

DATA ARTICLE

Vital rate estimates for the common eider *Somateria mollissima*, a data-rich exemplar of the seaduck tribe

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Funding information

Environment and Climate Change Canada; Natural Sciences and Engineering Research Council of Canada; Natural Environment Research Council, Grant/Award Number: NE/L002531/1; Sir James Dunn Wildlife Research Fund

Handling Editor: Natasha Gownaris

Abstract

1. This database collates vital rate estimates for the common eider (*Somateria mollissima*), providing a complete demographic parameterization for this slow life-history species. Monitored across its circumpolar range, the common eider represents a data-rich exemplar species for the less-studied seaducks, many of which are under threat.
2. The database contains estimates of the following vital rates: first-year survival; second-year survival; adult annual survival; first breeding (both age-specific recruitment probability, and breeding propensity across potential recruitment ages); breeding propensity of established female breeders; clutch size; hatching success; and fledging success. These estimates are drawn from 134 studies, across the scientific and grey literature, including three previously inaccessible datasets on clutch size that were contributed in response to a call for data through the IUCN Species Survival Commission's Duck Specialist Group.
3. Although clutch size has been much studied, the contributed datasets have enhanced coverage of studies reported in non-English languages, which were otherwise only represented when cited in English-language publications. Breeding propensity has been little studied, perhaps because adult females are often assumed to attempt breeding every year; we obtained a mean breeding propensity of 0.72. Our synthesis highlights the following gaps in data availability: juvenile and male survival; population change; and studies from Russia (at least accessible in English).
4. The database is intended to serve population modellers and scientists involved in the policy and practice of seaduck conservation and management.

KEYWORDS

breeding propensity, common eider, conservation, database, seaduck, vital rate

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1 | INTRODUCTION

A constrained speed of recovery following disturbance often imperils species with slow life histories, characterized by relatively high survival, delayed maturity and low or highly variable reproductive output across a number of breeding attempts (Musick, 1999; Purvis et al., 2000; Quetglas et al., 2016). One such group is the seaducks, a waterfowl tribe (Mergini) dependent on marine ecosystems for at least part of the life cycle and threatened by various hazards including oil spills, fisheries bycatch and disease (Bellebaum et al., 2012; Boyd et al., 2015). The large portions of seaduck life cycles spent in remote, high latitude regions render monitoring logistically difficult and costly, leading to a lack of sufficient demographic knowledge for many populations (Bellebaum et al., 2012; Bowman et al., 2015).

A number of seaduck species and populations are believed to be in decline, although specific drivers have yet to be identified in many cases (Bowman et al., 2015; IUCN, 2021; SDJV, 2007). Even the best-studied species, the common eider (*Somateria mollissima*) (Horswill & Robinson, 2015; Skarphedinnsson, 1996) is classed by the IUCN as near threatened with an 'unknown' global population trend (BirdLife International, 2018). This is not due to a lack of scientific or popular interest: the common eider is a charismatic species with a large Holarctic distribution, across which it has come into direct contact with humans through hunting and eiderdown farming since at least the seventh century (Berglund, 2009; Goryashko, 2020; Waltho & Coulson, 2015). Additionally, population ecologists are particularly interested in the females' extreme breeding biology: as partial capital resource breeders with uniparental incubation, females must acquire all requisite energy prior to egg laying, since incubation involves a month-long fast, during which up to half of the individual's body mass is lost (Harðardóttir et al., 1997; Yoccoz et al., 2002; Waltho & Coulson, 2015).

Unsurprisingly for a widespread species of conservation concern, the common eider has been studied in multiple environments, providing insight into varied influences on demography (Frederiksen et al., 2005). Indeed, the common eider has six recognized subspecies partitioning its geographic range, which differ to some extent in ecology and population trends (Furness et al., 2010; Waltho & Coulson, 2015; BirdLife International, 2018). While individual studies can identify regionally specific management priorities (e.g. Noel et al., 2021), range-wide synthesis provides a valuable overview of the species as a whole. This is important for the common eider, which is classed as Vulnerable in Europe, and at risk of being classed as globally Threatened, pending evidence for more severe or widespread declines (BirdLife International, 2015, 2018); although note that various conservation plans are in place or forthcoming (CAFF, 1997; AEW, 2020).

Collation of common eider vital rates from across the geographic range will have value in evidence-based management of the species, and in providing a data-rich exemplar for modelling the less well-studied seaducks. Such a synthesis should help to condense the 'burden of knowledge' faced by practitioners and policymakers, facilitating information exchange and efficient decision making (Carpenter et al., 2009; Pullin, 2012; Fabian et al., 2019). With complete datasets of

life-history parameters purported unavailable for 'most avian species, including sea ducks' (Flint, 2015, p. 65), we aimed to assemble one for the common eider.

We focused on the vital rates required to parameterize matrix population models (MPMs), which are used widely by population ecologists and conservation biologists to project population dynamics over time (Caswell, 2001; Logofet & Salguero-Gómez, 2021). MPMs streamline this process by representing stage-structured life histories in a mathematical format facilitating neat 'book-keeping' of vital rates (Caswell, 1997; Mills, 2012). Given the common eider's long lifespan and deferred recruitment, as well as females' relative ease of capture during breeding, we suspected that a useful proportion of the numerous common eider studies would include age-structured observations, allowing for more complex models and correspondingly tailored management recommendations.

2 | MATERIALS AND METHODS

We surveyed published academic and grey literature via keyword searches (e.g. '*Somateria mollissima*', 'clutch size') through Google Scholar, 'citation snowballing' (pursuing reference trails; see, e.g. Greenhalgh & Peacock, 2005), and cross-referencing authors' personal databases. Additionally, a call for data was posted on the IUCN Species Survival Commission's Duck Specialist Group website (www.ducksg.org/2018/10/seaducks/the-not-so-common-eider-can-you-help/), circulated through the corresponding mailing list, and advertised by ANH on Twitter in January 2019 and at conferences (the British Ecological Society's 'Quantitative Ecology' meeting in July 2019, the European Ornithologists' Union Conference in August 2019 and the Ecological Society of America's annual meeting in August 2020) thereafter. The call for data elicited three previously inaccessible datasets, of which one was recorded in Icelandic and another in Russian, broadening language coverage since non-English language reports were otherwise only covered by citations in English-language publications. We acknowledge that more needs to be done to reduce bias from monolingual data searches and calls (Nuñez & Amano, 2021).

Accessible vital rate estimates, and associated metadata, were collated in a relational database in Microsoft Excel, linked by a unique ID number associated with each study (or unique unpublished combinations thereof). A list of data sources used in the study are provided in the Data sources section. We included the following vital rates: first-year survival (measured either from hatching, or from fledging, to 1 year old), second-year survival, adult survival, breeding propensities for 2- to 5-year-olds (both probability of having recruited at a given age and breeding propensity at a given age), adult female breeding propensity, clutch size, hatching success and fledging success (alternatively included in first-year survival where measured from hatching). We define (i) hatching success as the proportion of all laid eggs that hatch (if probability of successful nesting – i.e. of at least one egg hatching – was provided, we used it to calculate hatching success where feasible) and (ii) fledging success as the proportion of hatchlings that fledge.

The two forms of breeding propensities for 2- to 5-year-olds correspond to two of the recruitment quantities discussed by Pradel and Lebreton (1999): the probability of having recruited at a given age, which sums to 1 across all possible ages of recruitment, is equivalent to their α_i (specifically, the second version described on p. S80); breeding propensities at age i ($2 \leq i \leq 5$) correspond to their a_i . Vital rates referring to subadults are assumed to refer to both sexes, whereas adult survival may refer to either sex or both (specified in the database), while adult breeding propensity has thus far only been estimated for females.

Where provided by the authors, we recorded the following meta-data at the study level: location (country and geographic coordinates); subspecies; and population trend (classified as increasing, decreasing, stable or variable). Further, for each estimate we recorded: sample size; variance measures (as provided and/or calculable from reported information); start and end years; and any covariates (freeform).

We did not formally screen studies, preferring instead to provide as complete a reference database as possible. We facilitate filtering with the following assignments: verification status (whether the source was seen in the original or cited by another verified source); precision (some estimates were simply the midpoints of observed ranges); and independence (which is not met when multiple estimates are provided by the same study, or when separate studies are based on the same datasets).

3 | Usage notes

The database is deposited in Dryad (Nicol-Harper et al., 2021). The 'master' sheet provides study-level information, with each study being assigned a unique identifier: numeric 1–127 for published studies, upper case A–B for unpublished contributed datasets (ID 127/Ragnarsdóttir et al., 2021 was contributed through the call for data but is published online, as an Icelandic-language publication not accessible through English-language searches), and lower case aa–ee for combinations of datasets reported in published studies (such as the combination: "Nyegaard, 2004 as cited in Gilliland et al., 2009 [thesis]; H.G. Gilchrist unpubl. data" reported in Gilliland et al., 2009, Table 1). Estimates and associated metadata for each vital rate are then recorded in separate sheets, with the ID column relating back to the studies in the 'master' sheet. Vital rate sheets include columns to replace imprecise overall study-level population growth rate, geographical coordinates, and subspecies entries where appropriate; for example, if the study provided vital rate data for each of several locations. Further information specific to each column can be found in comment boxes associated with the headers (.xlsx file only), and both studies and estimates are further annotated in 'Comments' columns where relevant. A text file with an English translation by AP of the summary from ID 127/Ragnarsdóttir et al. (2021) is also provided.

4 | General patterns

The call for data elicited a total of 21 responses, from academic institutions, governmental administrations, and NGOs across eight coun-

TABLE 1 Number of studies and independent estimates per vital rate across our database

Vital rate	Number of studies	Number of independent estimates	Unweighted arithmetic mean	Units
s_a	33	42	0.87	Transition probability
s_1_h	3	3	0.37	Transition probability
s_1_f	3	3	0.75	Transition probability
s_2	7	7	0.87	Transition probability
Pfb_2	4	4	0.20	Transition probability
Pfb_3	3	3	0.47	Transition probability
Pfb_4	1	1	0.38	Transition probability
Pfb_5	1	1	0.17	Transition probability
BP_2	3	3	0.18	Transition probability
BP_3	3	3	0.63	Transition probability
BP_4	1	1	0.77	Transition probability
BP_eb	6	6	0.72	Transition probability
CS	83	252	4.17	Eggs
HS	26	42	0.63	Rate (hatchlings per egg)
FS	13	15	0.22	Rate (fledglings per hatchling)

Notes: s_1_h, first-year survival from hatching; s_1_f, first-year survival from fledging; s_2, second-year survival; s_a, adult female annual survival; Pfb_x, probability of first breeding at age x; BP_x, breeding propensity at age x (regardless of recruitment status); BP_eb, breeding propensity of established breeders; CS, clutch size; HS, hatching success; FS, fledging success. Note that FS and s_1_f together cover the same transition/s (hatching to 1 year old) as s_1_h, so users should select either the product of FS and s_1_f, or s_1_h, but no other combination of the three, to cover this section of the life cycle. Unweighted arithmetic means exclude non-independent estimates (see rm_ind and rm_ind.Justification columns for in/exclusion and criteria) and are rounded to two decimal places. Here we present values for the female subset of adult annual survival, as this represents the majority of the data; additional estimates and studies consider males and/or disaggregated sexes. Means for Pfb_x exceed 1 across x = 2–5 due to the estimates coming from different studies, which provided estimates for different subsets of the age range, for example summing to 1 over just two age categories if they only monitored recruitment at ages 2–3.

tries (i.e. the majority of breeding range states). Three datasets, all on clutch size, were incorporated into the database as a result. The full database included 134 studies (or unique unpublished combinations thereof). Some studies ($n = 5$) do not contribute vital rates directly, but act as sources for unverified studies ($n = 42$), and some estimates are non-independent (e.g. where a later study re-analyses a dataset presented in an earlier study). The numbers of studies and estimates varied greatly amongst the parameters, with some parameters having multiple estimates per study across years or locations (Table 1).

We were particularly interested in estimates of adult female breeding propensity, as it is often assumed to equal to 1 by default (e.g. Kats, 2007; Noer & Hansen, unpublished, as cited in Christensen & Hounisen, 2014). In fact, the common eider is a relatively well-studied example of intermittent breeding, in which breeding attempts are interspersed

TABLE 2 Breeding propensity estimates for established (i.e. recruited) female common eiders. SD = standard deviation; SE = standard error; CrI = credible intervals

Study	Breeding propensity estimate	Variance measure	Year(s) covered	Location	Comments
Coulson (1984)	0.778	Not given	1958-1981	Coquet Island, Northumberland, UK	Updated by Coulson, 2010
Swennen (1991)	0.65	Not given	1989	Vlieland, Netherlands	As cited in Kats (2007)
Coulson (2010)	0.844	Not given	1958-2005	Coquet Island, Northumberland, UK	
Koneff et al. (2017)	0.92	0.60-1.00 (CrI)	N/A	North America	Subspecies <i>S. m. dresseri</i> only; meta-analysis with expert opinion
Jean-Gagnon et al. (2018)	0.45	0.142 (SE)	2002-2013	Southampton Island, Nunavut, Canada	
Öst et al. (2018)	0.77	0.15 (SD)	2003-2016	Tvärminne, Finland	
Tjørnløv et al. (2019)	0.70	Not given	N/A	Netherlands; Denmark; Sweden; Finland	Via back-calculation to fit population growth rate

with years of non-breeding, which has been described as one of the least-understood reproductive parameters in vertebrates (Reed et al., 2004). We found estimates ranging from 0.45 in Arctic Canada to 0.92 in a meta-analysis of vital rates for the *dresseri* subspecies across North America (Table 2).

In addition to the uneven distribution of study effort across the vital rates (Table 1), the database reveals a number of gaps in data availability. First, due to the relative ease of trapping nesting female common eiders (Waltho & Coulson, 2015), most survival estimates relate to adult females rather than males or juveniles. Since males are rarely the limiting sex, most seaduck MPMs are female-only, although having additional estimates of male survival could help to distinguish sex-specific mortality (Flint, 2015; Allen et al., 2019; Tjørnløv et al., 2019). Second, only a small minority of studies provided enough information to categorize population trend; while we appreciate that much data-gathering relates to finer-scale questions, we suspect that a broad-scale categorization would be possible in many cases, facilitating greater contextualization of reported demographic parameters. Finally, our database has a notable relative lack of data from Russia, in contrast to its large extent encompassing the disparate ranges of two common eider subspecies. While our call for data added a previously inaccessible dataset to complement three Russian studies cited by English-language publications, we hope that the gap will be further filled through multilingual data-gathering exercises and international collaboration.

ACKNOWLEDGEMENTS

This work was supported by a UK Natural Environment Research Council SPITFIRE DTP award (NE/L002531/1) to ANH. Work at Machias Seal Island [database study A] is funded by grants to AWD and HLM from Environment and Climate Change Canada, Natural Sciences

and Engineering Research Council of Canada, and Sir James Dunn Wildlife Research Fund. The authors thank all respondents to the call for data, in addition to the IUCN Species Survival Commission's Duck Specialist Group, particularly Richard Hearn. ANH gratefully acknowledges the British Ornithologists' Union for a Member Travel Award, which supported attendance to the European Ornithologists' Union Conference in August 2019, where the call was publicized in person. AWD and HLM thank the funders and many field technicians involved in data collection at Machias Seal Island. The authors thank Morten Frederiksen, Sveinn Are Hanssen and an anonymous reviewer for helpful comments improving this manuscript.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHORS' CONTRIBUTIONS

ANH, CPD, THGE, GMH and KAW conceived the idea. ANH collated the data, organized the database, and led writing of the manuscript. AWD, HLM, AP and GT provided previously inaccessible datasets. All authors contributed critically to the drafts and gave final approval for publication.

PEER REVIEW

The peer review history for this article is available at <https://publons.com/publon/10.1002/2688-8319.12108>

DATA AVAILABILITY STATEMENT

Database available from the Dryad Digital Repository: <https://doi.org/10.5061/dryad.x3ffb7ks> (Nicol-Harper et al., 2021). A list of data sources used in the study are provided in the Data sources section below.

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How to cite this article: Nicol-Harper, A., Wood, K. A., Diamond, A. W., Major, H. L., Petersen, A., Tertitski, G., Doncaster, C. P., Ezard, T. H. G., & Hilton, G. M. (2021). Vital rate estimates for the common eider *Somateria mollissima*, a data-rich exemplar of the seaduck tribe. *Ecological Solutions and Evidence*, 2, e12108. <https://doi.org/10.1002/2688-8319.12108>