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Project Proposal Title: Integrated modeling for Hawaiian Albatross Populations

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1. Purpose of the project and indicative results.

The purpose of the project is to analyze available information concerning Black-footed (*Phoebastria nigripes*) and Laysan (*Phoebastria immutabilis*) albatross (BFAL and LAAL for the sake of brevity in what follows). These analyses aim at assessing the status of their populations in relation with the potential impact of longline fisheries. While BFAL population size is about one tenth of LAAL's, the ratio of by-catch by longline fishing is higher. This suggests a relatively higher impact of longline fishing on BFAL, with potential biologically significant consequences. Due to the uncertainty about population size (roughly 300 000 individuals), and the amount of by-catch in the 90s (between 5 000 to 12 000 individuals), the impact of by-catch on population dynamics and sustainability in BFAL has not been assessed conclusively, but on general grounds the impact is thought to have been high enough to be detrimental (Cousins and Cooper, 1999). Gaps in our current knowledge of the demography and biology of both BFAL and LAAL--for example age and rate of recruitment, adult and juvenile survival, rate of pair reformation after widowhood—have here fore affected our ability to assess the impact of by-catch on these populations.

The project is being pursued in three main steps:

- Estimation of demographic parameters by capture-recapture analysis of existing data and analysis of census data
- Integration of these pieces of information in a matrix model, integrating as much biological specificities as possible, such as intermittent breeding, widowhood and time to repair…
- Last, development of integrated models, using in particular the Kalman filter and Bayesian approaches, to combine likelihoods for the various pieces of information available.

Estimation and impact of by-catch will be considered at each step of the project. For instance, we will develop specific capture-recapture models using specific covariates to test the impact of by-catch on adult and juvenile survival. A major task will be the estimation of annual and worldwide by-catch, as many different countries operate in the North Pacific, with different fishing methods, and not all of these supply equally reliable data about fishing effort and by-catch. A major source of information will come from Hawaiian fisheries and the observer program, which are thought to provide good quality data. In steps 2 and 3, we will attempt to

estimate a threshold level of by-catch that would, at a specified level of certainty, allow a sustainable growth rate for the albatross populations.

2. Progress during FY 2004. Provide a thorough discussion of accomplishments and problems.

Due to administrative problems, the subcontract with CNRS was signed only at the end of 2003. Actual funding became available from February 2004 onwards. This, together with difficulties of Bird banding Lab in Patuxent with data retrieval and their own analyses, has caused significant delay in processing analysis.

The main steps accomplished and to come are as follows:

1- Availability of data and review of USGS analyses

Contacts and collaboration with USGS: W.Kendall from USGS visited the Montpellier group from January 31st to February 3rd . In parallel, we made mail contacts with Paul Doherty from Colorado State University, who was in charge of analyses of demographic parameter for USGS. The USGS database concerning banding, capture and recapture of Laysan and Black-footed albatrosses (see Appendix 1) was made available to us at that time. During W.Kendall's visit, some features of the USGS analyses were examined in relation to goodness-of-fit tests.

2- Capture-recapture analyses specific to the present project

Several biological parameters are to be estimated from the data. Problems arise from the irregularity of surveys conducted in different islands and variation in capture-recapture effort conducted during those surveys. A key step consists on testing the goodness of fit of basic capture-recapture models to asses the degree of heterogeneity in the capture-recapture process, and attempt to alleviate it either by data selection or by using a more complex model as a starting point for analysis. All analyses thus far were performed using the software U-CARE and M-SURGE.

Due to the delay in obtaining the data, the analytical approach was first tried for estimation of survival rate of BFAL based on a pilot data set obtained on survival in Tern Island (1979-2003) covering the period of intensive by-catch (~1992-2000). This data set appeared as the most convenient because of the focus on by-catch and because the data coverage was reasonably good. Nevertheless, we encountered problems of goodness of fit, probably due to the large variation in geographic distribution of capture effort during years of surveys. This hypothesis about the effect of study area is currently being tested in collaboration with Mark Maunder and Simon Hoyle by methods based on simulation in order to develop bias correction for the models to be used.

We are presently investigating another approach to account for the effects of heterogeneity in capture effort in space and time by applying specific recapture parameters to batches of individuals marked in a given year (cohort effect in recapture probability).

We are also presently selecting data sets from the general database to estimate other demographic parameters, such as recruitment and survival in other islands. This is done using ACCESS and does not raise particular difficulties, and will be completed in June. The survival and recruitment models to be developed next summer will have to account for the heterogeneity mentioned above (either by bias correction or further structural features of the model) and to consider by-catch statistics as time-varying covariates, i.e., to investigate regression relationships

(embedded within the capture-recapture models) between that years' reported amount of by-catch and the estimate of apparent net survival rate that year.

3- Estimation of by-catch

Estimation of by-catch is obviously central to the project. Due to the delay in the project mentioned above, the first year of the contract was used for establishing contacts to decide the type and quality of data available. Two types of information are available; an annual by-catch estimate for from Hawaiian and Alaskan fleets (HAFBC: Hawaiian and Alaskan Fleet by-catch), obtained from an observer program conducted for several years, and for other fleets (Japanese, Korean, and Taiwanese) from reports on fishing effort consisting of geographical localization of boats, their type of fishing and the hook effort.

A first task to build as rapidly and efficiently as possible an overall measure of effort for the other fleets (OFE = Other Fleet Effort). Geographical localization and fishing effort will be added up with geographical information on albatross distribution at sea and foraging strategy, using GIS. A strategy for sharing the work between the different partners is being discussed.

We plan then to use models with the two covariates HAFBC and OFE to model by-catch effect on demographic parameters. This will account for the fact that the by-catch data for the two types of fleet are expressed in radically different units. This approach, discussed with Mark Maunder and Simon Hoyle, can be based on several predictions in relation with standard theory for exploited populations, in particular the approximate linearity of the relationship between survival and by-catch or any covariate reasonably proportional to by-catch such as effort.

More recently, we had access to information on the sex ratio in the by-catch.. Recent data from Alaskan fisheries (Kevin Winker, pers. comm.) seem to indicate a higher frequency of males relative to females in both species (with small samples sizes in BFAL). This will have to be accounted for in the population dynamics models.

4- Matrix model

A model with two states (widowed and paired) has been written as a particular case of a multistate Leslie matrix. In its simplest form, this model leads to a geometric sojourn time in the state widowed, a good approximation which may be restrictive in some cases. However, this formulation gives access to concepts of the multistate stable population theory (Lebreton, 1996, Theor.Pop.Biol.), such as explicit sensitivity results linked to generation time. In presence of an additional source of mortality, the drop in the growth rate is larger than in a model neglecting the cost of repairing after widowhood. The cost of repairing can be expressed as the equivalent change in mortality needed to obtain the same growth rate in a model not accounting for the cost. These results, discussed with Simon Hoyle, will be framed in papers in the next year (see ch. 3).

5- Integrated modeling

As recommended when the project was accepted, the collaboration with Mark Maunder and Simon Hoyle has started, with their visit to Montpellier in March 2004, 6 to 10. The first part of the collaboration was about CR analyses and simulations (see part 2). The second part of this collaboration will concern integrated modeling. Next fall, a further meeting will make it possible to compare these approaches and Bayesian ones (see next chapter 3).

In parallel, Matlab ® code for implementing the Kalman filter with the matrix model to be used was adapted and tested.

In conclusions, problems with delays in funding and data availability have now been overcome and, after an acceleration in the winter 2004, the project is now under normal development.

3. Plans for the next fiscal year.

- Complete CR analysis: cleaning database, select dataset for juvenile survival, recruitment in different islands to see if there are differences on survival between nest sites. A visit to Hawaii in fall of 2004 is planned, to meet people involved in albatross's projects, particularly dealing with census, recapture and by-catch, to learn precise details of how data were obtained, in order to help solve design problems due primarily to geographic distribution of effort.

- Test correlation between survival and by-catch based on a model with covariates by-catch (when known: Hawaiian fleet) and fishing effort when no estimate of by-catch is available.

- Meeting between Dan Goodman, Jean-Dominique Lebreton and Sophie Véran to start the phase devoted to integrated modeling, in particular for what concerns Bayesian approaches. This will be coordinated with the pursued collaboration with Mark Maunder and Simon Hoyle.

- Compare the various approaches to integrated modeling. Reassess using these tools the relationship between survival and by-catch and effort covariates. Assess the consequences at the population level

- Start writing down results, with co-authorship with Mark Maunder and Simon Hoyle as agreed upon during their visit to Montpellier.

APPENDIX: DATA RETRIEVAL AND CONTACTS

resources	where	for	In charge	comment
Census BFAL	FWS Hawai	To combine with demographic analysis in integrated model	Elizabeth Flint Maura Naughton	contacted Information on census for year 2003. Asked for other years . Waiting for answer
CR data BFAL	Patuxent	Demographic analysis	Bill Kendall / Paul Doherty	Incomplete data set : missing 2002-2003 : contacted and waiting for answer. Also need more information about protocol !!!
By-catch data (Hawaiian resources)	FWS Hawai	By-catch analysis	Marti Mccracken	-annual by-catch estimation from 1994 to 2002
By-catch data (others American resources)	Pacific Islands Regional Office	By-catch analysis	Alvin Katekaru	contacted
Japonese data	TOHO University	Estimation of population size	Hiroshi Hasegawa	
Mitigation measures	National marine fisheries service	Analysis if impact of mitigation measures. Incorporate them in models	Ed Melvin	Not contacted
Integrated modelisation	IATTC, La Jolla, CA	Integrated modelisation	Mark Maunder	To confirm
Catch effort		By-catch estimation		Driftnet data, grouped by 5x5 and month, cover 1983 to 1990 and the Pacific Ocean south of the equator. This fishery has been inactive since 1991. Longline data, grouped by 5x5 and month, cover 1952 to 2001 and the whole Pacific Ocean. Pole-and-line data, grouped by 5x5 and month, cover 1972 to 2001 and the western and central Pacific Ocean (west of 150W). Purse-seine data, grouped by 5x5 and month, cover 1967 to 2001 and the western and central Pacific Ocean (west of 150W).