A risk analysis for Hector's and Maui's dolphins commissioned by the Ministry of Fisheries (project IPA2006/05) was presented by Nick Davies to the Aquatic Environment Working Group (AEWG) on 17 September 2007. Before this meeting, a Hector's Dolphin Technical Working Group (HD-TWG) had met several times to guide the development of the component models.

The risk analysis consists of two components, a fitted, age-structured population model for the Banks Peninsula subpopulation (for which most data for Hector's dolphins exist) and projection simulations for all four subpopulations (with and without stochasticity) for up to 100 years into the future under different assumed management regimes. These management regimes were designed to be as similar as possible to those put forward in the Consultation Draft of the Hector's and Maui's Dolphin Threat Management Plan (TMP), although some structural differences (including the treatment of trawling, harbour set netting, and recreational fisheries) meant that the simulated management strategies could not be identical to the options in the TMP.

The Banks Peninsula population model was age-structured (0–20 years old, with a plus group), spatially and seasonally structured to account for the behaviour of the dolphins and the fishery, and had a density dependent calving rate with a maximum of one calf per female every two years. The model was fitted to an absolute abundance estimate from the 1998–2000 surveys of the South Island east coast, a time series of relative abundance indices for 1990 to 1996 from mark-recapture analyses of dolphin resightings around Banks Peninsula, an estimate of average annual adult survival rate over the period 1985 to 2002 (also from re-sightings), information on the age at first reproduction, the age composition of entangled dolphins, the catch of dolphins recorded by relevant observers, and the amount and distribution of relevant commercial set net fishing effort since 1970. Bayesian methods were used to estimate 17 parameters and their uncertainty. The model's sensitivity to some key assumptions was explored by fitting models based on alternative assumptions (e.g., about productivity, movement of dolphins among spatial cells, the subsequent survival of dolphins released from set nets, and the relative weights on different data sets) and by omitting some data sets.

Because so few data were available on the dolphin population and bycatch, the model could not easily be fitted without informative priors on most of the parameters to be estimated. These priors were developed in close consultation with HD-TWG. Even with the informative priors, however, the posterior distributions of most parameters in the Banks Peninsula model were broad, showing the great uncertainty in our understanding of historical dolphin dynamics and current population status. The model parameters estimated were sensitive to key assumptions, and were highly uncertain; estimates of population growth rate ranged from close to zero to the upper bound of what is biologically feasible for Hector's dolphin. This is probably a result of the paucity of data available for estimating productivity parameters.

The stochastic 100-year projections for each subpopulation entail additional uncertainty. The stochasticity introduced into starting abundance, annual calving and survival rates, and fishing effort is propagated through to estimates of future abundance, and the effect can be measured. However, uncertainty about the suitability of parameter estimates from the Banks Peninsula model for other subpopulations (e.g., catchability coefficients) is not propagated and its effect is not measured. Further, dolphin captures in harbour set net fisheries, trawl fisheries, and recreational fisheries are necessarily excluded (because of lack of data), and it proved extremely difficult to model "depensation[1]" effects at small population size so these were not included in the projections (although the relative likelihood of them occurring was estimated by noting the proportion of runs that led, at any time, to very small population sizes). Thus, as is typical for complex models, the stochastic projections do not capture all our uncertainty and, therefore, underestimate real uncertainty in current status and future outcomes.

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[1] *FAO defines depensation as "a negative effect on population growth that becomes proportionately greater as population size declines. Populations experiencing depensation are prone to further reductions in size, even in the absence of exploitation, and therefore have a greater risk of extinction."*

The AEWG agreed that:

- The combination of large measurable uncertainty in projected abundance, substantial un-measurable uncertainties, and the necessity for strong assumptions means that the outcomes of different management strategies cannot be predicted with any certainty. For all subpopulations and management strategies modelled, both population increases and decreases are plausible in the future.

- Taking the modelling results at face value and adopting the assumptions developed through HD-TWG, all three subpopulations of Hector's dolphin are more likely to decline than increase under status quo set net fishing effort, and the decline could be substantial. Conversely, under all of the alternative management strategies simulated, all three subpopulations of Hector's dolphins are more likely to increase than decrease.

- The predicted rates of increase or decrease of all subpopulations are sensitive to the assumed level of productivity.

- For Maui's dolphins, the status quo management regime already includes substantial protection, and the likelihood of continued decline depends strongly on the assumed level of productivity.

- The results for the East Coast South Island subpopulation (ECSI, including Banks Peninsula) required fewer strong assumptions than those for the other subpopulations and for Maui's dolphins and were, therefore, likely to be more reliable.

- The available data for Hector's and Maui's dolphins had been used in the best possible way and had been found not to be sufficient to support a definitive analysis. However, the modelling provided helpful guidance on areas where new information should be collected to reduce our uncertainty.

- If the risk analysis was to be communicated to managers, it should be with appropriate caveats around its shortcomings and uncertainty.

However, the AEWG could not agree whether or not it was reasonable to adopt all the necessary assumptions for all the subpopulations and, therefore, whether the risk analysis should be used to advise managers. Some members felt that the necessary assumptions had been developed in consultation with a technical working group of well-informed specialists (HD-TWG) and that they provided the best possible framework for analysing the very sparse data. They argued that the risk analysis could be used to provide qualitative guidance to managers. Others strongly disagreed, saying the assumptions were essentially arbitrary and the results must not be taken at face value. One argued that the modelling assumptions were so numerous and untenable that the results should not be used to guide management in any way.

Having been involved in three meetings of HD-TWG and the AEWG discussion, and having read various versions of the draft report, I, as Chair of AEWG, am of the opinion that the work can provide qualitative guidance as a risk assessment, but not reliable quantitative predictions of the actual performance of different management options:

- The information for all subpopulations is very sparse, some strong assumptions have been necessary, especially for subpopulations other than the ECSI subpopulation, and the model results, especially the projections, are highly uncertain (and underestimate real uncertainty). Both population increases and decreases are plausible in the future for all subpopulations and we cannot predict the outcome for Hector's or Maui's dolphins of any of the management options with any certainty.

- However, and accepting that we cannot predict outcomes with certainty, a risk assessment conducted using the sparse information available in a modelling exercise guided by a team of well-informed technical specialists suggests that all three subpopulations of Hector's dolphin are much more likely to decline than increase under status quo set net fishing effort, and those declines could be substantial. Conversely, the risk assessment suggests that all three subpopulations are more likely to increase than decrease under any of the alternative management options designed to reduce fishing related mortality of Hector's and Maui's dolphins (except for the smallest subpopulation, South Coast South Island, SCSI, at the lowest assumed level of productivity).

- The predicted rates of increase or decrease of all Hector's and Maui's subpopulations were sensitive to the assumed level of productivity. Except at the lowest assumed level of productivity, however, the differences between the performances of strategies other than status quo were not very large and all strategies were more likely to lead to increases rather than decreases. At the lowest assumed level of productivity, the small SCSI subpopulation was more likely to increase than decrease under zero set net mortality, but more likely to decrease than increase under other, less stringent management measures, and also quite likely to be affected by depensation.

- Some differences between the subpopulation models are worth mentioning. For Maui's dolphins, the status quo management regime already includes substantial protection for dolphins, and the likelihood of continued decline depends strongly on the assumed level of productivity. The results for the East Coast South Island subpopulation (including Banks Peninsula) required fewer strong assumptions than those for the other subpopulations and are, therefore, likely to be more reliable.