MINASKUAT PROJECT NO. M35

CLIMATE AND REPRODUCTIVE SUCCESS OF OSPREY IN CENTRAL LABRADOR

11 March 2004

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FINAL REPORT

CLIMATE AND REPRODUCTIVE SUCCESS OF OSPREY IN CENTRAL LABRADOR

PREPARED FOR

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1. BACKGROUND

Minaskuat has been involved with an extensive monitoring program by the Department of National Defence (DND) since 1991(Trimper *et al.* 2004, LFA 1992, JWE 1992, 1994, 1995, JWEL 1996, 1997, 1998, 1999, 2001), designed to investigate the potential effects of low-level jet aircraft noise on the behavior and reproductive success of nesting Osprey (*Pandion haliaetus*). Results of these investigations and the findings of others had indicated that nesting success of this species might be more closely related to weather than low-level jet aircraft training. To look at this suggestion in greater detail, the Institute of Environmental Monitoring and Research (IEMR) engaged Minaskuat to continue the annual monitoring program of Osprey inside and outside the Low-Level Training Area (LLTA) and also to collect 'local' weather information in order to investigate potential relationships between climate and related hydrological data in comparison to Osprey nesting success.

2. OBJECTIVES

The objective of this research was to examine climatological and hydrological parameters within and adjacent to the LLTA to identify relationships that may exist in relation to biological measures of Osprey reproductive success (e.g. how the timing of spring breakup or of peak runoff compare with available Osprey nesting data).

3. METHODOLOGY

3.1. Study Team

Mr. Perry Trimper (Jacques Whitford) was the project manager and, along with Ms. Karen Gosse (Minaskuat), assisted with the compilation of this report. Mr. Corey Cooney (Minaskuat) assisted with weather data collection (field surveys) and analyses. SGE Acres was subcontracted by Minaskuat to investigate climate and hydrological measures of indices likely to be of importance in Osprey nesting success. Susan Ricter, Joanna Barnard (SGE Acres) and Dr. Leonard Lye (Memorial University) participated as part of this team and compiled and statistically analyzed available weather data. SGE Acres issued a series of memoranda subsequently used in the compilation of this report.

3.2. Study Area

Osprey nesting success was examined inside (Experimental) and outside (Control) the military LLTA of Labrador. Weather stations were established within the LLTA at Park Lake (53º10'N, 58º50'W) and Anne Marie Lake (52º38'N, 60º50'W). Long-term climate, hydrological, and wind data was available from Environment Canada (EC) weather stations located at various locations within and near the LLTA (Tables 1 and 2).

3.3. Data Collection

Weather Wizard III wireless weather stations (Davis Instruments Corp.), capable of recording temperature, wind direction, wind speed and rainfall, were established at Park Lake and Anne Marie Lake prior to 2003 Osprey nest surveys (i.e. early June). Weather stations were preset to record information (i.e. precipitation, temperature, wind speed and direction) every 30 minutes, allowing for 30 days of observations before the stations had to be revisited to download the information.

While weather data from the airport at Goose Bay was available for several decades, long-term EC hydrological stations only were available in the LLTA (or study area). Several climate gauges, however, were located relatively close and were considered in the analyses. Table 1 and Table 2 provide a summary of climate and hydrological data available within and near the study area.

Table 1. Environment Canada (EC) climate stations within Labrador near the study area.

EC Station Name	Elevation (m)	Period of Record
Cartwright	14	1950-present
Churchill Falls	440	1993-present
Churchill Falls	489	1993-1998
Churchill Falls A	440	1968-1993
Goose A	49	1941-present

Table 2. Environment Canada (EC) hydrological stations within Labrador near the project study area.

EC Station Name	Drainage Area (km2)	Period of Record
Atikonak River above Panchia Lake	15,100	1972-present
Kempimits River below Kempimits Lake	7,070	1972-2000
Atikonak River above Atikonak Lake	3,680	1972-2000
Minipi River below Minipi Lake*	2,330	1979-present
Eagle River above falls*	10,900	1966-present
Alexis River near Port Hope Simpson	2,310	1978-present
Petit Mecatina en Aval du Lac Brenton	12,000	1978-1993
Coxipi a la Sortie du Lac Coxipi	1,060	1980-1993
Saint-Paul en aval de la Riviere Buieault	6,630	1967-2000

* Only these stations were used in data analyses

Information on Osprey nesting success was available through the DND annual long-term Osprey monitoring program, 1991-2002, and the continuation of this program by the IEMR during 2003 (Jacques Whitford, unpubl. data). To aid data analysis, the overall nesting success (number of young fledged per active Osprey nest) during each survey year was categorized as one of the four following: Poor, Mediocre, Good or Very Good, depending on relative success rates (Table 3).

Table 3. Success ratings used to categorize Osprey nesting success.

Nesting Success (no. young fledged/active nest)	Success Rating
<0.8	Poor
0.8-1.2	Mediocre
1.2-1.6	Good
>1.6	Very Good

3.4. Data Analyses

Osprey young are not able to thermoregulate (i.e. generate sufficient body temperature without external sources) during the early post-hatching stages. Cold and/or wet days in early July are thus most likely to significantly impact nestling survival rates. Poor weather during this critical period may further affect survival by limiting food deliveries by the adults, either because the adults can't fly in poor weather, visibility during foraging is obscured, or have to remain in the nest to protect the young. Based on the sensitivity of this period, and the fact that nest activity remains relatively constant between years, until after hatch (JWEL 1995, Trimper *et al*., submitted), data analyses concentrated on investigating climate data available for July of each year.

Climate data from the three gauges at Churchill Falls (Table 1) were combined to get a continuous time-period from 1990 to present. All data were downloaded from the EC database and processed into a form convenient for plotting and analysis. Available hourly data from each station was examined to generate a record of daily maximum and minimum temperatures. Note available precipitation data allowed only a 24-hour period assessment. An Excel spreadsheet was created for each climate station containing daily rain and snow, and daily minimum, maximum and mean temperature for the period 1990-2002 or 2003. Daily values calculated from the Weather Wizards installed in the experimental area were compared with data from the regional EC stations to establish whether the available long-term data were representative of the study area.

Analyses were performed on hydrometric data from Minipi River below Minipi Lake and Eagle River, located within or adjacent to the study area, for information on the day of last ice (indicative of the timing of spring thaw in the basin) and rainfall amounts, with subsequent comparison to Osprey nesting success. Hydrographs were developed to examine the relationship between hydrology and precipitation data collected, and to determine whether Osprey nesting success correlated with hydrology. River flow information aggregates the effects of precipitation and temperature and may therefore provide a simpler way to compare climate and Osprey success.

Chris Steeger (pers. comm.), in his presentation to the IEMR Osprey Workshop, St. John's, NL, October 2003, suggested that high winds can compromise the feeding of female and chick osprey by reducing the foraging success of the males. His research on Osprey in British Columbia indicated that at wind speeds greater than 20 km/h hunting profitably sharply declines and that at winds greater than 25 km/h, hunting is no longer energetically profitable, as the adult spends more energy capturing food than the energy value of the prey. Data on wind speed was obtained from climate stations at Goose Bay and Churchill Falls only, for the period 1996-2003, and examined to determine if a correlation between high winds and nesting success was apparent for the Labrador areas of interest.

4. RESULTS

4.1. Osprey Reproductive Success

Data analyses concentrated on that available during 1994-2003, the years when the most detailed information was documented. Table 4 provides a qualitative summary of the relative nesting success of Osprey during this time period.

Table 4. Osprey Reproductive Success within and adjacent to the Low-Level Training Area in Labrador, 1993-2003.

Year	**Success Rating**[*]
1993	Poor
1994	Good
1995	Good
1996	Poor
1997	Mediocre
1998	Very Good
1999	Very Good
2000	Poor
2001	Mediocre
2002	Poor
2003	Very Good

[*] From Table 3

4.2. Weather Data

Data from Anne Marie Lake was available from 7 June – 17 August. Unfortunately, a battery failure resulted in a loss of data from Park Lake so that data are only available from 7 June – 17 July from this location. Available temperature data from the local stations were compared with ECs long-term climate station at Goose Bay to determine similarities and differences between data sets (Figure 1 and Figure 2). Average daily temperatures at Goose Bay were also compared with those recorded at Churchill Falls (Figure 3). Temperature data recorded at both Churchill Falls and Goose Bay appear similar to those recorded within the study area at Anne Marie and Park Lakes.

Original precipitation data recorded at both Churchill Falls and Goose Bay (1995 data) appeared similar (Figure 4). Data from Goose Bay was also available for the 2003 year and compared with information collected from the local weather stations. The local gauges appeared to record rainfall on some of the same days (i.e. same weather system) as the gauge at Goose Bay during 2003 (Figure 5). However, the gauge at Goose Bay recorded significantly more precipitation than either of the local stations, and significantly more precipitation was recorded at Park Lake than at Anne Marie Lake (Figure 5). Though some variation in precipitation across the region is expected, the differences observed suggest that the local precipitation gauges, especially at Anne Marie Lake, may not be functioning properly.

Figure 1. Mean daily temperatures at Park Lake compared with Goose Bay, Labrador, 7 June - 31 July 2003.

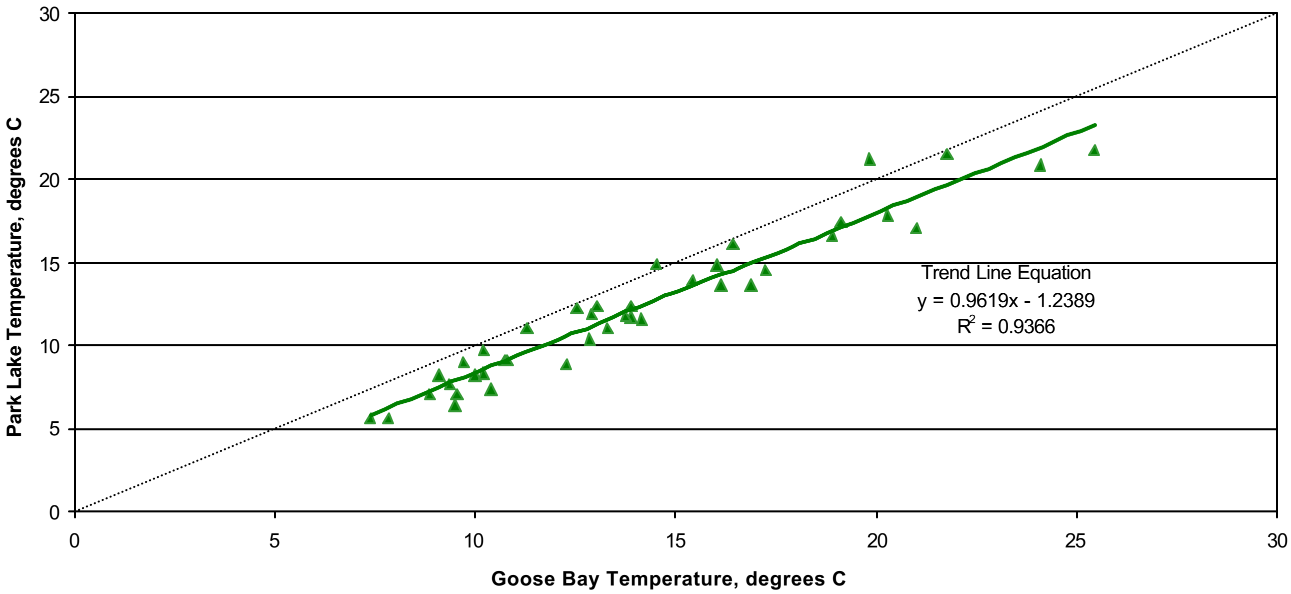


Figure 2. Mean daily temperatures at Anne Marie Lake compared with Goose Bay, Labrador, 7 June - 17 August 2003.

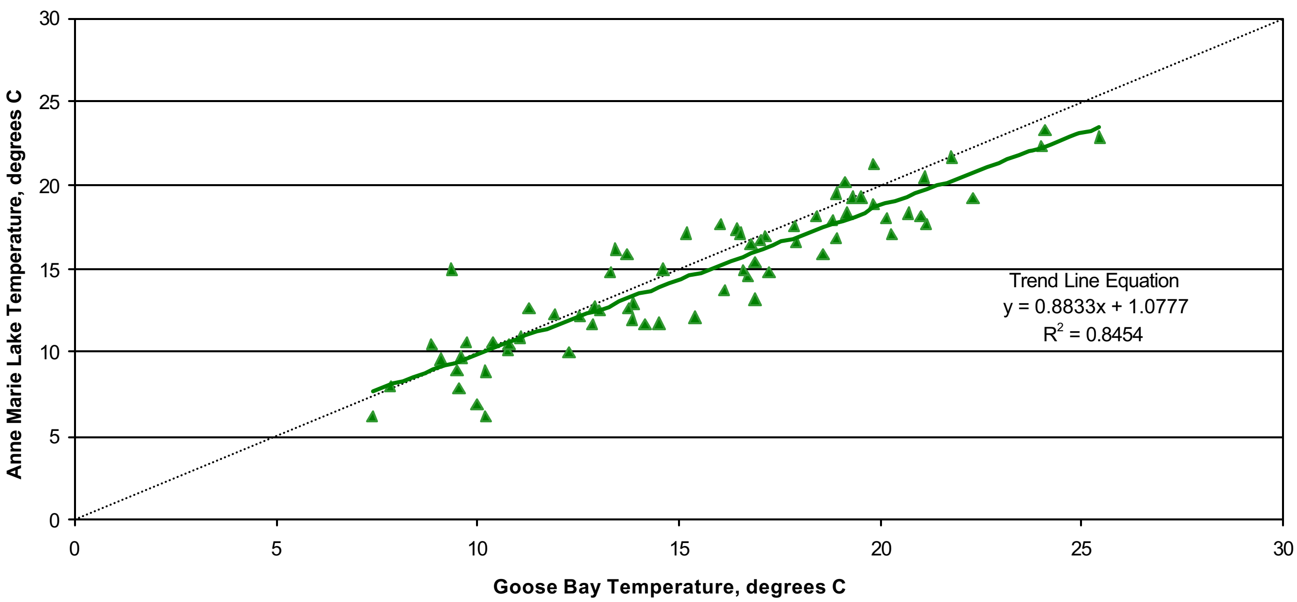


Figure 3. Mean daily temperatures at Churchill Falls compared with Goose Bay, Labrador, 7 June – 31 July 2003.

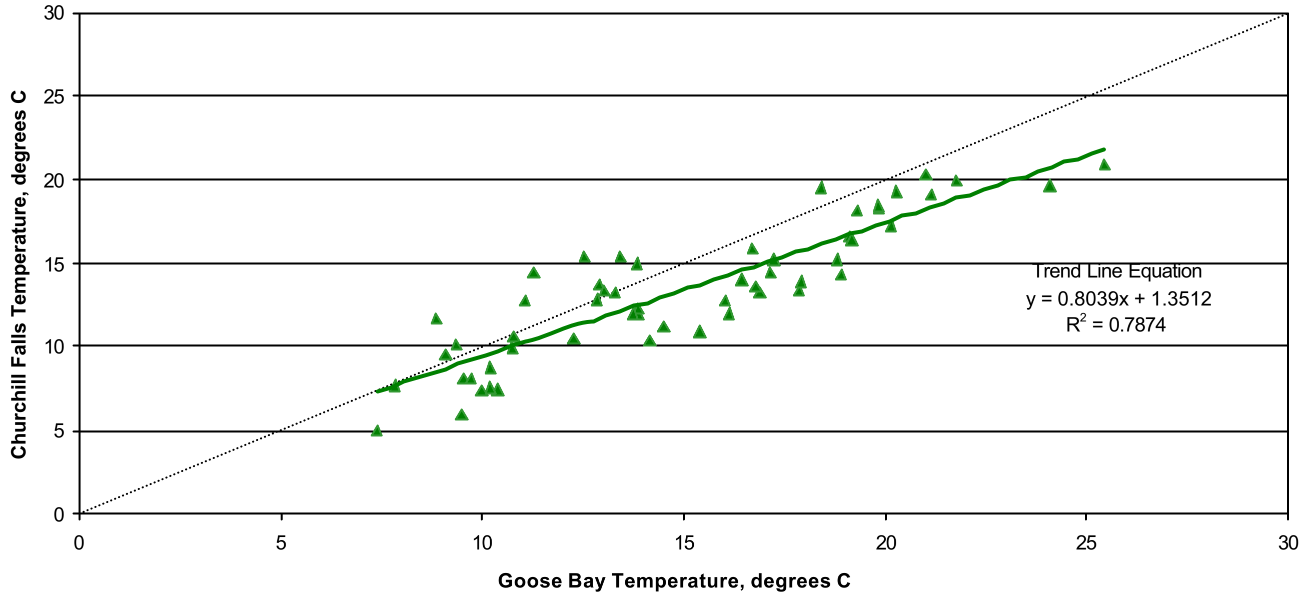


Figure 4. Cumulative precipitation recorded from Environment Canada weather stations at Churchill Falls and Goose Bay, Labrador, 1 June – 31 July 1995.

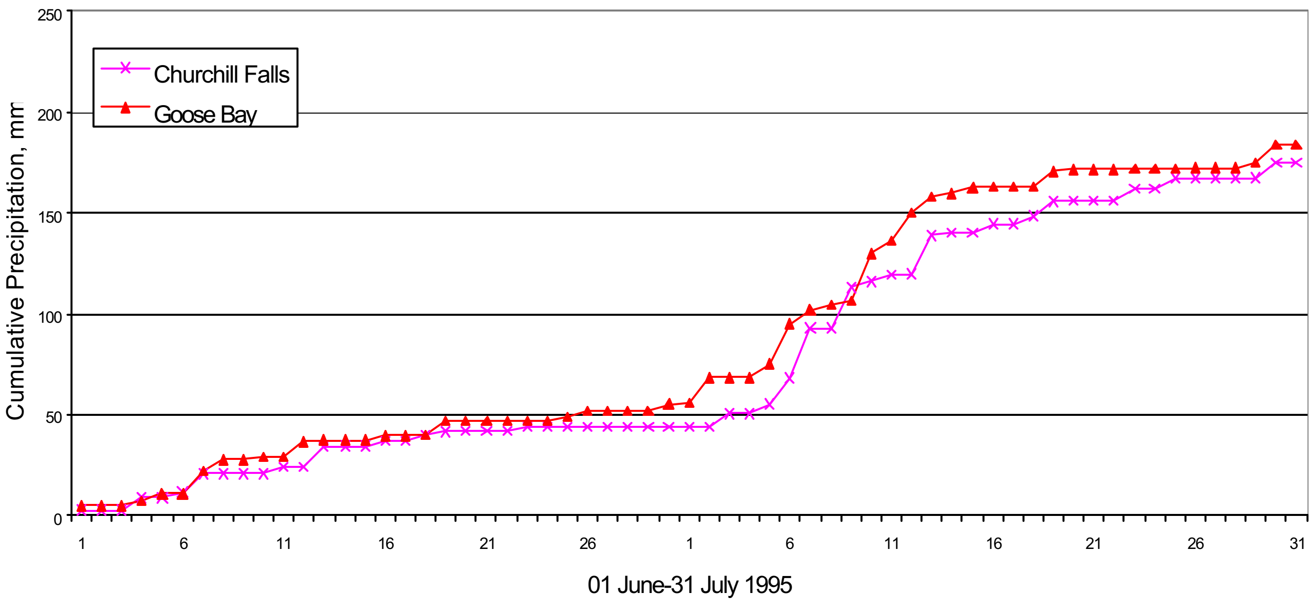
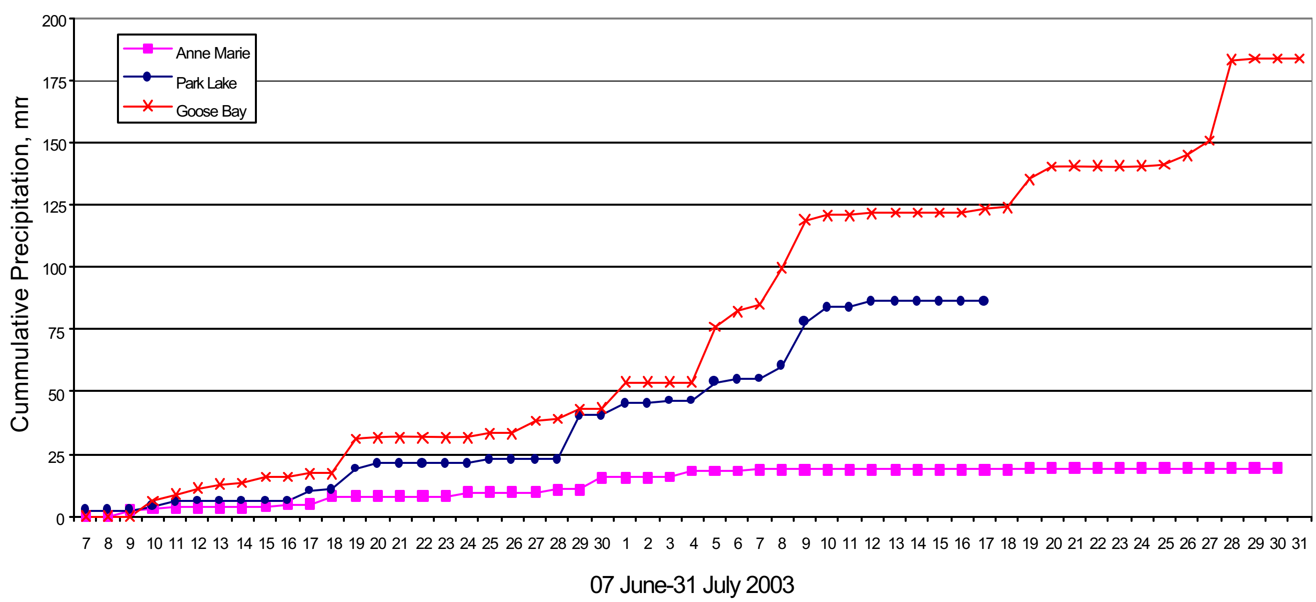


Figure 5. Cumulative precipitation (mm) recorded from local weather stations at Park and Anne Marie Lakes compared with Environment Canada's weather station at Goose Bay, Labrador, 7 June – 18 August 2003.



Between 1997-2003, snowmelt dominates river flows in the Eagle and Minipi Rivers until mid-late June, and until mid-July in 2000 (Appendix A). In general, river flows on the Minipi River are less variable and the effect of snowmelt and precipitation is less distinct. Some correlation exists between the amount of rainfall (precipitation and runoff) at Goose Bay and river flows on the Eagle River (Table 5, Appendix A). In general, peak flows in July and August were preceded by rainfall, however some rainfall occurred with no recognizable subsequent flow peaks, providing support that differences exist between the relative "wetness" of Goose Bay and the study area.

Table 5. Precipitation and runoff amounts collected at Goose Bay and Minipi and Eagle Rivers during 1999-2002.

Year	Success Rating*	Goose Bay Total Precipitation (mm)	Minipi River Runoff (mm)	Eagle River Runoff (mm)
1999	Very Good	1188	1062	960
2000	Mediocre	1024	992	911
2001	Poor	867	671	662
2002	Mediocre	985	705	676
Long term average		915	777	744

* From Table 3

Total number of hours of high winds recorded at Churchill Falls and Goose Bay EC weather stations between 1-10 July 1996-2003 are provided in Table 6. Hours of high wind speed varied between years, ranging from 5-50 hours recorded at Goose Bay to 1-74 hours at Churchill Falls (Table 6). In general, wind speeds appear to exhibit greater variation between Goose Bay and Churchill Falls than the temperature and precipitation data.

Table 6. Comparison of relatively strong wind speed in Goose Bay and Churchill Falls, Labrador, with Osprey nesting success.

Year	Success Rating*	# Young fledged/ active nest		Hours of high wind at Goose Bay, 1-10 July 2003		Hours of high wind Churchill Falls, 1-10 July 2003	
		LLTA	*Control*	*>20 km/h*	*>25 km/hr*	*>20 km/h*	*>25 km/hr*
1996	Poor	--	--	22	10	8	1
1997	Mediocre	--	--	38	14	53	21
1998	Very good	--	--	15	5	15	4
1999	Very good	1.77	1.57	29	17	46	19
2000	Mediocre	1.03	0.67	44	28	33	22
2001	Poor	0.60	0.70	39	20	16	11
2002	Mediocre	1.00	0.93	49	31	51	37
2003	Very good	1.73	1.90	50	24	74	40

* From Table 3
"--" indicates detailed data are not available

The comparison of Goose Bay and Churchill Falls data shows that the climate across the region is similar. Churchill Falls was cooler and drier than Goose Bay during the period under investigation, but the pattern of temperatures and precipitation, the climate parameters presumed to have the greatest effect on nesting success, was essentially the same. Thus, the long-term gauges were determined appropriate to infer weather information for the larger study area.

4.3. Weather and Nesting Success

Maximum and minimum daily temperature, rain and snowfall for each year and for each climate station were examined to assess weather conditions during early July, when Osprey eggs have just hatched and fledglings are most vulnerable. These parameters are also compared to Osprey nesting success for the years 1998-2003 (Tables 7 and 8, Appendix A). The examination of this data failed to identify any particular climate occurrence that occurred/did not occur which correlates with Osprey nesting success.

Table 7. Summary of climate statistics between 1-14 July for the years 1993-2003, at Goose Bay, Labrador.

Time Period		Success Rating*	Average Minimum Temperature (ºC)	Average Maximum Temperature (ºC)	Total Rainfall (mm)
1993	July 1 to 7	Poor	6.6	20.5	5.4
	July 8 to 14		10.1	19.6	4.0
1994	July 1 to 7	Good	8.2	19.9	15.7
	July 8 to 14		9.7	22.1	17.4
1995	July 1 to 7	Good	8.4	18.6	46.6
	July 8 to 14		12.1	21.5	57.8
1996	July 1 to 7	Poor	9.0	15.4	16.2
	July 8 to 14		8.3	20.6	43.2
1997	July 1 to 7	Mediocre	9.6	18.1	51.2
	July 8 to 14		8.5	16.8	52.4
1998	July 1 to 7	Very good	8.6	19.0	45.0
	July 8 to 14		9.8	23.5	1.6
1999	July 1 to 7	Very good	8.8	15.4	64.8
	July 8 to 14		10.2	20.4	25.0
2000	July 1 to 7	Mediocre	8.9	16.6	44.0
	July 8 to 14		7.6	17.4	29.2
2001	July 1 to 7	Poor	8.3	17.1	45.6
	July 8 to 14		9.0	13.8	74.8
2002	July 1 to 7	Mediocre	11.4	22.4	32.0
	July 8 to 14		7.1	17.0	43.6
2003	July 1 to 7	Very Good	9.3	15.0	41.6
	July 8 to 14		8.4	19.0	36.8

*From Table 3

Table 8. Summary of weather data collected in the study area.

Year	Success Rating*	Description of Weather
1993	Poor	0ºC or near 0ºC temperatures 4-5 July after high temps of 25 to 30ºC on July 3. July quite dry at Goose Bay but some rain on 4 July and a cool, wet period 21-24 July.
1994	Good	Minimum temperatures above 3-5ºC for 1-7 July at Churchill Falls and Goose Bay. Latest below 0ºC temperatures occurred in late June at Churchill Falls, mid-June at Goose Bay. One near 0ºC night on 8 July at Cartwright, 10 July at Churchill Falls. Cool, but dry, period July 22 to 23 at Churchill Falls.
1995	Good	Minimum temperatures above 4-5ºC for first week of July at all stations. Cool average temperatures in late June, early July. Latest below 0 temperatures at Churchill Falls and Goose Bay in first week of June. Significant rain between 3-13 July.
1996	Poor	Minimum temperatures above 3-4ºC for 1-7 July at Goose Bay and Churchill Falls, a little cooler at Cartwright. Latest 0ºC temperature or below 21 June at Churchill Falls, early June at Goose Bay and Cartwright. Cool average temperatures 3-8 July. Some rain on most days of the first week, a lot of rain on July 10 at Goose Bay.
1997	Mediocre	Minimum temperatures >5ºC for 1-7 July. Cool days on 1-2 and 14-15 July. Latest below 0ºC day in early June. Heavy rain at Goose Bay on 2,10 July, some rain on most days during 1-14 July.
1998	Very good	Minimum temperatures >5-6ºC for first week of July. Latest below 0ºC temperatures in early June. Cool wet day 2 July; relatively heavy rain on 2, 7 July.
1999	Very good	Minimum temperatures above 5ºC for first week of July. Latest below 0ºC temperatures in early June. Cool wet period 4-10 July; high temperatures 12-13 July. Relatively heavy rain on 3 July.
2000	Mediocre	Minimum temperatures >=5ºC for all of July at Goose Bay and Churchill Falls. Minimum temperature at Cartwright dipped to 2ºC on 14 July. Maximum temperatures at Goose Bay and Churchill Falls dipped to <10ºC after >15ºC for some time. Latest 0ºC temperature early to mid June. Relatively high rain on 5-6,9 July. Another cool wet period on 20-22 July.
2001	Poor	Minimum temperatures near 0ºC on 1 July at Churchill Falls and on 29 June at Cartwright, minimum temperature >5ºC for all July at Goose Bay. Latest 0ºC day early June at Goose Bay. Cool wet period 12-13 July at Goose Bay and Churchill Falls. Rain almost every day during 1-7 July.
2002	Mediocre	Minimum temperatures >5-6ºC 1-7 July. Cooler minimums on 13,18,29 July; latest 0ºC day mid June. High maximum temperatures (>30ºC) in early July at Goose Bay and Churchill Falls, slightly lower at Cartwright. Cool period on 11-13 July. Rain most days between 5-13 July.
2003	Very good	Minimum temperatures >5ºC for 1-7 July at Churchill Falls and Goose Bay. Latest 0ºC day early June. Minimum near 0ºC on 8 July at Anne Marie Lake Cool wet period from 5-10 July (both minimum and maximum temperatures low) Rain on most days 5-10 July.

*From Table 3

Hydrometric data from Minipi River below Minipi Lake and Eagle River above Falls provided long periods of record for the day of last ice each spring (Table 9). The day of last ice provides an indication of the timing of spring thaw in the basin. No relationship was apparent between this day and Osprey nesting success between 1993-2003, a parameter that Wetmore and Gillespie (1976) indicated may influence reproductive success of Osprey each spring. The two best years for which data were available (1998/99) occurred in years where the ice disappeared early, but poor success rates also occurred in years with similar timing of thawing (i.e. 1996, 2001).

Table 9. Day of last ice recorded at Minipi River and Eagle River weather stations compared with Osprey nesting success, 1993-2003.

	Success Rating*	Minipi River	Eagle River
1993	Poor	12 May	14 May
1994	Good	12 May	16 May
1995	Good	19 May	15 May
1996	Poor	NA	02 May
1997	Mediocre	NA	20 May
1998	Very Good	NA	09 May
1999	Very Good	03 May	05 May
2000	Mediocre	10 May	16 May
2001	Poor	18 May	09 May
2002	Mediocre	21 May	24 May
2003	Very Good	NA	NA

*From Table 3

Limited data (4 years total, 1999-2002) made it difficult to determine whether relationships between hydrology and nesting success existed (Table 5). The one poor year reported (2001) occurred when river flows were relatively high in mid-July, apparently reflecting relatively high precipitation in that month. River flows in July, however, were similar in 1999, a “Very Good” year, and in 2002, a “Mediocre” year.

Comparison of the number of hours of high winds at Goose Bay and Churchill Falls weather stations during early July with the fledgling success rating for the LLTA and control study areas similarly does not lead to any definitive conclusions (Table 6, Appendix B). Some “Very Good” years have a low number of hours of high winds, but so do some “Poor” years. Similarly year of both “Good” and “Poor” success have high numbers of days of high winds. As noted regarding the temperature and precipitation data, it is likely that small-scale conditions near individual nests are more important than large-scale climate trends.

Overall, no relationships were evident between the temperature, precipitation, hydrological, or wind data and Osprey nesting success for the years under consideration, however, small-scale climate effects may exist in the study area (or parts of the study area) that are not observed at the Goose Bay, Churchill Falls, or Cartwright weather stations.

5. SUMMARY

The objective of this study was to examine available hydrologic and climate data in Labrador to investigate whether relationships between climate or hydrology and Osprey breeding success could be demonstrated. If such a relationship could be confirmed, it would be possible to use climate and or hydrometric data to predict breeding success. The following general conclusions can be drawn from the study as a whole:

1. The long-term EC climate stations provide information on climate across Labrador. The experimental and control areas cover a significant area of Labrador and therefore it is not surprising that the data show a variation in climate across the area of interest. As an example, the eastern extent of the area of interest is influenced by its proximity to the coast and is therefore wetter and warmer than the inland area. Therefore, given the broad geographic areas under consideration in this program, proximate weather data is desirable when describing local environments.

2. The short-term data at the two climate stations in the experimental and control areas suggest that the climate in parts of the region may be significantly different than that recorded by the long-term EC gauges. Specifically, during the period of data available, the two local gauges recorded less precipitation than the stations at Goose Bay and at Churchill Falls. In some instances it appears that the same events occur across the region, but with less precipitation at the local gauges; in other instances, events seem to miss the local gauges all together. Local area residents confirm the observation of drier climate in the experimental and control areas of interest. Longer-term data are required before definitive comparisons can be made and to confirm that the local gauges are functioning properly.

3. Examination of daily temperature and precipitation and hourly wind speeds recorded at the EC gauges show no obvious relationship between climate and Osprey breeding success to date.

6. RECOMMENDATIONS

1. More data are required to better define the variation in climate across the experimental and control regions. If valid relationships can be derived to relate short-term local data to long term EC data, long term explanation and prediction are possible.

2. More data are required to confirm that weather stations instruments in use in the region are functioning properly; in particular that the rain gauges are recording all precipitation in the area. Installing a station adjacent to the Goose Bay EC station to enable direct comparison would be one way of validating the apparent differences between long term and local gauges.

3. More detailed data regarding the mortality of the Osprey would help in determining what effects weather may have had in the fledgling success. For instance, continual observation to determine what weather conditions each nest experienced, and whether there was inclement weather at the time of death of the young would be insightful.

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Appendix A. Precipitation and Climate Data at the Goose Bay Airport Climate Station and River Flows at Minipi and Eagle Rivers compared with Osprey nesting success, 1998-2003.

Figure 1. 1993 climate data compared with Osprey nesting success observed during a “Poor” year.

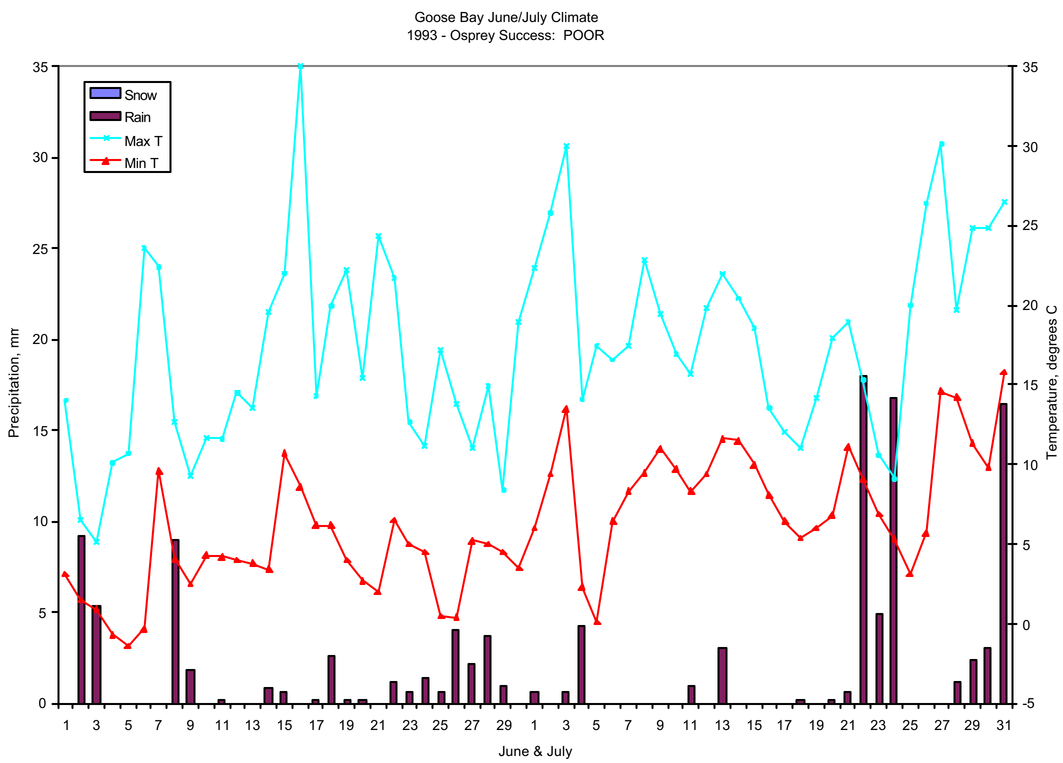


Figure 2. 1994 climate data compared with Osprey nesting success observed during a "Good" year.

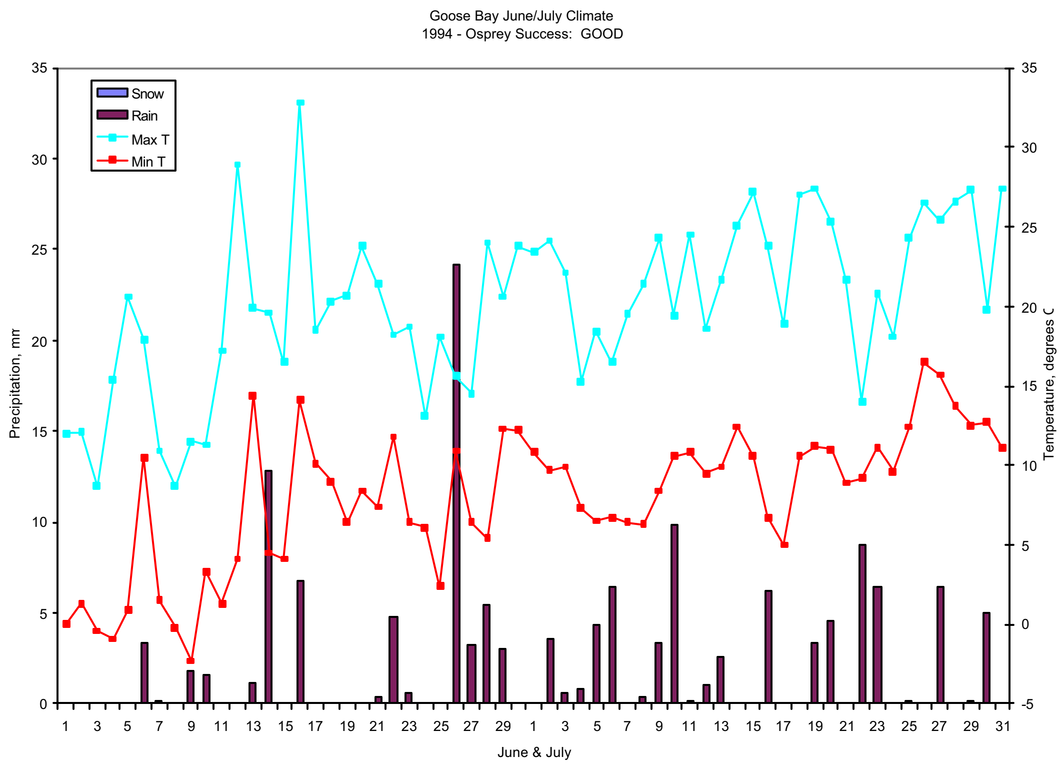


Figure 3. 1995 climate data compared with Osprey nesting success observed during a “Good” year.

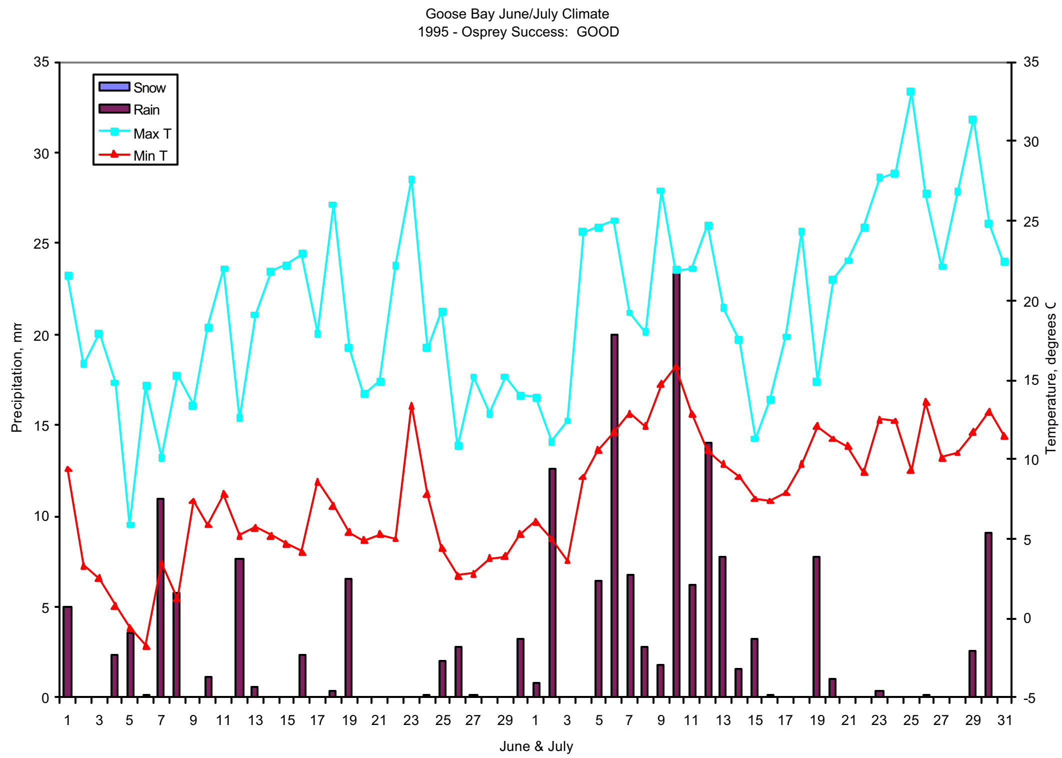


Figure 4. 1996 climate data compared with Osprey nesting success observed during a "Poor" year.

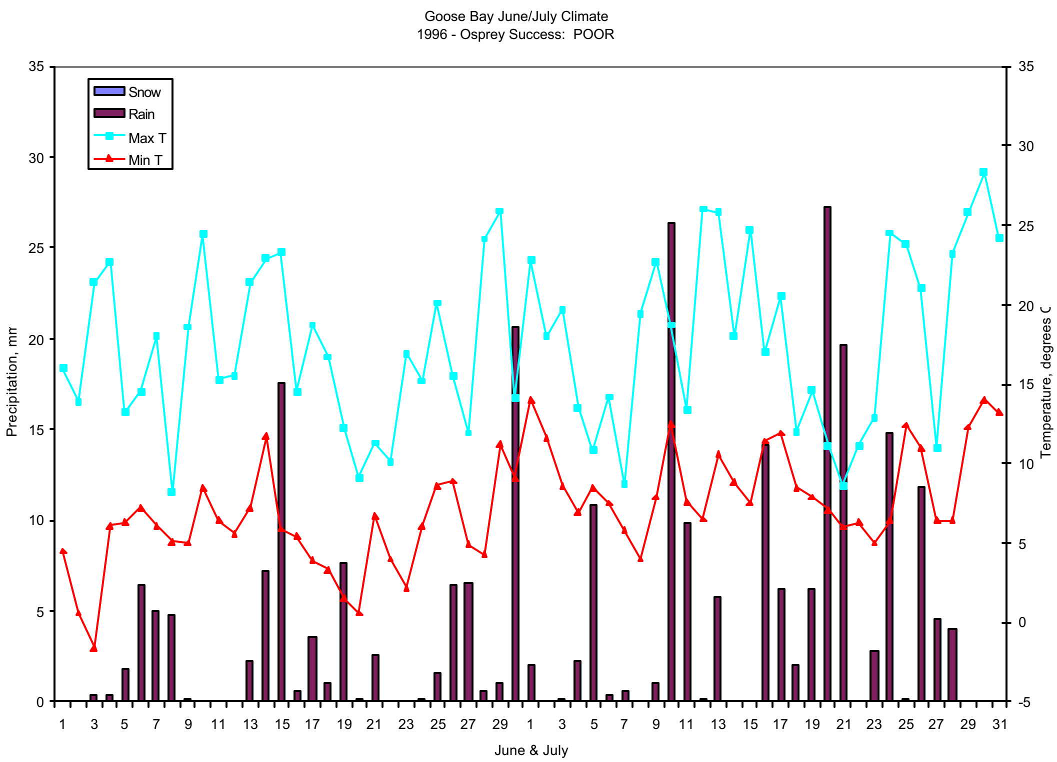


Figure 5. 1997 climate data compared with Osprey nesting success observed during a "Mediocre" year.

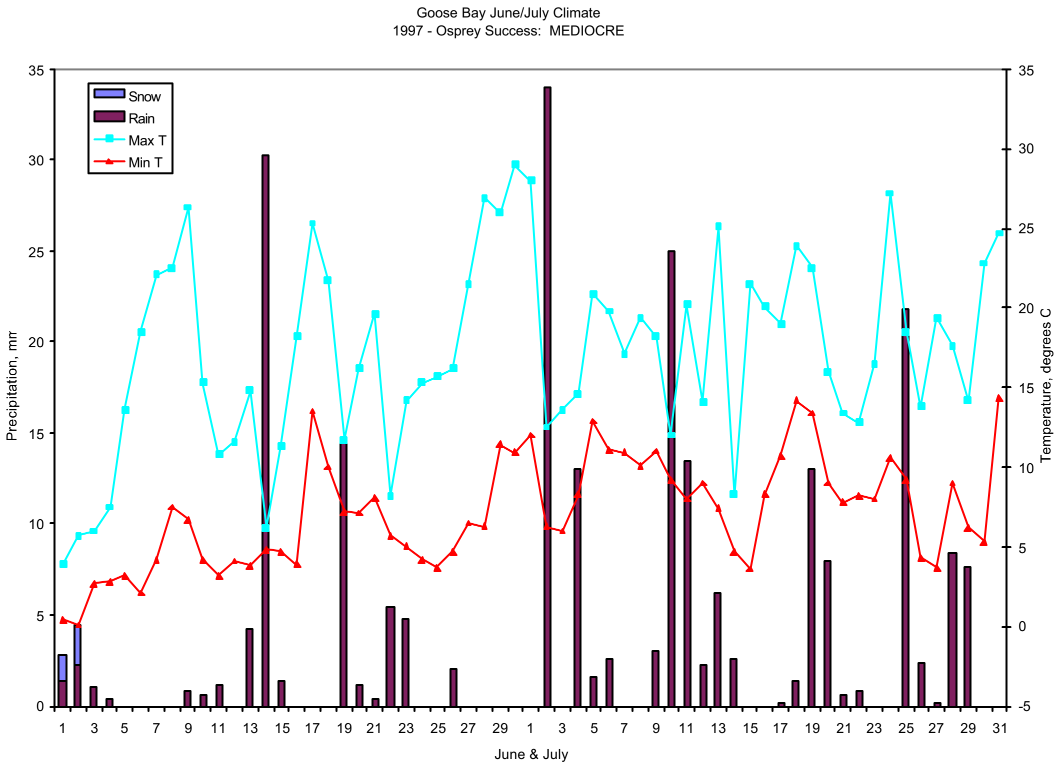


Figure 6. 1998 climate data compared with Osprey nesting success observed during a "Very Good" year.

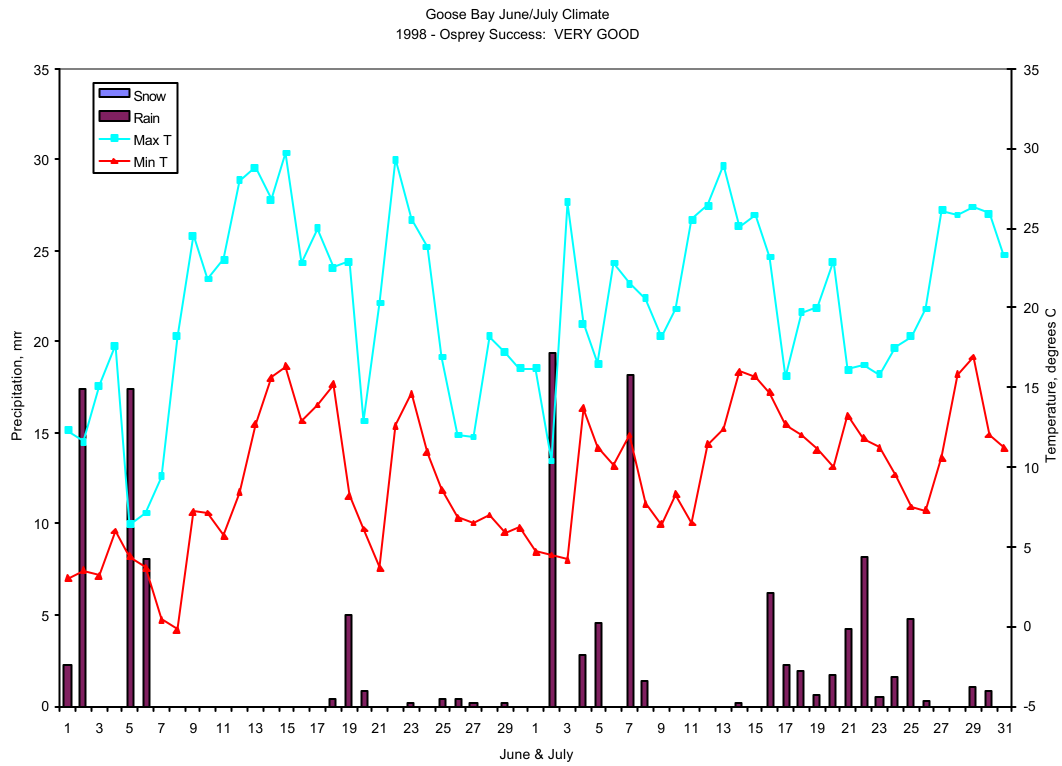
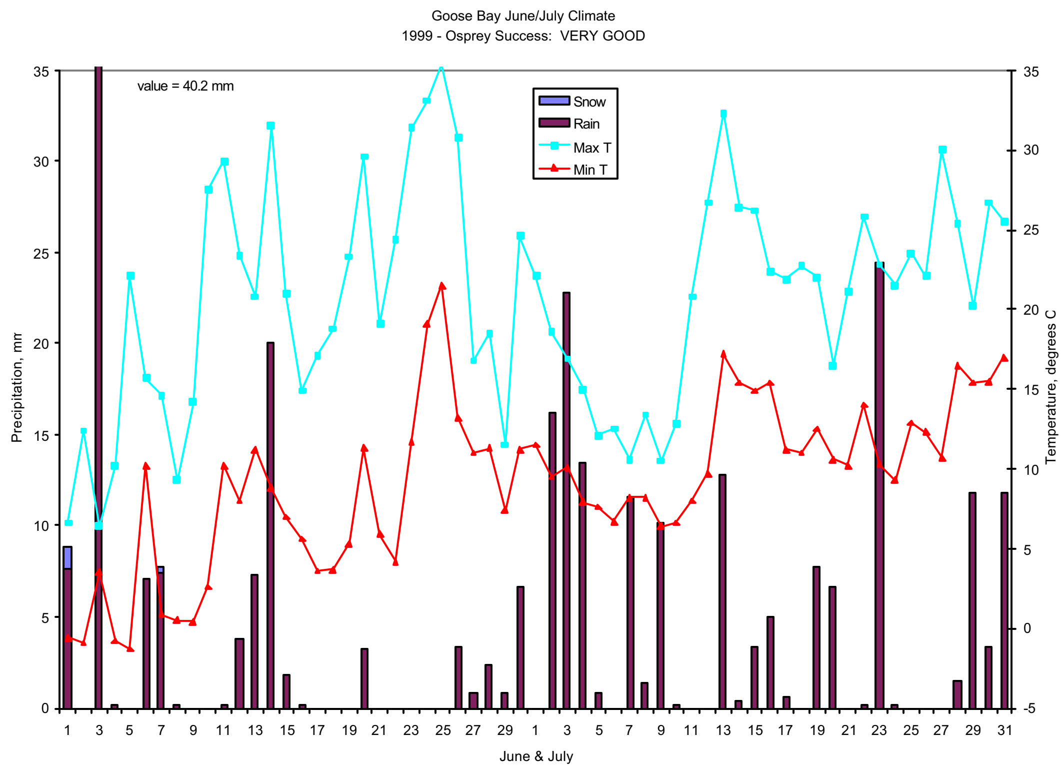


Figure 7. 1999 climate (above) and hydrology (below) data compared with Osprey nesting success during a "Very Good" year.



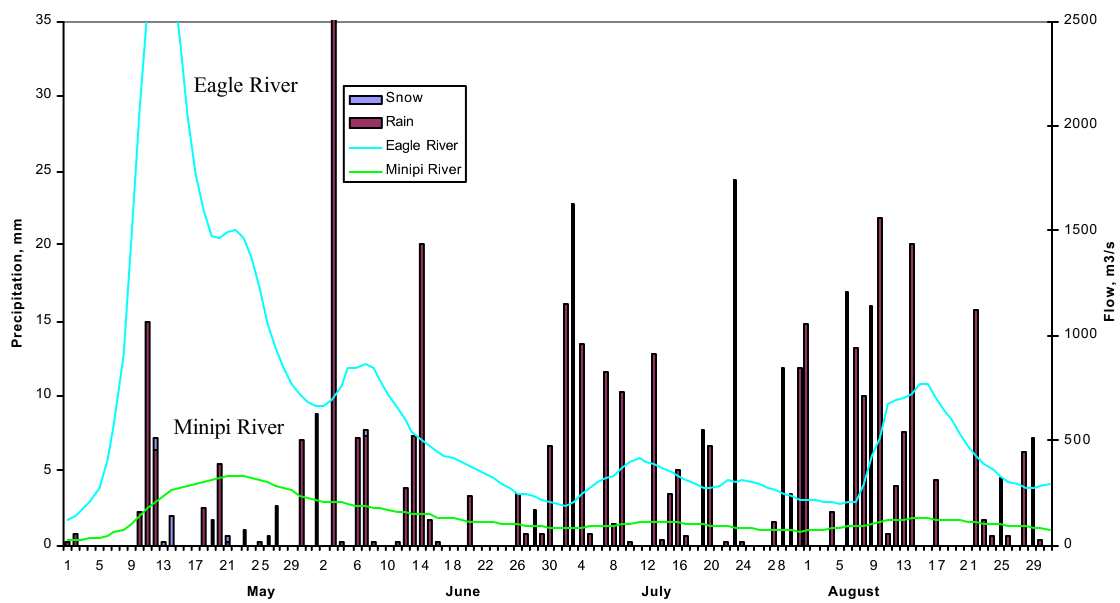
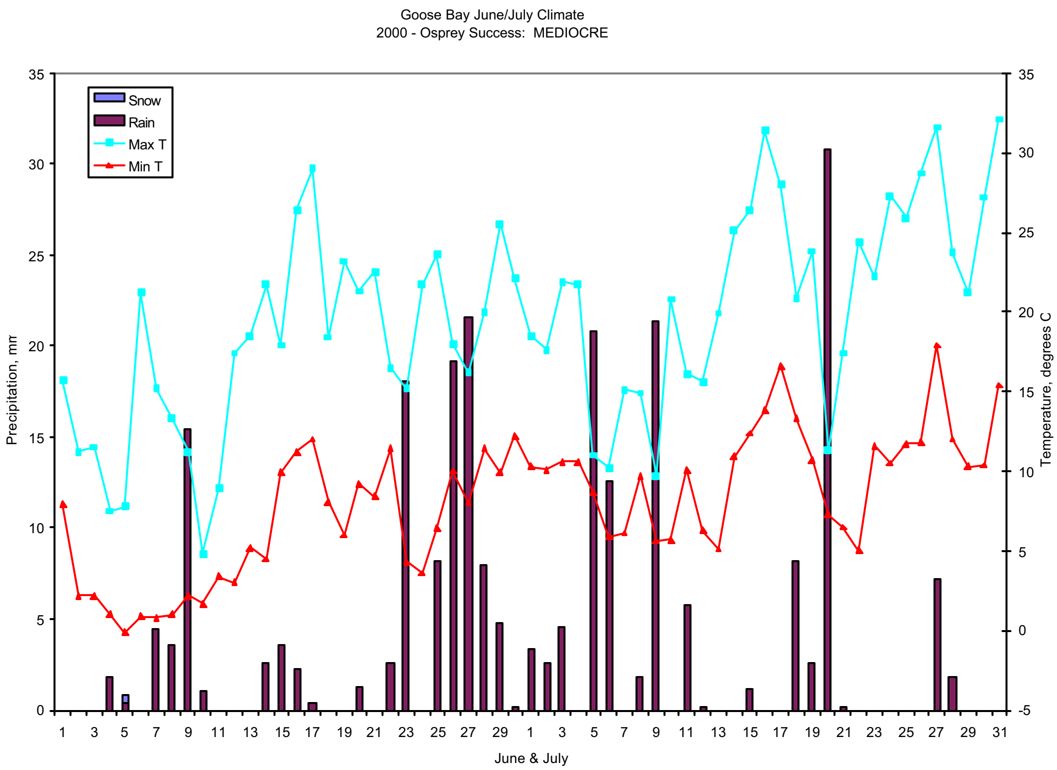


Figure 8. 2000 climate (above) and hyrdology (below) data compared with Osprey Nesting success observed during a "Mediocre" year.



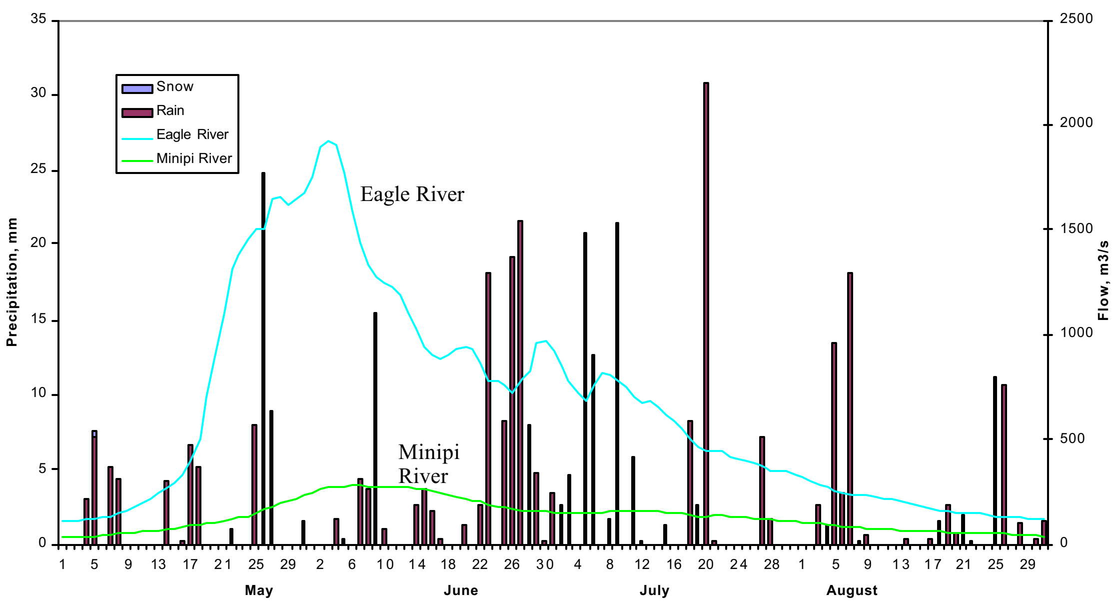
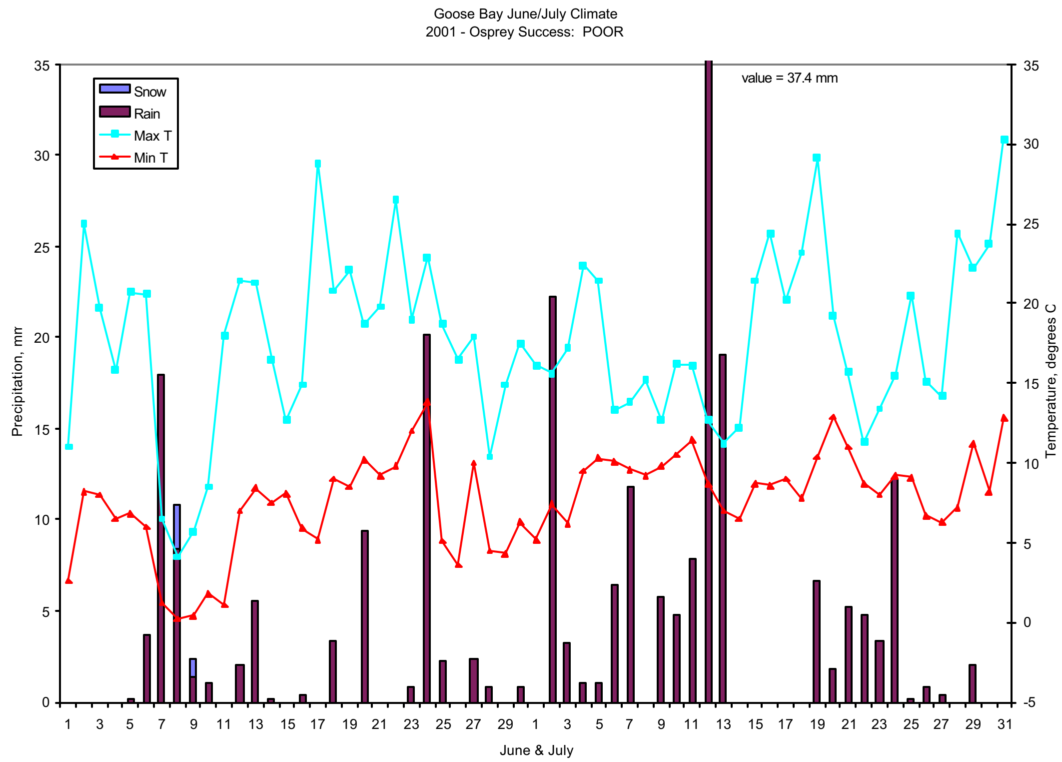


Figure 9. 2001 climate (above) and hydrological (below) data compared with Osprey nesting success during a "Poor" year.



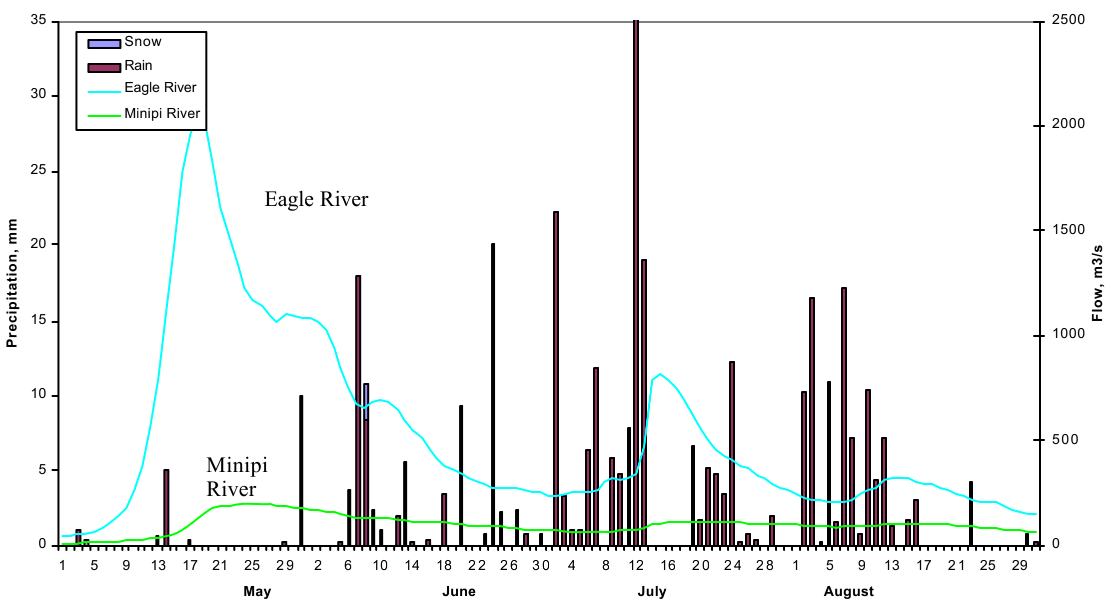
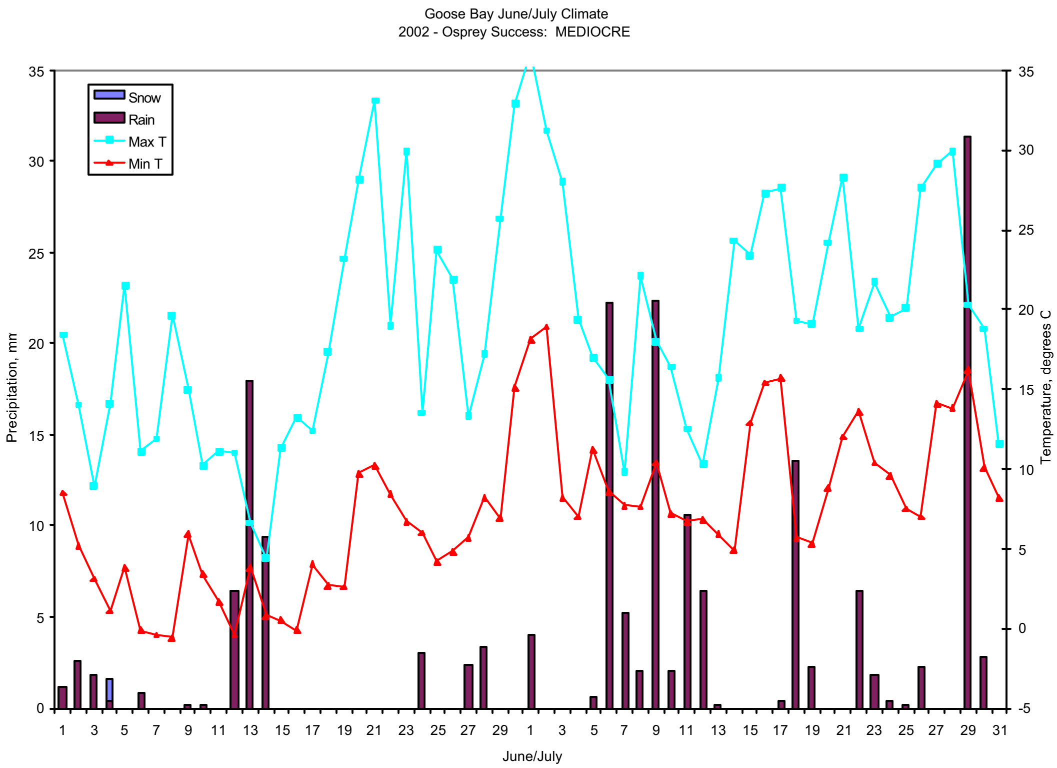


Figure 10. 2002 climate (above) and hydrology (below) data compared with Osprey nesting success during a "Mediocre" year.



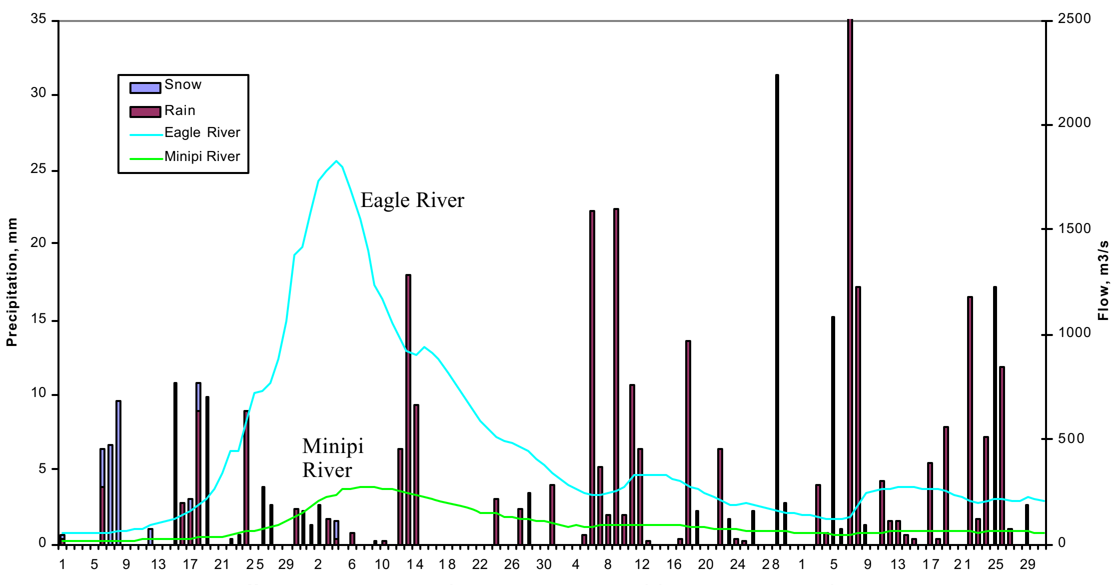
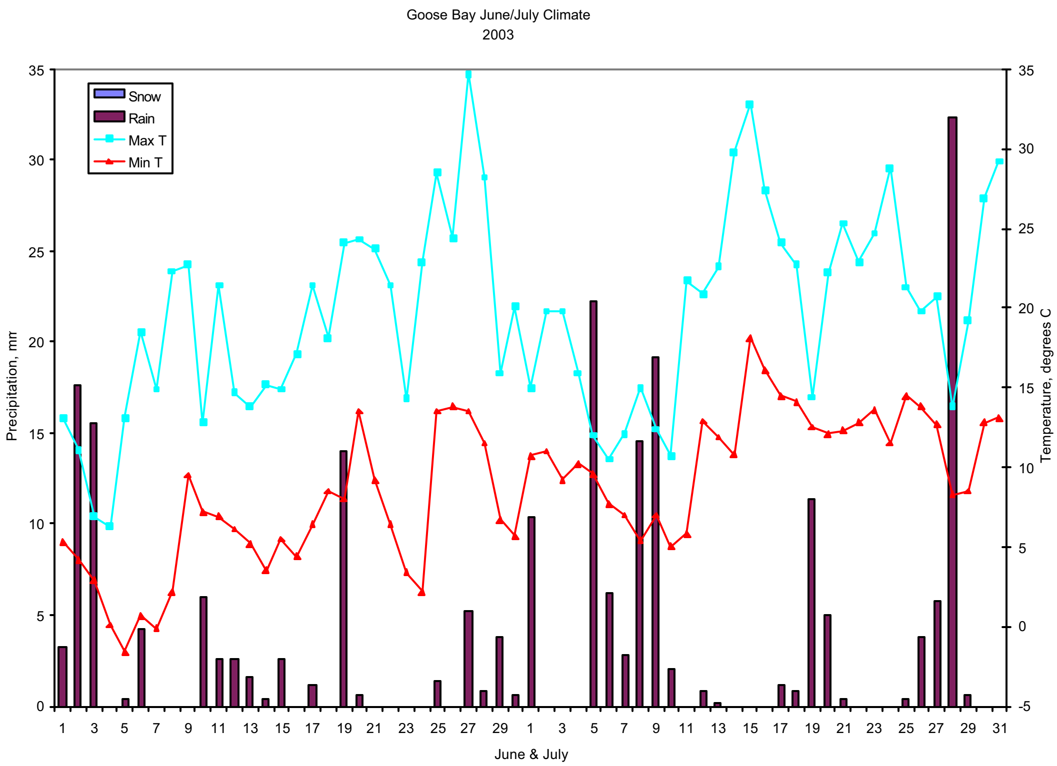
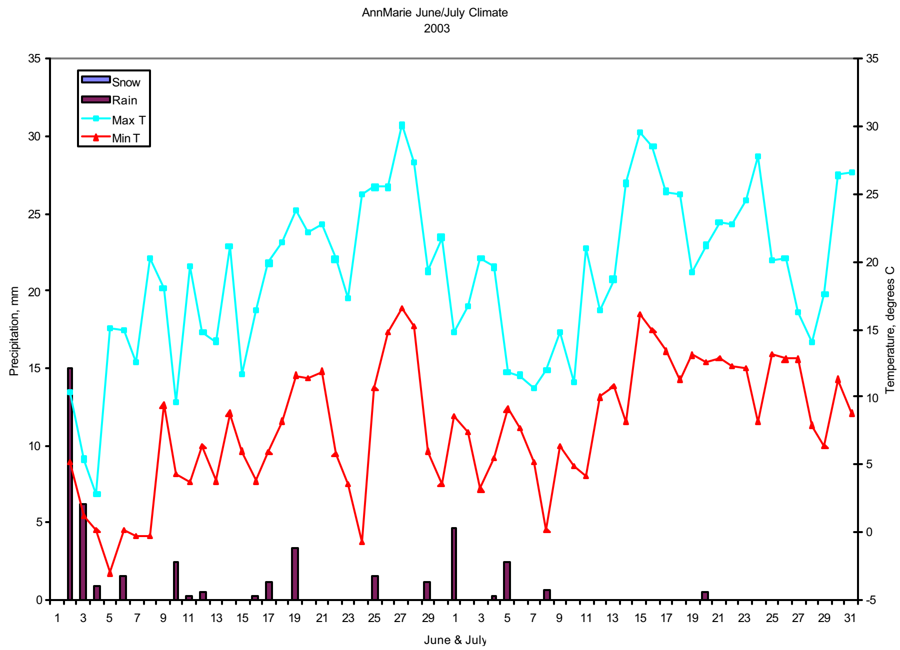
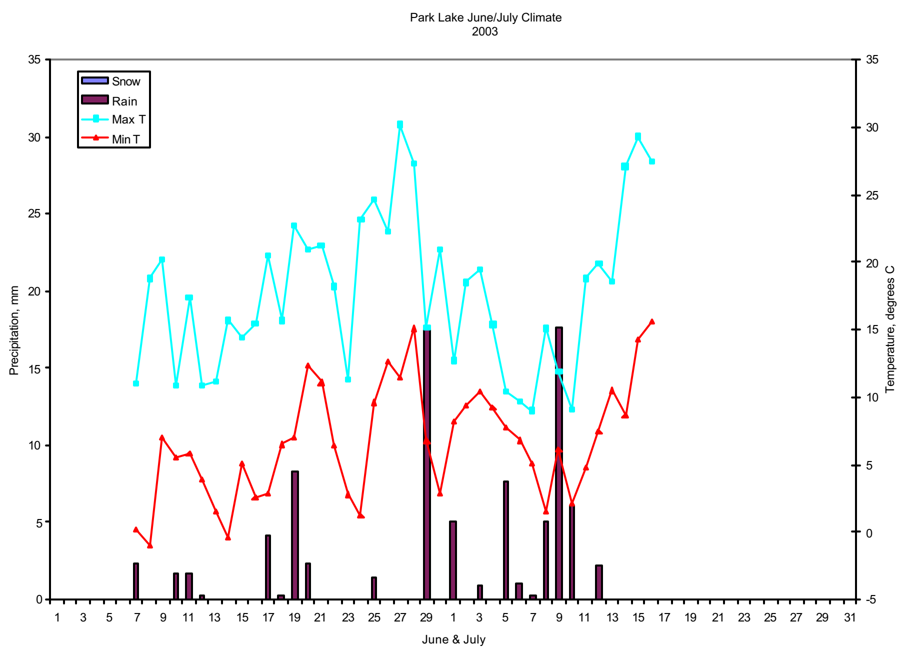


Figure 11. 2003 climate data compared with Osprey nesting success during a “Very Good” year.



Appendix B. Climate data collected at Anne Marie and Park Lakes during.





Appendix C. Number of hours of high winds at Goose Bay and Churchill Falls Climate Stations, 1997-2003.

Figure 1. 1996 wind data collected at Churchill Falls and Goose Bay compared with Osprey nesting success during a "Poor" year.

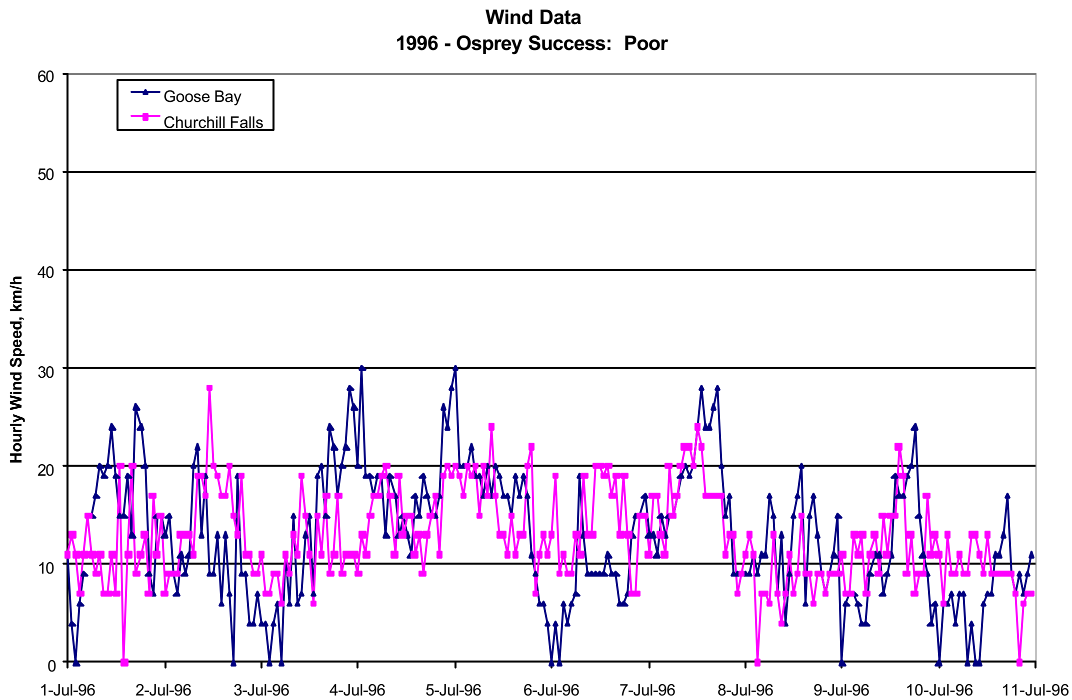


Figure 2. 1997 wind data collected at Churchill Falls and Goose Bay compared with Osprey nesting success during a "Mediocre" year.

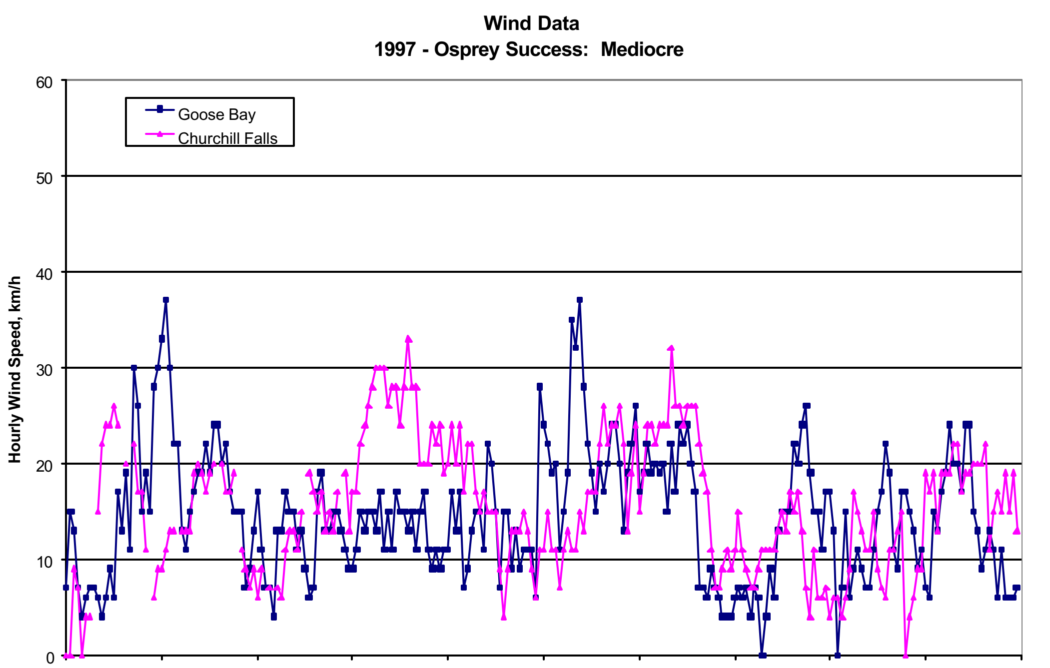


Figure 3. 1998 wind data collected at Churchill Falls and Goose Bay compared with Osprey nesting success during a "Very Good" year.

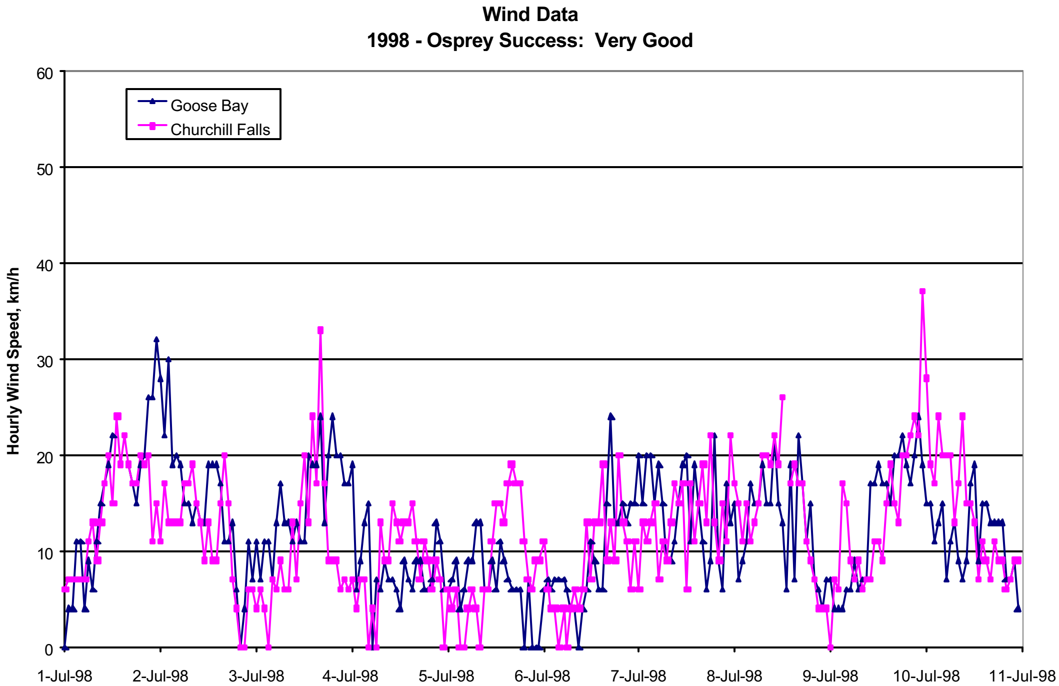


Figure 4. 1999 wind data collected at Churchill Falls and Goose Bay compared with Osprey nesting success during a "Very Good" year.

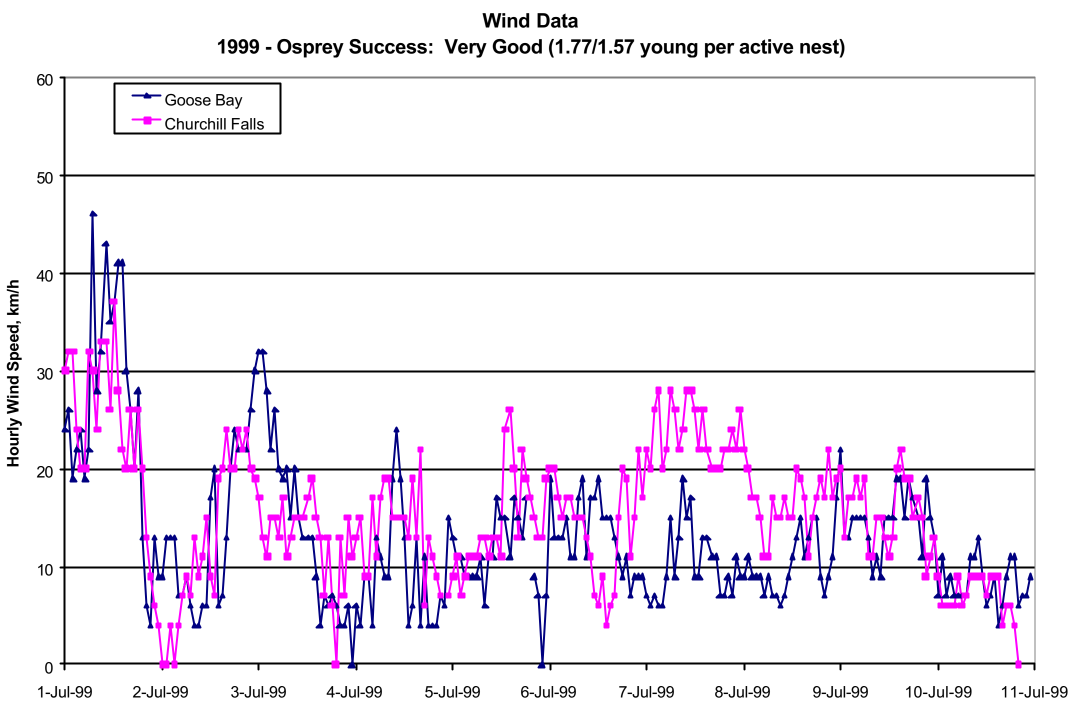


Figure 5. 2000 wind data collected at Churchill Falls and Goose Bay compared with Osprey nesting success during a "Mediocre" year.

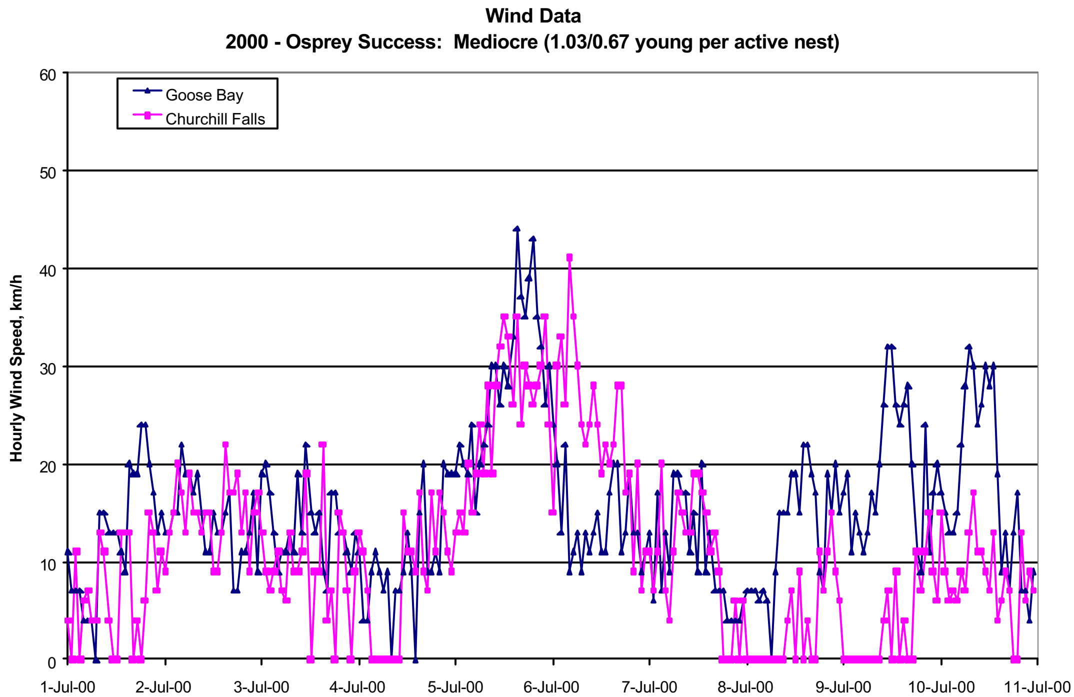


Figure 6. 2001 wind data collected at Churchill Falls and Goose Bay compared with Osprey nesting success during a "Poor" year.

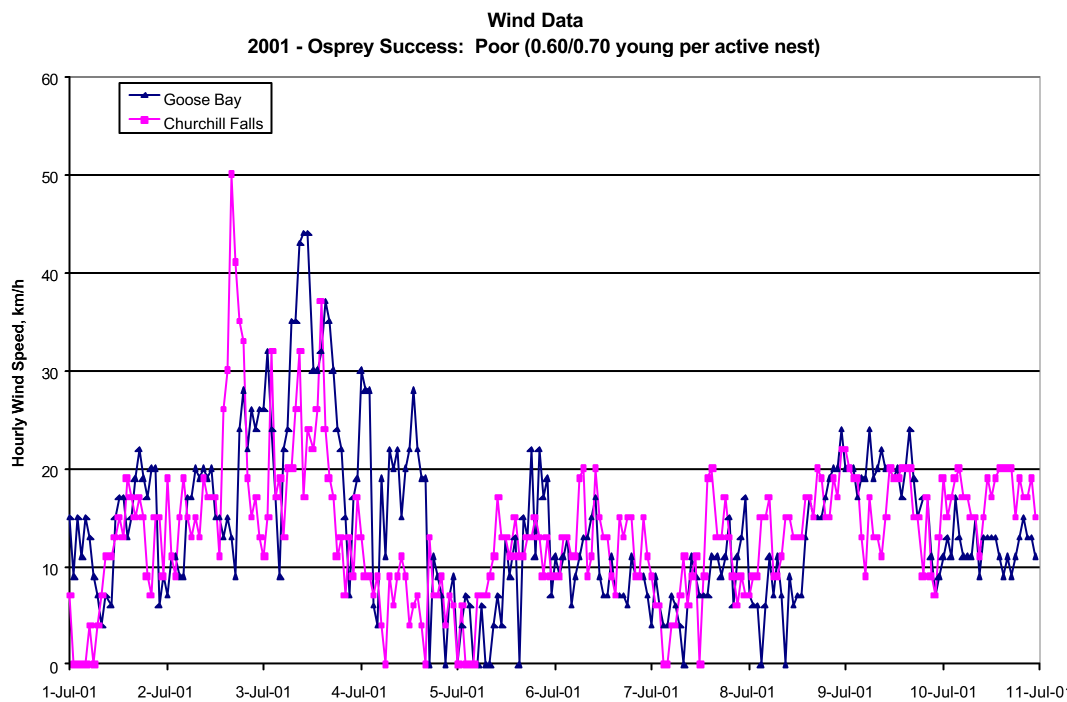


Figure 7. 2002 wind data collected at Churchill Falls and Goose Bay compared with Osprey nesting success during a "Mediocre" year.

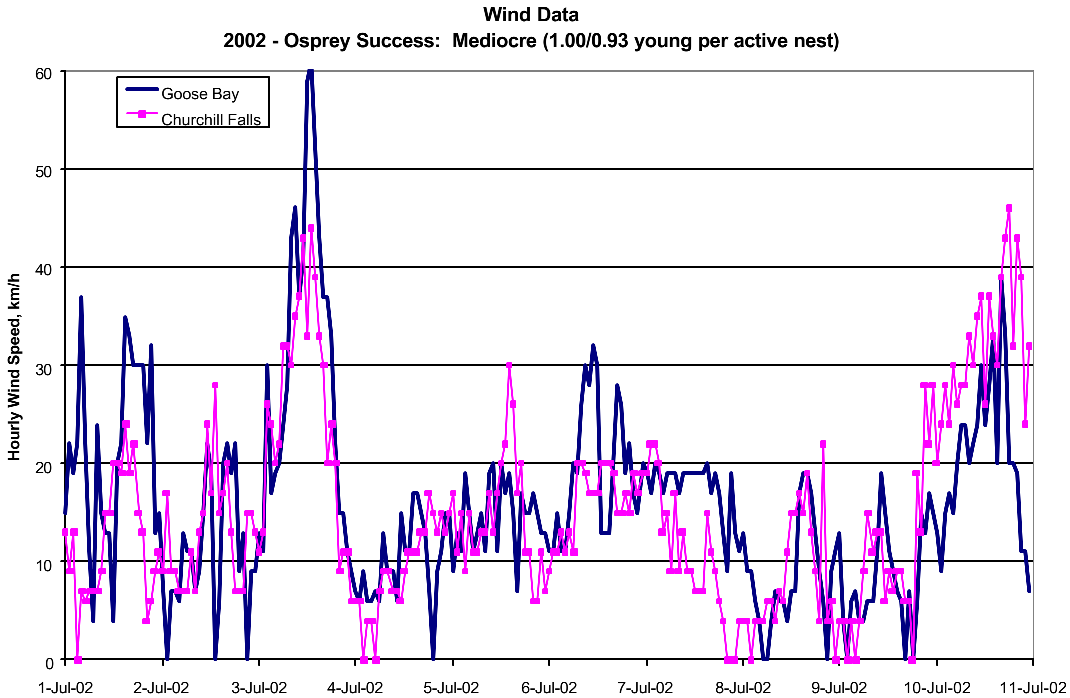


Figure 8. 2003 wind data collected at Churchill Falls and Goose Bay compared with Osprey nesting success during a "Very Good" year.