Summary report on black swan population dynamics and responses to customary egg harvest at Te Waihora/Lake Ellesmere, 2017-2019

Prepared by the Ngāi Tahu Waterfowl Advisory Committee,
Mark Herse, PhD Candidate, University of Canterbury,
Professor Jason Tylianakis, University of Canterbury and
Phil Lyver, Kairangahau Māori, Manaaki Whenua.

To inform Tangata Tiaki (Ngāi Tahu customary resource managers) of black swans, we used recent data on population size, nesting effort, hatching success (within both harvested and unharvested nests), and juvenile and adult mortality rates, to develop a model of population dynamics at Te Waihora (Fig. 1). We used the model to answer the following questions:

1. What is the annual population growth rate at Te Waihora?
2. How do annual swan fertility (number of eggs hatched per adult swan) and juvenile and adult swan mortality rates differentially affect population growth?
3. How do current levels of uncertainty in estimates of demographic rates differentially contribute to uncertainty in estimated population growth?
4. What is the egg-harvest equivalence of shooting 1 adult swan?
5. How does gamebird shooting affect the sustainability of customary egg harvest?

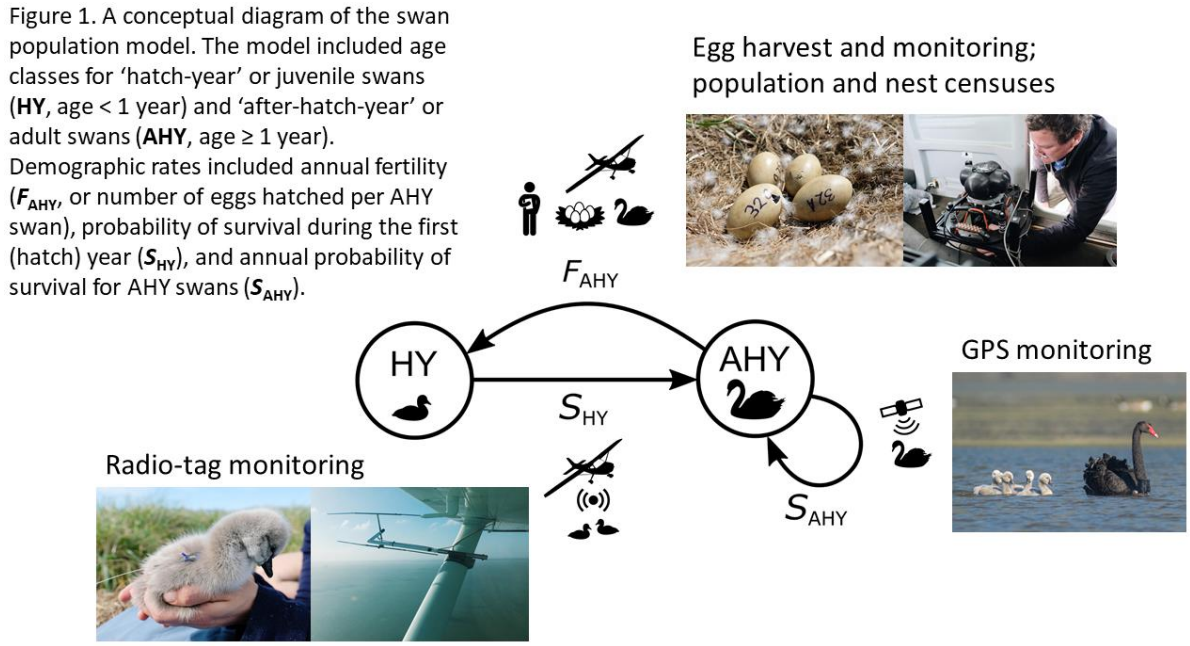

Figure 1. A conceptual diagram of the swan population model. The model included age classes for 'hatch-year' or juvenile swans (**HY**, age < 1 year) and 'after-hatch-year' or adult swans (**AHY**, age ≥ 1 year). Demographic rates included annual fertility ($\boldsymbol{F_{AHY}}$, or number of eggs hatched per AHY swan), probability of survival during the first (hatch) year ($\boldsymbol{S_{HY}}$), and annual probability of survival for AHY swans ($\boldsymbol{S_{AHY}}$).

Model outcomes:

1. During 2017-2019, the estimated annual population growth rate was 1.019 (1.9% annual growth). This estimate had a large 95% confidence range (−19.6% to 23.8%)

overlapping 0% annual growth and was therefore not significantly different from that of a declining population.

2. Population growth was most sensitive to changes in adult mortality, followed by juvenile mortality and fertility. Population growth was at least three times more sensitive to adult mortality than to changes in fertility.
3. Uncertainty in estimates of population growth and the effects of gamebird shooting and customary egg harvest was almost entirely due to uncertainty in swan mortality rates (60% of the total uncertainty was due to uncertainty in juvenile mortality, 35% was due to uncertainty in adult mortality, and 5% was due to uncertainty in fertility).
4. Accounting for estimated swan life expectancy and annual probability of attempting to breed, shooting 1 adult swan was equivalent to harvesting 6 fresh eggs, on average.
5. During 2017-2019, the estimated proportion of all nests at Te Waihora that could have all eggs from first clutches harvested sustainably was ~0.3 (Fig. 2). The sustainable population-level rate of egg harvest varied from none to more than half of all eggs, depending on small changes in annual adult survival probability (Fig. 2).

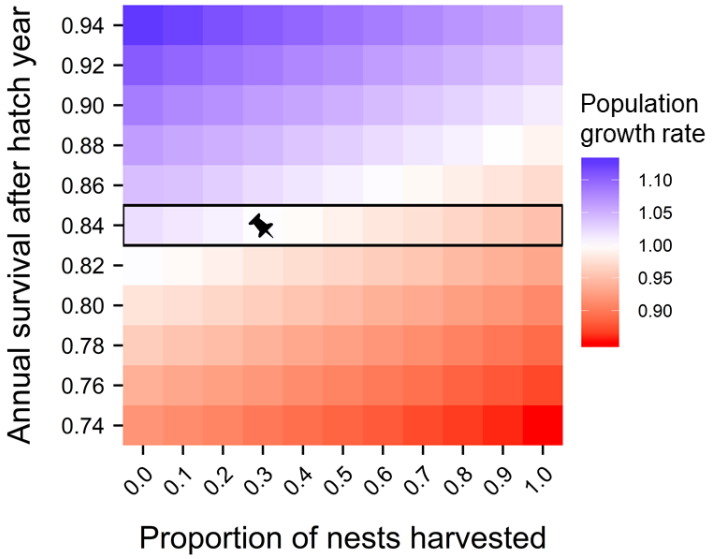

Figure 2. Heatmap showing how changes in annual adult survival probability (vertical axis) and nest harvest pressure (horizontal axis) influence annual population growth rate. Warm colors indicate a declining population (e.g., 0.95 = −0.05 or −5% growth), cool colors indicate a growing population (e.g., 1.05 = 0.05 or 5% growth), and neutral white indicates a stable population (1.0 = 0% growth). The row outlines in black indicates the estimated mean annual adult survival in 2019. The tack symbol indicates the model estimate for the maximum egg harvest pressure the population could have sustained during 2019, assuming the mean estimate of adult survival.

Management recommendations:

- **Improve monitoring of baseline swan mortality rates and offtake by landowners and gamebird license holders.** Most of the uncertainty in estimates of population growth and effects of gamebird shooting and egg harvest were due to uncertainty in swan mortality rates. More robust data on baseline mortality rates and offtake permitted within gamebird regulations could improve model estimates, and Tangata Tiaki abilities to assess sustainable levels of egg harvest. This could be achieved through the development of a long-term neckband-recovery program.
- **Reduce the shooting of swans during the duck shooting season and prohibit shooting outside of that season until data are available to ensure that offtake permitted within gamebird regulations is sustainable.** Population sensitivity to adult mortality indicates that limiting (and monitoring) offtake of adults is crucial to

maintaining a viable population. Even a slight over-estimation of the population's capacity to sustain offtake of adults could lead to population declines and preclude sustainable customary egg harvest (Fig. 2). The risk of such an over-estimation is elevated because the swan shooting season at Te Waihora (May-September) currently overlaps with the breeding season (peak nesting in August-September), and groups of hunters on farms surrounding the lake sometimes shoot large numbers of swans (> 100) as they stage for nesting (Donald Brown, Ngāi Tahu, 9 February and 22 June 2021, personal communication) in addition to swan drives. This activity could disproportionately impact the population, and potentially go undetected due to limited monitoring within current gamebird management[1]. Considering these issues, and the fact that swan breeding was almost entirely absent at Te Waihora in 2020 (Fig. 3), we recommend reducing the shooting of swans until data on baseline mortality and offtake become available. As a minimum step, we recommend prohibiting all shooting of black swans after July (before nesting begins at Te Waihora) and reducing the bag limit during May-June (currently 5 swans per day), to prevent large numbers of swans from being shot as they stage for nesting.

- **Re-institute customary egg harvest as a component of local species management.** Balancing the interests of sport hunters (and farmers) with those of local Ngāi Tahu, and re-instituting sustainable customary egg harvests, could lead to win-win outcomes. Local Ngāi Tahu who engage in customary egg harvest could continuously generate information on breeding (e.g., locations and sizes of nesting colonies, hatching success) and environmental pressures (e.g., water pollution, flooding and erosion of nesting habitat, nest depredation), which is currently lacking in local species management[1,2]. In addition, if an equitable decision was made to control swan numbers (to limit grazing impacts for farmers), customary egg harvest could provide a fine-tune dial for managing swan numbers, without wasting resources. Our model could aid in communication and decision-making between Tangata Tiaki and gamebird managers within a potential future co-management arrangement.
- **Restore black swans' macrophyte food supply.** Black swan numbers at Te Waihora have declined ten-fold over the past half-century[1,3,4]. These declines are undoubtedly linked to the high levels of pollution from agricultural runoff in the Selwyn-Waihora catchment[3], which have prevented macrophyte growth. Curbing pollution and re-establishing macrophyte beds is key to the health of the black swan population and could alleviate grazing impacts for farmers. Although most landowners around Te Waihora value wetland health, some prioritize economic gains and shoot swans to limit grazing on pasture[5]. We recommend curbing pollution that degrades Te Waihora and leads swans to feed on pasture, before resorting to local population control.

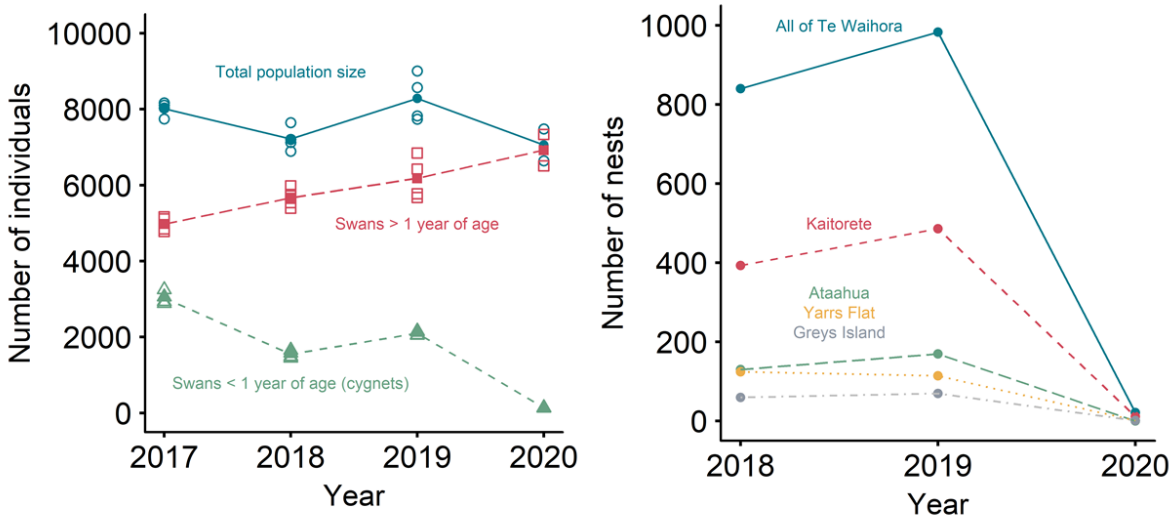

Figure 3. Plots showing changes in the number of individual swans (left) and nests (right) at Te Waihora over time during 2017–2020, as determined by aerial censuses (note: nest censuses began in 2018). The names in the right plot correspond with individual nesting colonies at Te Waihora.

References:

(1) Herse MR, Lyver PO'B, Scott NJ, McIntosh AR, Coats SC, Gormley AM, Tylianakis JM. 2020. Engaging indigenous peoples and local communities in environmental management could alleviate scale mismatches in social-ecological systems. *BioScience* 70, 699-707.

(2) Herse MR, Tylianakis JM, Scott NJ, Brown D, Cranwell I, Henry J, Pauling C, McIntosh AR, Gormley AM, Lyver PO'B. 2021. Effects of customary egg harvest regimes on hatching success of a culturally important waterfowl species. *People and Nature* 3, 499-512.

(3) Ford DE, Hughey KFD, Taylor KJW (eds). 2017. Te Waihora/Lake Ellesmere: State of the Lake 2017. Waihora Ellesmere Trust Technical Report No. 3.

(4) Williams M. 1979. Status and management of black swans *Cygnus atratus*, Lathum at Lake Ellesmere since the 'Wahine' storm. *New Zealand Journal of Ecology* 2, 34-41.

(5) Bataille CY. 2021. Cross-cultural interest groups' values and desired states inform biocultural management of wetlands in Aotearoa New Zealand. PhD thesis, University of Canterbury.