Stochastic simulation model of southwestern Pacific hawksbill population dynamics

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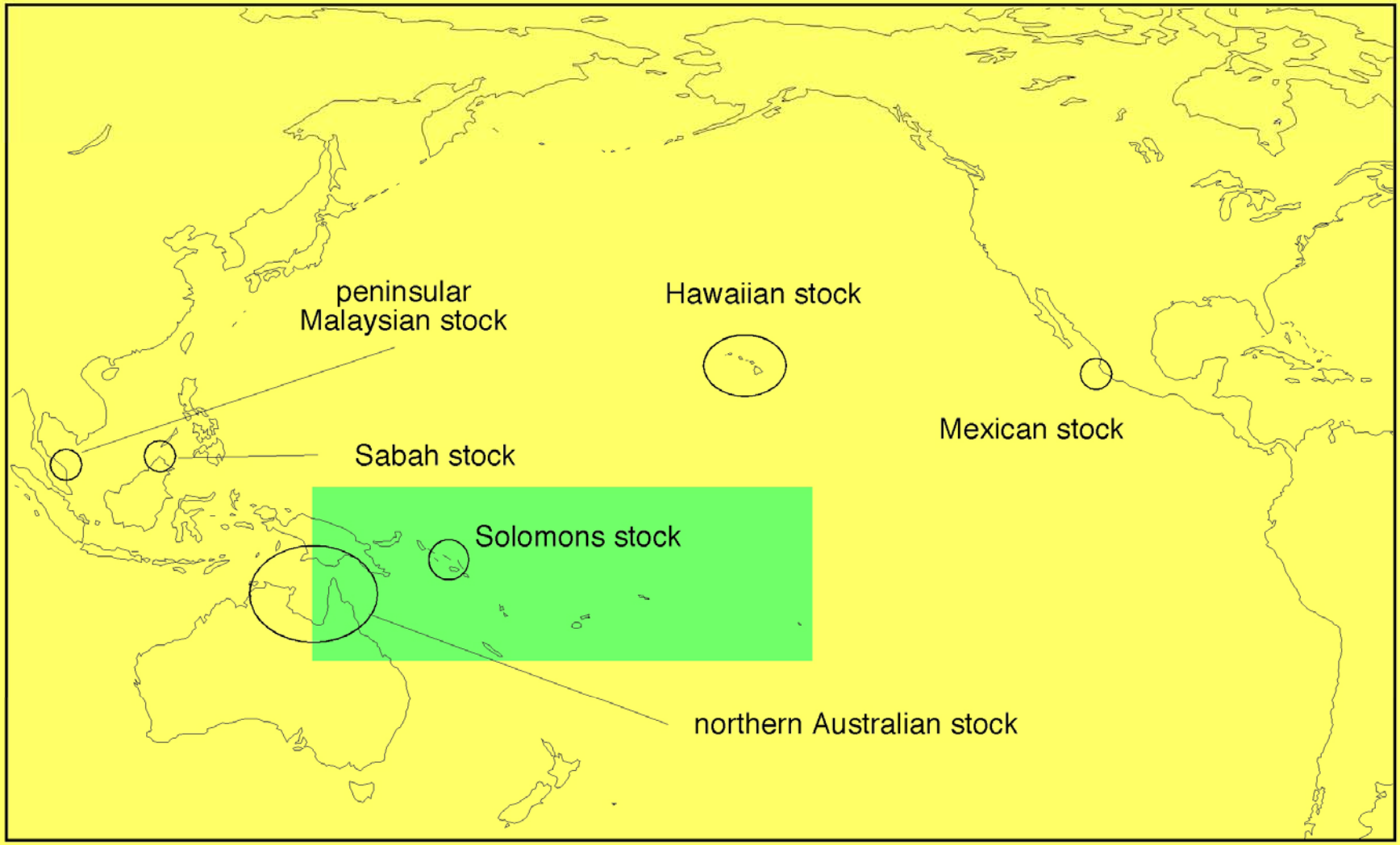
Purpose

- account for southwestern Pacific hawksbill population dynamics
- explain heuristic modelling
- demonstrate a stochastic simulation model
- explore some assumptions and functions
- explore competing risk factors affecting metapopulation viability
- basis for more comprehensive model development

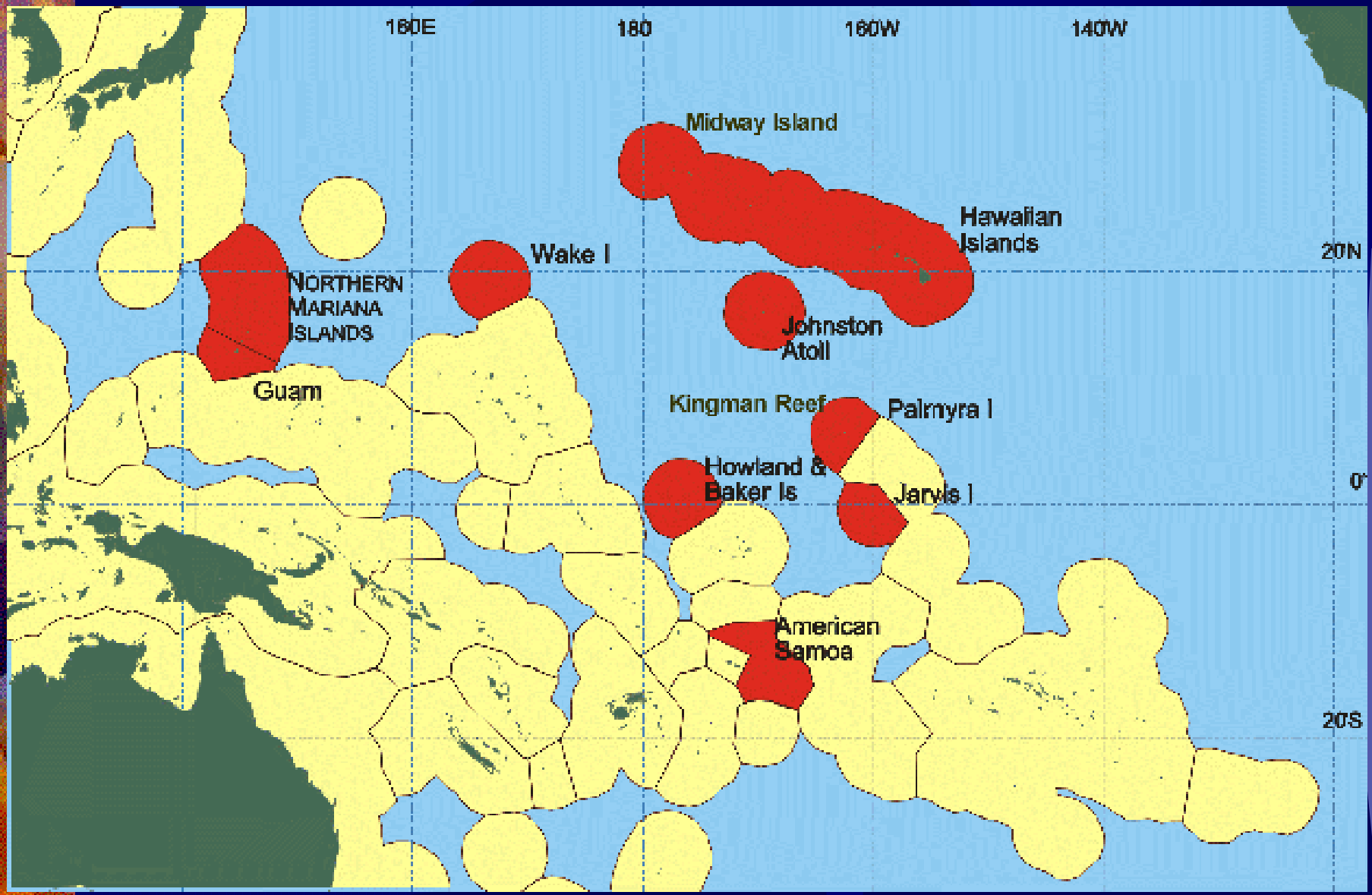
Acknowledgements …

- Support and funding from —
  - Western Pacific Regional Fishery Management Council
  - Irene Kinan (WPRFMC)
- Data and images from —
  - Alberto Abreu, George Balazs, Kirstin Dobbs, Peter Dutton, Julia Horrocks, Ursula Keuper-Bennett, Barry Kreuger, Col Limpus, Neca Marcovaldi, Nick Pilcher

Stock and assumed spatial structure …



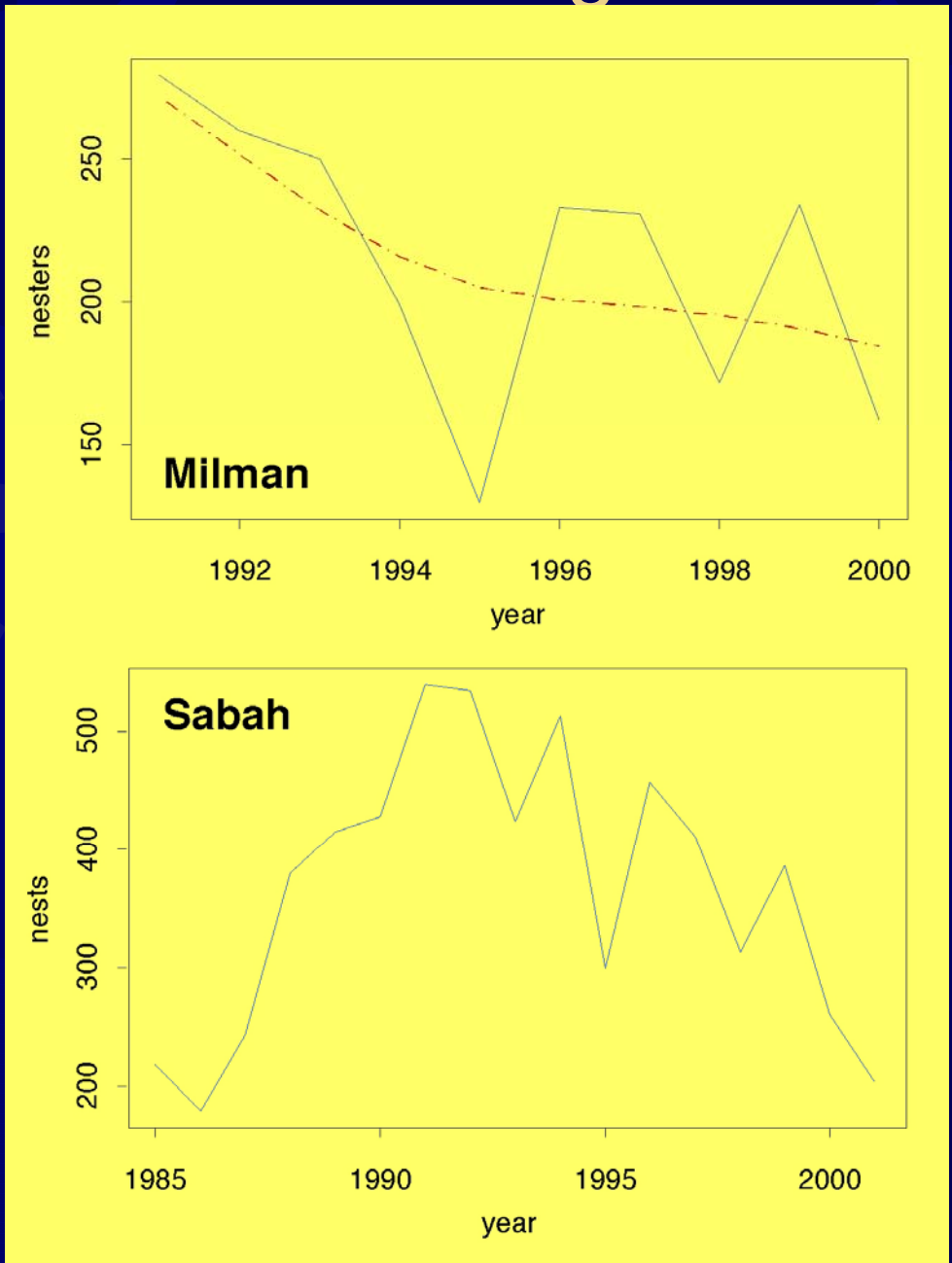
Relevance to the Council …



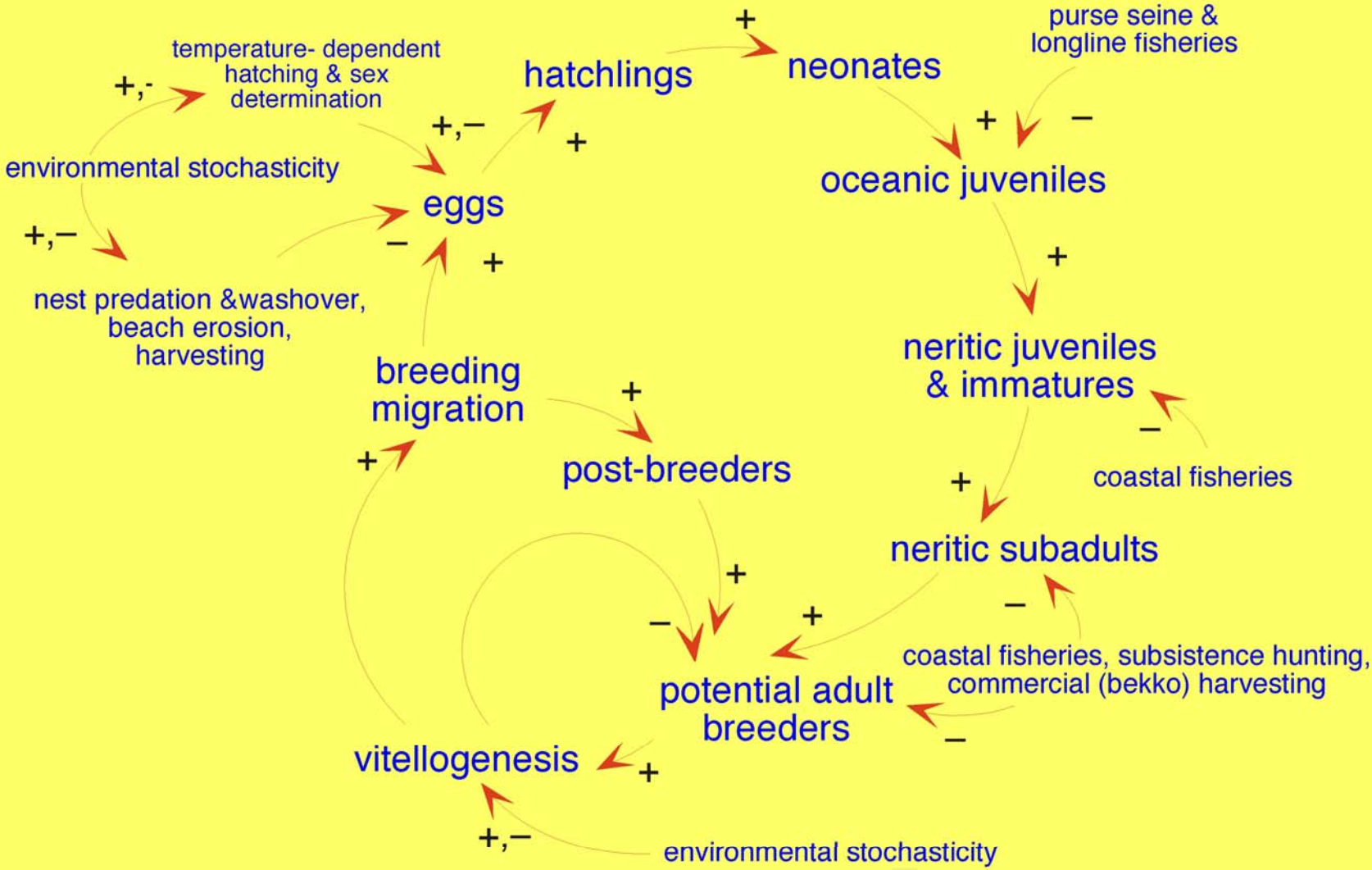
Status and trend …

- southwestern Pacific stock possibly decreasing in abundance
- Milman Island rookery in nGBR decline

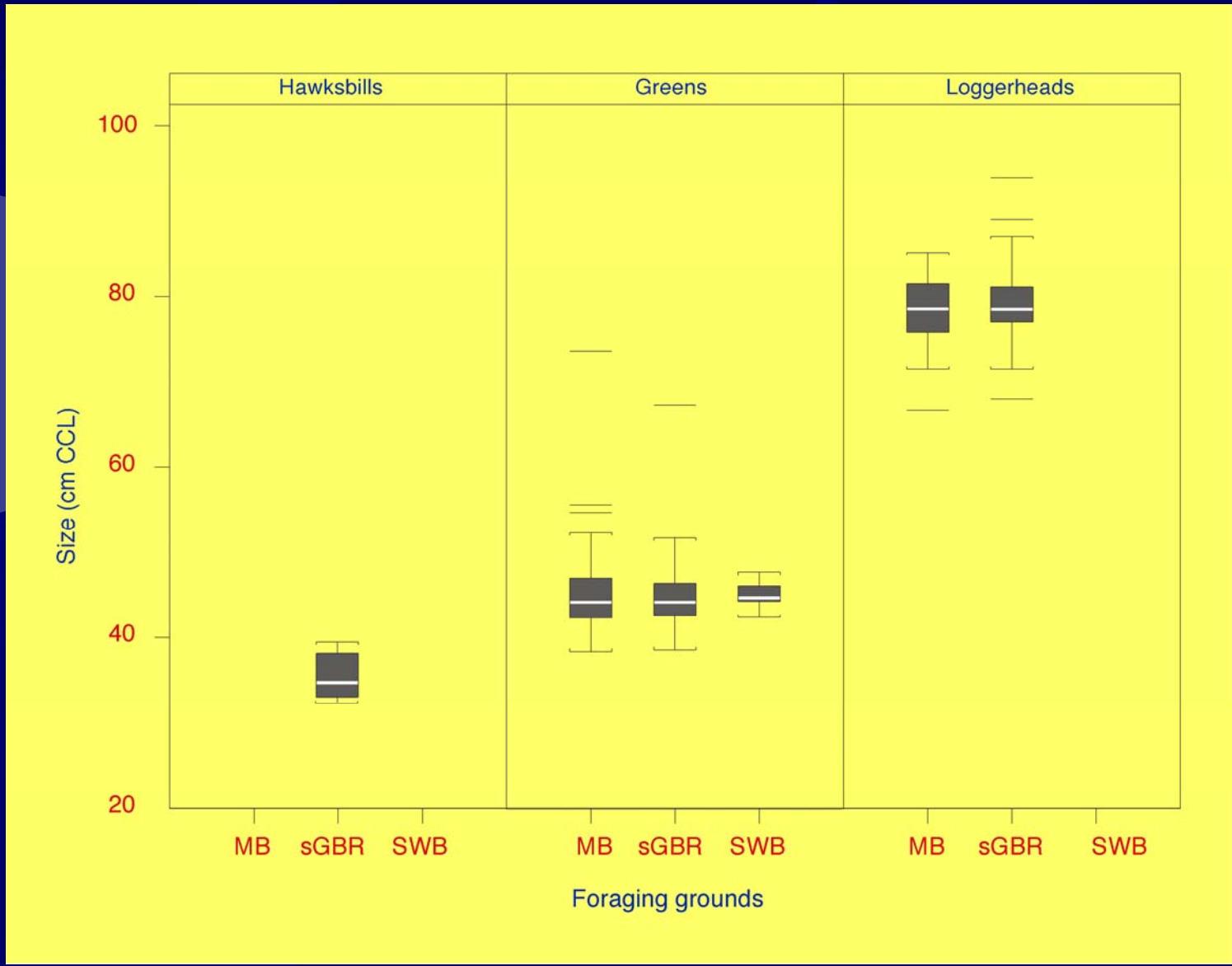
Pacific nesting trends …



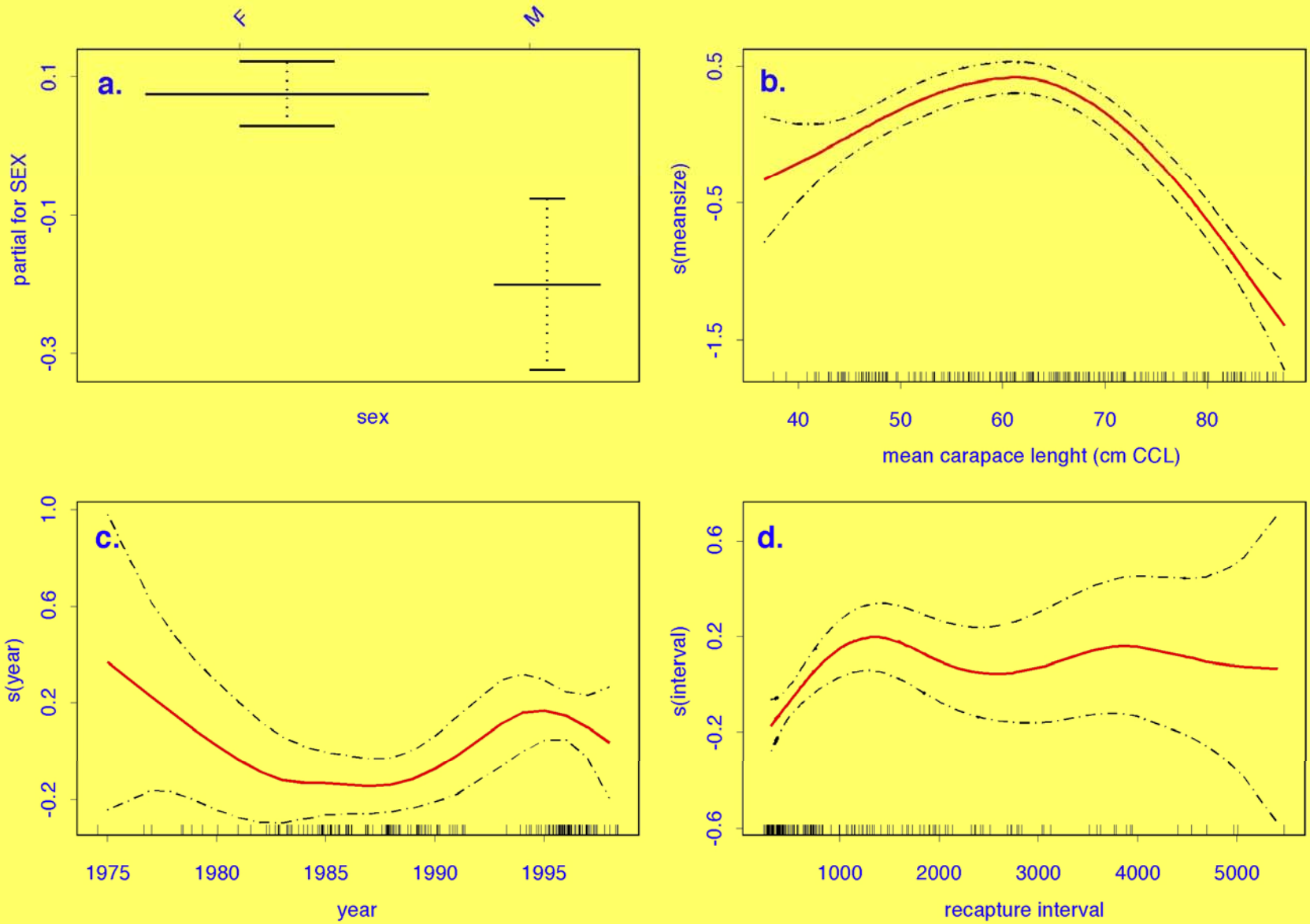
Hawksbill sea turtle life cycle



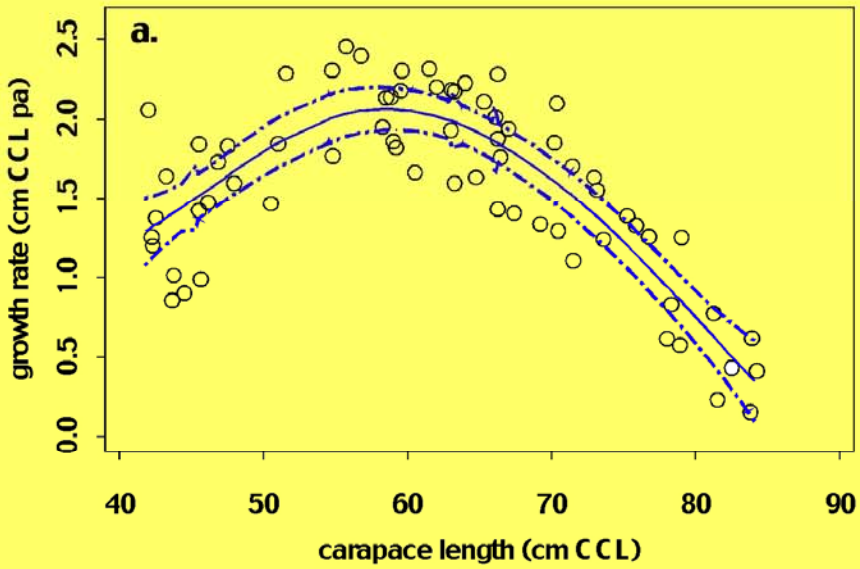
Neritic recruitment …

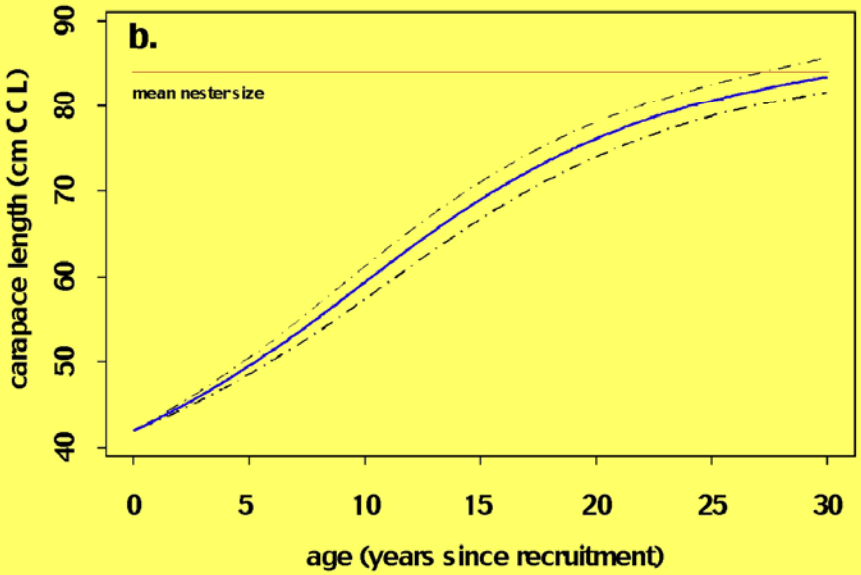


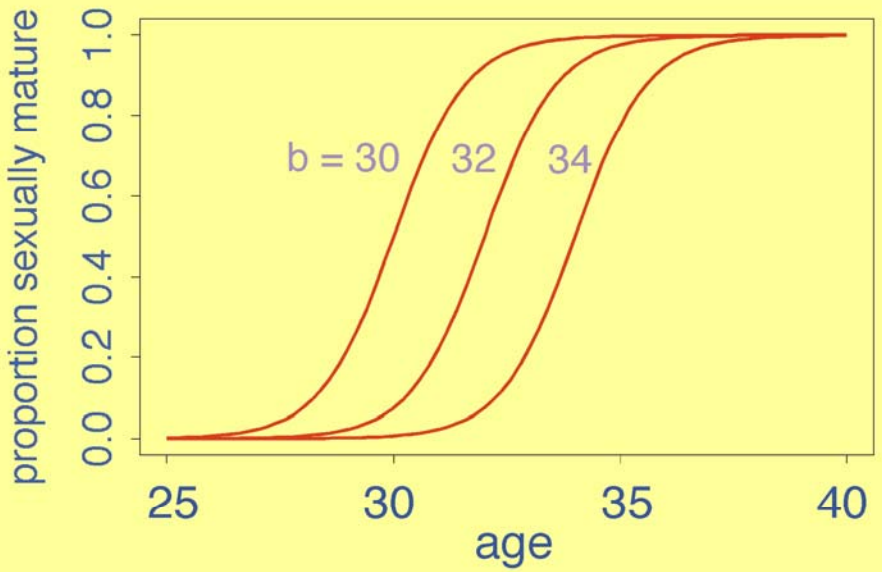
Growth and maturity …

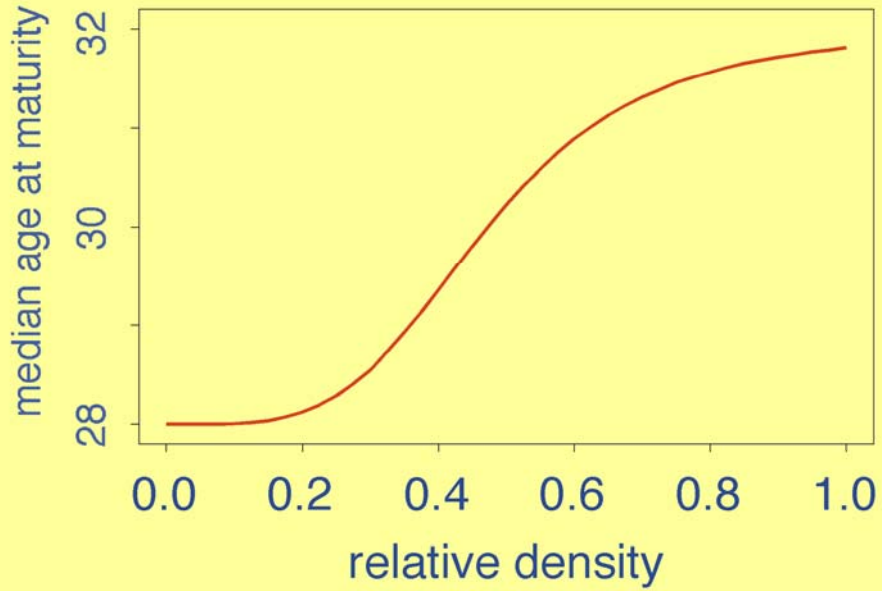


Growth and maturity …

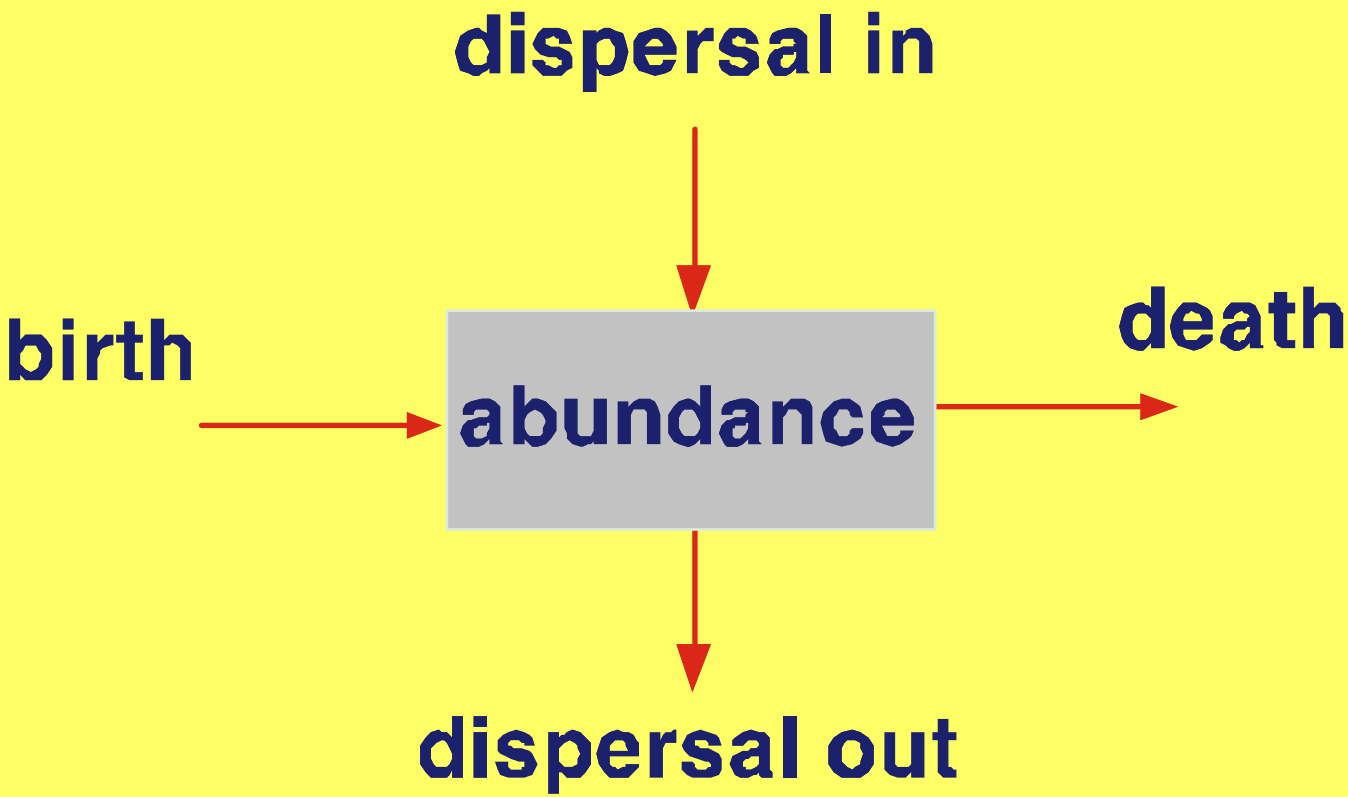





proportion sexually mature
0.0
0.2
0.4
0.6
0.8
1.0
b = 30
32
34
25
30
35
40
age


median age at maturity
28
30
32
0.0
0.2
0.4
0.6
0.8
1.0
relative density

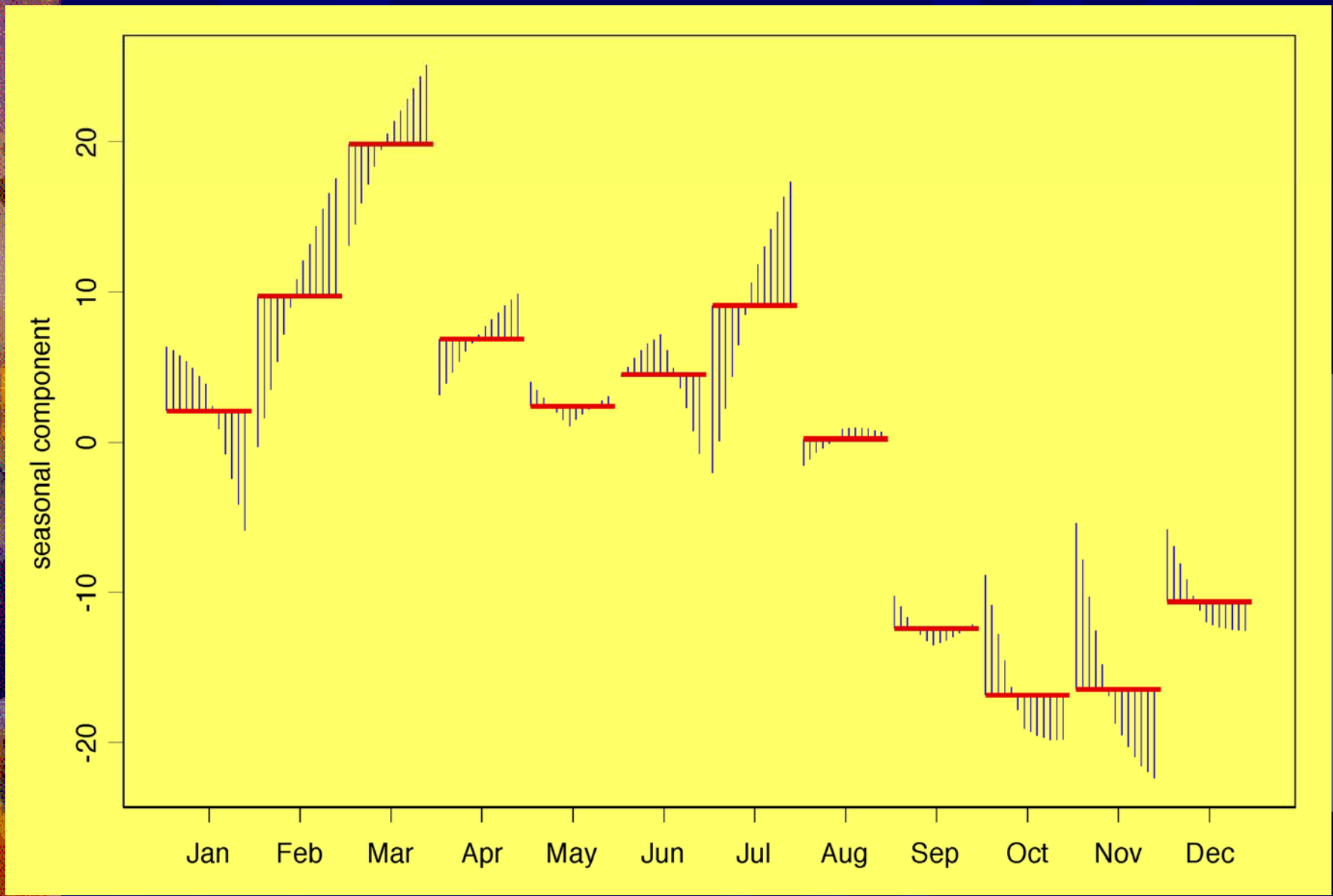
Key demographic processes



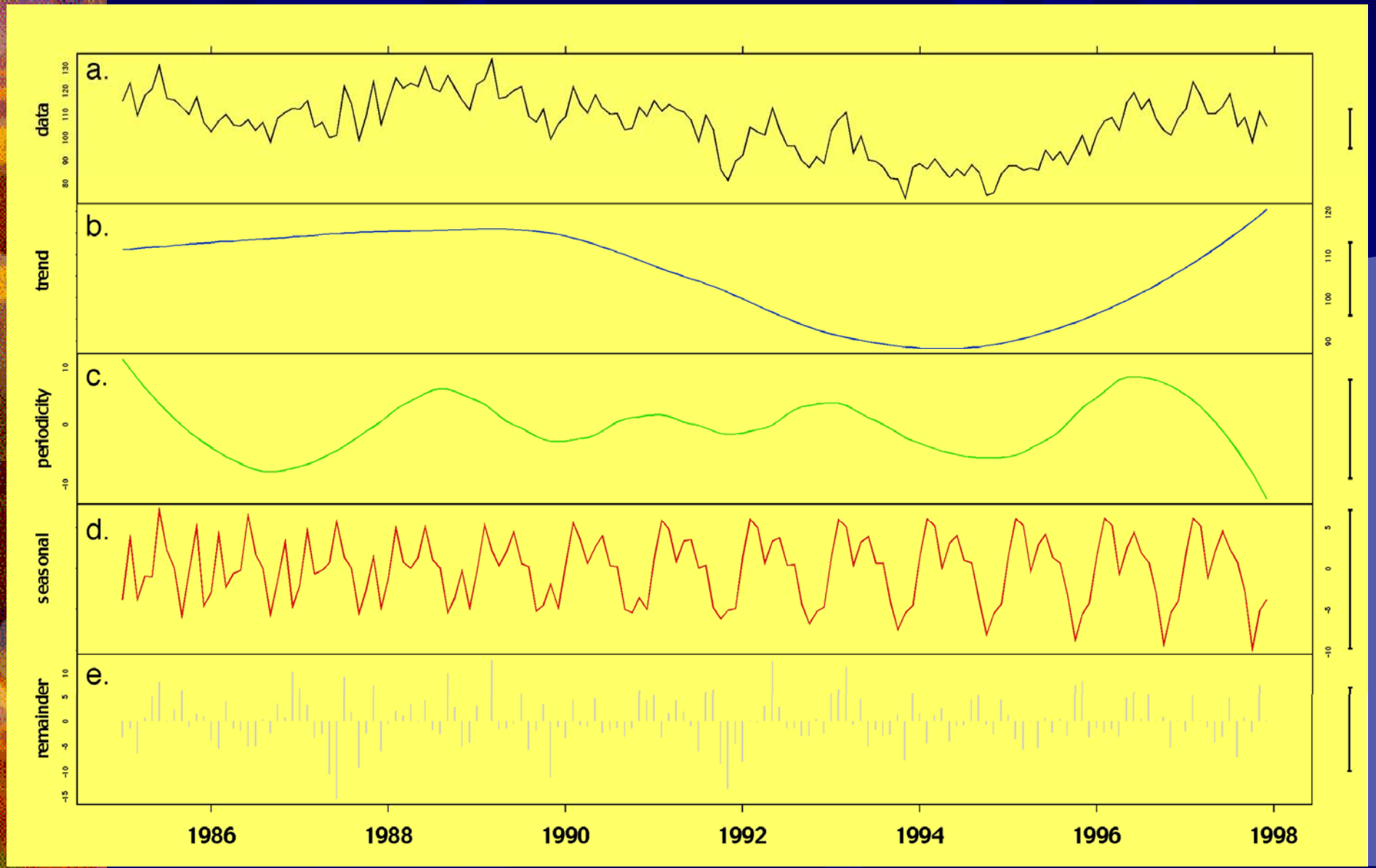
Birth (reproduction)

- year-to-year and sex-specific variability in breeding probabilities
- density-dependent and correlated
- seasonal nesting
- fecundity and sex-ratio include demographic stochasticty
- temperature-dependent hatching probabilities and hatchling sex-determination

Annual time step in model (seasonal nesting)



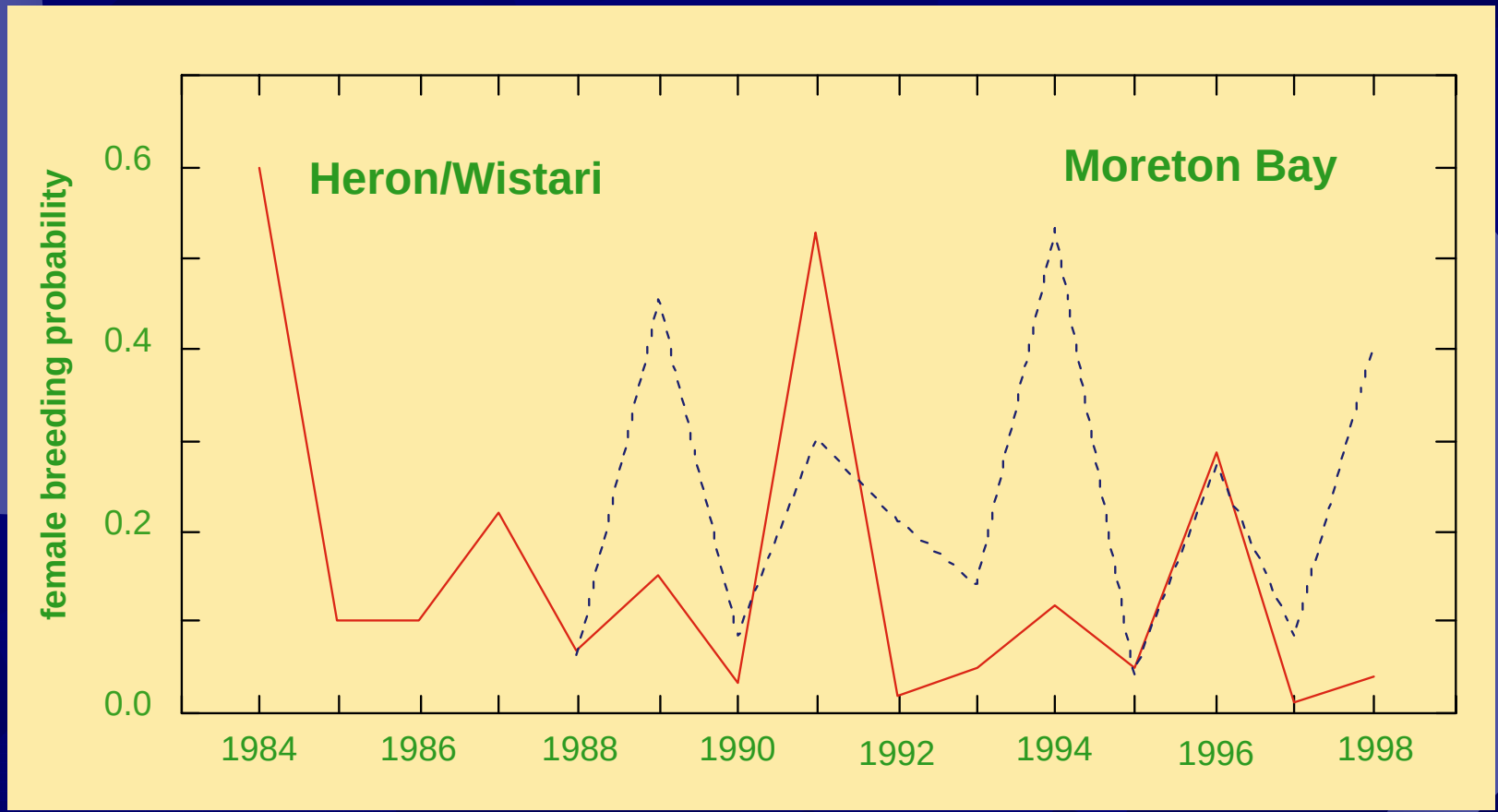
Trends in mean clutches laid (Sabah) …



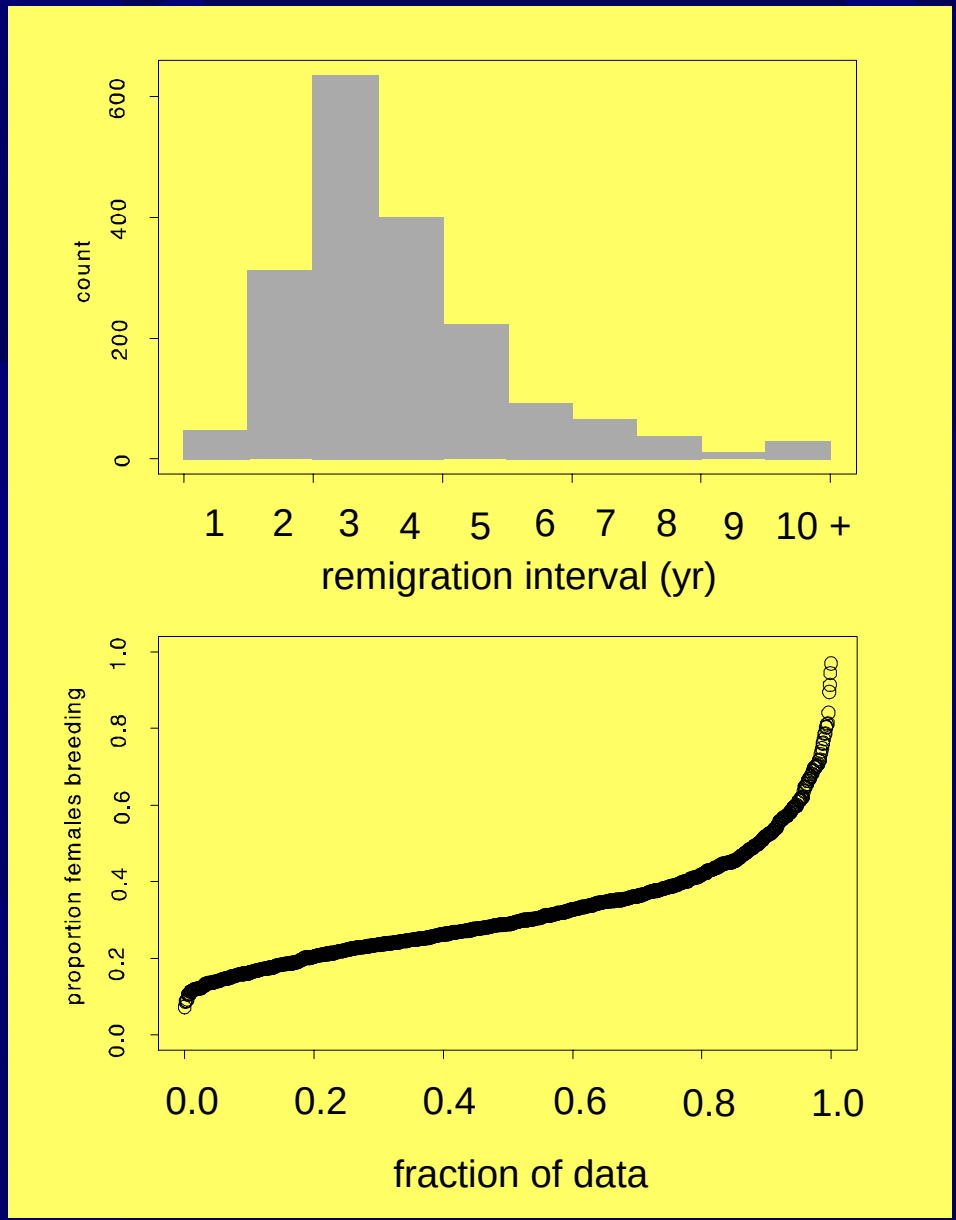
Breeding probablities

- based on laparoscopic studies
- Loop et al (1995, 1999, unpubl) for Milman nesters
- no foraging ground laparoscopy data

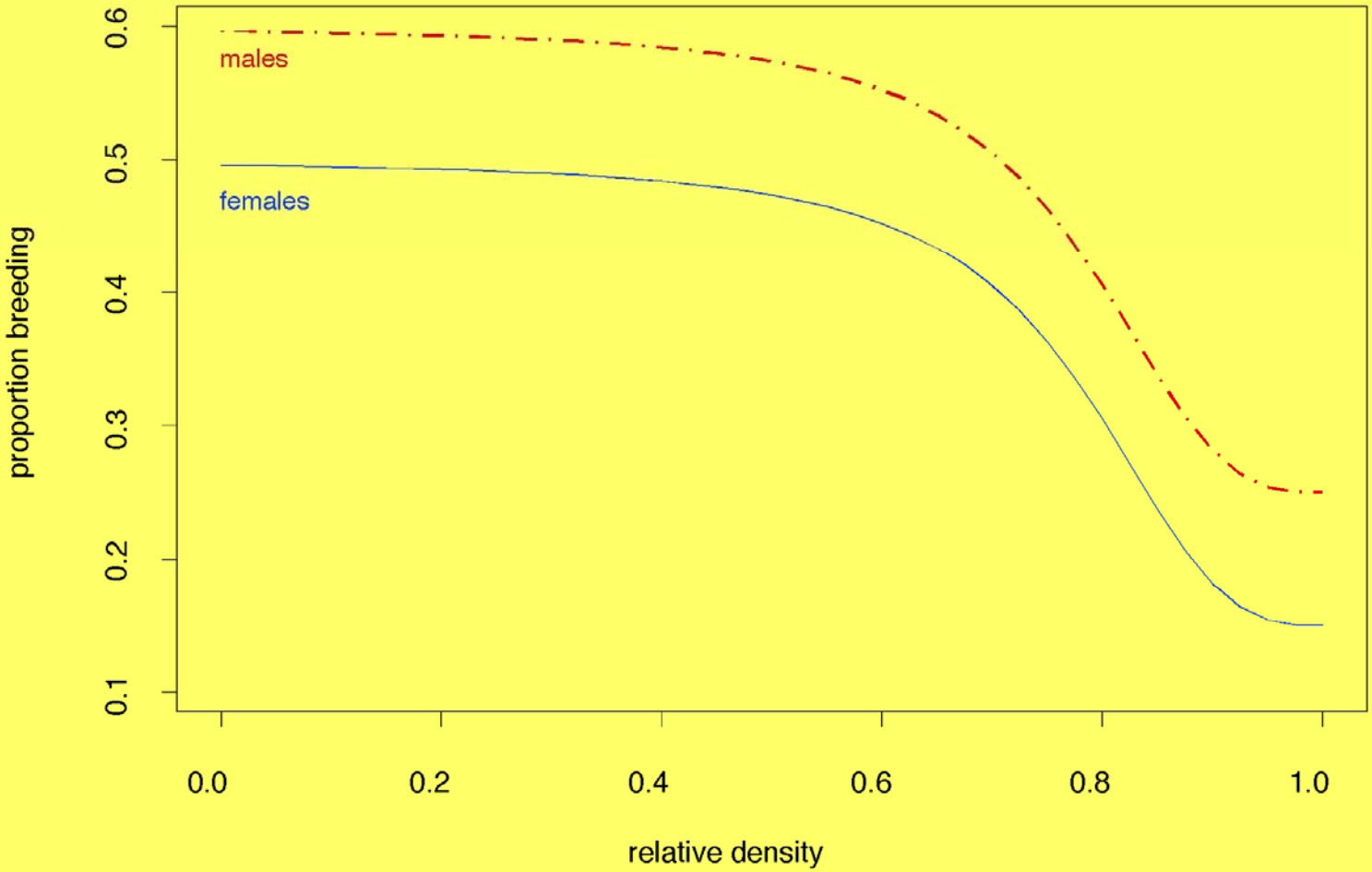
foraging ground-specific breeding probabilities (CJ Limpus)



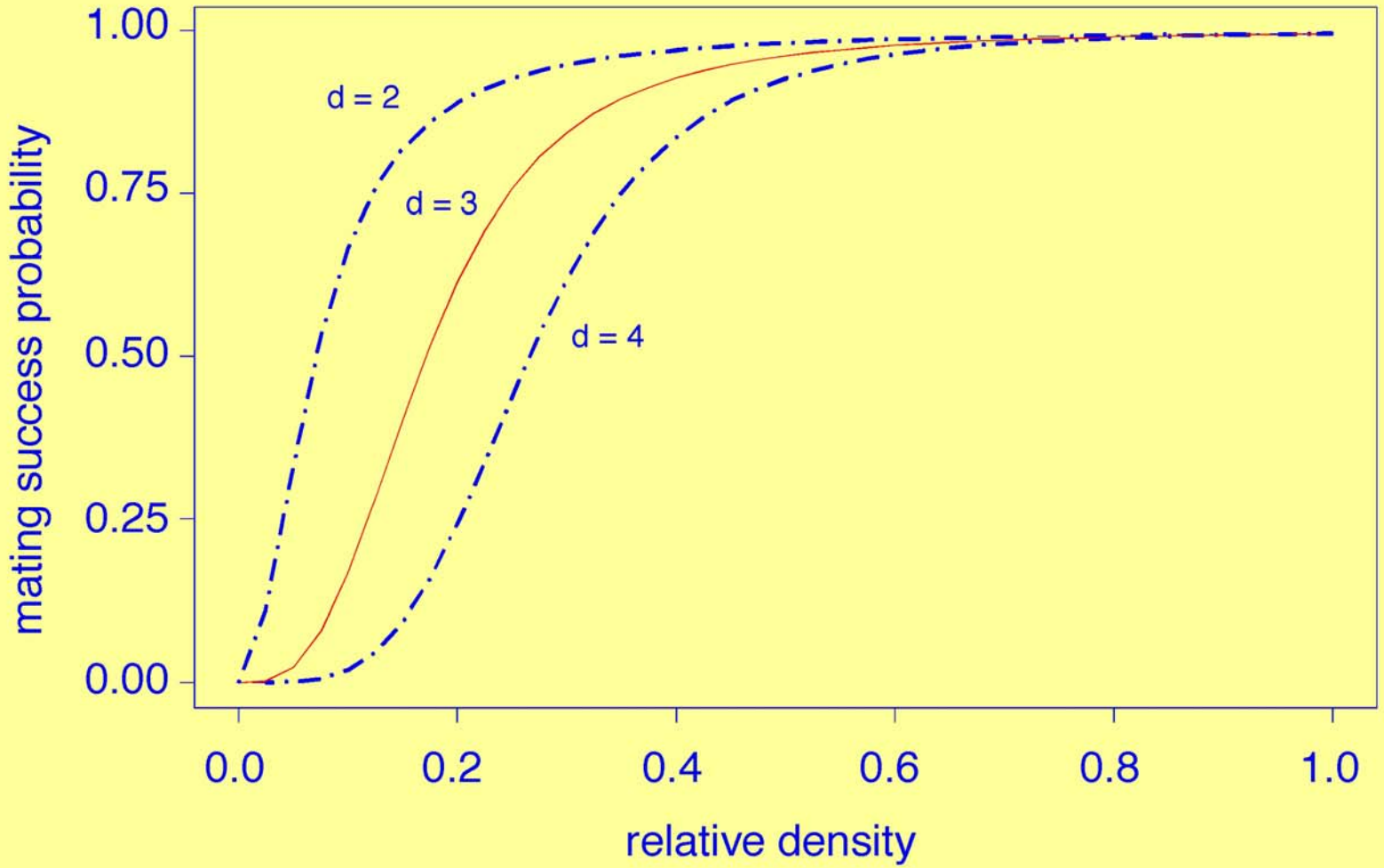
breeding probability functions (model based)



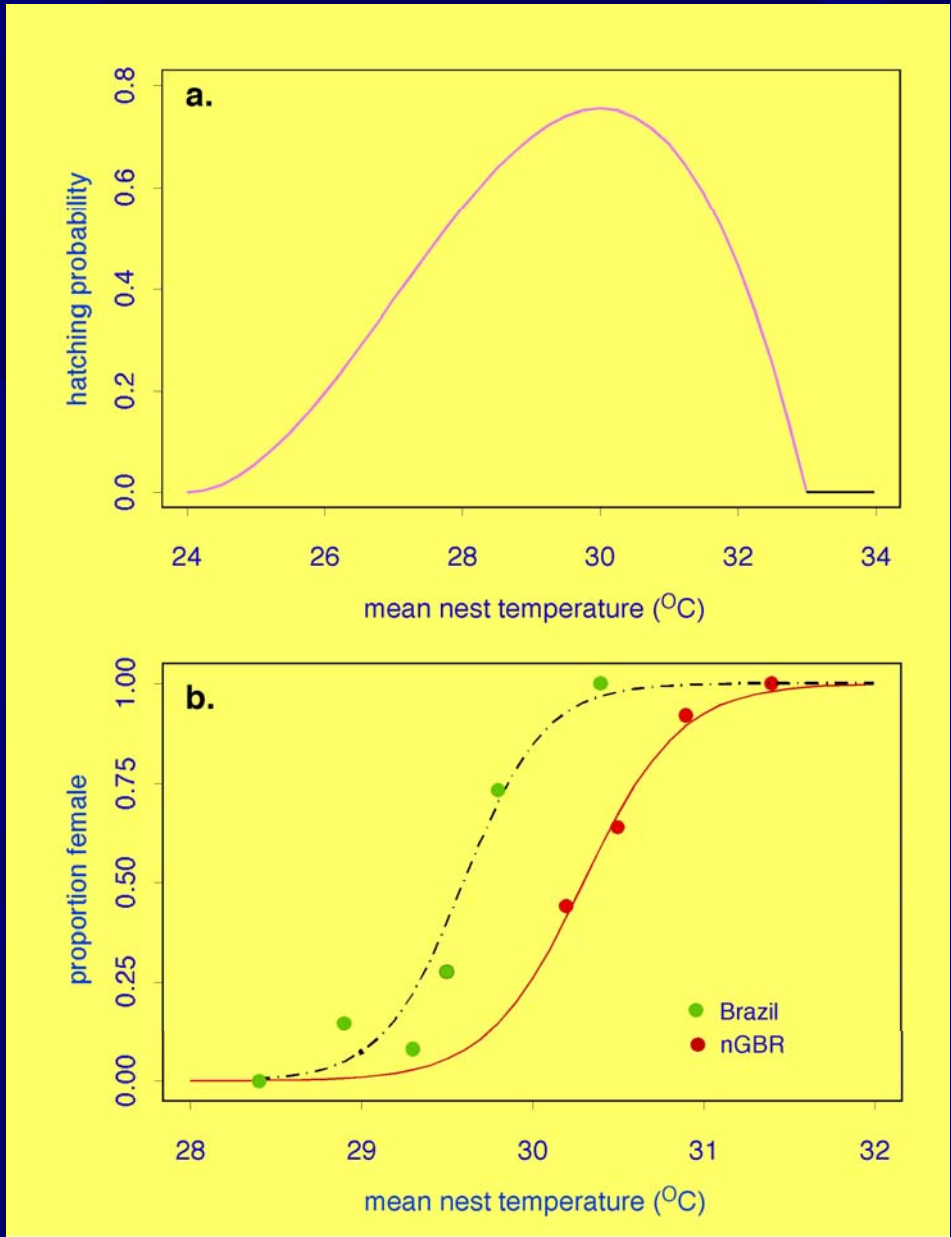
Compensatory effects



Depensatory effects



temperature dependent functions



Survival (mortality)

- ageclass-specific
- adult ageclass is high (>>90%)
- negligible environmental variability
- no sex-specific differences
- survival probabilities are correlated with between sexes and between some some ageclasses
- competing risks model

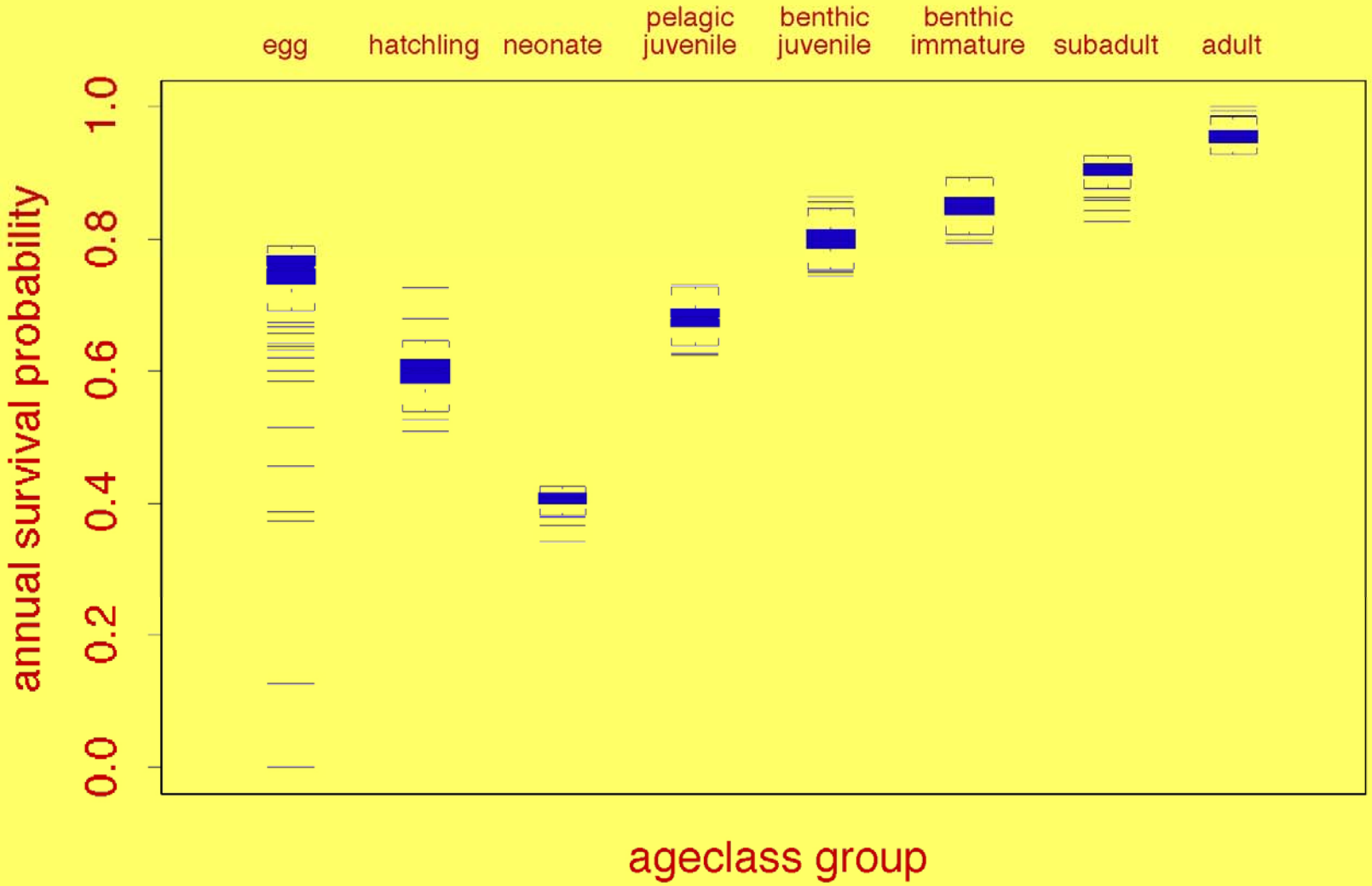
Human hazards in model ...

- egg harvesting and/or poaching
- nesting habitat loss and/or change
- harvesting of mature neritic ageclasses
- incidental capture in coastal fisheries of all neritic ageclasses
- incidental capture in pelagic purse seine and longline fisheries of all oceanic ageclasses

Survival probabilities …

- based on adult nesters in Antigua (Kendall & Bjorkland 2001)
- based on CJS modelling of data sets for immature hawksbills from Barbados and Fernando de Noronha (Brazil) foraging grounds
- supplemented with estimates for other sea turtle species

Ageclass-specific survival probabilities …



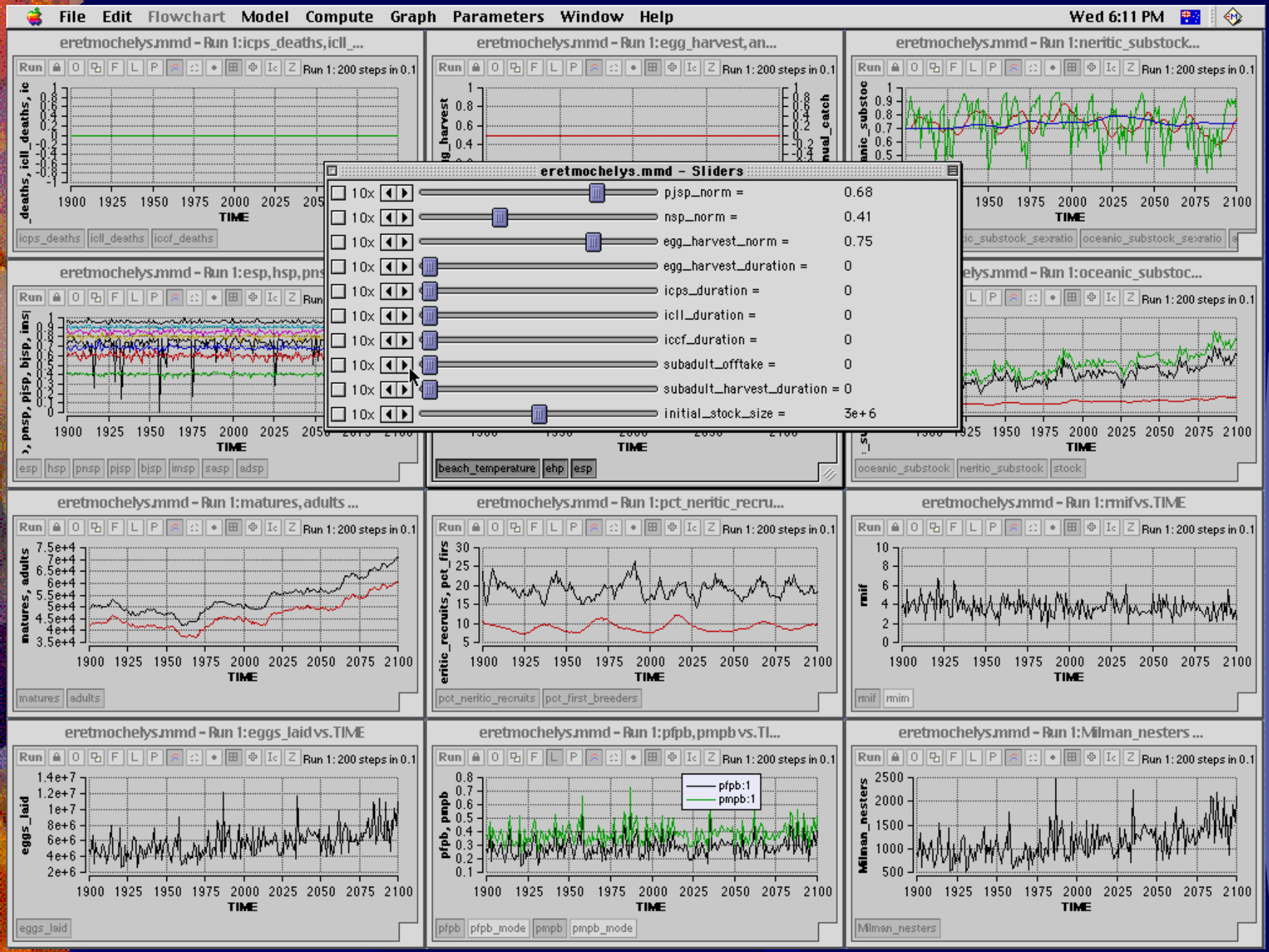
Dispersal

- neritic juvenile/immature dispersal probable
- no apparent sex-biased dispersal
- high rookery fidelity but leakage likely
- no explicit dispersal in model as not a metapopulation model

Heuristic simulation model

- heuristic meanings insight and learning
- model is sex- and ageclass-structured
- no explicit spatial structure
- model is stochastic (environmental and demographic - breeding, clutches laid, sex ratio, neritic recruitment etc)
- demographic processes are also density-dependent and correlated (breeding, maturity etc)

- model is fast and interactive to function as a learning tool
- model useful for risk assessment and conservation policy design
- but model based on limited empirical data at the moment …


File Edit Flowchart Model Compute Graph Parameters Window Help
Wed 6:11 PM
eretmochelys.mmd - Run 1:icps_deaths,icll_...
eretmochelys.mmd - Run 1:egg_harvest,an...
eretmochelys.mmd - Run 1:neritic_substock...
eretmochelys.mmd - Sliders
10x pjsp_norm = 0.68
10x nsp_norm = 0.41
10x egg_harvest_norm = 0.75
10x egg_harvest_duration = 0
10x icps_duration = 0
10x icll_duration = 0
10x iccf_duration = 0
10x subadult_offtake = 0
10x subadult_harvest_duration = 0
10x initial_stock_size = 3e+6
eretmochelys.mmd - Run 1:esp,hsp,pns
eretmochelys.mmd - Run 1:oceanic_substoc...
eretmochelys.mmd - Run 1:matures,adults ...
eretmochelys.mmd - Run 1:pct_neritic_recru...
eretmochelys.mmd - Run 1:rmifvs.TIME
eretmochelys.mmd - Run 1:eggs_laidvs.TIME
eretmochelys.mmd - Run 1:pfpb,pmpbvs.TI...
eretmochelys.mmd - Run 1:Milman_nesters ...
Run 1: 200 steps in 0.1
TIME

Data series and trends …

- some nesting time series (eg., Milman Island)
- some times series of somatic growth (eg., Heron Island)
- foraging ground abundance ?????
- harvesting and subsistence take ?????
- incidental take ?????

Some issues for the future …

- spatial configuration of the stock including fine resolution genetic substructure
- foraging ground population abundance series
- somatic growth models to include whole neritic phase for multiple foraging populations
- time series of historic takes
- foraging ground dispersal behaviour