Peace-Athabasca Delta Waterbird Inventory Program: 1998-2001 Final Report*

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September 2002

Canadian Wildlife Service
Environment Canada

* This report may be referenced as:

Butterworth *et al.*, 2002. Peace-Athabasca waterbird inventory program: !998-2001 Final Report, Ducks Unlimited Canada, Edmonton AB.

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EXECUTIVE SUMMARY

Historically, the Peace Athabasca Delta (PAD) in northeastern Alberta was recognized as one of the most important waterbird areas in North America and is considered a world-class wetland. The United States Fish and Wildlife Service (USFWS), in recognition of its importance to breeding and migrating waterfowl, designated the delta with its own strata (strata 20) in 1956. Two major rivers flow into the PAD, the Peace River in the north and the Athabasca River in the south. During the 1960's the Bennett Dam was built on the Peace River in British Columbia. This dam altered the subsequent hydrology of the large (7050km^2) inland delta that flows into Lake Athabasca. Included in the findings of the Peace-Athabasca Delta Technical Studies Steering Committee 1996 (PADTS) was the fact that the frequency of significant spring flooding of the PAD has decreased since the regulation of the Peace River. It was also determined through the PADTS that the outflow weirs have restored peak summer water levels, but have raised winter water levels and limited seasonal water-level draw down. The subsequent hydrological changes that have occurred in the delta and their potential causes have been varied and difficult to explain or allocate to a single cause (Timoney et. al. 1997, Timoney 2002). Those wetlands that are the most affected are the elevated perched basins that surround the core area of the delta (Timoney *et al*. 1997). The variability of flooding and climatic conditions in the delta since the 1950's has raised certain issues as to how well we understand the flood history of the delta and the influence of the dam (Timoney 2002).

In 1996-1997 a flood from an ice jam resulted in many of the perched basins being flooded for the first time in 25 years. The prediction was that the waterbird use would initially increase followed by a decrease during subsequent years as the basins dried. USFWS survey data of breeding pairs indicated a mean increase of 43% (compared to 5 years pre-flood) and an increase in total ducks of 89% for 1998 and 1999 followed by a decrease to pre-flood levels in 2000. No increase in waterbirds was noted the year of the flood 1997.

The results from surveys initiated in 1998 at the PAD, documented waterfowl use at a very high level for breeding, moulting and staging birds. Staging waterfowl showed a dramatic decline from 1999 to 2001, while breeding waterfowl estimates did not decline until 2001. Brood production declined from 1998 through 2000 but increased in 2001, although the increase was less than that recorded for 1999. Why the different components of the life cycle of waterfowl on the delta show different population changes over the three years is not known at this time.

While the response of waterbirds to the flood of 1996/1997 and subsequent decline in water levels (as indicated by the number of dry basins) support the hypothesis that flood events are crucial to waterfowl use of the delta. The delta continues to host substantial numbers of moulting and staging waterbirds from all four North American migratory flyways, exceeding numbers reported from other reputable staging areas.

We recommend that continued monitoring of the PAD is required to fully understand the effects of drying on a system reliant on flooding. We also recommend that a pilot study be conducted to evaluate the function and hydrology of key perched wetlands within the PAD to determine if waterbird use and productivity will increase with increased water levels. Increased water levels will potentially increase use by fish and muskrats and subsequent traditional use by First Nations. Our proposed approach is to select a perched basin complex in the PAD and flood the complex with water from either the core delta area or the Peace River. This program would follow an adaptive management approach with monitoring and evaluation.

BACKGROUND

The Western Boreal Forest (WBF) covers in excess of 3.0 million km^2 and expands Canada's four western Provinces, three northern Territories and continues into boreal Alaska (Weber and Stocks 1998). Interspersed throughout the spruce/poplar dominated forests are large wetland complexes that can comprise 20 to 30% of the total land cover. These wetland systems are vital to the continent's migratory waterfowl resources. Boreal forest wetlands found west of the pre-Cambrian Shield are among the most productive ecosystems for waterbirds and other wetland dependant wildlife on the continent. These marshes, fens, beaver ponds, shallow lakes, streams, floodplains and deltas are inherently productive as a result of their mineral and organic substrates resulting in both mesotrophic and eutrophic wetland systems (Ducks Unlimited/ University of Alberta unpublished data).

In recent years, increased activity by forestry, oil and gas, mining, hydro-electric, agricultural and recreational interests has greatly expanded the potential for impacts on this forest ecosystem (Province of Alberta 1998), the consequences of which remains largely unknown. Ducks Unlimited Canada's (DUC) Western Boreal Forest Initiative (WBFI) was initiated in the summer of 1997, to help begin to address the lack of information concerning the WBF. Partnerships have been established with industry, government agencies, First Nations, universities, foundations, and others who share DUC's goal of sustaining these important boreal wetland systems. Ducks Unlimited believes this goal is consistent, with and complementary to industry's goal of a developed, yet sustainable forest ecosystem.

Historically, the PAD in northeastern Alberta is recognized as one of the most important waterbird areas in North America and is considered an internationally important wetland. The Bennett Dam altered the subsequent hydrology of the large (7050 km^2) inland delta that flows into Lake Athabasca. The subsequent hydrological changes that have occurred in the delta and their potential causes have been varied and difficult to explain or allocate to a single cause (Timoney et. al 1997, Timoney 2002). Those wetlands that are the most affected are the elevated perched basins that surround the core area of the delta (Timoney *et al*. 1997). The variability of flooding and changes in the delta since the building of the dam has raised certain issues as to how well we understand the flood history of the delta prior to the building of the dam (Timoney 2002). This in turn raises the issue as to how well we can assess the influence of the dam.

Between 1993 and 1996 a cooperative research effort was undertaken by a consortium of interested and affected groups focusing on mechanisms to restore the role of water on the PAD. The logical and designed extension of this research effort is to lead to an Ecosystem Management Plan for the Delta. These efforts were completed in 1996 (Peace-Athabasca Delta Technical Studies Steering Committee 1996). DUC updated and revised the plan in 2000 (Stewart et. al. 2000) at the request of Parks Canada. The over riding tenet of the management plan was that further research is required to understand the flooding history of the delta to refine the application of water management options on the PAD. Also improved hydrological modeling of the Peace River catchment is a top priority**.** This modeling will lead to a better understanding of the flood history of the PAD and aid in identifying the nature of flood/dry cycles.

During both 1996 and 1997, the PAD received floodwaters, which followed a period of protracted drying (Timoney 1996). The lack of research during this re-wetting interval was inopportune given the option of investigating how the delta responded to flooding. Given that recession rates of the delta's perched basins is in the order of 5-7 years, resource managers hypothesized these basins would be optimally attractive to waterfowl for about three years in the absence of a subsequent flood event. Increasing our understanding of how the delta responds to extended dry periods is critically important to future ecosystem management of the delta. Of equal interest and importance is how wildlife, specifically waterfowl and muskrats, respond to the re-watering of the delta. An opportunity to investigate how waterfowl and muskrats utilize habitat on the delta following a flood event, presented itself in 1998. Upon initiation of this project, the information collected was intended for the development of future management scenarios for the delta and to assist in determining the use of various species groups as ecological indicators to the long term functioning and use of the delta.

DUC, at the request of, and in consultation with BC Hydro and Parks Canada staff, initiated development of a proposal to survey the PAD over a multi-year period commencing in 1998. Further discussions with Wood Buffalo National Park, Canadian Wildlife Service, Alberta Sustainable Resource Development, and local First Nations and Metis communities ensured the project met the interests of all involved. The work completed over the 4 years at the PAD compliment additional efforts, at other locations, under the umbrella of the Ducks Unlimited Canada's Western Boreal Region [Utikuma Lake, AB; Fort Nelson, BC; Southern Lakes, YK; Lower Mackenzie River, NT; Sahtu (Norman Wells area), NT; and Pasquia (Saskatchewan River Delta), SK/MB].

METHODS

Site Selection: Basin Specific

The survey effort was initially intended to provide an objective appraisal of response by wetland-dependant birds to recent flood events on the Delta. BC Hydro and DUC proposed that efforts be concentrated on the northern portion of the PAD, as this is the area that has undergone the most serious drought following construction of the Bennett Dam in 1967. Portions of the PAD that received water intermittently since 1974, received less intensive efforts. The basins selected originally reflected what Parks Canada, BC Hydro, Ducks Unlimited Canada and local aboriginal and Metis communities believed to be the most important wetlands to investigate (Figure 1). Additional basins (Jerry's Lake, Duck Lake, and Lynx Stand Bay) identified in consultation with First Nation's representatives and Parks Canada staff were selected to ensure systematic coverage of basin size and hydrologic connectivity subject to size constraints (i.e., < 1250 ha) required by the survey techniques employed.

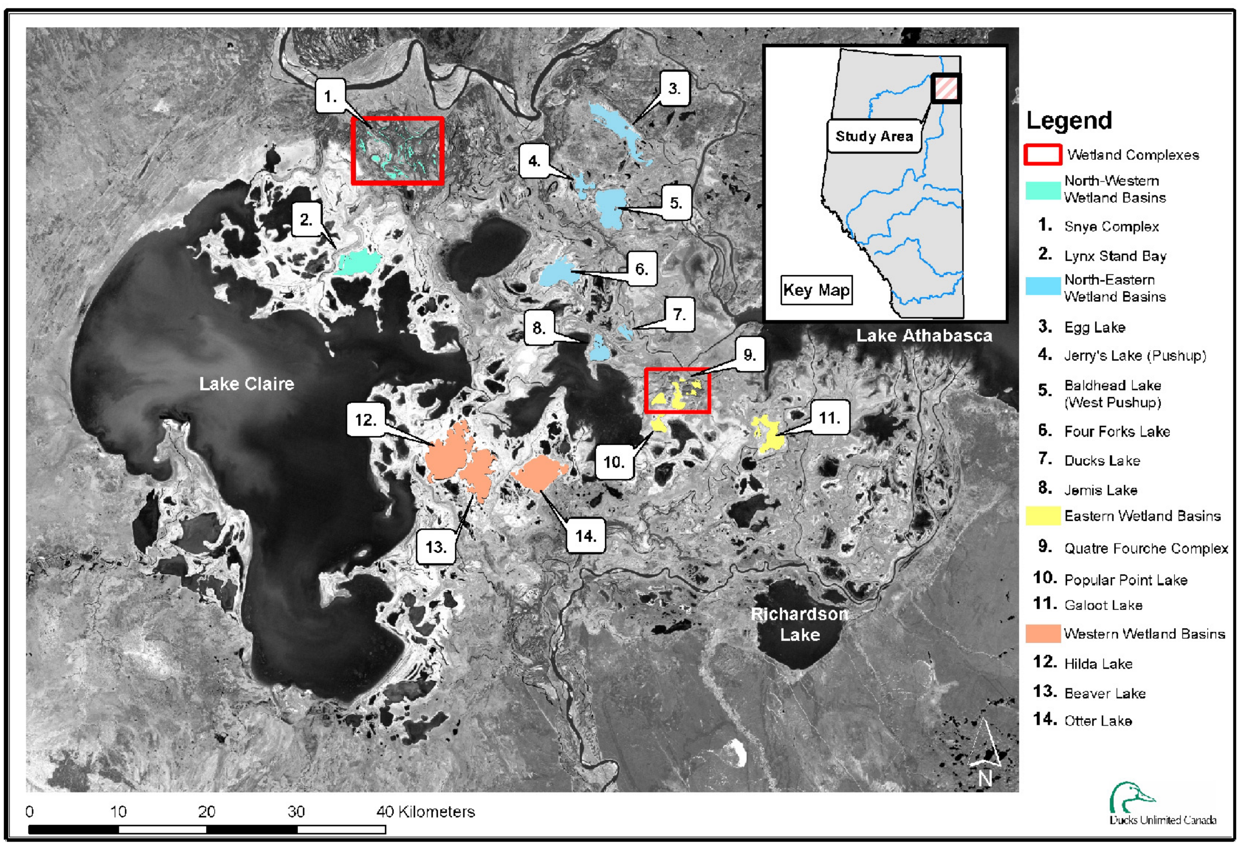

Figure 1. *Basins surveyed on the Peace-Athabasca Delta during breeding pair, brood, and moulting periods, 1998-2001.*

Results from work completed in 1998 and 1999 (Pollard and Stewart 1999, Pollard et. al. 2000) suggested a limitation in our ability to accurately survey breeding pairs and broods on basins exceeding 300 ha in size. Therefore, rotary-wing breeding pair and brood survey efforts in 2000 and 2001 were conducted on the Snye and the Quatre Fourches wetland complexes. These complexes were chosen to look at waterbird use throughout the season in areas with different levels of water availability and not to make delta-wide comparisons with the fixed-wing surveys. As identified in Pollard and Stewart (1999), wetland selection for inventory purposes would ideally incorporate a detailed wetland database. In the absence of this product, continued monitoring of the Snye and Quatre Fourches complexes represented the best opportunity to track changes in waterbird use across the delta over the short term. Additionally, results from 1998 and 1999 indicated that both Otter Lake and Lynx Stand bay hosted large numbers of birds following breeding, and thus were kept in the sample to survey moulting waterbirds. Appendix I contains a complete list of all basins surveyed, their respective locations, and years in which they were surveyed.

Breeding pair estimation on the basins surveyed appears to have been somewhat constrained by the presence of large numbers of migrating, pre-moulting and/or non-breeding waterfowl. For example, 164 pintail pairs were recorded on Popular Point Lake in early May 2000, yet no evidence exists (based on later surveys) suggesting that these birds remained on the PAD to breed (Gendron et. al. 2001). This scenario is not typical of other regions, such as the prairie pothole region, where migrating waterfowl are not normally encountered in high densities during pair surveys. This example demonstrates the complexity of separating local breeding and non-breeding birds and the difficulties to quantifying breeding effort (e.g., pair:brood ratios). For this reason, and to minimize this misclassification or over-representation of breeding ducks on the PAD, the conservative method of defining indicated breeding pairs (i.e. only pairs and lone males) was used for this study.

Site Selection: Delta-wide Transect Coverage

A set of 18 east to west transects oriented along UTM grid lines, running from the Peace River to the south end of Lake Claire along four kilometer intervals, were defined in 1998 (Figure 2). Transects were adjusted slightly in 1999 to extend coverage of the delta to 10%. These adjustments included extending 10 transects east to cover the Chipewyan First Nation Reserve, and shortening the ends of the four southern transects to eliminate unnecessary coverage of forested uplands (Figure 2). Coordinates of the transect endpoints are provided in Appendix II. Given the area of the delta surveyed (5375 km^2), these transects provide the best opportunity to achieve delta- wide estimates of waterbird use throughout the season, and among years.

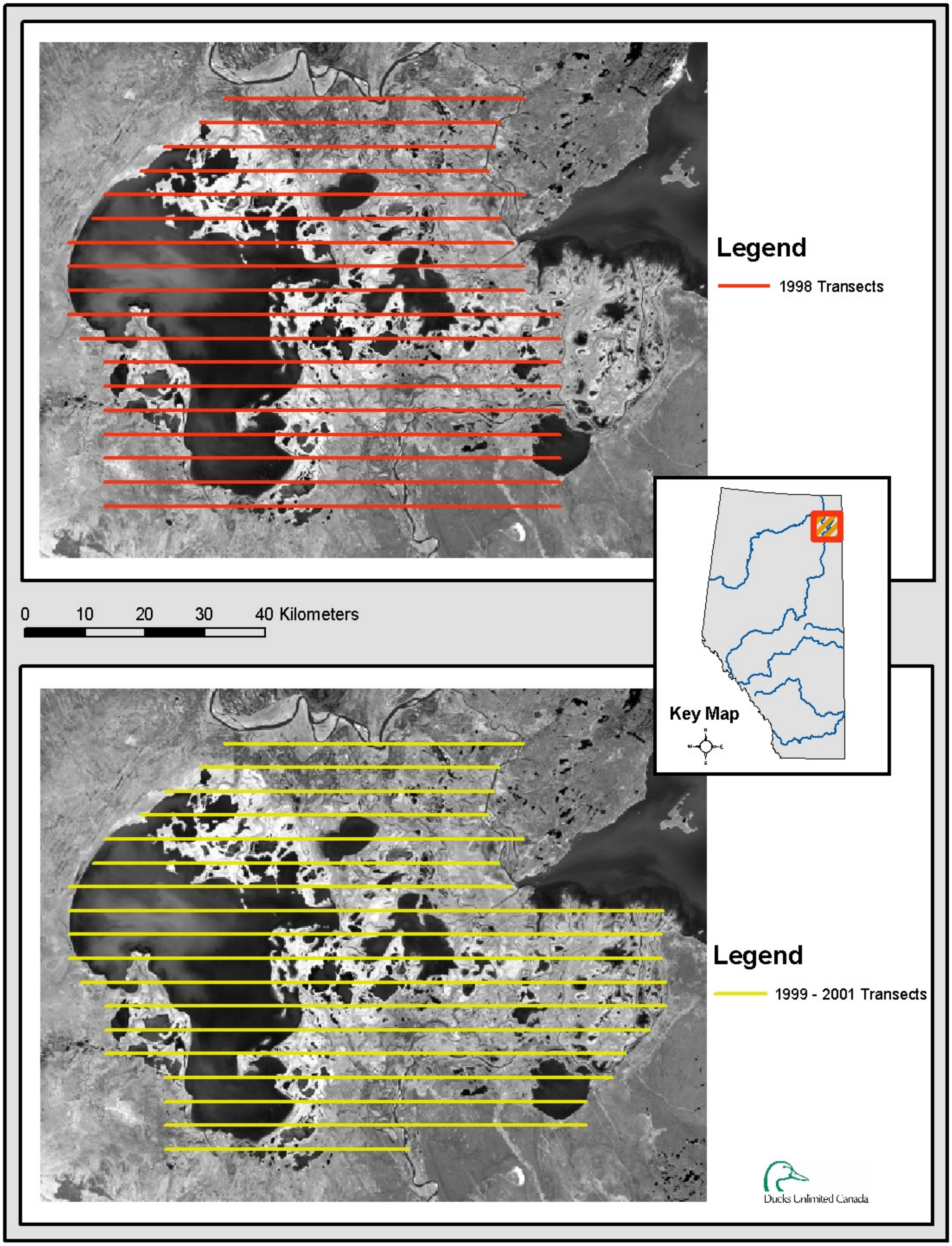

Figure 2. *Transect coverage of the Peace-Athabasca Delta during delta-wide fixed wing breeding, moulting, and staging surveys, 1998-2001.*

Rotary-Wing Breeding Pair, Brood, and Moulting Survey Protocols

Individual wetlands, from both the Snye and the Quatre Fourches basin complexes, functioned as the unit of measure for recording of all observations. Survey repeatability and accuracy was facilitated by using a moving map software (ArcView 3.2a software integrated with a Tracking Analyst extension (Environmental Systems Research Institute Inc. 1996) linked to a global positioning system (GPS). Depending on the size and shape of the basins, different flight paths were required to attain 100% coverage based on maximum estimated visibility (i.e. one central transect, multiple transects, shoreline etc). The survey crew consisted of a pilot, an observer/ navigator seated in the front beside the pilot, and a second observer seated in the rear behind the pilot. Individual observations were recorded on microcassette tape recorders. Techniques employed were adapted from protocols developed by the Canadian Wildlife Service (CWS) for application in Eastern North America for individual wetland basin surveys (Black Duck Joint Venture 1996).

Two breeding pair surveys were conducted in both early and late May for each year, with the exception of 1998, which was surveyed for breeding pairs in late May only (Appendix III). Surveys were flown at a nominal altitude of 35 m, however the survey elevation was occasionally reduced to between 15 and 35 m above ground level (AGL) as required given shoreline complexity, vegetative cover conditions, or unconfirmed species or sex. As well, ground speeds did not exceed 100 km/h during the active survey effort however, over areas with reduced visibility (e.g. heavy vegetated cover), significantly slower speeds (e.g. 30 km/h) were employed. Breeding pair surveys required the recording of species, sex, and social status for all waterbirds observed.

Two brood surveys were conducted each year to document waterbird productivity for early and late nesting species (Appendix III). Surveys were flown using the same protocols described above for the rotary-wing breeding pair surveys. For the brood surveys, species, age, brood size, and number of adults present were recorded. Age of duck broods were estimated based on Gollop and Marshall (1954).

Consistent with timing of the brood surveys, Lynx Stand Bay and Otter Lake were surveyed for moulting birds. Survey protocols were similar to those described above. Complete coverage was obtained by flying multiple transects over the long axes of the basins, as was done with the smaller basins.

Fixed-Wing Breeding Pair, Moulting, and Staging Survey Protocols

Two fixed-wing breeding pair surveys were scheduled to capture delta wide pair use of early (early May) and late nesting species (late May). Surveys differed slightly to those employed by the USFWS (Black Duck Joint Venture 1996). Observers recorded all observations within 300 m of the aircraft flight path (150 m to each side) at a nominal elevation of 40 m, as opposed to a 400 m flight path employed by the USFWS.

Large concentrations of moulting and staging waterbirds were recorded on several of the larger basins on the delta (e.g., Lynx Stand Bay, Otter Lake) (Gendron et. al. 2001). Therefore in 2001, two mid summer delta-wide surveys were added to compliment the existing fall surveys and to capture moulting and pre-migration use of the delta. Surveys were conducted using a Cessna 185 or 206 on floats in late June, late July, late August, mid September and late September and were flown at a nominal elevation of 100 m above ground level and observations were recorded within 400 m of the aircraft flight path (200 m to each side).

Survey Data Analysis

The breeding survey most accurately reflecting the onset of breeding (i.e. optimal surveying time) was used to calculate breeding effort for each species observed. This optimal survey time was achieved by determining, where possible, the median clutch initiation dates by species. Breeding chronology was calculated using brood data and back-dating (Wishart 1983, Klett 1986). Broods possessing clutch initiation dates preceding the minimum dates identified in Table 1, were re-classified in the database as moulting or staging birds (Brua 1999, Petrula 1991, Nieman 1972, IWWR/Ducks Unlimited, unpublished). Because the breeding pair surveys are designed to capture breeding effort of first waterfowl nesting attempts, broods with clutch initiation dates exceeding the maximum dates shown in Table 1 were re-classified as second nest attempts, and therefore not included in the estimation of median clutch initiation dates. When possible, maximum clutch initiation dates were determined by looking at the spread of clutch initiation dates for the species over multiple years. Obvious breaks in the distribution of these dates, preceding further clutch initiation date spikes, were used to cut off peak breeding intervals for species. Median clutch initiation dates were calculated using broods with median clutch initiation dates falling between these minimum and maximum extremes (Table 1). For species with insufficient data (i.e. low number of broods recorded), breeding effort was calculated using methods from similar studies in other regions.

The numbers of breeding waterfowl were summarized using the number of indicated breeding pairs (IBP). The latter employs the sum by species of pairs and lone males recorded. Waterfowl breeding population estimates were calculated for each complex during the basin surveys. Based on the median clutch initiation dates mentioned above, breeding survey I was used to calculate IBPs for mallard (Anas platyrhynchos), redhead (Aythya americana), canvasback (Aythya valisineria), northern pintail (Anas acuta), and common goldeneye (Bucephala clangula). Survey II provided the IBP for ring-necked duck (Aythya collaris), lesser scaup (Aythya affinis), gadwall (Anas strepara), blue-winged teal (Anas discors), American green-winged teal (Anas crecca), and ruddy duck (Oxyura jamaicensis). Bufflehead (Bucephala albeola), American wigeon (Anas americana), northern shoveler (Anas clypeata) and all unidentified species had the

IBP calculated using an average of both surveys. Although individual wetlands functioned as the unit of measure for recording all observations, data from wetland complexes consisting of smaller wetlands in close proximity to one another were combined to produce complex abundance and density estimates.

Table 1. *Clutch initiation date (CID) cut-offs for breeding waterfowl on the PAD, 1998-2001.*

SPECIES	Minimum CID (Julian Date)	Maximum CID (Julian Date)
Common Goldeneye	20 April (110)	03 June (154)
Mallard	25 April (115)	29 May (149)
Blue-winged Teal	03 May (123)	16 June (167)
Canvasback	04 May (124)	02 June (153)
Redhead	04 May (124)	-
American Green-winged Teal	04 May (124)	12 June (163)
Northern Shoveler	05 May (125)	23 June (174)
American Wigeon	10 May (130)	23 June (174)
Gadwall	10 May (130)	-
Lesser Scaup	20 May (140)	-
Ring-necked duck	20 May (140)	-
Ruddy Duck	30 May (150)	-
Unidentified Diver	Observations > Class 2A in late June deleted	-

Species identification during moulting and staging is difficult. This is in part due to the aircraft employed for these surveys (fixed versus rotary-wing) and also due to the likely presence of young of the year birds. Plumage characteristics for young of the year observed in early September is typically lacking in distinguishing feather color (Natal, Juvenile or Basic I plumage; Baldassarre and Bolen 1994) limiting the observers ability to identify individuals to species. Observations however can be combined into major species groups (or guilds) referred to as dabblers and divers.

Ideally, waterbird estimates would be associated with an accurate classified habitat inventory of the Delta. Because such product is unavailable, a classification of major drainages of the delta (Prowse and Demuth 1993) based on flow regime was used to estimate abundance and density from breeding, moulting and staging waterbirds during the fixed-wing surveys. The 3 classes (i.e. open, restricted, and severely restricted water flow) described by Prowse and Demuth (1993) were further subdivided based on wetland complex and/or general habitat and geographic features (Figure 3).

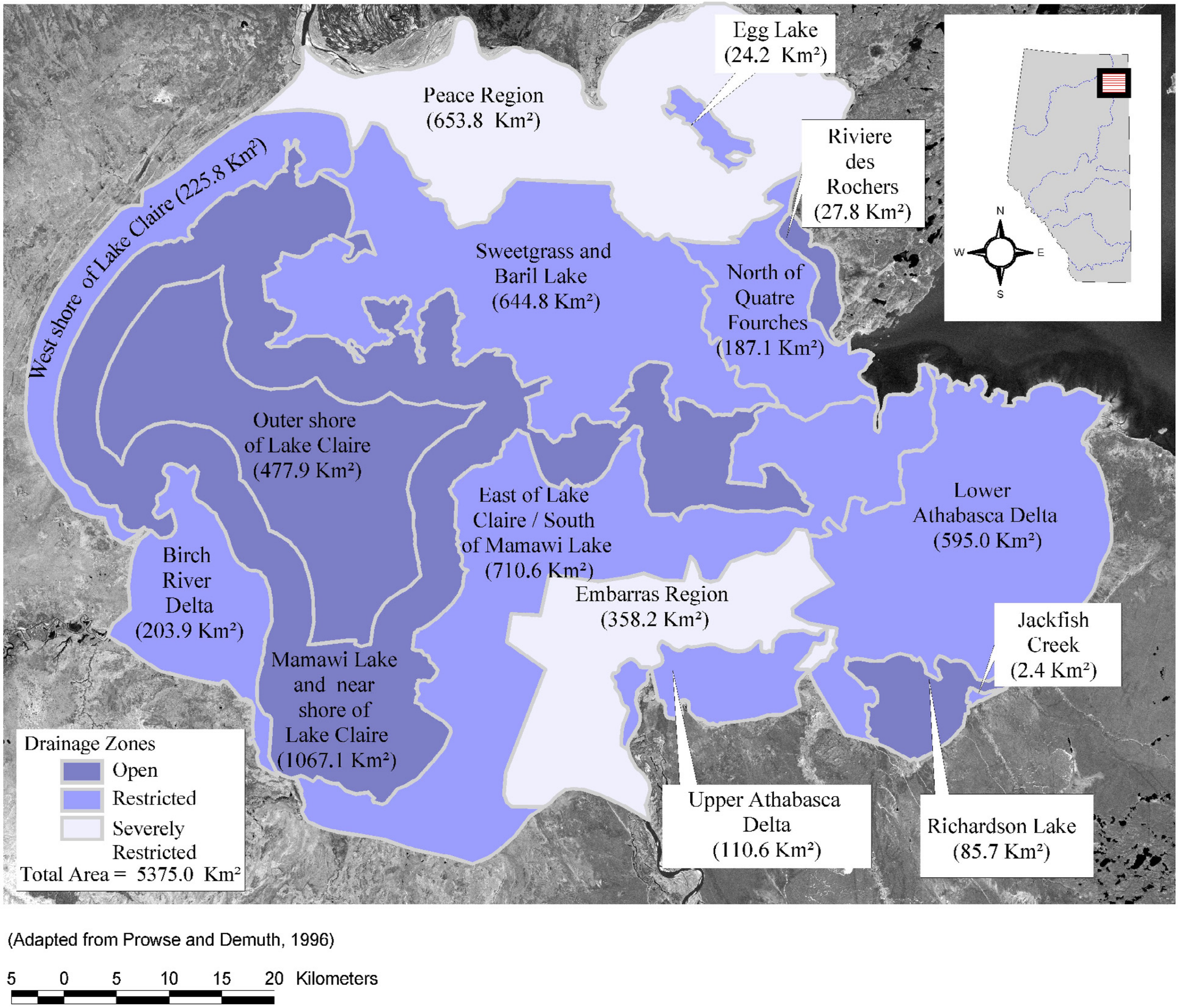

Figure 3. *Regional subdivisions of major drainage water flows of the Peace-Athabasca Delta. Based on Prowse and Demuth (1996).*

Integrating estimates of waterbird abundance from the 3 survey intervals, late August, mid-September and late September, generated estimates of total waterbird use for September 1999 to 2001. Delta-wide estimates of waterbirds from each staging survey were averaged and then multiplied by the number of days between the first and the last survey to achieve total waterbird use days. Waterbird estimates can be considered conservative as no visibility correction factor was applied. This is especially the case for species such as American green-winged teal, which have high visibility correction factors or adjustments. The formulas outlined below describe basic procedures for estimating delta-wide estimates of total waterbirds and waterbird use days.

Estimate of Delta Wide Totals = $\sum_{zone\ i}$\{(Observed waterbirds$_{zone\ i}$ X Total Area$_{zone\ i}$) / Area Surveyed$_{zone\ i}$\}.

Where:

Zone i = Zones 1 to 14,

Observed waterbirds$_{zone\ i}$ = total waterbirds or IBP observed within a zone,

Total Area$_{zone\ i}$ = total area of a zone,

Area Surveyed$_{zone\ i}$ = area surveyed within a zone.

Waterbird Use Days = (Total Estimated Waterbirds / Number of Surveys) X # Days Between Surveys.

Densities of waterbirds in each of the drainage zones were calculated and compared among years. Waterbird densities within zones were determined by dividing the total estimated waterbirds within a zone, by the zone's area. Summing observations and applying a correction factor consistent with the extent of survey coverage in each polygon derived total waterbird population estimates for the entire delta.

RESULTS

Basin-specific Breeding Pair Surveys

Surveys were initiated on the PAD in late May 1998. The breeding pair survey effort in 1998 was terminated prior to completion of scheduled surveys in order to facilitate the procurement of a Federal Research and Collecting Permit. Breeding surveys on all scheduled basins were completed successfully in early and late May 1999, 2000, and 2001 (Appendix III). A summary of breeding pair observations by guild is provided in Table 2. In both 1998 and 1999, diving ducks dominated the breeding ducks on the majority of all basins. Although not all basins were surveyed in 1998, it appears as though pair density increased in 1999 (Table 2).

Specific to the Snye and Quatre Fourches basins, breeding pairs increased in 2000 but decreased in 2001 to levels 49% below those of 1999 (Table 3). Mallard was, by far, the most abundant species present each year. Ring-necked duck, blue-winged teal, and northern pintail, all dominant breeding species each year, experienced decreases in IBP from 1999. Lesser scaup, American wigeon, shoveler, American green-winged teal, canvasback, and ruddy duck also decreased, whereas only bufflehead, common goldeneye, gadwall, redheads, and scoters showed increases (Table 3).

Table 2. *Peace-Athabasca Delta rotary-wing waterfowl Indicted Breeding Pair (pairs and lone males) survey results by species and basin or basin complex in 1998 and 1999*

Basin or Complex	Area (ha)	Dabblers		Divers		Total IBP		IBP/ ha		Total Ducks	
		98	99	98	99	98	99	98	99	98	99
Egg Lake	1137	120	323	225	333	345	679	0.303	0.597	1081	1564
Four Forks Lake	932	-	139	-	62	-	201	-	0.216	-	309
Galoot Lake	735	-	120	-	7	-	130	-	0.176	-	577
Jemis Lake	412	-	151	-	66	-	216	-	0.524	-	1167
Lynx Stand Bay	996	-	120	-	148	-	280	-	0.281	-	1851
Otter Lake	1464	-	90	-	231	-	324	-	0.221	-	993
Popular Point Lake	223	-	152	-	17	-	165	-	0.739	-	647
Jerry's Lake	1151	49	51	77	68	126	118	0.109	0.102	396	258
Quatre Fourches	513	-	600	-	58	-	643	-	1.253	-	2222
The Snyes	453	-	301	-	241	-	530	-	1.169	-	1125
Baldhead	296	28	30	59	91	87	114	0.294	0.385	344	360
Total	8312	197	2075	361	1319	558	3397	0.216	0.409	1821	11071

Table 3. *Peace-Athabasca Delta rotary-wing waterfowl Indicted Breeding Pair (pairs and lone males) survey results by species for the Quatre Fourches and Snyes complexes, from 1999- 2001.*

Species[1]	IBP Interval[2]	Basin Complex									Change from 1999 (%)
		Snyes			Quatre Fourches			Total IBP			
		1999	2000	2001	1999	2000	2001	1999	2000	2001	
MALL	I	172	164	90	348	324	126	520	488	216	-58
RNDU	II	98	72	61	27	12	8	125	84	69	-45
BUFF	Avg	24.5	53	33.5	3.5	2	4	28	55	37.5	34
BWTE	II	31	64	26	20	59	11	51	123	37	-27
NOPI	I	3	1	6	119	71	30	122	72	36	-70
AMWI	Avg	10	36.5	16.5	52.5	48	18.5	62.5	84.5	35	-44
NSHO	Avg	21	15	15	31	57.5	19	52	72.5	34	-35
COGO	I	21	27	20	1	5	5	22	32	25	14
GADW	II	3	13	12	3	30	9	6	43	21	250
LESC	II	40	39	15	6	1	5	46	40	20	-57
AGWT	II	36	102	12	8	20	4	44	122	16	-64
CANV	I	36	40	12	18	28	4	54	68	16	-70
RUDU	II	15	11	13	0	5	0	15	16	13	-13
REDH	I	5	8	2	3	14	9	8	22	11	38
SCOT	II	1	2	2	0	0	0	1	2	2	100
MERG	Avg[3]	0	0	0.5	0	1	0.5	0	1	0.5	-
UNDA	Avg	4.5	1	0.5	0.5	0.5	0	5	1.5	0.5	-90
UNTE	II	1	0	0	1	0	3	2	0	3	50
UNDU	Avg	4.5	3	0.5	0.5	3.5	0.5	5	6.5	1	-80
UNDI	Avg	3.5	4.5	3.5	0.5	1	0	4	5.5	3.5	-13
Total		**530**	**656**	**342**	**643**	**683**	**257**	**1173**	**1339**	**598**	**-49**

Delta-Wide Transect Breeding Pair Surveys

Adverse weather conditions (i.e., snow, strong winds) prevented the completion of scheduled fixed-wing breeding pair surveys in 2000 and 2001. Four transects from the second breeding pair survey in 2000 were not flown. In 2001, the first survey in early May was not flown due to a delayed ice break up. Estimates of breeding pair abundance were analyzed using a reduced area of the Delta (transects 5-18) for comparison among years (Table 4). Breeding pair estimates for 2001 were 54% below 1999. The greatest observed decline in indicated breeding pairs included American green-winged teal, canvasback, mallard, ring-necked duck, and American wigeon. Only gadwall and ruddy duck indicated breeding pairs increased from 1999 to 2001 (Table 4). Mallards, the dominant species in the PAD, were most abundant in 2001, followed by gadwall, lesser scaup, bufflehead, and northern shoveler. Breeding pair density was not associated with regional water flow (i.e., open, restricted and severely restricted water flow; Fig. 3) across the PAD in both 1999 and 2000 (Kruskal-Wallis test, 1999: $p = 0.10$, 2000: $p = 0.51$). Total ducks declined from 1999-2001 by 32%. A substantial decline in the number of total ducks was observed for American green-winged teal, common goldeneye, canvasback, and lesser scaup (Table 4).

Table 4. *Species-specific Indicted Breeding Pair (pairs and lone males only) and total estimated ducks derived from delta-wide fixed-wing transect surveys on the Peace-Athabasca Delta, 1999-2001.*

	IBP						Total Ducks					
	1999		2000	2001		Change	1999		2000	2001		Change
Species	**All[1]**	**5-18[2]**	**5-18[2]**	**All[1]**	**5-18[2]**	**from 1999 (%)**	**All[1]**	**5-18[2]**	**5-18[2]**	**All[1]**	**5-18[2]**	**from 1999 (%)**
MALL	6,986	5,819	8,013	2,013	1,701	-71.19	22,676	19,331	22,698	16,098	13,577	-29.01
GADW	282	282	2,240	1,956	1,646	+593.48	573	546	4,966	4,269	3,659	+645.02
LESC	2,915	2,000	1,686	1,203	675	-58.73	16,530	13,720	4,732	7,696	5,531	-53.44
BUFF	1,967	1,158	630	1,156	592	-41.24	5,070	3,639	1,781	3,534	2,522	-30.29
NSHO	1,985	1,923	2,334	992	885	-50.02	3,970	3,865	5,216	5,875	5,487	+47.99
AMWI	1,437	1,149	1,343	532	404	-62.98	3,816	3,247	6,300	2,378	1,775	-37.67
REDH	726	661	590	522	493	-28.16	2,031	1,890	2,302	3,124	3,080	+53.84
RNDU	1,316	1,094	661	433	310	-67.07	4,162	3,654	2,307	2,896	1,522	-30.41
COGO	1,250	890	977	295	268	-76.4	7,474	6,635	4,568	2,701	2,271	-63.86
BWTE	243	193	548	223	79	-8.05	814	738	1,563	751	563	-7.71
RUDU	197	171	389	201	174	+2.03	374	302	4,454	1,416	950	+278.71
CANV	1,392	1,116	1,475	188	126	-86.53	9,146	8,528	9,715	4,103	3,328	-55.14
NOPI	256	240	1,313	164	80	-35.89	646	623	4,509	348	228	-46.13
AGWT	880	675	376	104	67	-88.15	2,684	2,244	726	195	120	-92.72
SCOT	10	10	68	-	-	-100	130	130	457	307	267	+136.15
MERG	41	41	26	-	-	-100	102	102	79	-	-	-100
UNTE	139	80	13	199	136	+43.35	730	618	216	791	675	+8.31
UNDU	260	100	2,207	141	66	-45.74	8,264	7,830	30,141	4,897	4,245	-40.74
UNDA	299	234	332	55	42	-81.6	13,053	12,938	13,260	4,777	4,633	-63.4
UNDI	186	172	123	42	42	-77.37	7,335	7,257	17,019	8,058	6,742	+9.86
Total	**22,767**	**18,009**	**25,345**	**10,419**	**7,786**	**-54.23**	**109,580**	**97,838**	**137,010**	**74,217**	**61,175**	**-32.27**

[1] All= All transects 1 to 18.

[2] Adverse weather conditions in 2000 prevented completion of transects 1 to 4. Data from 1999 and 2001 were therefore also summarized using only transects 5-18 for comparison.

Brood Surveys

Rotary-wing brood surveys were successfully completed each year in late June and late July with the exception of 1998 (see Appendix III). Basins surveyed were identical to those completed during breeding pair surveys. All basins or basin complexes surveyed for broods in 1998 were also flown in 1999. Waterfowl production declined between 1998 and 1999 (Table 5). Dabblers declined by almost 66% and divers by almost 42%. Comparison over the four-year period of brood numbers recorded for both the Snye and the Quatre Fourches complexes showed that production continued to decline from 1999 to 2000, but then increased again in 2001 (Figure 4).

Species contributing to the increased production in 2001 include mallard, northern shoveler, American wigeon, common goldeneye, American green-winged teal, northern pintail, lesser scaup, bufflehead, and blue-winged teal (Table 6). Of these species, production of both mallard and American wigeon were higher than in 1999. Additionally, shoveler, pintail and American green-winged teal showed the highest levels in 2001 than all other years. Of concern are ring-necked duck, canvasback, ruddy duck, and redhead broods, which have not been observed since 1999. Furthermore, production of lesser scaup, a species of concern continentally, has declined notably since 1998. And although brood production has increased in 2001 from 2000, production has still decreased by 21% since 1999, which corresponds with the net decrease (49%) of observed indicated breeding pairs since 1999 (Table 6). Similar to breeding pair results, the majority of broods observed in 2001 were dabbling ducks (77%), especially on the Quatre Fourches complex (97%).

Table 5. *Peace-Athabasca Delta waterfowl brood production, by wetland or complex, for all duck species in 1998 & 1999.*

Basin or Complex	Area (ha)	Dabblers		Divers		Unidentified		Total		Broods/Ha	
		98	99	98	99	98	99	98	99	98	99
Egg Lake	1137	63	16	31	30	13	0	107	46	0.09	0.04
Four Forks Lake	931.9	34	9	6	1	1	0	41	10	0.04	0.01
Galoot Lake	735.3	22	7	9	0	1	0	32	7	0.04	0.01
Jemis Lake	411.6	16	4	1	0	1	1	18	5	0.04	0.01
Lynx Stand Bay	995.8	17	16	13	2	0	0	30	18	0.03	0.02
Otter Lake	1464	54	3	21	0	4	0	79	3	0.05	<0.01
Popular Point Lake	223.3	18	3	1	0	3	0	22	3	0.1	0.01
Jerry's Lake	1151	43	6	29	21	7	2	79	29	0.07	0.03
Quatre Fourches	512.9	53	25	4	9	18	1	75	35	0.15	0.07
Snye Complex	453.2	30	32	74	45	13	1	117	78	0.26	0.17
Baldhead Lake	296.3	14	3	18	5	5	0	37	8	0.12	0.03
Total	**8312**	**364**	**124**	**207**	**113**	**66**	**5**	**637**	**242**	**0.08**	**0.03**

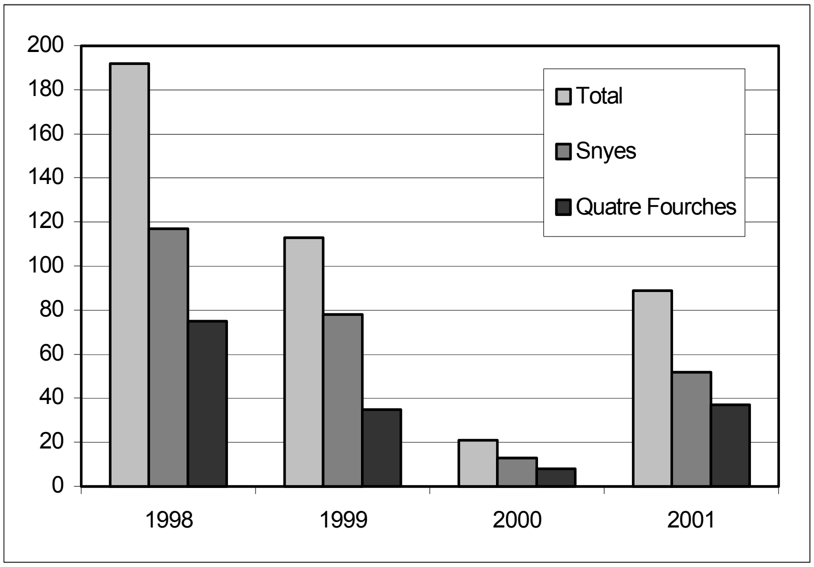

Figure 4. *Brood production from two basin complexes on the Peace-Athabasca Delta, 1998-2001.*

Table 6. *Brood production by species and basin complex on the Peace-Athabasca Delta, 1998-2001.*

Species	Snyes				Quatre Fourches				Total Broods				Change from 1999 (%)
	1998	1999	2000	2001	1998	1999	2000	2001	1998	1999	2000	2001	
MALL	14	6	4	10	21	8	3	10	35	14	7	20	43
NSHO	-	3	-	8	3	3	-	12	3	6	-	20	233
AMWI	3	5	1	6	2	7	1	7	5	12	2	13	8
COGO	-	8	1	5	-	1	-	1	-	9	1	6	-33
AGWT	-	3	1	2	3	-	2	2	3	3	3	4	33
NOPI	-	-	1	1	-	2	-	2	-	2	1	3	50
LESC	21	8	-	3	2	-	-	-	23	8	-	3	-63
BUFF	2	4	1	2	-	2	-	-	2	6	1	2	-67
GADW	-	-	-	1	2	1	2	-	2	1	2	1	0
BWTE	3	7	-	-	2	1	-	1	5	8	-	1	-88
RNDU	13	8	-	-	-	-	-	-	13	8	-	-	-
CANV	5	1	-	-	-	3	-	-	5	4	-	-	-
REDH	-	-	-	-	-	2	-	-	-	2	-	-	-
RUDU	1	1	-	-	1	-	-	-	2	1	-	-	-
RN/SC	17	-	-	2	-	-	-	-	17	0	-	2	-
BU/GO	1	4	1	4	-	1	-	-	1	5	1	4	-20
UNDA	7	8	1	3	16	3	-	2	23	11	1	5	-55
UNTE	3	-	1	2	4	-	-	-	7		1	2	-
UNDI	14	11	1	1	1	-	-	-	15	11	1	1	-91
UNDU	13	1	-	2	18	1	-	-	31	2	-	2	0
Total	**117**	**78**	**13**	**52**	**75**	**35**	**8**	**37**	**192**	**113**	**21**	**89**	**-21**

Table 7. *Estimates of pre-moulting and moulting ducks and American Coots recorded on 2 large basins in late June and July from 1999 to 2001.*

Year	Lynx Stand Bay (996 ha)		Otter Lake (1464 ha)	
	Late June	Late July	Late June	Late July
1999	*	14,820	10,000+	4,432
2000	10,167	4,357	3,960	12,356
2001	1843	2565	4687	8018

* Waterbirds were noted as abundant but not quantified

Moulting and Staging Fixed-wing Surveys

Estimates of total waterbird use during the late July moulting surveys (2000 and 2001) are summarized in Table 8. Most waterbirds recorded during the late July moulting survey consisted of ducks and coots (over 99% both years), with few geese, and no swans. Numbers of moulting waterbirds were higher on the July moulting survey than on the June survey (Table 8). Additionally, density increased in July 2001 from July 2000. The Birch River Delta, Lake Claire shoreline, Mamawi Lake, the inner shores of Lake Claire, Richardson Lake and Egg Lake were all zones with high moulting duck densities (Figure 5).

Table 8. *Moulting waterbird estimates on the Peace-Athabasca Delta derived from delta-wide fixed-wing transects in late June and late July, 2000 and 2001.*

Species	Moulting 1		Moulting 2	
	2000*	2001	2000	2001
Dabbling Ducks	-	24,365	26,756	114,539
Diving Ducks	-	20,575	25,364	61,712
Ducks and Coots	-	93,186	277,961	225,898
Geese	-	1,028	482	1,038
Swans	-	60	-	-
Total Waterbirds	-	139,214	330,563	403,187

*An early moulting survey was not flown in 2000

Waterbird use peaked during the first fall staging survey in late August, in all three years. Contrary to both 1999 and 2000, waterbird use declined for the mid-September survey but then rebounded for the late September survey (Table 9). The proportion of swans recorded in the last survey in September has increased substantially since 1999 with a 26% increase. In 2001 during the final staging survey there was an influx of swans, which comprised 16% of all waterbirds compared to 0% and 4% on surveys 1 and 2 respectively (Table 9). Waterbird use days for the month of September (30 day period) were estimated for all three years surveyed and the results indicate the importance of this area to staging waterbirds with over 9 million birds as the lowest estimate in 2000 and over 18 million at its peak in 1999.

Although staging densities were higher in 1999 than in both 2000 and 2001, relative use (low and high use areas) by ducks and coots across the delta remained fairly consistent for both years (Figure 6). Ducks and coots preferred areas such as the Birch River Delta, region east of Lake Claire and south of Mamawi Lake, Mamawi Lake and near shore of Lake Claire, and, to a lesser degree, the Lower Athabasca Delta whereas areas that were avoided include the forested region south of the Peace River, the Upper Athabasca Delta, North of Quatre Fourches, and the Riviere des Rochers region (Table 7).

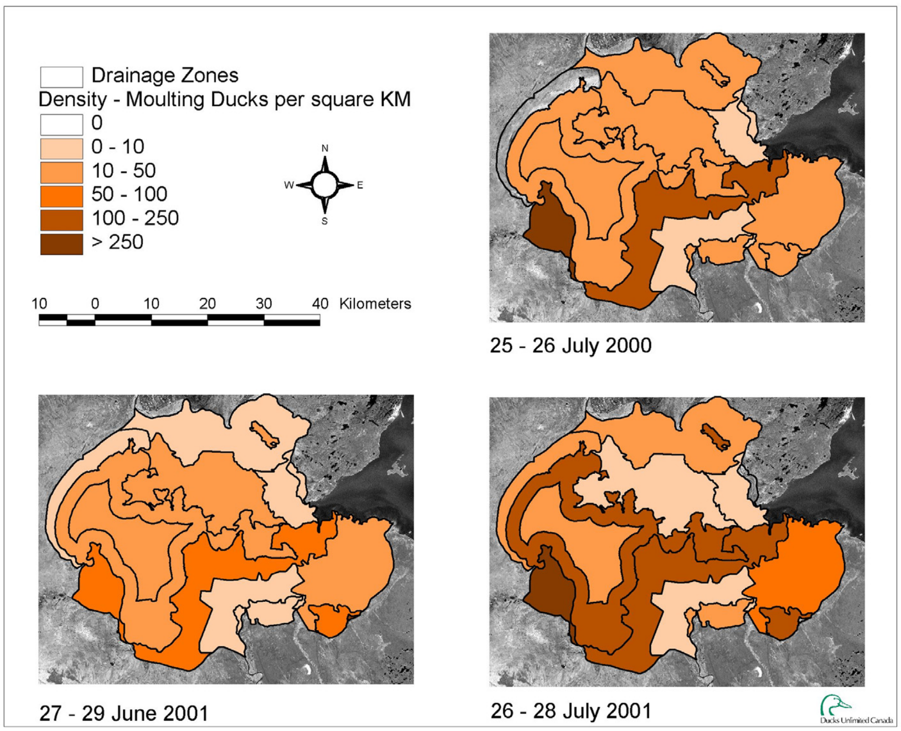

Figure 5. *Temporal and spatial distribution of ducks on the Peace-Athabasca Delta during delta-wide fixed-wing transect surveys in late June and July, 2000 and 2001.*

Table 9. *Fall staging waterbird estimates on the Peace-Athabasca Delta derived from delta-wide fixed-wing transects in 1999-2001*

Species	Staging I			Staging II			Staging III			September Total Use Days		
	1999	2000	2001	1999	2000	2001	1999	2000	2001	1999	2000	2001
Dabbling Ducks	270,808	60,606	135,628	169,409	69,118	121,099	95,741	49,527	35,959	4,937,569	1,797,906	3,024,431
Diving Ducks	45,844	67,738	35,448	169,106	70,859	55,525	24,259	37,010	39,788	2,858,205	1,779,197	1,351,190
Ducks and Coots	696,256	360,041	446,278	745,724	308,091	231,908	271,194	237,870	223,501	17,212,286	8,771,632	9,317,432
Geese	29,921	43,753	13,128	52,870	13,943	3,752	9,658	10,254	27,185	1,017,233	585,350	455,338
Swan	0	0	70	1,512	4,353	11,373	38,022	61,153	47,774	287,322	521,766	611,909
Total Waterbirds	**726,177**	**403,794**	**459,476**	**800,106**	**326,387**	**247,033**	**318,874**	**309,277**	**298,460**	**18,517,723**	**9,883,284**	**10,384,680**

Spatial and temporal use by geese in 2001 differs from that of both 1999 and 2000 (Figure 7). For example, in 1999 and 2000, the Birch River Delta received high use by geese in late August and mid-September but was avoided in late September. In 2001 the Birch River Delta was avoided in late August. Additionally, geese show the greatest density during different survey intervals each year (i.e. 1999 mid-September; 2000 Late August; 2001 Late September). Similar among both years and survey intervals however, was the avoidance, by geese, of the northeastern and Embarras regions of the PAD (Figure 7). The northeastern region of the PAD was consistently avoided by swans during all surveys whereas Mamawi Lake and near shore of Lake Claire were consistently preferred (Figure 8).

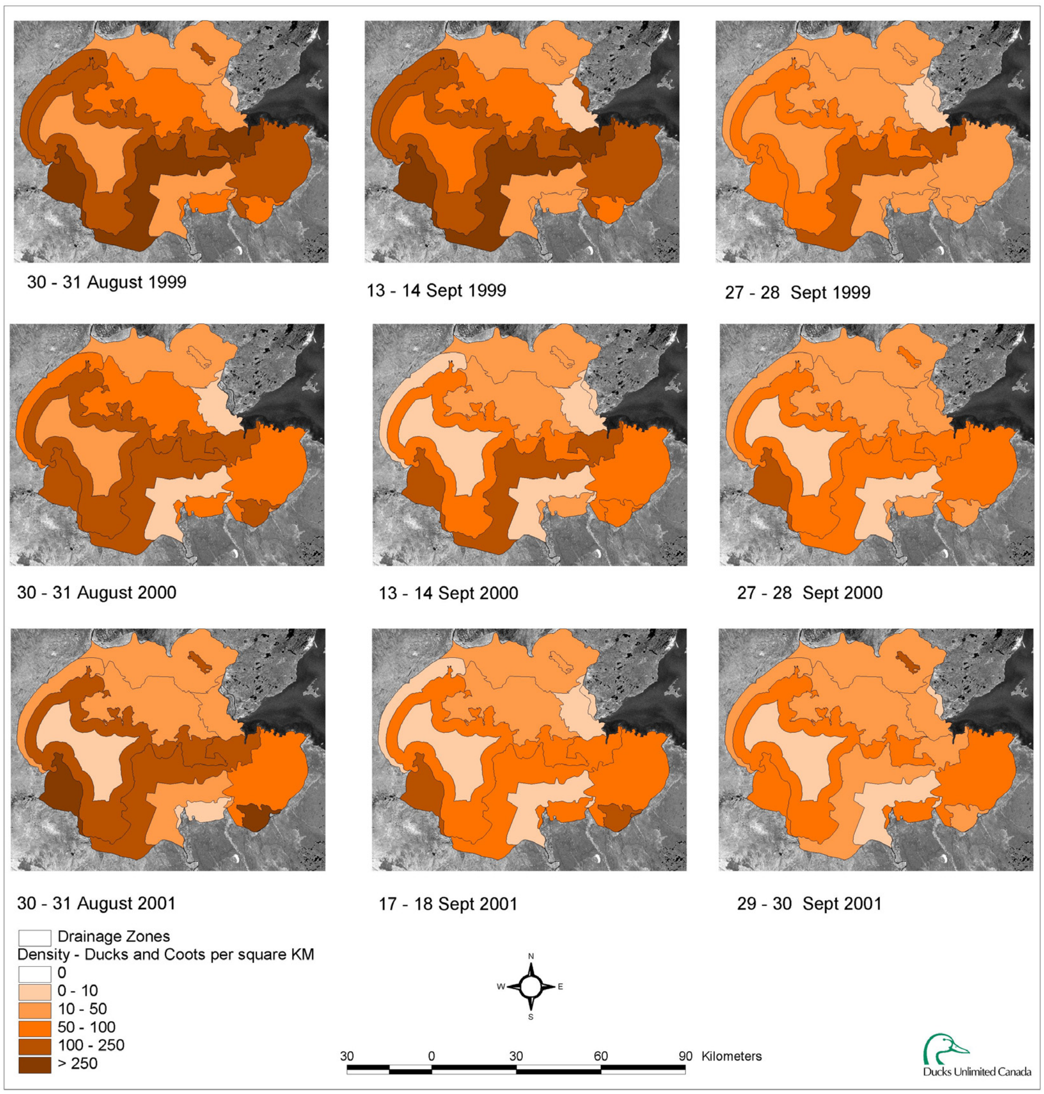

Figure 6. *Temporal and spatial distribution of ducks and coots on the Peace-Athabasca Delta during 3 fall staging surveys, 1999-2001.*

Densities of ducks and coots, geese, and swans were not associated with surface flow hydrology of the Delta (Kruskal-Wallis test, all p-value > 0.19), perhaps suggesting that adequate food resources and resting areas were available within all 3 types of water flow classes (i.e., severely restricted, restricted, and open) or that the drainage classes are too coarse and do not reflect the function associated with actual water levels (Figures 6,7,8).

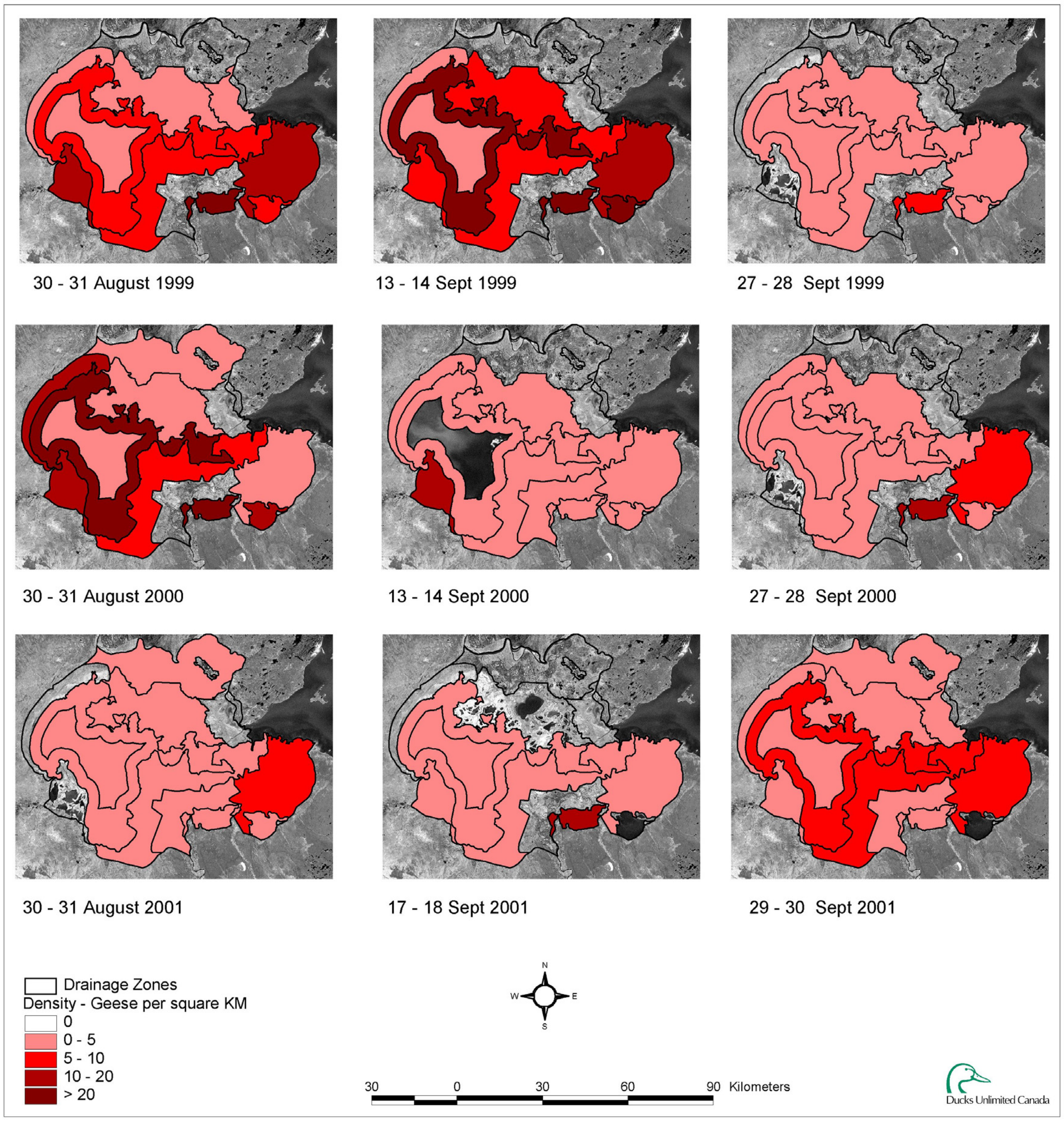

Figure 7. *Temporal and spatial distribution of geese on the Peace-Athabasca Delta during 3 fall staging surveys in 1999-2001.*

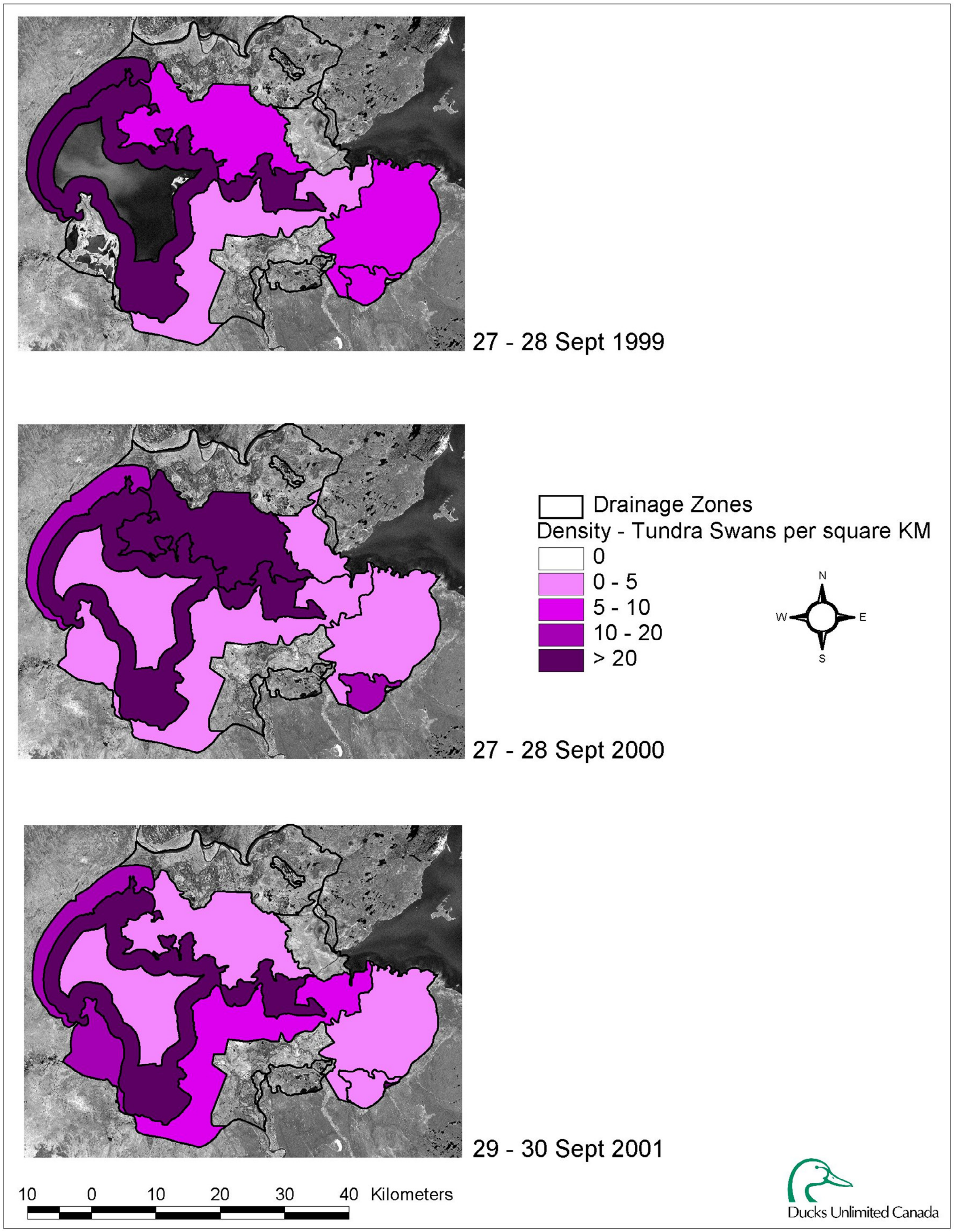

Figure 8. *Temporal and spatial distribution of swans on the Peace-Athabasca Delta in late September, 1999-2001.*

DISCUSSION

This study assessed whether the ice-jam flood of 1996/1997 influenced the waterfowl populations of the delta. The hypothesis proposed that waterfowl populations would initially increase followed by a decline in populations in subsequent years.

The USFWS survey data of breeding pairs indicated an mean increase of 43% (compared to 5 years pre-flood) and an increase in total ducks of 89% for 1998 and 1999 followed by a decrease to pre-flood levels in 2000. No increase in waterbirds was noted the year of the flood 1997.

The results from our surveys started in 1998 and, waterfowl population use on the delta was documented at a very high level for breeding, moulting and staging birds. Staging waterfowl showed a dramatic decline from 1999 to 2001 while breeding waterfowl estimates did not decline until 2001. Brood production declined from 1998 through 2000 but increased in 2001, although the increase was less than that recorded for 1999. Why the population fluctuations of different stages of waterfowl life cycle do not coordinate over the three years is not understood. One surprising observation from 1998 to 2001 was the increase in breeding pairs of gadwall and ruddy duck on the delta. Both species are traditionally considered to have breeding activities centered on the northern prairie pothole regions (Bellrose 1976). One potential reason for the increase in gadwall, during a period when gadwall numbers have been declining over North America, is they are over flying their traditional breeding areas that are dry (USFWS 2001). The same reason may also account for the increase in ruddy ducks. Without a doubt the PAD is a world-class wetland of significant importance to waterbirds in North America.

Since the flood event of 1996/1997 water levels have continued to drop in the delta. The decline in breeding pairs, brood production and staging populations from 1998 to 2001 may be indicative of the importance of the perched basins and lakes to waterfowl when the delta is flooded. It was hypothesized prior to the initiation of our project that these perched basins may be optimally attractive to waterfowl for about three years. Given that since this last flood event, 3 years have been in the top 5 warmest years on record and 2 have been in the top 5 driest (54 year dataset), it would be important to determine if water is receding at a faster rate than has occurred historically (Environment Canada 2002). Since surveys began in 1998, 5 basins were completely dry on both Snye and Quatre Fourches complexes combined. Moreover, Ferguson (2001) reported Baril Lake to be the lowest he's seen in 15 years of USFWS breeding pair surveys on the PAD.

The delta-wide breeding pair, moulting, and staging fall surveys have been informative. The identification of high use areas is extremely important in developing predictive models of waterbird abundance, if an adaptive management approach is adopted as part of the ecosystem planning exercises for the PAD. However, the analyses of all data collected during waterbird inventories are limited by the lack of an accurate, digital landcover map. All our data is thus far been recorded spatially and are ideal for analysis in a GIS environment.

Significant use by brood rearing waterfowl of virtually all wetlands surveyed was documented. The Snye complex had some of the highest brood densities (brood/ha) in the delta when weighted for area. This complex is in the northern part of the delta and most likely to be influenced by the frequency of ice-jam flooding from the Peace. In 1998, five species (mallard, lesser scaup, green and blue-winged teal, and ring-necked duck) comprised 81% of all broods positively identified to species, and nearly 58% of all broods observed in 1998. Species composition of waterfowl broods were consistent with results reported by Nieman and Dirschl (1973), as in both instances, mallard was the dominant species. The relative abundance of teal appears to have increased substantially since the early 70's while the data suggest that canvasback brood production has declined considerably relative to other species abundance. Scaup were the most abundant diving duck species observed in 1998, consistent with the status of this species in 1969 and 1970 (Nieman and Dirschl 1973). As the water levels in basins continued to decline in 1999, 2000 and 2001 (based on the number of dry basins in each year) there is a noticeable decline in brood numbers, particularly in 1999 and 2000. In 2001, brood numbers increased with mallard and shoveler the dominant species. Why there is an increase in 2001 is not known at this time. However only 3 scaup broods and no ring-necked duck broods were recorded in 2001 representing an 85% decline for scaup and 100% for ring-necked ducks since 1998. This suggests that as the water depth decreases these two diving species are not using this habitat. Again the information points to the importance of viewing this data in relation to recorded water depths in specific areas of the delta.

Results from the fixed-wing survey revealed that waterbird abundance in late summer on the PAD was high. Although waterbird density was not significantly related to drainage class across the Delta, several factors could be affecting temporal and spatial abundance of moulting birds. Waterbirds consistently had higher densities in the open water area of the shoreline of Lake Claire and Mamawi Lake and the restricted waters of the eastern part of the same two lakes. These data need to be related to direct water levels as well as the drainage classes (we are currently in the process of gathering this information).

Although estimates of staging waterbird use of the delta in 2000 and 2001 declined from 1999 during the late August and mid-September surveys, estimates for the late September survey were comparable between years. This decline could represent an unusually high year for migrating waterfowl in 1999. Contrary to 1999, use by ducks, coots and geese (mainly Canada geese) on the delta in 2000 and 2001 was highest in late August and declined over the next 2 surveys. This suggests that either fewer birds in 2000 and 2001 originating from higher latitudes migrated through the PAD region or that perhaps in 1999 the fall migration was late to commence.

Results from all 3 staging surveys in 2000 and 2001 estimate approximately 10,000,000 waterbird-use days during the month of September across the Delta. Although this estimate is 44% less than that calculated in 1999, is it still exceeding estimates of fall waterfowl use for other notable staging areas in Canada (Table 10). These data continue to support the assertion that the PAD is of continental importance to migrating and staging waterfowl (Soper 1934, 1951; Smith *et al*. 1964; Timoney 1996, Ramsar 1993).

Table 10. *Staging use of selected Canadian wetlands.*

SITE	DOCUMENTED USE	REFERENCE
Peace-Athabasca Delta, AB	9,883,284 total waterbird use-days (September 2000) 800,164 waterbirds peak count (mid-September 1999) >18,517,723 total waterbird use-days (September 1999)	This Study
Peace-Athabasca Delta, AB	Over 333,333 waterfowl in September	Soper, 1951
Peace-Athabasca Delta, AB	1,200,000 fall staging ducks 110,220 fall staging geese 165,800 fall staging swans	Heenan, 1973
Boundary Bay, BC	8,000,000 dabbling duck use-days annually	Baldwin and Lovvorn 1994
Long Point, ON	8,333,000 waterfowl use-days (1977-78) 8,117,473 waterfowl use days (1998)	Petrie, 1998 Petrie, 1999
SW Lake Erie Lake St. Clair Delta (Can.)	9,521,000 waterfowl use-days (mean 1980-1990) 7,087,000 waterfowl use-days (1976)	Prince *et al*., 1992

Duck use of the delta was highest early in the season. Declines in abundance later in the year likely relate to early departure of locally produced waterfowl, especially those species known to migrate early (i.e., blue-winged teal, American wigeon, northern pintail). Goose use peaked in mid-September based on the three surveys flown in 1998. These data are consistent with other information for dark geese at similar latitudes [mean (1978-1989) date of peak migration at Hay-Zama Lake Complex, AB: 09 Sept.; Pollard and Young 1990]. Tundra Swans were not commonly observed on the delta until later in the season (survey III).

The lack of use of the expansive open water areas associated with the central portion of Lake Claire and Mamawi Lake by either broods or staging waterbirds is notable. We substantiated these observations during brood surveys of Mamawi Lake, and along multiple survey segments flown across Lake Claire during the staging waterfowl component in each year. While not completely unexpected, these observations should be taken into consideration when extrapolating waterbird density across the large basins of the PAD (i.e., the 3,900 km^2 of lakes Claire, Baril and Mamawi; Prowse *et al.* 1996). Clearly, some areas of the PAD are more important for waterbirds than others. A comprehensive analysis and interpretation of the data collected over the four year period with particular respect to the staging (transect) surveys is, however, constrained by the continued lack of availability of digital base map data.

Surveys undertaken during 1998 were designed primarily as a pilot effort to refine the timing and required techniques and to provide an initial estimate of bird abundance on the delta during the specified periods. The information gathered during 1998 and 1999 assisted in confirmation of waterbird site selection, allowed testing of the proposed protocols, and provided an opportunity to evaluate on the relative merit of the survey techniques employed versus those previously conducted on the delta (EMA 1984, Wayland and Arnold 1993). Furthermore, experience gained during surveys undertaken in 1998 and 1999 with reference to the unique logistical constraints on the delta directly benefited future survey efforts. The methods developed in the first two years formed the basis of a standard operating procedure that DUC currently uses throughout the boreal forest in western Canada.

RECOMMENDATIONS

Proposed Monitoring of Waterbird Use

In order to continue to assess the influence of current climatic conditions and the drying of the delta we propose that waterfowl use of the delta continue to be monitored over the next 5 years. This will provide baseline information on the variability associated with the use of the delta by waterfowl.

Historical Hydrological Processes

The historical frequency of flooding in various regions of the PAD is of specific interest. Such an historical record may be provided by methods of paleo-flood stratigraphy, calibration of dendrochronological information, traditional knowledge, oral history and historical documents (e.g., Thomson 1993, Prowse and Lalonde 1994, Peterson 1995). Understanding the historical hydrological process in the delta is essential to interpreting the context of current variability in waterfowl use of the delta. If the delta continues to dry, the impact on waterfowl will require assessment. The development of a landcover classification will be essential to enhance interpretation of waterfowl use and would be useful in detection of habitat changes. This will allow for improved hydrological modeling of the Peace River catchment and lead to a better understanding of the flood history of the PAD and aid in identifying the nature of flood/dry cycles. This will allow the development of scientifically sound, ecologically based intervention, restoration and management options. It will also provide insight on the current state of ecological integrity of the PAD.

Proposed Enhancement of the Perched Basins of the PAD

Those wetlands that are the most affected by the decline in water levels over the last 25 years are the elevated perched basins that surround the core area of the delta. Included in the findings of the PADTS was the fact that the frequency of significant spring flooding of the PAD has decreased since the regulation of the Peace River. It was also determined through the PADTS that the outflow weirs have restored peak summer water levels, but have raised winter water levels and limited seasonal water-level drawdown. In 1996-97 a flood from an ice jam resulted in many of the perched basins being flooded after a period of protracted drying (Timoney 1997, 2002). The prediction was that the waterbird use would initially increase followed by a decrease during subsequent years. This hypothesis is partially supported both by the USFWS survey results and the WBF survey results. However the increase in brood production in 2001 points to the complexity of the issues surrounding the delta, the water levels and suitability for waterfowl production of the various habitats.

We propose that the adoption of an adaptive management (AM) approach (Stewart *et al.*, 2000) would be most effective to determine if increased water levels in perched basin complexes of the PAD will increase the use by waterbirds, muskrats, fish and traditional activities by First Nations. The waterbird survey is strongly suggestive of that, but the inherent variability of this complex system complicates the interpretation of the data in the absence of detailed water levels and wetland trophic studies. Our objective is to use an adaptive management (AM) approach to influence function and hydrology to key perched wetlands within the PAD with the outcome that waterbird use and productivity will increase. Increased water levels will also potentially increase use by fish and muskrats and subsequent traditional use by First Nations. Our proposed approach is to select perched basins in the PAD and flood them with water from the core delta area. Aerial surveys will be done comparing waterbird use of treated (flooded) wetlands versus untreated. Historical DUC data from 1999-2001 will provide background comparison of the comparative wetland use. If there is an increased waterbird response in treated basins over four years further basins will be selected for treatment. Basins within the complexes will be evaluated until waterbird use approaches those of untreated basins. In order to do this we propose that a pilot study be conducted that pumps water into selected basins in order to determine if it is feasible economically and physically to enhance these basins for waterbird and other uses.

The high numbers of waterfowl reported in this study from 1998 to 2000 followed by a decline in 1999 for staging populations and broods and 2000 for breeding populations suggests that when the delta and the associated wetlands are flooded waterfowl use increases. There are however key uncertainties. For instance:

- Will the basins hold water? Experience from recent flood events suggest they will for a few years.
- Can we economically get access and transport water to the perched basins? This is an unknown risk at this time however experience from the Saskatchewan River Delta (SRD) suggests it will be feasible.
- Will the waterbirds respond as predicted to the water input that does not arise from a natural flood that would also affect other areas of the delta? In order to test this we would pilot a few selective basins and evaluate the response.
- The costs will vary annually depending upon conditions and need. Only experience from a pilot study will provide an answer to this. However the benefits are extremely high.
- Who will pay for this activity? We will seek partners for funding.
- Who will maintain the project and cover annual costs? We will seek partners for long-term maintenance of the project.
- What are the effects of global climate change? Under the predicted effects of global warming and increased demand on water resources we ultimately could lose the delta as a major world-class wetland.

We consider the degree of certainty that the proposed action will be successful to be moderate to high providing we can economically gain access to water and transport it to the basins.

DUC has 40 years experience of management challenges in the SRD. While the experience may not be directly transferable the lessons learned in the SRD may prove useful in the PAD. The National Hydrology and Water Institute have conducted 2-D Modelling of the hydrology of the PAD. Successional modelling has also been conducted on the Copper River Delta in Alaska and may be applicable to the PAD. Other information is available from B.C. Hydro and the First Nations (as Traditional Knowledge). A retrospective analysis will be conducted on all available information.

ACKNOWLEDGEMENTS

BC Hydro (Alan Chan-McLeod) provided financial support for this survey program as did Environment Canada (Frank Letchford) and Parks Canada (Mark Bradley). Special gratitude is extended to Parks Canada Staff in Fort Chipewyan, AB for providing extensive logistical assistance. Their support was invaluable to us throughout this program and was much appreciated. Alberta Resource Data Division (Marilyn Rayner) provided in-kind support in the form of aircraft fuel; Bernie Schmitte provided logistical support for the aircraft while working out of the Fort Chipewyan Initial Attack base. We are grateful for permission, provided by Chief Archie Cyprien, to access the Athabasca Delta (Chipewyan I.R. 201) for the purpose of completing the aerial survey program. In addition to the authors, many Ducks Unlimited Canada staff participated in the delivery of these surveys (Appendix III). Staff out of Edmonton provided GIS technical support. Appreciation is extended to all pilots from Canadian Helicopters (Fort McMurray), Big River Air (Fort Smith), and Air Mikisew (Fort Chipewyan) whose expertise made it possible for the surveys to be completed safely and efficiently.

LITERATURE CITED

Baldassarre, G.A. and E.G. Bolen. 1994. Waterfowl ecology and management. John Wiley and Sons, NY. 609 pp.

Baldwin, J.R. and J.R. Lovvorn. 1994. Habitats and tidal accessibility of the marine foods of dabbling ducks and brant in Boundary Bay, British Columbia. Marine Biology 120: 627-638.

Bellrose, F. 1976. Ducks, Geese and Swans of North America. 2nd Edition. Stackpole Books, USA

Black Duck Joint Venture. 1996. Revised standard operating procedure for helicopter based surveys of breeding populations of waterfowl in eastern Canada and northeastern United States. Ottawa, ON. 3 pp.

Brua, R.B. 1999. Ruddy duck nesting success: Do nest characteristics deter nest predation? Condor 101: 867-870.

EMA. 1984. Migratory Birds Survey- Spring 1984. Prepared for The Slave River Hydro Study Group by Environmental Management Associates, Calgary.

Environment Canada. 2002. Climate trends and variations bulletin for Canada. Meteorological Service of Canada- Climate Research Branch, Environment Canada. http://www.msc-smc.ec.gc.ca/ccrm/bulletin/annual01/page2.htm. 4 pp.

Environmental Systems Research Institute Inc. 1996. ArcView spatial analyst: Advanced spatial analyst using raster and vector data. Redlands, CA. 148 p.

Fergusen, C. 2001. Waterfowl breeding population survey for northern Alberta, northeastern British Columbia, and the North West Territories (Mackenzie District): Preliminary Report. Unpublished. United States Fish and Wildlife Service. Laurel, MD. 14 pp.

Gendron M., Smyth S.A., Stewart G.R., and J.B. Pollard. 2001. Peace Athabasca Delta waterbird inventory 2000 surveys: final report. Unpublished. Western Boreal Region, Ducks Unlimited Canada. 32 pp.

Gollop, J.B., and W.H. Marshall. 1954. A guide for aging duck broods in the field. Mississippi Flyway Council, Technical Section, Minneapolis, MN.

Heenan, E. 1973. Status of waterfowl on the Peace Athabasca Delta. Ecological investigations: volume two. Peace-Athabasca Delta Project Group, Canada, Alberta, Saskatchewan. Pp.K1-K105 *In*: Timoney, K. 1996. Vegetation Monitoring Program. Task E.2 – Vegetation Monitoring. Peace-Athabasca Delta Technical Studies.

Klett, A.T., H.F. Duebbert, C.A. Faanes and K.F. Higgins. 1986. Techniques for studying nest success of ducks in upland habitats in the Prairie pothole region. U.S.Fish Wildl. Serv., Resour. Publ. 158. 24 p.

Nieman, D.J. 1972. Breeding biology and habitat relationships of mallard and canvasback in the peace-Athabasca Delta. Unpubl. MS thesis. University of Saskatchewan, Saskatoon., SK.78 pp.

Nieman, D.J. and H.J. Dirschl. 1973. Waterfowl populations on the Peace-Athabasca Delta, 1969 and 1970. Can. Wildl. Serv. Occas. Pap. No. 17. Ottawa, ON. 25 pp.

Peace-Athabasca Delta Technical Studies Steering Committee. 1996. Peace-Athabasca Delta Technical Studies:Final Report, November 1996.

Peterson, M. 1995. Peace-Athabasca Delta flood history study. Peace-Athabasca Delta Technical Studies, Task F.1- Flood History.

Prowse, T.D. and V. Lalonde. 1994. The nature of flooding controlling a northern delta ecosystem, 10th International Northern Research Basins Symposium and Workshop, 28 Aug – 3 Sept, Spitsbergen, Norway.

Thomson, S. 1993. Peace-Athabasca Delta flood history. Historical Services, Prairie and Northern Region. Park Library.

Petrie, S. 1998. Waterfowl and wetlands of Long Point Bay and Old Norfolk County: Present conditions and future options for conservation. Norfolk Land Stewardship Council. Simcoe, ON. 182 p.

Petrie, S. 1999. Long Point Waterfowl and Wetlands Research Fund. Mid-Year Update.

Petrula, M.J. 1991. Nesting ecology of ducks in interior Alaska. Unpubl. M.S. thesis. University of Alaska Fairbanks. 124 pp.

Pollard, J.B., M. Gendron, S.A. Smyth, A.J. Richard and G.R. Stewart. 2000. Peace Athabasca Delta waterbird inventory: 1999 Final report. Report submitted to BC Hydro, Canadian Heritage-Parks Canada, Canadian Wildlife Service and Alberta Environment. 18 pp.

Pollard, J.B. and G.R. Stewart. 1999. Peace-Athabasca Waterbird Inventory. Final Report: 1998 (Pilot Year) Surveys. Report submitted to Canadian Heritage-Parks Canada and BC Hydro. 15 June 1999. 24 pp.

Pollard, J.B. and D.A. Young. 1990. Waterfowl migration activities in relation to oil production activities, Hay-Zama lakes, Alberta: Fall 1989 Monitoring Study. Prep. For Esso Reources Canada, Ltd., Lasmo Exploration Canada, Mobil Oil, North Canadian Oils Ltd., PanTerra Petroleum Ltd., Retriever Resources, Ltd., Westcoast Petroleum Ltd. and Zama Holdings, Ltd. by Environmental Management Assoc., Calgary.

Prince, H.H., P.I. Padding and R.W. Knapton. 1992. Waterfowl use of the Laurentian Great Lakes. J. Great Lakes Res. 18: 673-699

Prowse, T.D. and M.N. Demuth, 1993. Strength variability of major river-ice types. Nordic Hydrology, 24(3), 169-182.

Prowse, T.D., D.L. Peters and P. Marsh. 1996. Modelling the water balance of Peace-Athabasca Delta perched basins. Task D.4 – Perched Basins water balance. Peace-Athabasca Delta Technical Studies. Unpubl. Environ. Can., NHRI Rep., Saskatoon, SK. 72 pp. + appendices.

Ramsar Bureau. 1993. Fact Sheet – Peace Athabasca Delta. http://www.wetlands.agro.nl/ramsar/Ramsar_Dir/Canada/CA007D99.doc

Soper, J.D. 1934. A waterfowl reconnaissance of Wood Buffalo Park. Trans. 20th Amer. Game Conf. 20: 258-266

Soper, J.D. 1951. Waterfowl and related investigations in the Peace Athabasca delta region of Alberta, 1949. Ministry of Resources And Development, Wildl. Manage. Bull. Ser. 2, No. 2, Ottawa.

Stewart, G.R., M. Gendron and J. B. Pollard. 2000. Establishing a Management Framework for the Peace-Athabasca Delta: An Ecosystem Management Plan. Ducks Unlimited Canada Report, Edmonton. AB., 16 pp.

Timoney, K. 1996. Vegetation Monitoring Program. Task E.2 – Vegetation Monitoring. Peace-Athabasca Delta Technical Studies.

Timoney, 2002. A Dying Wetland? A case study of a wetland paradigm. Wetlands. 22:282-300.

Timoney, K., G. Peterson, P. Fargey, M. Peterson, S. McCany, R, Weins. 1997. Spring-Ice Jam Flooding of the Peace Athabasca Delta: Evidence of Climatic Oscillation. Climatic Change. 35: 463-483.

USFWS, 2001. Waterfowl Population Status, 2001. U.S. Dept. of Interior, Washington, D.C. 50 pp.

Wayland, M. and T. Arnold. 1993 A survey of birds: Wapiti, Peace and Athabasca River, June and July 1992. Northern River Basins Study Rep. No. 6. 36 pp+ appendices.

Wishart, R.A. 1983. Aging and back-dating duck broods. *In*: Biological Techniques Manual. Unpubl. Ducks Unlimited Canada Rep.

APPENDIX I:
PEACE-ATHABASCA DELTA PAIR AND BROOD/MOULTING BASIN LOCATIONS

A) Basins surveyed for each year and survey type.

	Latitude, Longitude	1998		1999		2000		2001	
		Pair	Brood	Pair	Brood	Pair	Brood	Pair	Brood
North East Delta									
Egg Lake	58.89936,-111.42067	x	x	x	x				
Jerry's Lake	58.81970,-111.43425	x	x	x	x				
Baldhead Lake	58.83185,-111.48790	x	x	x	x				
Four Forks Lake	58.74863,-111.53767		x	x	x				
Duck Lake	58.68733,-111.40714								
Jemis Lake	58.66682,-111.45674		x	x	x				
North West Delta									
Snye Complex	58.86307,-111.84355		x	x	x	x	x	x	x
Lynx Stand Bay	58.75729,-111.91339		x	x	x				
East Delta									
Popular Point Lake	58.59172,-111.34092		x	x	x				
Quatre Fourche Complex	58.62293,-111.30652		x	x	x	x	x	x	x
Galoot Lake	58.58102,-111.11954		x	x	x				
South Delta									
Hilda Lake	58.56009,-111.74526								
Beaver Lake	58.54240,-111.68900								
Otter Lake	58.54433,-111.57128		x	x	x				

B) Snye and Quatre Fourche Complex basin locations.

Basin	Latitude	Longitude	Basin	Latitude	Longitude
Snye 01	58.8857	-111.815	QF 01/02/03	58.6347	-111.267
Snye 02	58.87632	-111.808	QF 04	58.6266	-111.273
Snye 04	58.85254	-111.804	QF 05	58.62433	-111.285
Snye 05	58.86087	-111.836	QF 06	58.63555	-111.288
Snye 07/08	58.86588	-111.825	QF 07	58.63868	-111.296
Snye 09/10	58.87573	-111.829	QF 08	58.63372	-111.305
Snye 11	58.89128	-111.856	QF 09	58.62294	-111.305
Snye 12	58.88702	-111.888	QF 10	58.63772	-111.319
Snye 13	58.87762	-111.884	QF 11	58.61351	-111.301
Snye 14	58.85796	-111.869	QF 12	58.61746	-111.339
Snye 15	58.85296	-111.878			
Snye 16	58.84189	-111.862			
Snye 17	58.88153	-111.903			
Snye 18	58.85959	-111.893			
Snye 19	58.87286	-111.922			
Snye 20	58.84112	-111.834			
Snye 21	58.84598	-111.846			
Snye 22	58.85086	-111.856			
Snye 23	58.85542	-111.845			
Snye 24	58.86081	-111.844			
Snye 25	58.86617	-111.85			
Snye 26	58.87114	-111.845			
Snye 27	58.8765	-111.85			
Snye 28	58.85191	-111.759			
Snye 29	58.8496	-111.77			
Snye 30	58.85583	-111.78			
Snye 31	58.863	-111.782			

APPENDIX II: PEACE-ATHABASCA DELTA TRANSECT ENDPOINTS

A) Transect endpoints 1998

Transect	Western Terminus	Eastern Terminus	Length (km)
1	-112.04152, 58.90553	-111.17360, 58.90961	50.0
2	-112.10979, 58.86904	-111.24279, 58.87357	50.0
3	-112.21255, 58.83219	-111.25986, 58.83762	55.0
4	-112.28049, 58.79560	-111.27690, 58.80166	58.0
5	-112.38286, 58.75862	-111.17289, 58.76592	70.0
6	-112.41595, 58.72233	-111.24179, 58.72988	68.0
7	-112.48347, 58.68564	-111.20704, 58.69402	74.0
8	-112.48195, 58.64973	-111.17235, 58.65814	76.0
9	-112.48043, 58.61382	-111.17218, 58.62222	76.0
10	-112.47891, 58.57790	-111.06880, 58.58639	82.0
11	-112.44305, 58.54238	-111.06873, 58.55047	80.0
12	-112.37295, 58.50722	-111.06866, 58.51454	76.0
13	-112.37155, 58.47130	-111.06859, 58.47862	76.0
14	-112.37016, 58.43539	-111.06852, 58.44269	76.0
15	-112.36876, 58.39947	-111.06845, 58.40676	76.0
16	-112.36737, 58.36356	-111.06838, 58.37084	76.0
17	-112.36598, 58.32764	-111.06831, 58.33491	76.0
18	-112.36460, 58.29172	-111.06824, 58.29899	76.0

B) Transect endpoints 1999-2001

Transect	Eastern Terminus	Western Terminus	Length (km)
1	-111.17476, 58.91157	-112.04272, 58.90748	50.0
2	-111.24395, 58.87553	-112.11100, 58.87099	50.0
3	-111.26102, 58.83957	-112.21376, 58.83413	55.0
4	-111.27806, 58.80361	-112.28171, 58.79755	58.0
5	-111.17404, 58.76787	-112.38407, 58.76056	70.0
6	-111.24294, 58.73184	-112.41717, 58.72427	68.0
7	-111.20819, 58.69597	-112.48469, 58.68758	74.0
8	-110.76967, 58.66001	-112.48317, 58.65167	99.5
9	-110.77394, 58.62409	-112.48165, 58.61576	99.2
10	-110.77379, 58.58817	-112.48013, 58.57985	99.3
11	-110.76344, 58.55222	-112.44427, 58.54432	97.9
12	-110.76332, 58.51630	-112.37416, 58.50916	93.9
13	-110.80470, 58.48044	-112.37276, 58.47325	91.5
14	-110.87943, 58.44461	-112.37136, 58.43733	87.1
15	-110.87918, 58.40876	-112.19961, 58.40321	77.2
16	-110.98783, 58.37262	-112.19881, 58.36701	70.9
17	-110.98746, 58.33701	-112.13213, 58.33201	67.1
18	-111.49771, 58.29983	-112.13142, 58.29580	37.2

APPENDIX III: PEACE-ATHABASCA DELTA SURVEY SCHEDULE, 1998-2001

A) 1998 Survey Schedule

Breeding Pair 1	Basin	29-May	Bruce Pollard Lee Foote Michel Gendron
Brood/ Moulting 1	Basin	14-16 July	Bruce Pollard Lee Foote
Brood/ Moulting 2	Basin	10-12 Aug	Bruce Pollard Gary Stewart
Staging 1	Transect	25-Aug	Bruce Pollard Dave Kay
Staging 2	Transect	16-17 Sept	Bruce Pollard Alain Richard
Staging 3	Transect	29-30 Sept	Alain Richard Ken Lumbis

B) 1999 Survey Schedule

Breeding Pair 1	Basin	7-9 May	Bruce Pollard Jackie Dixon
Breeding Pair 2	Basin	29-30 May	Bruce Pollard Lee Foote
	Transect	26-28 May	Bruce Pollard Lee Foote
Brood/ Moulting 1	Basin	28-30 June	Gary Stewart Brett Calverley
Brood/ Moulting 2	Basin	6-8 August	Bruce Pollard Kim Eskowich
Staging 1	Transect	30-31 August	Bruce Pollard Michel Gendron
Staging 2	Transect	13-14 Sept	Alain Richard Michel Gendron
Staging 3	Transect	27-28 Sept	Bruce Pollard Debbie van de Wetering

C) 2000 Survey Schedule

Breeding Pair 1	Basin	3-4 May	Michel Gendron Kim Eskowich
	Transect	07-May	Michel Gendron Kim Eskowich
Breeding Pair 2	Basin	26-May	Michel Gendron Chris Smith
	Transect	27 & 30 May	Michel Gendron Chris Smith
Brood/ Moulting 1	Basin	26-28 June	Gary Stewart Bruce Pollard
Brood/ Moulting 2	Basin	24-25 June	Michel Gendron Brad Arner
	Transect	25-26 June	Michel Gendron Brad Arner
Staging 1	Transect	30-31 Aug	Michel Gendron Dave Pochailo
Staging 2	Transect	13-14 Sept	Michel Gendron Amy Leach
Staging 3	Transect	27/29 Sept	Michel Gendron

D) 2001 Survey Schedule

Breeding Pair 1	Basin	4-5 May	Michel Gendron Amy Leach
Breeding Pair 2	Basin	26-May	Amy Leach James Gonek
	Transect	27-28 May	Amy Leach James Gonek
Brood/ Moulting 1	Basin	25-26 June	Amy Leach James Gonek
	Transect	27-29 June	Amy Leach James Gonek
Brood/ Moulting 2	Basin	26-Jul	Amy Leach Brett Calverley
	Transect	26-28 July	Amy Leach Brett Calverley
Staging 1	Transect	30-31 Aug	Amy Leach Michel Gendron
Staging 2	Transect	17-18 Sept	Amy Leach Eric Butterworth
Staging 3	Transect	29-30 Sept	Amy Leach Wally Price

APPENDIX IV. AMERICAN ORNITHOLOGICAL UNION SPECIES ALPHA-CODES

Common Name	Numeric Code	Scientific Name	Alpha-Code
Common Merganser	1290	*Mergus merganser*	COME
Mallard	1320	*Anas platyrhnchos*	MALL
Gadwall	1350	*Anas strepera*	GADW
American Wigeon	1370	*Anas americana*	AMWI
American Green-winged	1390	*Anas crecca*	AGWT
Blue-winged Teal	1400	*Anas discors*	BWTE
Unidentified Teal	1401	n/a	UNTE
Northern Shoveler	1420	*Anas clypeata*	NSHO
Northern Pintail	1430	*Anas acuta*	NOPI
Redhead	1460	*Aythya americana*	REDH
Canvasback	1470	*Aythya valisineria*	CANV
Lesser Scaup	1490	*Aythya affinis*	LESC
Ring-necked Duck	1500	*Aythya collaris*	RNDU
Common Goldeneye	1510	*Bucephala clangula*	COGO
Barrow's Goldeneye	1520	*Bucephala islandica*	BAGO
Bufflehead	1530	*Bucephala albeola*	BUFF
Black Scoter	1630	*Melanitta nigra*	BLSC
White-winged Scoter	1650	*Melanitta fusca*	WWSC
Surf Scoter	1660	*Melanitta perspicillata*	SUSC
Ruddy Duck	1670	*Oxyura jamaicensis*	RUDU
Lesser Snow Goose	1690	*Chen caerulescens*	LSGO
Greater White Fronted	1710	*Anser albifrons*	GWFG
Canada Goose	1720	*Branta canadensis*	CAGO
Whistling (Tundra) Swan	1800	*Cygnus columbianus*	WHSW
American Coot	2210	*Fulica americana*	AMCO
Scoter spp.	n/a	n/a	SCOT*
Scaup spp.	n/a	n/a	SCAU*
Ring-neck or Scaup	n/a	n/a	RN/SC*
Bufflehead or Goldeneye	n/a	n/a	BU/GO*
Unidentified Dabbler	n/a	n/a	UNDA*
Unidentified Diver	n/a	n/a	UNDI*
Unidentified Duck	n/a	n/a	UNDU*
Unidentified Swan	n/a	n/a	UNSW*
Unidentified Merganser	n/a	n/a	Merganser*

* not listed as A.O.U. Alpha-codes