Turn off powerpoint

https://www.youtube.com/watch?v=DsNJjKURSiw (first)

https://www.youtube.com/watch?v=_D0ZQPqeJkk (sequence)

Reverse time models in CMR (Pradel seniority)

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Different classes of CMR (MR) models

CJS models

- Cormack-Jolly-Seber models
- Originally “Closed-population model”
- “conditional upon the animal being released alive at first encounter, and survival and catchability refer only to these marked animals”
- Developed initially for survival rates
- Translation: we can get extinction rates if we are only interested in the taxa that entered the fossil record and are sampled at least once.
- (almost never used in paleo situations because of what we are interested in)

JS models

- Jolly-Seber models
- “Open-population model”
- “unmarked animals in the population have the same probability of capture as marked animals in the population, i.e., that newly captured unmarked animals are a random sample of all unmarked animals in the population”
- Developed for parameters like abundance, population growth, recruitment.
- Translation: we can get extinction rates, origination rates, taxonomic richness and we include those taxa never sampled or have never entered the fossil record.

Different classes of models

CJS models

- Cormack-Jolly-Seber (CJS) models
- “Closed-population model”
- http://www.phidot.org/software/mark/docs/book/pdf/chap3.pdf

JS models

- Jolly-Seber (JS) models
- “Open-population model”
- http://www.phidot.org/software/mark/docs/book/pdf/chap12.pdf

RD models

- Robust-design (RD) models
- Hybrid “open-closed population model”
- http://www.phidot.org/software/mark/docs/book/pdf/chap15.pdf

Within each class, many different model types,
with each model type, you can formulate many different specific models (e.g. time-varying, time constant, covariates)

RT models

$\Pr. CJS(01101|release\ in\ 2) = \phi_2 p_3 \phi_3 (1 - p_4)\, \phi_4\, p_5$

ϕ_i= probablity that if alive in i, also alive in $i + 1$

Turn 01101 around = 10110

γ = seniority parameter (complement of origination probability in paleo speak)

γ_i = probablity that if alive in i, also alive in $i - 1$

$\Pr. RT(01101|last\ capture\ in\ 5) = \gamma_5 (1 - p_4)\, \gamma_4\, p_3 \gamma_3 p_2 (1 - \gamma_2\, p_1)$

RT models

$$\phi_t N_t = \gamma_{t+1} N_{t+1}$$

$$E(\lambda_t) = E\left[\frac{N_{t+1}}{N_t}\right]$$

$$E(\lambda_t) = \frac{\phi_t}{\gamma_{t+1}}$$

Pradel seniority model

The Pradel seniority (1996) model (ϕ_t, γ_t, p_t) can

be reparameterized in multiple ways,

including

(ϕ_t, λ_t, p_t) population growth rate

(ϕ_t, f_t, p_t), recruitment as functions of covariates, for example

Note that the POPAN; the Link-Barker and Pradel-recruitment; and the Burnham JS and Pradel-lambda formulations.

Pradel (1996): Likelihood expression to maximize

In terms of the u_i's, n_i's, v_i's, and d_i's,

$$L(\phi,p,\gamma,\mu)=\prod_{i=1}^{s}\left(\xi_i^{u_i}\right)\left(\gamma_i^{\sum_{j<i}u_j}\right)\left(p_i^{n_i}\right)\left[(1-p_i)^{\sum_{j\le i}u_j-\sum_{j<i}v_j-n_i}\right]\left(\phi_i^{\sum_{j>i}v_j}\right)\left(\mu_i^{n_i-d_i}\right)$$
$$\cdot\left[(1-\mu_i)^{d_i}\right]\left[(1-p_i(1-\mu_i))^{\sum_{j>i}u_j}\right]\left(\chi_i^{v_i-d_i}\right)$$
$$\Big/\left(\sum_{i=1}^{s}\xi_i\left\{\prod_{j=1}^{i-1}\phi_j(1-p_j(1-\mu_j))\right\}\left\{\prod_{j=i+1}^{s}\gamma_j\right\}p_i\right)^{\sum_{i=1}^{s}u_i}. \qquad (2)$$

Pradel 1996

openCR to the rescue

5.1 Non-spatial openCR models

5.1.1 Parameters and model types

Table 2. Parameter definitions and default link functions (nonspatial models)

Parameter	Symbol	Link	Description
p	p	logit	capture probability (recapture probability for CJS)
phi*	ϕ	logit	apparent survival
b	b	mlogit	entry probability cf PENT in MARK
f*	f	log	per capita recruitment rate
gamma*	γ	logit	seniority (Pradel 1996)
lambda*	λ	log	population growth rate (finite rate of increase)
superN	N	log	superpopulation size
BN	B_N	log	number of entrants
N	N_j	log	time-specific population size

* parameters marked with an asterisk are scaled by the interval between primary sessions.

"Translations"

p	Sampling probability
phi	Survival probability (1-phi is extinction probability)
b	Similar to 1-gamma but not "scaled"
f	Per capita origination/speciation
gamma	Seniority probability (1-gamma is origination probability)
lamda	Net diversification rate
superN	Richness of the whole "data" (including those not seen)
BN	Number of new taxa appearning
N	Number of taxa in time interval

Table 3. Parameters of nonspatial **openCR** models

Type	Alias	p	phi	b	f	gamma	lambda	superN	BN	N
CJS		+	+							
JSSAbCL	PLBb	+	+	+						
JSSAfCL	PLBf	+	+		+					
JSSAgCL	PLBg	+	+			+				
JSSAlCL	PLBl	+	+				+			
JSSAb		+	+	+				+		
JSSAf		+	+		+			+		
JSSAg		+	+			+		+		
JSSAl		+	+				+	+		
JSSAB		+	+						+	
JSSAN		+	+							+

Conditional (closed populations)

Open populations, hence the estiamtes of some form of N

Models with type ending in CL are of the Pradel–Link–Barker type, with aliases as shown.

https://cran.r-project.org/web/packages/openCR/vignettes/openCR-vignette.pdf

Chapters in MARK book most relevant (if not using MARK)

- Chapter 1 (introduction)
- Chapter 4 (dipper example, but skip the MARK specific bits)
- Chapter 5 (goodness of fit –not covered in lectures but important)
- Chapter 6 (more on covariates and link functions)
- Chapter 11 (individual covariates)
- Chapter 12 (Pradel) and 13 (JS models in general)
- Liow, L.H. and Nichols, J.D. (2010) Estimating rates and probabilities of origination and extinction using taxonomic occurrence data: Capture-recapture approaches. In *Short Courses in Paleontology: Quantitative Paleobiology* (Hunt, G. and Alroy, J., eds), pp. 81–94, Paleontological Society (Supplementary has step by step for MARK if you are a windows user)

Reverse-Time (RT) models

- https://projecteuclid.org/journals/statistical-science/volume-31/issue-2/And-the-First-One-Now-Will-Later-Be-Last/10.1214/16-STS546.full Nice free download review paper by Jim Nichols

- https://sites.google.com/site/cmrsoftware/lecture-lab-schedule/week-10-open-cmr-abundance-and-recruitment/pradel-temporal-symmetry-models Michael Conroy course notes

- http://www.phidot.org/software/mark/docs/book/pdf/chap13.pdf The relevant MARK book chapter