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Red-throated Loon Monitoring in the Southeast Beaufort Sea Region: 2007-2008 Update

D. Lynne Dickson, Jessica Beaubier

Prairie and Northern Region

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D. Lynne Dickson,[1] Jessica Beaubier

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Canadian Wildlife Service
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ABSTRACT

In 1985, the Canadian Wildlife Service initiated a long-term monitoring program using the Red-throated Loon as an indicator of the environmental change that could result from offshore oil and gas development in the Beaufort Sea. Data were collected for five years at five study plots to obtain a predevelopment baseline measure of the abundance and productivity of loons in the region. Renewed interest in offshore hydrocarbon extraction prompted a second set of aerial surveys conducted in 2007 and 2008 at four of the five study plots. The same survey method was used, so that results could be directly compared to the earlier surveys.

There was little change in the number of Red-throated Loon resident pairs between the two survey periods at all four study plots combined (185 ± 19.3 pairs during 1985–1989 compared to 197 ± 36.8 in 2007–2008). However, when each plot was examined separately, the number of resident pairs at the Toker Point plot had increased by 28%. Productivity likewise remained unchanged at three of the four plots, with an increase occurring only at Toker Point. The marked increase at Toker Point was likely a result of depressed productivity during the earlier survey period (1985–1989) caused by disturbance from intensive searches on foot throughout the nesting season. The more recent measure of productivity at Toker Point (0.9 ± 0.2 chicks per resident pair in 2007–2008) is therefore more representative of the natural undisturbed state.

For results to be comparable across years, surveys must be timed to correspond with peak incubation period and dates when chicks are 4 to 5 weeks old. To address this problem we developed an equation that predicts timing of nest initiation based on the date when temperatures at Tuktoyaktuk reached 30 thawing degree-days. We recommend the use of this inexpensive non-invasive technique to ensure optimum timing of surveys.

As with most monitoring studies, consistency among observers is key to ensuring that the data are comparable across years. We recommend the following to minimize bias due to observer level of skill.

1) To the extent possible, maintain the same observers.

2) New observers should become familiar with relevant aspects of loon biology such as habitat types used for nesting territories and where the nest tends to be located within the territory.

3) New observers should familiarize themselves with past locations of loon territories at each plot, since Red-throated Loons tend to use the same areas year after year.

4) New observers and pilots should practice on a nearby wetland for 1 to 2 hours prior to starting the first set of surveys.

5) Resurvey part of two of the plots the following day to obtain detection rates for loons, nests and chicks.

Monitoring should be conducted for 3 years every 8 years (i.e. 3 on and 5 off) until development is underway. More frequent monitoring will likely be required during the development phase so that negative impacts can be detected and mitigated in a timely manner.

Assuming the above measures are adopted, we view these surveys as a viable way of detecting changes in loon abundance and productivity, and thus recommend continued use of the Red-throated Loon as an indicator of the environmental change that may occur as regional hydrocarbon reserves are developed.

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INTRODUCTION

It is predicted that offshore hydrocarbon development will occur in the Canadian Beaufort Sea in the near future. While most of the proposed development is offshore (seismic programs, drill rigs), coastal marine and terrestrial areas are likely to be affected by supporting activities (supply ships, air traffic, fuel transfer) and infrastructure (e.g. port development). Although each individual project is subject to an environmental assessment, there is currently little requirement for companies to monitor the ongoing environmental effects of their activities. As such, the cumulative effects from offshore oil and gas might go undetected in the Beaufort Sea area, particularly in the midst of natural ecological variability and ongoing climate change.

The potential ecological effects from offshore development include habitat loss from terrestrial infrastructure, massive or chronic oiling of wildlife from marine contaminant spills, changes to prey communities through marine pollution, increased predation in the vicinity of terrestrial developments, and increased disturbance from shipping/aircraft and terrestrial development activities (National Research Council 2003). Apart from a large oil spill, each of these factors is likely to have a chronic, low-level effect which on its own may not have a large ecological impact. However, individual, chronic and low-grade impacts are most likely additive and possibly synergistic and together can exert significant ecological effects (Ramachandra et al. 2007). It is therefore important to have a reliable way of detecting cumulative effects of industrial activity in the Beaufort Sea ecosystem.

An appropriate monitoring program requires pre-development baseline data against which post-development monitoring results can be compared, and that allow subtle and cumulative effects to be detected (IUCN 1993). It is also important that pre-development data capture the extent of natural fluctuations so that they are not confused with the effects of development (IUCN 1993). To that effect, Environment Canada's Canadian Wildlife Service initiated a monitoring program in the 1980s that used the Red-throated Loon (*Gavia stellata*) as an indicator of cumulative effects from offshore hydrocarbon development in the Canadian Beaufort Sea region (Dickson 1987, 1989, 1991, 1992).

The Red-throated Loon was selected as an indicator species because of its vulnerability to the effects of offshore hydrocarbon production, its ubiquitous distribution throughout the Beaufort Sea region (Hines et al. 2004), and its conspicuous nature, even when nesting (Dickson 1992, 1994). The sensitivity of Red-throated Loons to development should allow the identification of industry-associated impacts (Dickson 1991) and help in determining appropriate forms of mitigation. It should also allow for the detection of subtle and cumulative effects that could not be identified through the more classic approach of monitoring single abiotic factors like sediment contamination (Dickson 1992).

The initial portion of this study was conducted over a five-year period in the late 1980s and involved a thorough evaluation of the suitability of the Red-throated Loon as an environmental indicator in the Beaufort Sea area (Dickson 1992). During the initial phase, we monitored the natural variation of three primary parameters: abundance of Red-throated Loon pairs, their breeding effort and their breeding success. We also estimated variation in natural factors known to have an effect on the monitored parameters, including prey availability, predator densities and timing of spring thaw (Dickson 1992).

The initial phase produced a reliable benchmark estimate of parameters during the pre-development phase and concluded that the Red-throated Loon would be an effective species for monitoring the effects of offshore hydrocarbon development. However, the project was suspended when oil and gas activity in the Beaufort Sea region declined during the 1990s. Thus the benchmark data it provided now better reflect environmental conditions of the late 1980s than those currently prevailing.

The objective of the second study phase (2007–2008) was to produce an updated baseline estimate of the three core monitoring parameters (abundance of loons, their breeding effort and their breeding success). Because phase two retains the original aerial survey design, it also provides a comparison of Red-throated Loon abundance and productivity between the late 1980s and the present day. The need for an updated baseline is demonstrated by the results of annual monitoring in Alaska, where the Red-throated Loon breeding population declined by 53% between 1977 and 1993 (Groves et al. 1996), followed by a decade of no recovery, then a partial recovery by 2007–2008 (Mallek and Groves 2008). No comparable survey has been conducted in Canada, hence the need for updated baseline data. We had originally planned to collect three years of data, but this was shortened to two years due to staffing problems.

METHODS

We followed the aerial survey methods of Dickson (1992), with the following three exceptions: (1) we surveyed only four of the five original study plots; (2) we developed a way to determine the optimal time to survey based on weather data from Tuktoyaktuk airport; and (3) we navigated survey plots and marked territories in a real-time GIS environment (OziExplorer, Version 3.9.4m, D&L Software, Australia) rather than by using paper maps.

Study Plot Descriptions

The original study identified five survey plots appropriate for monitoring based on their likely exposure to hydrocarbon development activities. In the second phase of the study, one of the sites (Nuvorak Point) had to be eliminated to reduce the cost. See Figure 1 for the location of the four study plots retained during the second stage of the study. Two sites, King Point and Atkinson Point, have been identified by the petroleum industry as suitable for port development (Dome Petroleum Ltd. et al. 1982). Toker Point was selected as a control site for monitoring the effects of port development, as no onshore development has been proposed for the area. The Husky Lakes plot serves as a control for both port development and the effects of marine pollution, as there are no plans for oil and gas development in the area and its inland position makes it less exposed to ship traffic and effects from marine spills.

Toker Point

Most of the wetland areas at Toker Point consist of a complex of lakes, ponds and patterned ground surrounding a pingo. Around the perimeter of many ponds there is a band of shallow water with sedges, which increases the amount of search effort required to locate nests. The polygon habitat must be well searched too, as loons will sometimes nest on the larger low-centred polygons. During the 1985–1989 survey period, Toker Point plot had the highest density of loons, at 1.8 pairs per km^2 (Dickson 1993).

Atkinson Point

Atkinson Point is similar in relief to Toker Point, but has a higher proportion of polygon habitat. It also contains a landing strip and an old industrial area (a Distance Early Warning (DEW) Line site) that was reclaimed in 2008. There are some large bays on the east side of the plot that open directly onto the ocean and, although loons can be seen on them, they are not appropriate nesting habitat due to tidal fluctuations. The areas with polygons, including the patch north of the airstrip, should be flown in straight parallel lines in order to ensure that they are adequately covered.

King Point

The King Point plot is located on the Yukon North Slope and borders the Beaufort Sea. The plot is at a higher elevation (~20 m) than the other plots (0–5 m) and has a much lower density of small ponds and lakes. The topography of the plot is mostly low-rolling tundra interspersed with water bodies. A number of shallow wetlands also occur in the plot and are at times used for nesting by Red-throated Loons. The water bodies themselves are mostly bordered by low banks covered in low-lying vegetation (cloudberry, mountain aven), although the shallow wetlands, and some ponds, have longer sedge vegetation. Most lakes and ponds are well contained. At King Point, Red-throated Loons occasionally nest in enlarged ditches in high-centred polygon habitat.

Husky Lakes

The Husky Lakes plot borders Husky Lakes rather than the Beaufort Sea. It contains several large sedge wetland complexes with multiple ponds interspersed by higher relief rolling hills. The long sedges in the wetlands, especially the complex in the southwestern part of the plot, make it more difficult than usual to locate nests and chicks, so that more passes around the ponds are required than in the other plots. The water bodies tend to be less well-defined than in other plots and there are several areas where the grasses between ponds are waterlogged, so that chicks can feasibly access a much more widespread area. This again requires more search time than well-contained ponds.

The upper east corner contains a large lake with scattered islands and shallow areas. Although Red-throated Loons do not typically nest on large lakes at this latitude (Dickson 1994), they have been observed nesting there most years.

Survey Methods

Each plot was surveyed three times each year by two observers in a Bell 206B Jet Ranger helicopter on floats: twice during nesting to obtain information on abundance of loon pairs and nesting effort, and once when chicks were close to fledging to get an estimate of productivity. Surveys were not conducted during rainy or windy (> 30 km/hr) weather.

Nesting Surveys

The nesting surveys were conducted approximately 10 days apart in order to accommodate the 2–4 week range in timing of nest initiation (Dickson 1993). During nesting surveys, every wetland in each plot was searched to obtain a total count of loon territories (2007–2008) and nests (2007 only). To locate loons on territory, including incubating birds, we flew at approximately 25–30 m above ground, at a speed ranging 50-100 km/hr depending on habitat complexity. To avoid missing birds due to glare on water, we positioned the helicopter so that the sun was behind us when viewing potential Red-throated Loon nesting habitat. If a loon was observed in plausible breeding habitat (as established by Dickson 1994), we marked the location as a loon territory and recorded the number of adult loons present. We georeferenced each loon territory by centreing the helicopter over the pond then marking the territory with a waypoint using OziExplorer. We used high-resolution digitized orthophotos for Toker Point, Husky Lakes and Atkinson Point, and a georeferenced satellite image of King Point as base maps.

Once a territory was recorded, we hovered beside the pond at approximately 30 m above ground and did a visual scan of the pond edge and islands to determine if a nest was present (see Dickson (1994) for description of nest characteristics). If we did not see a nest during the visual scan (approximately 1–2 minutes of looking), we dropped down to approximately 8 m altitude and circled the pond edge by skimming around it sideways very slowly (~10 km/hr). We circled each pond 1 to 4 times depending on the complexity of the pond edge vegetation. We initially focused our search on islands and wet areas within 5 m of open water in the pond; if no nest was found we included any continuous water-logged areas within 10 m of the open water. To facilitate detection of the nests, the surveys were conducted during the mid-day period when the sun was most directly overhead. Earlier or later in the day the tall sedges cast a shadow over the typically dark brown nesting platform, making it more difficult to detect. We documented nest presence/absence and the number of eggs at each territory. If a loon remained on a nest, we assumed it was incubating eggs.

During 2008, we did not conduct nest searches due to the Inuvik Hunters and Trappers Committee's concerns over disturbance. Instead, we did a single binocular scan of the pond edge while hovering beside the pond at approximately 30 m. We were unsuccessful at finding many of the nests using this technique, so eliminated nesting status from the 2008 data analysis.

We repeated the same survey approach approximately 10 days later at each plot, with the exception of the King Point plot, where we were unable to do the first survey in 2007 due to inclement weather. Flight dates are presented in Table 1.

Productivity Survey

The third survey, to determine productivity, was flown 4–5 weeks after the median date of hatch (see *Survey Timing*). We resurveyed all water bodies appropriate for Red-throated Loon nesting at approximately 50 km/hr and 30–35 m above ground. Most chicks were on the water body surface and easily detectable with or without an adult loon. At territories where a nest had been confirmed but no chicks observed, we did a more thorough search by passing over the pond slowly and at a low level (8 m). If no chick appeared, we then hovered at 90 m above the pond for about a minute to see if any young loons surfaced from underwater.

Loon territories were classified as either occupied or active (as per Dickson 1992). An occupied territory was one where a loon (or pair) was observed at least once in suitable nesting habitat and it was unlikely part of another loon territory. Active territories were those at which we observed evidence of nesting (eggs, fresh egg remains, live or dead chick). A resident pair was a pair of loons that occupied a territory. Even if we only ever saw a single loon in a territory we assumed it represented a pair. If we observed evidence of nesting in the loon territory, the occupants were referred to as a nesting pair. A successful pair was one with young near fledging.

Survey Timing

Based on Dickson's (1991) observation that nest initiation was closely correlated to when loon nesting ponds became ice-free, we developed a formula to determine the optimum time to survey for chicks using weather data from Tuktoyaktuk Airport (Environment Canada http://climate.weatheroffice.ec.gc.ca/climateData/canada_e.html). Specifically, we used the date that 30 thawing degree-days were reached as an indicator of the timing of spring thaw. Thawing degree-days start to occur in spring when the average daily temperature exceeds 0°C (i.e. average of hourly temperatures taken over a 24-hour period). Thirty thawing degree-days are reached when the sum of all average daily temperatures over 0°C exceeds 30. We regressed the natural log (ln) of the median nest initiation date against the date when 30 thawing degree-days had been reached at the Tuktoyaktuk airport, using data from 1985 to 1989 collected and compiled in Dickson (1991), and supplemented with data from 2008. Dickson (1991) estimated the median nest initiation date by observing either nest initiation or hatch date at 22–46 loon nests each year from 1985 to 1989 at the Toker Point plot. The median nest initiation estimate for 2008 was based on back-dating from egg ages estimated by flotation (see Fig. 6 in Dickson 1989). We added an average incubation period of 26 days (Dickson 1993) to the median nest initiation date to obtain a median hatch date. For the regression, dates were converted into sequential numbers (May 31st = 1, June 1st = 2, etc.). All assumptions of linear, least squares regression were met once the dependant variable was ln transformed.

Statistical Analyses

Differences in loon abundance and productivity between the two study periods at each study plot were calculated using *t*-tests. Number of resident pairs and number of chicks near fledging were ln-transformed prior to analysis to meet assumptions of normality. We first tested for homogeneity of variance between groups using a cut-off value of $p = 0.20$ to identify samples with unequal variances due to small sample sizes. Samples with unequal variances were then compared using Welch's *t*-tests (Welch 1947). We report results as mean ± standard deviation (SD).

RESULTS

Loon Abundance and Productivity

Number of Resident Pairs

Overall there was little change in the number of resident pairs of Red-throated Loons in all four plots combined from the 1985–1989 to the 2007–2008 survey period (185 ± 19.3 pairs during 1985–1989 compared to 197 ± 36.8 in 2007–2008 survey period; see Appendix A). However, examining plots separately, there was a significant increase in number of pairs at Toker Point between the two time periods (two-sample t-test: $t = -3.873$, df = 5, $p = 0.01$), but no change at the other plots (Table 2; Fig. 2).

From 2007 to 2008, the number of resident pairs observed increased at every plot (two-sample *t*-test [2007 vs. 2008 – plots pooled within each year]: $t = -2.636$, df = 6, $p = 0.04$). The number of resident pairs increased by 17 to 28% at three of the plots, and by 67% at Husky Lakes (Appendix A).

Nesting Success

At Toker Point, the percentage of resident pairs that were successful at rearing at least one chick to near fledging increased substantially from the earlier years (two-sample t-test: t = -2.665, df = 5, p = 0.04). By contrast, there was no change in percent success of resident pairs at the three other study plots (Table 3; Fig. 3; Appendix A).

At Atkinson Point in 2007, only 15% of the resident pairs were successful, which was low compared to all other years at that study plot (Appendix A). King Point success was also low in 2007, but unlike Atkinson Point, recovered to an all-time high in 2008.

Number of Chicks Fledging

The number of chicks near fledging, as well as the number of young fledged per resident pair, increased markedly at Toker Point (two-sample t-test: t = -3.052, df = 5, p = 0.03 and t = -3.788, df = 5, p = 0.01 respectively), but remained unchanged at the other three plots (Table 4 and 5, Figs. 4 and 5). The large increase in number of chicks near fledging at Husky Lakes from 2007 to 2008 coincided with the substantial increase in number of resident pairs, so that young fledged per resident pair remained unchanged between years (Appendix A).

Brood Size Near Fledging

At all plots combined, there was a greater tendency for both chicks in a brood to survive to near fledging in recent years than during the earlier survey period (one-way ANOVA: F = 8.05; df = 1.23; p = 0.009). When plots were examined separately, this was the case only at Toker Point (Welch two-sample t-test: t = -2.855, df = 4.30, p = 0.04) (Table 6, Fig. 6).

Survey Timing

In 2008, the median hatch date was July 14 (range July 4–26) based on aging the eggs at nine nests at three of the four study plots (Table 7). Thus the optimum time to survey (when chicks were 4–5 weeks old) that year was from August 11 to 18.

Based on six years of data (1985–1989 and 2008), the date on which 30 thawing degree-days was reached at the Tuktoyaktuk Airport predicted Red-throated Loon nest initiation date ($F_{1,4}$ = 33.35, p = 0.005, R^2 = 0.89, Equation 1, Fig. 7, Table 8). The relationship between the date at

30 thawing degree-days and the median nest initiation date is provided by the following regression equation:

Equation (1) ln(median nest initiation date) = 0.025*(date at 30 thawing degree-days) + 2.993

Based on this relationship, we estimated the median nest initiation date for nests during 2007 as follows:

Median nest initiation date = $\exp^{(0.025*[\text{Date} >30 \text{ thawing degree days}] + 2.993)}$

In 2007 that date on which 30 thawing degree-days was reached was June 3; therefore, the median date of nest initiation was June 22, the median hatch date was July 18, and the optimum time for surveying chicks was from August 15 to 22 (Table 9).

Overall, the median nest initiation during 2007 was close to that observed from 1985 to 1989 (Table 9), whereas in 2008 it was earlier than had been observed in the 1980s.

The estimated age of chicks at the time of all surveys ranged from 3.9 to 5.4 weeks (Table 9).

Loon Response to Helicopter

Red-throated Loons typically remained on their nests while the helicopter was nearby, even at low altitudes. Most incubating loons only left their nests when the helicopter was within about 5 m, while some did not leave the nest at all. In such cases, we left the loons on the nest and did not record the number of eggs.

When the helicopter was 30 m above ground, most loons remained on the water or on their nests and responded with territorial displays. A small number of loons responded by diving, while even fewer flew from the territory.

The reactions of the loons increased with the amount of time the helicopter was at the site, and when the helicopter descended to search for nests. When the helicopter was at low altitude (~8 m), loons on the pond surface dove repeatedly and were more likely to fly away from the territory than when we were at higher altitudes. In shallow ponds loons repeatedly dove and quickly resurfaced, while in larger ponds loons remained underwater for prolonged periods of time.

DISCUSSION

Abundance of Resident Pairs

Although there was little change in the number of loons in all four study plots combined between the two survey periods (1985–1989 and 2007–2008), the number of resident pairs did increase at Toker Point. Given that it is also the plot with the highest density of loons (Dickson 1993), it appears that Toker Point is a core breeding area for Red-throated Loons in the southeast Beaufort Sea. The importance of the Toker Point area to nesting Red-throated Loons should be taken into consideration during the planning phase of offshore petroleum development.

As a piscivorous species, the Red-throated Loon is relatively vulnerable to environmental contaminants, which may influence survival, reproductive success and, ultimately, their abundance. A small sample of eggs and adult livers collected in 1986 and 1987 were analyzed for organochlorine residues by the National Wildlife Research Centre (NWRC) in Ottawa. Levels of all substances were low, indicating very little contamination at that time (Dickson 1991). However, a recent investigation concluded that Red-throated Loons breeding along the Beaufort Sea coast in Alaska may be at risk due to high levels of exposure to organochlorine contaminants on their wintering area in southeast Asia (Schmutz et al. 2009). It is unknown where loons that nest in the Canadian Beaufort Sea region spend the winter, but given the proximity of the two breeding areas, they are likely affiliated with the Alaskan Beaufort Sea population and thus also winter in southeast Asia. If productivity drops in our study area in the future, samples should be collected and levels of contaminants retested. While adults and eggs reflect contaminant levels on the wintering area and migration route, the young-of-the-year reflect levels in the Beaufort Sea region. Note that the following specimens were collected from 1986 to 1989 and stored in the tissue bank at the NWRC to serve as a baseline for environmental contaminants: 10 eggs, 9 adults, 11 young-of-the-year and 52 fish.

Number of resident pairs observed increased at all plots from 2007 to 2008. A similar increase occurred during the first three years of the earlier set of surveys. Given that this trend was consistent across plots and the two survey periods, it may have been partly due to an increase in level of skill of observers as they gained experience doing the surveys. Another possible reason for the marked increase in the number of loons was increased recruitment. Breeding success varies considerably across years, which could in turn affect recruitment. For example, during the five-year study period from 1985 to 1989, the number of young near fledging in the study area varied from 64 to 141 loons (Dickson 1991). Loons are long-lived (Barr et al. 2000) and tend to return to the same territories each year (Furness 1983; Okill 1992), so the difference was unlikely due to loons shifting territories in response to variable local breeding conditions. Another factor that could have affected the count of resident pairs was survey conditions. However, we minimized this effect by not surveying during rain or high winds.

At King Point in 2007, only one survey was conducted during the incubation period. The lower search effort likely resulted in an underestimate of number of resident pairs, and an even more pronounced underestimate of the number of nesting pairs, which is based on nests found. Nest initiation occurs over a 2–4-week period, which is why two surveys are preferential to just a single survey for nesting pairs (Dickson 1993).

Productivity

The marked difference in productivity between the two time periods (1985–1989 and 2007–2008) that was observed only at the Toker Point plot was likely a result of human disturbance. The loons breeding at Toker Point were subjected to intense ground-based research activities during the 1980s, and were disturbed by researchers on foot every few days throughout the nesting season (Dickson 1991, 1992). The loons usually reacted to an observer on foot by getting off the nest and not returning until the observer was out of sight (Dickson 1992). Given that most of the vegetation at Toker Point was less than half a metre high, an observer often remained within view of a loon even at a distance of several kilometers. Thus, loons remained off their nests for extended periods of time, leaving their eggs vulnerable to predation, overheating and chilling. Additional losses due to disturbance likely occurred in the first few days following hatch when loon chicks are unable to dive to escape avian predators such as the Glaucous Gull (Dickson 1993; Barr et al. 2000). The high level of disturbance due to researchers on foot occurred only at Toker Point, which also had the lowest nesting success throughout the 1980s, despite having some of the highest densities of nesting loons (Dickson 1993). The absence of researchers on the ground during the recent surveys is likely the main reason why we observed higher rates of reproductive output at Toker Point during 2007–2008. The more recent measurements of productivity at Toker Point are likely more representative of natural variation.

Similarly, the year with the lowest productivity at Atkinson Point coincided with elevated human activity. During 2006–2007, there was a high level of human activity, including a long-term camp, in the northern section of the Atkinson Point plot throughout the breeding season. The activity involved remediation of contaminated soil. Red-throated Loon pairs with nesting territories in the vicinity of the airstrip and camp failed to produce any young near fledging that year. While the camp activity was concentrated in the top quarter section of the plot, it is possible that its effects were more widespread. People working at Atkinson Point reported seeing at least one fox family in the vicinity of the camp, which—combined with disturbance from human activity—could increase the local rate of nest predation. Although there is insufficient evidence to discern the respective roles of human disturbance, natural predation and human-induced predation, our results suggest that further investigation into the localized effects of industrial activity on Red-throated Loons is warranted.

Interestingly, although human presence on the ground had a marked effect on productivity, it did not seem to affect number of resident pairs returning the following year. However, prolonged reduced productivity would eventually affect the number of resident pairs as old loons died and were not replaced by new recruits.

Survey Timing

For results to be comparable across years, timing of surveys must be correct. This is especially critical for the single survey for chicks, where the opportunity to get an accurate count of chicks that are likely to survive until fledging is brief. If the survey is too early, some of the chicks will be < 3 weeks old, hence less likely to survive until fledging (Dickson 1993). If the survey is too late, some of the chicks will have already fledged and left the nesting territory (departure occurs at 6–7 weeks (Dickson 1993)). Timing is further constrained because nest initiation occurs over a 2–4-week period (Dickson 1993). Thus, the optimum survey time is when the majority of chicks are 4–5 weeks old. During this study, there was a 15-day spread in the date when chicks reached 4 weeks of age (ranged from August 11 to 26). Due to this variation, it is essential to determine the timing of nest initiation each year and set survey dates accordingly. This could be done by aging eggs, but a less invasive technique would be to use our formula that predicts median nest initiation date based on temperatures at Tuktoyaktuk.

The correlation that we observed between spring temperatures above freezing and date of nest initiation suggests that timing of nest initiation is directly influenced by timing of thaw of ponds used as nesting territories (Dickson 1991). This is supported by Dickson's (1993) observation that loons arrived on their nesting ponds within a day of their ponds becoming ice-free.

Ensuring Data Are Comparable Across Years

An inherent problem with long-term monitoring is that it is generally not possible to keep the same observers. Every time there are new observers for the surveys, there will be a period of learning how to effectively collect the data. The new observer must develop a search image for both loons and nests, as well as become familiar with habitat types used by loons as nesting territories. Furthermore, the observer must become familiar with the technique and level of effort required to find all of the loons within a plot. To avoid bias due to observer inexperience, we recommend the following.

1) New observers should practice the survey technique in several wetlands outside the study plots before starting. This could be done in the area east of the Toker Point plot where loon densities are high and the fuel cache at Tuktoyaktuk is nearby. This would give the observer an opportunity to develop the search images needed to spot the loons, nests and chicks as well as work out the technique with the helicopter pilot. For example, in order to approach a wetland at a reduced speed, the pilot will find it easiest if he or she is flying into the wind. Another important consideration is the sun's glare, which makes it more difficult to see the loons. Areas where there could potentially be loons should be searched with the sun behind at least one of the observers. Furthermore, the pilot should try to avoid disturbing adjacent wetlands while surveying, since often the easiest way to detect a nest is to see the loon either incubating or getting off the nest.

2) Even once the technique has been mastered, there may still be differences between observers in their ability to detect loons and nests. To ensure that data collected by different observers are comparable across years, a portion of the study area should be resurveyed to obtain a minimum detection rate. Because observers on the ground have such a profound effect on loon productivity (Dickson 1992), we do not recommend that these surveys be done on foot. Instead, we recommend that a portion of two of the study plots be resurveyed the following day (e.g. Day 1, an hour of practice east of Toker Point, then survey Toker Point plot; Day 2, survey Husky Lakes, then resurvey part of Toker Point; Day 3, survey Atkinson Point then resurvey part of Husky Lakes). This would likely only be necessary during the observer's first year of surveys. Another

advantage of resurveying an area the next day is that the new observers will soon learn whether the intensity of their search effort is appropriate to locate all loons.

3) New observers should become familiar with certain aspects of loon biology before attempting the survey.

a) Characteristics of water bodies used as breeding territories

Red-throated Loons in the southeast Beaufort Sea typically nest on small ponds < 0.1 ha in size (Dickson 1994). However, a few loons nest in atypical habitat, which must also be checked. These include the following:

– enlarged ditches among high-centred polygons;
– atypically deep centres of a low-centred polygons;
– large shallow lakes up to 20 ha in size (loon territory is usually partially separated from the rest of lake by islands or a point of land);
– ponds on small islands in a large, deep lake
– brackish ponds susceptible to flooding due to storm tides, but not affected by normal tides

See Dickson (1994) for a more thorough description of nesting habitat used by the Red-throated Loon in the Beaufort Sea region.

b) Location of nest

The majority of nests occur along the shore in wet sedge habitat within 5 m of open water, although they have been located as far back as 15 m. Nests also occur on islands, and occasionally on dry shore. See Dickson (1994) for a more complete description of where to look for the nests.

c) Nesting territories that consist of more than one pond

It is generally not difficult to ascertain whether a loon seen on a pond for the first time during the second survey represents another resident pair or is likely from a territory identified in the previous survey. In most cases, the pond is far enough away from other occupied water bodies to conclude that it is a separate territory. However, in areas where both pond and loon densities are high, it is sometimes not clear, and therefore adds a degree of subjectivity to the study. Observers must keep in mind that loons often do include more than one pond in their nesting territory, especially at Toker Point. If a loon is observed on a pond right next to where there was a loon on the previous survey, check for an active nest on both ponds. Check also to see if the two ponds are connected by a channel or if there is an obvious reason why the loon might have moved to the new pond (e.g. first pond has dried up). As you are searching for a nest, does the loon move to the nearby pond identified as a territory in the first survey? This would be an indication that it is all one territory.

d) Replacement clutches

Loons will often re-lay if the first clutch is lost to predators (Barr et al. 2000). At the Toker Point plot during the 1985–1989 study period, 29% of the loons that lost their first clutch laid a second clutch (Dickson 1993). The second clutch was laid on average 11 days later and often on a different nest platform within the nesting territory. This can potentially lead to confusion if there is more than one pond in a pair's territory and they lay their second clutch on a platform in the second pond.

e) Chicks occasionally move from the natal pond to an adjacent water body

In some cases, the ponds are linked by a small opening, hence easy to recognize as part of the same nesting territory. However, sometimes the chicks will actually move across the land to a larger or deeper water body (Dickson 1992; Eberl 1993). If the natal pond has become dry or ice-covered, check for chicks in adjacent water bodies.

4) Given that loons tend to use the same territories each year (Furness 1983; Dickson 1993; Eberl and Picman 1993), new observers should become familiar with where loons nested in previous years and make sure each of those locations is included in the search for resident pairs. Refer to Appendix B for locations of loons in 2008, and Fig. 12 in Dickson (1991) for locations used at Toker Point from 1985 to 1989.

5) Study coordinators should try and maintain the same observers for the monitoring study in order to minimize observer bias. This could be done by assigning the surveys to permanent staff as part of their ongoing program rather than hiring temporary help in years when the surveys are to be done. Observers should never be used for *less* than one full season.

Is Locating the Nest Critical to the Monitoring Study?

Not all loons on territories attempt to nest each year. For example, at the Toker Point study plot during the 1985–1989 survey period, an average of 20% of the pairs did not nest each year (range 13–37%) (Dickson 1991). The advantage of searching each territory for a nest with eggs is that it confirms that the pair is nesting. We then have an indication of what proportion of the resident pairs attempted to nest and ultimately how successful the nesting pairs were at rearing at least one chick to near fledging. Knowing what proportion of the birds nested helps sort out whether a year when few chicks were produced was a result of fewer birds attempting to nest (as in 1986 when spring thaw was delayed) or due to high rates of egg or chick loss. The presence of a nest with eggs also confirms that the loon is on its territory and not just visiting a pond temporarily. Furthermore, knowing where the nests are helps focus the search effort for chicks. Each of the ponds that had a nesting loon earlier in the season should be double-checked for chicks, as described in the Methods section.

There are a number of disadvantages to searching for nests. The level of disturbance to wildlife in the wetland increases. If a nest is not detected right away from 25–30 m above the pond, the helicopter drops to about 8 m and slowly moves around the edge of the pond. Although the duration is brief (< 5 min.), it is noisy. Strictly from the point of view of cost, nest searching can take a fair amount of time, particularly over wetlands with tall sedges that tend to shadow the nest and make it difficult to find (4 minutes of nest searching at 10 territories equates to a total of 40 minutes of helicopter charter time). Nest searches thus add to the cost of the helicopter charter. Although locating the nests provides a count of the number of pairs that are nesting, it is at best a minimum count. Ground truthing during the earlier phase of the study showed that only 90% of the nests are detected (Dickson 1987). Even if all of the active nests were detected, it would still represent a minimum number of nesting pairs, since eggs at some nests would have been depredated prior to the survey. While Red-throated Loon adults and chicks on the water are generally conspicuous, their nests are less so. Thus, the detection rate for nests will likely be more variable depending on observer experience.

In 2008, we removed the low-level nest searches due to Inuvik Hunters and Trappers Committee concerns over the potential for bird and mammal disturbance. Although we still obtained information on the number of resident pairs and productivity, we sacrificed collecting information on the number of nesting pairs. In hindsight, we should have done the low-level nests searches. Disturbance by the helicopter was short-lived and the loss of data from cancelling the nest searches made it more difficult to interpret the survey results. The most common response by loons to the helicopter was territorial displays—similar to what would be elicited by an aerial predator. Most loons remained on their nests, or swam in display behaviour across the pond. In these instances, the stress associated with the helicopter was likely limited, and it is very unlikely that nests were abandoned or that adults suffered anything more than a short-lived fight or flight response. Our conclusion is further supported by the fact that in spite of helicopter use during the five-year set of surveys, the loons tended to return to the same sites each year.

In conclusion, if the funding is available, we recommend that searches for nests continue, since it does add to our understanding of what factors might be behind a change in productivity, as well as help define territories and focus the survey for chicks. However, every effort should be made to try and locate the nest from 30 m above and to limit low-level passes. If a low level pass is necessary, search islands and shoreline first, then wet sedge areas within 10 m of the edge of the open water, keeping in mind that most nests are within 5 m of open water. If no nest is located, but you suspect this is due to habitat type (e.g. a wide expanse of wet sedge habitat surrounds the pond, or sedges are very tall, or lighting is poor), note this in the data file and double-check for chicks during the third survey just as you would a pond where there was a nest. Nests found on the first survey do not need to be relocated on the second survey. However, if on the second survey there is any question as to whether loons in the area are within the same territory or a different one, it would be worth searching the first pond to see if there is still an active nest. Also when presenting the results, note that the breeding pair count is a minimum. Given that the number of eggs is not critical to this monitoring survey, if a loon on a nest is reluctant to leave, assume it is incubating eggs and move on.

Other Recommendations

Timing of Surveys

Correct timing of surveys is important to obtain comparable data across years. The first two surveys should be conducted during the period of peak nesting, while the third should be done when the chicks are 4–5 weeks old (Dickson 1991). Given the correlation between the date that temperatures at Tuktoyaktuk reach 30 thawing degree-days and the date of median nest initiation, we recommend that the weather data for Tuktoyaktuk be used each year to calculate the optimum time to conduct the surveys, especially the survey for chicks. The alternative would be to age eggs at 10+ nests, but this would be a more expensive and more invasive option.

Frequency of Surveys

The monitoring survey should be repeated on a regular basis, even if offshore oil and gas development is delayed, to ensure that we have a current baseline of loon abundance and productivity for the region. We recommend three years of surveys every eight years (i.e. three on and five off) until development is underway, then more frequently if need be after that. A minimum of three consecutive years of surveys is recommended because if one year has extreme conditions (e.g. 1986), doing three years will help sort out which is the unusual year.

Time of Day to Survey

Surveys should be conducted during mid day when the sun is most directly overhead. This will facilitate finding nests by minimizing shadows created by tall sedges. Avoid surveying more than four to five hours (not including ferry time), as fatigue will affect the detection rate.

Applicability of Plot Locations

The sites in this study were selected based on historical projections of likely exposure to industrial activity. While these sites still hold relevance for acting as control sites and will provide a general index of Red-throated Loon abundance and productivity, their function as indicators of industrial effects depends in part on development occurring at those sites (King Point and Atkinson Point). New sites may have to be added to this project as plans for offshore oil and gas development become more explicit. However, old plots should be retained if possible in order to provide baseline data on abundance and productivity.

SUMMARY AND CONCLUSIONS

As was determined during the first phase of the monitoring program, the Red-throated Loon is an effective indicator of environmental change in the Beaufort Sea region (Dickson 1992). The loon is vulnerable to the types of environmental change that could occur as a result of offshore oil and gas development, and reliable data on the abundance and productivity can be obtained rapidly by helicopter with little effect on the loons.

Completion of the second set of surveys in 2007–2008 brought to our attention the importance of consistency in the level of skill of the observers doing the counts. Ideally, the same observers should always be used. However, if this is not possible, we recommend that the new observers do the following to help ensure that the data are comparable across years:

– become familiar with relevant information on loon biology (e.g. habitat used for nesting)

– practice the survey technique in several wetlands outside the study plots prior to starting the survey

– resurvey part of the study area to calculate a detection rate

– when searching for nesting pairs, check all sites where there were breeding pairs in the past.

Correct timing of surveys is important to ensure results across years are comparable. Given the correlation between the date that temperatures at Tuktoyaktuk reach 30 thawing-degree days and the date of median nest initiation, we recommend that weather data for Tuktoyaktuk be used each year to calculate the optimum time to conduct the surveys, especially the survey for chicks.

While the study has the potential to cause disturbance to wildlife populations, this disturbance can be minimized by taking care in the vicinity of wildlife (caribou, bears). The low-level nest searches and aerial surveys in general likely have minimal prolonged effects on loons, as they are infrequent and short in duration.

During the pre-development phase, baseline data will have to be updated periodically in order to accommodate change due to factors that are unrelated to offshore hydrocarbon development such as climate change and accumulation of contaminants in the wintering area (Schmutz et al. 2009). We recommend three years of survey followed by five years of no survey, then more frequent surveys once offshore development starts to accelerate.

The study results at Atkinson Point and Toker Point suggest that prolonged human presence in loon nesting areas, whether due to research or industry, may negatively affect local loon productivity. Until this hypothesis can be well tested, we advise that both researchers and industry take a precautionary approach and assume that loon nesting will be adversely affected by prolonged human presence during the breeding season. The impact of a camp would be greatly expanded if people were allowed to explore the tundra for recreational purposes.

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Table 1. Flight dates for Red-throated Loon surveys, 2007–2008

	Survey One		Survey Two		Survey Three	
Plot	2007	2008	2007	2008	2007	2008
Husky Lakes	26 Jun	28 Jun	7 Jul	8 Jul	18 Aug	19 Aug
Atkinson Point	29 Jun	26 Jun	8 Jul	6 Jul	19 Aug	20 Aug
Toker Point	29 Jun	27 Jun	8 Jul	7 Jul	19 Aug	20 Aug
King Point	n/a [a]	25 Jun	9 Jul	9 Jul	20 Aug	18 Aug

[a] Bad weather prevented first survey at King Point.

Table 2. Number of resident pairs of Red-throated Loons observed in four study plots in the Beaufort Sea region in 2007–2008 compared to the 1980s

	Number of resident pairs[a] (occupied territories)								
	1985–1989			2007–2008			Comparison between periods[b]		
Plot	Mean	SD	Range	Mean	SD	Range	t-test	df	*P*
Atkinson	42.8	5.4	35–48	44.5	7.8	39–50	–0.322	5	0.76
Husky	45.5	4.9	35–47	48.0	17	36–60	–0.867	5	0.43
King[c]	55.6	7.8	46–64	46.5	6.4	42–51	1.509	1.96	0.27
Toker	45.8	2.9	43–50	58.5	6.4	54–63	–3.873	5	0.01

[a] Single or pair of loons observed at least once during breeding season in appropriate nesting habitat

[b] ln transformed

[c] Welch two-sample t-test – unequal variances

Table 3. Percentage of resident pairs that were successful at producing at least one chick to near fledging in four study plots in the Beaufort Sea region in 2007–2008 compared to the 1980s

	Percent resident pairs successful								
	1985–1989			2007–2008			Comparison between periods		
Plot	Mean	SD	Range	Mean	SD	Range	t-test	df	*P*
Atkinson	43.7	19.5	23–70	22.7	10.3	15–30	1.392	5	0.22
Husky	41.5	7.2	32–51	42.5	1.2	42–43	–0.181	5	0.86
King	41.5	10.6	30–55	41.5	21.7	26–57	–0.004	5	1.00
Toker	24.8	15.6	8–42	58.9	13.7	49–68	–2.665	5	0.04

Table 4. Number of Red-throated Loon chicks near fledging observed in four study plots in the Beaufort Sea region in 2007–2008 compared to the 1980s

	Number of chicks near fledging								
	1985–1989			2007–2008			Comparison between periods[a]		
Plot	Mean	SD	Range	Mean	SD	Range	t-test	df	*P*
Atkinson	25.6	13.5	14–46	17.0	8.5	11–23	0.869	5	0.42
Husky	20.0	6.0	12–29	27.5	9.2	21–34	–1.226	5	0.27
King[b]	29.6	7.8	21–40	27.5	19.1	14–41	0.332	1.10	0.79
Toker	14.0	8.0	5–24	53.5	7.8	48–59	–3.052	5	0.03

[a] ln transformed

[b] Welch two-sample t-test – unequal variances

Table 5. Number of young fledged per resident pair at four study plots in the Beaufort Sea region in 2007–2008 compared to the 1980s

	1985–1989			2007–2008			Comparison between periods		
Plot	Mean	SD	Range	Mean	SD	Range	t-test	df	*P*
Atkinson	0.59	0.26	0.34–0.98	0.40	0.10	0.28–0.46	1.073	5	0.33
Husky[a]	0.50	0.19	0.32–0.83	0.58	0.00	0.57–0.58	–0.844	4.03	0.45
King	0.54	0.15	0.38–0.69	0.60	0.30	0.33–0.8	–0.165	5	0.88
Toker	0.31	0.17	0.11–0.56	0.90	0.20	1.09–0.76	–3.788	5	0.01

[a] Welch two-sample t-test – unequal variances

Table 6. Brood size near fledging at four study plots in the Beaufort Sea region in 2007–2008 compared to the 1980s

	Young fledged per successful pair								
	1985–1989			2007–2008			Comparison between periods		
Plot	Mean	SD	Range	Mean	SD	Range	t-test	df	*P*
Atkinson	1.36	0.15	1.11–1.52	1.68	0.21	1.53–1.83	–2.140	5	0.09
Husky	1.18	0.23	1.00–1.61	1.35	0.07	1.31–1.40	–0.909	5	0.41
King	1.29	0.05	1.24–1.38	1.34	0.10	1.41–1.27	–0.875	5	0.42
Toker[a]	1.28	0.20	1.05–1.63	1.57	0.03	1.55–1.59	–2.855	4.301	0.04

[a] Welch two-sample t-test – unequal variances

N.B.: A general linear model (ANOVA) indicated an overall significant effect of period ($F = 8.05$; $df = 1,23$; $p = 0.009$). Brood size was generally higher in 2007–2008 than in 1985–1989.

Table 7. Optimum timing of survey for Red-throated Loon chicks near fledging in 2008 based on aging eggs, then estimating hatch and fledge dates

Nest	*Plot*	*Date eggs aged*	*Days to hatch egg 1*	*Days to hatch egg 2*	*Estimated hatch date*	*Earliest fledge date*
1	Atkinson	26 Jun	22–26	n/a	18–22 Jul	30 Aug
2	Atkinson	26 Jun	9	10–13	5–6 Jul	17 Aug
3	Toker	27 Jun	6–8	6–8	3–5 Jul	15 Aug
4	Toker	27 Jun	10–13	14–17	10–11 Jul	22 Aug
5	King	5 Jul	18–21	22–26	26–27 Jul	7 Sept
6	King	5 Jul	8	9	13–14 Jul	25 Aug
7	King	5 Jul	10–13	14–17	18–19 Jul	30 Aug
8	Atkinson	6 Jul	6–8	6–8	12–13 Jul	24 Aug
9	Atkinson	6 Jul	14–17	18–21	23–24 Jul	4 Sept
Estimated median hatch date					14 July	
Optimum dates to survey in 2008					11–18 Aug	

Table 8. Summary statistics for regression for relationship between date reached > 30 thawing degree-days and Red-throated Loon nest initiation date

Effect	Coefficient (SE)	t	$p_{(2\ Tail)}$
Constant	2.993 (0.040)	75.49	< 0.001
Date > 30 thawing degree-days	0.025 (0.003)	5.78	0.005

Table 9. Estimated median age of Red-throated Loon chicks when surveyed at Toker Point plot based on estimated nest initiation date

Date						
Year[a]	Thawing degree-days > 30[a]	Median nest initiation[b]	Hatch (+ 26 days)	4-weeks post-hatch (+28 days)	Survey for chicks	Median age of chicks at survey (weeks)
1985	31 May	20 Jun	16 Jul	13 Aug	10–14 Aug	3.9
1986	18 Jun	3 Jul	29 Jul	26 Aug	25–27 Aug	4.0
1987	9 Jun	24 Jun	20 Jul	17 Aug	18–20 Aug	4.3
1988	4 Jun	19 Jun	15 Jul	12 Aug	17–18 Aug	4.9
1989	31 May	19 Jun	15 Jul	12 Aug	28–29 Aug	6.3
2007	3 Jun	22 Jun	18 Jul	15 Aug	18–20 Aug	5.0
2008	25 May	18 Jun	14 Jul	11 Aug	18–20 Aug	5.1

[a] Based on temperature data for Tuktoyaktuk Airport (Environment Canada).

[b] Except for 2007, based on back-dating of eggs aged by floating. In 2007, based on observed relationship between thawing degree-days at the Tuktoyaktuk Airport and Red-throated Loon date of first egg laying at Toker Point (see *Survey Timing*).

$$\text{Nest initiation date} = \exp^{(0.025*[\text{Date} > 30 \text{ thawing degree days}] + 2.993)}$$

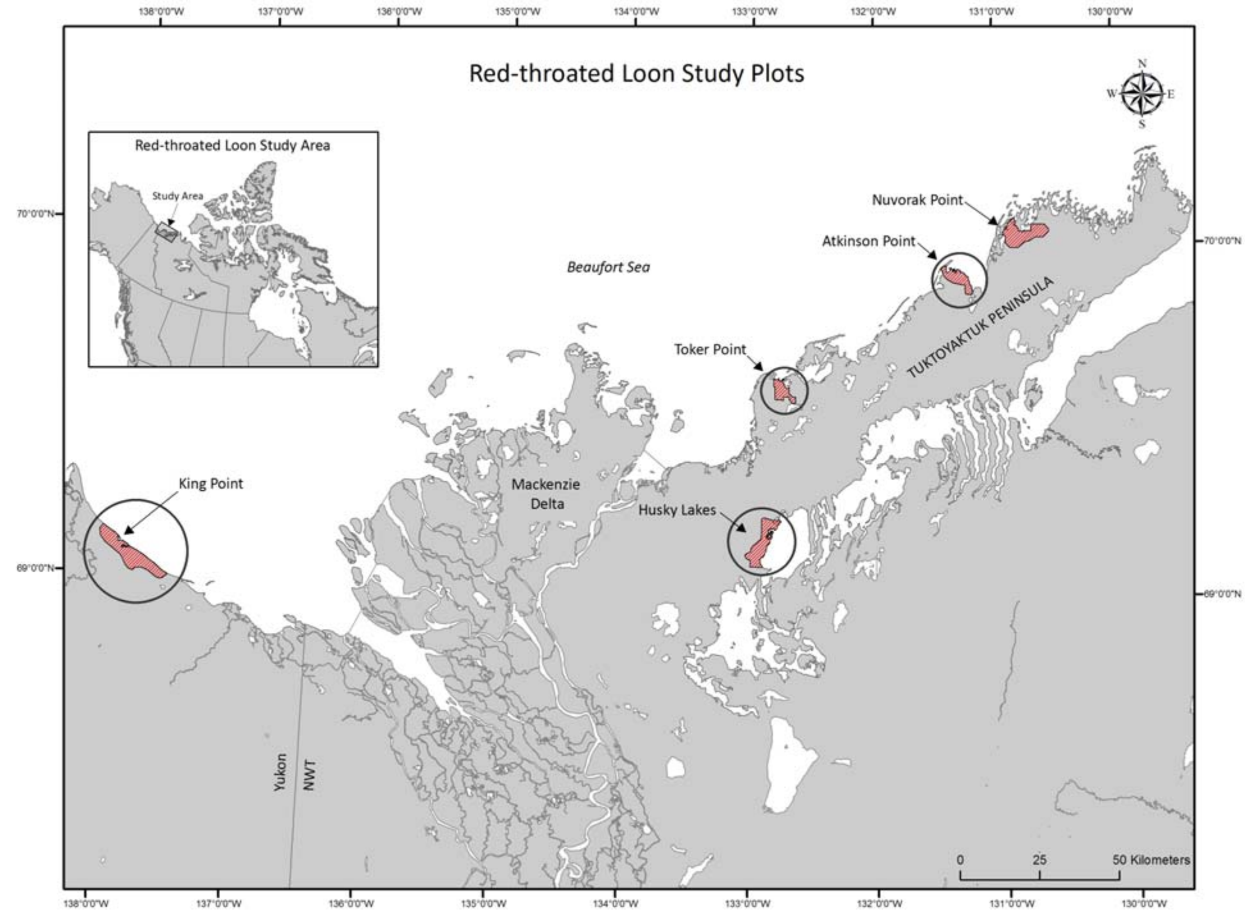


Figure 1. Location of Red-throated Loon study plots (hatched areas) surveyed from 1985 to 1989. Plots with circles are those that were resurveyed in 2007–2008.

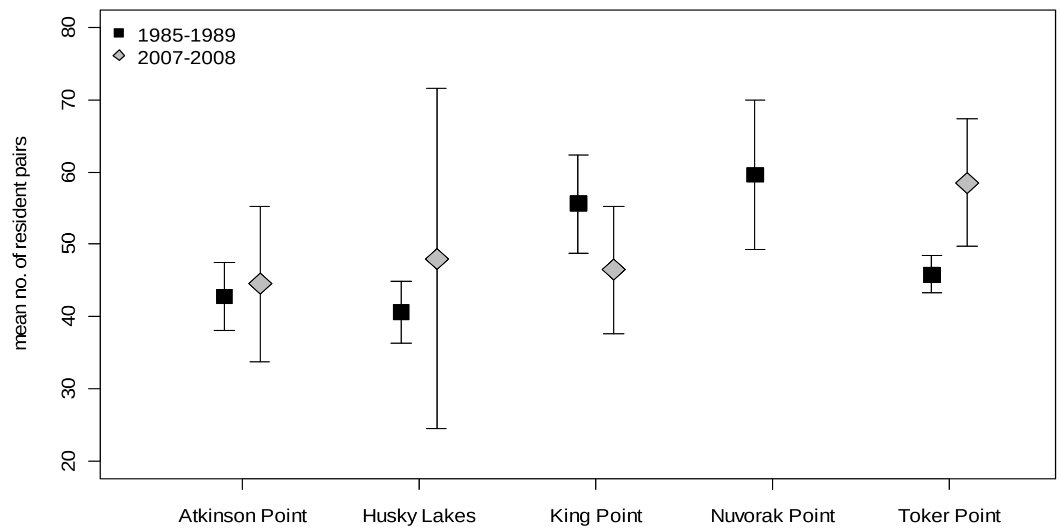


Figure 2. Mean number of resident pairs (± 95% CI) during each period of surveys at each study plot in the Beaufort Sea region

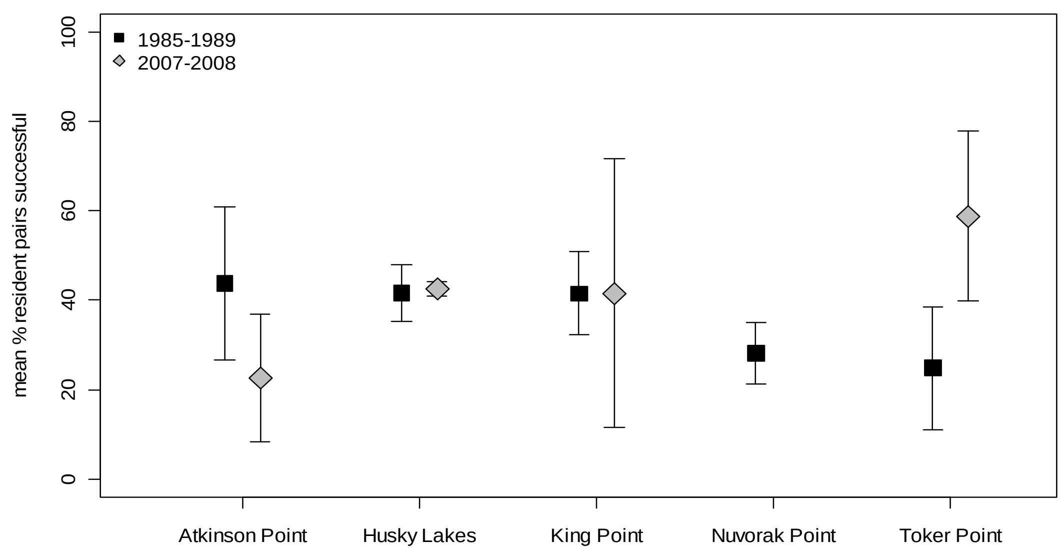


Figure 3. Mean percentage of resident pairs that were successful at producing at least one chick near fledging (± 95% CI) during each period of surveys at each study plot in the Beaufort Sea region

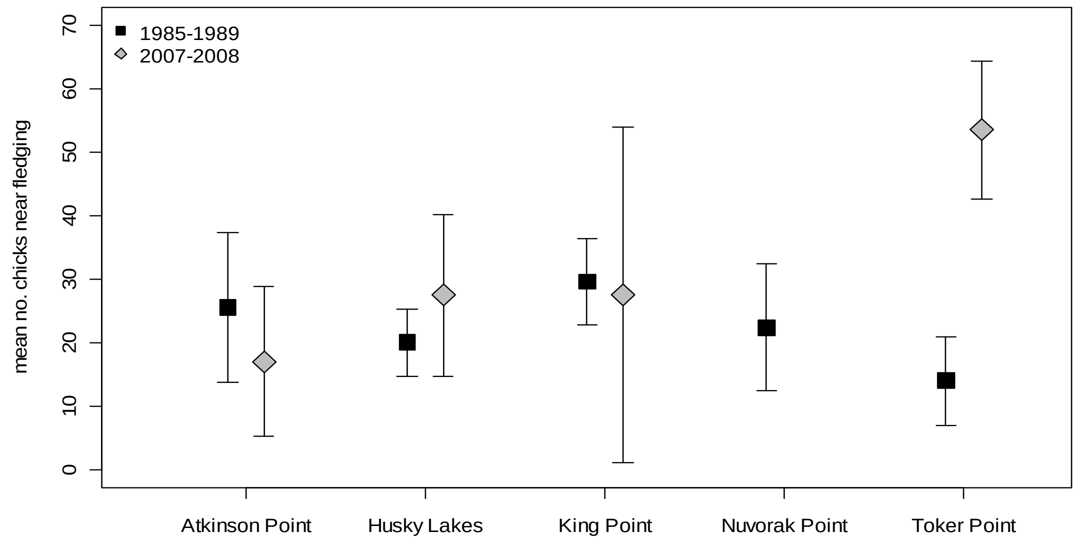


Figure 4. Mean number of chicks near fledging (± 95% CI) during each period of surveys at each study plot in the Beaufort Sea region

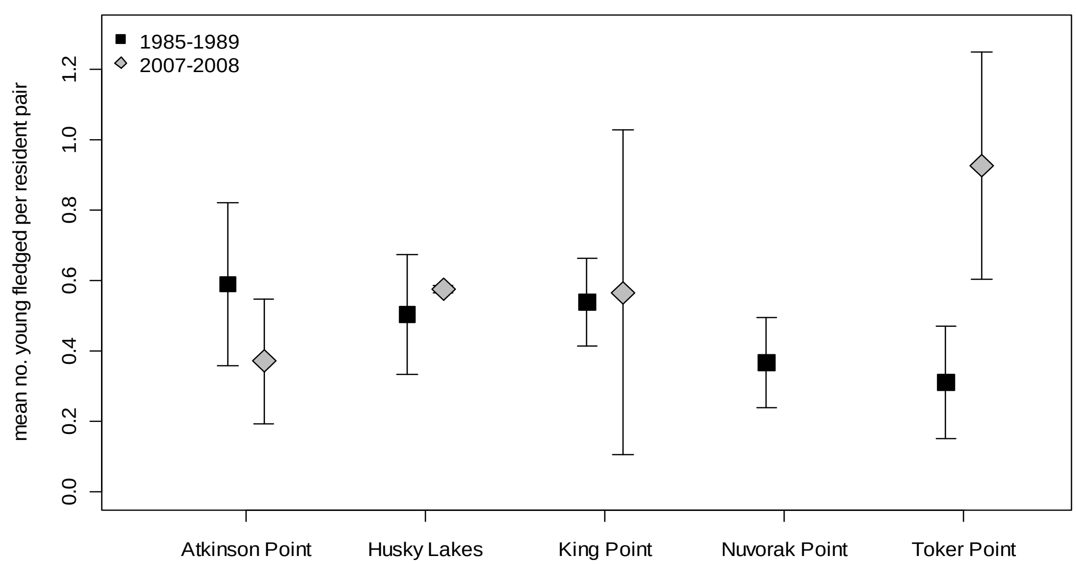


Figure 5. Mean number of young fledged per resident pair (± 95% CI) during each period of surveys at each study plot in the Beaufort Sea region

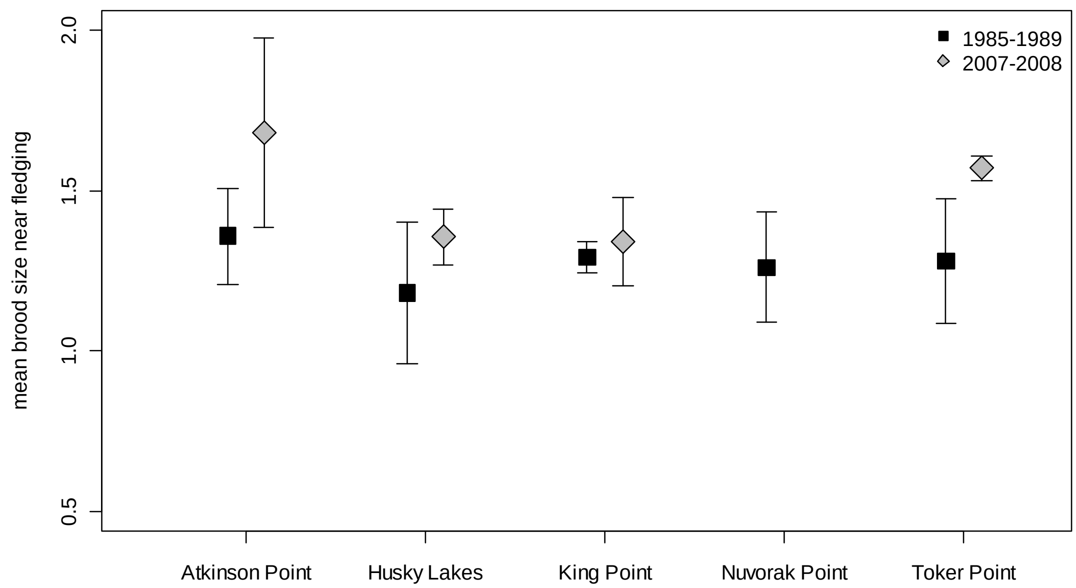


Figure 6. Mean brood size near fledging (± 95% CI) during each period of surveys at each study plot in the Beaufort Sea region

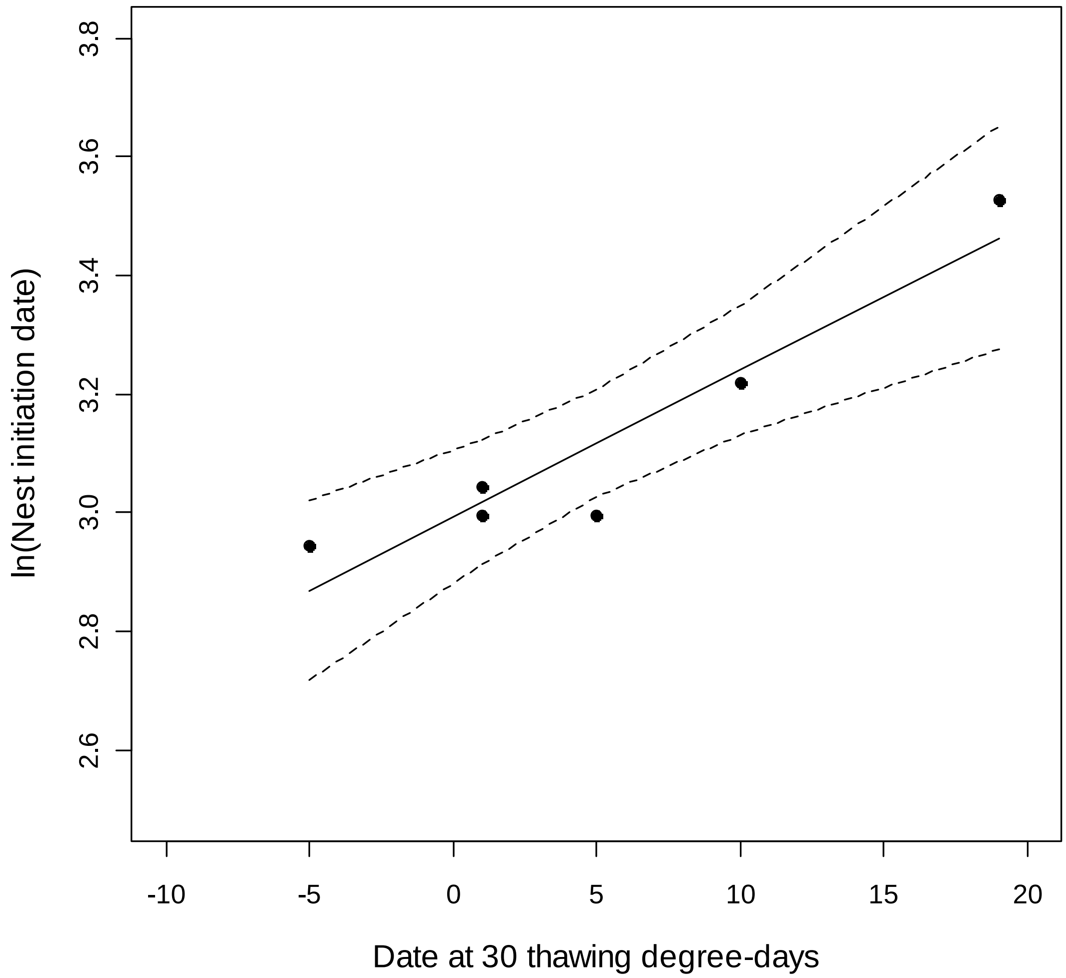


Figure 7. Predicted nest initiation date (solid line) ± 95% CI (dashed lines) based on the date at which 30 thawing degree-days was observed at the Tuktoyaktuk Airport. All dates were converted to a numerical scale where May 31 = 1 prior to analysis. The date at 30 thawing degree-days is an indicator of the timing of spring. The relationship is best described by ln(Nest initiation date) = 0.025*Date at 30 thawing degree days + 2.993 ($R2 = 0.893$, $p = 0.005$).

Appendix A. Results of aerial surveys for Red-throated Loons at 5 study plots in the Beaufort Sea region from 1985–1989 and 2007–2008

Study plot	Year	No. of resident pairs	No. of nesting pairs	% of resident pairs that nested	No. of eggs laid	No. of chicks near fledging	No. of success-ful pairs	% of resident pairs that were success-ful	% of known nesters that were success-ful	Young fledged per resident pair	Young fledged per nesting pair	Brood size near fledging
Toker Point	1985	43	37	86.0	64	24	18	41.9	48.6	0.56	0.65	1.33
	1986	43	27	62.8	48	8	7	16.3	25.9	0.19	0.30	1.14
	1987	50	39	78.0	70	13	8	16.0	20.5	0.26	0.33	1.63
	1988	46	39	84.8	69	20	19	41.3	48.7	0.43	0.51	1.05
	1989	47	41	87.2	78	5	4	8.5	9.8	0.11	0.12	1.25
	Average	**45.8**	**36.6**	**79.8**	**65.8**	**14.0**	**11.2**	**24.8**	**30.7**	**0.31**	**0.38**	**1.28**
	SD	2.9	5.5	10.1	11.1	8.0	6.8	15.6	17.4	0.17	0.18	0.20
	2007	54	43	79.6	77	59	37	68.5	86.0	1.09	1.37	1.59
	2008	63	no data		no data	48	31	49.2		0.76		1.55
	Average	**58.5**				**53.5**	**34.0**	**58.9**		**0.93**		**1.57**
	SD	6.4				7.8	4.2	13.7		0.23		0.03
Atkinson Point	1985	35	26	74.3	44	21	19	54.3	73.1	0.60	0.81	1.11
	1986	40	21	52.5	36	14	11	27.5	52.4	0.35	0.67	1.27
	1987	48	38	79.2	65	32	21	43.8	55.3	0.67	0.84	1.52
	1988	47	42	89.4	77	46	33	70.2	78.6	0.98	1.10	1.39
	1989	44	33	75.0	61	15	10	22.7	30.3	0.34	0.45	1.50
	Average	**42.8**	**32**	**74.1**	**56.6**	**25.6**	**18.8**	**43.7**	**57.9**	**0.59**	**0.77**	**1.36**
	SD	5.4	8.6	13.5	16.5	13.5	9.3	19.5	19.1	0.26	0.21	0.15
	2007	39	21	53.8	34	11	6	15.4	28.6	0.28	0.52	1.83
	2008	50	no data		no data	23	15	30.0		0.46		1.53
	Average	**44.5**				**17.0**	**10.5**	**22.7**		**0.37**		**1.68**
	SD	7.8				8.5	6.4	10.3		0.13		0.21

Study plot	Year	No. of resident pairs	No. of nesting pairs	% of resident pairs that nested	No. of eggs laid	No. of chicks near fledging	No. of success-ful pairs	% of resident pairs that were success-ful	% of known nesters that were success-ful	Young fledged per resident pair	Young fledged per nesting pair	Brood size near fledging
Husky Lakes	1985	35	27	77.1	46	29	18	51.4	66.7	0.83	1.07	1.61
	1986	37	24	64.9	36	12	12	32.4	50.0	0.32	0.50	1.00
	1987	40	32	80.0	55	19	16	40.0	50.0	0.48	0.59	1.19
	1988	47	36	76.6	62	20	18	38.3	50.0	0.43	0.56	1.11
	1989	44	33	75.0	52	20	20	45.5	60.6	0.45	0.61	1.00
	Average	**45.5**	**30.4**	**74.7**	**50.2**	**20.0**	**16.8**	**41.5**	**55.5**	**0.50**	**0.67**	**1.18**
	SD	4.9	4.8	5.8	9.8	6.0	3.0	7.2	7.8	0.19	0.21	0.23
	2007	36	22	61.1	37	21	15	41.7	68.2	0.58	0.95	1.40
	2008	60	no data		no data	34	26	43.3		0.57		1.31
	Average	**48.0**				**27.5**	**20.5**	**42.5**		**0.58**		**1.35**
	SD	17.0				9.2	7.8	1.2		0.01		0.07
King Point	1985	49	33	67.3	48	34	27	55.1	81.8	0.69	1.03	1.26
	1986	46	25	54.3	42	21	17	37.0	68.0	0.46	0.84	1.24
	1987	58	42	72.4	76	40	29	50.0	69.0	0.69	0.95	1.38
	1988	64	44	68.8	71	30	23	35.9	52.3	0.47	0.68	1.30
	1989	61	43	70.5	70	23	18	29.5	41.9	0.38	0.53	1.28
	Average	**55.6**	**37.4**	**66.7**	**61.4**	**29.6**	**22.8**	**41.5**	**62.6**	**0.54**	**0.81**	**1.29**
	SD	7.8	8.2	7.1	15.3	7.8	5.3	10.6	15.6	0.15	0.18	0.05
	2007	42	17	40.5	24	14	11	26.2	64.7	0.33	0.82	1.27
	2008	51	no data		no data	41	29	56.9		0.80		1.41
	Average	**46.5**				**27.5**	**20.0**	**41.5**		**0.57**		**1.34**
	SD	6.4				19.1	12.7	21.7		0.33		0.10

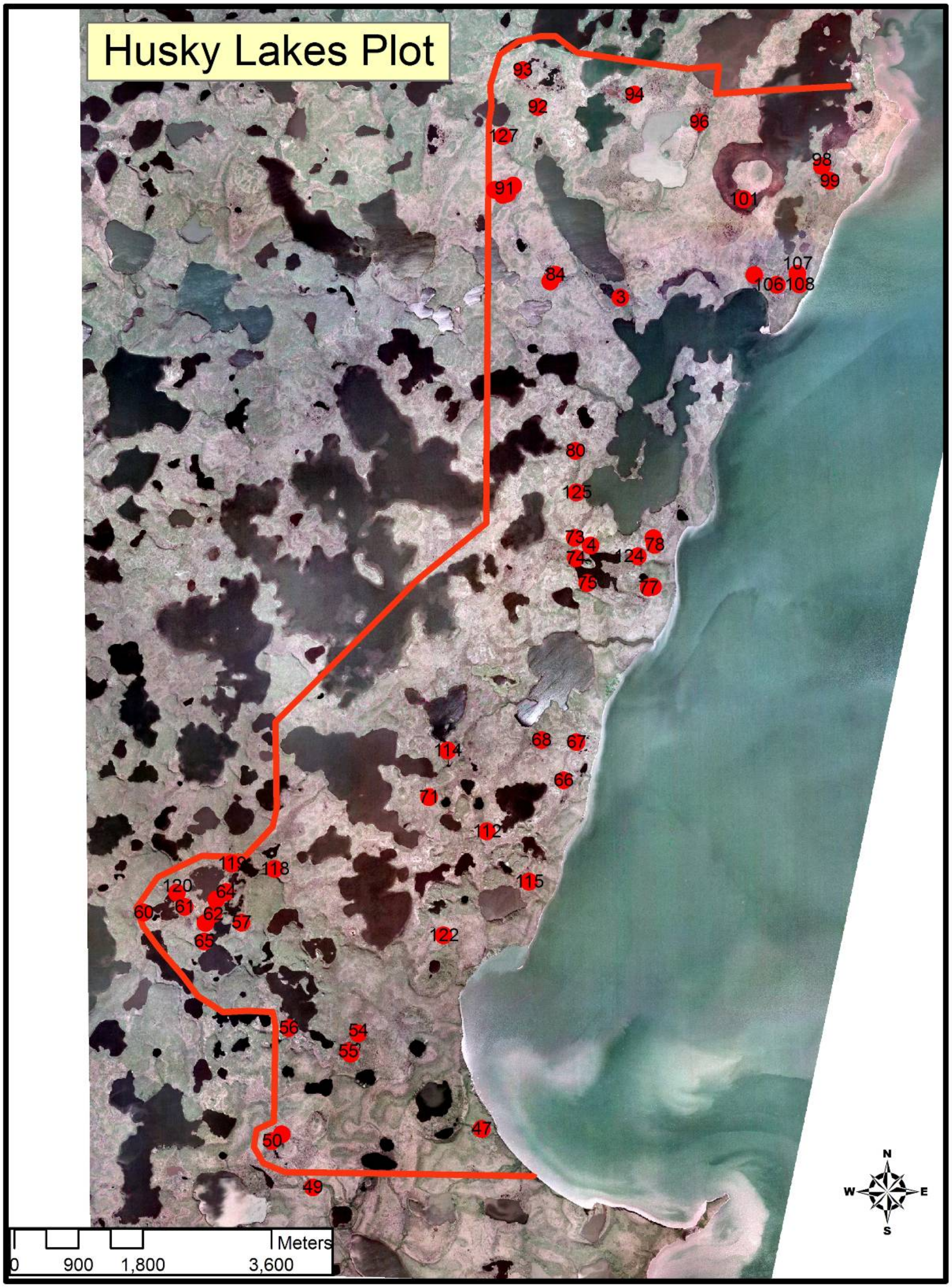
Study plot	Year	No. of resident pairs	No. of nesting pairs	% of resident pairs that nested	No. of eggs laid	No. of chicks near fledging	No. of success-ful pairs	% of resident pairs that were success-ful	% of known nesters that were success-ful	Young fledged per resident pair	Young fledged per nesting pair	Brood size near fledging
Nuvorak	1985	44	28	63.6	43	15	13	29.5	46.4	0.34	0.54	1.15
Point	1986	50	28	56.0	45	9	9	18.0	32.1	0.18	0.32	1.00
	1987	69	53	76.8	91	37	26	37.7	49.1	0.54	0.70	1.42
	1988	70	53	75.7	89	20	16	22.9	30.2	0.29	0.38	1.25
	1989	65	46	70.8	77	31	21	32.3	45.7	0.48	0.67	1.48
	Average	**59.6**	**41.6**	**68.6**	**69.0**	**22.4**	**17.0**	**28.1**	**40.7**	**0.36**	**0.52**	**1.26**
	SD	11.8	12.7	8.7	21.0	11.5	6.7	7.8	8.8	0.14	0.15	0.17
	2007	not surveyed										
	2008	not surveyed										

Number of resident pairs is based on the number of occupied territories. An occupied territory was an area where a loon was observed at least once in suitable habitat that was not likely part of another loon's territory.

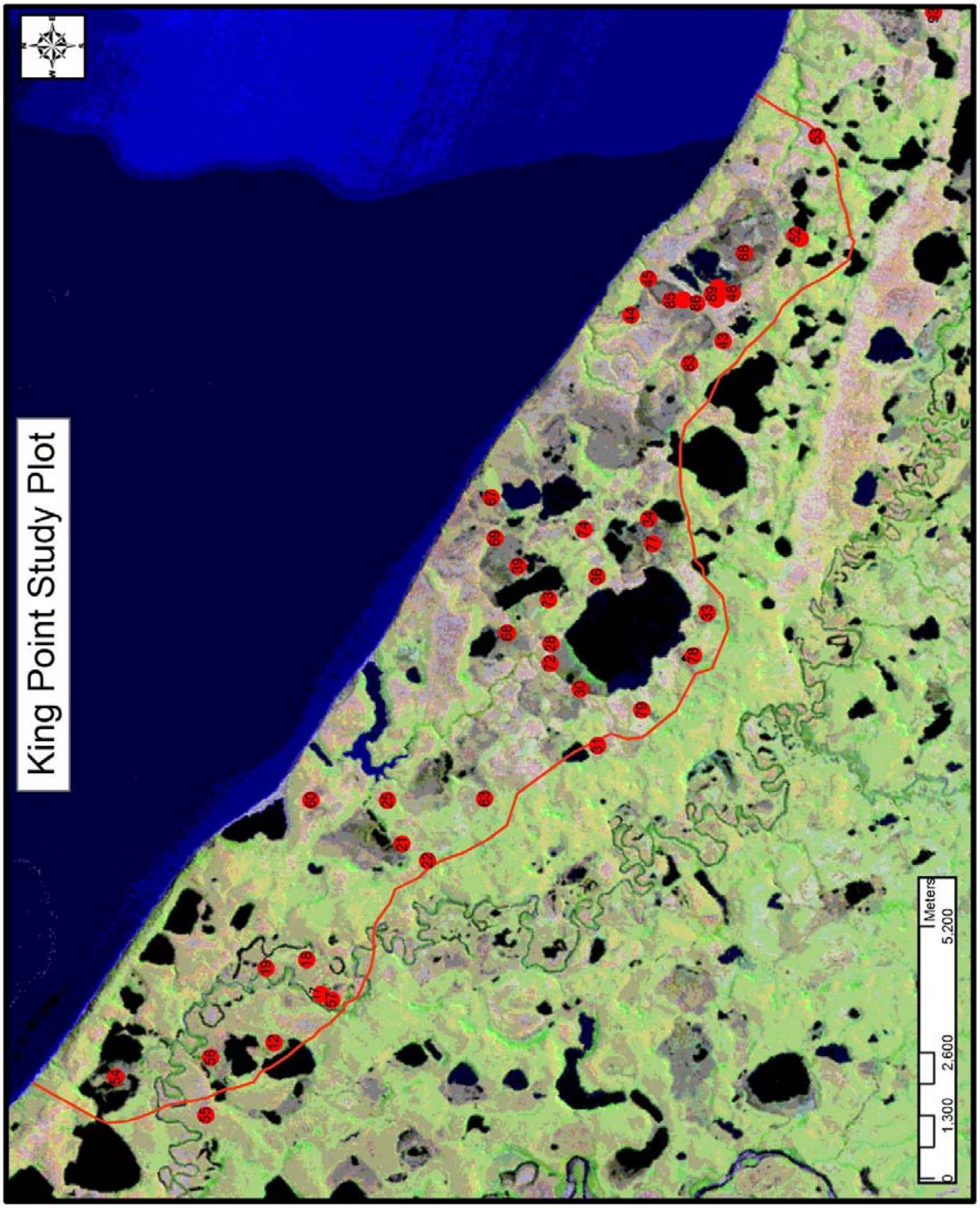
Number of nesting pairs is based on the number of active territories. An active territory was one at which we observed evidence of nesting (eggs, chicks, fresh egg remains, dead chick, loon refusing to get off a nest when helicopter hovering within 15 m).

Number of eggs laid includes number of chicks seen in territories where the nest was not located.

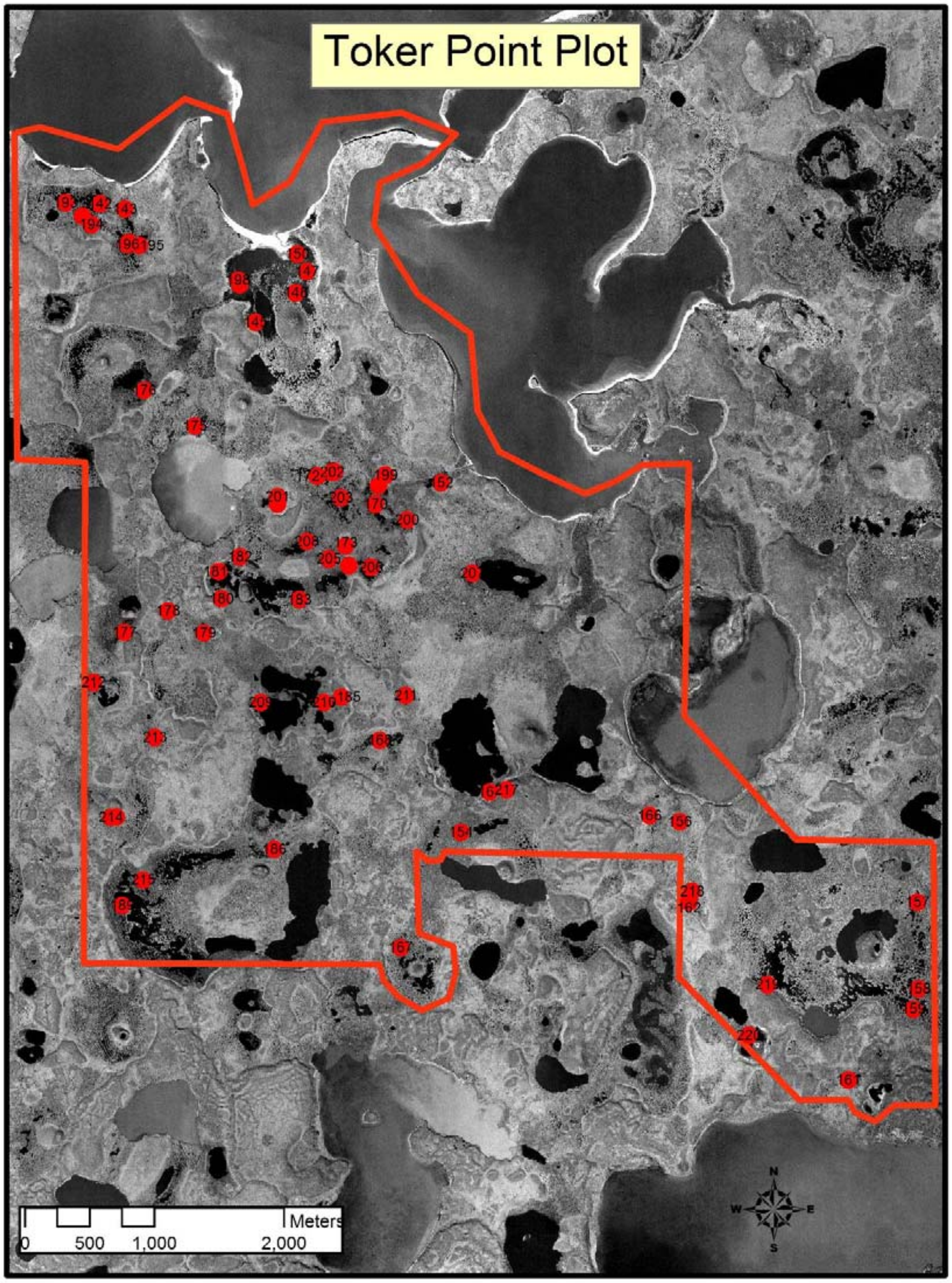
Appendix B1. Atkinson Point study plot. Red dots show Red-throated Loon territory locations during the 2008 breeding season.



Appendix B2. Husky Lakes study plot. Red dots show Red-throated Loon territory locations during the 2008 breeding season.



Appendix B3. King Point study plot. Red dots show Red-throated Loon territory locations during the 2008 breeding season.



Appendix B4. Toker Point study plot. Red dots show Red-throated Loon territory locations during the 2008 breeding season.

www.**ec.gc.ca**

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