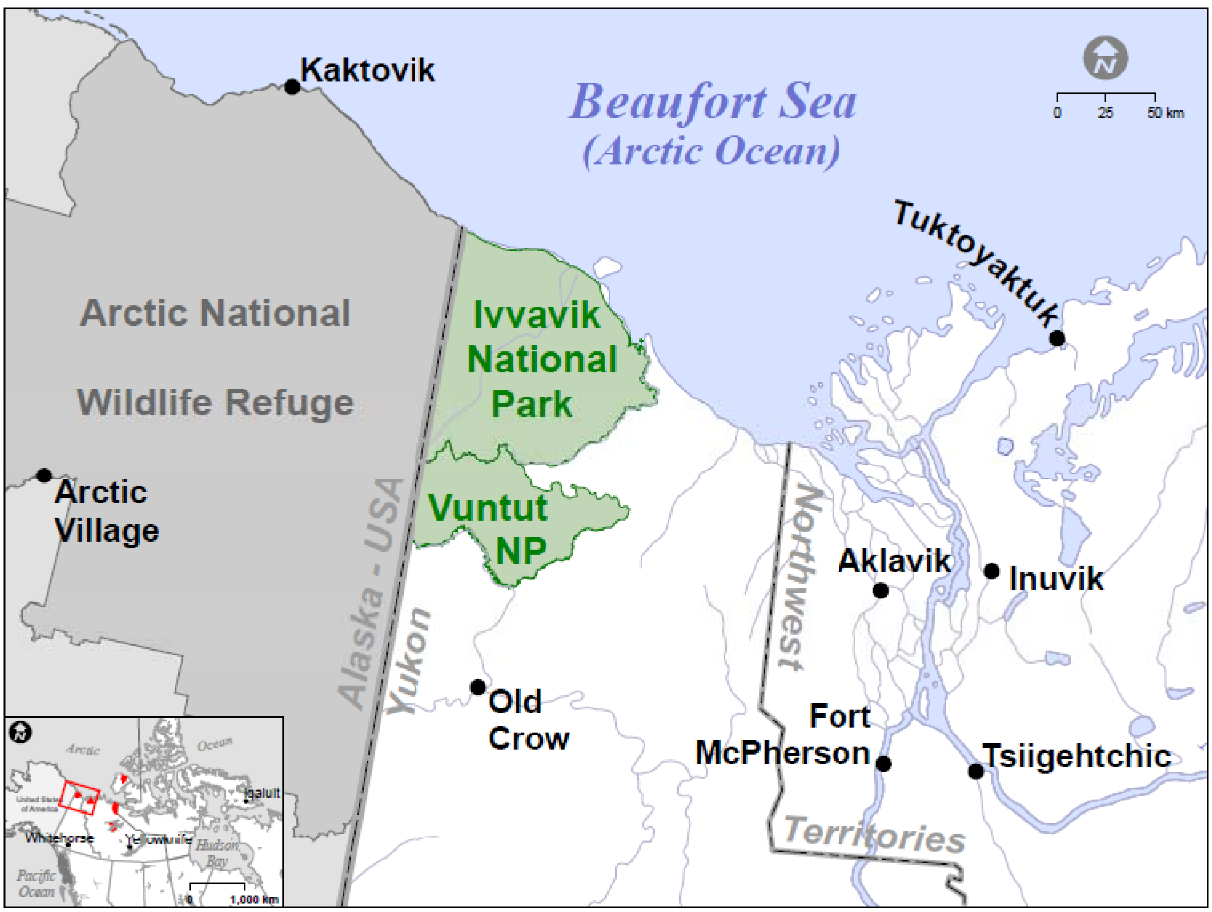


Figure 1. Map of the eight Arctic communities where the Arctic Borderlands Ecological Knowledge Coop gathers local ecological knowledge.

2.2 Survey questions

Although the Coop tried to keep the survey relatively consistent for the past 13 years, interview questions were added or dropped (Appendix A). Consequently, data for some questions were limited to a few years. Interview questions spanned a wide range of topics aimed at monitoring and assessing ecosystem changes arising from climate change, contaminants, and regional development (Appendix A; Arctic Borderlands Ecological Knowledge Society 2011).

Interviewees were asked to recount what they had observed. All candidates were questioned on the same topics, although there was often a clear demarcation in the responses given by different harvesters. Typically, interviewees were strong on observation for resources that they harvested and freely admitted to areas where they were lacking in knowledge. Overall, the survey questionnaire was structured with a fixed set of responses (Appendix B), although interviewees had an opportunity to elaborate on their responses.

2.3 Responses

Terms used by interviewees for local names of berry and fish species were often different than those used in scientific literature and, accordingly, some interpretation was necessary with the help of local Parks Canada staff and traditional knowledge literature (e.g., Andre and Fehr 2002, Papik et al. 2003, Badringer 2010). It was, however, difficult to distinguish between certain fish species with the inconsistent use of local names by different harvesters. Four types of fish have been identified from the different responses by harvesters: (1) char specifically *iqaluqpiq* (Dolly Varden, *Salvelinus malma malma*); (2) coney specifically *siirgarq* (inconnu, *Stenodus leucichthys*); (3) herring includes *qaaqtaq* (Arctic cisco, *Coregonus autumnalis*), *iriqpaligaurat*, (least cisco, *Coregonus sardinella*)*, and qaluhaq* (Pacific herring, *Clupea sardinella*); and (4) whitefish includes *aanaarlirq* (broad whitefish, *Coregonus nasus*) and *pikuktung* (lake whitefish, *Coregonus clupeaformis*).

2.4 Statistical analyses

Data were synthesized and analyzed for Inuvialuit harvesters in Aklavik, Northwest Territories. To err on the side of caution and uncertainty, data were screened to censor years when local monitors had insufficient sample size for a question ($n < 5$). Since the goal of these analyses was to identify any temporal trends, statistical analyses were completed for data with more than five years. The observed and expected values were calculated for all analyses. For binomial data, the Cochran-Armitage Trend test was used to assess an association with time, but also the underlying linear trend over time (Cochran 1954, Armitage 1955). Due to small sample size, an exact probability was calculated in StatXact 9 (Cytel Inc. 2010).

For other categorical data ($\geq$3 fixed responses), the Fisher-Freeman-Halton test was used to assess the association between response and year (Freeman and Halton 1951). Due to the degree of imbalance in the allocation of responses and the number of ties in the data (Cytel Inc. 2010), a Monte Carlo sample of 100,000 tables from the reference set was conducted to calculate probability. In order to assess the underlying linear trend over time, all responses for a given year were collapsed into one metric (Russell et al. 2008). This index was similar to Russell et al. (2008), where an arbitrary score was assigned to each fixed response (Appendix B). The big difference with this index was that annual values were averaged by the total number of responses in that given year. All indices were $\log_{10}$ transformed to resemble a normal distribution prior to conducting a linear regression. Statistical significance was set at $\alpha = 0.05$.

3.0 RESULTS

3.1 People

3.1.1 Time spent on the land

In Aklavik, Northwest Territories, approximately 10 to 23 harvesters participated in interviews conducted by the Coop during 1998-2008 (Figure 2a). The number of harvesters that spent time on the land with day trips or day trips with overnights was consistently low among years. Conversely, harvesters that spent more than one week at a time were the lowest reported in 2003-2005. At the same time, harvesters reported spending more than expected half of their time on the land during this period (Figure C1; Appendix C). These results correspond to the Fisher-Freeman-Halton test, where the amount of time that harvesters spent on the land was significantly associated with year ($\chi^2_{30} = 61.85$, Monte Carlo $P < 0.001$). On average, harvesters spent more than one week on the land (Figure 2b).

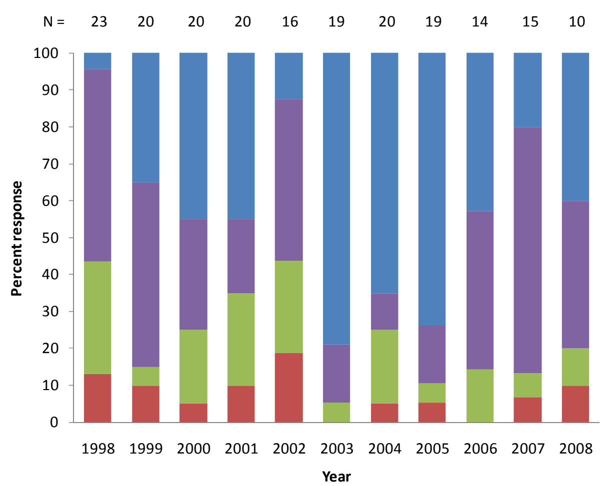


Figure 2a. The percentage of harvesters that spent time on the land with day trips (*red*); day trips with overnights (*green*); ≥1 weeks at a time (*purple*); and more than half of their time (*blue*).

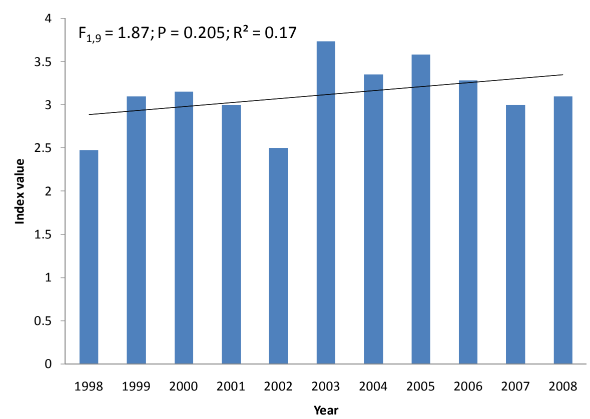


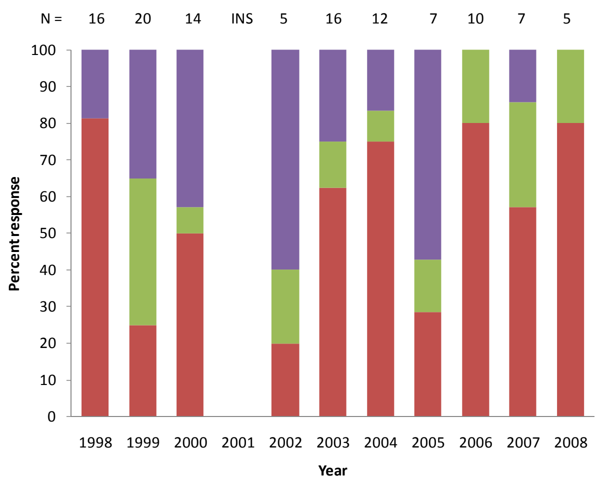
Figure 2b. Index illustrating how much time Aklavik harvesters spent on the land (1 = day trips; 2 = day trips with overnights; 3 = ≥1 weeks at a time; 4 = more than half of their time).

3.2 Berries

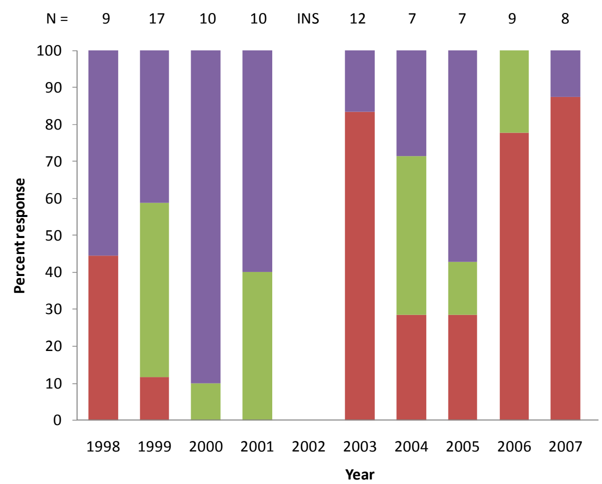
3.2.1 Quantity rating

The main berries harvested were *aqpik*, yellowberry (*Rubus chamaemorus*) and *kimmingnaq*, cranberry (*Vaccinium vitis-idaea* ssp. *minus*), although other berries might have been available. Generally, harvesters indicated a significant association between year and quantity of both yellowberry (χ^2_{18} =

27.87, Monte Carlo P = 0.028) and cranberry (χ^2_{16} = 54.27, Monte Carlo P < 0.001; Figure 3). In the latter years, the number of interviewees who responded with *few* berries was less than expected (Figure C2; Appendix C). Overall, the quantity of berries, particularly cranberry ($F_{1,7}$ = 4.78, P = 0.07, R^2 = 0.41), appeared to be more plentiful over time (Figure 4).

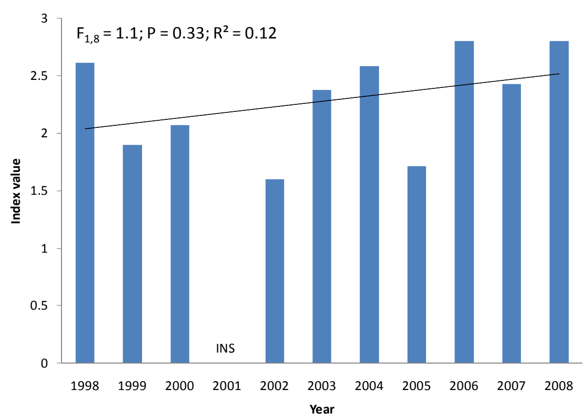


(a) yellowberry

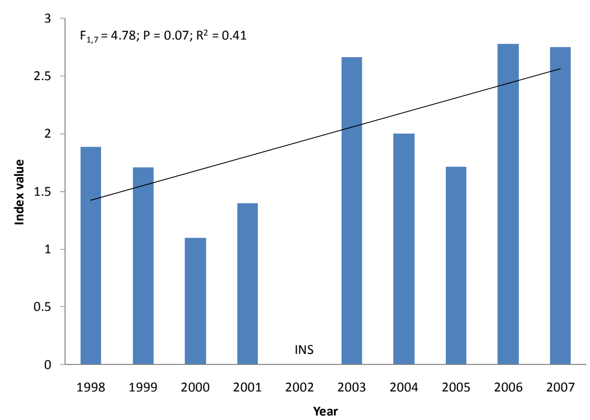


(b) cranberry

Figure 3. The quantity rating of berries (few = *purple*; average = *green*; lots = *red*) harvested by interviewees in Aklavik, Northwest Territories, 1998-2008. INS denotes insufficient data (n < 5).



(a) yellowberry



(b) cranberry

Figure 4. Indices illustrating the quantity of berries (1 = few; 2 = average; 3 = lots) harvested by interviewees in Aklavik, Northwest Territories, 1998-2008. INS denotes insufficient data (n < 5).

3.2.2 <u>Subsistence needs being met</u>

All berry types (e.g., cranberries, yellowberries, and blueberries) were grouped to compensate for insufficient data. The Cochran-Armitage Trend test indicated an association between subsistence needs being met and year (Z = 45, Exact P = 0.002), where berry harvesters generally met their needs over time (Figure 5).

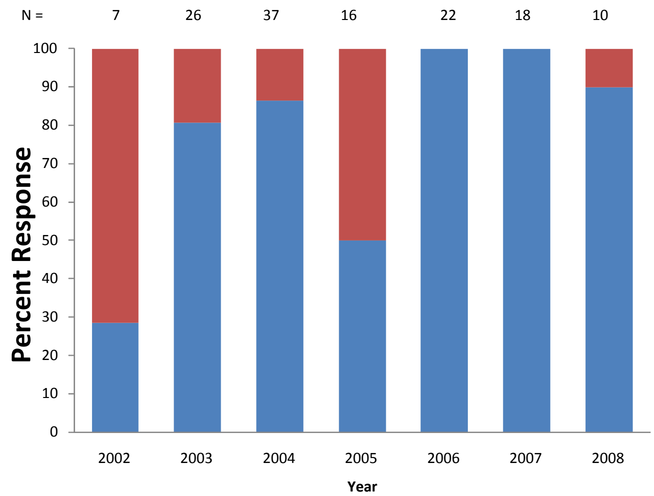
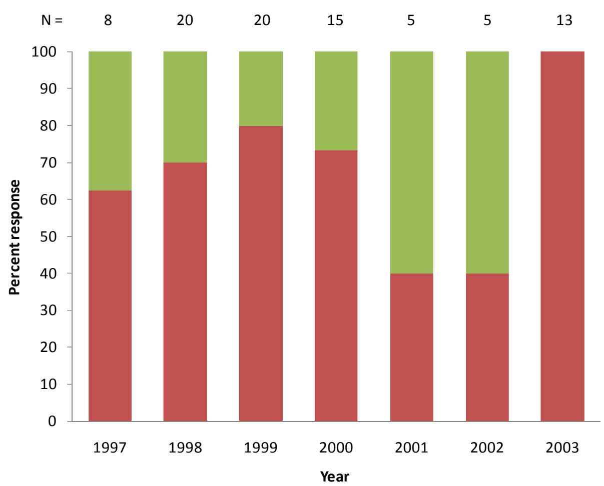


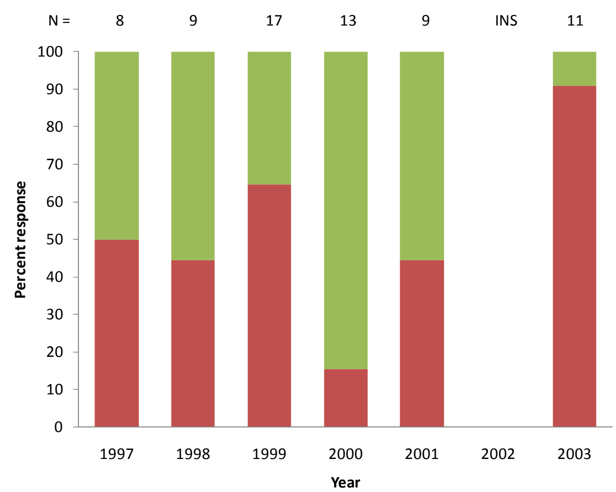
Figure 5. The percentage of berry harvesters that met their subsistence needs (yes = *blue*; no = *red*) in Aklavik, Northwest Territories, 2002-2008.

3.2.3 Health and condition

Four ambiguous responses were used to rate the health and condition of berries. These responses were reclassified into two categories (good vs. bad). The Cochran-Armitage Trend test did not show any association between year and yellowberry (Z = 75, Exact P = 0.34) or cranberry (Z = 75, Exact P = 0.25). No underlying trend in responses for both berry types was observed over time (Figure 6).



(a) yellowberry



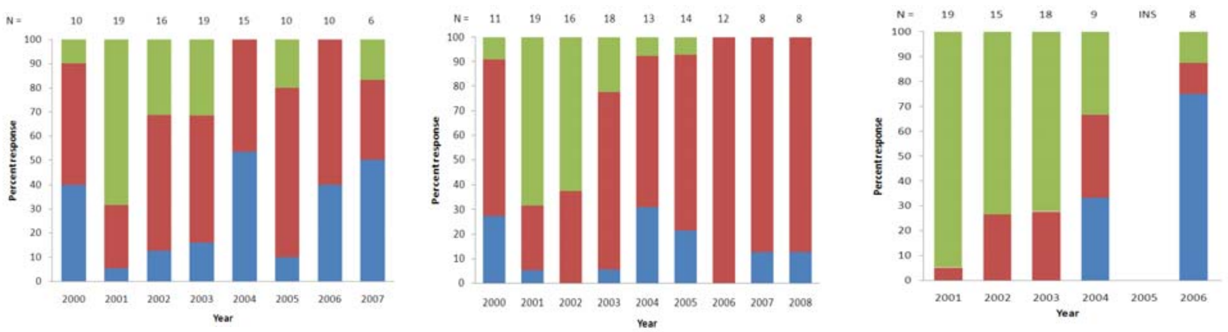
(b) cranberry

Figure 6. The health and condition of berries (good = *red*; bad = *green*) reported by harvesters in Aklavik, Northwest Territories, 1997-2003. INS denotes insufficient data (n < 5).

3.3 Caribou

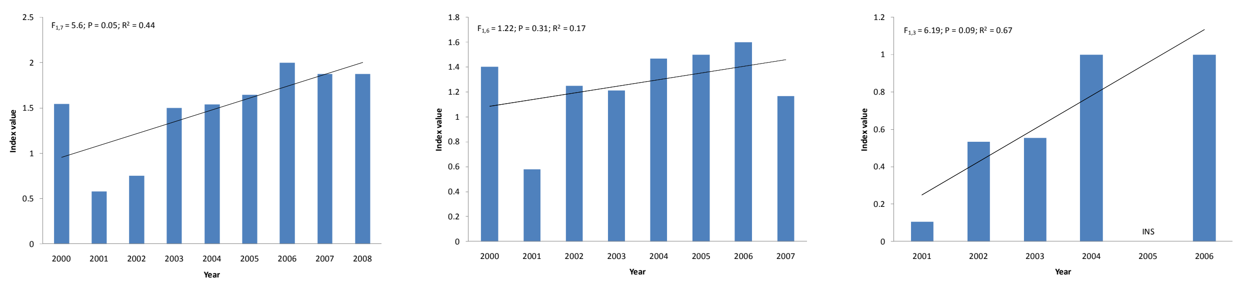
3.3.1 Availability

Caribou availability was associated with year for all seasons (spring: $\chi^2_{16} = 48.73$, Monte Carlo $P < 0.001$; fall: $\chi^2_{14} = 35.24$, Monte Carlo $P < 0.001$; winter: $\chi^2_{8} = 33.42$, Monte Carlo $P < 0.001$; Figure 7). In general, harvesters reported that caribou availability tended to increase over time (Figure 8). These observations were more significant in the spring ($F_{1,7} = 5.60$; $P = 0.05$; $R^2 = 0.44$) than in the fall ($F_{1,6} = 1.22$; $P = 0.31$; $R^2 = 0.17$) and winter ($F_{1,3} = 6.19$; $P = 0.09$; $R^2 = 0.67$) due largely to the number of harvesters responding with *not available* being less than expected (Figure C5; Appendix C).



(a) Spring (b) Fall (c) Winter

Figure 7. Seasonal availability of caribou (not available = *green*; not close = *red*; close = *blue*) reported by harvesters in Aklavik, Northwest Territories, 2000-2008. INS denotes insufficient data (n < 5).

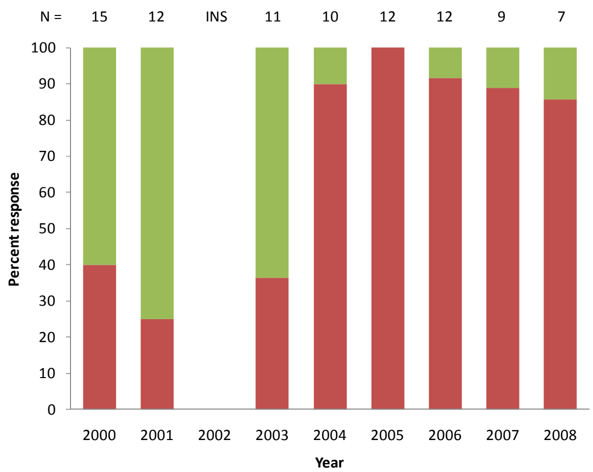


(a) Spring (b) Fall (c) Winter

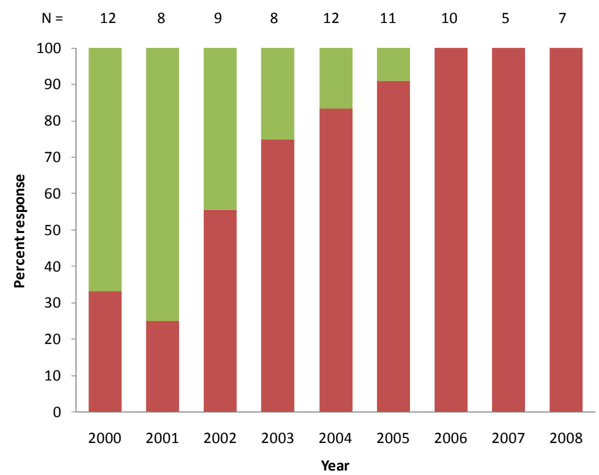
Figure 8. Indices illustrating the seasonal availability of caribou (0 = not available; 1 = not close; 2 = close) reported by harvesters in Aklavik, Northwest Territories, 2000-2008. INS denotes insufficient data (n < 5).

3.3.2 Subsistence needs being met

Insufficient data was available for winter. Subsistence needs of caribou harvesters tended to be associated with year in spring ($Z = 44$, Exact $P < 0.001$) and fall ($Z = 33$, Exact $P < 0.001$; Figure 9). Overall, the percentage of caribou harvesters who responded with their subsistence needs being met tended to increase over time. In winter, insufficient data was available by caribou harvesters.



(a) Spring



(b) Fall

Figure 9. The percentage of caribou harvesters that met their subsistence needs (yes = *red*; no = *green*) in Aklavik, Northwest Territories, 2002-2008. INS denotes insufficient data ($n < 5$).

3.3.3 Body condition

Four ambiguous responses were used to rate the caribou body condition. These responses were reclassified into two categories (good vs. bad). Insufficient data was available for spring and winter. The Cochran-Armitage Trend test showed a significant association between body condition and year ($Z = 20$, Exact $P = 0.014$; Figure 10). Over time, fewer harvesters thought that caribou body condition was poor.

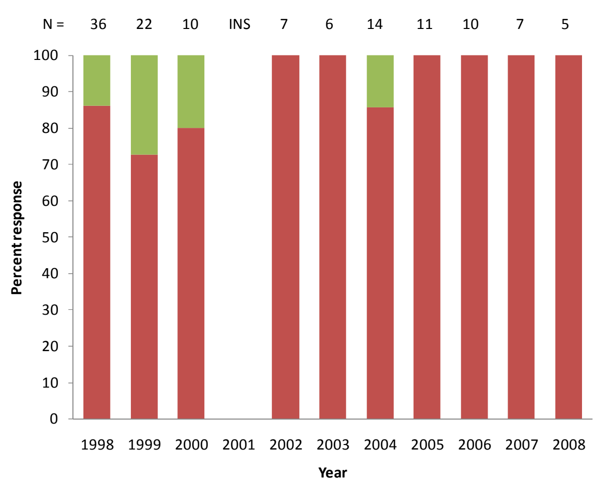
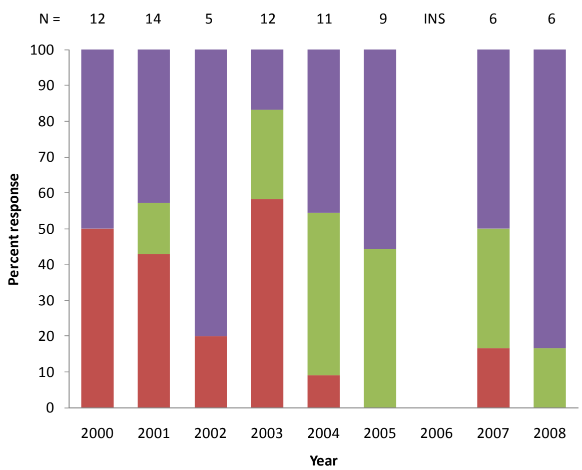


Figure 10. The body condition of caribou (good = *red*; bad = *green*) reported by harvesters in Aklavik, Northwest Territories, 1998-2008. INS denotes insufficient data ($n < 5$).

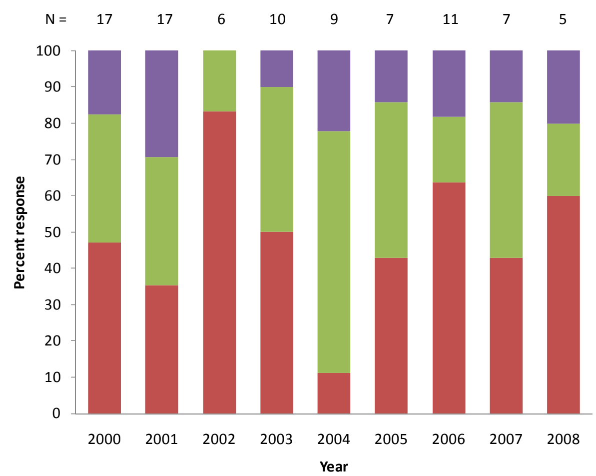
3.4 Fish

3.4.1 Quantity rating during run

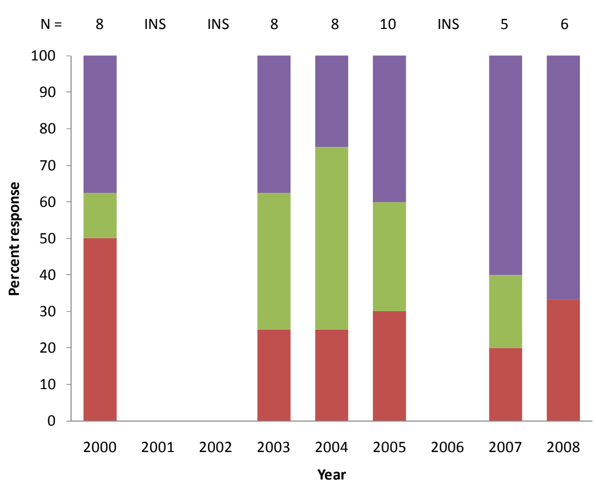
Char was the only fish species where quantity was significantly associated with year ($\chi^2_{14} = 25.80$, Monte Carlo $P = 0.009$; Figure 11). The number of harvesters that reported seeing *lots* of char was continuously less than expected after 2004 (Figure C8; Appendix C). Overall, harvesters reported a general decline in the quantity of char over time ($F_{1,6} = 3.75$; $P = 0.10$; $R^2 = 0.38$; Figure 12).



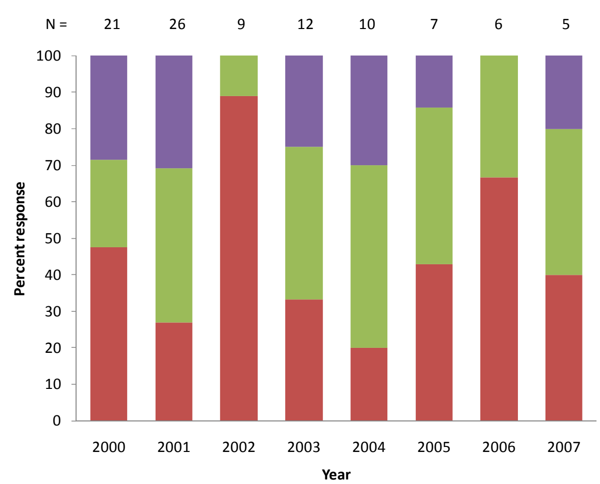
(a) Char



(b) Coney

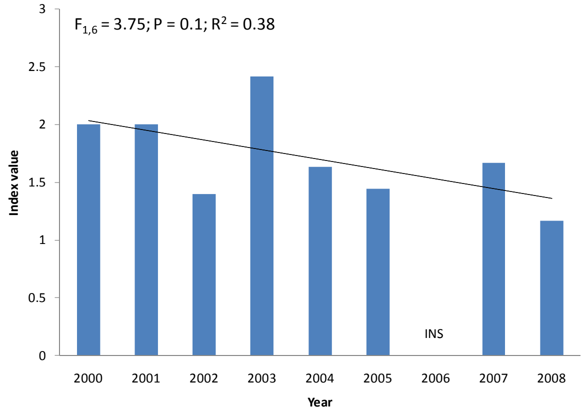


(c) Herring

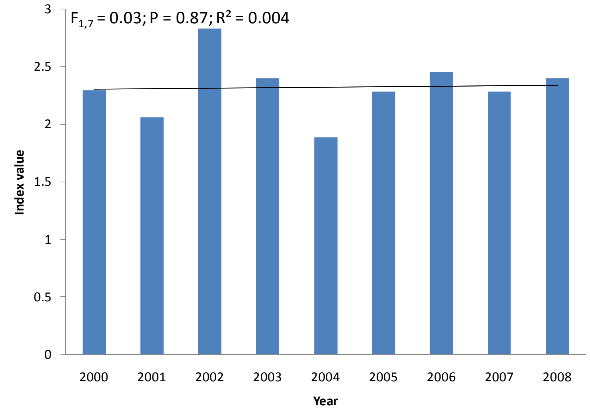


(d) Whitefish

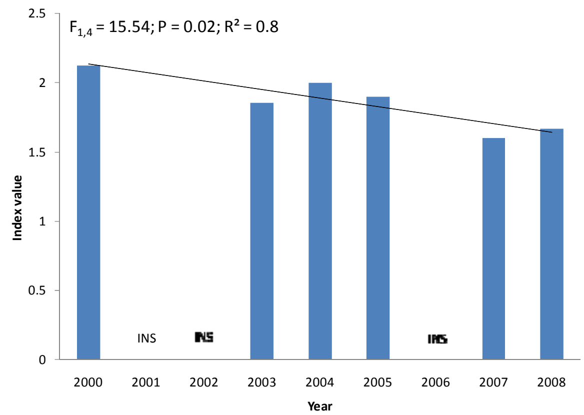
Figure 11. The percentage of harvesters rating the quantity of different fish species during their run (few = *purple*; average = *green*; lots = *red*) in Aklavik, Northwest Territories, 2000-2008. INS denotes insufficient data (n < 5).



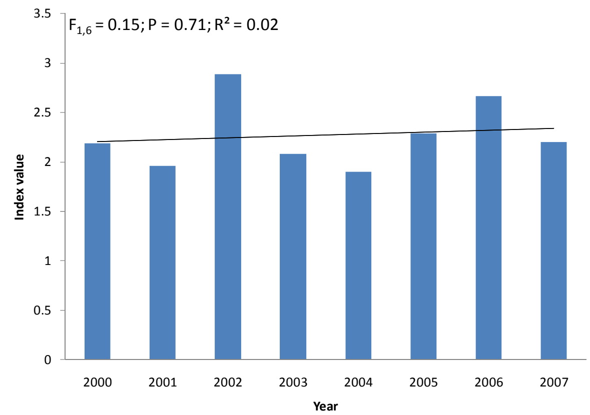
(a) Char



(b) Coney



(c) Herring

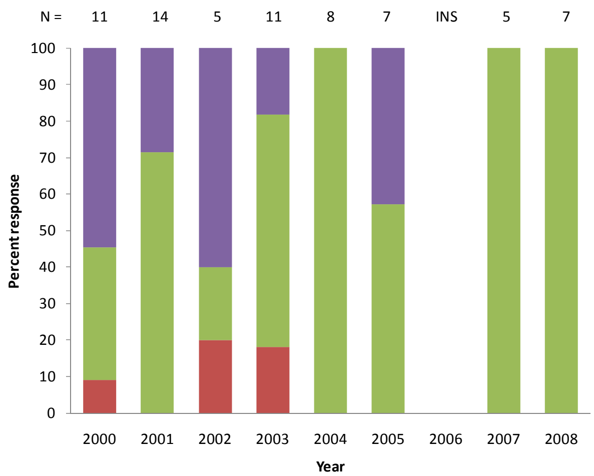


(d) Whitefish

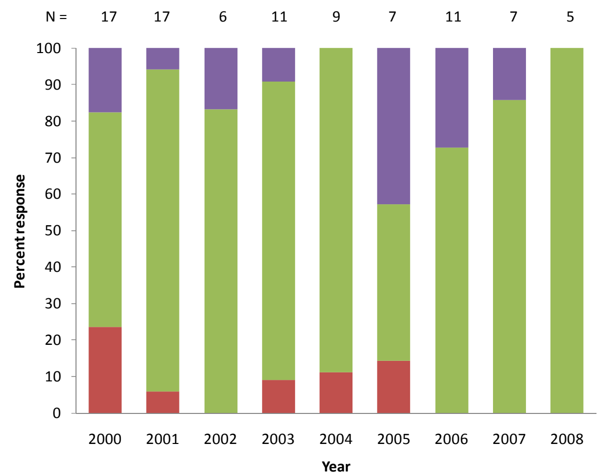
Figure 12. Indices illustrating the quantity of different fish species (1 = few; 2 = some; 3 = lots) reported by harvesters in Aklavik, Northwest Territories, 2000-2008. INS denotes insufficient data (n < 5).

3.4.2 Timing of run

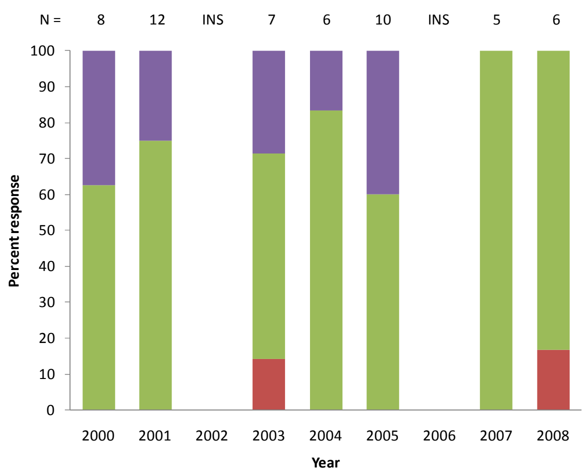
Char was the only fish species where timing of run was significantly associated with year ($\chi^2_{14} = 22.6$, Monte Carlo P = 0.009), although whitefish approached significance ($\chi^2_{14} = 19.57$, Monte Carlo P = 0.06; Figure 13). These observations are due largely to the absence of harvesters seeing them run *early* after 2003. Overall, harvesters reported timing of run of different fish species as *normal* (Figure 14).



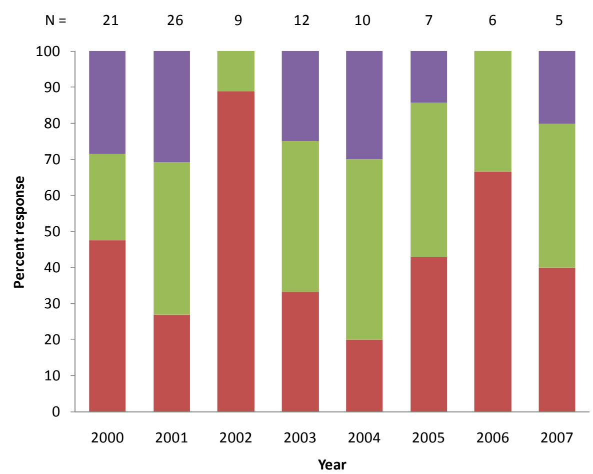
(a) Char



(b) Coney

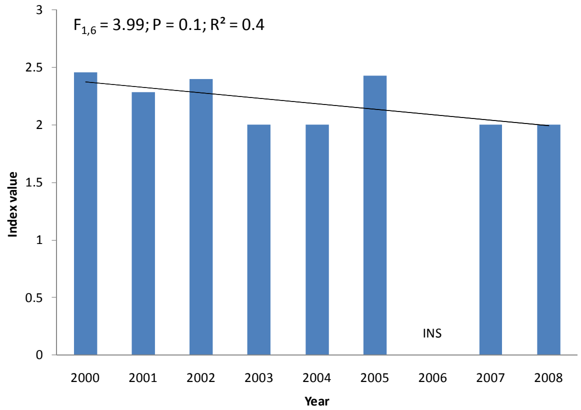


(c) Herring

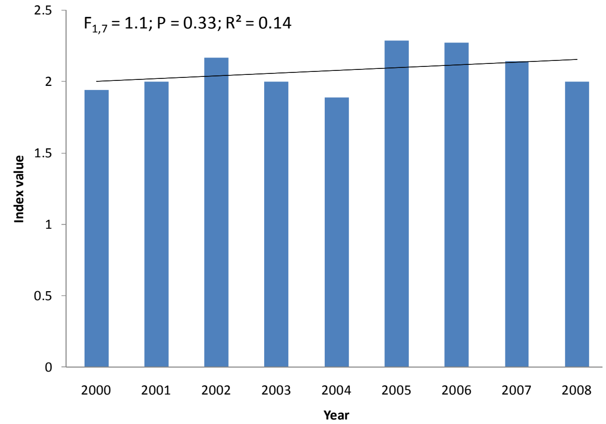


(d) Whitefish

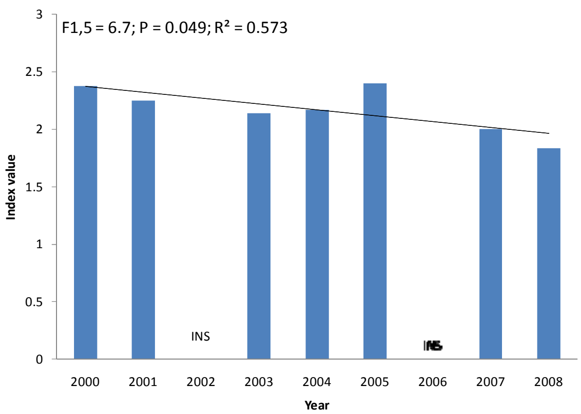
Figure 13. The percentage of harvesters rating the timing of run for different fish species (early = *red*; normal = *green*; late = *purple*) in Aklavik, Northwest Territories, 2000-2008. INS denotes insufficient data (n < 5).



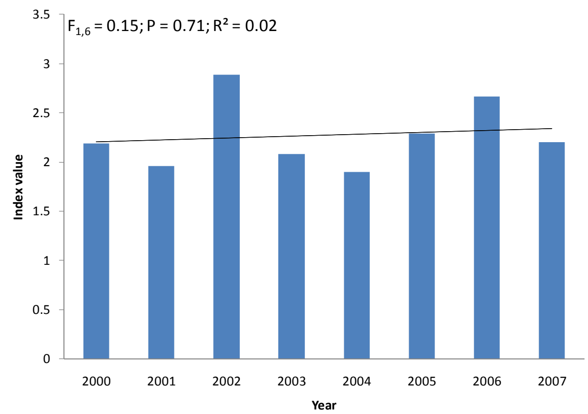
(a) Char



(b) Coney



(c) Herring

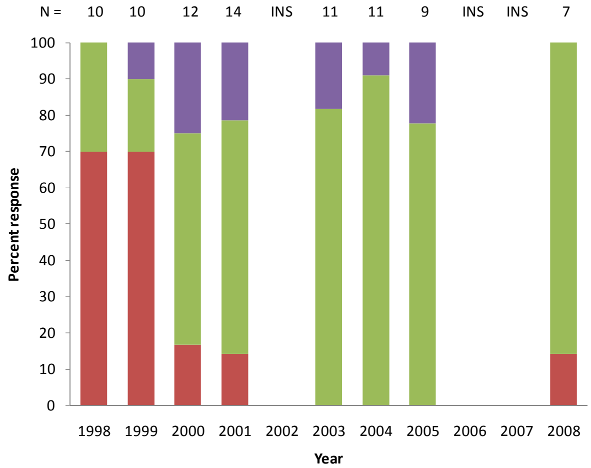


(d) Whitefish

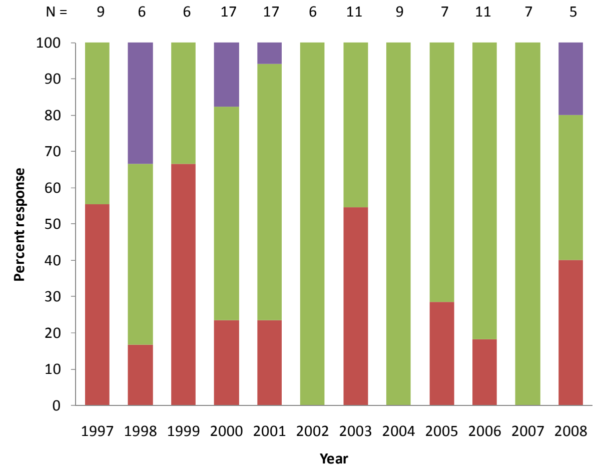
Figure 14. Indices illustrating the timing of run for different fish species (1 = early; 2 = normal; 3 = late) reported by Inuvialuit harvesters in Aklavik, Northwest Territories, 2000-2008. INS denotes insufficient data ($n < 5$).

3.4.3 Size

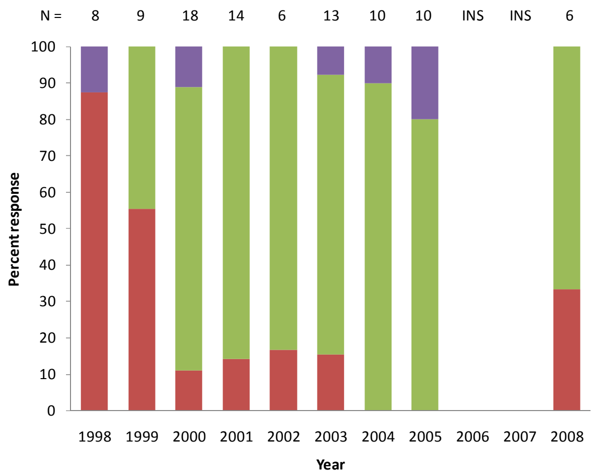
Fish size was significantly associated with year for all species (char: $\chi^2_{14} = 33.40$, Monte Carlo $P < 0.001$; coney: $\chi^2_{22} = 31.33$, Monte Carlo $P = 0.010$; herring: $\chi^2_{16} = 34.59$, Monte Carlo $P < 0.001$; whitefish: $\chi^2_{20} = 29.95$, Monte Carlo $P = 0.008$), where few harvesters reported seeing any *small* fish (Figure 15). Harvesters, on average, reported fish size as being *normal* (Figure 16).



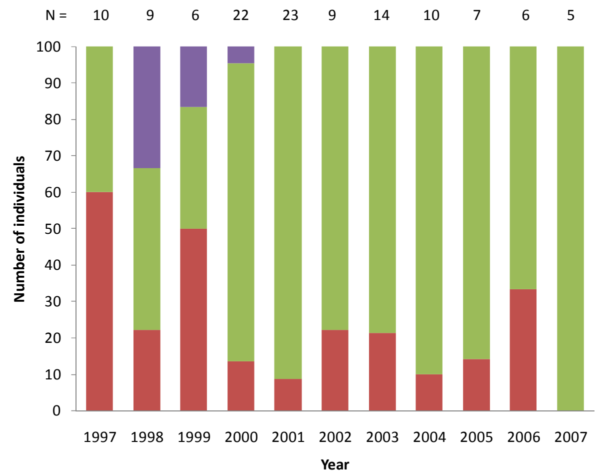
(a) Char



(b) Coney

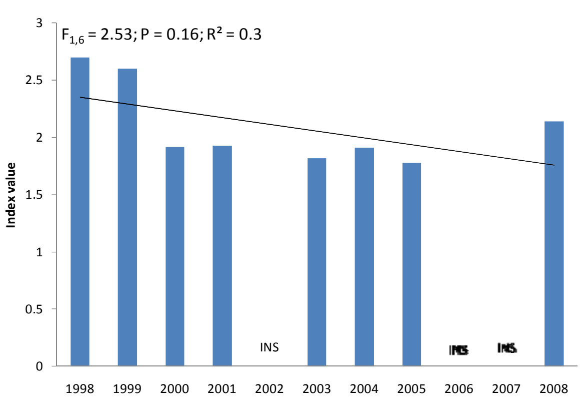


(c) Herring

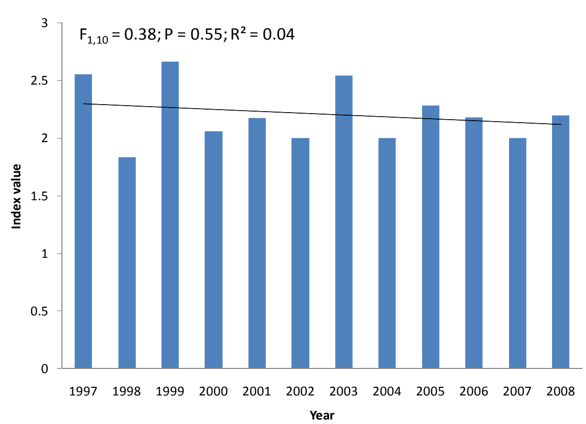


(d) Whitefish

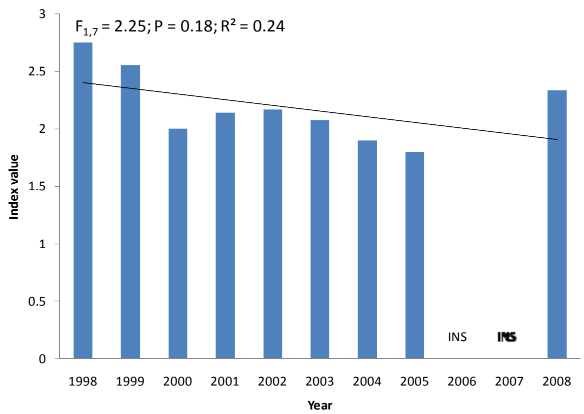
Figure 15. The size of different fish species (small = *purple*; normal = *green*; large = *red*) reported by Inuvialuit harvesters in Aklavik, Northwest Territories, 1997-2008. INS denotes insufficient data (n < 5).



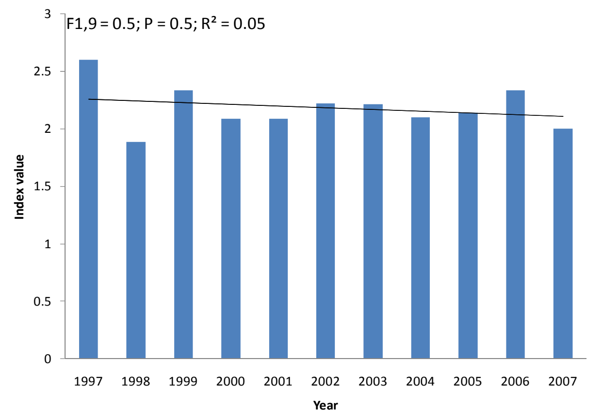
(a) Char



(b) Coney



(c) Herring



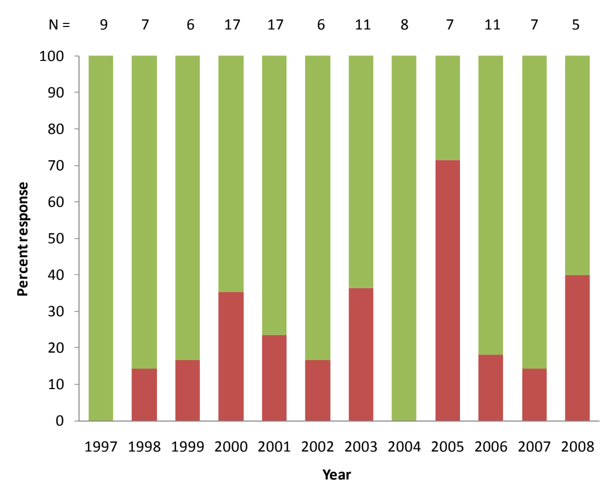
(d) Whitefish

Figure 16. Indices illustrating the size of different fish species (1 = small; 2 = average; 3 = large) reported by Inuvialuit harvesters in Aklavik, Northwest Territories, 1997-2008. INS denotes insufficient data (n < 5).

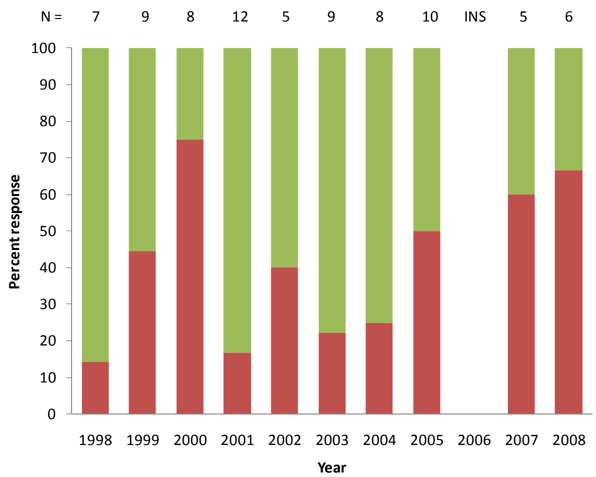
3.4.4 Parasite

Four fixed responses were used to rate the quantity of parasites in different fish species. Due to insufficient data for some categories, responses were reclassified into two categories (presence vs. absence). Whitefish was the only fish showing a significant association between number of parasites and year (Z = 495, Exact P = 0.029), where harvesters generally reported a decline in the number of parasites found over time (Figure 17). Although not significant, harvesters reported an increase in the number of parasites found in char (Z = 250, Exact P = 0.053; Figure 17).

(a) Char



(b) Coney



(c) Herring

(d) Whitefish

Figure 17. The percentage of harvesters rating the quantity of fish parasites (presence = *green*; absence = *red*) in Aklavik, Northwest Territories, 1997-2008. INS denotes insufficient data (n < 5).

3.4.5 <u>Body condition</u>

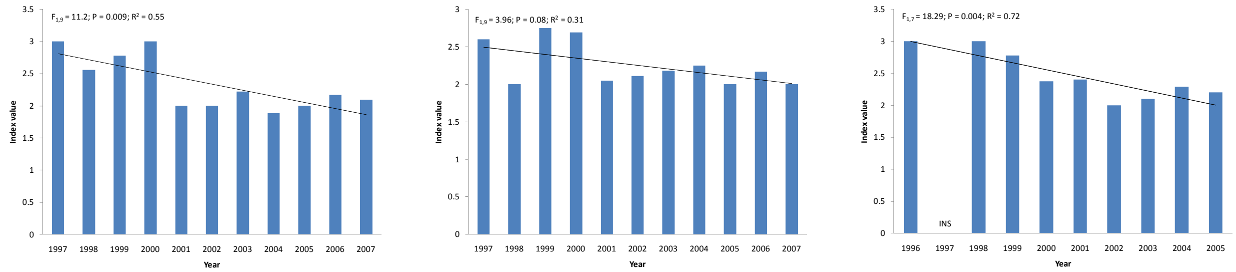
Insufficient data were available for char. Fish body condition was significantly associated with year for all species (coney: $\chi^2_{20} = 81.24$, Monte Carlo $P < 0.001$; herring: $\chi^2_{16} = 50.25$, Monte Carlo $P < 0.001$; whitefish: $\chi^2_{20} = 80.99$, Monte Carlo $P < 0.001$). Few harvesters reported fish body condition as being *soft* (Figure 18). During the study period, harvesters saw a decline in fish body condition with the majority of the responses changing from *firm* to *normal* (Figure 19).

(a) Coney

(b) Whitefish

(c) Herring

Figure 18. The percentage of harvesters rating fish body condition (soft = *red*; normal = *green*; firm = *purple*) in Aklavik, Northwest Territories, 1996-2007. INS denotes insufficient data (n < 5).



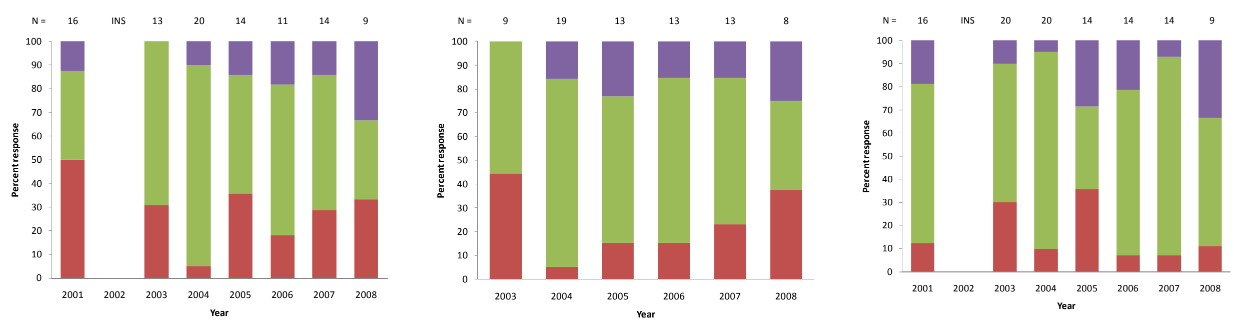
(a) Coney (b) Whitefish (c) Herring

Figure 19. Indices illustrating the fish body condition (1 = soft; 2 = normal; 3 = firm) reported by Inuvialuit harvesters in Aklavik, Northwest Territories, 1996-2007. INS denotes insufficient data (n < 5).

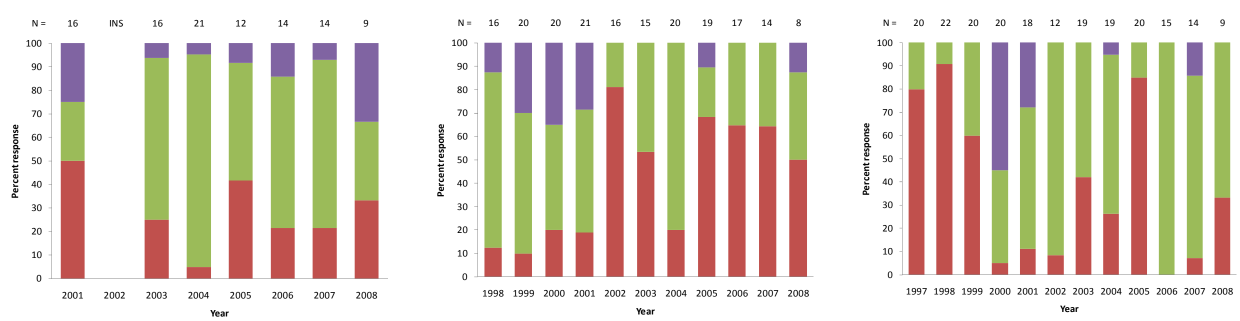
3.5 Other animals

3.5.1 <u>Quantity rating</u>

Harvesters reported a significant association between animal quantity and year for geese (χ^2_{12} = 23.45, Monte Carlo P = 0.009), mosquitoes (χ^2_{20} = 66.34, Monte Carlo P < 0.001), and Arctic hares (χ^2_{22} = 128.5, Monte Carlo P < 0.001; Figure 20), due largely to fewer harvesters seeing *less* animals over time. Overall, harvesters did not see any changes in animal numbers with many of their responses remaining as *same* for many species over time (Figure 21). However, harvesters reported a significant change in mosquito numbers with a majority of the responses changing from *same* to *more* over the same time period.

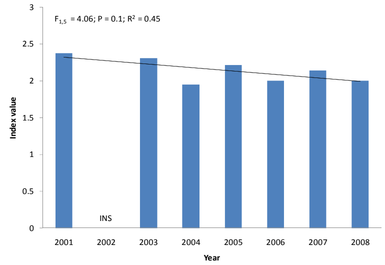


(a) Swan (b) Crane (c) Duck

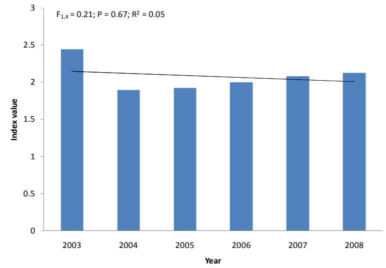


(d) Goose (e) Mosquito (f) Arctic hare

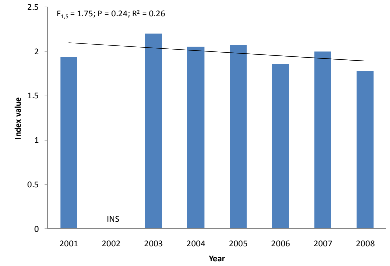
Figure 20. The percentage of harvesters rating the quantity of different animals (less = *purple*; same = *green*; more = *red*) in Aklavik, Northwest Territories, 1997-2008. INS denotes insufficient data (n < 5).



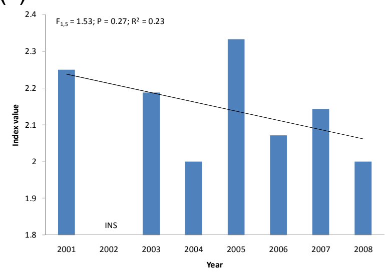
(a) Swan



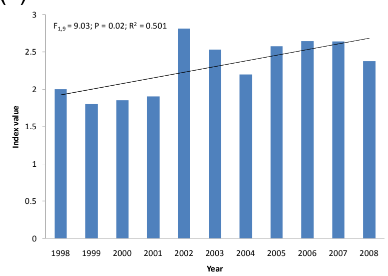
(b) Crane



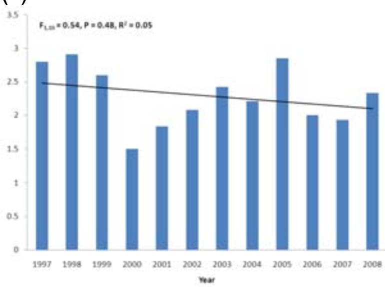
(c) Duck



(d) Goose



(e) Mosquito



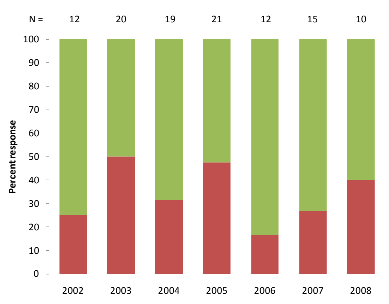
(f) Arctic hare

Figure 21. Indices illustrating animal quantity (1 = less; 2 = same; 3 = more) reported by Inuvialuit harvesters in Aklavik, Northwest Territories, 1997-2008. INS denotes insufficient data (n < 5).

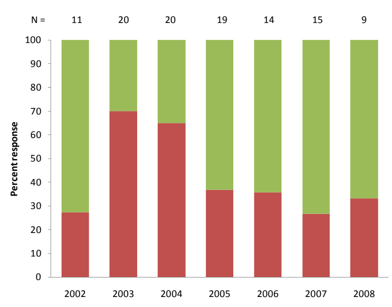
3.6 Weather

3.6.1 Temperature

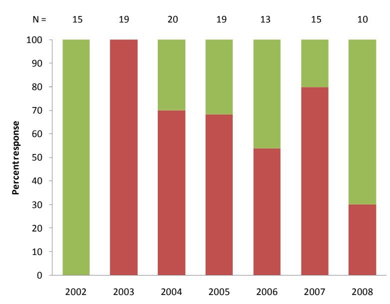
Interviewees often reported *warmer* temperatures in the summer, and *colder* temperatures in the winter (Figure 22). The Cochran-Armitage Trend test did not show any association between seasonal temperature and year for all seasons.



(a) Summer



(b) Fall

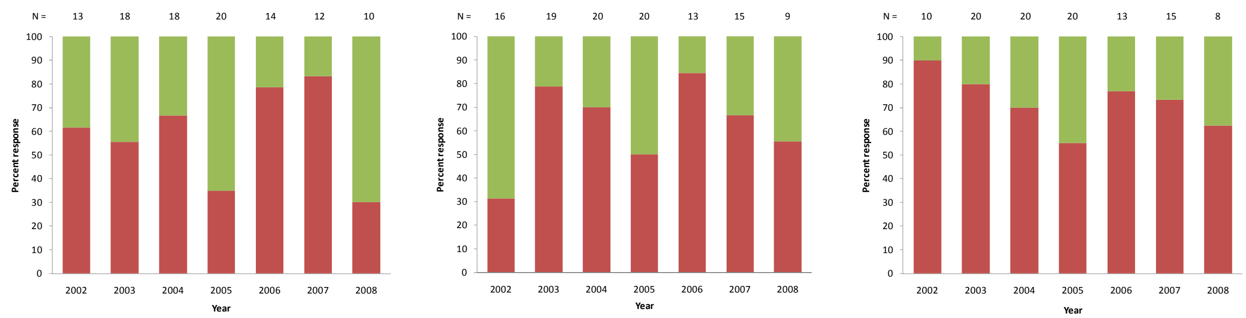


(c) Winter

Figure 22. Seasonal temperature rating (warm = *green*; cold = *red*) reported by Inuvialuit harvesters in Aklavik, Northwest Territories, 2002-2008.

3.6.2 Precipitation

Interviewees often reported *dry* conditions throughout the season (Figure 23). The Cochran-Armitage Trend test also did not show any association between precipitation and year for all seasons.

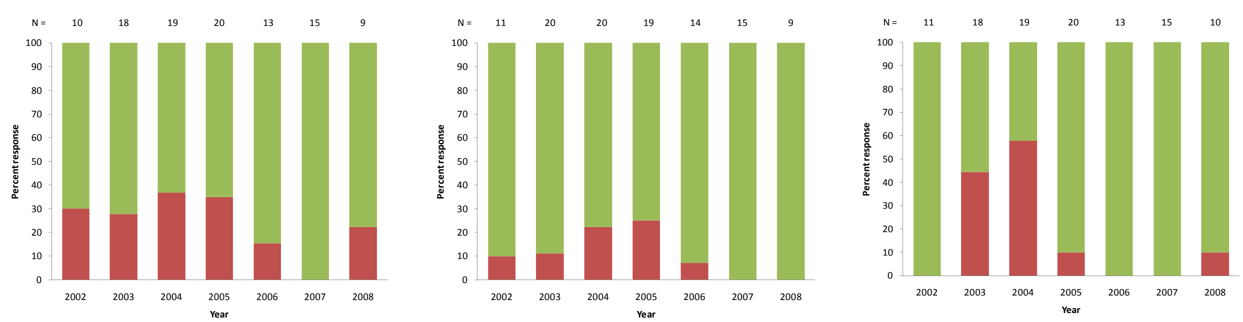


(a) Summer (b) Fall (c) Winter

Figure 23. Seasonal precipitation rating (wet = *green*; dry = *red*) reported by Inuvialuit harvesters in Aklavik, Northwest Territories, 2002-2008.

3.6.3 Storms

Interviewees often reported seeing *few* storms throughout the years (Figure 24). The Cochran-Armitage Trend test showed a significant association between the number of storms and year in winter (Z = 261, Exact P = 0.007), where fewer people reported seeing *lots* of storms over time.

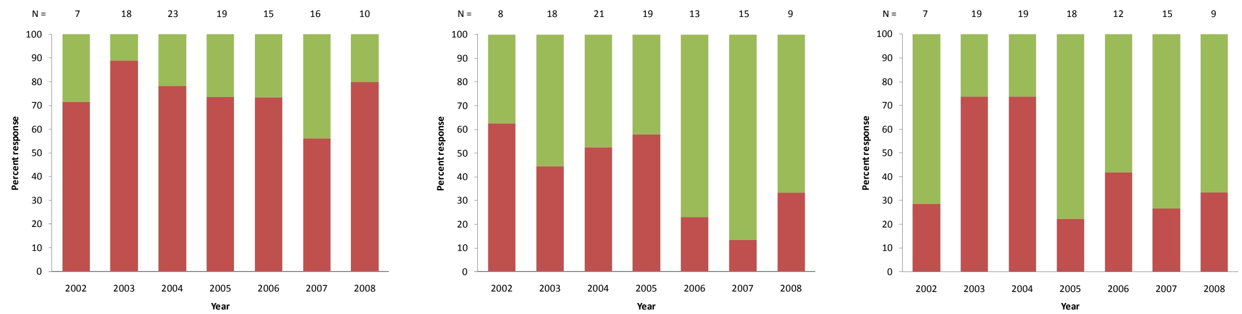


(a) Summer (b) Fall (c) Winter

Figure 24. Number of seasonal storms (few = *green*; lots = *red*) reported by Inuvialuit harvesters in Aklavik, Northwest Territories, 2002-2008.

3.6.4 Wind

Inuvialuit participants indicated no change in wind conditions throughout the summers (Figure 25). However, the number of interviewees that reported *windy* conditions in fall and winter generally declined over time in the fall (Z = 195, Exact P = 0.017 and Z = 176, Exact P = 0.014; respectively).



(a) Summer (b) Fall (c) Winter

Figure 25. Seasonal wind conditions (calm = *green*; windy = *red*) reported by Inuvialuit harvesters in Aklavik, Northwest Territories, 2002-2008.

3.6.5 Overflow

Most interviewees reported annual overflows as either *few* or *lots*. Few people rated overflows as *average* (Figure 26a). These results correspond to the Fisher-Freeman-Halton test, where the amount of overflows that people observed was significantly associated with year ($\chi^2_{14} = 40.35$, Monte Carlo $P < 0.001$). Overall, harvesters reported annual overflows as *average* because these opposing responses cancelled each other (Figure 26b).

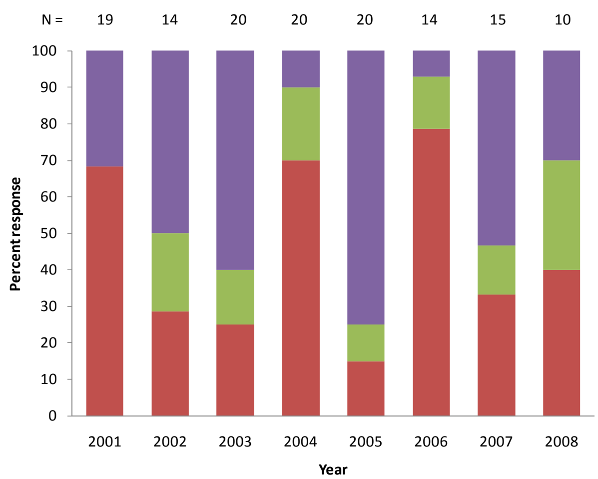


Figure 26a. The percentage of harvesters rating the amount of overflows (few = *red*; average = *green*; lots = *purple*;) in Aklavik, Northwest Territories, 2001-2008.

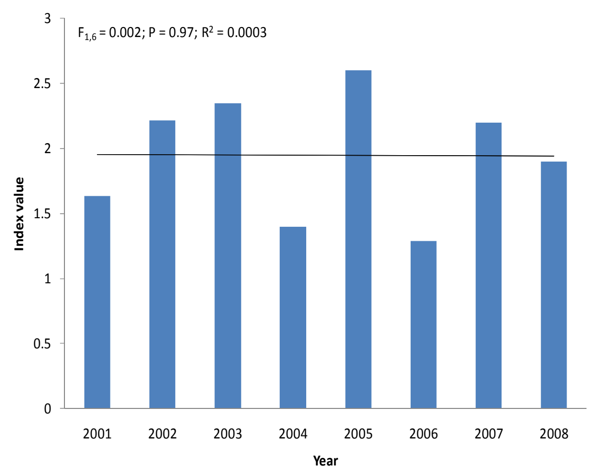
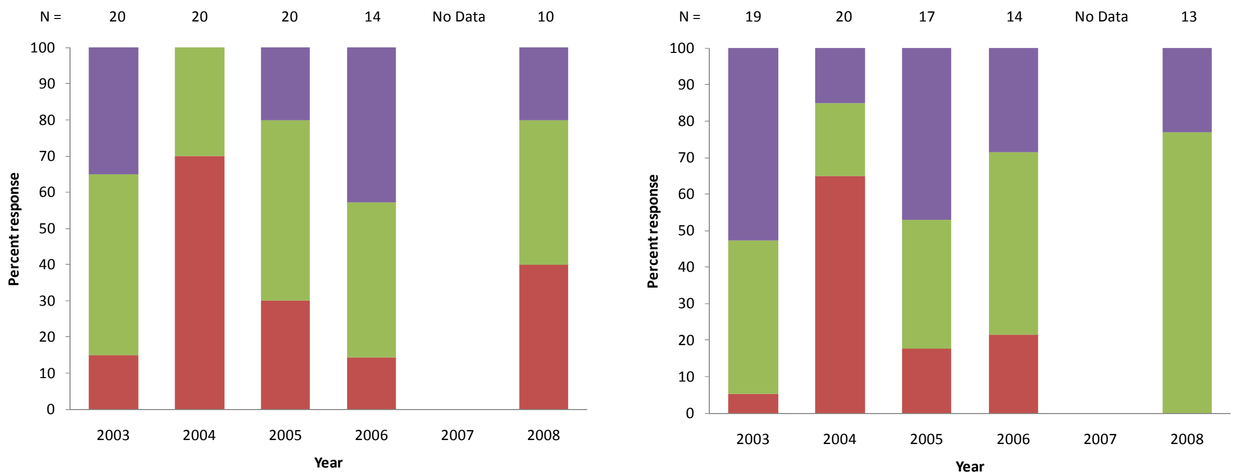


Figure 26b. Index illustrating the amount of overflows (1 = few; 2 = average; 3 = lots) reported by Inuvialuit harvesters in Aklavik, Northwest Territories, 2001-2008.

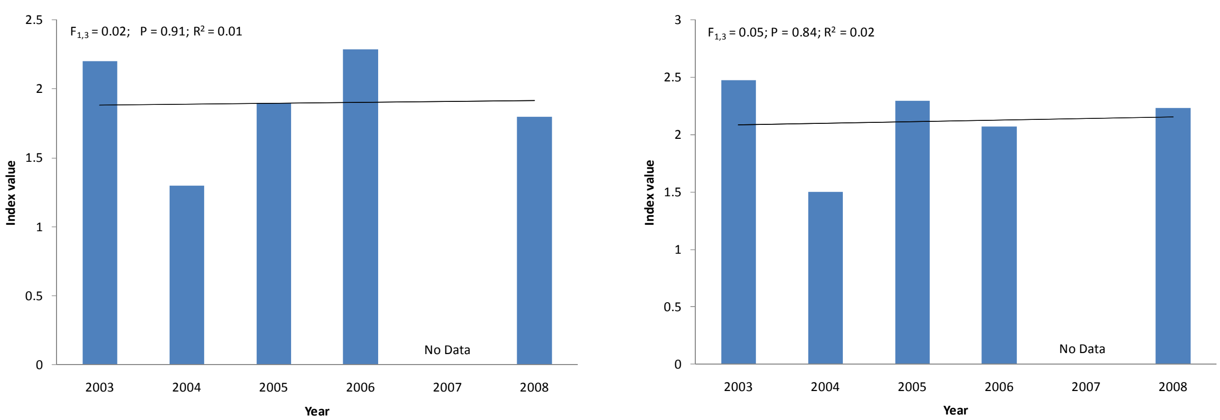
3.6.6 Timing of freeze-up

Timing of freeze-up was significantly associated with year for both rivers ($\chi^2_8 = 28.08$, Monte Carlo $P < 0.001$) and lakes ($\chi^2_8 = 21.21$, Monte Carlo $P = 0.004$; Figure 27). Overall, interviewees did not see any changes in timing of freeze-up with many of their responses remaining *normal* over time (Figure 28).



(a) Rivers (b) Lakes

Figure 27. The percentage of harvesters rating the timing of freeze-up (early = *red*; normal = *green*; late = *purple*) in Aklavik, Northwest Territories, 2003-2008. No data were available in 2007.

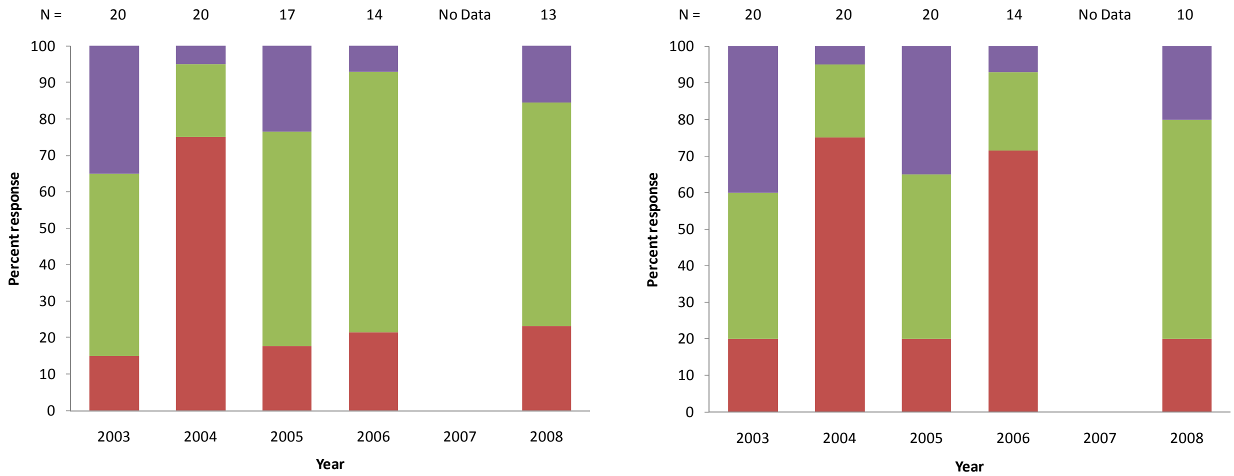


(a) Rivers (b) Lakes

Figure 28. Indices illustrating the timing of freeze-up (1 = early; 2 = normal; 3 = late) reported by Inuvialuit harvesters in Aklavik, Northwest Territories, 2003-2008. No data were available in 2007.

3.6.7 Speed of freeze-up

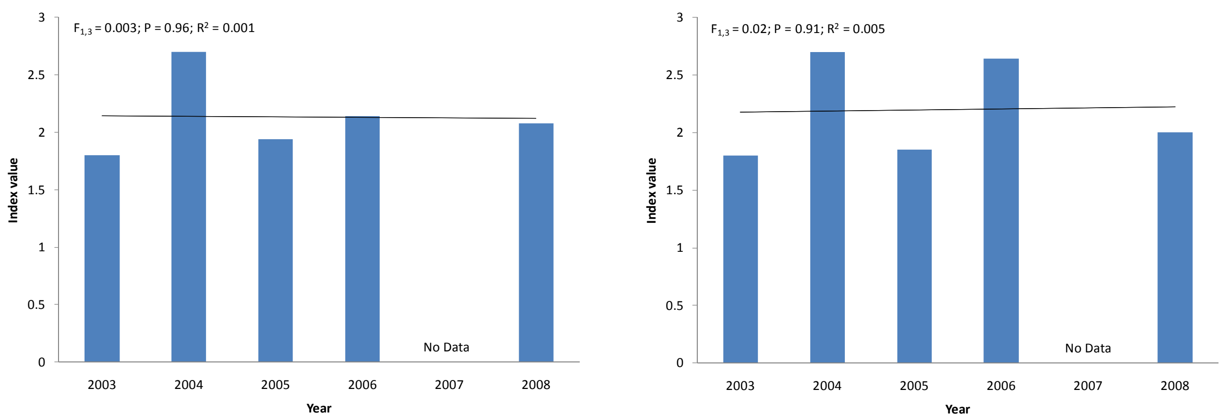
The speed of freeze-up was significantly associated with year for both rivers (χ^2_8 = 23.77, Monte Carlo P = 0.001) and lakes (χ^2_8 =25.3, Monte Carlo P = 0.001; Figure 29). Again, interviewees did not see any changes in speed of freeze-up with many of their responses remaining *normal* over time (Figure 30).



(a) Rivers

(b) Lakes

Figure 29. The percentage of harvesters rating the speed of freeze-up (slow = *purple*; normal = *green*; fast = *red*) in Aklavik, Northwest Territories, 2003-2008. No data were available in 2007.



(a) Rivers

(b) Lakes

Figure 30. Indices illustrating the speed of freeze-up (1 = slow; 2 = normal; 3 = quick) reported by Inuvialuit harvesters in Aklavik, Northwest Territories, 2003-2008. No data were available in 2007.

4.0 DISCUSSION

This report analyzed and synthesized 13-years of LEK data provided by Inuvialuit harvesters in Aklavik, Northwest Territories, and evaluated its role in monitoring and assessing ecosystem changes in the range of the Porcupine caribou herd and adjacent coastal and marine areas. The results provided a strong example to guide future LEK work in this field, as accessibility may encourage governments, aboriginal and non-aboriginal communities, and scientists to integrate LEK with other knowledge. Unlike other LEK studies where the data are often short-term and qualitative (e.g., Papik et al. 2003; Wildlife Management Advisory Council (North Slope) 2008, 2009), the data collected by the Coop were long-term. This provided a unique opportunity to quantitatively analyze the data for comparison to other science knowledge.

Interviewees spent, on average more than one week on the land each year harvesting berry, caribou, and/or fish. Since spending time on the land is important for local harvesters to retain intimate knowledge of the surroundings and to observe annual changes that may occur, it is important to continuously ask this question to better assess responses of local harvesters on topics related to subsistence harvesting. As in many data collection exercises, there was bound to be inconsistencies in the data when collecting LEK from different people. No single person could be expected to have LEK of all topics relating to subsistence harvesting. This often produced different sample sizes for different questions, making statistical analyses challenging. However, the Coop has repeatedly conducted similar surveys in Aklavik, Northwest Territories since 1996, accumulating information spanning a longer period of time than usually seen for LEK surveys. This serves to strengthen the power of the analyses, and has also made it possible to modify the survey over the years.

Although interviewees commented on several topics, many of the noticeable changes were observed in the quantity of berries, caribou, and char. Berries are important traditional foods to the Inuvialuit people (Bandringa 2010). Animals, which the Inuvialuit harvest, also depend on these berries for food as highlighted by one anonymous interviewee (1999) who reported, “If you don't get much berries there is hardly any geese. When there are a lot of berries, then there are a lot of geese.” In general, berry harvesters saw an increase in the number of yellowberry and cranberry. Some harvesters offered explanations for these changes by saying that willows also increased in the area. This provided more shade for the berries, which grew better under these conditions. If this is the case, the expected warming of the Arctic will likely increase and expand shrub growth into new areas, and potentially, provide new suitable berry habitat.

Caribou is the preferred food of most Inuvialuit (Usher 2002, Wildlife Management Advisory Council (North Slope) 2009), where one anonymous interviewee (1999) went as far as saying, “... We can't go without eating caribou.” Another interviewee (2001) commented on the financial problems that their family experienced following a bad hunt with “There was no caribou, so it was hard on us because we have to spend money if we have to buy it [meat] from the store.” Harvesters often reported more caribou being available (i.e., how close the caribou approached the community) throughout the season. This result, in conjunction with an increase in the number of interviewees meeting their subsistence needs for caribou, were similar to findings by Russell et al (2008). These results contradicted western science knowledge by suggesting that either the caribou were moving closer to the community or quantity of caribou had increased over time. Photocensus efforts between 1992 and 2001 documented a decline in caribou numbers, so many governments, aboriginal and non-aboriginal communities, and scientists feared the worst with unsuccessful photocensus efforts between 2002 and 2009 (Alaska Department of Fish and Game 2011). However, the 2010 photocensus indicated that the Porcupine caribou herd had indeed grown to an estimated 169,000 animals.

Fishing is an important activity, both for subsistence and cultural purpose (Papik et al. 2003). Whitefish, for example, was traditionally used primarily as dog food. However, this species is not fished as extensively today due to the decline of dog sledding as a means of transport (Usher 2002). Other fish species, such as char and herring, are still fished today for subsistence (Papik et al. 2003). However, stock assessments of char, specifically Dolly Varden, have shown a decline in the Northwest Territories and Yukon North Slope (Fisheries and Oceans Canada et al. 2010). LEK also supports these scientific findings, where interviewees have reported a decline in char numbers.

5.0 CONCLUSION

The community-base monitoring conducted by the Coop is a means of gathering information about remote areas where it may not be feasible to conduct typical research due to financial and logistical costs associated with the north. The results of this report in some cases agreed with and other times corrected recent scientific conclusions, demonstrating the value and efficiency of such community based ecological monitoring programs. The results also provided a strong example to guide future LEK work in this field, as accessibility may encourage governments, aboriginal and non-aboriginal communities, and scientists to integrate LEK with other knowledge. Further analyses should be conducted in the other communities where the Coop collects LEK to assess whether results are similar.

6.0 ACKNOWLEDGEMENTS

This report is the result of a collaborative effort by a number of individuals and organizations to document local ecological knowledge for monitoring changes on the land from the perspectives of the Inuvialuit of Aklavik, Northwest Territories. Thank you to those who contributed to making the report a success. We are sincerely thankful to all interviewees for sharing with us their knowledge, and the community monitors for gathering this data. We hope the results are served well in this report, and that it may be useful as a resource for governments, aboriginal and non-aboriginal communities, and scientists to aid in decision making.

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Appendix A. Summary of survey questions with sufficient data for statistical analyses from harvesters in Aklavik, Northwest Territories, 1996-2008.

Table A1. Summary of survey questions and data available for statistical analysis. Questions were analyzed when data were sufficient (i.e., n ≥5 years).

Topic	General Question	Data Analysis	Years
People	Time spent on the land	Yes	1998-2008
Berries	Year compared to last	No	
	Quantity rating	Yes	1998-2008
	Health and condition	Yes	1997-2003
	Quality rating	No	
	Berry harvest needs met	Yes	2002-2008
Caribou	Caribou body condition	Yes	1998-2008
	Caribou availability	Yes	2000-2008
	Caribou harvest needs met	Yes	2000-2008
	Caribou observation	No	
	Caribou hunting	No	
	Yearly caribou harvest number	No	
	Caribou calf observation	No	
	Firmness of flesh	No	
	Taste abnormalities	No	
Fish	Liver abnormalities	No	
	Body condition	Yes	1996-2007
	Quantity rating during run	Yes	2000-2008
	Parasites	Yes	1997-2008
	Importance of fish species	No	
	Fishing location	No	
	Size of fish	Yes	1997-2008
	Timing of run	No	
Other animals	Arctic hare observation	Yes	1997-2008
	Waterfowl observation	Yes	2001-2008
	Mosquito observation	Yes	1998-2008
	Beluga whale arrival/departure time	No	
	Quantity/quality of furs collected	No	
	Blubber thickness	No	
Weather	Speed/timing of freeze-up	Yes	2003-2008
	Fall/winter snow description	No	
	Summer/fall/winter weather	Yes	2002-2008
	Overflow	Yes	2001-2008

Appendix B. Survey questions administered by the Arctic Borderlands Ecological Knowledge Coop in Aklavik, Northwest Territories, 1996-2008.

1.0 PEOPLE

1.1 Time spent on the land

Interviewees were asked how long they spent out on the land during the year. Responses were classified into one of four categories: (1) day trips; (2) day trips with overnights; (3) ≥1 weeks at a time; or (4) more than half the time on the land. The number of responses in each category was multiplied by an arbitrary score to create annual index values:

$$\frac{(\text{Day trips}) + 2(\text{Day trips with overnights}) + 3(\geq 1 \text{ weeks at a time}) + 4(\text{more than half the time on the land})}{\text{Annual sample size}}$$

2.0 BERRIES

2.1 Quantity rating

Interviewees rated the quantity of different berries into one of three categories: (1) few; (2) average; or (3) lots. The number of responses in each category was multiplied by an arbitrary score to create annual index values:

$$\frac{(\text{Few}) + 2(\text{Average}) + 3(\text{Lots})}{\text{Annual sample size}}$$

2.2 Subsistence needs being met

Interviewees rated whether the year's berry harvest filled their subsistence needs with a binomial response: yes or no. All berry types were grouped to compensate for insufficient data.

2.3 Health and condition

Participants were asked to rate the overall health and condition of berries, and the responses were categorized into four responses: (1) exceptionally good year; (2) good year; (3) not that good a year; or (4) really bad year. Due to insufficient data in some categories, responses were further broken down into two categories: good or bad. Analysis was conducted on cranberry and yellowberry because the data available for blueberry were insufficient.

3.0 CARIBOU

3.1 Availability

Interviewees rated the availability of caribou during spring, fall, and winter as: (1) not available; (2) not close; or (3) close. The number of responses in each category was multiplied by an arbitrary score to create annual index values:

$$\frac{0(\text{Not available}) + (\text{Not close}) + 2(\text{Close})}{\text{Annual sample size}}$$

3.2 Subsistence needs being met

Interviewees rated whether the year's spring, fall, and winter caribou hunt filled their subsistence needs with a binomial response: yes or no. Only spring and fall seasons were analyzed because winter data were insufficient.

3.3 Body condition

Interviewees rated the body condition of caribou into one of four categories during the spring, fall, and winter seasons: (1) most in good shape; (2) between fat and poor/most in fair shape; (3) mix of some fat, some poor; or (4) most in poor shape. Only fall data were analyzed because of insufficient data for other seasons. Due to insufficient data in some categories, responses were further broken down to binomial responses: good or bad.

4.0 FISH

4.1 Quantity rating during run

Interviewees rated the quantity of fish species during their run into one of three categories: (1) few; (2) some; or (3) lots. Unless otherwise indicated, the fish species analyzed throughout this section were: char, coney, herring, and whitefish. The number of responses in each category was multiplied by an arbitrary score to create annual index values:

$$\frac{(\text{Few}) + 2(\text{Some}) + 3(\text{Lots})}{\text{Annual sample size}}$$

4.2 Timing of run

Interviewees rated the timing of run of different fish species as: (1) early; (2) normal; or (3) late. The number of responses in each category was multiplied by an arbitrary score to create annual index values:

$$\frac{(\text{Early}) + 2(\text{Normal}) + 3(\text{Late})}{\text{Annual sample size}}$$

4.3 Size

Interviewees rated the size of different fish species into one of three categories: as: (1) small; (2) normal; or (3) large. The number of responses in each category was multiplied by an arbitrary score to create annual index values:

$$\frac{(\text{Small}) + 2(\text{Normal}) + 3(\text{Large})}{\text{Annual sample size}}$$

4.4 Parasite

Interviewees rated the quantity of fish parasites into one of five categories: (1) none; (2) few; (3) average; (4) some; or (5) many. Due to insufficient data in some categories, responses were further broken down into two categories: present or absent.

4.5 Body condition

Interviewees rated the firmness of flesh of different certain fish species into one of three categories: (1) firm; (2) normal; or (3) soft. The number of responses in each category was multiplied by an arbitrary score to create annual index values:

$$\frac{(\text{Soft}) + 2(\text{Normal}) + 3(\text{Firm})}{\text{Annual sample size}}$$

5.0 OTHER ANIMALS

5.1 Quantity rating

Interviewees rated the quantity of swans, cranes, ducks, geese, mosquitoes, and Arctic hares into one of three categories: (1) more; (2) same; or (3) less. The number of responses in each category was multiplied by an arbitrary score to create annual index values:

$$\frac{(\text{Less}) + 2(\text{Same}) + 3(\text{More})}{\text{Annual sample size}}$$

6.0 WEATHER

6.1 Temperature

Interviewees rated seasonal (summer, fall, and winter) temperature with a binomial response: cold or warm.

6.2 Precipitation

Interviewees rated seasonal (summer, fall, and winter) precipitation with a binomial response: wet or dry.

6.3 Storms

Interviewees rated frequency of seasonal (summer, fall, and winter) storms with a binomial response: few or lots.

6.4 Wind

Interviewees rated seasonal (summer, fall, and winter) wind conditions with a binomial response: calm or windy.

6.5 Overflow

Interviewees rated the amount of overflow on ice into one of three categories: (1) lots; (2) average; or (3) few. The number of responses in each category was multiplied by an arbitrary score to create annual index values:

$$\frac{(\text{Few}) + 2(\text{Average}) + 3(\text{Lots})}{\text{Annual sample size}}$$

6.6 Timing of freeze-up

Interviewees rated the timing of the freeze-up of rivers and lakes into one of three categories: (1) early; (2) normal; or (3) late. The number of responses in each category was multiplied by an arbitrary score to create annual index values:

$$\frac{(\text{Early}) + 2(\text{Normal}) + 3(\text{Late})}{\text{Annual sample size}}$$

6.7 Speed of freeze-up

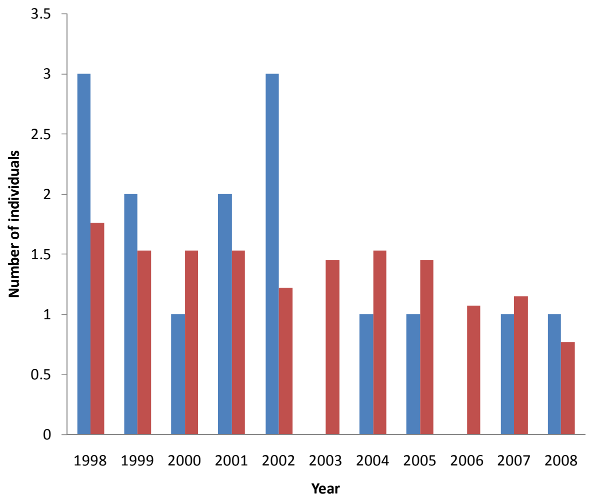
Interviewees rated the speed at which lakes and rivers froze over into one of three categories: (1) quick; (2) normal; or (3) slow. The number of responses in each category was multiplied by an arbitrary score to create annual index values:

$$\frac{(\text{Slow}) + 2(\text{Normal}) + 3(\text{Quick})}{\text{Annual sample size}}$$

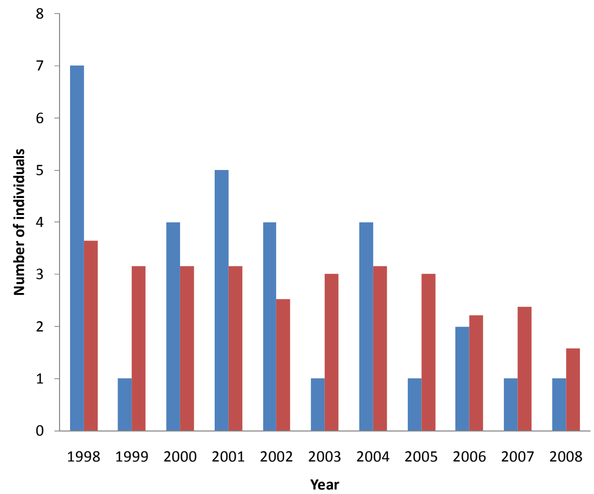
Appendix C. Summary of local ecological knowledge by harvesters in Aklavik, Northwest Territories, 1996-2008.

1.0 PEOPLE

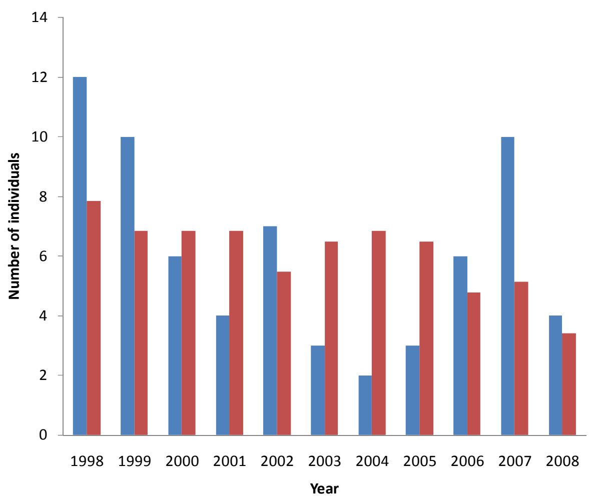
1.1 Time spent on the land



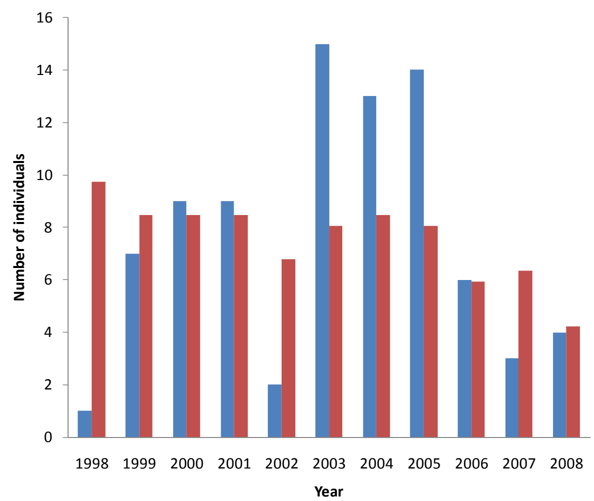
(a) Day trips



(b) Day trips with overnights



(c) $\geq$1 weeks at a time

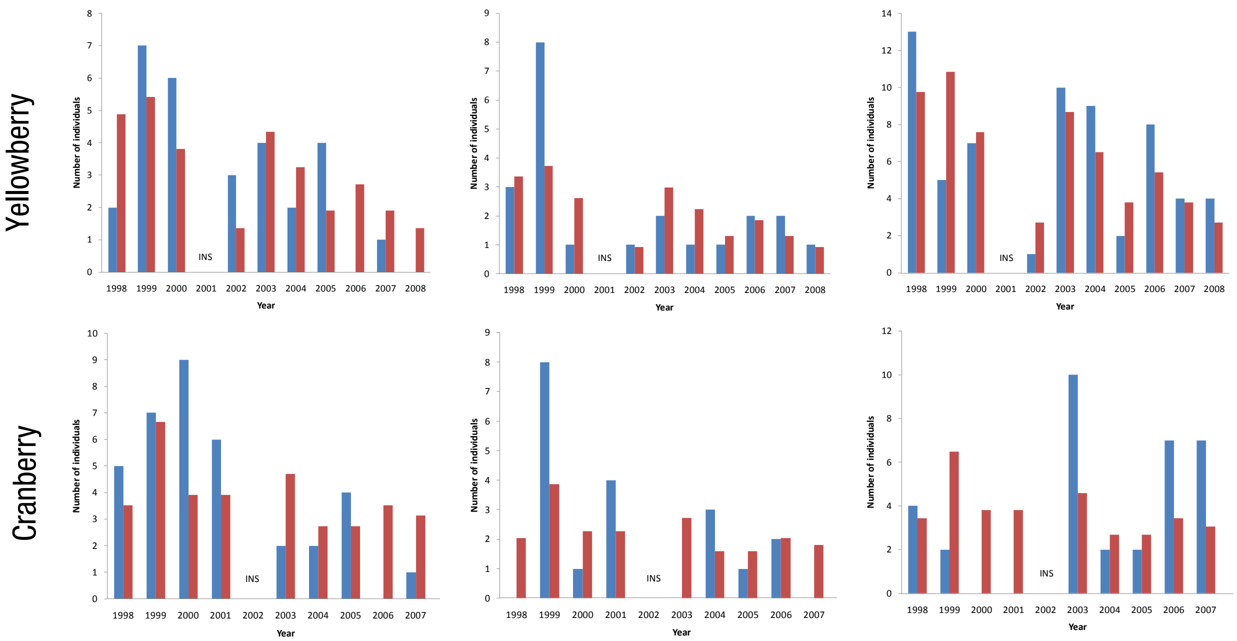


(d) More than half the time on the land

Figure C1. The observed (*blue*) and expected (*red*) number of Aklavik harvesters spending different lengths of time on the land during 1998-2008.

2.0 BERRIES

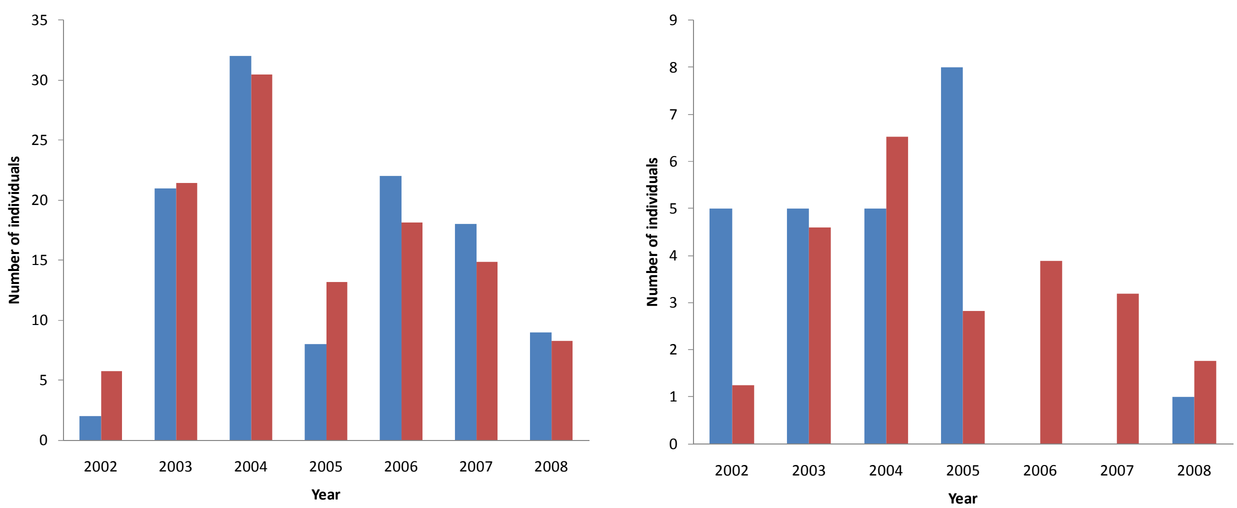
2.1 Quantity rating



(a) Few (b) Average (c) Lots

Figure C2. The observed (*blue*) and expected (*red*) number of berry harvesters rating the quantity of yellowberry and cranberry near Aklavik, Northwest Territories, 1998-2008.

2.2 Subsistence needs being met



(a) Yes (b) No

Figure C3. The observed (*blue*) and expected (*red*) number of harvesters who met their subsistence needs by berry picking.

2.3 Health and condition

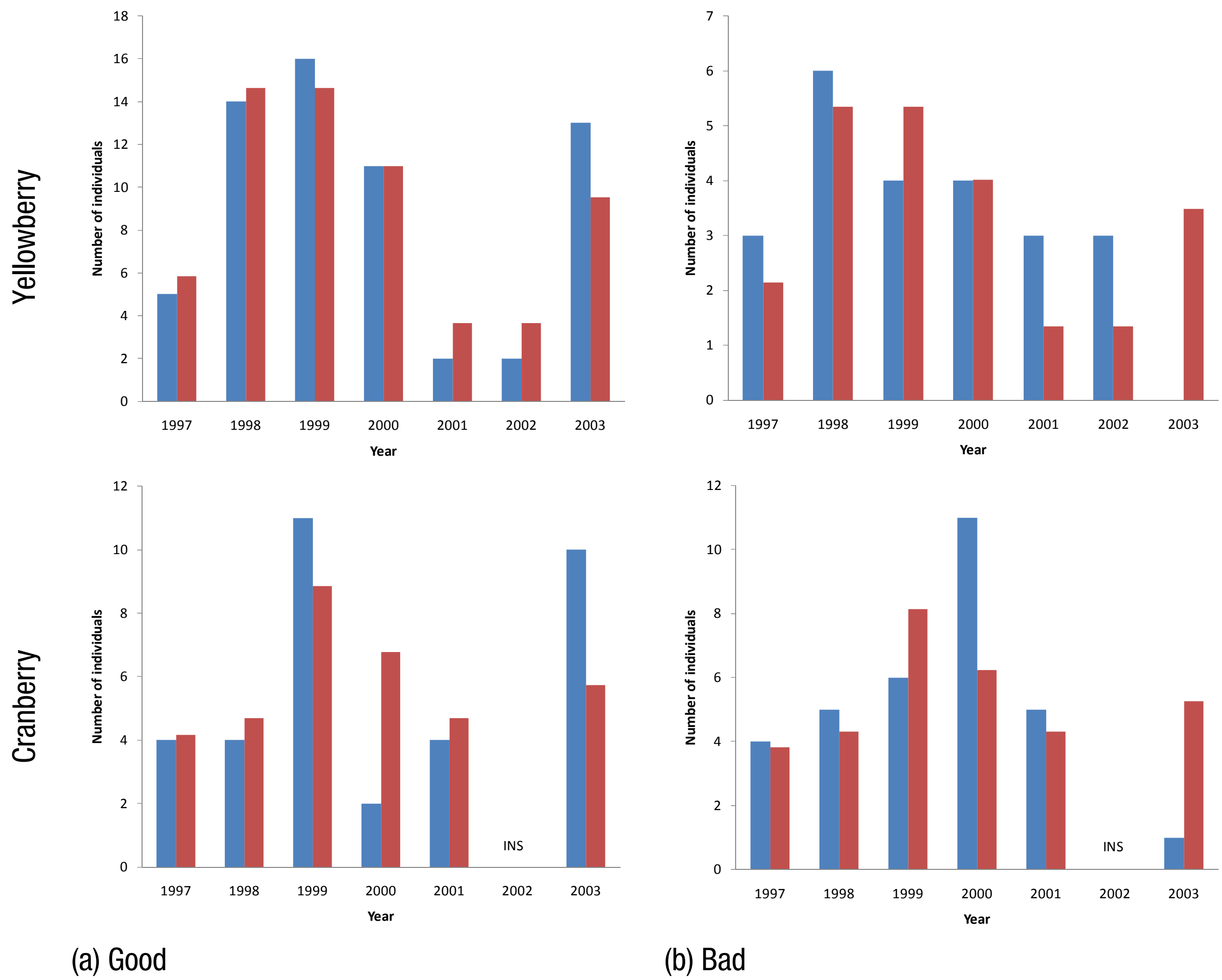
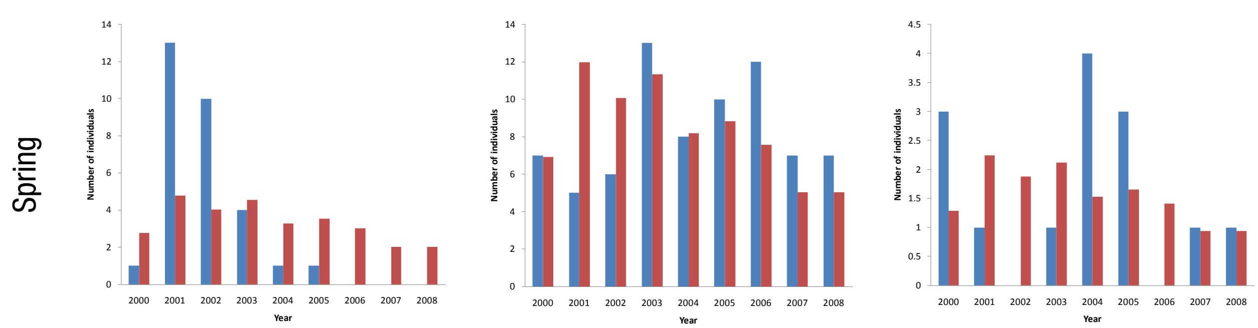


Figure C4. The observed (*blue*) and expected (*red*) number of berry harvesters rating the health and condition of yellowberry and cranberry near Aklavik, Northwest Territories, 1997-2003.

3.0 CARIBOU

3.1 Availability



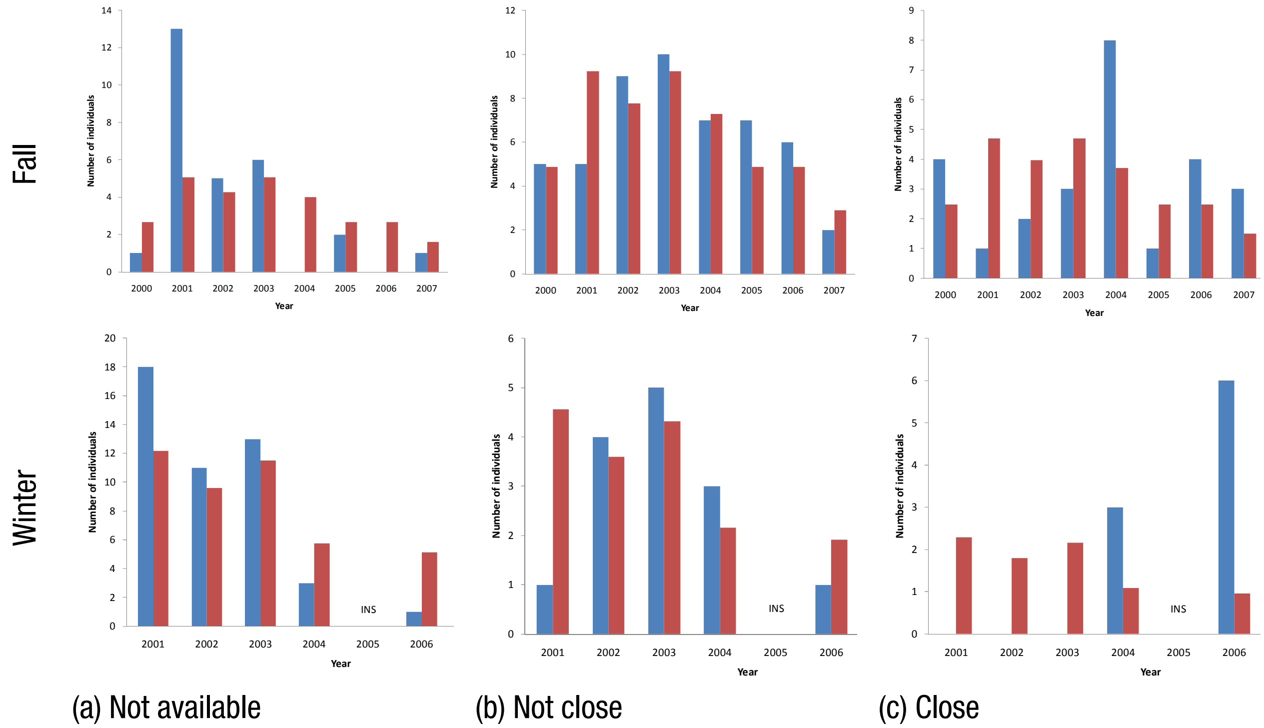
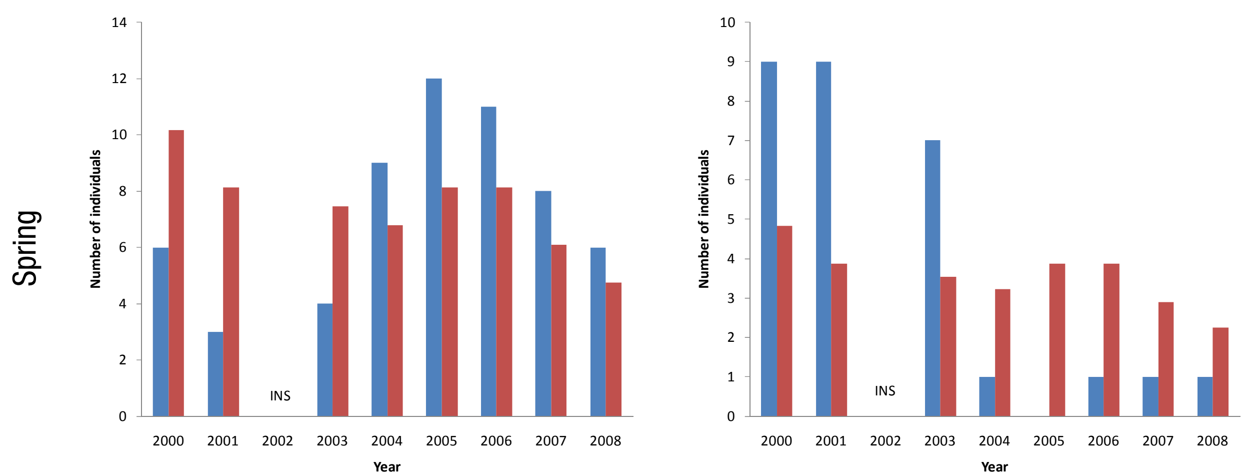
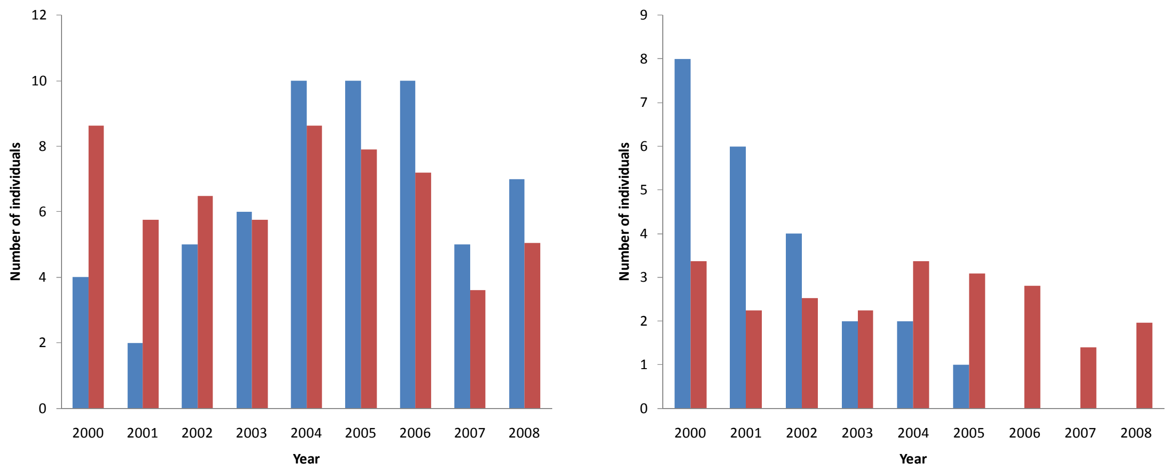


Figure C5. The observed (*blue*) and expected (*red*) number of harvesters rating the seasonal availability of caribou in Aklavik, Northwest Territories, 2000-2008. INS denotes insufficient data (n < 5).

3.2 Subsistence needs being met



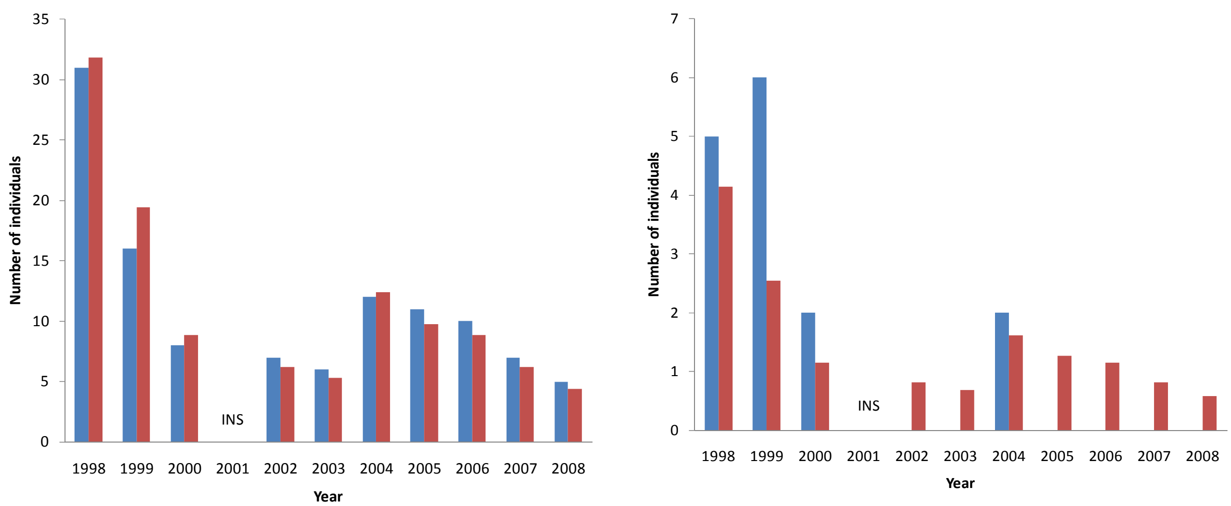
Fall



(a) Yes (b) No

Figure C6. The observed (*blue*) and expected (*red*) number of caribou harvesters who met their subsistence needs in Aklavik, Northwest Territories, 2000-2008.

3.3 Body condition



(a) Good (b) Bad

Figure C7. The observed (*blue*) and expected (*red*) number of harvesters rating caribou body condition in Aklavik, Northwest Territories, 1998-2008.

4.0 FISH

4.1 Quantity rating during run

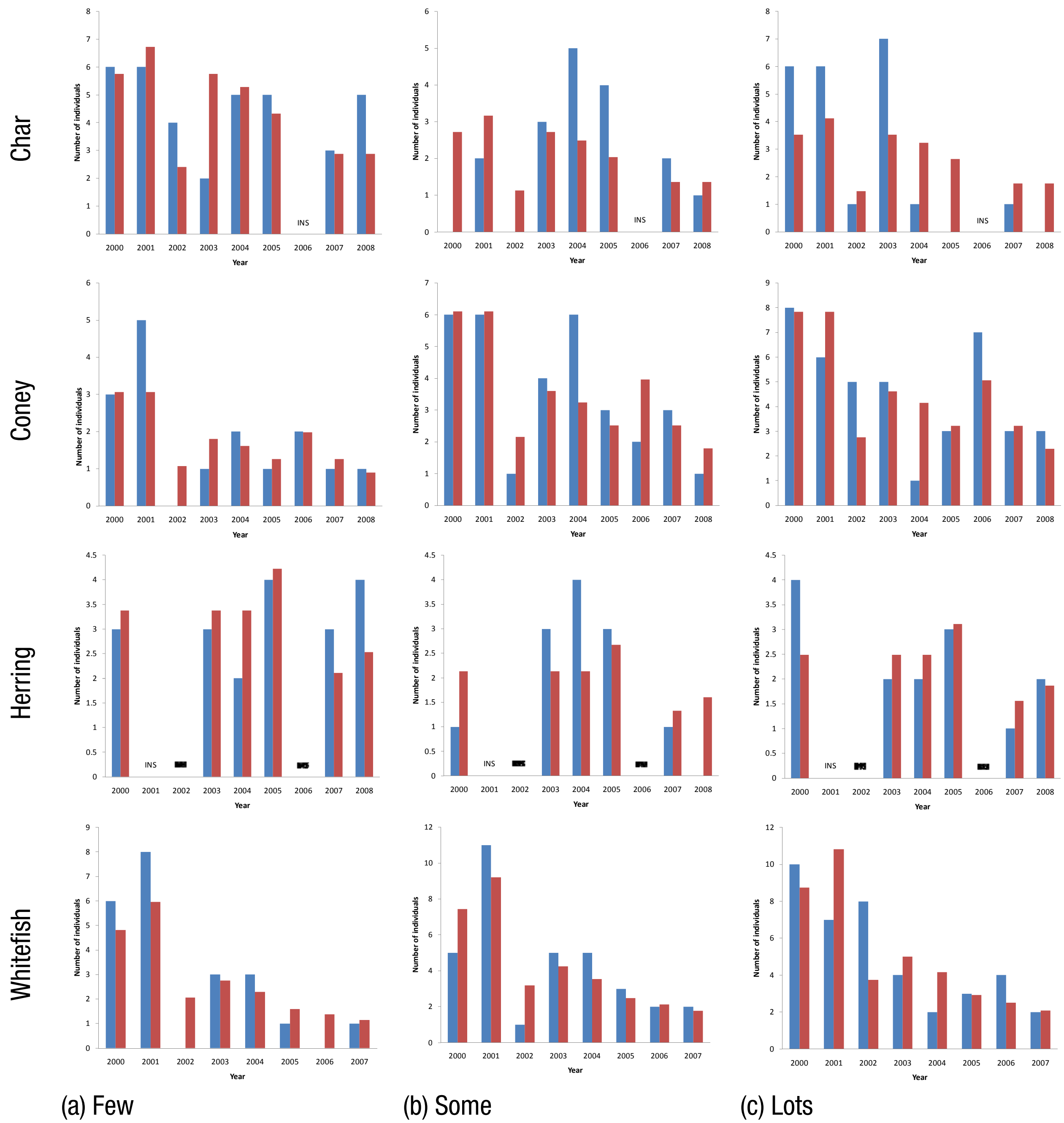
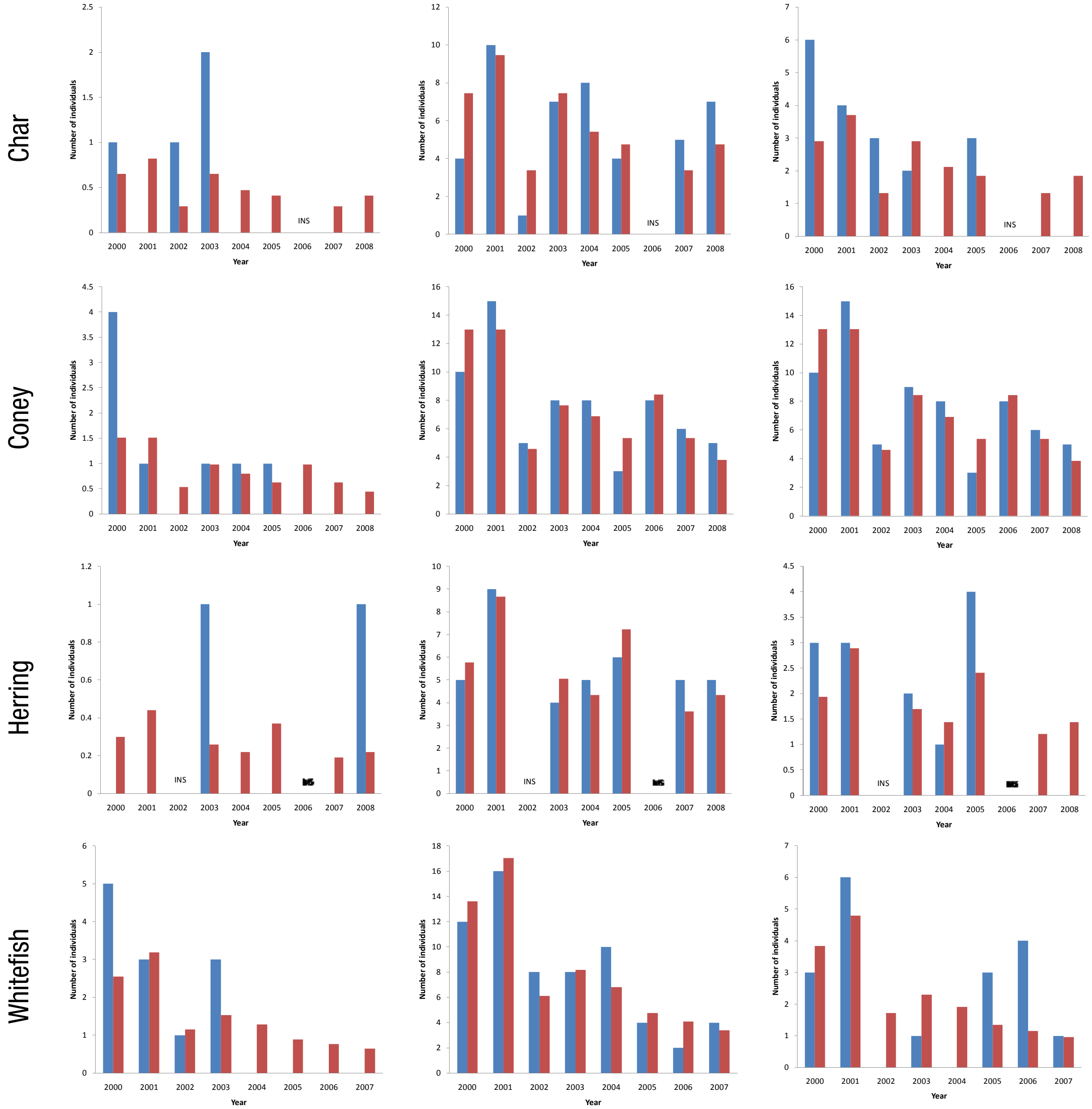


Figure C8. The observed (*blue*) and expected (*red*) number of harvesters rating the quantity of different fish species during the run in Aklavik, Northwest Territories, 2000-2008.

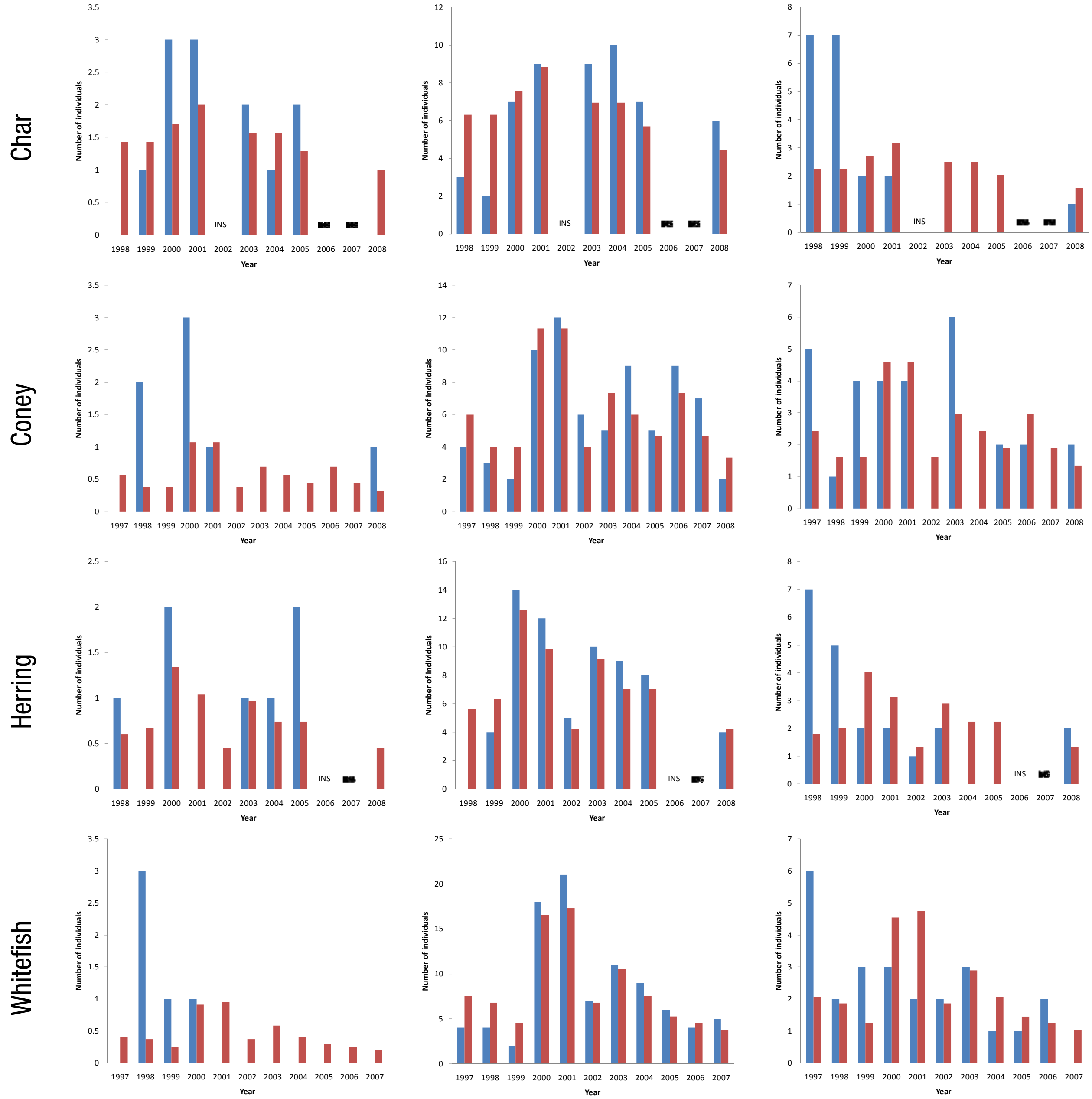
4.2 Timing of run



(a) Early (b) Normal (c) Late

Figure C9. The observed (*blue*) and expected (*red*) number of harvesters rating when the timing of run occurred for different fish species in Aklavik, Northwest Territories, 2000-2008.

4.3 Size

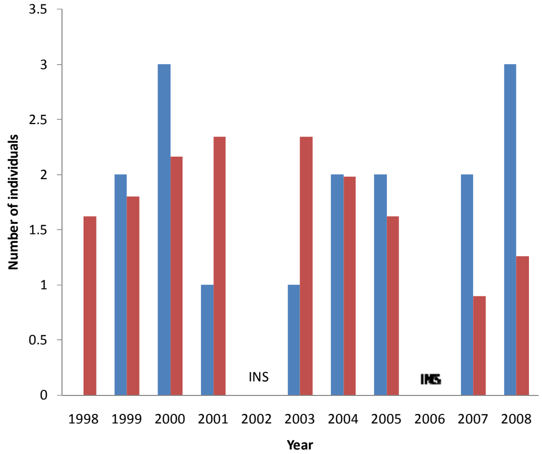


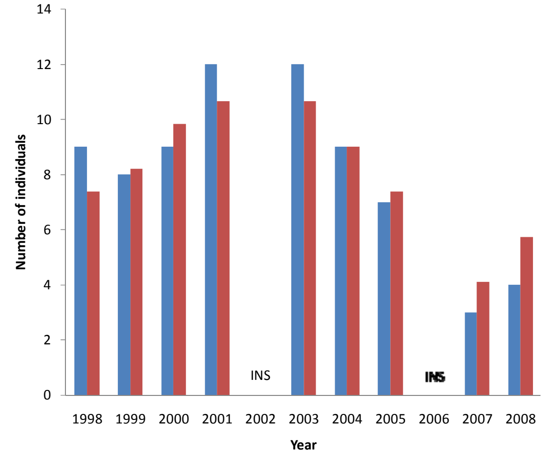
(a) Small (b) Average (c) Large

Figure C10. The observed (*blue*) and expected (*red*) number of harvesters rating the size of different fish species in Aklavik, Northwest Territories, 1997-2008.

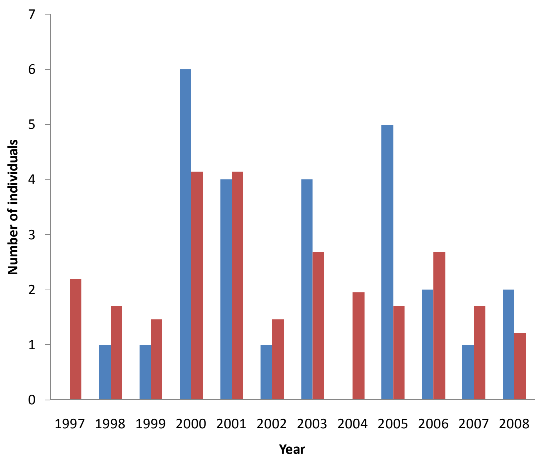
4.4 Parasite

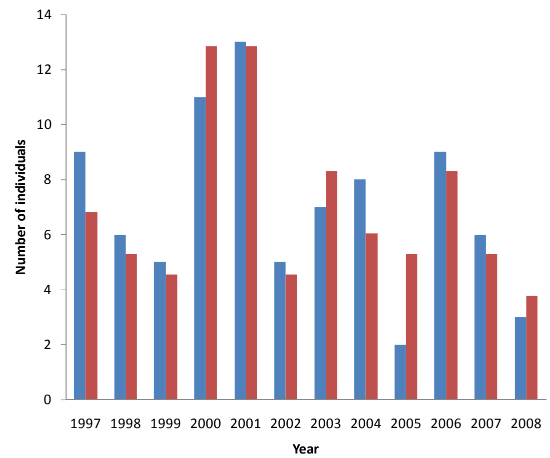
Char



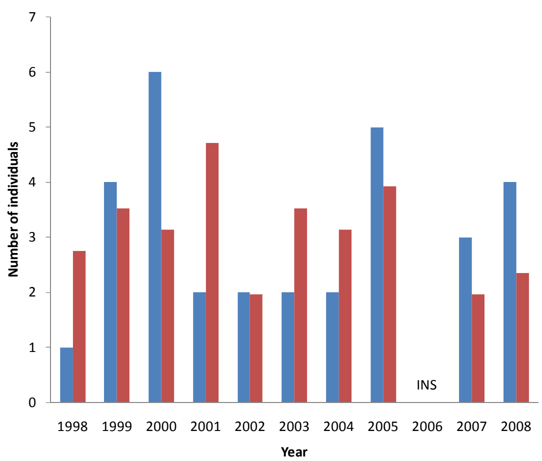


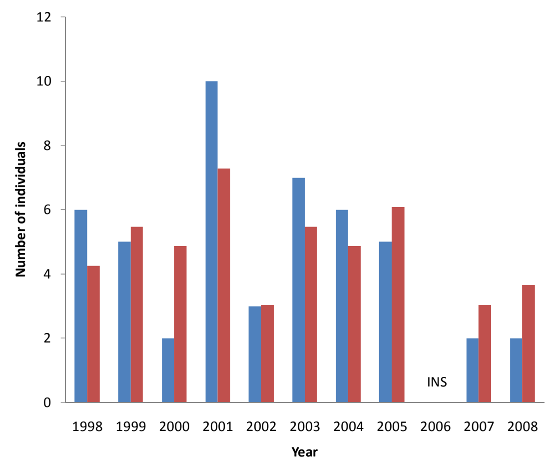
Coney



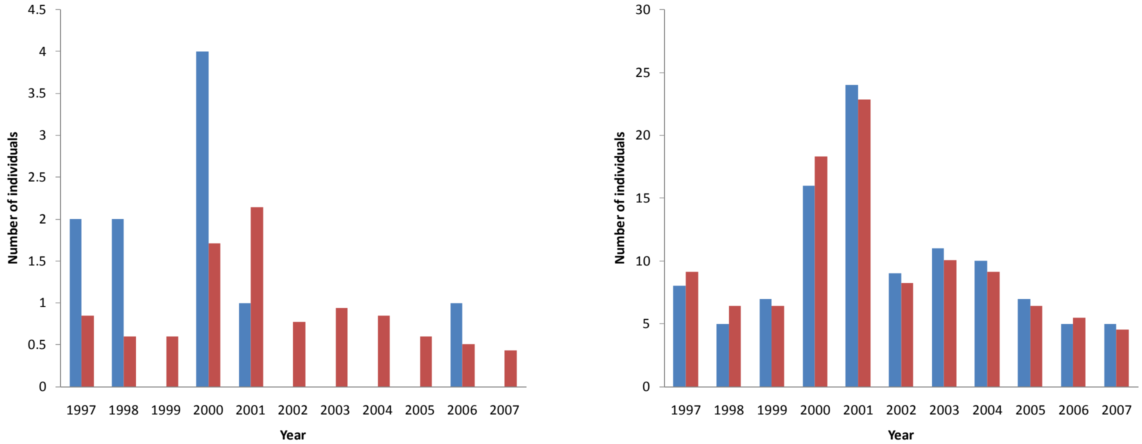


Herring





Whitefish



(a) Presence (b) Absence

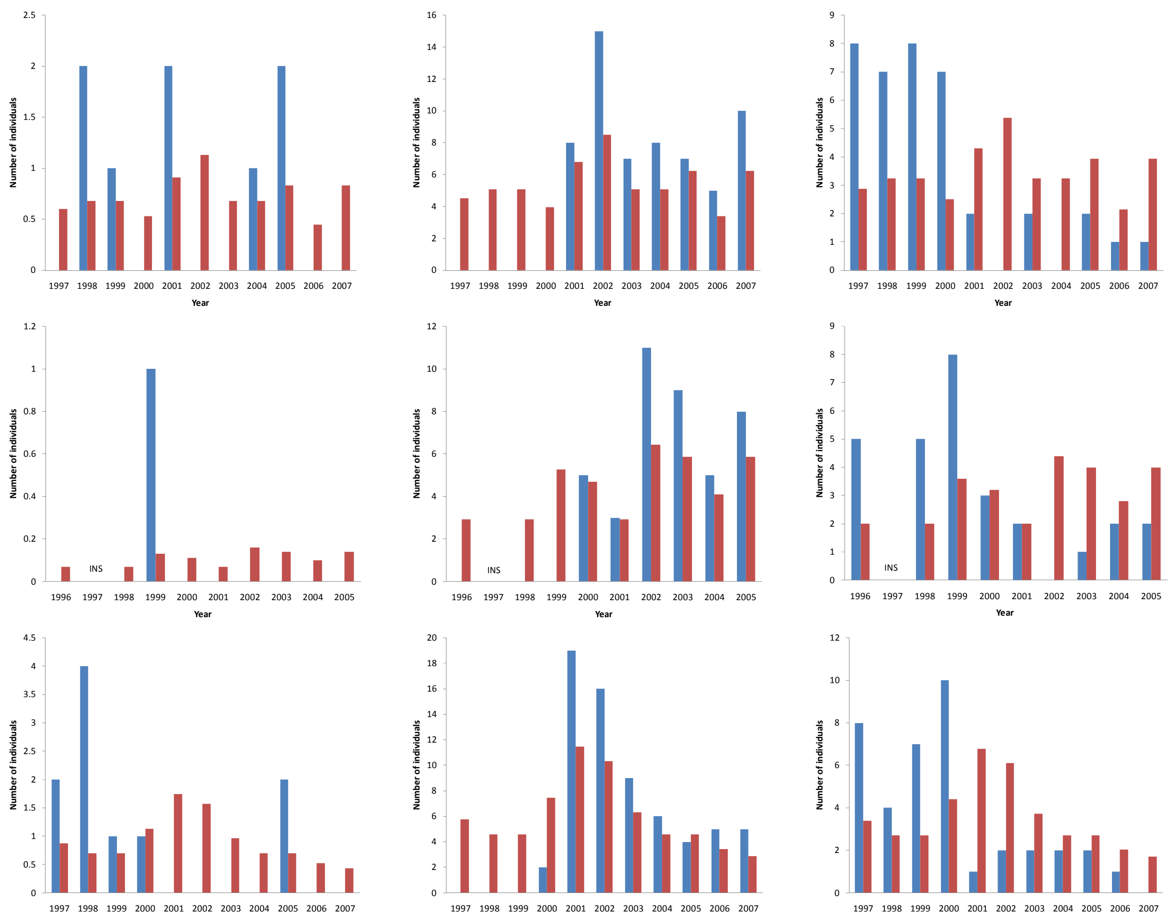
Figure C11. The observed (*blue*) and expected (*red*) number of harvesters seeing fish parasites near Aklavik, Northwest Territories, 1997-2008.

4.5 Body condition

Coney

Herring

Whitefish



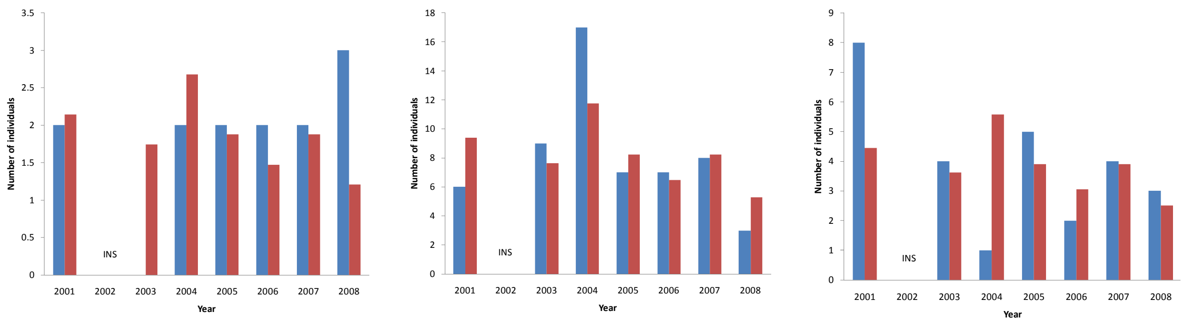
(a) Soft (b) Normal (c) Firm

Figure C12. The observed (*blue*) and expected (*red*) number of harvesters rating the body condition of different fish species in Aklavik, Northwest Territories, 1996-2007.

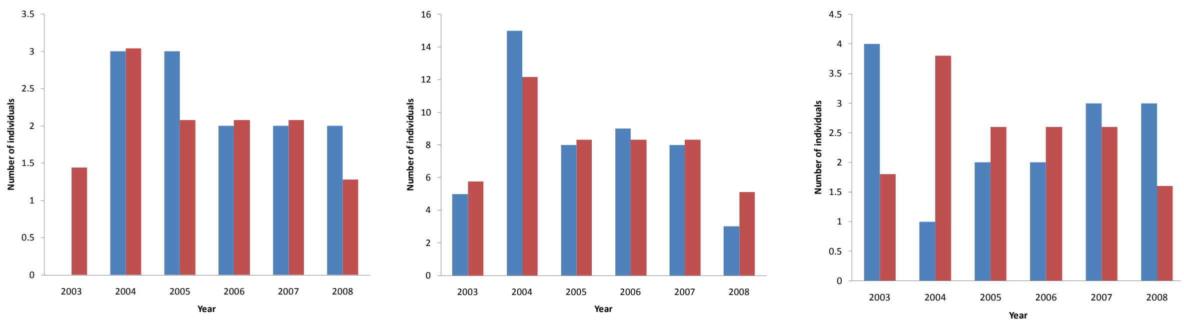
5.0 OTHER ANIMALS

5.1 Quantity rating

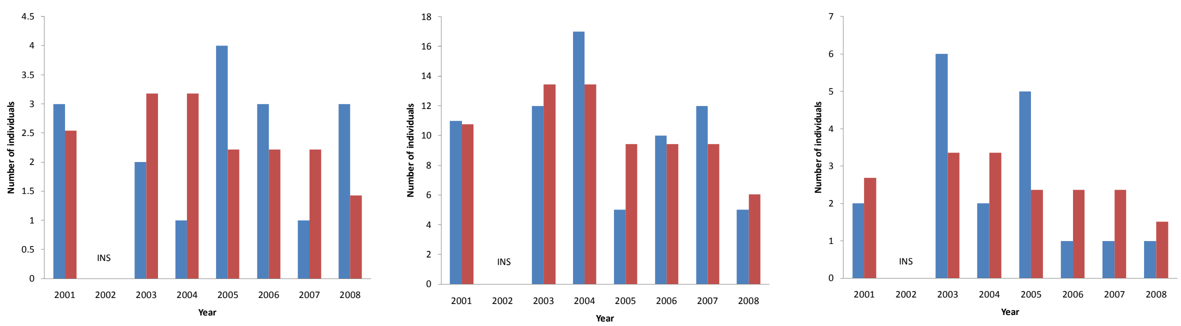
Swan



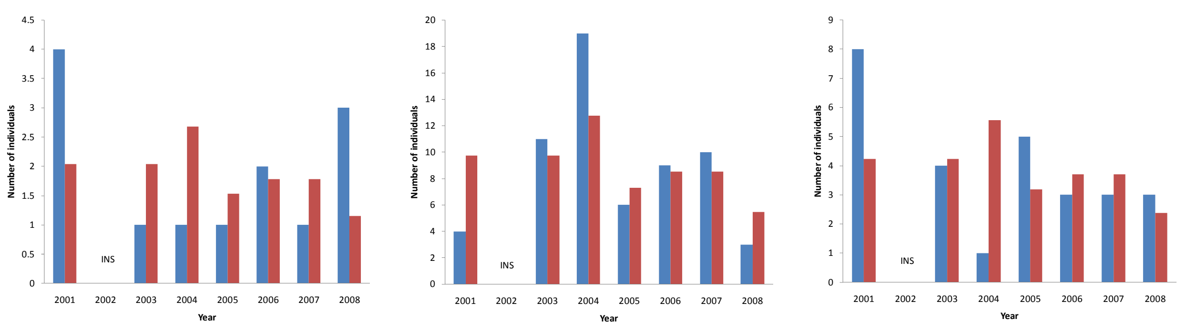
Crane



Duck



Goose



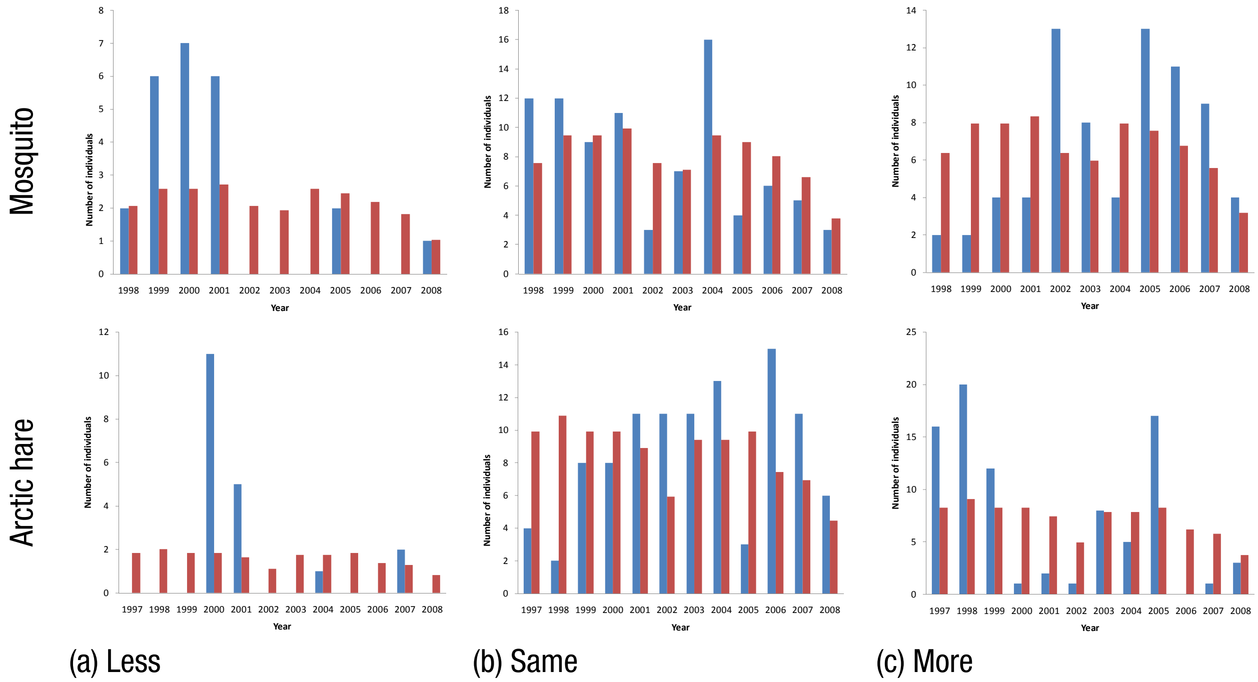
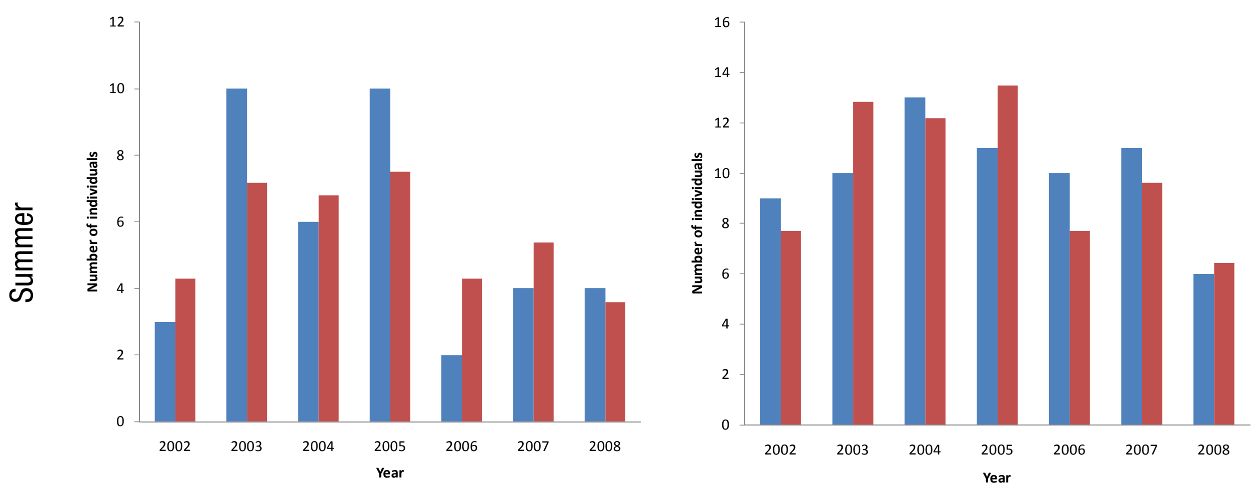


Figure C13. The observed (*blue*) and expected (*red*) number of harvesters rating animal quantity in Aklavik, Northwest Territories, 1997-2008.

6.0 WEATHER

6.1 Temperature



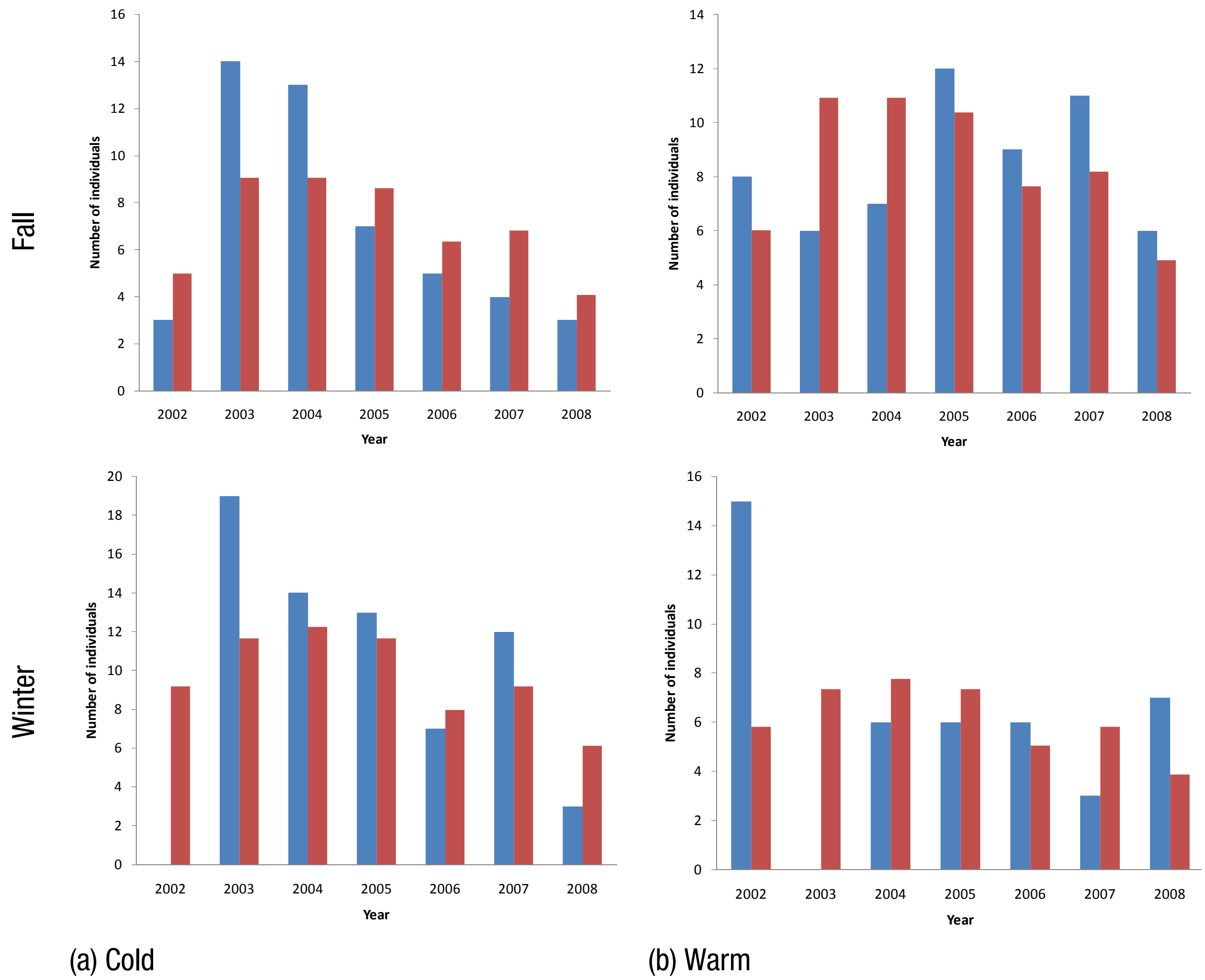
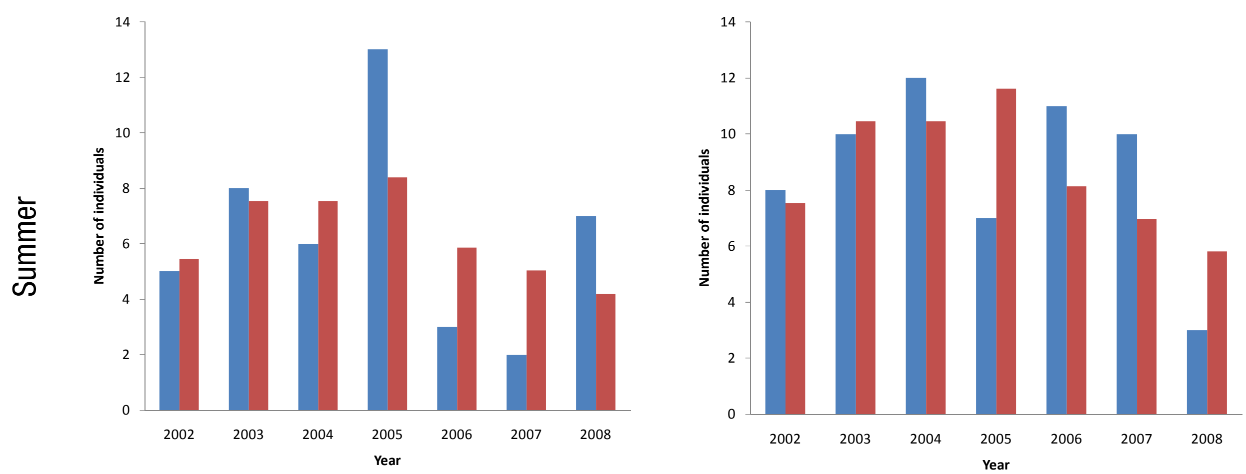


Figure C14. The observed (*blue*) and expected (*red*) number of harvesters rating seasonal temperature in Aklavik, Northwest Territories, 2002-2008.

6.2 Precipitation



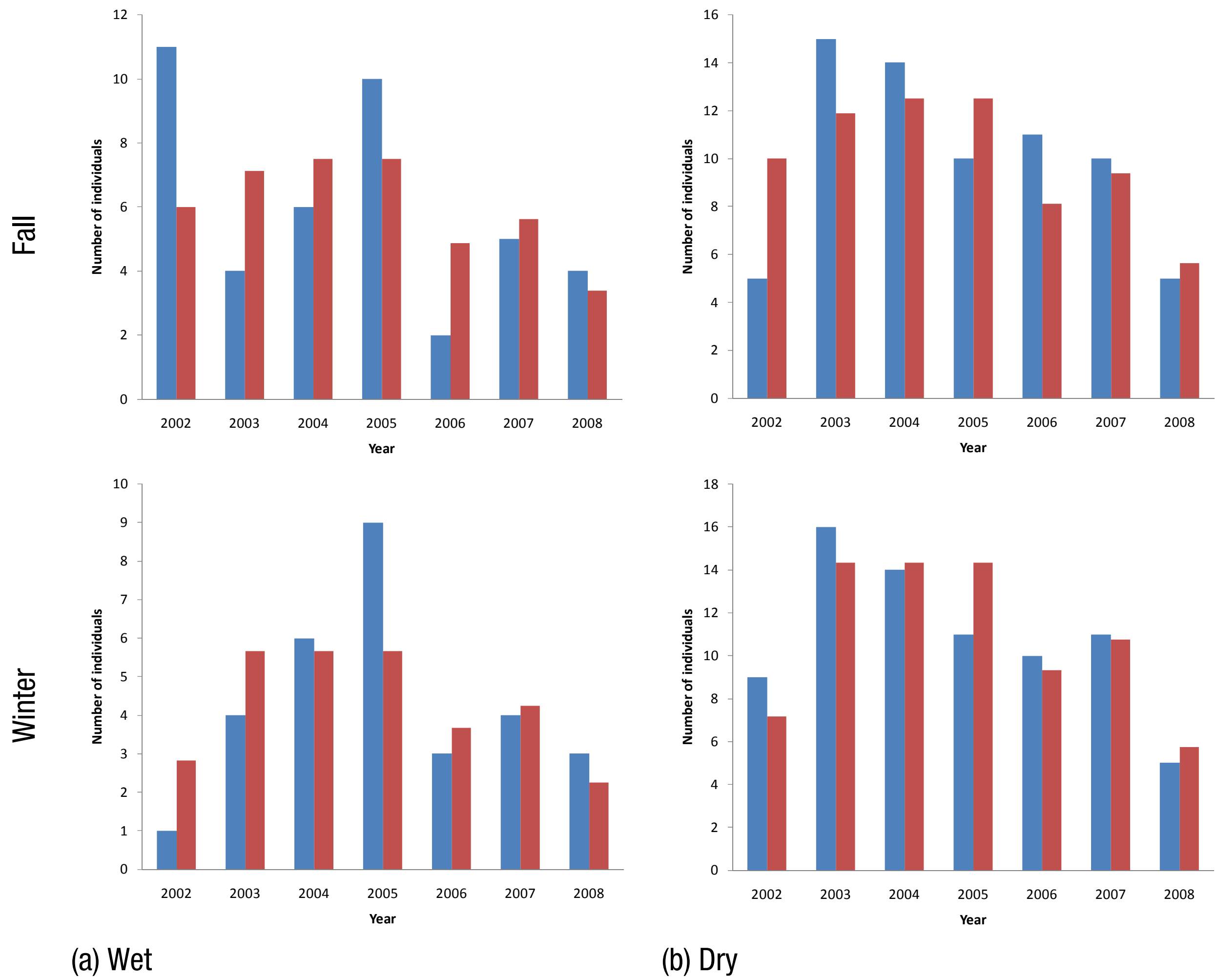
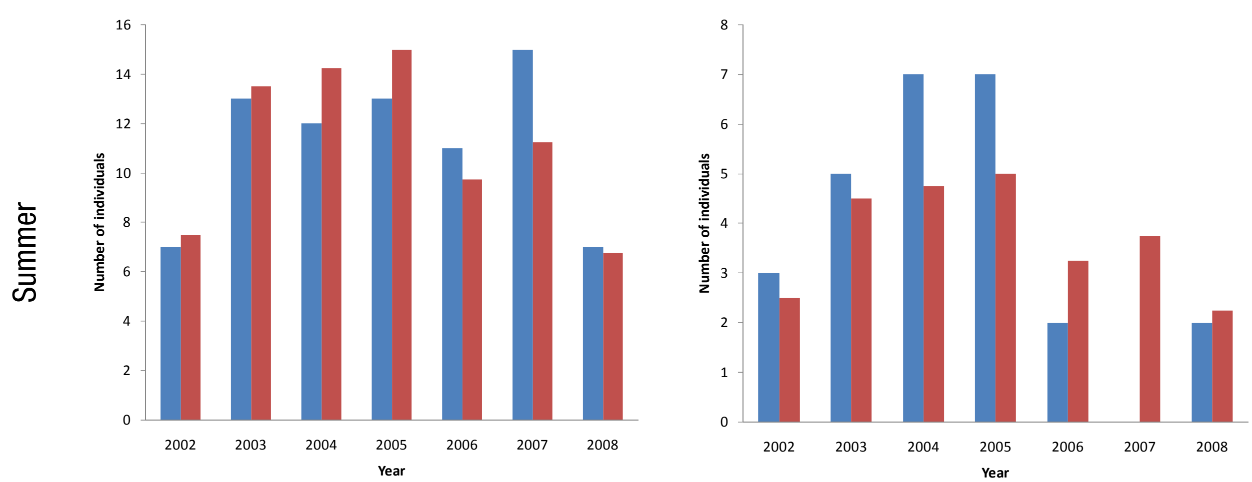
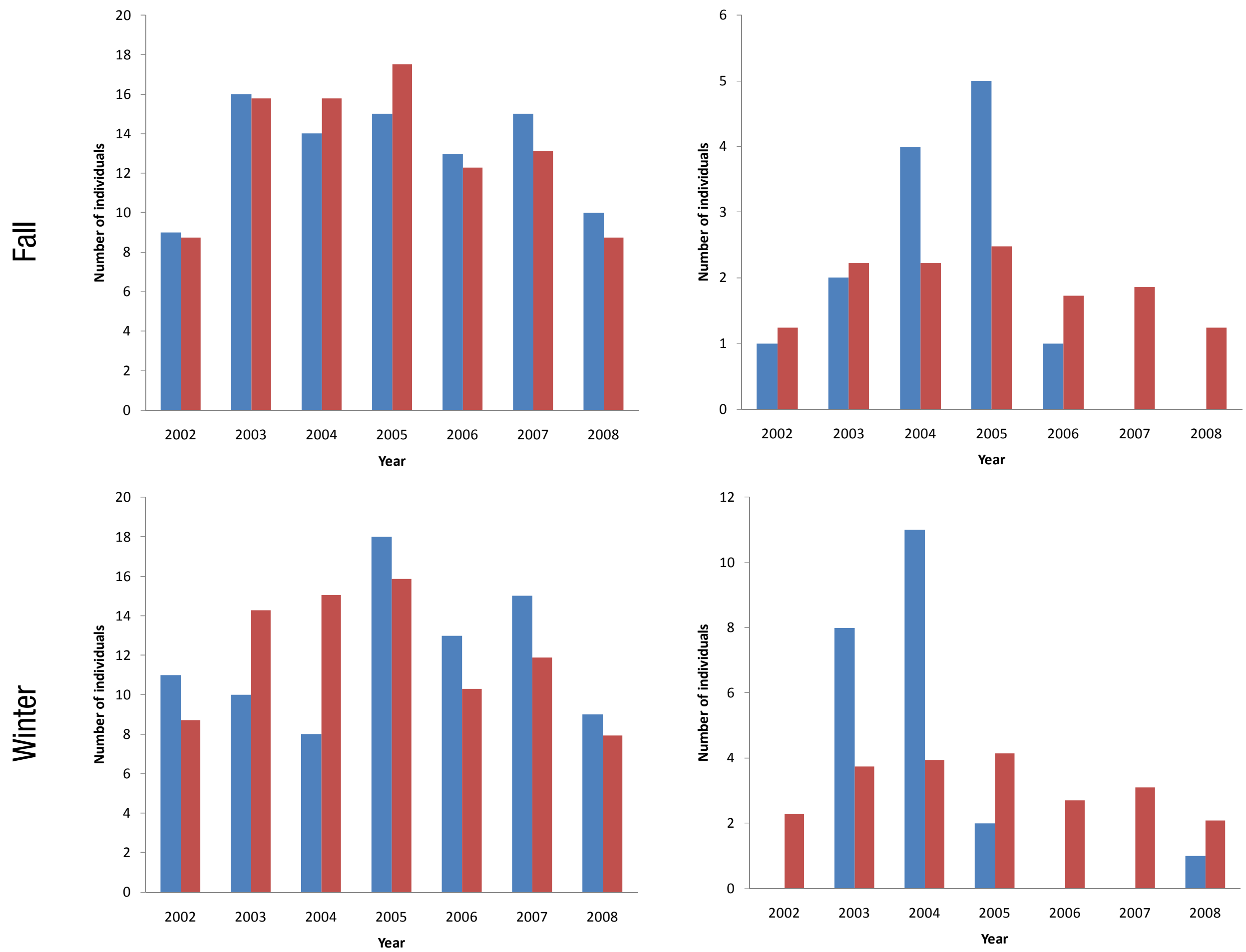


Figure C15. The observed (*blue*) and expected (*red*) number of harvesters rating seasonal precipitation in Aklavik, Northwest Territories, 2002-2008.

6.3 Storms

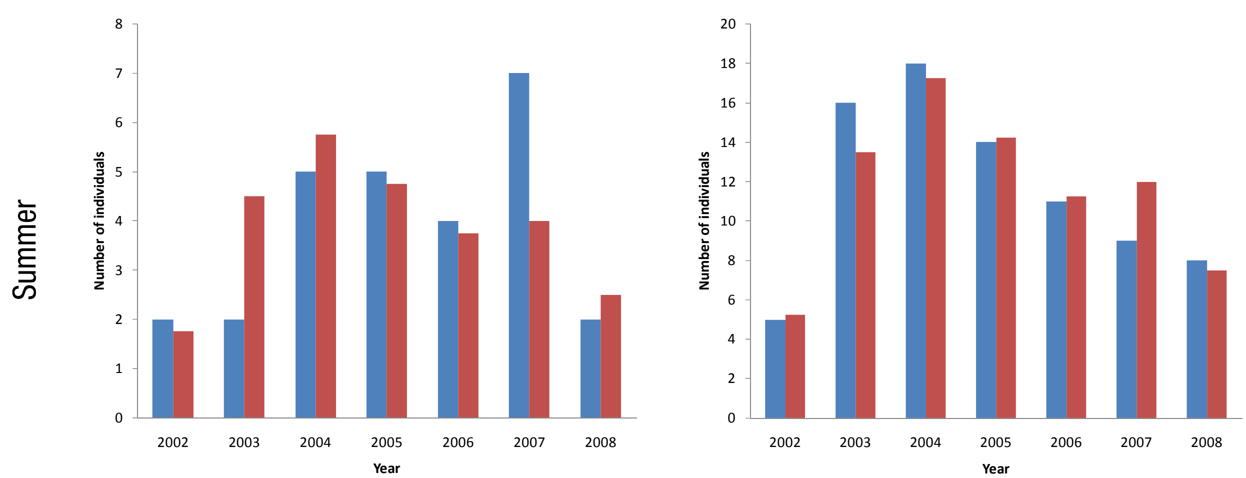


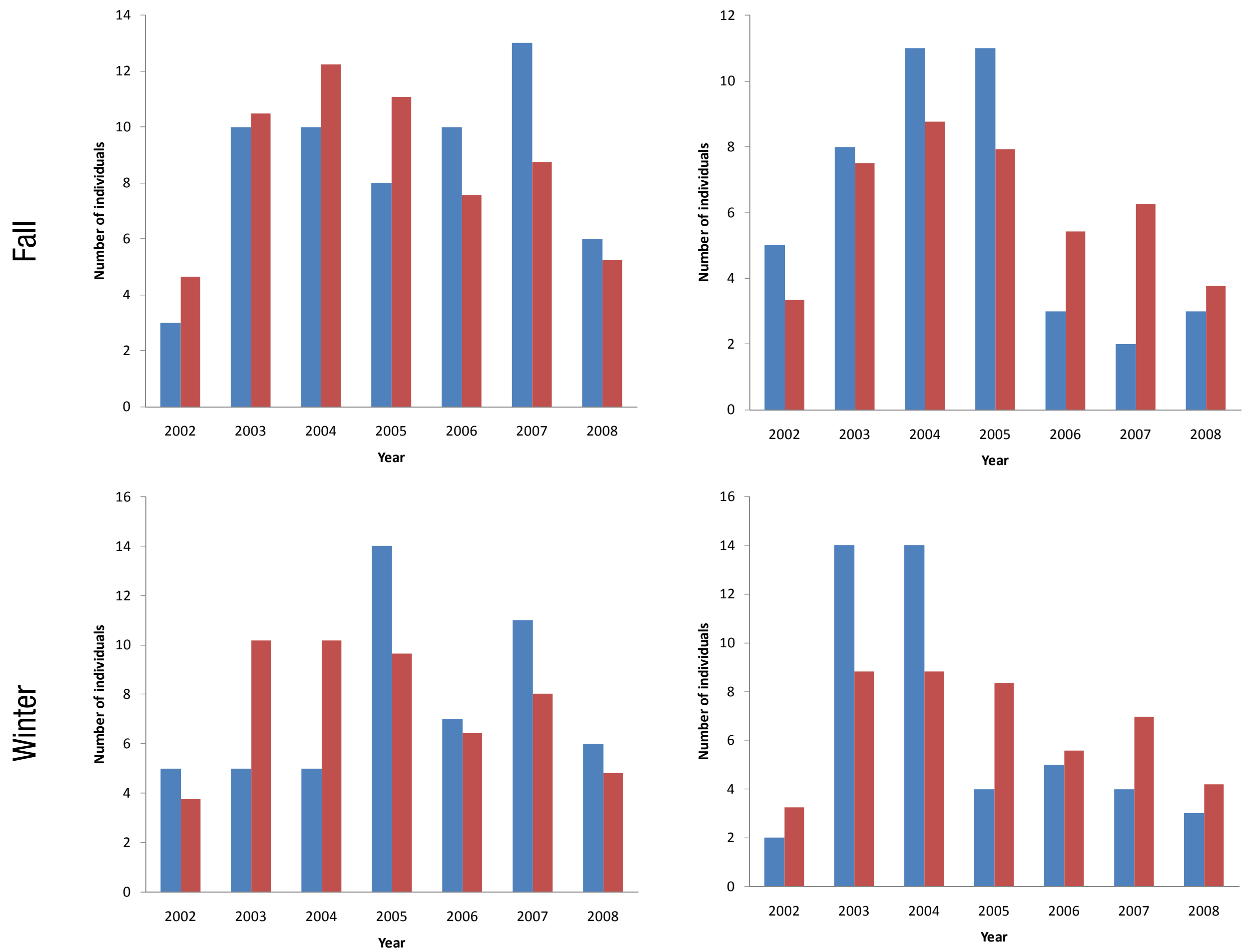


(a) Few (b) Lots

Figure C16. The observed (*blue*) and expected (*red*) number of harvesters rating the number of storms in Aklavik, Northwest Territories, 2002-2008.

6.4 Wind



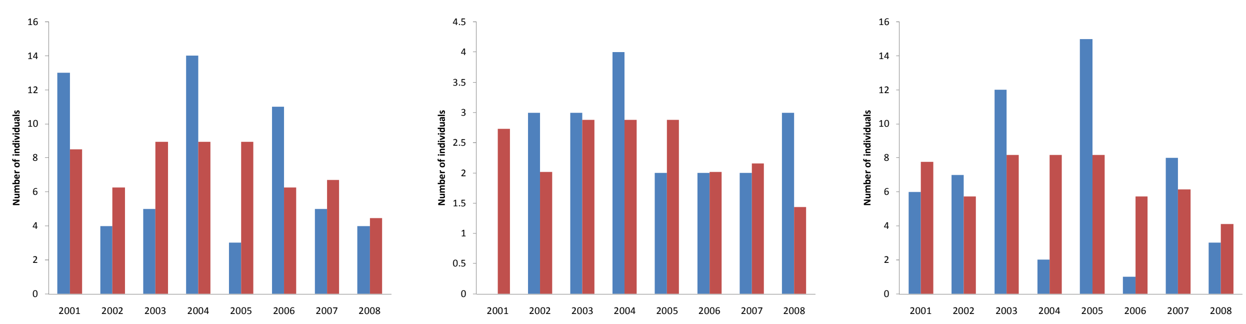


(a) Calm

(b) Windy

Figure C17. The observed (*blue*) and expected (*red*) number of harvesters rating seasonal wind conditions in Aklavik, Northwest Territories, 2002-2008.

6.5 Overflow



(a) Few

(b) Average

(c) Lots

Figure C18. The observed (*blue*) and expected (*red*) number of harvesters rating the amount of overflow in Aklavik, Northwest Territories, 2001-2008.

6.6 Timing of freeze-up

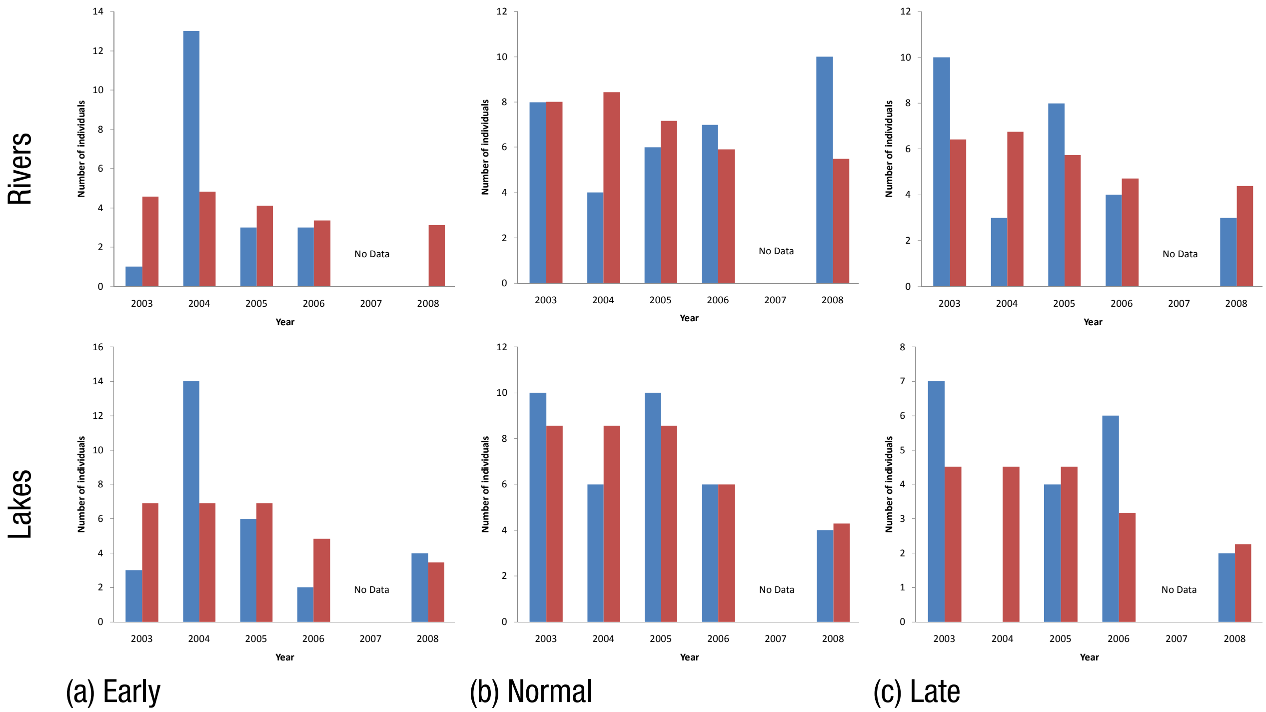
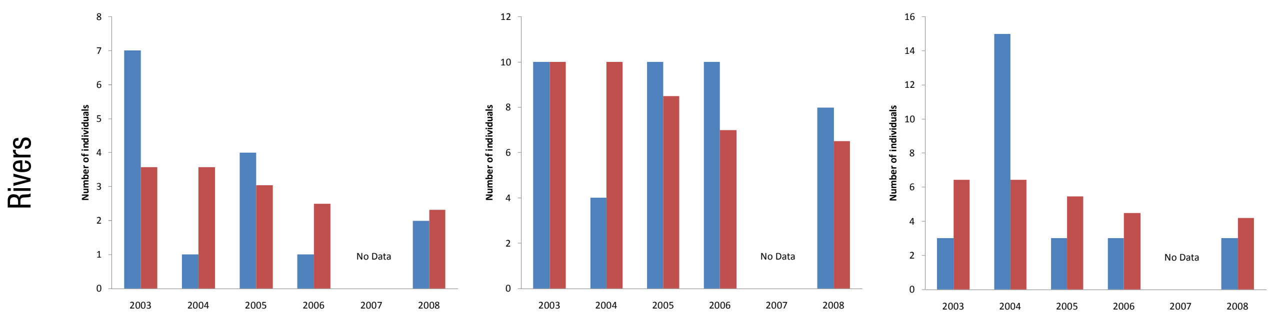
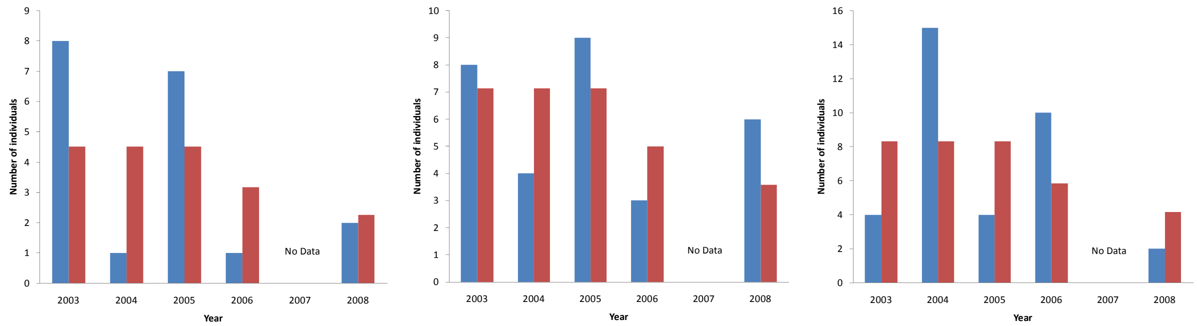


Figure C19. The observed (*blue*) and expected (*red*) number of harvesters rating the timing of freeze-up in Aklavik, Northwest Territories, 2003-2008. No data were available in 2007.

6.7 Speed of freeze-up



Lakes



(a) Slow (b) Normal (c) Fast

Figure C20. The observed (*blue*) and expected (*red*) number of harvesters rating the speed of freeze-up in Aklavik, Northwest Territories, 2003-2008. No data were available in 2007.