A Bayesian Approach to model Atlantic salmon life cycle in the Foyle catchment (Northern Ireland)

G. Dauphin[1,2,3], E. Prévost[1], C.E. Adams[2], P. Boylan[3]

[1]: INRA, UMR ECOBIOP
[2]: Scottish Centre for Ecology & the Natural Environment, Glasgow University
[3]: Loughs Agency

International Statistical Ecology Conference
University of St Andrews, July 10th 2008

Background

Objectives of population dynamics biology

- Evaluate the size of a population and its dynamics
- Understand the regulation mechanisms

→ Special interest for harvested population for which sustainable exploitation is required

Data available for harvested population

- Exploitation statistics (catches, effort, etc.)
- Scientific studies independent from fisheries

Heterogeneity of datasets

- Temporal differences (i.e. length of time series differs, changes in time of the sampling)
- Spatial differences (i.e. scale differences, data is not collected in the same place every year)

Background

Problematic

- How do we join all these datasets together in order to reflect the history of the population
- How do we take in account the associated uncertainties

Methodology used

- State-space modelling
- Bayesian inference
- Monte Carlo Markov Chain (MCMC) methods used with WinBUGs software

Background

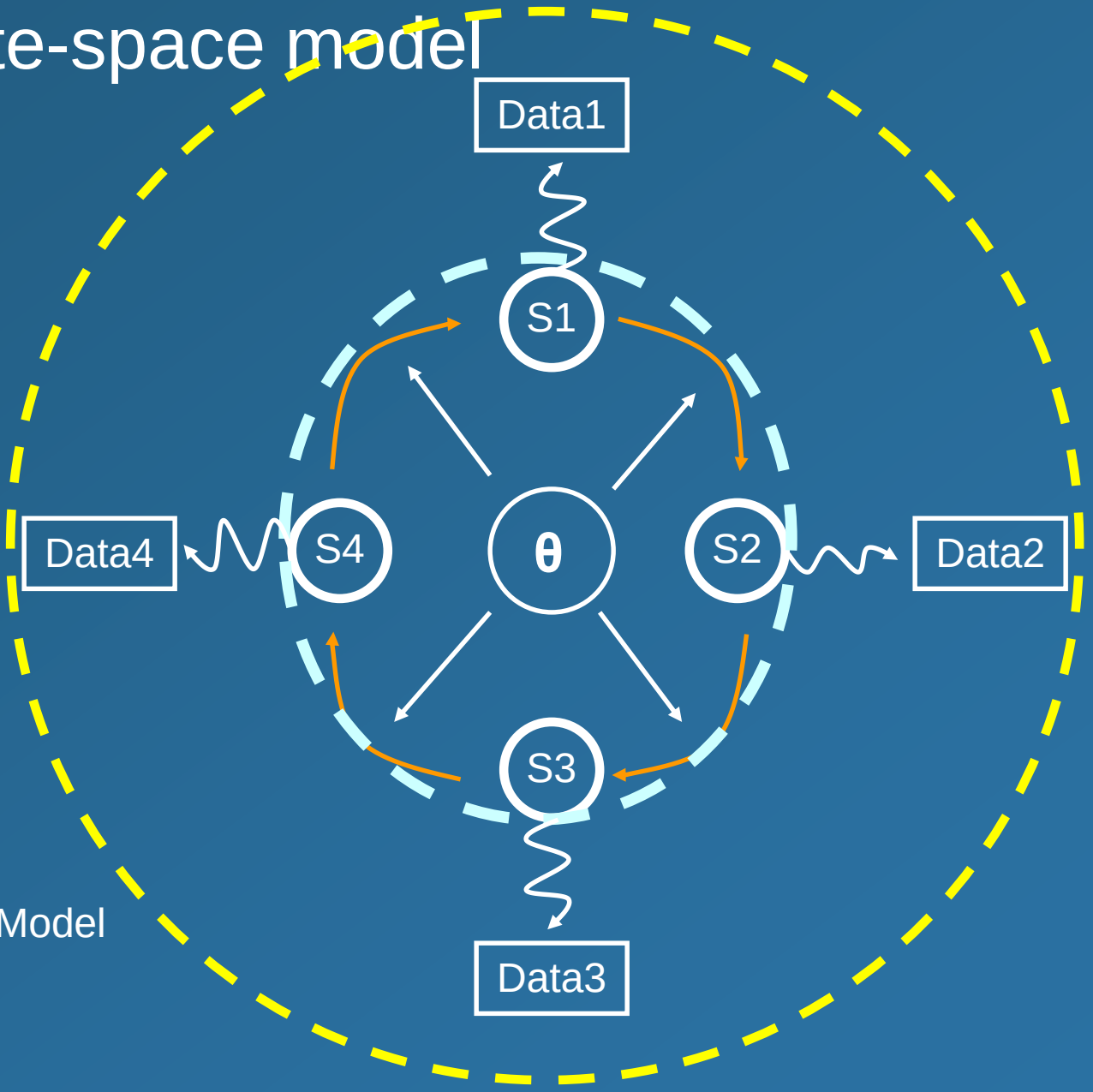
Bayesian state-space model

: population life stage

: Relationship between life stages

θ : Parameters

: Observation process



: Population dynamic Model

: Observation Models

Background

Bayesian inference

: Hidden state

: Relationship between hidden states

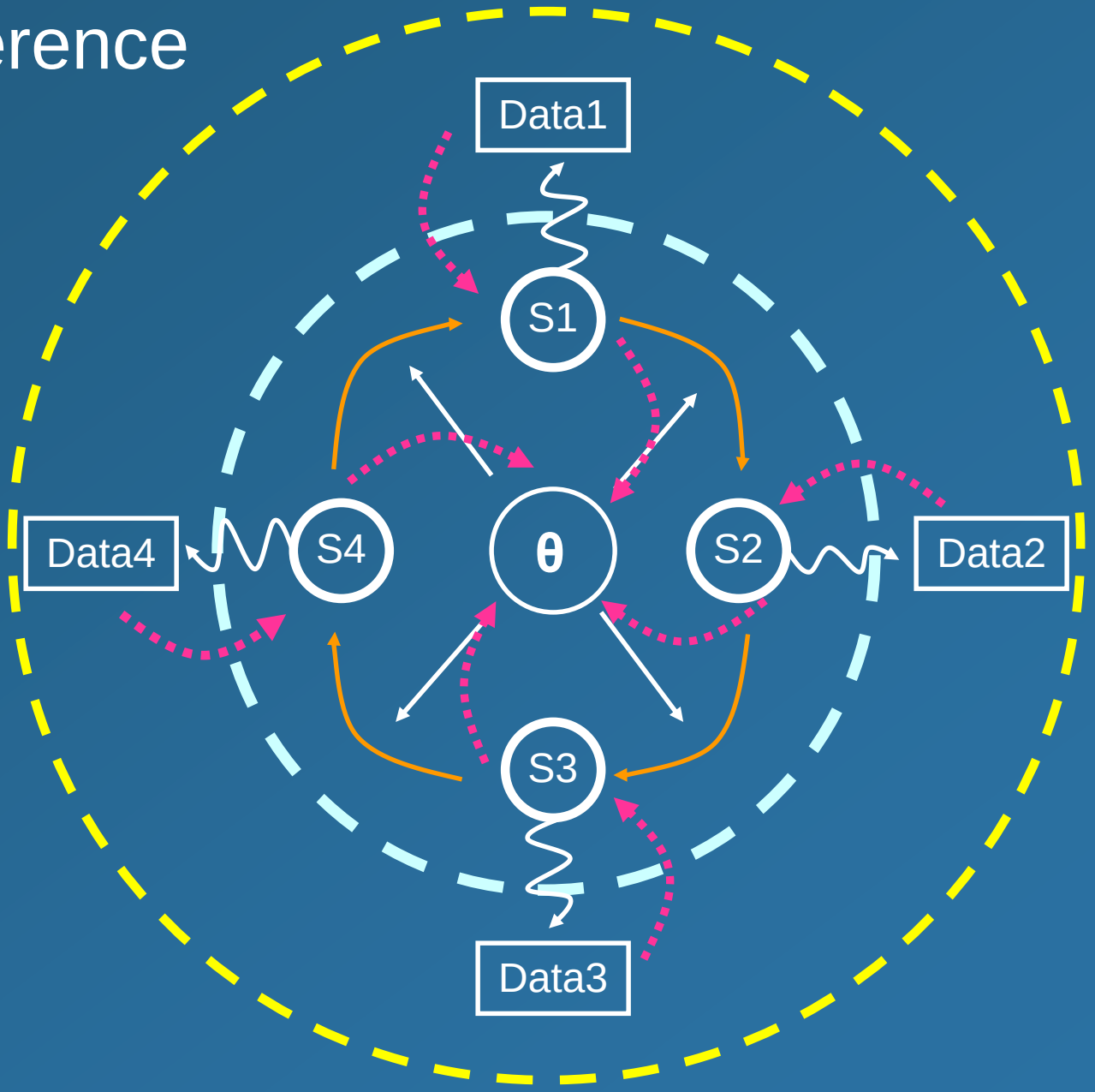
θ : Parameters

: Observation process

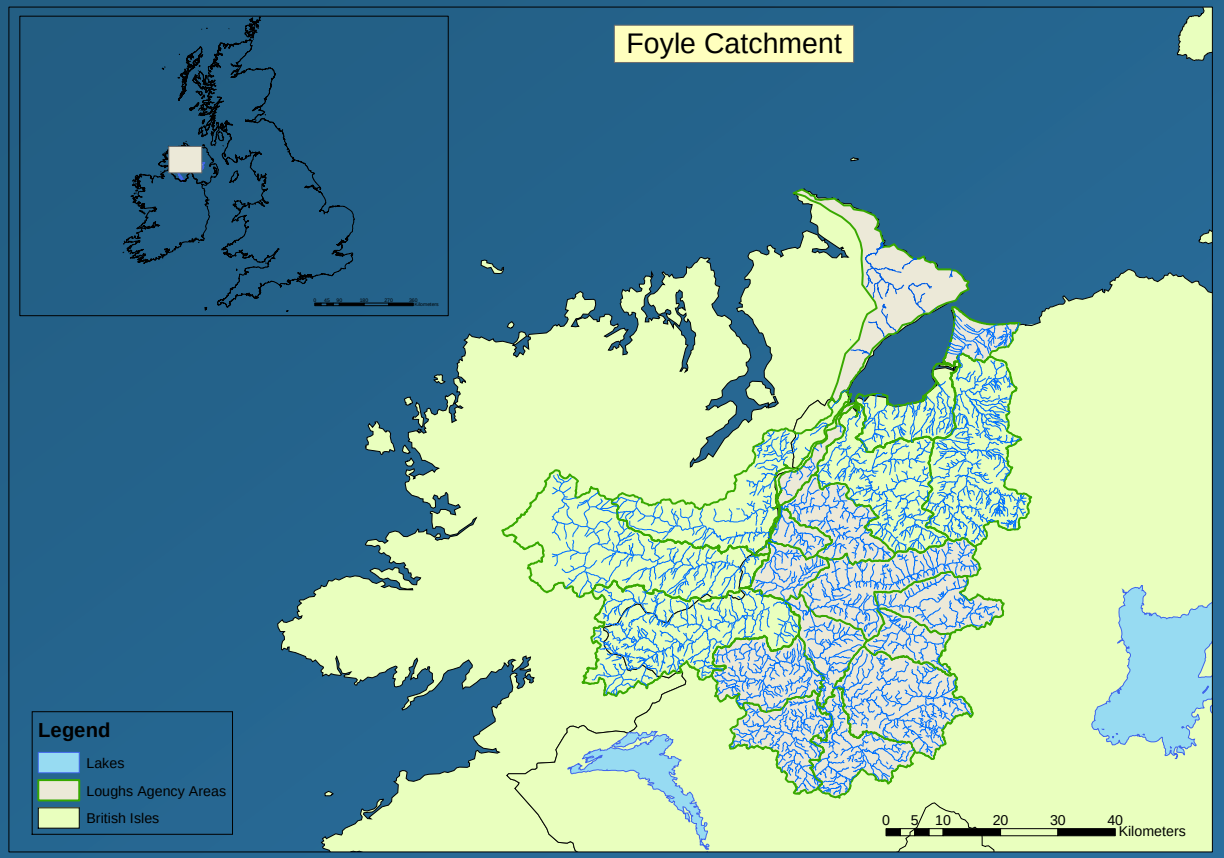
: Bayesian inference

: Dynamic Model

: Observation Models

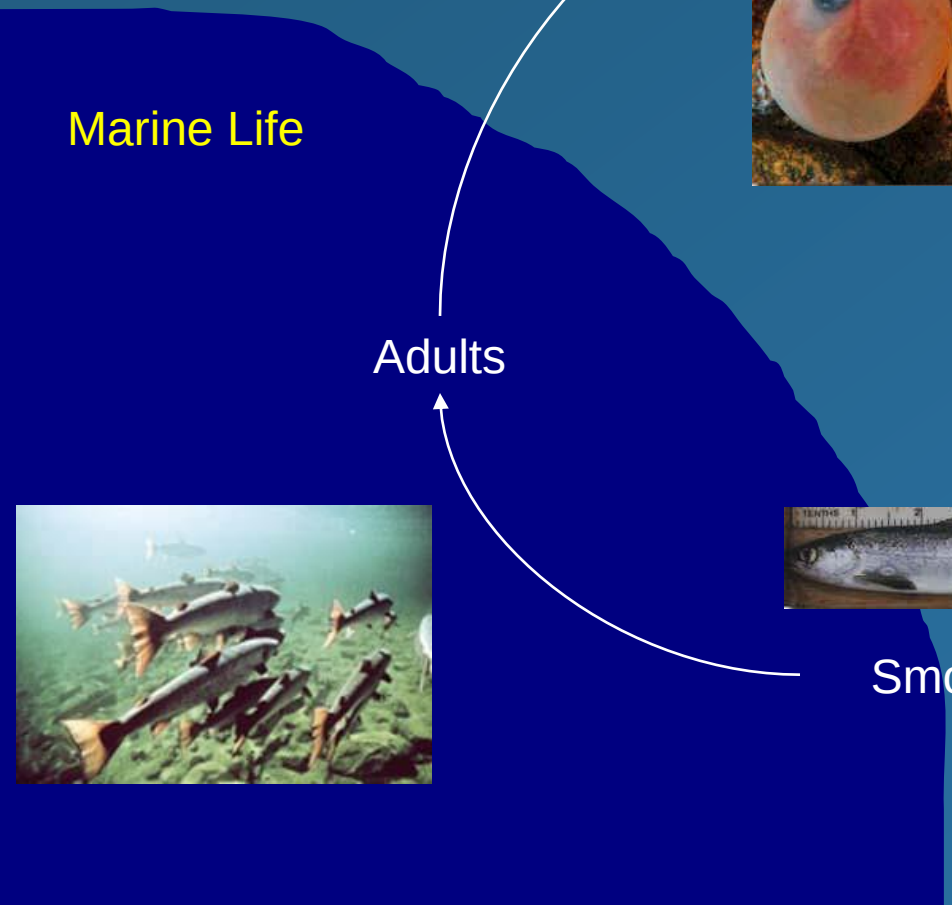


Case study: the Foyle catchment



- Located in the North-West of Ireland
- Total area: approximately 4500 km²
  Wetted area: about 11.5 million m²
- the system is divided in several units (18) corresponding to the different sub-catchments

Case study: A. salmon biology and data available



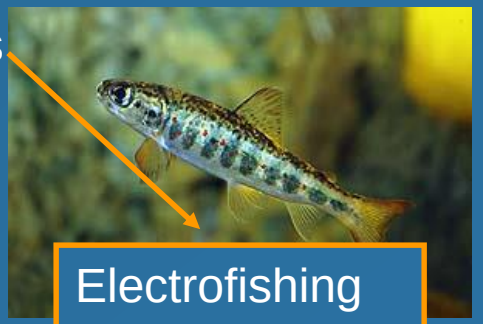
Case study: A. salmon biology and data available

eggs

Alevins

Freshwater life

Fry / Juveniles



Electrofishing index
t-s: 9 years

Smolts

Adults

Marine Life

Case study: A. salmon biology and data available

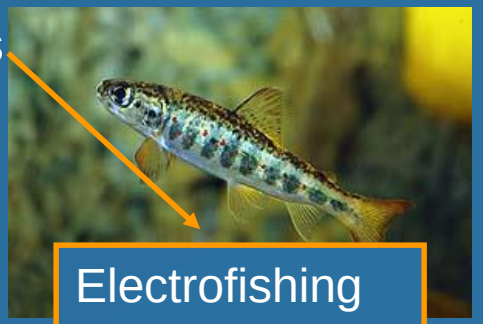
Commercial Fisheries
t-s: 48 years

eggs

Alevins

Freshwater life

Fry / Juveniles



Electrofishing index
t-s: 9 years

Smolts

Adults

Marine Life

Returns

Case study: A. salmon biology and data available

Rod catch
t-s: 6 and 48 years

Counters
t-s: 6 years

Redds
t-s: 48 years

Commercial Fisheries
t-s: 48 years

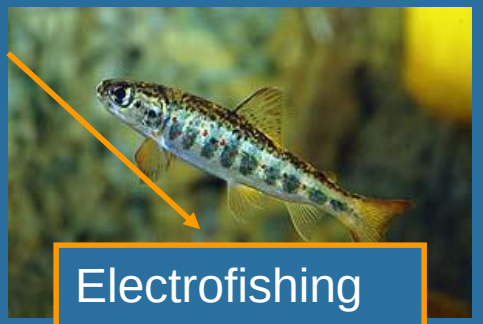
Spawners

eggs

Alevin

Freshwater life

Fry / Juvenile



Electrofishing index
t-s: 9 years

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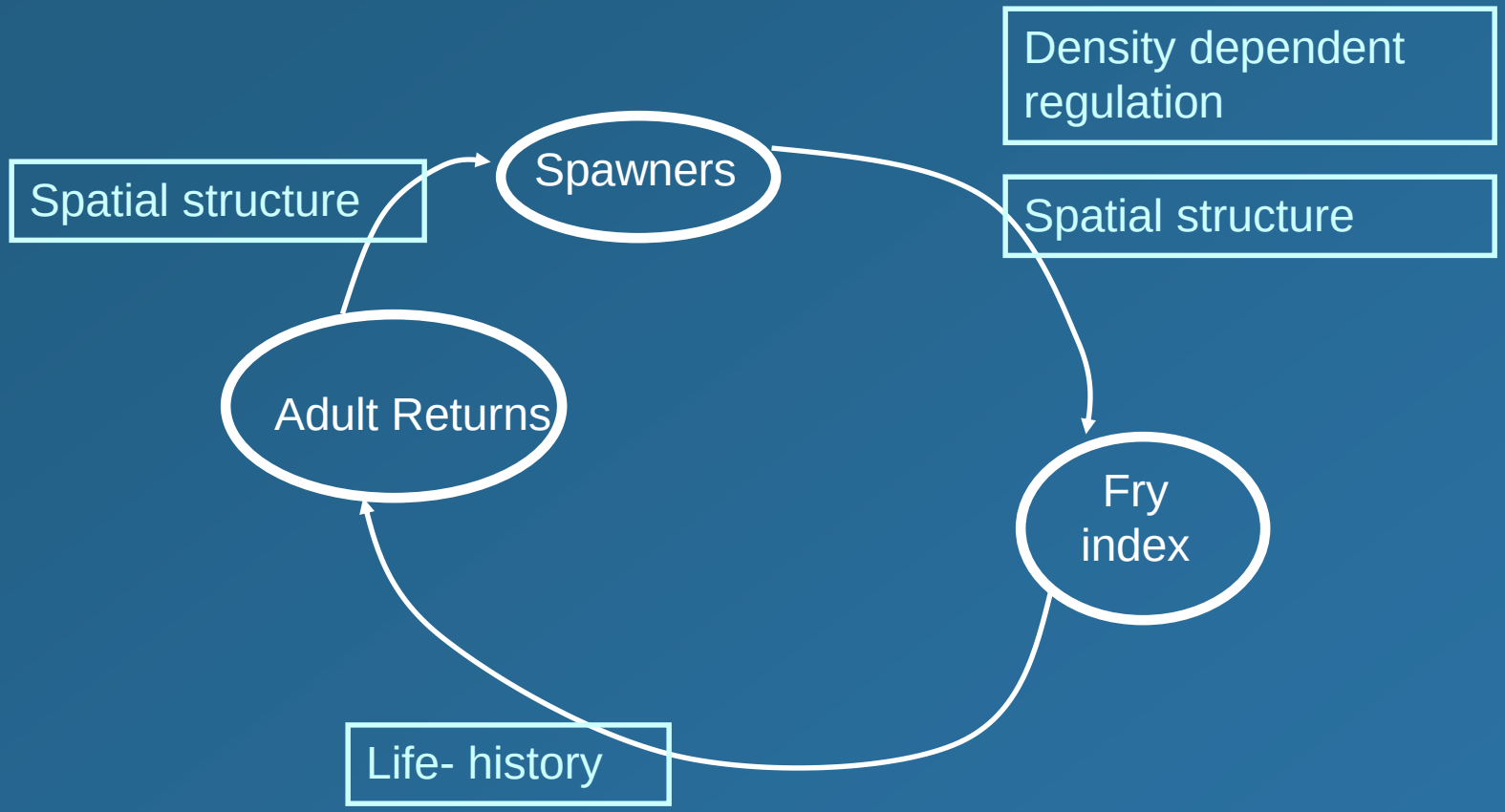
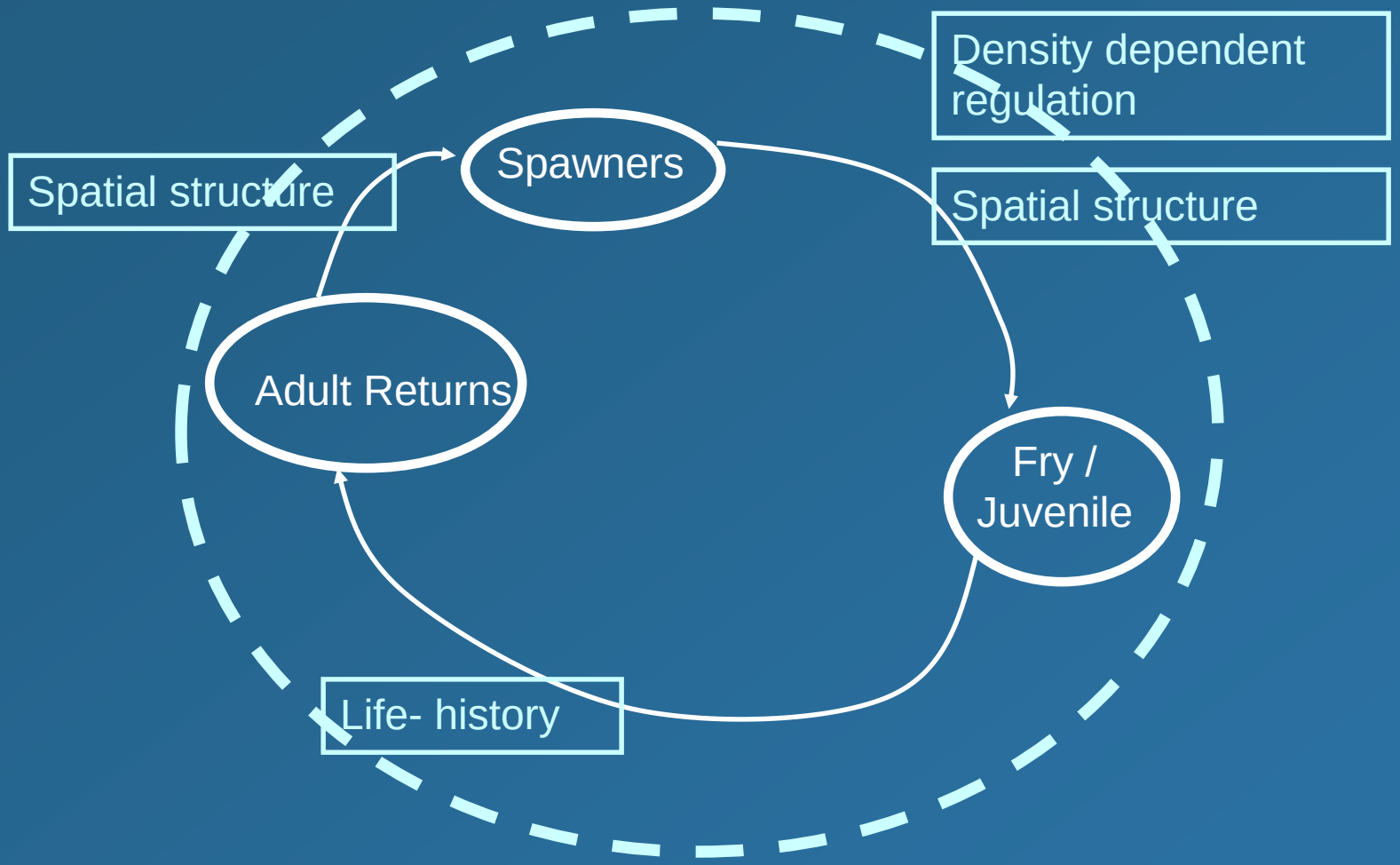
Marine Life

Returns

Modelling


Density dependent regulation
Spawners
Spatial structure
Spatial structure
Adult Returns
Fry index
Life- history

Modelling


Density dependent regulation
Spawners
Spatial structure
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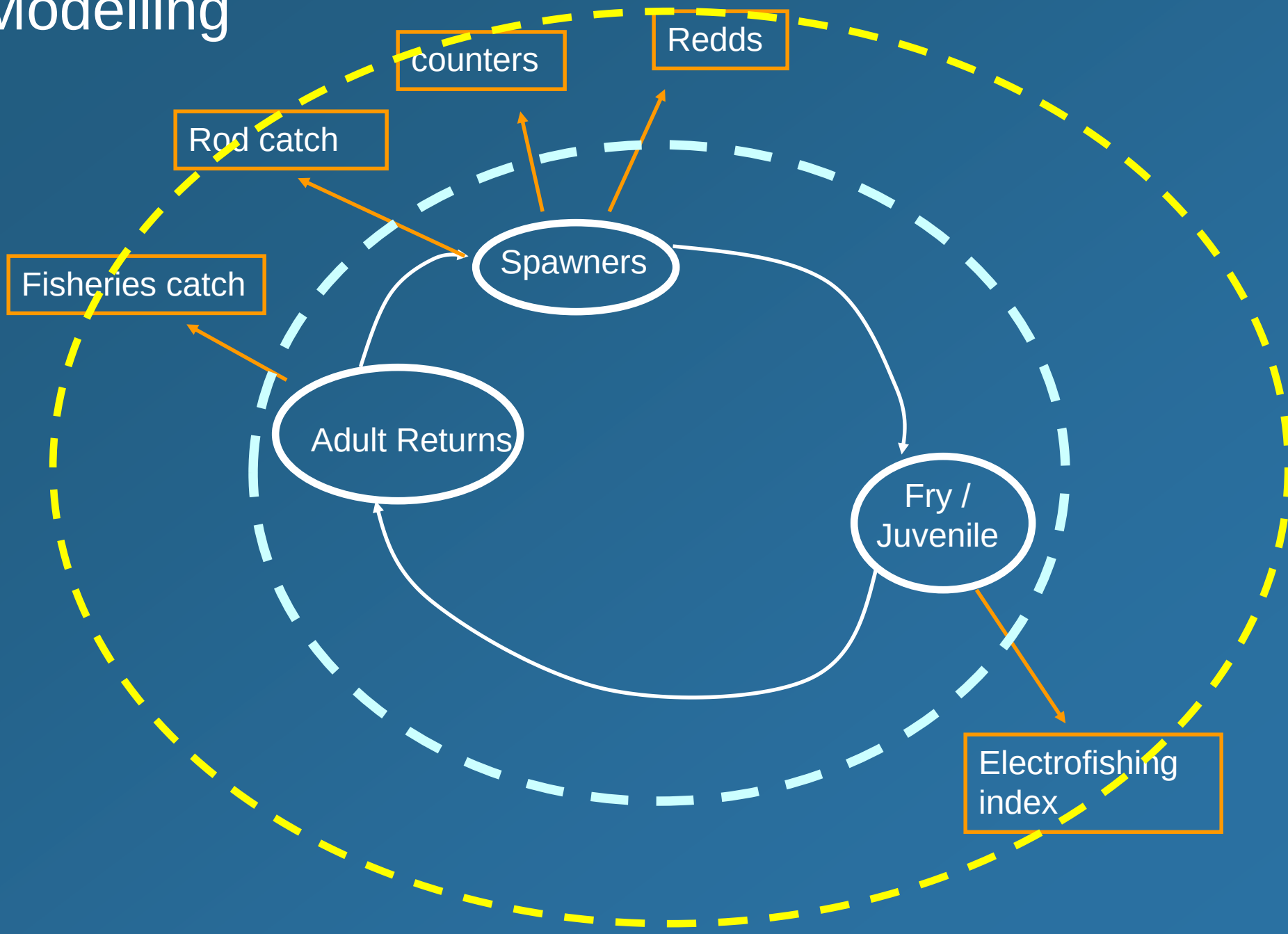
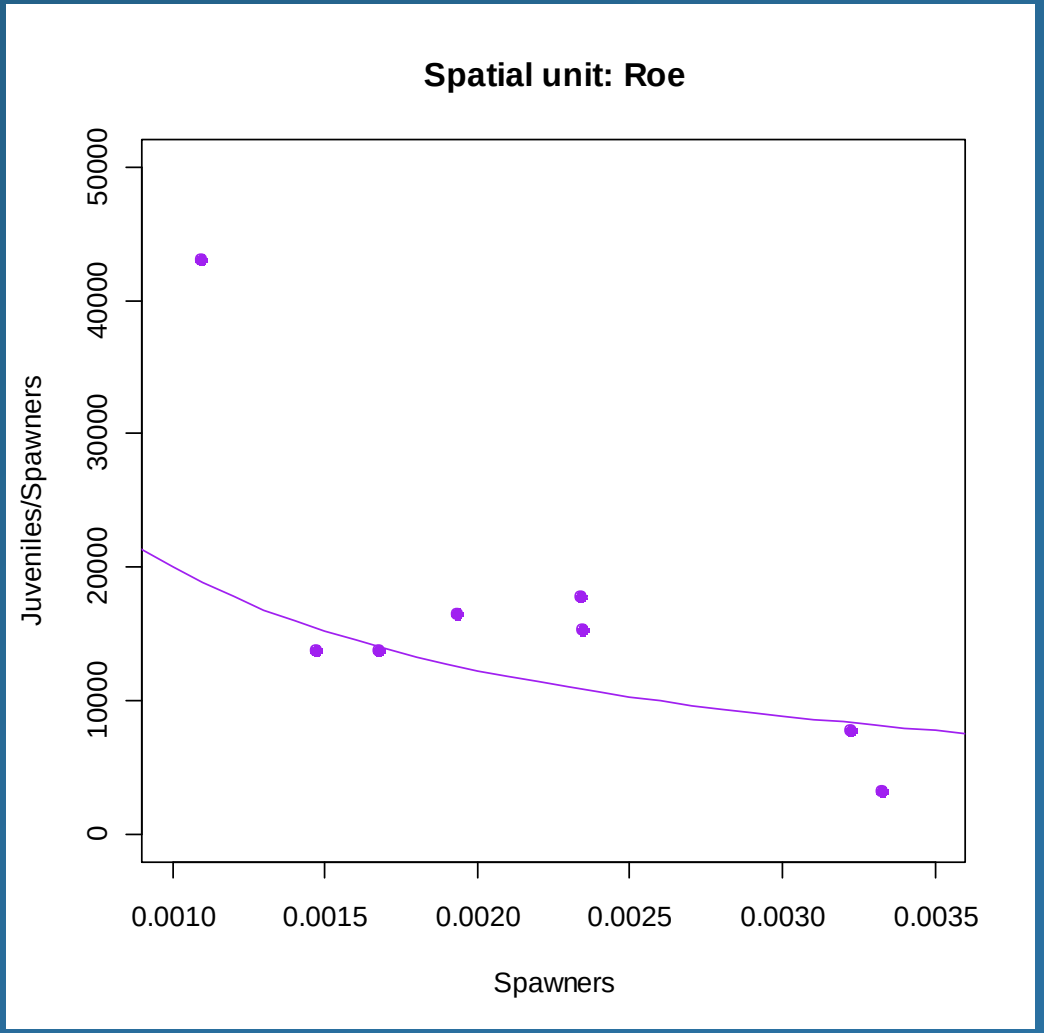
Adult Returns
Fry / Juvenile
Life- history

Modelling

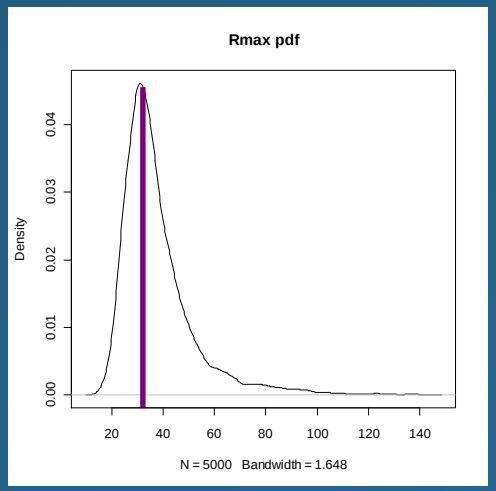

counters
Redds
Rod catch
Fisheries catch
Spawners
Adult Returns
Fry /
Juvenile
Electrofishing
index

Results
Density dependent regulation

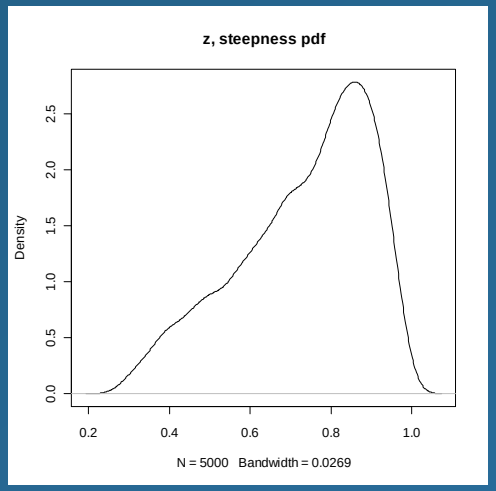
Spawners to juveniles ratio relationship



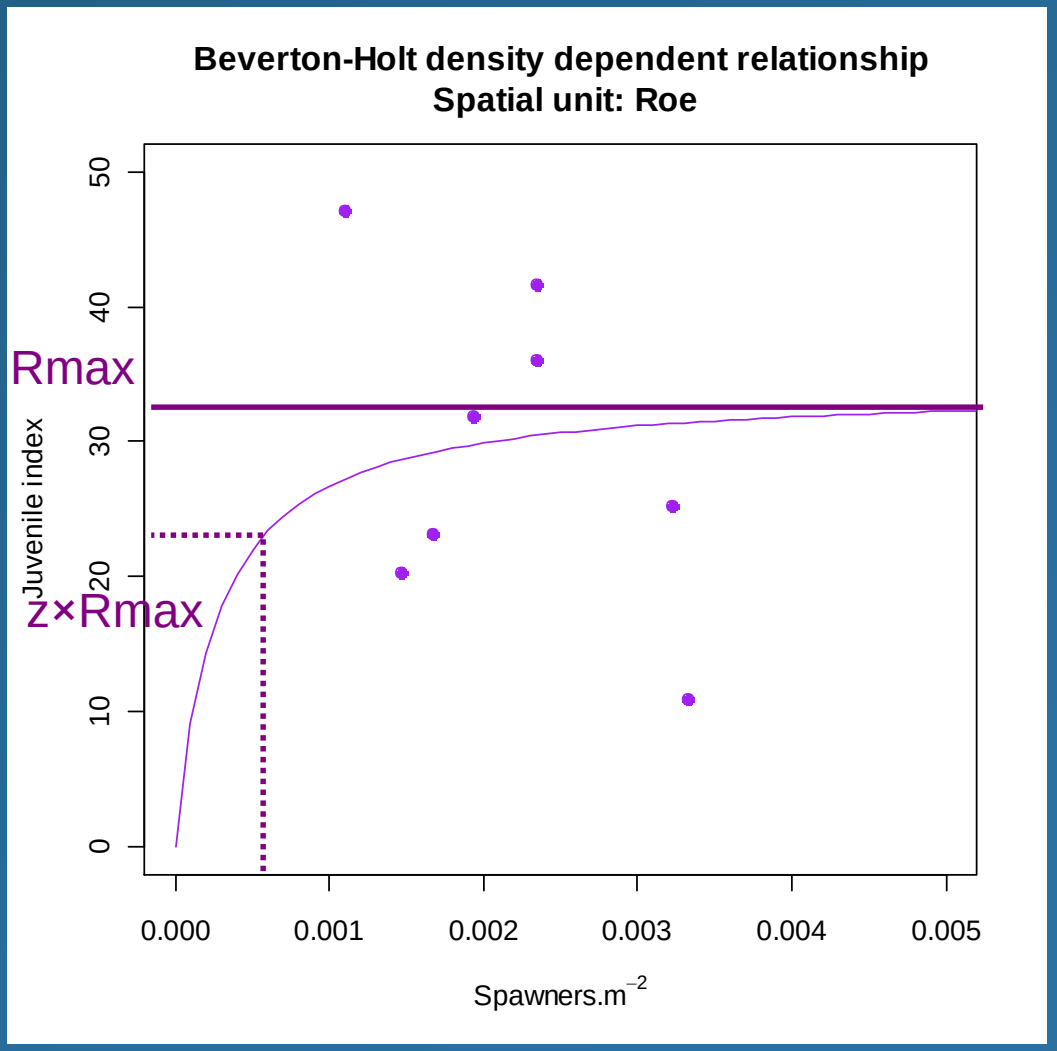
Results
Density dependent regulation



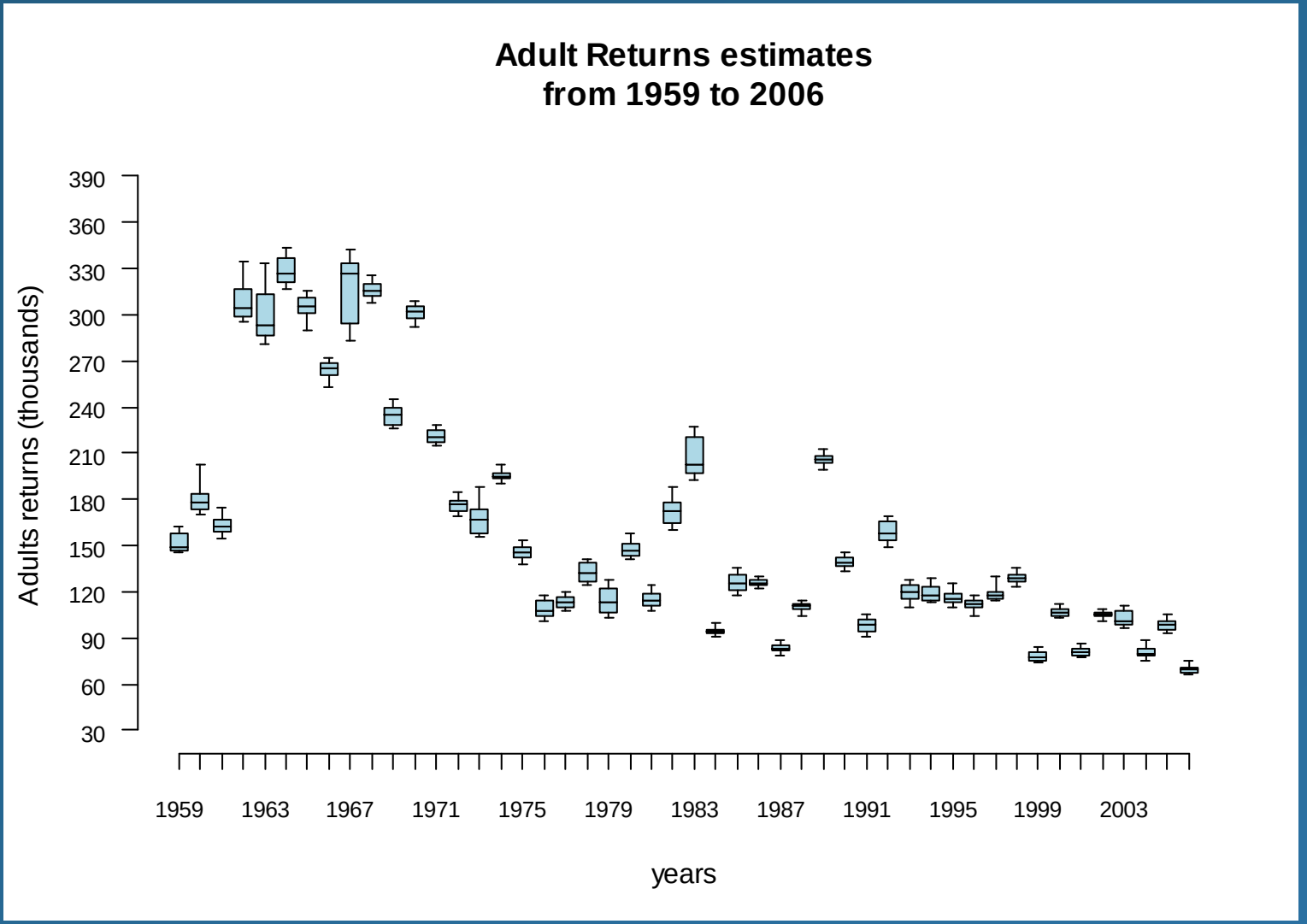
Rmax



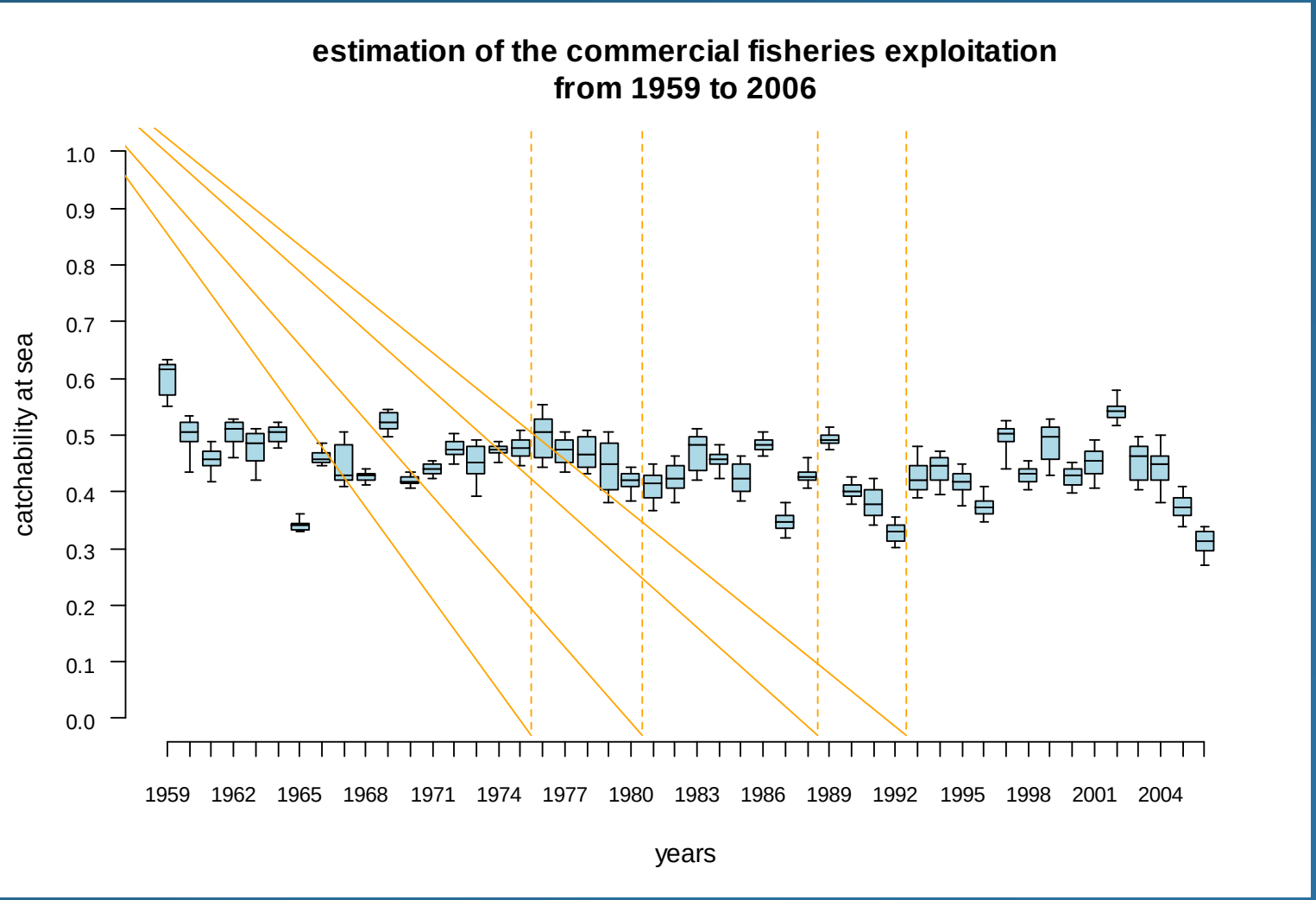
z, steepness



Results
Adult returns estimates



Results
Outputs of population management interest



Conclusions

Main Outputs:

- Adults returns abundance estimates

Limits of WinBUGS for these model:

- Long calculation time / problems of convergence

Methodology

- Work presented here is an example of a generic approach than can be applied for any population as long as time series are large enough

Predictions/analysis

- This kind of model can be used to provide short term predictions
- Retrospective analysis, “What if” scenarios ….

Thank you for your attention !

Funding: Loughs Agency

Supervisors: Colin Adams, Patrick Boylan, Etienne Prévost

Acknowledgments: Art Niven, Loughs Agency field crew