

REPORT: SECOND WHOI WORKSHOP ON ALBATROSS DEMOGRAPHY, 1–7 MAY, 2005

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1 Goals

The second meeting of the Working Group on Albatross Demography was held from 1–7 May 2005, at Harvard Forest in Petersham, Massachusetts. The overall goals were to estimate a set of models based on the life cycles developed in the previous meeting and to take advantage of the opportunity to interact in person. The following list of meeting goals (extracted from the report of the September 2004 meeting) was distributed on the first day:

1. Fit models (from a well-defined family) to as many data sets as possible.
2. Use model selection to identify the best models from the family.
3. Constraints are needed to overcome rank deficiency due to temporary emigration; explore the consequences of these constraints.
4. To the extent possible, evaluate goodness-of-fit. At the very least, discuss the GOF problem and prospects for theoretical developments.
5. Compare parameter estimates across models and across populations/species.
6. Carry out initial explorations of covariate-dependent models.
7. Carry out some preliminary demographic analyses of the results.
8. Discuss, discuss, discuss:
 - (a) prospects for incorporating additional types of data (e.g., integrated modelling of census and mark-recapture data) and biological detail (e.g., details on mate loss, nest failure, etc.)
 - (b) models necessary to address new theoretical questions
 - (c) plans for analytical work between now and the next meeting
 - (d) and what about that next meeting?
9. Have fun. See some birds. (Extra points for ivory-billed woodpecker). Drink beer.

By consensus, Goal 9 was achieved. More on the others follows ...

Attendees:

Hal Caswell	Woods Hole Oceanographic Institution, MA, USA
Sarah Converse	USGS, Patuxent, MD, USA
John Croxall	British Antarctic Survey, United Kingdom
Paul Doherty	Colorado State University, CO, USA
Jaume Forcada	British Antarctic Survey, United Kingdom
Christine Hunter	Woods Hole Oceanographic Institution, MA, USA
Stephanie Jenouvrier	CEBC-CNRS, Chize, France
Bill Kendall	USGS, Patuxent, MD, USA
Marie Nevoux	CEBC-CNRS Chize, France
Roger Pradel	CEFE-CNRS Montpellier, France
C.J.R. Robertson	Wild Press, New Zealand
Peter Ryan	University of Cape Town, South Africa
Paul Scofield	Canterbury Museum, New Zealand
Sophie Veran	CEFE-CNRS Montpellier, France
Zack Vincent	University of Cape Town, South Africa

2 Analyses

2.1 The adult life cycle

Much of the activity during the workshop focussed on parameter estimation using the adult life cycle developed in the previous workshop. This life cycle distinguishes between birds that breed in a given year and those that do not, and between birds that succeed and those that fail. The four stages in the life cycle are 1) successful breeders, 2) unsuccessful breeders, 3) post-success non-breeders, and 4) post-failure non-breeders (Figure 1). Each transition in Figure 1 has an associated probability of breeding β_i , probability of a breeding attempt being successful γ_i , and probability of survival σ_i . There is no dependence on age since birth or age since recruitment.

2.2 Goodness-of-fit

Roger Pradel kindly led us through the murky waters of goodness-of-fit (GOF) tests, attempting to give the rest of us a better understanding of how these tests work and how to implement them. We thank him for his patience. Here is our interpretation of these discussions and how we implemented these methods.

The purpose of a GOF test is to determine whether the data adequately obey the assumptions of the model. Unfortunately, reliable GOF tests are not available for all models. Of particular relevance to us is that GOF tests are not available for the Arnason-Schwarz (AS) model or multi-state models. Given that we cannot conduct GOF tests for the multi-state models we wish to use for estimation, the best alternative is to conduct GOF tests for the JMV model, which is a generalization of the AS model. The JMV and AS models differ in whether capture probability depends only on the state at time $t + 1$ (AS) or on both the state at time t and the state at time $t + 1$ (JMV). For our purposes, estimating \hat{c} from the JMV GOF test will be conservative because this model has fewer states, so makes stronger assumptions about similarity among individuals than our 4-state models.

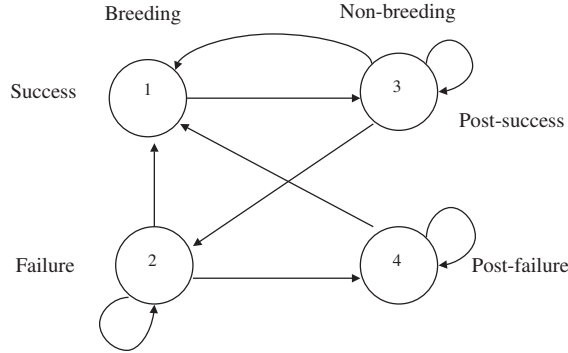


Figure 1: Adult life cycle, stages are: 1) successful breeders; 2) unsuccessful breeders; 3) non-breeders whose previous breeding attempt was successful; and 4) non-breeders whose previous breeding attempt failed. As shown here the life cycle is strictly biennial (breeding in the year following a successful breeding attempt is not allowed). Each stage has an associated probability a bird in stage i breeds β_i , probability a breeding attempt for a bird in stage i is successful γ_i , and probability a bird in stage i survives from time t to time $t + 1$, σ_i

Table 1: Dependence of parameters in the Arnason-Schwartz (AS) and JMV models on state of departure (from), state of arrival (to) and time (t).

	Arnason-Schwartz	JMV
survival	from. t	from. t
capture	to. t	from.to. t
transition	from.to. t	from.to. t

Goodness-of-fit tests are designed to detect departures from assumptions of the estimation procedures. The assumptions of the JMV model that relate to model structure are that 1) all animals behave independently, and that 2) all animals present at a given time and in a given state behave the same a) whatever their past capture history, and b) whether they are currently captured or not. The two components of the JMV GOF test, Test M and Test 3G, are designed to test assumptions 2a and 2b. Test M determines whether the behavior of animals is independent of whether they are currently captured or not. Test 3G determines whether the behavior of animals is independent of their past capture history. These GOF tests decompose the capture histories into groups that would be expected to behave the same if the assumptions hold. These tests identify cell probabilities in the m-array that are expected to be proportional because they have a common structure and tests for their homogeneity using contingency tables. A more complete GOF test would compare expected and observed numbers of animals for each possible capture history but is not generally possible.

The two components of the goodness-of-fit test for the JMV model.

- Test 3G: tests for dependence on past capture history.
This test takes each row of the m-array (which corresponds to a time and stage of release) and splits the element in each column of that row depending on the previous capture history (splitting it into $s + 1$ rows). These contingency tables are then tested for homogeneity. This is a straightforward generalization of test 3 for the CJS model.
 - Test WBWA ("where before where after"): tests for state dependence.
A component of Test 3G, this tests for memory extending over an indeterminate number of time steps. This test is an $s \times s$ contingency table for next seen in state $1, \dots, s$ versus last seen in state $1, \dots, s$. If individuals 'select' states according to past experience an excess of individuals is observed on the diagonal of the contingency table.
- Test M: tests dependence on whether currently captured or not.
This tests whether animals alive and not captured at time i behave the same from that time onwards as animals released at the same time in any of the s states. This tests homogeneity between elements in one row with a mixture of elements from lower rows in the m-array. For example, animals released at time 1 in state 1 and not seen at time 2 but seen later are known to be alive at time 2. However, because their state is unknown they can't be compared directly to other sites but should behave the same as some mixture of the other sites. This is the analogue of Test 2 for the CJS model.

Conventional wisdom states that a GOF test does not need to be conducted for the most general model. As long as one model provides a reasonable fit we can assume any model with smaller AIC also provides a reasonable fit. So, given a reasonable fit for the JMV model it is currently accepted that any model with lower AIC can be assumed to provide an adequate fit to the data.

Under Roger's guidance we agreed on the following procedure for the GOF tests. Noting, of course, that it is not possible to conduct a GOF test on a JMV model with 2 observable and 2 unobservable states. These tests were conducted in U-Care.

1. Conduct the GOF test for the JMV model (fully time-varying) with 2 observable states with all transitions possible. Obtain results for Test 3G, Test WBWA, and Test M. Calculate \hat{c} as:

$$\hat{c} = \frac{\chi^2(\text{Test3G}) + \chi^2(\text{TestM})}{df(\text{Test3G}) + df(\text{TestM})} \quad (1)$$

2. Conduct the GOF test for the JMV model (fully time-varying) with 2 observable and 1 unobservable states with all transitions possible. Fix values for capture probability for the unobservable state to zero. Obtain results for Test 3G, Test WBWA, and Test M. In general Test M was not possible for this model and returned values of $\chi^2 = 0.0$ and $df = \text{NAN}$. In this case calculate \hat{c} as:

$$\hat{c} = \frac{\chi^2(\text{Test3G})}{df(\text{Test3G})} \quad (2)$$

3. Assuming \hat{c} is less than or not much greater than 2, fit four JMV models using MSURGE and obtain the AIC values for each model.

- a constant JMV model with 2 observable states

- a time-varying JMV model with 2 observable states
 - a constant JMV model with 2 observable and 1 unobservable state
 - a time-varying JMV model with 2 observable and 1 unobservable state
4. Continue with parameter estimation, fitting the multi-state models with 2 observable and 2 unobservable states using the Matlab routines. Use the lowest \hat{c} from the GOF tests to adjust the AIC values (theoretically either \hat{c} can be used).

Results for the GOF tests conducted during the workshop are included in the estimation results below.

Issues that may arise in the GOF testing that we did not address include i) whether some strategy of pooling can be used if small expected values frequently appear in some cells, and ii) that small data sets may not show GOF problems because of a lack of data.

2.3 Estimability

The adult model in Figure 1 contains four parameter types: survival rates σ_i , breeding propensities β_i , breeding success probabilities γ_i and capture probabilities p_i . There is a σ_i , β_i , γ_i and p_i associated with each of the four stages (where i denotes the stage). Capture probabilities p_3 and p_4 are zero if stages 3 and 4 are assumed to be strictly unobservable. If the model is assumed to be strictly biennial β_1 and γ_1 are also zero.

Annual and biennial versions of the adult model with no constraints have 12 and 14 parameters, respectively, if all parameters are constant over time. Even when all parameters are constant over time, it is not possible to separately estimate all parameters for these models because of the unobservable states. Some constraints are therefore required for parameter estimation. Parameter constraints should preferably have some biological meaning. Biologically it seems reasonable to suggest that birds attending the colony (i.e. birds in states 1 and 2) experience similar conditions so may have similar vital rates and that birds not attending the colony (i.e. birds in states 3 and 4) may have similar vital rates. Alternatively, breeding success may be an indication of ability or condition, suggesting that birds whose most recent breeding attempt was successful would have similar vital rates (i.e. birds in states 1 and 3) and birds most recent breeding attempt failed would have similar vital rates (i.e. birds in states 2 and 4).

Ch and HC investigated parameter estimability for time-constant models with different constraints prior to the workshop. Four constraints were investigated for both survival rates and breeding propensities giving a total of 16 possible models (Table 2). The four constraints were: i) equal for all states; ii) equal for states 1 and 2 and equal for states 3 and 4 (i.e. attending versus absent from the colony); iii) equal for states 1 and 3 and equal for states 2 and 4 (i.e. successful versus failed breeders); and iv) independent for all states. We also investigated constraints on the breeding success probabilities γ_i and capture probabilities p_i but these had little effect on estimability of parameters.

For the annual life cycle, all parameters are estimable in columns 1–3 of Table 2, except Models 9 and 11 which have a rank deficiency of 1. For biennial breeding Models 9 and 11 become full rank so all parameters are estimable for Models 1–12. For both the annual and biennial life cycles Models 13–15 have a rank deficiency of 1 and Model 16 has a rank deficiency of 2. Note that in the

Table 2: Number of parameters and indication of identifiability (Y=all parameters estimable, N=rank deficient) for the time-constant annual adult life cycle with constraints on survival and breeding propensity. Model number in parentheses.

Breeding Propensity	Survival			
	$\sigma_1 = \sigma_2 = \sigma_3 = \sigma_4$	$\sigma_1 = \sigma_3, \sigma_2 = \sigma_4$	$\sigma_1 = \sigma_2, \sigma_3 = \sigma_4$	$\sigma_1, \sigma_2, \sigma_3, \sigma_4$
$\beta_1 = \beta_2 = \beta_3 = \beta_4$	8 Y (M1)	9 Y (M5)	9 N (M9)	11 N (M13)
$\beta_1 = \beta_3, \beta_2 = \beta_4$	9 Y (M2)	10 Y (M6)	10 Y (M10)	12 N (M14)
$\beta_1 = \beta_2, \beta_3 = \beta_4$	9 Y (M3)	10 Y (M7)	10 N (M11)	12 N (M15)
$\beta_1, \beta_2, \beta_3, \beta_4$	11 Y (M4)	12 Y (M8)	12 Y (M12)	14 N (M16)

biennial case the models in rows 1 through 3 of Table 2 have 1 less parameter and models in row 4 have 2 less parameters.

Investigations of the estimability of time-varying versions of Figure 1 and of the pre-breeder life cycle are ongoing. Estimability for constant versions of Figure 1 were determined using analytical methods (Gimenez et al. 2003). Unfortunately this has not been possible for time-varying models because of the large number of parameters and consequently the size of the matrices involved. We are still investigating alternative methods but obtaining reliable results is proving a challenge.

2.4 Parameter estimation

The focus of this meeting was parameter estimation and we spent much of our time estimating parameters for the the adult life cycle (Figure 1). We divided up into groups focused around each of the data sets represented at the meeting and began by fitting the constant models from the first three columns of Table 2 (Models 1-12). The lowest \hat{c} from the GOF tests was used to adjust the AIC values. Some results for this exploration are shown in Tables 4 – 6.

Information was available on attendance at the colony of birds in states 3 and 4, the unobservable states, for some data sets. This information was considered to be consistent for the Northern Royal Albatross data set but less consistent for other data sets. This is interesting because it allows us to ask what the merits of treating the species as strictly biennial are. For comparative purposes models with all 4 states observable were run for these data sets.

2.4.1 Data sets

The data sets are summarized in Table 3. These data sets represent four comparable studies (the British, French, and South African data sets, and the Buller’s study) and two more anomalous studies (Taiaroa Head and Hawaii). The Taiaroa Head and Hawaii data sets are interesting in that they represent two opposite extremes from the other studies. The Taiaroa Head study is a small population that is studied and managed very intensely, whilst the Hawaii population has been

Table 3: Data sets represented at the meeting. Initials in parentheses are participants who were not present.

Species	Locations	Length of study	Representatives
Yellow-nosed Albatross	Gough Is.	1980-present	PR, ZV
Grey-headed Albatross	Marion Is.		PR, ZV
Wandering Albatross	Marion Is.		PR, ZV
Northern Royal Albatross	Taiaroa Hd	1938- present	CJRR, PSc
Buller's Albatross ¹	Snares, Solander Is.	1995-present	(PSa), PSc
Black-footed Albatross ²	FFS, Tern, Midway Is.	sporadic	PD, BK, SC, SV
Laysan Albatross ³			PD, BK, SC, SV
Wandering Albatross ⁴	Bird Is.	1958-present	JC, JF
Grey-headed Albatross	Bird Is.	recaps 1971-present	JC, JF
Black-browed Albatross	Bird Is.		JC, JF
Wandering Albatross ^{5 6}	Crozet Is.	1958-present	(HW), SJ
Black-browed Albatross	Kerguelen Is.	recaps 1973-present	(HW), MN

monitored much less consistently.

Bird Island. This study started in 1958-1963 with banding of adults and chicks. Recaptures of known and unknown age birds started in the early 1970's and since 1971 all chicks have been banded. Some extra data has been collected on pre-breeding and non-breeding. There is a low probability of missing breeders or misclassification of stage due to high effort. Effort has been consistent except for 2 years. The entire island can be calibrated with smaller study areas that are visited twice a day. There are about 17,000 known-age Wandering Albatross, 6,000 known-age Grey-headed Albatross, and about 3600 known-age Black-browed Albatross. Birds were color-banded for about 10 years making them easier to re-sight, so for a particular period within the study there is a greater probability of capture for birds in state 3. Observations for state 2 birds split into two groups: early failures and late failures. Although the Black-browed albatross is an annual breeder, 15-20% still skip after successfully breeding. Only data for known age birds was analyzed.

Crozet. This study began in 1958 but there were no recaptures until 1973. Some breeding information was available prior to 1973, but reliable success/failure data is available from 1973. Males, females and unknown sex birds were combined for analyses.

Northern Royal Albatross. This is a small, intensively monitored population. See notes in section 3.3. Data from 1970–1995 were analyzed (1995–present not yet coded).

Hawaii. Information on the success or failure of breeding attempts is not available for the Hawaiian Black-footed and Laysan Albatross populations. Two-state models were run for these data sets. Goodness-of-fit data for the Laysan Albatross on Tern island indicated problems with transients.

This could be effectively dealt with by removing the first captures. Band loss is a potential problem. Some dead recoveries have been made.

2.4.2 Time-invariant results

Estimates for the time-invariant models are given for annual species in Table 4 and for biennial species in Table 5. In most cases the models in row 4 of Table 2 had the lowest AIC values. This suggests that difference in breeding propensities among states are more important than differences in survival rates among states.

Table 4: Parameter estimates for Model 4 for annual breeding species (Model 7 for BBA Kerguelen).

Species	Sex	State	σ	β	γ	p	\hat{c}
YNA	All	Succ	0.914	0.82	0.6	0.92	1.00
Gough		Fail	0.914	0.94	0.54	0.57	
		P-Br	0.914	0.66	0.66	0	
		P-Fa	0.914	0.19	0.05	0	
BFA	All	Succ & Fail	0.92	0.97	-	0.84	3.4-100
Tern		P-Br & P-F	0.92	0.6	-	-	
BBA	All	Succ	0.928	0.881	0.326	1.00	2.10
South Georgia		Fail	0.928	0.751	0.279	1.00	
		P-Br	0.928	0.632	0.312	0	
		P-Fa	0.928	0.659	0.343	0	
BBA	All	Succ	0.937	0.966	0.587	0.967	1.54
Kerguelen		Fail	0.907	0.966	0.446	0.492	
		P-Br	0.937	0.180	0.339	0	
		P-Fa	0.907	0.180	0.673	0	
BBA	All	Succ	0.922	0.943	0.590	1.00	
Kerguelen		Fail	0.922	0.919	0.473	0.519	
(delta AIC 1.36)		P-Br	0.922	0.647	0.753	0	
		P-Fa	0.922	0.252	0.390	0	
Bullers	All	Succ	0.966	0.95	0.76	0.97	1.8
Snares		Fail	0.966	0.97	0.66	0.86	
		P-Br	0.966	0.48	0.79	0	
		P-Fa	0.966	0.31	0.66	0	

Table 5: Parameter estimates for Model 4 for biennial species (Model 8 and 12 for WA Crozet).

Species	Sex	State	σ	β	γ	p	\hat{c}
GHA	All	Succ	0.943	0.077	0.44	0.991	1.68
Marion		Fail	0.943	0.98	0.45	0.692	
		P-Br	0.943	1.00	0.61	0	
		P-Fa	0.943	0.36	0.88	0	
GHA	All	Succ	0.948	0	0	1.00	1.96
South Georgia		Fail	0.948	0.529	0.231	0.842	
		P-Br	0.948	0.786	0.458	0	
		P-Fa	0.948	0.661	0.208	0	
WA	M	Succ	0.939	0	0	0.937	1.40
South Georgia		Fail	0.939	0.927	0.512	0.510	
		P-Br	0.939	1.00	0.655	0	
		P-Fa	0.939	0.280	0.563	0	
WA	F	Succ	0.924	0	0	0.969	1.11
South Georgia		Fail	0.924	0.952	0.496	0.4932	
		P-Br	0.924	1.00	0.644	0	
		P-Fa	0.924	0.394	0.711	0	
WA	All	Succ	0.899	0.07	0.37	0.91	1.92
Crozet		Fail	0.899	0.93	0.56	0.51	
86-03		P-Br	1.00	1.00	0.7		
M8		P-Fa	1.00	0.41	0.61		
WA	All	Succ	0.947	0.07	0.37	0.91	1.92
Crozet		Fail	0.915	0.91	0.56	0.51	
86-03		P-Br	0.947	1.00	0.7		
M12		P-Fa	0.915	0.36	0.61		
NRA	All	Succ	0.946	0	0	0.996	0.61
Taiaroa		Fail	0.946	0.93	0.32	0.82	
		P-Br	0.946	0.95	0.58	0	
		P-Fa	0.946	0.32	0.3	0	

2.4.3 Beyond time-invariant models

There was a lot of interest in exploring beyond the time-invariant models. In extending the time-invariant models we branched out in 3 directions: i) alternative model structures; ii) models with time-varying parameters; and iii) covariate models.

There are a large number of potential options for constructing time-varying models depending on the constraint model, the type of time-variation (free, trend additive), and the parameter or combination of parameters that are allowed to vary. We began by selecting Model 4 and allowing p and σ to vary over time. Results for the time-varying models are preliminary as the Matlab programs for these models were still in development during the workshop.

Similarly, covariate model programs were in development during the workshop. The idea here was to use logistic dependence, i.e. let p be a probability $\text{logit}(p) = a + bx$. Then $p = \text{invlog}(a + bx)$. These models were tried on a few data sets.

Discussion of alternative model structures centered around including early/late failures in the model. This would be a more complex model. In favor of the simpler model is easier estimation and fewer data categories (which are therefore available for more data sets). In favor of the more complex model(s) is the ability to test hypotheses about pooling individuals before doing so. Late failures may behave in a similar manner to successful birds based on energetics arguments which imply that late failures have invested a similar amount of energy to successful birds, and may expend more energy in a last-ditch attempt to feed a chick. Arguments based on mate loss would suggest that a late failure resulting from mate loss would behave differently from a successful bird.

2.5 Pre-breeder model

Unfortunately we did not have time during the workshop to explore the pre-breeder part of the life-cycle. We discussed how to structure and parameterize this model and possible choices for constraints. This will be an important next step towards getting estimates of population growth.

3 Issues discussed

Over the course of the week, a number of issues were discussed and points raised, both formally and informally. Here is a selection of those points.

3.1 Data and estimation issues

- Uncertain states – Information on success or failure of breeding is not always available for the early years of a study. (e.g. the Crozet Wandering Albatross)
- Observability of post-breeding states – In some studies stages 3 and 4 of the adult cycle are observable, albeit with a lower probability. Observations of stages 3 and 4 are not generally consistent, but the Taiaroa Head Northern Royal Albatross data set is a notable exception.
- Observability of pre-breeding states – Observations of pre-breeding birds are also generally opportunistic and inconsistent. However, some cases exist where particular effort has been made to collect this data. John Croxall discussed 6 years of juvenile resighting data that was collected on the Bird Island Wandering Albatross. Particular effort was made to resight pre-breeders which were categorized as first-resighting, gaming or keeping company. John hypothesized a second mortality bump after return to the colony associated with the behavioral change of switching from random feeding to needing to feed within reach of the colony.

- Definition of failure – The definitions of failure will be important in applying these models. The definition of success or failure differs depending on whether you use the point of view of adult or chick. Whether birds fail early or late may also be important but may not be clear from the data. The boundary between early and late failures is likely to differ among species.
- Study protocols – Many new albatross (and other seabird) studies are being started as a result of conservation initiatives. It will be important if we can provide advice for those studies.
- Although albatross are generally considered monogamous, 3-20 % of chicks result from extra-pair paternity.
- Further discussion on the definition of states is warranted.
- In estimation of time-varying models we will need to be more careful about local minima.
- M-surge can fit models in Row 4 but does not allow specification of the constraints necessary to fit the models in rows 1–3.
- Reliability (or more correctly unreliability) of the hessian surfaced several times and some issues arose related to optimization in different versions of Matlab (v.7.0 compared to v. 6.5)

3.2 Study design

Bill Kendall led a discussion on study design issues. Colonies that are too large to monitor in their entirety raise the issue of how to most effectively and efficiently allocate effort. Study design considerations include number of plots, plot size, data to record (stages, age, etc.), marking of unknown birds, handling effects.

Study problems can arise from a number of sources:

Problems	Possible solutions
inconsistent effort	consistent effort
band loss	double band (say 10 percent)
spatio-temporal overlap with fisheries unknown	greater observer effort to assess mortality
temporary emigration	additional information

Temporary emigration may result from skipped breeding or from movement in and/or out of a study plot. If the entire colony cannot be monitored it is difficult to distinguish these. To predict proportions moving out of plot additional information is needed. This may come from telemetry, the robust design, or from buffer areas around plots. A non-uniform distribution of nests (e.g. Weimerskirch and Inchausti) can make buffer areas more difficult to utilize.

3.3 Taiaroa Head data set

The Taiaroa Northern Royal Albatross data set is unusual in the amount of detail it contains. CJRR presented an overview of the history of the colony and discussed the type of information available in the data set.

Northern Royal Albatross Timeline:

1899	first record
1919	1935 occasional eggs seen or stolen
1936	chick hatched (but killed by people throwing stones)
1937	Richdale protected nests
1938	first chick fledged
1940 – 1945	closed due to war
1951	first protection in place
1951 – 1967	casual observations
1967 – present	specific regime of monitoring and rigorous observation
1970 – present	best data

When chicks are fostered the original parent is treated as failed when the chick is removed. About 50 % of the birds in the colony have not had any breeding intervention. Disturbance or intervention in the early years of the study was due primarily to predation by humans, dogs, cats, stoats, and ferrets. Present disturbance and intervention consists primarily of impacts of blowflies, and fostering of chicks. An interesting note made by CJRR is that when NRA first return to the colony as pre-breeders they can't walk for the first few days. This makes it possible to identify whether an immigrant is a young bird based on whether or not it can walk. These birds are assigned a nominal age of 5 years.

3.4 Connection with international management efforts

CAAMLR The Convention on the Conservation of Antarctic Marine Living Resources (CAAMLR) – is concerned with albatross because of interaction with fisheries that CAAMLR manages. The primary question management agencies such as CAAMLR are interested in is "Is management having any discernable impact?" CAAMLR has established observation and mitigation programs that require large amounts of money, so they want to know whether the programs work. CAAMLR needs to balance concerns for albatross species with concerns from constituencies that think fisheries are overregulated. This leads to PBR-like concerns and questions related to the point at which mitigation should be required.

Questions related to fisheries interactions with albatross include: Are fisheries having an impact? Are mitigation measures changing the impact of fisheries on albatross? Are the albatross populations recovering? At what level do population consequences to albatross become serious enough to warrant mitigation? These questions are difficult to answer in and of themselves and are made more difficult because of unknown impacts from illegal fishing and impacts elsewhere. CAAMLR is only beginning to recognize that a modelling framework can be used to help answer these questions.

CAAMLR has a scientific team and an assessment team. The assessment team is mostly fisheries oriented (e.g. developing generalized yield models). The scientific team has two working groups that are relevant to albatross issues. Every member country can send delegates to CAAMLR meetings. Invited experts may attend but any one member country can veto attendance. CAAMLR also commissions consultant work.

ACAP The Agreement on the Conservation of Albatross and Petrels (ACAP) has 12 committed members, 8 with breeding ranges and 4 others (Spain, Brazil, Ecuador, Peru). The USA is not a

Table 6: Parameter estimates for Northern Royal Albatross for variations of Model 4.

Species	Model	Sex	State	σ	β	γ	p	\hat{c}
NRA	M4	All	Succ	0.946	0	0	0.996	0.61
Taiaroa			Fail	0.946	0.93	0.32	0.82	
			P-Br	0.946	0.95	0.58	0	
			P-Fa	0.946	0.32	0.3	0	
NRA	M4	All	Succ	0.944	0	0	1.00	0.61
Taiaroa	(LAST 25 years)		Fail	0.944	0.88	0.33	0.85	
			P-Br	0.944	0.93	0.56	0	
			P-Fa	0.944	0.5	0.6	0	
NRA	M4	All	Succ	0.949	0	0	0.958	0.61
Taiaroa	(Hal time var)		Fail	0.949	0.969	0.336	1.00	
			P-Br	0.949	0.986	0.571	0	
			P-Fa	0.949	0.131	0	0	
NRA	s(.)p(.)psi(.)	All	Succ	0.933	0.030	0.003	0.995	0.61
Taiaroa	Mark		Fail	0.932	0.819	0.344	0.998	
	– all states obs		P-Br	0.968	0.77	0.632	0.373	
			P-Fa	0.928	0.41	0.454	0.757	
NRA	M4	All	Succ	0.949	0.032	0	0.994	0.61
Taiaroa	Hal		Fail	0.949	0.822	0.343	1.00	
	– all states obs		P-Br	0.949	0.783	0.624	0.369	
			P-Fa	0.949	0.546	0.465	0.768	

member (and is unlikely to sign any time soon). ACAP is designed to improve status of breeding areas and conditions at sea for albatross and petrels (knowing what populations are doing and why will be fundamental to implementing this). There are two working groups i) taxonomy, and ii) status and trends. There is some budget for scientific objectives. The scientific committee was established in November 2004, and holds it's first meeting in July 2005.

John Croxall will be at the advisory board meeting representing the UK. He suggested we table the report from the first meeting at the July ACAP meeting. Kim Rivera (NMFS) will be the US observer and would be the appropriate person to table the report.

3.5 A reprise on biological questions

Evening discussion – questions of interest.

Biological issues

- Breeding frequency, productivity and survival (biologists have long been interested in relationships among these factors)

- Age (senescence, 1st breeding, experience)
- sex
- pair (divorce, mate loss)
- effort

Related Issues

- density-dependence
- sex ratio
- environmental effects
- dispersal (implicit in above)
- timing intervals (implicit in above)
- stochasticity

Management Issues

- demographic consequences of "bad years"
- potential biological removals (PBR)
- power to detect changes (n, t , variance)
- best-practice manual/advice

4 Next meeting

Chize was offered and agreed as the location of the next meeting, which will probably be in the northern hemisphere spring of 06. Probable items on the agenda will be:

- Demographic analysis of pre-breeder and breeder life cycles using rigorous estimates.
- Count data as comparison
- Beginning demographic calculations

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