Population Dynamics of American Common Eider (*Somateria mollissima dresseri*): Estimating Population Growth and Recruitment Rates.

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Martin Patenaude-Monette & Jean-François Giroux
in collaboration with
Brad Allen, Scott G. Gilliland, Mark L. Gloutney,
Dan G. McAuley, Nic R. McLellan, Katherine R. Mehl,
G. Randy Milton, Glen J. Parsons, and Eric T. Reed

INTRODUCTION

The current American Common Eider (*Somateria mollisima dresseri*) population estimate is around 300,000 birds (C. Lepage and D. Bordage 2013). This species is found along the coastal areas of Eastern Canada and US and is among the most commonly harvested sea ducks through sport hunting as well as by native people for subsistence. The current harvest is believed to exceed the sustainable harvest rate (C. Lepage and D. Bordage 2013, Koneff et al. 2015, Padding and Klimstra 2008). Furthermore, this species faces many threats, both from natural sources (e.g. disease outbreaks, predation) and anthropogenic ones (e.g. disturbance during nesting, marine oil spills, commercial exploitation of molluscs). Although the distribution and relative abundance of American Common Eider has been well described, there exists no comprehensive monitoring program for this subspecies. Despite the lack of population data, waterfowl managers are concerned about the status of this population, especially across the southern portion of its breeding range (e.g. Maine, New Brunswick, and Nova Scotia) where numbers appear to be declining (Milton et al. 2016; Brad Allen, pers. commun.).

Although there is no long-term large-scale survey program for *S. m. dresseri*, there have been several extensive banding programs focused on adult females caught on their breeding colonies. Using Pradel's (1996) models, capture-recapture data can be used to estimate population growth and recruitment rates (see Sandercock and Bessinger 2002 and Sandercock 2006 for examples). These models have been successfully used to estimate recruitment and growth rates for a few colonies in Quebec, Newfoundland, and Labrador (Gloutney and Mehl 2010; Pannetier Lebeuf and Giroux 2014). Pannetier Lebeuf and Giroux (2014) have demonstrated that estimates of growth rates using the Pradel model and capture-recapture data were comparable to growth rates estimated from nest count data in three major colonies of the St. Lawrence Estuary.

The primary goal of this study was to estimate recruitment and population growth rates of *S. m. dresseri* in colonies located across the breeding range. This was achieved by compiling the capture-recapture histories for past and current banding programs. Our analyses included 14 colonies in four geographical areas covering the entire breeding range of *S. m. dresseri*. As a preliminary step, we also wanted to further validate the Pradel approach for the three Quebec colonies using updated banding and nest count data. These analyses provide the first independent estimates of population growth of American Common Eiders. The demographic parameters are essential to eventually determine factors that influence population dynamics and to assess a Prescribed Take Level (PTL). By comparing colonies with different recruitment rates, we may be able to learn more about factors that limit recruitment and thus population growth.

METHODS

Data sets and study areas

Several collaborators provided data sets for colonies located in Quebec, Nova Scotia, New Brunswick, Newfoundland, Labrador, and Maine (Fig. 1). We kept data sets from banding programs that spanned during at least five years with regular annual capture operations, and which included more than 400 banded breeding females within a given insular colony or within nearby islands of an archipelago.

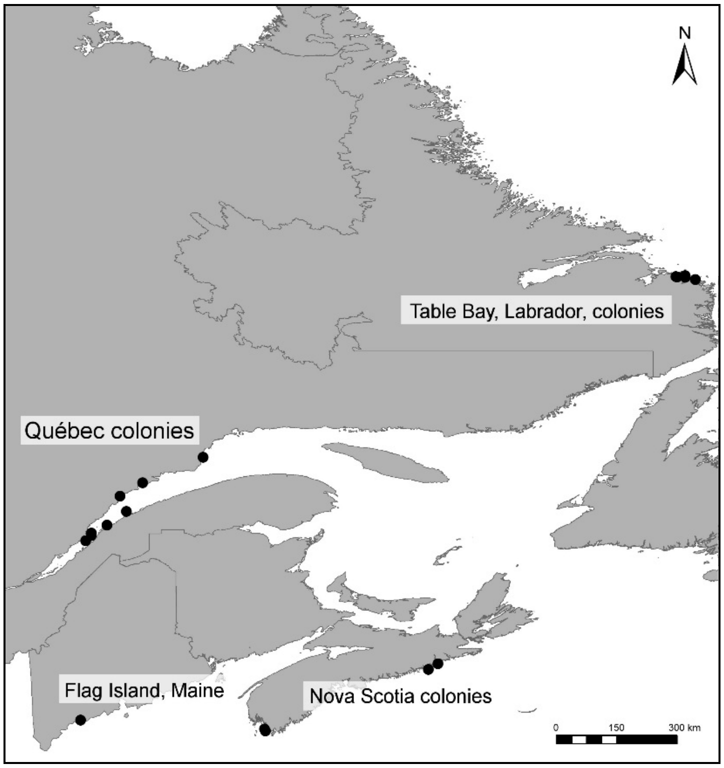


Figure 1. Location of the 14 eider colonies grouped in four regions in Quebec, Maine, Nova Scotia, and Labrador.

A first data set came from a series of islands situated in the estuary and gulf of St-Lawrence estuary in Quebec (JFG). Common eiders are nesting on about fifteen islands or archipelagos of small islands in this area (JWGMCE 2004). Eight colonies with sufficient banding data and supporting most of the breeding pairs were kept for the analyses (Fig. 2). In addition to the banding data, the total number of nests (harvested or not) located on each island were tallied by the down harvest crews. However, nest counts were more systematic and thus more reliable on Île aux Fraises, Île Blanche, and Île aux Pommes because all portions of these islands are easily accessible.

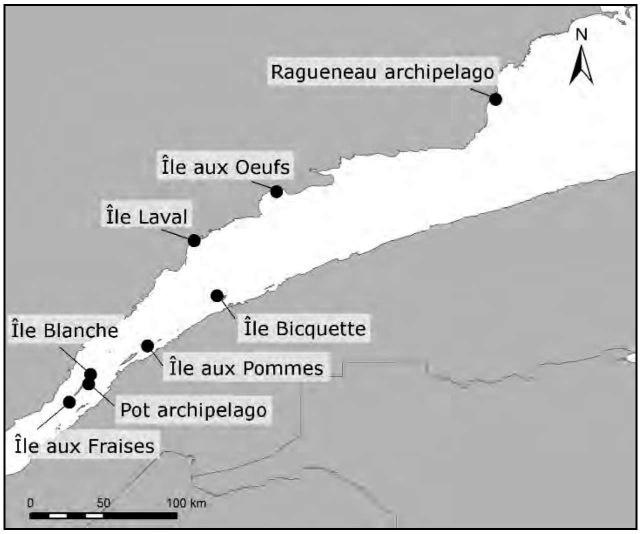


Figure 2. Map of eight eider colonies in Quebec

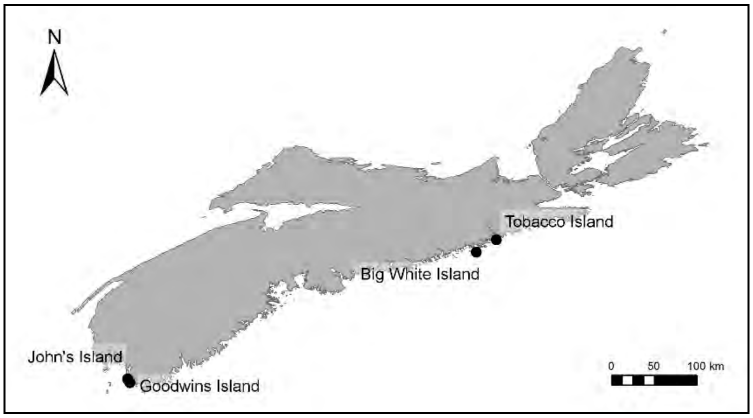


Figure 3. Map of four eider colonies in Nova Scotia.

In Nova Scotia, breeding females were captured in many colonies, located at 72 sites (GRM, GJP). However, data from four colonies fulfilled our criteria of annual banding operations and a minimum number of banded females (Fig. 3). In Labrador, data from five islands located within Table Bay and obtained during the same period were pooled for this study (Fig. 4; MLG, KRM). In Newfoundland, the dataset was too limited for analysis. In Maine, there were sufficient data of captures and recaptures during the breeding season for one colony, Flag Island (Fig. 1; BA, DGM). Many birds had been banded at Green Island, but this was conducted after the nesting period (mostly in August).

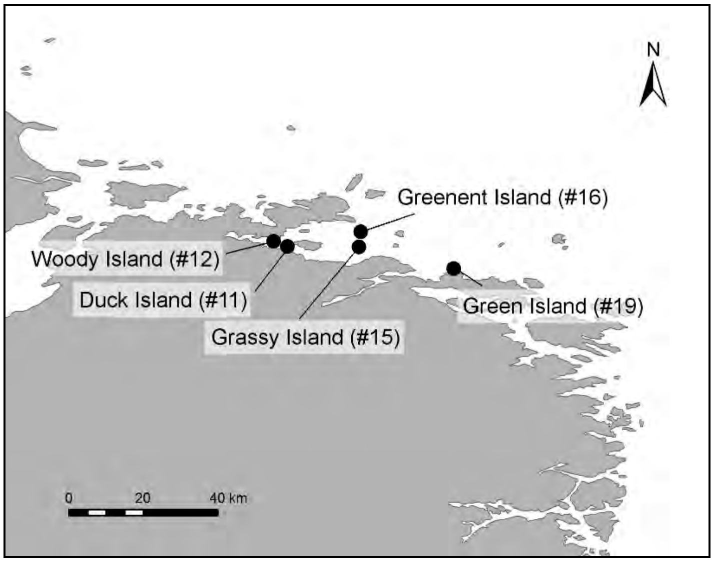


Figure 4. Map of eider colonies in Table Bay, Labrador.

Banding operations

Quebec

Banding operations were conducted each year between 2003 and 2016 during down harvesting operations on Île Blanche, Île aux Fraises, Île aux Pommes, Pot archipelago, and Île Bicquette (Fig. 5). The time series slightly varied on Île Laval (2004 to 2016), Île aux Oeufs (2004 to 2016, except 2014), and Ragueneau archipelago (2006 to 2016, except 2009). The timing of operations coincided with the end of incubation each year in all colonies except at Bicquette where it has been more variable. Females were captured on or close to their nest, using long-handled dip nets. Eiders captured for the first time were fitted with a U.S. Fish and Wildlife Service leg band, while band number of recaptured birds was noted. In 2003, bands were made from aluminium, but due to concern over aluminium resistance in salt water conditions, stainless-steel bands started to be used in 2004. From 2004 to 2008, a sample of newly-captured birds were fitted with one aluminium and one stainless-steel band to evaluate aluminium band wear and loss rate. After 2008, only stainless-steel bands were used. Pannetier Lebeuf and Giroux (2014) found a significant effect of double banding on reporting rate but not on apparent survival probability. All birds were therefore used for the analyses, unless otherwise specified.

The sampling design to capture nesting females varied according to topography and vegetation cover on each island. On Île Blanche, nest boxes have been disposed in 1985 to compensate for poor vegetation cover (The Joint Working Group on the Management of the Common Eider 2004). Captures were therefore carried out by two persons walking ahead of the down harvesting crew along parallel transects inspecting each of the 420 nest boxes. Birds nesting in the residual cover were also caught haphazardly as the banders progressed in front of the harvest crew. On Île aux Pommes and the Ragueneau archipelago, banders walked ahead of the down harvest crew across the nesting cover, moving from one side of the island to the other, and capturing female eiders as they were encountered on or near their nest. On the more forested islands such as Île aux Fraises, Pot archipelago, Île aux Oeufs, and Île Laval, banders were walking along the shores, catching eiders that were flushed from the nesting cover by the down harvesting crew. On the eastern part of Île Gros Pot (Pot archipelago), however, eiders flushed by the down crew were caught using a vertical net set across a large gully near the water. On Île Bicquette, a portion of the island is covered by trees, and the banders positioned themselves on the outer edge of the forest to capture eiders flushed by down harvesters. In the more open portions of this island, banders were walking along transects, capturing eiders on or near their nest.

Nova Scotia

Data used for this report were collected during the breeding seasons (May 1st to July 1st) between 1970 and 2016 (Fig. 5). Captures were carried out from 1970 to 2000 on Tobacco island (except 1984, 1986, 1987, 1988, 1992, and 1996), from 1975 to 2010 on Big White island (except 1976, 1985, 1994, 1996, 2003, and 2009), from 1995 to 2009 on Goodwins island (except 1997, 2003, and 2008), and from 1996 to 2016 on John's island (except 1997 and 2003). Females captured for the first time were fitted with a U.S. Fish and Wildlife Service stainless steel or aluminium leg band, while band number of recaptured birds was noted. Nesting cover varied among islands from graminoids to forests. Different capture techniques were thus used including by hand and with dip nets but most banding was conducting with retriever dogs (see Milton et al. 2016 for more details).

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Québec																								
Bicquette																								
Blanche																								
Fraises																								
Laval																								
Œufs																								
Pommes																								
Pot																								
Ragueneau																								
Nova Scotia																								
Big White						▨		▨	▨	▨	▨	▨	▨	▨	▨		▨	▨	▨	▨	▨	▨	▨	▨
Goodwins																								
John's																								
Tobacco	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨		▨				▨	▨	▨		▨
Labrador																								
Table Bay																								
Maine																								
Flag Island																								

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Québec																							
Bicquette										▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Blanche										▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Fraises										▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Laval											▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Œufs											▨	▨	▨	▨	▨	▨	▨	▨	▨	▨		▨	▨
Pommes										▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Pot										▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Ragueneau													▨	▨	▨		▨	▨	▨	▨	▨	▨	▨
Nova Scotia																							
Big White		▨		▨	▨	▨	▨	▨	▨		▨	▨	▨	▨	▨		▨						
Goodwins		▨	▨		▨	▨	▨	▨	▨		▨	▨	▨	▨		▨							
John's			▨		▨	▨	▨	▨	▨		▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Tobacco	▨	▨		▨	▨	▨	▨																
Labrador																							
Table Bay											▨	▨	▨	▨	▨	▨	▨						
Maine																							
Flag Island										▨	▨	▨	▨	▨	▨	▨	▨						

Figure 5.: Capture and recapture years for each studied colonies.

Labrador

Female common eiders were captured at five different sites in Table Bay from 2004 to 2010. Most birds were nesting in nest shelters that had been placed on the islands while others were nesting in tuckamores (spruce tree bent and entangled by winds). When captured for the first time, females were fitted with a U.S. Fish and Wildlife Service aluminium or stainless steel metal leg band, while band number of recaptured birds was noted. Different capture techniques were used including mist nets, dip nets, and bow-net traps.

Maine

Female common eiders were captured during breeding season (May and June) from 2003 to 2010 on Flag Island. The island is cover by mature spruce (*Picea sp.*) and fir (*Abies sp.*), and by hardwoods, with a very heavy understory of poison ivy (*Toxicodendron radicans*). The island edges are covered by bayberry (*Myrica sp.*) and poison ivy. Female eiders captured for the first time were fitted with a U.S. Fish and Wildlife Service aluminium or stainless steel leg band, while band number of recaptured ones was noted. At least 10 people lined the edge of the island and waited for the birds. Two or three other people were at the center of the island and pushed the birds towards them, on the edge, for capture with dip nets.

Data analyses

Log-linear models

The accuracy of capture-recapture methods for estimating population growth rate was tested by comparing variation of annual nest counts in three Quebec colonies (île aux Fraises, île Blanche, and île aux Pommes). The analysis covered the 2003-2016 period, which corresponded to the banding program in the St. Lawrence estuary. This is an update of Pannetier Lebeuf and Giroux (2014) analysis, that already validated capture-recapture methods with nest counts for the 2003-2013 period. Population growth can be expressed in a simple form as $\lambda = N_t/N_{t-1}$ where N_t and N_{t-1} denote population size at time t and t-1 respectively. Using a sequence of population sizes (N_t), it is possible to obtain λ through a log-linear regression: $\log N_t = \log N_0 + t \log \lambda$, where N_0 represents initial population size (Eberhardt and Simmons 1992, Wilson et al. 2012). The annual eider nest count provided by the down harvest crew was used as an estimation of breeding female population size. The searching methods and effort were relatively similar each year in all three colonies. All linear regressions were performed using program R 3.3.3 (R Core Team 2017).

Reverse capture-recapture models

Population growth rate (λ) was computed for each colony using Pradel reverse capture-recapture modeling (Pradel 1996). While the usual forward analysis of capture histories permits to evaluate the probability that an animal present at time *i* in the population will be present in the next time interval (survival), analysing the same encounter histories backward will estimate the probability that an individual present at time *i* was present in the previous time interval (seniority). Estimates of recruitment and population growth can therefore be obtained. This analysis was performed with program MARK 8.1 (White and Burnham 1999). Three structures of Pradel reverse capture-recapture model are implemented in program MARK : $\phi p \gamma$, $\phi p f$ and $\phi p \lambda$, where ϕ is the probability of apparent survival and represents the probability that an individual survives from time *i* to time *i+1* and does not emigrate, *p* is the capture probability and represents the probability that an individual alive and present in the study population at time *i* is captured, γ is the seniority probability and represents the probability that an animal present at time *i* was already present in the population at time *i*-1, f is the *per capita* recruitment probability and represents the addition of new animals that enter the population (through birth and immigration) between time *i* and *i*+1 per animal alive at time *i*, and λ is the population growth rate and represents the ratio of successive population sizes. All three of these model structures can give values of λ since $\lambda_i = \phi_i + f_i$ and $\lambda_i = \phi_i / \gamma_{i+1}$. These three structures were thus used for each colony and estimates of λ were compared.

To be able to compare values of λ obtained with reverse capture-recapture models with those calculated from nest counts in three Quebec colonies through log-linear regressions, only models where λ was constant were tested. Thus, the most general model was $\phi_t p_t \gamma.$, $\phi_t p_t f.$, and $\phi_t p_t \lambda.$, where "*t*" indicates that the parameter varies with years (time effect) whereas "." indicates that the parameter is constant through time. For model structures based on γ and f, all possible combinations of constant and time-varying ϕ and *p* were tested, yielding four models for each structure. For the structure containing λ, only two models with constant apparent survival were considered since allowing ϕ to vary while λ is constant makes the unlikely assumption that recruitment compensates exactly for mortality.

Goodness-of-fit of the most general model was assessed through TESTS CT2 and SR3 of program U-CARE (Choquet et al. 2009). The variance inflation factor ($\hat{c}$) was calculated by dividing the overall χ^2 by the degrees of freedom, and used to correct for overdispersion where $\hat{c} > 1$. In presence of underdispersion, where $\hat{c} < 1$, no correction was applied. Model selection was based on Akaike's Information Criterion adjusted for small sample-size and overdispersion ($QAIC_c$) (Burnham and Anderson 2002).

Apparent survival heterogeneity

Goodness-of-fit tests conducted on the Quebec and Labrador Pradel models revealed a lower apparent survival probability after initial capture, based on TEST3.SR (See Results). Apparent survival probability being a combination of true survival probability and fidelity to the area (opposite of emigration probability), a lower apparent survival probability for newly marked individuals compared to recaptured ones can be due either to a lower probability of true survival or a lower site fidelity. Provided that the CJS model with a time-since-marking structure for apparent survival was selected over a classic CJS model for Quebec 2003-2013 dataset (Pannetier Lebeuf and Giroux 2014), an attempt was made at finding if this lower apparent survival for newly-marked individuals was due to a difference in true survival or site fidelity. Accordingly, data from Île Bicquette, Île Blanche, Île aux Fraises, and Île aux Pommes was used to fit Burnham models combining recaptures and band recoveries (Burnham 1993). By including both sources of information, the Burnham model allows the separation of apparent survival in its two components: true survival and site fidelity.

Between 2004 and 2008, some birds were marked with two bands, an aluminium one and a stainless steel one to assess the wear rate of aluminium bands. A specific analysis on the effect of double-banding has revealed that recovery rate was higher for double-banded birds (Pannetier Lebeuf and Giroux 2014). The double-banded birds were thus excluded from this analysis. Band recoveries included both harvesting by hunters and other forms of mortality. Since band recovery can take place all year round, unlike recaptures that are restricted to a short period, recoveries that occurred from May 1st in year t to April 30th in year t+1 were associated to year t. Recovery data were obtained from the BBL and supplemented with data from the Quebec eider database maintained by JFG.

The general model structure as implemented in program MARK is S*p*rF where S is the true survival probability, *p* is the capture probability, F is the site fidelity probability that represents the probability that a female remains in the sample area, and r is the recovery probability, which represents the probability that a dead marked individual is found and reported. Based on preliminary analyses, survival and recapture probabilities were allowed to vary with time in the most general model, while recovery and fidelity probabilities were held constant, yielding the general model $S_t p_t r.F$. To determine if the lower apparent survival after first capture was attributable to differences in survival or fidelity, models with a time-since-marking structure, allowing a different probability for the interval after initial marking than for subsequent intervals, on survival or fidelity probabilities were fitted. The probability after the first capture was permitted to vary with years for both survival and fidelity. The most general model was thus $S_{t/t} p_t r.F_{t/}$. A set of reduced models, where some time-varying parameters were set constant, was fit. A total of 36 models, including those with and without the time-since-marking structure on survival and fidelity, were fit to the data. The variance inflation factor was calculated using the bootstrap goodness-of-fit procedure of program MARK (with 1000 iterations), and model selection was based on $QAIC_c$.

A lower apparent survival after initial capture may have several causes, including the presence of transient animals (Loery et al. 1997, Pradel et al. 1997). These individuals that do not belong to the resident catchable population and are therefore never resighted have a zero probability of apparent survival, thus reducing the estimated survival probability for newly-marked individuals after initial capture (Pradel et al. 1997). In a CJS model with a time-since marking structure, when dealing with transients, a comparison of apparent survival probability after the first capture (containing a mix of transients and residents) with the probability after subsequent captures (containing only residents) can give the proportion of transients among the unmarked population (Pradel et al. 1997, Sandercock 2006).

RESULTS

Log-linear models

Log-linear models were used on the number of nests counted each year on Île Blanche, Île aux Fraises, and Île aux Pommes to estimate population growth between 2003 and 2016 (Table 1). Two of the three models were significant (Table 2). Growth rates on Île Blanche and Île aux Fraises were positive, with respectively 3-8% and 1-7% increase per year (95% confidence intervals). On Île aux Pommes, population size tended to slightly increase (-1% to 3% per year), but the trend was not significant.

Table 1. Annual count of common eider nests on Île Blanche, Île aux Fraises, and Île aux Pommes Quebec, 2003 - 2016. Data provided by Société Duvetnor Ltée.

Year	Number nests		
	Blanche	Fraises	Pommes
2003	1,338	1,401	2,693
2004	1,315	895	2,168
2005	1,375	896	2,190
2006	1,450	1,052	2,331
2007	1,611	788	2,430
2008	1,681	1,215	2,101
2009	1,465	778	2,071
2010	1,445	1,046	1,878
2011	1,318	1,452	2,142
2012	1,717	1,272	2,319
2013	2,207	1,288	2,595
2014	2,643	1,424	2,559
2015	2,585	1,427	2,589
2016	2,926	1,766	2,949

Table 2. Growth rates (λ) estimated from log-linear regression models of annual nest counts of common eiders on Île Blanche, Île aux Fraises, and Île aux Pommes, Québec, 2003-2016.

Colony	λ (95% CI)	R^2	$F_{1,12}$	p
Blanche	1.06 (1.03-1.08)	0.71	29.91	< 0.001
Fraises	1.04 (1.01-1.07)	0.38	7.34	0.02
Pommes	1.01 (0.99-1.03)	0.14	1.96	0.19

Reverse capture-recapture models

Quebec – A total of 13,372 female common eiders were banded during the nesting period in eight Quebec colonies between 2003 and 2016 (Table 3). The number of recaptures totaled 5,039 for 3,354 females recaptured between one and eleven times.

The assumption that apparent survival probabilities be homogeneous throughout the capture occasions was violated in several occasions in most colonies. Goodness-of-fit tests based on TEST3.SR was used to determine whether apparent survival of animals caught for the first time at occasion *i* was homogeneous to that of individuals captured at the same occasion but that had been captured at least once before. Homogeneity in apparent survival was violated at Île Bicquette (2/12 occasions), Île Blanche (8/12), Île aux Fraises (3/12), Île Laval (5/11), Île aux Oeufs (4/10), Îles aux Pommes (7/12), and Pot archipelago (4/10) but not on the Ragueneau islands (0/8). On all these capture occasions, apparent survival of newly captured birds was lower than apparent survival of recaptured ones. The overall TEST3.SR was thus rejected for all colonies, except

Ragueneau archipelago ($p < 0.0001$ for Île Blanche, Île aux Fraises, Île Laval, Île aux Oeufs, Îles aux Pommes, and Pot archipelago). On Île Bicquette, homogeneity of apparent survival was also violated but to a lesser extent (overall TEST3.SR; $p = 0.03$).

The other assumption of homogeneity in capture probabilities (TEST2.CT) was not violated except for one occasion on Île Laval and Île aux Pommes. Values of $\hat{c}$ calculated for the eight islands were 1.27 (Île Bicquette), 2.83 (Île Blanche), 1.33 (Île aux Fraises), 1.76 (Île Laval), 1.50 (Île aux Pommes), 1.55 (Île aux Oeufs), 1.63 (Pot archipelago), and 0.91 (Ragueneau Archipelago). Pradel models were fit even though one of the model assumption was violated for seven colonies, but reasons behind this assumption violation and possible countermeasures were explored.

Pradel models based on γ, f, and λ yielded identical values of λ. The only difference among the modeling structures was that incertitude on parameter estimates varied among different structures. Since lambda is the parameter that we are most interested with, results of models with structure $\phi p \lambda$ are therefore presented, except for Île Bicquette for whom confidence interval of λ did not converge well. Results from $\phi p f$ is therefore present for this colony. For all eight colonies, the best model had a $QAIC_c$ weight of 0.94 or higher (Appendix A). Model averaging was therefore not used. On all colonies, the selected model had a constant probability of apparent survival and a year-specific capture probability. Based on these reverse capture-recapture models, the nesting population was decreasing on Île Bicquette and Ragueneau archipelago for the 2003-2016 period but the 95% confidence intervals included 1.0 (Table 4). On Île aux Pommes, the population was stable but the 95% CI included values below and above 1.0. This was also the case on île Laval, Île aux Oeufs, and Île aux Fraises where the growth was positive. Finally, population growth was definitively positive on Île Blanche.

Table 3. Number of adult female common eiders banded and recaptured, and total number of recaptures in colonies located in Québec, Nova Scotia, Labrador, and Maine.

	Number banded females	Number recaptured females	Total number recaptures
Québec 2003-2016[a]			
Bicquette	3048	511	620
Blanche	1754	661	1273
Fraises	1335	367	528
Laval	1301	310	431
Œufs	1452	299	400
Pommes	2026	599	929
Pot	1964	513	749
Ragueneau	492	94	109
Nova Scotia 1975-2016[b]			
Big White	1678	467	637
Goodwins	400	71	86
John's	1115	205	278
Tobacco	1080	208	285
Labrador 2004-2010			
Table Bay	1592	300	553
Maine 2003-2010			
Flag Island	747	237	342

a. *Except* Île Laval*, 2004-2013;* Île aux Œufs *2004-2013 & 2015-2016;* Ragueneau *2006-2008 & 2010-2016.* **b.** Big White *1975-2010, except 1976, 1985, 1995, 1996, 2003, and 2009;* Goodwins *1995-2009, except 1997, 2003, and 2008;* John's *1996-2016, except 1997 and 2003;* Tobacco *1970-2000, except 1984, 1986-1988, 1992, and 1996.*

Table 4. Values (95% CI) of λ, f, and γ obtained from Pradel reverse capture-recapture models with structure φfλ based on captures of female common eiders in eight colonies located in the St. Lawrence estuary, Quebec, 2003-2016.

Colony	λ (95% CI)	f (95% CI)	γ (95% CI)
Québec			
Bicquette	0.99 (0.82-1.00)	0.18 (0.15-0.22)	0.82 (0.79-0.85)
Blanche	1.07 (1.04-1.10)	0.22 (0.19-0.25)	0.80 (0.77-0.82)
Fraises	1.06 (0.99-1.13)	0.22 (0.18-0.26)	0.80 (0.76-0.83)
Laval	1.01 (0.96-1.05)	0.14 (0.10-0.20)	0.86 (0.81-0.90)
Oeufs	1.02 (0.97-1.07)	0.22 (0.17-0.27)	0.79 (0.74-0.83)
Pommes	1.00 (0.98-1.03)	0.17 (0.14-0.19)	0.83 (0.81-0.85)
Pot	1.04 (1.01-1.08)	0.22 (0.19-0.26)	0.79 (0.76-0.82)
Ragueneau	0.95 (0.88-1.03)	0.06 (0.01-0.22)	0.94 (0.78-0.99)
Nova Scotia			
Big White	0.99 (0.98-1.00)	0.14 (0.13-0.16)	0.85 (0.84-0.87)
Goodwins	0.82 (0.75-0.89)	0.02 (0.001-0.35)	0.97 (0.61-1.00)
John's	0.96 (0.93-0.98)	0.14 (0.11-0.18)	0.83 (0.79-0.86)
Tobacco	0.98 (0.96-0.99)	0.14 (0.12-0.17)	0.85 (0.83-0.87)
Labrador			
Table Bay	1.05 (0.93-1.17)	0.25 (0.15-0.38)	0.77 (0.66-0.85)
Maine			
Flag Island	0.93 (0.84 - 0.97)	0.08 (0.04-0.16)	0.91 (0.83-0.96)

Contribution of recruitment to population growth (f/λ) was especially low on Ragueneau archipelago (Table 5). It was also low on Île Laval, Île aux Pommes, and Île Bicquette, but much higher on Île Blanche, Île aux Fraises, Pot archipelago, and Île aux Oeufs.

Nova Scotia - During the 1970-2016 period, 4,273 female common eiders were banded during the breeding season in four Nova Scotia colonies (Table 3). The number of recaptures totaled 5,039 for 3,354 females recaptured between one and six times.

Goodness-of-fit tests showed no violation of assumptions, except on Tobacco where homogeneity in capture probability was violated (TEST2.CT; $p = 0.01$). Apparent survival was homogeneous in all colonies (TEST3.SR; $p > 0.05$). Values of $\hat{c}$ calculated for the four islands were 0.94 (Big White), 0.39 (Goodwins), 1.05 (John's) and 1.08 (Tobacco).

Table 5. Contribution of recruitment to population growth (f/ λ) for each colony.

Colony	f/λ (95% CI)
Québec	
Bicquette	0.18 (0.14-0.24)
Blanche	0.21 (0.17-0.25)
Fraises	0.21 (0.16-0.26)
Laval	0.14 (0.09-0.22)
Oeufs	0.22 (0.15-0.29)
Pommes	0.17 (0.13-0.20)
Pot	0.21 (0.17-0.27)
Ragueneau	0.06 (0.01-0.27)
Nova Scotia	
Big White	0.14 (0.13-0.17)
Goodwins	0.02 (0.00-0.49)
John's	0.17 (0.16-0.19)
Tobacco	0.14 (0.12-0.18)
Labrador	
Table Bay	0.24 (0.12-0.46)
Maine	
Flag Island	0.09 (0.04-0.19)

Pradel models based on γ, f and λ yielded identical values of λ, the only difference being that incertitude on parameter estimates varied among the different structures. For this study, only the results of models with structure $\phi p\lambda$ are presented. For all four colonies, the best model had a $QAIC_c$ weight of 0.99 or higher. Model averaging was therefore not used. On all colonies, the selected model had a constant probability of apparent survival and a year-specific capture probability (model selection was slightly different for structure $\phi p\gamma$ on Big White and for structure $\phi p f$ on John's, see Appendix A). Based on these reverse capture-recapture models, population abundance was decreasing on Goodwins Island from 1995 to 2009, on John's from 1996 to 2011, and on Tobacco Island from 1970 to 2000 (Table 4). On Big White Island, population growth rate was also negative, but still the highest of Nova Scotia growth rates.

Contribution of recruitment to population growth (f/λ) on Goodwins was 0.02, the lowest value of all colonies (Table 5), although its large confidence interval. It was also relatively low on Big White (0.12), Tobacco (0.14), and John's (0.17).

Labrador – From 2004 to 2010, 1,592 female common eiders were banded during the breeding season in Table Bay (Table 3). The number of recaptures totaled 553 for 300 females recaptured between one and seven times.

Goodness-of-fit tests showed violation of the assumption of homogeneity in apparent survival (TEST3.SR; $p < 0.001$). Value of $\hat{c}$ was 3.06 and the Pradel models were fit even though a model assumption was violated.

Pradel models based on γ, f and λ also yielded identical values of λ and we thus retained the model with structure ϕ*p*λ. The best model had a $QAIC_c$ weight > 0.99 and model averaging was therefore unnecessary. For all structures, the selected model had a constant probability of apparent survival and a year-specific capture probability (Appendix A). Based on these reverse capture-recapture models, population abundance was increasing from 2004 to 2010, with the third highest growth rate after Île Blanche and île aux Fraises in Quebec (Table 4). Contribution of recruitment to population growth (f/λ) in Table Bay was the highest of all colonies studied (0.24, Table 5).

Maine – A total of 747 female common eiders were banded during the breeding season on Green Island between 2003 and 2010 (Table 3). The number of recaptures totaled 342 for 237 females recaptured between one and six times. Goodness-of-fit tests showed no violation of assumption and a value calculated value of $\hat{c}$ of 1.28.

Models based on γ, f and λ yielded identical values of λ but different incertitude on parameter estimates. We limited the result presentation to models with structure ϕ*p*λ. The best model had a $QAIC_c$ weight > 0.90 and model averaging was therefore not used. For all structures, the selected model had a constant probability of apparent survival and a year-specific capture probability (Appendix A). Based on these reverse capture-recapture models, population abundance was decreasing from 2003 to 2010 (Table 4). Contribution of recruitment to population growth (f/λ) on Flag Island was among the lowest values of all colonies (0.09, Table 5).

Apparent survival heterogeneity

Burnham models were carried out to investigate the heterogeneity in apparent survival detected through TEST3.SR for Pradel models using recapture and recovery data for eiders banded in four Quebec colonies. After excluding birds that were double-banded, 7,167 adult females (2,746 recaptures and 402 band recoveries) marked between 2003 and 2016 on Île Bicquette, Île Blanche, Île aux Fraises, and Île aux Pommes were used to fit Burnham models on joint live recapture and dead recovery data (Table 6).

Table 6. Number of adult female common eiders banded and recaptured in four Quebec colonies and recovered, 2003-2016.

	Number banded females	Number recaptures	Number recoveries
Bicquette	2,853	562	160
Blanche	1,528	1,036	74
Fraises	1,021	398	68
Pommes	1,765	750	100
Total	7,167	2,746	402

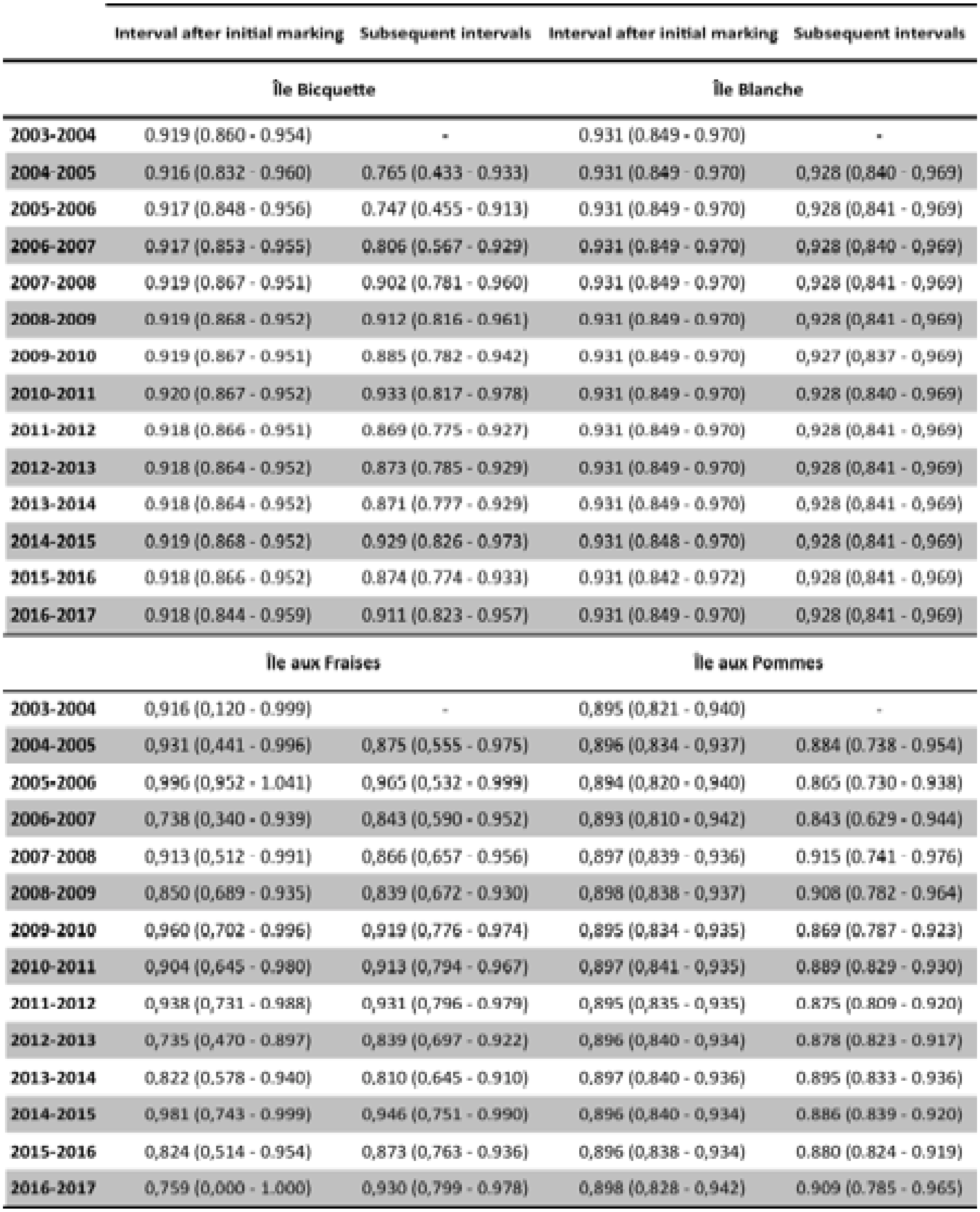
The general model $S_{t/t}p_{t}r.F_{t/}$. showed some degree of overdispersion for Île Blanche ($\hat{c}$ = 1.18) and Île aux Pommes ($\hat{c}$ = 1.11), but still fit the data well. Uncertainty in model selection was appreciable for these colonies that had three models with good support ($\Delta\text{QAIC}_c < 2$) and furthermore with ΔQAIC between 2 and 4 (Appendix B). Uncertainty in model selection was lower for Île Bicquette and Île aux Fraises for which the general model fit the data well ($\hat{c}$ = 1.05 and 1.02, respectively). For these islands, the top three models had ΔQAIC < 4. Yet, all these models had a time-since-marking structure on fidelity probability. The sums of QAIC_c weights from models with time-since-marking structure on fidelity probability for Île Bicquette, Île Blanche, Île aux Fraises, and Île aux Pommes were respectively 0.98, 1.00, 1.00 and 1.00. While the time-since-marking structure on true survival was strongly present in top-ranking models of Île Bicquette, the single-age structure was strongly present in top models of Île Blanche, and both structures were present in top-ranking models of Île aux Fraises and Île aux Pommes. The sums of QAIC_c weights from models that had a time-since-marking structure on true survival for Île Bicquette, Île Blanche, Île aux Fraises, and Île aux Pommes were respectively 0.87, 0.29, 0.50 and 0.39.

Results obtained from model averaging showed that the fidelity probabilities after the first capture were much lower than the constant value for subsequent intervals in each colony (Table 7). On the contrary, model averaging showed that true survival probability for the interval after initial capture was higher than for subsequent intervals, for Île Bicquette (Table 8). On Île Blanche, there was no difference between survival probabilities for the interval after initial capture and the others. On Île aux Fraises, model averaging showed no clear trend: some years the survival probability for the interval after initial capture was lower, some years it was higher. Therefore, the lower apparent survival after initial marking seems to be due to a lower site fidelity rather than a lower probability of true survival.

Table 7. Fidelity probability (F; 95% CI) for female eiders marked on Île Bicquette, Île Blanche, Île aux Fraises, and Île aux Pommes, 2003-2016, estimated from the Burnham model SprF averaged over the eleven models with some support, all having a time-since-marking structure on fidelity probability, with a different value for the interval after initial marking than for subsequent intervals.

	Île Bicquette	**Île Blanche**	**Île aux Fraises**	**Île aux Pommes**
Interval after initial marking				
2003-2004	0.672 (0.503-0.806)	0.686 (0.528-0.810)	0.682 (0.528-0.804)	0.642 (0.457-0.792)
2004-2005	0.667 (0.488-0.808)	0.686 (0.488-0.834)	0.697 (0.526-0.809)	0.762 (0.456-0.924)
2005-2006	0.672 (0.508-0.803)	0.639 (0.457-0.789)	0.686 (0.544-0.800)	0.317 (0.080 - 0.713)
2006-2007	0.677 (0.506-0.811)	0.668 (0.527-0.784)	0.685 (0.526-0.809)	0.670 (0.488 - 0.812)
2007-2008	0.675 (0.510-0.806)	0.793 (0.319-0.969)	0.688 (0.534-0.809)	0.802 (0.528 - 0.936)
2008-2009	0.676 (0.509-0.808)	0.623 (0.491-0.739)	0.695 (0.559-0.803)	0.581 (0.415 - 0.732)
2009-2010	0.675 (0.512-0.805)	0.660 (0.522-0.775)	0.690 (0.565-0.792)	0.846 (0.475 - 0.971)
2010-2011	0.676 (0.508-0.809)	0.636 (0.532-0.728)	0.689 (0.562-0.793)	0.695 (0.508 - 0.833)
2011-2012	0.675 (0.512-0.805)	0.703 (0.509-0.844)	0.693 (0.564-0.798)	0.626 (0.437 - 0.783)
2012-2013	0.674 (0.511-0.804)	0.586 (0.424-0.731)	0.684 (0.546-0.796)	0.844 (0.447 - 0.973)
2013-2014	0.674 (0.508-0.805)	0.571 (0.382-0.742)	0.686 (0.555-0.793)	0.696 (0.439 - 0.870)
2014-2015	0.672 (0.506-0.805)	0.625 (0.470-0.758)	0.703 (0.522-0.837)	0.524 (0.289 - 0.749)
2015-2016	0.665 (0.465-0.819)	0.478 (0.181-0.792)	0.682 (0.525-0.807)	0.538 (0.281 - 0.776)
Subsequent intervals				
Constant	0.945 (0.830-0.984)	0.979 (0.623-0.999)	1.000 (0.998-1.002)	1.000 (0.992-1.008)

Table 8. True survival probability (S; 95% CI)) for female eiders marked on Île Bicquette, Île Blanche, Île aux Fraises, and Île aux Pommes, 2003-2016, estimated from the Burnham model SprF averaged over the eleven models with some support, all having a time-since-marking structure on fidelity probability, with a different value for the interval after initial marking than for subsequent intervals.



	Interval after initial marking	Subsequent intervals	Interval after initial marking	Subsequent intervals
	Île Bicquette		Île Blanche	
2003-2004	0.919 (0.860 - 0.954)	-	0.931 (0.849 - 0.970)	-
2004-2005	0.916 (0.832 - 0.960)	0.765 (0.433 - 0.933)	0.931 (0.849 - 0.970)	0,928 (0,840 - 0,969)
2005-2006	0.917 (0.848 - 0.956)	0.747 (0.455 - 0.913)	0.931 (0.849 - 0.970)	0,928 (0,841 - 0,969)
2006-2007	0.917 (0.853 - 0.955)	0.806 (0.567 - 0.929)	0.931 (0.849 - 0.970)	0,928 (0,840 - 0,969)
2007-2008	0.919 (0.867 - 0.951)	0.902 (0.781 - 0.960)	0.931 (0.849 - 0.970)	0,928 (0,841 - 0,969)
2008-2009	0.919 (0.868 - 0.952)	0.912 (0.816 - 0.961)	0.931 (0.849 - 0.970)	0,928 (0,841 - 0,969)
2009-2010	0.919 (0.867 - 0.951)	0.885 (0.782 - 0.942)	0.931 (0.849 - 0.970)	0,927 (0,837 - 0,969)
2010-2011	0.920 (0.867 - 0.952)	0.933 (0.817 - 0.978)	0.931 (0.849 - 0.970)	0,928 (0.840 - 0,969)
2011-2012	0.918 (0.866 - 0.951)	0.869 (0.775 - 0.927)	0.931 (0.849 - 0.970)	0,928 (0,841 - 0,969)
2012-2013	0.918 (0.864 - 0.952)	0.873 (0.785 - 0.929)	0.931 (0.849 - 0.970)	0,928 (0,841 - 0,969)
2013-2014	0.918 (0.864 - 0.952)	0.871 (0.777 - 0.929)	0.931 (0.849 - 0.970)	0,928 (0,841 - 0,969)
2014-2015	0.919 (0.868 - 0.952)	0.929 (0.826 - 0.973)	0.931 (0.848 - 0.970)	0,928 (0,841 - 0,969)
2015-2016	0.918 (0.866 - 0.952)	0.874 (0.774 - 0.933)	0.931 (0.842 - 0.972)	0,928 (0,841 - 0,969)
2016-2017	0.918 (0.844 - 0.959)	0.911 (0.823 - 0.957)	0.931 (0.849 - 0.970)	0,928 (0,841 - 0,969)
	Île aux Fraises		Île aux Pommes	
2003-2004	0,916 (0,120 - 0.999)	-	0,895 (0,821 - 0,940)	-
2004-2005	0,931 (0,441 - 0.996)	0,875 (0,555 - 0.975)	0,896 (0,834 - 0,937)	0.884 (0.738 - 0.954)
2005-2006	0,996 (0,952 - 1.041)	0,965 (0,532 - 0.999)	0,894 (0,820 - 0,940)	0.865 (0.730 - 0.938)
2006-2007	0,738 (0,340 - 0.939)	0,843 (0,590 - 0.952)	0,893 (0,810 - 0,942)	0.843 (0.629 - 0.944)
2007-2008	0,913 (0,512 - 0.991)	0,866 (0,657 - 0.956)	0,897 (0,839 - 0,936)	0.915 (0.741 - 0.976)
2008-2009	0,850 (0,689 - 0.935)	0,839 (0,672 - 0.930)	0,898 (0,838 - 0,937)	0.908 (0.782 - 0.964)
2009-2010	0,960 (0,702 - 0.996)	0,919 (0,776 - 0.974)	0,895 (0,834 - 0,935)	0.869 (0.787 - 0.923)
2010-2011	0,904 (0,645 - 0.980)	0,913 (0,794 - 0.967)	0,897 (0,841 - 0,935)	0.889 (0.829 - 0.930)
2011-2012	0,938 (0,731 - 0.988)	0,931 (0,796 - 0.979)	0,895 (0,835 - 0,935)	0.875 (0.809 - 0.920)
2012-2013	0,735 (0,470 - 0.897)	0,839 (0,697 - 0.922)	0,896 (0,840 - 0,934)	0.878 (0.823 - 0.917)
2013-2014	0,822 (0,578 - 0.940)	0,810 (0,645 - 0.910)	0,897 (0,840 - 0,936)	0.895 (0.833 - 0.936)
2014-2015	0,981 (0,743 - 0.999)	0,946 (0,751 - 0.990)	0,896 (0,840 - 0,934)	0.886 (0.839 - 0.920)
2015-2016	0,824 (0,514 - 0.954)	0,873 (0,763 - 0.936)	0,896 (0,838 - 0,934)	0.880 (0.824 - 0.919)
2016-2017	0,759 (0,000 - 1.000)	0,930 (0,799 - 0.978)	0,898 (0,828 - 0,942)	0.909 (0.785 - 0.965)

DISCUSSION

Validation of the reverse capture-recapture models

Using capture-recapture data with the Pradel model, relatively similar values of λ were obtained for the 2003-2016 period on Île Blanche, Île aux Fraises, and Île aux Pommes than when using the log-linear regressions on nest count data, confirming results of Pannetier Lebeuf and Giroux (2014). Despite some violation of the assumption of homogeneity in apparent survival probability (see below), we are confident that banding and recapture data can be used to estimate λ for eider colonies where total counts are difficult or impossible to obtain.

Our validation was done in three colonies with similar banding effort each year and at the same time in relation to the eider breeding chronology. This was not the case for all data sets that included differences in banding effort, timing and with some years missing. Moreover, the time series available varied among the four banding programs. These limits should be considered when interpreting our results.

Trends in population size

Quebec St. Lawrence estuary

Based on nest count and capture-recapture data, we found that eider abundance has increased on Île Blanche and Île aux Fraises between 2003 and 2016 while there was no trend on Île aux Pommes indicating some stability. This confirmed the previous results of Pannetier Lebeuf and Giroux (2014) based on a slightly shorter period (2003-2013). It should be recalled that no important avian cholera outbreaks have occurred in these colonies since the last one in 2002 (Société Duvetnor, unpublished data). In addition, numerous conservation efforts have been carried out since 1986 to increase eider population size in St Lawrence estuary (The Joint Working Group on the Management of the Common Eider 2004).

Population growth rate on Île Bicquette is of prime interest since it is the island supporting the largest number of eider nests in the St. Lawrence estuary and possibly in eastern North America. Unfortunately, nest counts on Bicquette are not reliable and cannot be used to determine population trend. However, reports by the local down harvest organisation indicate a significant decline in the number of nesting females (Marc Lapointe, SPEE, pers. communication). The banding data also showed that the population size slightly decreased between 2003 and 2016. Again, no mass mortality occurred on Île Bicquette after the 2002 die-off when at least 2,500 nesting females died (Jean Rodrigue, CWS, pers. communication). The parameters estimated by the Pradel models for Bicquette and Pommes were very similar. As nest counts showed stability on Île aux Pommes, the apparent decline on Île Bicquette since 2003 is difficult to explain.

Because of the size of the Bicquette colony and a similar banding effort (one day) than for the other islands, a lower proportion of birds have been marked on Bicquette compared to other colonies (3% vs 6-8%; J-F. Giroux, unpublished data). Moreover, the timing of the banding has not been optimal each year because of logistic problems. In has been sometimes conducted after hatching peak which resulted in early females being not available to be captured or recaptured. This may have biased our parameter estimates for Bicquette. Other possibilities could be a reduced recruitment, as hinted by a lower value of f at Bicquette compared to Île Blanche and Île aux Fraises. It has been reported that gulls, especially Great black-backed gulls (*Larus marinus*), cause significant mortality on ducklings when they leave the island (Marc Lapointe, SPEE, pers. communication). A better understanding of duckling and first year survival could help to understand the population dynamics on Bicquette.

The Pradel models showed different trends in the other Quebec colonies for the 2003-2016 period. Population size increased on Pot archipelago. The trend was also slightly positive on Île Laval and Île aux Oeufs. On the contrary, population size decreased on Ragueneau archipelago, where recruitment (f=0.06) was very low compared to other colonies, although its incertitude was the highest value among the Quebec colonies. The presence of red fox (*Vulpes vulpes*) on one of the main island of this archipelago for three consecutive years (2011-2013) has prevented females from nesting on this island. Moreover, we have not observed any significant movements of marked females from this island to nearby islands.

Nova Scotia

Models showed negative trends for all four colonies studied in Nova Scotia. Milton et al. (2016) found that female eiders in Nova Scotia had a lower survival rate (*S*) than males (0.827 ± 0.23 vs. 0.915 ± 0.21). This could explain the global negative trend in population growth. These authors noted that recovery rates were almost the same for both sexes, meaning that difference in survival rate was not caused by human hunting. Milton et al. (2016) suggested that the higher female mortality could be attributable to degradation of habitat vegetation by nesting cormorants (*Phalacrocorax* spp.) or by dynamic processes of vegetation changes. They also hypothesised that female eiders were more exposed to the increasing population number of predators such as bald eagles (*Haliaeetus leucocephalus*), minks (*Neovison vison*), and river otters (*Lontra canadensis*) along the Nova Scotia coastline. Finally, females could be affected differently by diseases, although no outbreaks have been detected in recent years.

Labrador

The model showed a 5% annual increase of nesting eiders in Table Bay between 2004 and 2009. This is slightly less than the 8% reported by Gloutney and Mehl (2010) and could result from different criteria used to select the data and the model selection process. Nevertheless, our estimate for Table Bay can be compared to the other studied colonies. Recruitment contributed to 24% to growth rate, which was the highest among all colonies studied.

Maine

The model showed a negative population growth rate on Flag Island between 2003 and 2010. Low contribution of recruitment to population growth may be related to duckling predation (Dan McAuley, pers. comm.). A reduced food source that could affect female condition and breeding propensity could not be discarded to explain a decline in population growth. Blue mussels are declining in the Gulf of Maine and this may be related to the presence of the introduced green crabs (Sorte et al. 2017).

Reliability of population growth rates estimated through capture-recapture model

Pradel models for most of Québec and Labrador colonies showed a violation of homogeneity in apparent survival. This means that apparent survival of individuals caught for the first time at occasion *i* was lower than that of individuals captured at the same occasion but that had been captured at least once before. Homogeneity in apparent survival is one of the few assumptions associated with population growth modelling using the Pradel approach. Pannetier Lebeuf and Giroux (2014) investigated the potential bias associated with a lower apparent survival after initial capture using different models. Their results suggested that λ obtained from Pradel models, even with this assumption violated, were quite robust, since the λ values estimated with models accounting for heterogeneity in apparent survival were very similar.

Pannetier Lebeuf and Giroux (2014) explored different causes for a lower apparent survival after initial capture. Using dead recoveries and live recaptures with Burnham models, they found that it was due to a lower fidelity probability and not a lower true survival probability. This was corroborated by our updated analyses with three more years of data. Therefore, the hypothesis that capture and marking had an adverse effect on survival, as well as the presence of an age-dependence in true survival, can be rejected. The problem appears to be the presence of transients.

Pannetier Lebeuf and Giroux (2014) observed that less than 1% of marked females moved to another island in the St. Lawrence estuary. They thus proposed that the lower apparent fidelity of some birds was related to an avoidance behavior rather than emigration to another colony. They suggested that some females leave their nest before the banders and/or the down harvest crew reach their nest site and are therefore not recaptured. Ydenberg and Dill (1986) proposed that flight distance from a nest should increase if the costs of remaining on the nest increase. If we assume that all birds have the same body condition, shy individuals that perceived an higher risk than bold individuals or in other words that are less prone in taking a risk should flee earlier and further. The flight initiation distance has been shown by Carrete and Tella (2010) to be repeatable in time for burrowing owls (*Athene cunicularia*). Such a repeatable behavior trait has been recently associated to personality (Réale et al. 2007).

Interestingly, Pradel models for Nova Scotia and Maine showed no violation of homogeneity of apparent survival. If violation of this assumption in Quebec implied capture heterogeneity, capture methods in Nova Scotia (retriever dogs) and Maine (banders in line catching flushing birds) could reduce the problem of avoidance. It is possible that retriever dogs are more efficient than banders in catching shy birds on their nest. Capture technique on Flag Island, Maine, was more random than capture at the nest, and could also have a higher probability of catching shy birds. The condition of females towards the end of incubation cannot be discarded but Pannetier Lebeuf and Giroux (2014) found no difference in condition (index of breast muscles) of females when initially banded between those that were recaptured at least once and those never recaptured.

CONCLUSION

Using several data sets of banded nesting females, we determined population trends of common eiders in several colonies of Quebec, Maine, Nova Scotia, and Labrador. Population trends were declining in Maine and Nova Scotia and increasing in Labrador and in several Quebec colonies. There is still some concern about the largest colony in Quebec and possibly in eastern North America, Île Bicquette. Th banding data show a gradual decline which is supported by the opinion of the down harvest organisation but the confidence limits on our estimates were large possibly because of a bias data set (lower proportion of marked birds and annual variation in the timing of the banding operation).

Research efforts should be focused on Maine and Nova Scotia colonies, and on Île Bicquette. They should focus on what affect female condition and survival (Maine and Nova Scotia), and on duckling and first year survival (Maine and Île Bicquette). Unfortunately, we did not have enough data in some colonies in Maine and Nova Scotia (number of females and number of consecutive years) to use the Pradel model. could not be studied. Banding programs should be continued where possible with a constant annual effort and at the same time during the breeding chronology, that is just before hatching.

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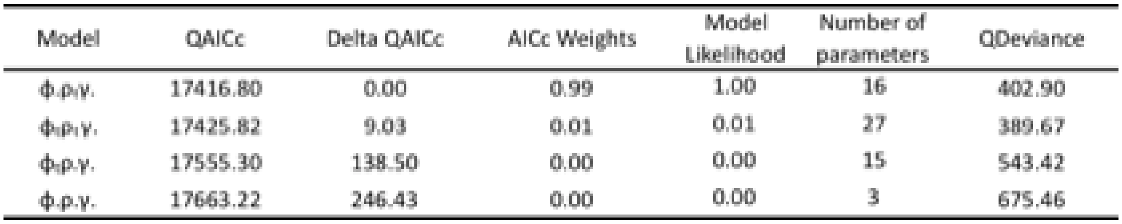
APPENDIX A – Details of model selection for capture-recapture and capture-recapture-recovery data.

Table A-I. Model selection for Pradel model φργ for female common eiders banded on Île Bicquette, 2003-2016.

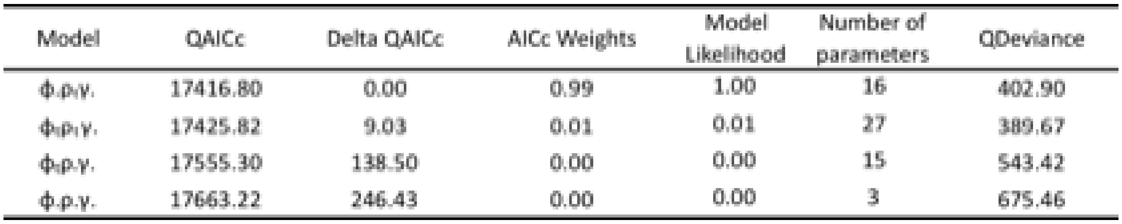


Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$\phi_{.}p_{t}\gamma_{.}$	17416.80	0.00	0.99	1.00	16	402.90
$\phi_{t}p_{t}\gamma_{.}$	17425.82	9.03	0.01	0.01	27	389.67
$\phi_{t}p_{.}\gamma_{.}$	17555.30	138.50	0.00	0.00	15	543.42
$\phi_{.}p_{.}\gamma_{.}$	17663.22	246.43	0.00	0.00	3	675.46

Table A-II. Model selection for Pradel model φρλ for female common eiders banded on Île Bicquette, 2003-2016.

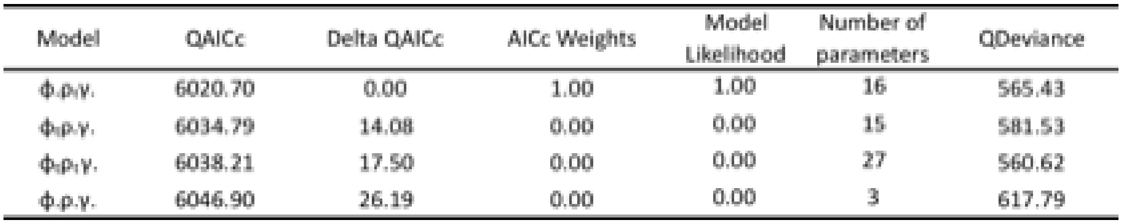
Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$\phi_{.}p_{t}\lambda_{.}$	17416.80	0.00	1.00	1.00	16	402.90
$\phi_{.}p_{.}\lambda_{.}$	17663.22	246.43	0.00	0.00	3	675.46

Table A-III. Model selection for Pradel model φρf for female common eiders banded on Île Bicquette, 2003-2016.



Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$\phi_{.}p_{t}\gamma_{.}$	17416.80	0.00	0.99	1.00	16	402.90
$\phi_{t}p_{t}\gamma_{.}$	17425.82	9.03	0.01	0.01	27	389.67
$\phi_{t}p_{.}\gamma_{.}$	17555.30	138.50	0.00	0.00	15	543.42
$\phi_{.}p_{.}\gamma_{.}$	17663.22	246.43	0.00	0.00	3	675.46

Table A-IV. Model selection for Pradel model φργ for female common eiders banded on Île Blanche, 2003-2016.

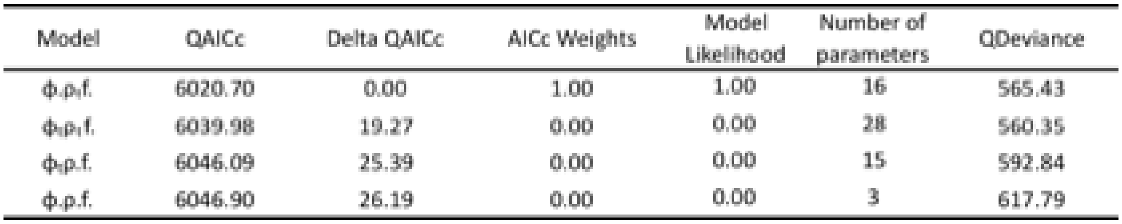


Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$\phi_{.}p_{t}\gamma_{.}$	6020.70	0.00	1.00	1.00	16	565.43
$\phi_{t}p_{.}\gamma_{.}$	6034.79	14.08	0.00	0.00	15	581.53
$\phi_{t}p_{t}\gamma_{.}$	6038.21	17.50	0.00	0.00	27	560.62
$\phi_{.}p_{.}\gamma_{.}$	6046.90	26.19	0.00	0.00	3	617.79

Table A-V. Model selection for Pradel model φρλ for female common eiders banded on Île Blanche, 2003-2016.

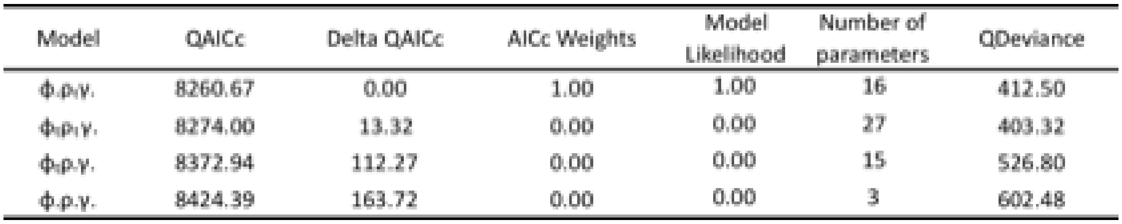
Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$\phi_{.}p_{t}\lambda_{.}$	6020.70	0.00	1.00	1.00	16	565.43
$\phi_{.}p_{.}\lambda_{.}$	6046.90	26.19	0.00	0.00	3	617.79

Table A-VI. Model selection for Pradel model φρf for female common eiders banded on Île Blanche, 2003-2016.



Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$\phi_{.}p_{t}f_{.}$	6020.70	0.00	1.00	1.00	16	565.43
$\phi_{t}p_{t}f_{.}$	6039.98	19.27	0.00	0.00	28	560.35
$\phi_{t}p_{.}f_{.}$	6046.09	25.39	0.00	0.00	15	592.84
$\phi_{.}p_{.}f_{.}$	6046.90	26.19	0.00	0.00	3	617.79

Table A-VII. Model selection for Pradel model φργ for female common eiders banded on Île aux Fraises, 2003-2016.

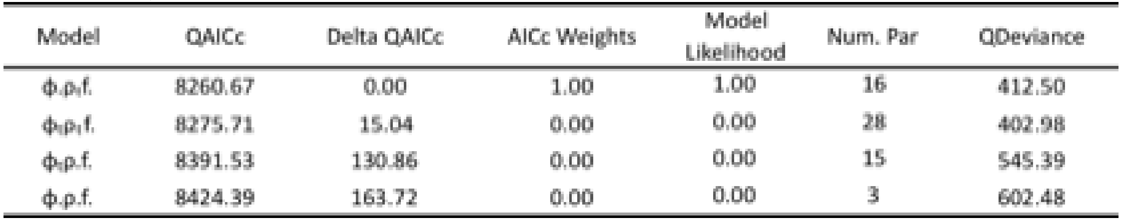


Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$\phi_{.}\rho_{t}\gamma_{.}$	8260.67	0.00	1.00	1.00	16	412.50
$\phi_{t}\rho_{t}\gamma_{.}$	8274.00	13.32	0.00	0.00	27	403.32
$\phi_{t}\rho_{.}\gamma_{.}$	8372.94	112.27	0.00	0.00	15	526.80
$\phi_{.}\rho_{.}\gamma_{.}$	8424.39	163.72	0.00	0.00	3	602.48

Table A-VIII. Model selection for Pradel model φρλ for female common eiders banded on Île aux Fraises, 2003-2016.

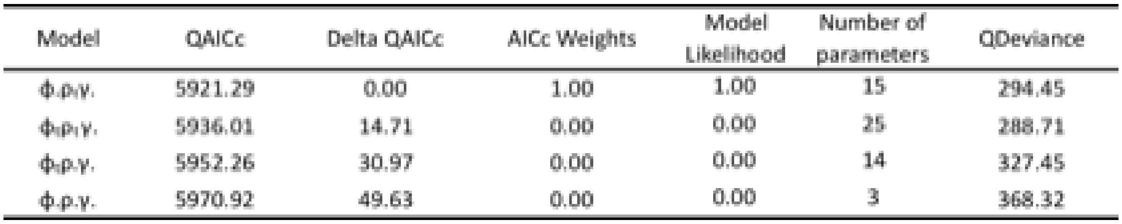
Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$\phi_{.}\rho_{t}\lambda_{.}$	8260.67	0.00	1.00	1.00	16	412.50
$\phi_{.}\rho_{.}\lambda_{.}$	8424.39	163.72	0.00	0.00	3	602.48

Table A-IX. Model selection for Pradel model φρf for female common eiders banded on Île aux Fraises, 2003-2016.



Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Num. Par	QDeviance
$\phi.\rho_{t}f.$	8260.67	0.00	1.00	1.00	16	412.50
$\phi_{t}\rho_{t}f.$	8275.71	15.04	0.00	0.00	28	402.98
$\phi_{t}\rho.f.$	8391.53	130.86	0.00	0.00	15	545.39
$\phi.\rho.f.$	8424.39	163.72	0.00	0.00	3	602.48

Table A-X. Model selection for Pradel model φργ for female common eiders banded on Île Laval, 2004-2016.

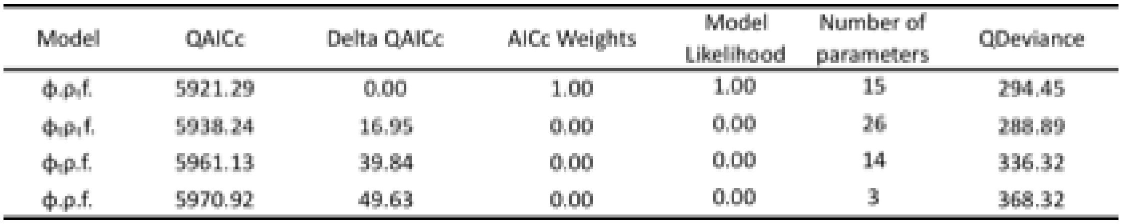


Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$\phi.\rho_{t}\gamma.$	5921.29	0.00	1.00	1.00	15	294.45
$\phi_{t}\rho_{t}\gamma.$	5936.01	14.71	0.00	0.00	25	288.71
$\phi_{t}\rho.\gamma.$	5952.26	30.97	0.00	0.00	14	327.45
$\phi.\rho.\gamma.$	5970.92	49.63	0.00	0.00	3	368.32

Table A-XI. Model selection for Pradel model φρλ for female common eiders banded on Île Laval, 2004-2016.

Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$\phi.\rho_{t}\lambda.$	5921.29	0.00	1.00	1.00	15	294.45
$\phi.\rho.\lambda.$	5970.92	49.63	0.00	0.00	3	368.32

Table A-XII. Model selection for Pradel model φρf for female common eiders banded on Île Laval, 2004-2016.



Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$\phi.\rho_{t}f.$	5921.29	0.00	1.00	1.00	15	294.45
$\phi_{t}\rho_{t}f.$	5938.24	16.95	0.00	0.00	26	288.89
$\phi_{t}\rho.f.$	5961.13	39.84	0.00	0.00	14	336.32
$\phi.\rho.f.$	5970.92	49.63	0.00	0.00	3	368.32

Table A-XIII. Model selection for Pradel model φργ for female common eiders banded on Île aux Pommes, 2003-2016.

Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$\phi_{.}p_{t}\gamma_{.}$	11972.22	0.00	0.94	1.00	16	663.54
$\phi_{t}p_{t}\gamma_{.}$	11977.74	5.53	0.06	0.06	27	646.75
$\phi_{t}p_{.}\gamma_{.}$	12014.93	42.72	0.00	0.00	15	708.28
$\phi_{.}p_{.}\gamma_{.}$	12032.34	60.13	0.00	0.00	3	749.84

Table A-XIV. Model selection for Pradel model φρλ for female common eiders banded on Île aux Pommes, 2003-2016.

Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$\phi_{.}p_{t}\lambda_{.}$	11972.22	0.00	1.00	1.00	16	663.54
$\phi_{.}p_{.}\lambda_{.}$	12032.34	60.13	0.00	0.00	3	749.84

Table A-XV. Model selection for Pradel model φρf for female common eiders banded on Île aux Pommes, 2003-2016.

Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$\phi_{.}p_{t}f_{.}$	11972.22	0.00	0.98	1.00	16	663.54
$\phi_{t}p_{t}f_{.}$	11979.56	7.35	0.02	0.03	28	646.54
$\phi_{t}p_{.}f_{.}$	12022.56	50.35	0.00	0.00	15	715.91
$\phi_{.}p_{.}f_{.}$	12032.34	60.13	0.00	0.00	3	749.84

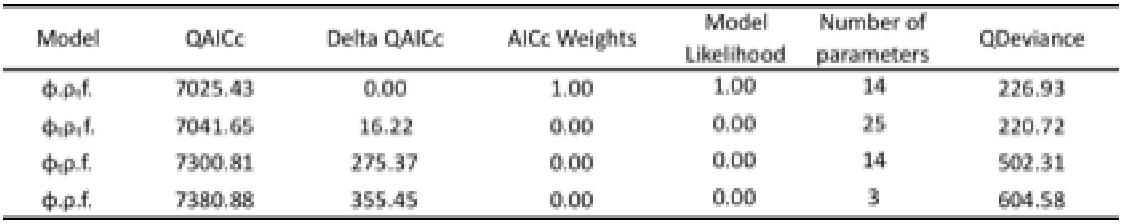
Table A-XVI. Model selection for Pradel model φργ for female common eiders banded on Île aux Oeufs, 2004-2016.

Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$\phi_{.}p_{t}\gamma_{.}$	7025.43	0.00	1.00	1.00	14	226.93
$\phi_{.}p_{.}\gamma_{.}$	7380.88	355.45	0.00	0.00	3	604.58
$\phi_{t}p_{t}\gamma_{.}$	238523.17	231497.74	0.00	0.00	23	231706.34
$\phi_{t}p_{.}\gamma_{.}$	238698.88	231673.45	0.00	0.00	14	231900.39

Table A-XVII. Model selection for Pradel model φρλ for female common eiders banded on Île aux Oeufs, 2004-2016.

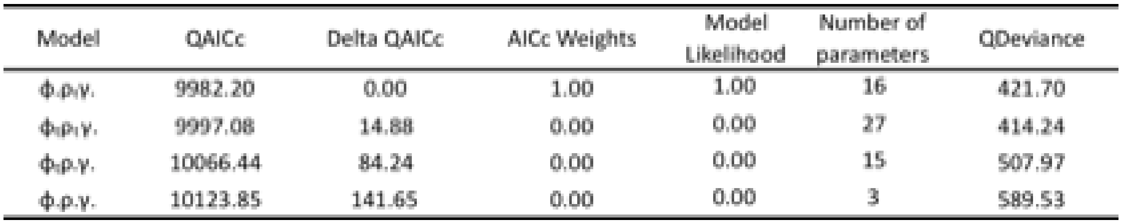
Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$\phi.p_{t}\lambda.$	7025.43	0.00	1.00	1.00	14	226.93
$\phi.p.\lambda.$	7380.88	355.45	0.00	0.00	3	604.58

Table A-XVIII. Model selection for Pradel model φρf for female common eiders banded on Île aux Oeufs, 2004-2016.



Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$\phi.p_{t}f.$	7025.43	0.00	1.00	1.00	14	226.93
$\phi_{t}p_{t}f.$	7041.65	16.22	0.00	0.00	25	220.72
$\phi_{t}p.f.$	7300.81	275.37	0.00	0.00	14	502.31
$\phi.p.f.$	7380.88	355.45	0.00	0.00	3	604.58

Table A-XIX. Model selection for Pradel model φργ for female common eiders banded on Pot Archipelago, 2003-2016.



Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$\phi.p_{t}\gamma.$	9982.20	0.00	1.00	1.00	16	421.70
$\phi_{t}p_{t}\gamma.$	9997.08	14.88	0.00	0.00	27	414.24
$\phi_{t}p.\gamma.$	10066.44	84.24	0.00	0.00	15	507.97
$\phi.p.\gamma.$	10123.85	141.65	0.00	0.00	3	589.53

Table A-XX. Model selection for Pradel model φρλ for female common eiders banded on Pot Archipelago, 2003-2016.

Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$\phi.p_{t}\lambda.$	9982.20	0.00	1.00	1.00	16	421.70
$\phi.p.\lambda.$	10123.85	141.65	0.00	0.00	3	589.53

Table A-XXI. Model selection for Pradel model φρf for female common eiders banded on Pot Archipelago, 2003-2016.

Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$\phi.p_{t}f.$	9982.20	0.00	1.00	1.00	16	421.70
$\phi_{t}p_{t}f.$	10000.39	18.20	0.00	0.00	28	415.52
$\phi_{t}p.f.$	10090.84	108.64	0.00	0.00	15	532.36
$\phi.p.f.$	10123.85	141.65	0.00	0.00	3	589.53

Table A-XXII. Model selection for Pradel model φργ for female common eiders banded on Ragueneau Archipelago, 2006-2016.

Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$\phi.p_{t}\gamma.$	3330.32	0.00	0.91	1.00	12	115.84
$\phi_{t}p_{t}\gamma.$	3335.02	4.71	0.09	0.10	19	105.83
$\phi_{t}p.\gamma.$	3497.87	167.55	0.00	0.00	12	283.39
$\phi.p.\gamma.$	3512.86	182.55	0.00	0.00	3	316.83

Table A-XXIII. Model selection for Pradel model φρλ for female common eiders banded on Ragueneau Archipelago, 2006-2016.

Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$\phi.p_{t}\lambda.$	3330.32	0.00	1.00	1.00	12	115.84
$\phi.p.\lambda.$	3512.86	182.55	0.00	0.00	3	316.83

Table A-XXIV. Model selection for Pradel model φρf for female common eiders banded on Ragueneau Archipelago, 2006-2016.

Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$\phi.p_{t}f.$	3330.32	0.00	0.99	1.00	12	115.84
$\phi_{t}p_{t}f.$	3338.76	8.44	0.01	0.01	21	105.30
$\phi_{t}p.f.$	3502.22	171.90	0.00	0.00	12	287.74
$\phi.p.f.$	3512.86	182.55	0.00	0.00	3	316.83

Table A-XXV. Model selection for Pradel model φργ for female common eiders banded on Big White, 1975-2010.

Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$\phi_{t}p_{t}\gamma_{.}$	15471.77	0.00	1.00	1.00	33	979.55
$\phi_{.}p_{t}\gamma_{.}$	15511.94	40.16	0.00	0.00	32	1021.77
$\phi_{t}p_{.}\gamma_{.}$	16450.14	978.37	0.00	0.00	37	1949.66
$\phi_{.}p_{.}\gamma_{.}$	17209.36	1737.59	0.00	0.00	3	2778.11

Table A-XXVI. Model selection for Pradel model φρλ for female common eiders banded on Big White, 1975-2010.

Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$\phi_{.}p_{t}\lambda_{.}$	15511.94	0.00	1.00	1.00	32	1021.77
$\phi_{.}p_{.}\lambda_{.}$	17209.36	1697.42	0.00	0.00	3	2778.11

Table A-XXVII. Model selection for Pradel model φρf for female common eiders banded on Big White, 1975-2010.

Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$\phi_{.}p_{t}f_{.}$	15511.94	0.00	1.00	1.00	32	1021.77
$\phi_{t}p_{t}f_{.}$	15529.58	17.65	0.00	0.00	59	983.20
$\phi_{t}p_{.}f_{.}$	16552.62	1040.68	0.00	0.00	37	2052.14
$\phi_{.}p_{.}f_{.}$	17209.36	1697.42	0.00	0.00	3	2778.11

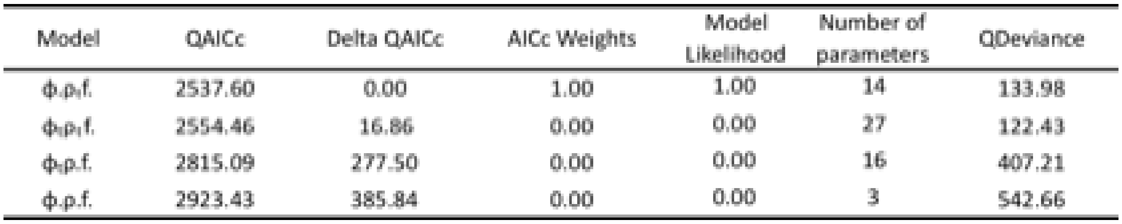
Table A-XXVIII. Model selection for Pradel model φργ for female common eiders banded on Goodwins, 1995-2009.

Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$\phi_{.}p_{t}\gamma_{.}$	2537.60	0.00	0.98	1.00	14	133.98
$\phi_{t}p_{t}\gamma_{.}$	2545.90	8.30	0.02	0.02	23	122.79
$\phi_{t}p_{.}\gamma_{.}$	2776.23	238.64	0.00	0.00	16	368.35
$\phi_{.}p_{.}\gamma_{.}$	2923.43	385.84	0.00	0.00	3	542.66

Table A-XXIX. Model selection for Pradel model φρλ for female common eiders banded on Goodwins, 1995-2009.

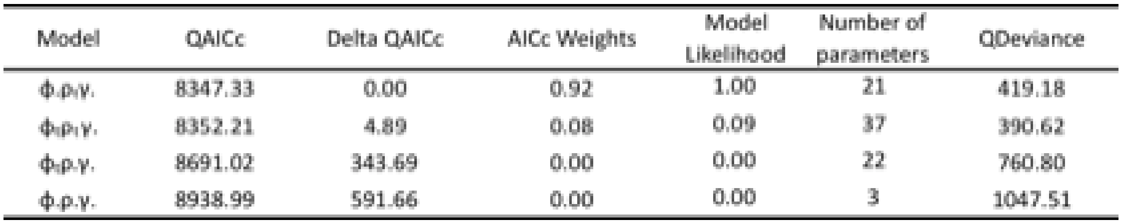
Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$\phi.p_t\lambda.$	2537.60	0.00	1.00	1.00	14	133.98
$\phi.p.\lambda.$	2923.43	385.84	0.00	0.00	3	542.66

Table A-XXX. Model selection for Pradel model φρf for female common eiders banded on Goodwins, 1995-2009.



Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$\phi.p_t f.$	2537.60	0.00	1.00	1.00	14	133.98
$\phi_t p_t f.$	2554.46	16.86	0.00	0.00	27	122.43
$\phi_t p.f.$	2815.09	277.50	0.00	0.00	16	407.21
$\phi.p.f.$	2923.43	385.84	0.00	0.00	3	542.66

Table A-XXXI. Model selection for Pradel model φργ for female common eiders banded on John’s, 1996-2016.



Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$\phi.p_t\gamma.$	8347.33	0.00	0.92	1.00	21	419.18
$\phi_t p_t\gamma.$	8352.21	4.89	0.08	0.09	37	390.62
$\phi_t p.\gamma.$	8691.02	343.69	0.00	0.00	22	760.80
$\phi.p.\gamma.$	8938.99	591.66	0.00	0.00	3	1047.51

Table A-XXXII. Model selection for Pradel model φρλ for female common eiders banded on John’s, 1996-2016.

Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$\phi.p_t\lambda.$	8351.46	0.00	1.00	1.00	23	419.18
$\phi.p.\lambda.$	8938.99	587.52	0.00	0.00	3	1047.51

Table A-XXXIII. Model selection for Pradel model φρf for female common eiders banded on John’s, 1996-2016.

Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$\phi_{t}p_{t}f_{.}$	8347.18	0.00	0.52	1.00	39	381.34
$\phi_{.}p_{t}f_{.}$	8347.33	0.15	0.48	0.93	21	419.18
$\phi_{t}p_{.}f_{.}$	8735.55	388.38	0.00	0.00	22	805.34
$\phi_{.}p_{.}f_{.}$	8938.99	591.81	0.00	0.00	3	1047.51

Table A-XXXIV. Model selection for Pradel model φργ for female common eiders banded on Tobacco, 1970-2000.

Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$\phi_{.}p_{t}\gamma_{.}$	8212.69	0.00	1.00	1.00	27	614.69
$\phi_{t}p_{t}\gamma_{.}$	8231.19	18.50	0.00	0.00	53	577.96
$\phi_{t}p_{.}\gamma_{.}$	8649.99	437.30	0.00	0.00	32	1041.54
$\phi_{.}p_{.}\gamma_{.}$	9074.34	861.65	0.00	0.00	3	1525.45

Table A-XXXV. Model selection for Pradel model φρλ for female common eiders banded on Tobacco, 1970-2000.

Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$\phi_{.}p_{t}\lambda_{.}$	8212.69	0.00	1.00	1.00	27	614.69
$\phi_{.}p_{.}\lambda_{.}$	9074.34	861.65	0.00	0.00	3	1525.45

Table A-XXXVI. Model selection for Pradel model φρf for female common eiders banded on Tobacco, 1970-2000.

Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$\phi_{.}p_{t}f_{.}$	8214.77	0.00	1.00	1.00	28	614.69
$\phi_{t}p_{t}f_{.}$	8241.86	27.09	0.00	0.00	57	579.94
$\phi_{t}p_{.}f_{.}$	8745.57	530.80	0.00	0.00	32	1137.12
$\phi_{.}p_{.}f_{.}$	9074.34	859.56	0.00	0.00	3	1525.45

Table A-XXXVII. Model selection for Pradel model φργ for female common eiders banded on Flag Island, 2003-2010.

Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$\phi_{.}p_{t}\gamma_{.}$	3868.18	0.00	0.90	1.00	10	113.98
$\phi_{t}p_{t}\gamma_{.}$	3872.62	4.44	0.10	0.11	15	108.17
$\phi_{t}p_{.}\gamma_{.}$	3905.08	36.89	0.00	0.00	9	152.91
$\phi_{.}p_{.}\gamma_{.}$	3927.10	58.92	0.00	0.00	3	187.09

Table A-XXXVIII. Model selection for Pradel model φρλ for female common eiders banded on Flag Island, 2003-2010.

Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$\phi_{.}p_{t}\lambda_{.}$	3868.18	0.00	1.00	1.00	10	113.98
$\phi_{.}p_{.}\lambda_{.}$	3927.10	58.92	0.00	0.00	3	187.09

Table A-XXXIX. Model selection for Pradel model φρf for female common eiders banded on Flag Island, 2003-2010.

Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$\phi_{.}p_{t}f_{.}$	3868.18	0.00	0.97	1.00	10	113.98
$\phi_{t}p_{t}f_{.}$	3875.06	6.88	0.03	0.03	16	108.55
$\phi_{t}p_{.}f_{.}$	3908.59	40.41	0.00	0.00	9	156.43
$\phi_{.}p_{.}f_{.}$	3927.10	58.92	0.00	0.00	3	187.09

Table A-XXXX. Model selection for Pradel model φργ for female common eiders banded on Flag Island, 2003-2010.

Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$\phi_{.}p_{t}\gamma_{.}$	2796.01	0.00	0.98	1.00	9	46.26
$\phi_{t}p_{t}\gamma_{.}$	2803.35	7.34	0.02	0.03	13	45.51
$\phi_{t}p_{.}\gamma_{.}$	2837.30	41.29	0.00	0.00	8	89.57
$\phi_{.}p_{.}\gamma_{.}$	2917.92	121.91	0.00	0.00	3	180.26

Table A-XXXXI. Model selection for Pradel model φρλ for female common eiders banded on Flag Island, 2003-2010.

Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$\phi_{.}p_{t}\lambda_{.}$	2796.01	0.00	1.00	1.00	9	46.26
$\phi_{.}p_{.}\lambda_{.}$	2917.92	121.91	0.00	0.00	3	180.26

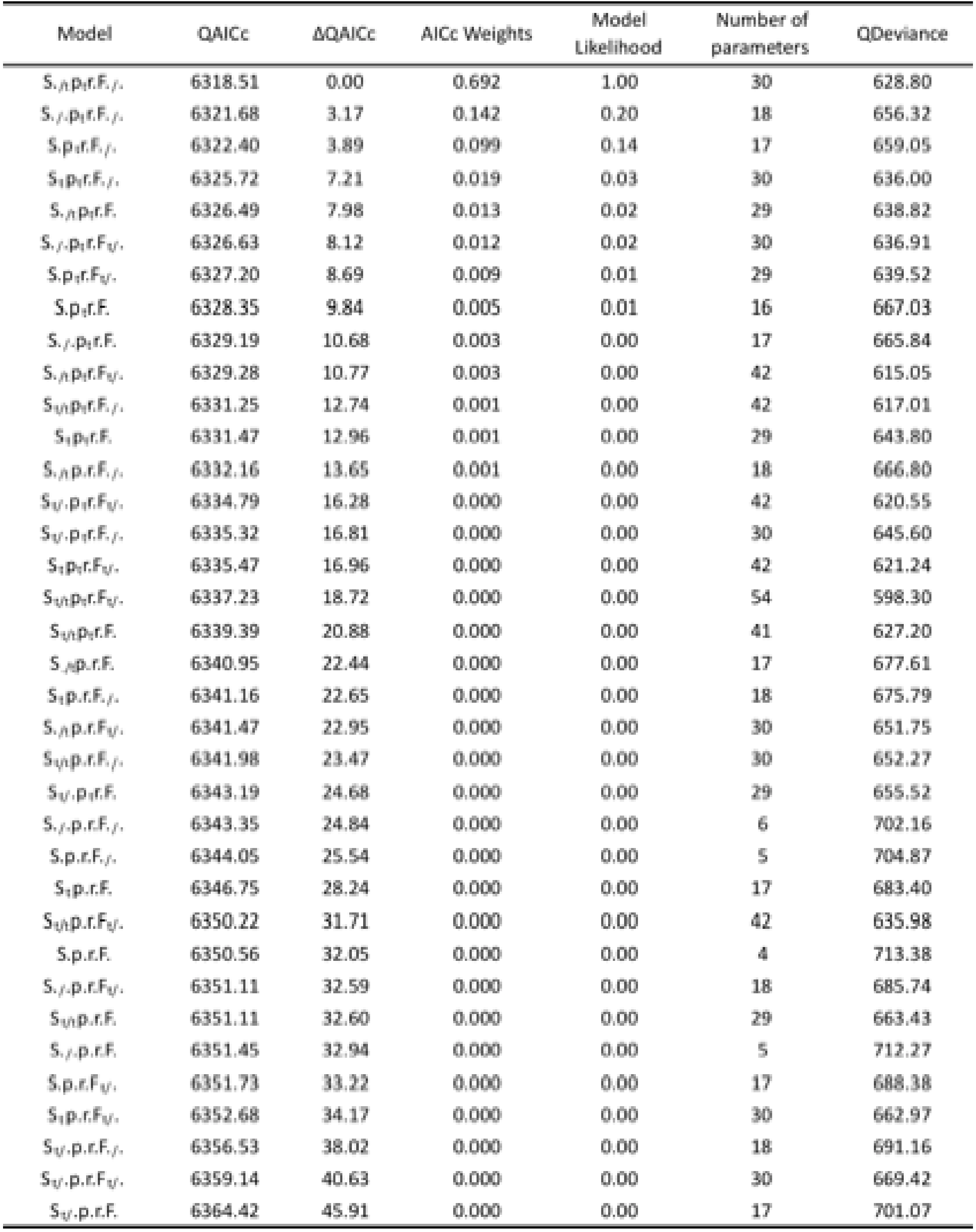
Table A-XXXXII. Model selection for Pradel model φρf for female common eiders banded on Flag Island, 2003-2010.

Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$\phi_{.}p_{t}f_{.}$	2306.18	0.00	0.97	1.00	9	48.34
$\phi_{t}p_{t}f_{.}$	2313.07	6.90	0.03	0.03	13	46.97
$\phi_{t}p_{.}f_{.}$	2389.59	83.42	0.00	0.00	8	133.81
$\phi_{.}p_{.}f_{.}$	2558.14	251.97	0.00	0.00	3	312.53

APPENDIX B – Details of model selection for Burnham model SprF

Table B-I. Details of model selection for Burnham model SprF with and without time-since-marking structure on true survival and/or fidelity for female common eiders banded on Île Bicquette, 2003-2016.

Table B-II. Details of model selection for Burnham model SprF with and without time-since-marking structure on true survival and/or fidelity for female common eiders banded on Île Blanche, 2003-2016.



Model	QAICc	ΔQAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$S_{./t}.p_{t}.r.F_{./.}$	6318.51	0.00	0.692	1.00	30	628.80
$S_{./.}.p_{t}.r.F_{./.}$	6321.68	3.17	0.142	0.20	18	656.32
$S.p_{t}.r.F_{./.}$	6322.40	3.89	0.099	0.14	17	659.05
$S_{t}p_{t}.r.F_{./.}$	6325.72	7.21	0.019	0.03	30	636.00
$S_{./t}.p_{t}.r.F.$	6326.49	7.98	0.013	0.02	29	638.82
$S_{./.}.p_{t}.r.F_{t/.}$	6326.63	8.12	0.012	0.02	30	636.91
$S.p_{t}.r.F_{t/.}$	6327.20	8.69	0.009	0.01	29	639.52
$S.p_{t}.r.F.$	6328.35	9.84	0.005	0.01	16	667.03
$S_{./.}.p_{t}.r.F.$	6329.19	10.68	0.003	0.00	17	665.84
$S_{./t}.p_{t}.r.F_{t/.}$	6329.28	10.77	0.003	0.00	42	615.05
$S_{t/t}.p_{t}.r.F_{./.}$	6331.25	12.74	0.001	0.00	42	617.01
$S_{t}p_{t}.r.F.$	6331.47	12.96	0.001	0.00	29	643.80
$S_{./t}.p.r.F_{./.}$	6332.16	13.65	0.001	0.00	18	666.80
$S_{t/.}.p_{t}.r.F_{t/.}$	6334.79	16.28	0.000	0.00	42	620.55
$S_{t/.}.p_{t}.r.F_{./.}$	6335.32	16.81	0.000	0.00	30	645.60
$S_{t}p_{t}.r.F_{t/.}$	6335.47	16.96	0.000	0.00	42	621.24
$S_{t/t}.p_{t}.r.F_{t/.}$	6337.23	18.72	0.000	0.00	54	598.30
$S_{t/t}.p_{t}.r.F.$	6339.39	20.88	0.000	0.00	41	627.20
$S_{./t}.p.r.F.$	6340.95	22.44	0.000	0.00	17	677.61
$S_{t}p.r.F_{./.}$	6341.16	22.65	0.000	0.00	18	675.79
$S_{./t}.p.r.F_{t/.}$	6341.47	22.95	0.000	0.00	30	651.75
$S_{t/t}.p.r.F_{./.}$	6341.98	23.47	0.000	0.00	30	652.27
$S_{t/.}.p_{t}.r.F.$	6343.19	24.68	0.000	0.00	29	655.52
$S_{./.}.p.r.F_{./.}$	6343.35	24.84	0.000	0.00	6	702.16
$S.p.r.F_{./.}$	6344.05	25.54	0.000	0.00	5	704.87
$S_{t}p.r.F.$	6346.75	28.24	0.000	0.00	17	683.40
$S_{t/t}.p.r.F_{t/.}$	6350.22	31.71	0.000	0.00	42	635.98
$S.p.r.F.$	6350.56	32.05	0.000	0.00	4	713.38
$S_{./.}.p.r.F_{t/.}$	6351.11	32.59	0.000	0.00	18	685.74
$S_{t/t}.p.r.F.$	6351.11	32.60	0.000	0.00	29	663.43
$S_{./.}.p.r.F.$	6351.45	32.94	0.000	0.00	5	712.27
$S.p.r.F_{t/.}$	6351.73	33.22	0.000	0.00	17	688.38
$S_{t}p.r.F_{t/.}$	6352.68	34.17	0.000	0.00	30	662.97
$S_{t/.}.p.r.F_{./.}$	6356.53	38.02	0.000	0.00	18	691.16
$S_{t/.}.p.r.F_{t/.}$	6359.14	40.63	0.000	0.00	30	669.42
$S_{t/.}.p.r.F.$	6364.42	45.91	0.000	0.00	17	701.07

Model	QAICc	ΔQAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
S.p$_t$r.F$_{./}$.	5660.67	0.00	0.3592	1.00	17	1257.59
S.p$_t$r.F$_{t/}$.	5660.90	0.23	0.3198	0.89	29	1233.37
S$_{./}$.p$_t$r.F$_{./}$.	5662.47	1.80	0.14576	0.41	18	1257.36
S$_{./}$.p$_t$r.F$_{t/}$.	5662.73	2.06	0.12814	0.36	30	1233.15
S.p.r.F$_{t/}$.	5665.89	5.23	0.02634	0.07	17	1262.81
S$_{./}$.p.r.F$_{t/}$.	5667.69	7.02	0.01074	0.03	18	1262.58
S$_{./t}$p$_t$r.F$_{./}$.	5669.34	8.67	0.0047	0.01	30	1239.76
S.p.r.F$_{./}$.	5671.09	10.42	0.00196	0.01	5	1292.23
S$_{./t}$p$_t$r.F$_{t/}$.	5672.02	11.35	0.00123	0.00	42	1217.74
S$_{./}$.p.r.F$_{./}$.	5672.86	12.20	0.00081	0.00	6	1291.99
S$_t$p$_t$r.F$_{t/}$.	5674.30	13.64	0.00039	0.00	42	1220.03
S$_t$p$_t$r.F$_{./}$.	5674.43	13.77	0.00037	0.00	30	1244.86
S$_{t/}$.p$_t$r.F$_{./}$.	5674.78	14.11	0.00031	0.00	30	1245.20
S$_{t/}$.p$_t$r.F$_{t/}$.	5676.84	16.17	0.00011	0.00	42	1222.56
S$_{./t}$p.r.F$_{t/}$.	5677.37	16.70	0.00008	0.00	30	1247.80
S$_t$p.r.F$_{t/}$.	5679.30	18.63	0.00003	0.00	30	1249.72
S$_{t/}$.p.r.F$_{./}$.	5680.75	20.08	0.00002	0.00	18	1275.64
S$_{t/}$.p.r.F$_{t/}$.	5681.67	21.01	0.00001	0.00	30	1252.10
S$_{t/t}$p$_t$r.F$_{./}$.	5683.49	22.82	0	0.00	42	1229.21
S$_{./t}$p.r.F$_{./}$.	5683.66	23.00	0	0.00	18	1278.55
S$_{t/t}$p$_t$r.F$_{t/}$.	5685.86	25.19	0	0.00	54	1206.65
S$_t$p.r.F$_{./}$.	5686.71	26.04	0	0.00	18	1281.60
S$_{t/t}$p.r.F$_{t/}$.	5691.21	30.54	0	0.00	42	1236.93
S$_{t/t}$p.r.F$_{./}$.	5694.47	33.80	0	0.00	30	1264.89
S$_{./}$.p$_t$r.F.	5717.01	56.34	0	0.00	17	1313.93
S$_{t/}$.p$_t$r.F.	5717.91	57.25	0	0.00	29	1290.38
S$_{t/}$.p.r.F.	5725.76	65.09	0	0.00	17	1322.67
S$_{./}$.p.r.F.	5727.32	66.65	0	0.00	5	1348.45
S$_{./t}$p$_t$r.F.	5735.10	74.43	0	0.00	29	1307.57
S$_{t/t}$p$_t$r.F.	5738.18	77.51	0	0.00	41	1285.97
S.p$_t$r.F.	5738.80	78.13	0	0.00	16	1337.74
S$_{t/t}$p.r.F.	5744.03	83.36	0	0.00	29	1316.50
S$_{./t}$p.r.F.	5745.63	84.96	0	0.00	17	1342.55
S.p.r.F.	5749.51	88.84	0	0.00	4	1372.65
S$_t$p$_t$r.F.	5751.51	90.84	0	0.00	29	1323.98
S$_t$p.r.F.	5763.30	102.64	0	0.00	17	1360.22

Table B-III. Details of model selection for Burnham model SprF with and without time-since-marking structure on true survival and/or fidelity for female common eiders banded on Île aux Pommes, 2003-2016.

Model	QAICc	ΔQAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$S.p.r.F_{t/.}$	5689.23	0.00	0.421	1.00	17	926.43
$S_{./.}.p.r.F_{t/.}$	5690.63	1.40	0.209	0.50	18	925.80
$S_{./t}p.r.F_{t/.}$	5690.87	1.64	0.185	0.44	30	901.57
$S_{./t}p.r.F_{./.}$	5692.73	3.51	0.073	0.17	18	927.90
$S.p.r.F_{./.}$	5693.71	4.48	0.045	0.11	5	955.13
$S_{./.}.p.r.F_{./.}$	5695.13	5.90	0.022	0.05	6	954.54
$S_{t}p.r.F_{t/.}$	5695.45	6.22	0.019	0.04	30	906.15
$S_{t}p.r.F_{./.}$	5696.78	7.55	0.010	0.02	18	931.95
$S.p_{t}r.F_{t/.}$	5697.10	7.87	0.008	0.02	29	909.84
$S_{./.}.p_{t}r.F_{t/.}$	5698.11	8.88	0.005	0.01	30	908.80
$S_{./t}p_{t}r.F_{t/.}$	5699.57	10.34	0.002	0.01	42	885.55
$S.p_{t}r.F_{./.}$	5702.23	13.00	0.001	0.00	17	939.43
$S_{./.}.p_{t}r.F_{./.}$	5703.55	14.32	0.000	0.00	18	938.72
$S_{t/t}p.r.F_{./.}$	5703.66	14.43	0.000	0.00	30	914.35
$S_{./t}p_{t}r.F_{./.}$	5703.73	14.50	0.000	0.00	30	914.42
$S_{t}p_{t}r.F_{t/.}$	5704.09	14.86	0.000	0.00	42	890.07
$S_{t/.}.p.r.F_{./.}$	5705.15	15.92	0.000	0.00	18	940.32
$S_{t/.}.p.r.F_{t/.}$	5706.13	16.91	0.000	0.00	30	916.83
$S_{t/t}p.r.F_{t/.}$	5706.35	17.13	0.000	0.00	42	892.34
$S_{t}p_{t}r.F_{./.}$	5707.53	18.30	0.000	0.00	30	918.23
$S_{t/.}.p_{t}r.F_{t/.}$	5713.94	24.71	0.000	0.00	42	899.92
$S_{t/.}.p_{t}r.F_{./.}$	5714.77	25.54	0.000	0.00	30	925.47
$S_{t/t}p_{t}r.F_{./.}$	5715.13	25.91	0.000	0.00	42	901.12
$S_{t/t}p_{t}r.F_{t/.}$	5715.46	26.23	0.000	0.00	54	876.49
$S_{./t}p.r.F.$	5722.10	32.87	0.000	0.00	17	959.30
$S_{./.}.p.r.F.$	5722.56	33.33	0.000	0.00	5	983.98
$S.p.r.F.$	5723.22	34.00	0.000	0.00	4	986.65
$S_{t}p.r.F.$	5723.55	34.33	0.000	0.00	17	960.75
$S_{t/.}.p.r.F.$	5727.24	38.01	0.000	0.00	17	964.43
$S_{t/t}p.r.F.$	5727.29	38.06	0.000	0.00	29	940.03
$S_{./.}.p_{t}r.F.$	5729.06	39.84	0.000	0.00	17	966.26
$S.p_{t}r.F.$	5729.12	39.89	0.000	0.00	16	968.35
$S_{./t}p_{t}r.F.$	5731.21	41.98	0.000	0.00	29	943.95
$S_{t}p_{t}r.F.$	5734.00	44.78	0.000	0.00	29	946.75
$S_{t/.}.p_{t}r.F.$	5736.78	47.55	0.000	0.00	29	949.52
$S_{t/t}p_{t}r.F.$	5738.39	49.16	0.000	0.00	41	926.44

Table B-IV. Details of model selection for Burnham model SprF with and without time-since-marking structure on true survival and/or fidelity for female common eiders banded on Île aux Fraises, 2003-2016.

Model	QAICc	ΔQAICc	AICc Weights	Model Likelihood	Number of parameters	QDeviance
$S_{t}p_{t}r.F_{./.}$	3969.47	0.00	0.552	1.00	30	610.75
$S_{t/.}p_{t}r.F_{./.}$	3970.87	1.40	0.273	0.50	30	612.16
$S_{t/t}p_{t}r.F_{./.}$	3972.95	3.48	0.097	0.18	42	589.19
$S_{t}p_{t}r.F_{t/.}$	3975.29	5.82	0.030	0.05	42	591.53
$S_{t}p.r.F_{./.}$	3977.31	7.85	0.011	0.02	18	643.29
$S_{./t}p_{t}r.F_{./.}$	3977.41	7.95	0.010	0.02	30	618.70
$S.p_{t}r.F_{./.}$	3978.04	8.57	0.008	0.01	17	646.06
$S_{./.}p_{t}r.F_{./.}$	3978.79	9.33	0.005	0.01	18	644.77
$S.p_{t}r.F_{t/.}$	3979.77	10.30	0.003	0.01	29	623.12
$S_{t}p.r.F_{t/.}$	3980.42	10.95	0.002	0.00	30	621.71
$S_{t/.}p_{t}r.F_{t/.}$	3980.65	11.18	0.002	0.00	42	596.89
$S_{./.}p_{t}r.F_{t/.}$	3980.86	11.39	0.002	0.00	30	622.15
$S_{t/t}p.r.F_{./.}$	3980.96	11.49	0.002	0.00	30	622.24
$S_{t/t}p_{t}r.F_{t/.}$	3982.25	12.78	0.001	0.00	54	573.08
$S_{./t}p_{t}r.F_{t/.}$	3982.39	12.92	0.001	0.00	42	598.63
$S_{t/.}p_{t}r.F.$	3984.05	14.58	0.000	0.00	29	627.41
$S_{t/.}p.r.F_{./.}$	3984.94	15.48	0.000	0.00	18	650.92
$S_{./t}p.r.F_{./.}$	3985.80	16.34	0.000	0.00	18	651.78
$S_{t/t}p.r.F_{t/.}$	3986.02	16.55	0.000	0.00	42	602.26
$S_{./t}p.r.F_{t/.}$	3987.22	17.75	0.000	0.00	30	628.50
$S_{t/t}p_{t}r.F.$	3988.35	18.88	0.000	0.00	41	606.69
$S_{t}p_{t}r.F.$	3988.94	19.48	0.000	0.00	29	632.30
$S_{t/.}p.r.F_{t/.}$	3990.79	21.33	0.000	0.00	30	632.08
$S.p.r.F_{t/.}$	3991.18	21.72	0.000	0.00	17	659.21
$S_{./.}p.r.F_{t/.}$	3991.82	22.35	0.000	0.00	18	657.80
$S_{./.}p_{t}r.F.$	3992.22	22.76	0.000	0.00	17	660.24
$S_{./t}p_{t}r.F.$	3992.31	22.84	0.000	0.00	29	635.67
$S.p.r.F_{./.}$	3992.64	23.17	0.000	0.00	5	684.98
$S_{./.}p.r.F_{./.}$	3992.99	23.52	0.000	0.00	6	683.32
$S_{t}p.r.F.$	3995.71	26.25	0.000	0.00	17	663.73
$S_{t/t}p.r.F.$	3997.45	27.98	0.000	0.00	29	640.81
$S.p_{t}r.F.$	3997.67	28.21	0.000	0.00	16	667.73
$S_{t/.}p.r.F.$	3999.37	29.90	0.000	0.00	17	667.39
$S_{./t}p.r.F.$	4001.62	32.15	0.000	0.00	17	669.64
$S_{./.}p.r.F.$	4008.23	38.76	0.000	0.00	5	700.58
$S.p.r.F.$	4014.74	45.28	0.000	0.00	4	709.10