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Management and Conservation Note

Evidence of Recent Population Recovery in Common Eiders Breeding in Western Greenland

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ABSTRACT Severe population declines were reported for common eiders (*Somateria mollissima*) in western Greenland over the period 1960–2000. A monitoring program, concurrent with more restrictive hunting regulations on common eiders, revealed breeding numbers increasing by 212%, from 2,558 active nests in 2000 to 7,982 nests in 2007. Though it was not possible to directly link harvest reduction and population growth in West Greenland, a similar increase in breeding numbers in Canada was correlated with the harvest reduction in Greenland and linked to increasing adult survival and recruitment of first-time breeders, and a similar explanation is suggested for West Greenland. The study emphasizes that appropriate restrictions in hunting can be efficient in wildlife management and that common eiders can sustain dramatic rates of increase during population regrowth. It also shows that cost-efficient monitoring programs can be established through cooperation with local residents.

KEY WORDS Arctic, common eider, community-based nest counts, population increases, *Somateria mollissima*, West Greenland.

Through time, many people in the Arctic have used local resources as the foundation for their communities and societies, and the future of such traditional lifestyles depends on sustainable management of wildlife populations (Huntington 2001). However, knowledge about Arctic wildlife populations and their ecology is often fragmentary and may complicate the understanding of population trends, as has been the situation for eider species (*Somateria* spp. and *Polysticta steller*) in northern areas. During the 1980s and 1990s there were several reports on declining populations of eiders in Alaska (USA; Kertell 1991, Stehn et al. 1993, Ely et al. 1994, Suydam et al. 2000), Canada (Reed and Erskine 1986, Gratto-Trevor et al. 1998, Robertson and Gilchrist 1998), Greenland (Mosbech and Boertmann 1999, Merkel 2004*a*), and Russia (Bustnes and Tertitski 2000, Goudie et al. 2000). Factors behind some of these declines appeared to include human disturbances, excessive harvest, and climatic events; however, in most cases causes were unknown (Robertson and Gilchrist 1998, Suydam et al. 2000, Merkel 2004*a*). More recently, evidence of increasing eider populations has been reported for common eiders (*Somateria mollissima*) in eastern Canada (Hipfner et al. 2002, Chaulk et al. 2005*a*). Again it was uncertain what caused the population increase, but improved management was suggested as a contributing factor in both cases.

The common eider is a common breeder in West Greenland, and Greenland probably sustained $\geq$150,000 eiders at the turn of the 19th century (Müller 1906). However, apart from some stable colonies in the most northern breeding area (Qaanaaq; Christensen and Falk 2001), a large decline in breeding numbers occurred during the 20th century (Salomonsen 1967, Boertmann et al. 1996). The most recent and best documented decline is from the central–northern part of West Greenland (69°N–74°N), where an 80% reduction in breeding numbers occurred during 1960–2000 (Merkel 2004*a*). The breeding eider population of West Greenland winters in Southwest Greenland along with many breeding birds from eastern Canada (Lyngs 2003, Mosbech et al. 2006). For centuries this winter population has been an important component of the seabird harvest in Southwest Greenland, and recent population modeling showed indirect evidence that annual winter harvest levels of 55,000–70,000 eiders (1993–2000) was not sustainable and probably a major contributor to previous declines (Gilliland et al. 2009). The model indicated that harvest should be reduced by $\geq$40% to stop projected declines and harvest during late winter should be avoided.

As a management response, harvest regulations changed in 2001. The closed season was extended by 4 months, from 1 June–1 October to 15 February–15 October. At the same time, the Greenland Institute of Natural Resources (GINR), in close cooperation with local residents, initiated more regular surveys of common eider in West Greenland, covering areas of decline between 69°N and 74°N (Merkel and Nielsen 2002). This monitoring program includes annual surveys of representative colonies throughout the area, aiming to detect any possible signs of recovery. I examined the results from the first 7 years of the monitoring program (2001–2007) and the possible link between detected population change and the newly enforced harvest restrictions in Greenland.

STUDY AREA

We (local residents and GINR) conducted nest surveys in central and northern parts of West Greenland, during the incubation period in June–July (2001–2007), from Ilulissat (69°15′N) in the south to Nuussuaq (74°05′N) in the north (Fig. 1). Colonies consisted of small islands with sparse

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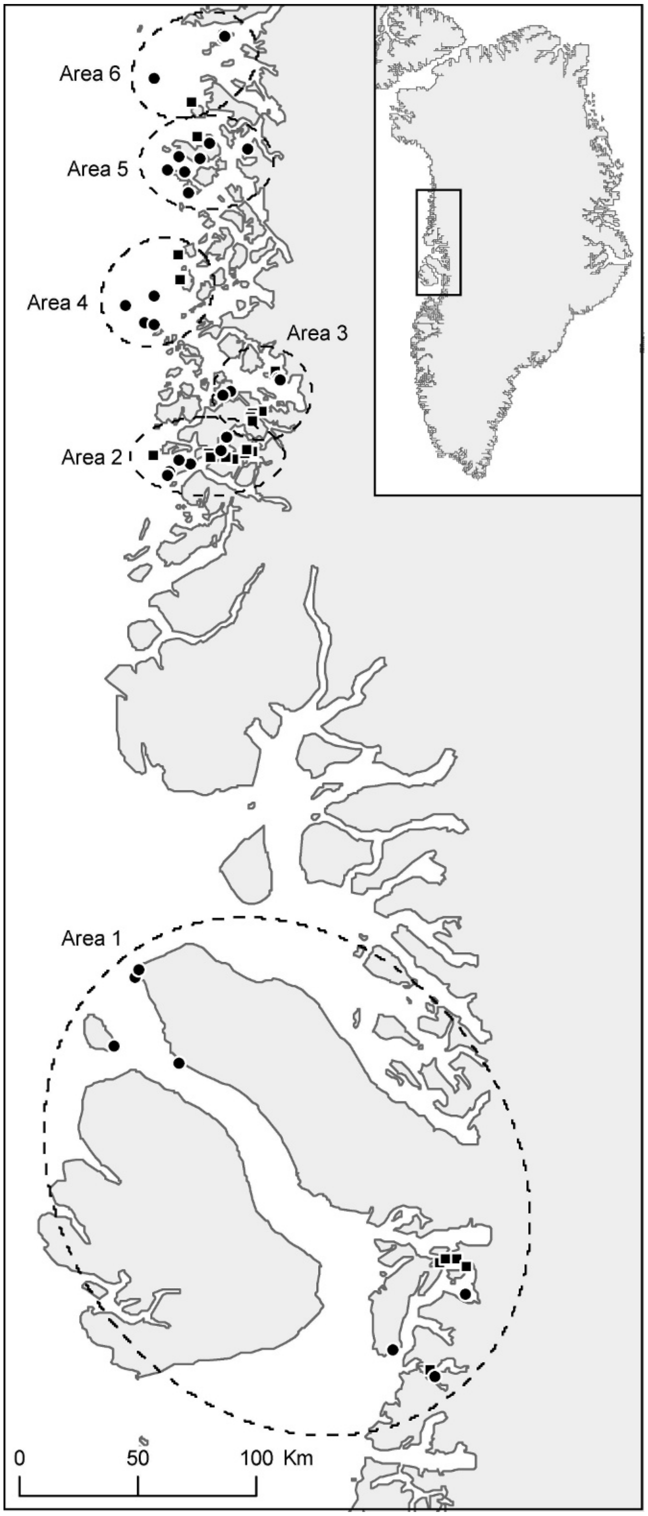

Figure 1. Common eider colonies in West Greenland (69°–74°N) included in the Greenland Institute of Natural Resources monitoring program. Circles indicate colonies surveyed annually from 2000 to 2007, and square symbols show reference colonies surveyed only twice in this period.

vegetation and limited nesting cover. Some colonies located in the fjords were more densely covered with ground vegetation, such as dwarf willow (*Salix herbacea*) and crowberry (*Empetrum nigrum*).

METHODS

Local residents conducted annual nest surveys including 32 colonies (114 islands). On a south–north gradient I divided the study area into 6 areas (Fig. 1), corresponding to 6 survey teams, each consisting of 1–3 residents. To standardize the survey procedure, GINR produced a survey manual and trained resident observers in the nest-counting technique in the field in 2001, and residents reported nest findings in standardized form (Merkel and Nielsen 2002; see also Merkel 2004*a* for the nest-count procedure). Subsequently, resident observers conducted surveys in 2002–2006 and jointly with GINR in 2007. The 32 colonies were first surveyed by GINR in 2000 when preparing for the monitoring program (Table 1). Another 25 reference colonies (65 islands) were surveyed twice and only by GINR, once during 1998–2001 and again in 2007 (Fig. 1). Reference colonies were included as part of the validation of trend information obtained from the main survey program. We selected survey and reference colonies from among 106 known colonies in the study area (Merkel 2002). All colonies in the monitoring program consisted of small islands <1.0 km^2, for which it was easy to replicate search efforts between years. When eiders nested on one or several small islands within a group of islands, we included all the islands as part of the colony to account for intra-colony movements between years.

I calculated the number of breeding pairs as the sum of active nests, including 5 types of nests: 1) nests containing plant material and eggs (early laying), 2) nests containing only down (eggs missing), 3) nests containing down and eggs, 4) nests containing ducklings, and 5) nests containing fresh egg membranes (ducklings hatched). I did not include nests lined merely with plant material (prospected or abandoned nest) as active nests, and old (>1 yr) nest cups were not recorded. Because the different nest types represented progressive stages of breeding, I could use frequency distribution of nest types to validate survey timing and to detect systematic errors in nest type recording. Multiple nest type recording also helped me to detect changes in illegal egging (type 2 nests) and in clutch sizes (type 3 nests). Illegal egging was previously identified as a problem within this breeding area (Merkel 2004*a*). When calculating mean clutch size (type 3 nests), I excluded nests containing >7 eggs, because these are typically a result of nest-parasitism (Robertson et al. 1992).

To describe population trend I calculated annual growth rates (λ) with regression analyses of log-transformed nest-count data (active nests). Because large colonies contribute more to the overall population trend, I weighted the regression according to the original number of nests in 2000. To describe overall population trend, accounting for possible geographical variation, I examined regression coefficients of log-transformed active nest counts across years (analyses of covariance [ANCOVA]) while controlling for differences among areas using the interaction term area × year. Because the interaction term was not significant, I derived overall population trend from a second run of the model without

Table 1. Survey dates, population size (active nests), annual growth rates (%), and clutch sizes for common eiders breeding in West Greenland (69°–74°N), 2000–2007.

Yr	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Total	Clutch size[a]	SD
Survey dates	Jun	Jul	Jul	Jul	Jul	Jul			
2000	23–28	9–10	11–14	13	19	21			
2001	27–29	2	4	5	7	8–9			
2002		14–16[b]	4–6	16[b]	17–18[b]	16[b]			
2003	27–28	2–3		6–9[b]	8–9	13			
2004	23–28	9–11	7–8		10–11				
2005		11–16	7–8[b]	2	10–11[b]	10			
2006		11–13[b]	7–8[b]	8	10–11				
2007	26–28	1	3	4	6	6–7			
Mean	27	8	7	8	11	13			
SD	1.3	5.4	3.0	3.0	4.6	5.3			
Active nests, annual program									
2000	81	163	689	439	126	200	1,698	3.4	0.3
2001	46	127	580	496	81	240	1,570	3.5	0.3
2002	53[c]	152	868	500	24	290	1,887	3.7	0.2
2003	100	242	950[c]	650	54	313	2,309	3.8	0.6
2004	143	302	1,195	748[c]	61	357[c]	2,806	4.1	0.4
2005	165[c]	253	1,079	971	153	402	3,023	3.8	0.4
2006	191[c]	389	1,307	983	93	458[c]	3,421	4.1	0.8
2007	219	418	1,314	1,222	321	786	4,280	3.7	0.3
Growth rate (%)	15.6	11.3	9.5	15.0	12.5	13.9	12.6		
Clutch size[a]	3.7	3.6	4.0	3.6	3.8	3.9		3.7	
SD	0.4	0.1	0.3	0.2	0.6	0.5		0.4	
Active nests, reference colonies									
1998–2000	54	137	633		36[d]		860		
2007	71	489	2,933		209[d]		3,702		
Growth rate (%)	4.0	15.2	18.6		28.6		20.0		

[a] Eggs/nest, calculated as mean of annual means; I excluded nests containing >7 eggs.
[b] Some nests containing only fresh egg membranes (ducklings already left).
[c] No data. I projected the no. from previous yr using mean annual growth rate.
[d] 5 colonies distributed in areas 4–6.

the interaction term. I treated colony (nested within area) as a random factor in the model, because repeated nest counts in individual colonies represent repeated measurements over time. To meet assumptions of normality, I tested the log-transformed dependent variable (active nests) using the Andersen–Darling test and I used Bartlett's test to test for homogeneity among variances. When summing the number of nests for all colonies, I compensated for missing data within subareas by projecting the number of nests from the previous year using the mean annual growth rate for that particular area. I examined geographic variation in clutch size between areas using one-way analyses of variance (ANOVA).

Harvest statistics on common eider were made available by the Greenland Ministry of Hunting, Fishery and Agriculture (K. Winther Hansen, Greenland Ministry of Hunting, Fishery and Agriculture, unpublished data). Statistics were collected nationally since 1993 and were based on hunters' annual reports on monthly bag numbers. Hunters were obligated to report their harvest to have their hunting license renewed.

RESULTS

Since the start of the program in 2001, GINR and resident observers obtained survey data in 35 of 42 possible cases (6 areas in 7 yr). Missing survey activity was caused by bad weather or personal issues preventing observers from surveying. I had to exclude data in one case due to errors in nest-type recording (2004: area 4). Based on the number of type 5 nests, timing of surveys was late in 8 cases, where an average of 27% (range = 2–89%) of broods had already left nests (Table 1). However, in all other surveys timing was ideal, with an average of 2% (0–11%) of females still laying eggs (type 1 nests), 96% (88–100%) of clutches being incubated (type 3 nests), and 1% (0–10%) of nests hatching (type 4 nests), with ducklings still at nests.

Number of nesting common eiders increased markedly in all 6 study areas from 2000 to 2007 at a mean annual growth rate of 12.6% for the entire area (Table 1; ANCOVA, $F = 65.7$; $P < 0.001$; df = 1). The increase varied from 9.5% in area 3 to 15.0–15.6% in areas 1 and 4; however, there was no interaction between area and year (ANCOVA, $F = 0.82$; $P = 0.54$; df = 5). Compared to 2001, when the number of nesting eiders was at a minimum, the 32 colonies almost tripled by 2007. Number of breeding birds in the 25 reference colonies apparently increased even more, on average 20.0%/year, although there was large variation between areas (4.0–28.6%; Table 1). Combining all 57 colonies, the number of breeding birds increased by 212%, from 2,558 active nests around 2000 to 7,982 nests in 2007.

Clutch sizes differed among years within all 6 areas (ANOVA: $F > 2.3$; $P < 0.026$). Pooled over areas, clutch size increased slightly from 2000 to 2004 and subsequently leveled off (Table 1). However, frequency of presumed nest-

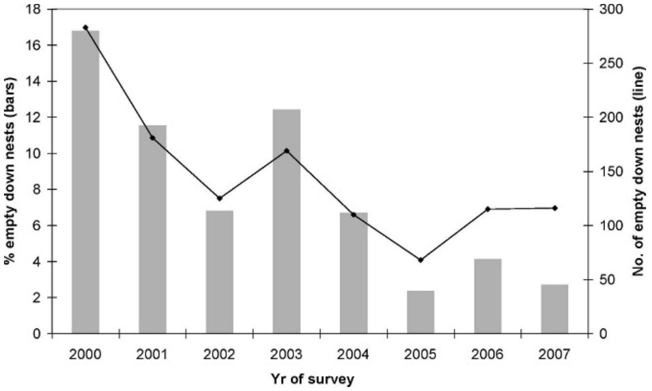

Figure 2. Percentage and actual number of empty down nests recorded during common eider nest surveys in West Greenland (69°–74°N), 2000–2007.

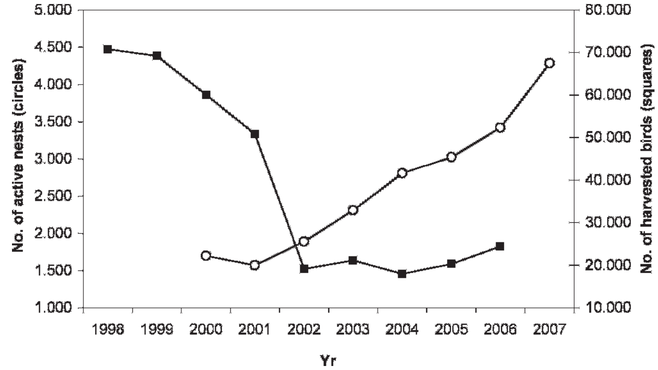

Figure 3. Common eider population index in West Greenland (69°–74°N) in 2000–2007 and number of birds harvested in West Greenland (Qaanaaq excluded). I obtained harvest statistics from Greenland Ministry of Fishery, Hunting and Agriculture.

parasitism also varied over the study period, with 0.9% and 2.7% of nests containing >7 eggs in 2000–2002 and in 2003–2006, respectively, and the nest-parasitism may have influenced the analyses of clutch sizes, despite excluding the most obvious cases of egg dumping (>7 eggs/nest). Combining all years and areas mean clutch size was 3.7 eggs/nest (excluding clutches with >7 eggs/nest; Table 1).

The proportion of down nests that had their eggs removed during incubation (illegal egging or predation, type 2 nests) declined from 7% to 17% in the first half of the study period to 2–7% in the second half (Fig. 2). This decline in ratio was not a consequence of the overall increase in active nests; the actual number of empty down nests also declined ($r = -0.77$, $P = 0.03$, $N = 8$). The 2007 surveys of reference colonies confirmed a low proportion of empty down nests at the end of the survey period (approx. 1% among 3,702 active nests). Harvest levels of common eiders in West Greenland started to decline already before the hunting regulation change in 2001. A gradual decline from approximately 70,000 eiders to approximately 50,000 eiders harvested from 1998 to 2001 ($r = -0.97$, $P = 0.03$, $N = 4$), followed by a 62% decline in harvest from 2001 to 2002, coincided with new hunting restrictions (Fig. 3). Subsequently, harvest levels remained low ($r = 0.62$, $P = 0.26$, $N = 5$), with a mean of 20,583 ± 1,088 (SE) eiders reported shot during 2002–2006.

DISCUSSION

Population monitoring is critical to evaluating wildlife management and conservation, and involvement of local communities can be a critical component of such monitoring, as we demonstrated here. We found that after several decades of marked declines for breeding common eiders in West Greenland, colonies between 69°N and 74°N recovered surprisingly fast when extensive harvest restrictions were introduced in 2001. Further, the program appears to have had the added benefit of reducing human disturbance and egging in the breeding colonies.

Resident observers were enthusiastic about the survey program and provided information according to the standard survey procedure (Merkel and Nielsen 2002). Our results did not indicate major differences in trends (active nests, egg removal) between annually surveyed colonies and reference colonies. Apparently higher variation in growth rates among reference colonies may be because they were surveyed only twice. When initiating the survey program I speculated that the resident observers might unintentionally serve to protect the colonies from illegal egging, potentially leading to more human disturbances in colonies that were not regularly monitored by resident observers (i.e., reference colonies). This could potentially lead to gradual redistribution of breeding birds from reference colonies (or other colonies not included in the annual survey program) to colonies annually monitored by the resident observers. However, this concern appeared to be invalidated.

Considering the history of population decline in West Greenland (Salomonsen 1967, Merkel 2004*a*), our observed increase of 12.6%/year represents a surprisingly rapid recovery rate for the common eider. As a K-selected species, population growth in common eiders is usually considered more heavily influenced by adult survival than annual recruitment (Coulson 1984, Goudie et al. 2000, Wilson et al. 2007, but see also Hario et al. 2009). However, several studies have shown that common eider populations do hold potential for rapid growth: annual growth rates were reported between 11% and 24% from the Gulf of St. Lawrence (Chapdelaine 1995), 17–28% from the Netherlands (Swennen 2002), 25–35% from Denmark (Bregnballe et al. 2002), and recently 13–22% from the Labrador coast (Chaulk et al. 2005*a*). Except for Denmark, where immigration was identified as an important factor in growth rates, rapid increases were mainly explained as natural growth under favorable conditions.

The Gilliland et al. (2009) population model that pinpointed the Greenland harvest as unsustainable was apparently adequate for assessing the impact of harvest on the Canadian–Greenlandic common eider population. Although the initial model included several assumptions, in an assessment of model performance using population-specific vital rates (fecundity and survival) from Canada (East Bay) and new harvest estimates from Greenland

(2002–2007), the model projected annual population increases (approx. 11%) close to growth rates observed in Canada and Greenland (Gilliland et al. 2008), emphasizing the utility of the model as a tool for conservation purposes.

More restrictive harvest regulations introduced in Greenland in 2001 resulted in a massive reduction in the number of eiders reported shot (Fig. 3). Although the relationship between population growth in West Greenland and the harvest reduction may appear obvious, it is impossible to directly link the two, mainly because spatial resolution of population trend information in West Greenland prior to the harvest regulation change is limited. However, the influence of harvest in West Greenland is now being analyzed by Canadian researchers in a demographic study of common eiders in the Hudson Strait (East Bay) initiated in 1996. The East Bay breeding colony shares a wintering area (SW Greenland) with the Greenland breeders and, thus, contributes to the Greenland harvest (Lyngs 2003, Mosbech et al. 2006). During 1997–2005 Canadian researchers detected a negative correlation between numbers of birds shot in Southwest Greenland and the growth rate in the East Bay colony (Buttler 2009). Population growth was most rapid from 2002 to 2005 (after which avian cholera broke out in East Bay), coincident with the severe harvest restrictions introduced in Southwest Greenland in 2001. Canadian researchers linked the harvest reduction in Southwest Greenland to a 10–15% increase in female survival rates, and furthermore suspect that a substantial increase in recruitment of first-time breeders took place (G. Gilchrist and S. Descamps, Environment Canada, personal communication). Such recruitment could easily be explained by the harvest restrictions; previous studies in Southwest Greenland (Nuuk) showed that approximately 60% of birds shot during the nonbreeding season were juvenile birds (<1 yr; Frich and Falk 1997, Merkel 2004*b*).

Fewer human disturbances in breeding areas may also have contributed to the population increase in West Greenland. First of all, the absence of spring hunting probably benefited both survival of potential breeders and overall recruitment. Previous studies in the districts of Ilulissat, Uummannaq, and Upernavik showed that illegal egg collection was common in 1998–2001 (Merkel 2004*a*), but the number of empty down nests we found suggests illegal egg collection is now much less common. Not only does egging reduce chick production, but disturbances in the colony may also induce higher avian predation on eggs or ducklings and may affect willingness of breeders and prospectors to return to the colony the following year (Milne 1974, Wakeley and Mendall 1976, Schamel 1977, Götmark and Ahlund 1984).

As expected, clutch size appeared to increase in our study area, but only until 2004. A plausible explanation could be that increasing clutch size stopped due to substantial recruitment of first-time breeders that usually produce smaller clutch sizes (Baillie and Milne 1982). However, this explanation is purely speculative, because I have no direct information about recruitment in the study area and because it is unclear how nest parasitism influenced the analysis of clutch sizes. The overall mean clutch size of 3.7 eggs/nest is higher than previously reported for this area (3.3 eggs/nest; Joensen and Preuss 1972), but it was similar to clutch sizes reported further north (3.7 eggs/nest; Christensen and Falk 2001) and further south (3.8 eggs/nest; Frich et al. 1998) in West Greenland and also in Labrador (3.5–4.2 eggs/nest; Chaulk et al. 2004, 2005*b*).

Management Implications

Based on eider population recovery in the central and northern parts of West Greenland, politicians decided in 2008 to expand the hunting seasons in this area (69°N–75°N) to allow for some subsistence harvest. The 2001 regulations prevented resident hunters' access to eider harvest, because birds in most cases were still in the wintering areas when the hunting season ended. This decision to partly reopen the closed season defines an urgent need to agree on the overall management goal for common eiders in Greenland in terms of total population size or growth rates. To safeguard the sustainability of future changes in utilization I recommend continued annual monitoring. A geographic expansion of the program may be necessary if the number of breeding birds continues to increase, because critically high nest densities can be expected to occur in some colonies and may cause emigration to alternative breeding grounds. Future climate change can be expected to cause a shift in the breeding phenology of the eiders, and I recommend expanding the program to include more accurate information on egg-laying dates to be able to detect such changes. Finally, I recommend consulting the Gilliland et al. (2009) population model in case harvest levels change or are expected to change in the future or if vital rates are reduced due to factors such as disease or food limitations.

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