Toward Adaptive Management of Parera (*Anas superciliosa*) and Mallard (*A. platyrhynchos*) Duck in New Zealand.

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Abstract

Wildlife exploitation is encumbered with uncertainty. To ensure sustainability of wildlife populations managers must understand the consequences of, and account for, uncertainty in their decisions. This is most pertinent if the goal is to optimise or maximise the harvest or take.

Uncertainty can be separated into four main categories: environmental variation, partial management control, structural uncertainty (e.g., density dependence) and partial observability. This thesis examines the first three categories in the context of mallard (*Anas platyrhynchos*) and parera (grey duck, *A. superciliosa*) harvest in New Zealand, and specifically addresses sustainable and maximum annual mallard harvest.

A simple heuristic harvest model is proposed to represent a population subject to a seasonal annual harvest. The heuristic model is then converted into a series of quantitative models that can be used to predict the effect of regulations on hunter behaviour (partial management control). Specifically, how regulations may affect hunter effort (hours hunted) and the consequences of hunter effort on, harvest rates, survival, and productivity. Survival and productivity were further evaluated as a function of post-harvest population size (structural uncertainty). Harvest rate, survival, and productivity data were derived from 22,500 (1,024 recaptures; 3100 recoveries) mallard and parera banded from 1997 to 2009 in the Eastern and Hawke's Bay Fish and Game Regions and a telemetry study of 46 mallard in the Eastern Region. Harvest data and reporting rate estimates were derived from a randomised hunter survey over the study period.

In the Eastern Region hunter effort explained changes in survival better than any of the other candidate models ($w_i = 0.851$). In the Hawke's Bay changes in survival was explained by changes in season length ($w_i = 0.334$), hunter effort ($\Delta QAIC_c = 0.739$; $w_i = 0.231$), and spring temperature in the year of banding (*SpcT*) ($\Delta QAIC_c = 0.1.53$; $w_i = 0.155$). Correlation of harvest rates and effort approached significance (*P*=0.053) in the Eastern Region for adults only while in the Hawke's Bay data there was no relationship. This was assumed a consequence of reporting rate confounding

harvest rate estimates as correlation between hunter effort and harvest was good in both Eastern (R=0.85, $t_{(10)}$=5.3193, P<0.001) and Hawke's Bay (R=0.76, $t_{(8)}$ = 3.3878, P = 0.0095).

A deterministic model was developed (from the quantitative models), to maximise annual harvest subject to the criteria that harvest should not compromise the ability to maximise the following season's harvest. The performance of the quantitative models was validated using a partially stochastic model to simulate harvest. Harvest simulations were used to predict 2010 (outside of the study period) harvest (41,549 mallard and parera; SE=3,552) in the Eastern Fish and Game Region. Simulations predicted harvest accurately (42,045; SE=1,992). Simulations indicated that mallard harvest was not sustainable over a 10 year period when juvenile female: adult female ratios ≤ 0.8 when constrained by Eastern Regions regulation set (season length 30 to 71 days). When productivity increased (≥ 0.95 juvenile female: adult female) long term harvest was viable under the most relaxed season constraint (71 days). This has important implications when managing breeding habitat.

It was proposed that managing populations within similar climate zones would reduce environmental uncertainty. Survival of mallard and parera were analyzed using a set of linear climate covariate models fitted to data from 91,500 mallard and parera banded throughout New Zealand (1969–2009). Climate explained changes in survival better than or was comparable to the alternate candidate models in 11 of 17 data sets.

The quantitative models in this thesis provide a platform for Fish and Game managers to initiate an adaptive management approach to mallard and parera harvest management in New Zealand.

Should Fish and Game wish to review current mallard and parera management areas, establishing management units on homogenous climate zones would contribute to creating a good management system.

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