**Appendix S1. Supporting information**

**Figure A1:** Generic model of seabird colony growth considering both site-specific parameters and metapopulation processes.



*rt* – per capita growth rate, N*t* – number of individuals in a colony, (D+/D−)i – intrinsic density dependence, I*t* – immigration, NA*t* – number of adults, NPr*t*– number of pre-breeding birds, NJ*t* – number of immature birds, SA – adult survival, SPr – pre-breeder survival, AFR – age at first return, Pret – probability of return (philopatry), SJ[AFR] – immature survival until age at first return, F*t* – fecundity, Skip*t* – number of adults skipping breeding, BS*t* – breeding success per breeding adult, *ft* – number of immature birds prospecting a new colony, (D+/D−)e – extrinsic density dependence, *R* – probability of prospectors recruiting into a new colony, ΣNPr*t* – total pool of pre-breeding birds in a metapopulation, Ds – distance to natal colony, H – habitat quality, C – social cues.

**Generic colony growth model**

The rate of growth of a seabird colony depends on “intrinsic” or site-specific growth, influenced by the per capita growth rate, *rt*,at any moment in time, t,the number of individuals in the colony N*t*, and positive or negative intrinsic (i) density-dependent effects (D+/D-)i; and “extrinsic” metapopulation dynamics, or the number of immigrants recruiting from other colonies I*t* (Fig. 1).

Colony growth = *rt*N*t*(D+/D-)i+ I*t* (1)

Per-capita growth rate, *rt* depends on an interaction between species-specific life history strategies and environmental stochasticity moderated by density-dependence (D+/D-) i. Although mechanisms associated with density dependence are not well understood in seabird populations (Moller et al. 2009), negative density-dependence may occur as a result of limitations in breeding sites and food (Baker & Wise 2005; Croxall & Rothery 1991; Sandvik et al. 2012), while positive density dependence may be associated with coloniality (i.e. "safety in numbers" from predators, Jones 2003; Lyver et al. 2000). Even less is understood about seabird dispersal and immigration to new colonies (I*t*), which are assumed to be regulated by negative density-dependent factors; however, social behaviour may over-ride their importance (Hunter et al. 2000; Kerbiriou et al. 2012; Kildaw et al. 2005). We predict that immigration will play a disproportionately large role in colony growth, considering the effects of seabirds’ characteristic long generation times and low *rt* values. To simplify the general model, we excluded dispersal by adults , as site fidelity is common among seabirds once breeding has been established (Dubois & Cézilly 2002).

Intrinsic growth

Seabird life histories are characterised by prolonged absences from breeding sites following fledging, and a number of years of attendance as “pre-breeders” before pair bonding and successful breeding. Thus, the number of individuals associated with a seabird colony in any given season (N*t*) is made up of the number of breeding-age adults (NA*t*), the number of pre-breeders (NPr*t*), and the number of immature birds (NJ*t*; Fig. 1).

N*t* = NA*t* + NPr*t*+ NJ*t* (2)

For most seabirds, as in other long-lived animals, the number of adults from the previous season (NA*t*-1) that survive, at a rate SA, to breed has the greatest influence on intrinsic population growth rate (Igual et al. 2009; Russell 1999; Saether & Bakke 2000). Variables affecting SA include natural (e.g. disease) and anthropogenic (e.g. fisheries bycatch; Burger & Gochfeld 1994) factors. The number of adults in a season (NA*t*) will also depend on the number (NPr*t*-1) and survival (SPr*t*-1) of pre-breeding birds from the previous season.

NA*t*= (NA*t*-1\* SA) + (NPr*t*-1\* SPr) (3)

The number of pre-breeders (NPr*t*) that return to the natal colony will depend on the number (NJt-AFR) and survival (SJ[AFR]) of immature birds until the species’ characteristic ‘age at first return’ to the colony (AFR), and the probability of return (Pret) to the natal site (i.e. philopatry). Although AFR can vary between individuals and with environmental stochasticity and Pret is generally considered to be high in seabirds (Milot et al. 2008; Warham 1990); each species is likely to have a characteristic values for these parameters (Aubry et al. 2009; Mougin 2001; Ovenden et al. 1991). Factors that are thought to influence immature survival include natural and anthropogenic variation in at sea conditions (e.g. sea surface temperature and oil spills; Votier et al. 2008). Immature birds often represent a significant proportion of a population and their dynamics can therefore potentially have large consequences for population growth (Hunter et al. 2000; Votier et al. 2008; Votier et al. 2011). However, seabirds cannot be easily monitored away from breeding areas, so the precise effects of factors affecting the survival (SJ)of immature birds on population growth are not well understood (Oro et al. 2006).

NPr*t*= (NJt-AFR \* SJ[AFR]) \* Pret(4)

The number of immature birds produced by a colony will depend on the number of breeding adults (NA*t*) and their fecundity (F*t*).

NJ*t*= (NAt\* Ft) (5)

Short-term changes in fecundity (F*t*) generally have little effect on long-term intrinsic population growth trajectories*.* Variation in reproductive success can be high, which serves to buffer populations from environmental stochasticity (Cairns 1989; Doherty et al. 2004). However, long-term decreases or increases in fecundity will eventually translate to changes in per capita population growth and one of the main causes of prolonged suppression of reproductive success is predation by alien mammals or humans (Muñoz Del Viejo et al. 2004). Fecundity is the product of breeding success (BS*t*; the number successfully reared fledglings per individual breeding attempt) and the number of adults attempting breeding (1-Skipt; Baker & Wise 2005; Pascoe et al. 2011). Intermittent breeding, or “skipping,” (Skip*t*) is a characteristic of seabirds that produce one offspring per year (i.e.procellariiformes; Cubaynes et al. 2011) and is considered to be a buffer against adverse environmental conditions (Erikstad et al. 1998).

F*t* = (1-Skip*t*) \* BS*t* (6)

Extrinsic processes

Although seabirds exhibit high rates of philopatry, immigration of immature individuals (I*t*) has been shown to be a significant factor in the dynamics of metapopulations (Inchausti & Weimerskirch 2002; Milot et al. 2008; Pascoe et al. 2011). We assume here that immigration rate is influenced by density-dependent processes, both at the source, affecting the size of the available pool of birds exploring a new colony (prospectors; NPr*t*), and locally, by the number of birds already breeding at that colony (Nt; Oro et al. 2006).

I*t* α *ft*(D+/D-)e \* *Rt* (D+/D-)i (7)

Where *f*trepresents the number of immature birds available to prospect a new colony, mediated by extrinsic (e) density-dependence (D+/D-)e, and *R* is the probability that these prospectors recruit to the new colony, mediated by intrinsic density-dependence (D+/D-)i within the new colony.

The number of birds prospecting a new colony depends on the size of the pool of pre-breeding birds available to prospect (ΣNPr*t*) which, in turn, likely reflects density-dependence at the source colony (e.g. availability of breeding sites); and the distance between the prospective colony and the natal colony (Ds).

*ft*= ΣNPr*t* /Ds (8)

The probability of recruitment to a new colony depends on the interaction between habitat quality (H) at the new colony (Kildaw et al. 2005) and the strength of positively density-dependent social cues (C, i.e. social facilitation, Danchin et al. 2004; or Allee effects, Schippers et al. 2011).

*R* = H \* C (9)

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