Incorporating Uncertainty in Management Processes

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Why am I doing this?

- Because I was asked…...
- Because I am an “escapee”
  - started out with the US/Canada Chinook Technical Committee (the real old days)
  - moved on and because a groundfish (and shellfish) scientist in ~1992
  - bring perspective of once having been heavily involved in salmon assessment, followed by switch to groundfish modelling

Caveats

- Unsure of my audience
  - there is a wide range of experience in this room
- I am a “guerrilla” mathematician
  - get the job done with a little help from my friends
  - formal mathematics is not my strength
- I am going to generalise unmercifully
  - otherwise will get bogged down in detail

Salmon Scene

- Don’t explicitly address uncertainty in our models (e.g.. CTC model)
  - deterministic
  - got the job done
  - “what if?” approach
- Implicit understanding of uncertainty in sampling design of CWT release and recovery projects

Salmon Scene (2)

- Other salmon analysis methods did not address uncertainty very well (or at all)
  - run reconstruction (sockeye)
  - cohort analysis
  - Fraser River pink tagging reconstruction

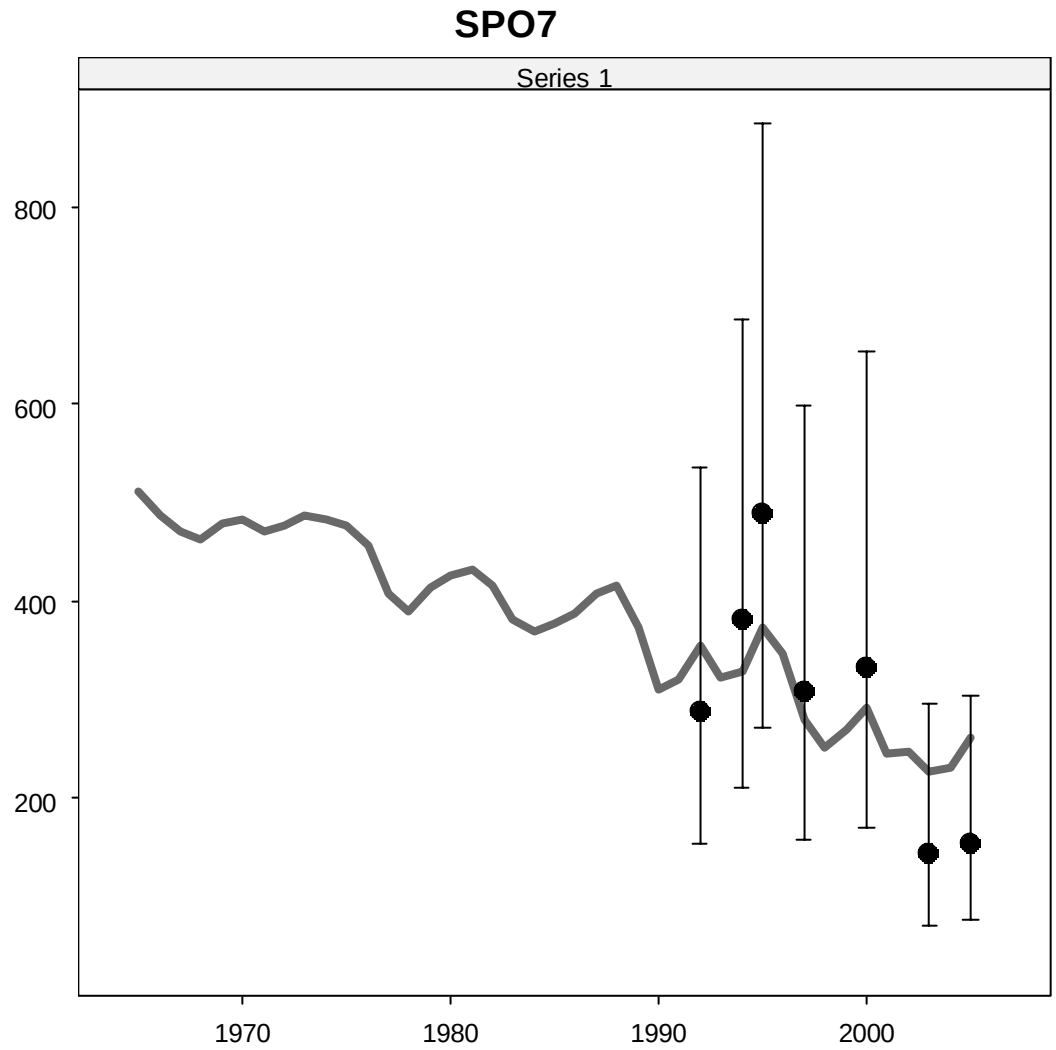
Groundfish Scene

- Two schools:
  - old school=VPA (=cohort analysis)
    - a lot like salmon: not much consideration of uncertainty
    - assumed catch@age known without error
    - reconstruction of stock was straightforward as long as you knew the exploitation rate in the last year
    - mainly western Europe and east coast Canada & US

Groundfish Scene (2)

- Second school:
  - west coast US & Canada: stock synthesis
    - integrated models which explicitly describe, through equations, the population dynamics and other important processes (e.g. migration)
    - model predicts observations and then obtains the best fit to the data by adjusting model parameters
    - requires that we make assumptions about the underlying statistical distributions which describe the processes we are modelling

These models are complex non-linear regressions:



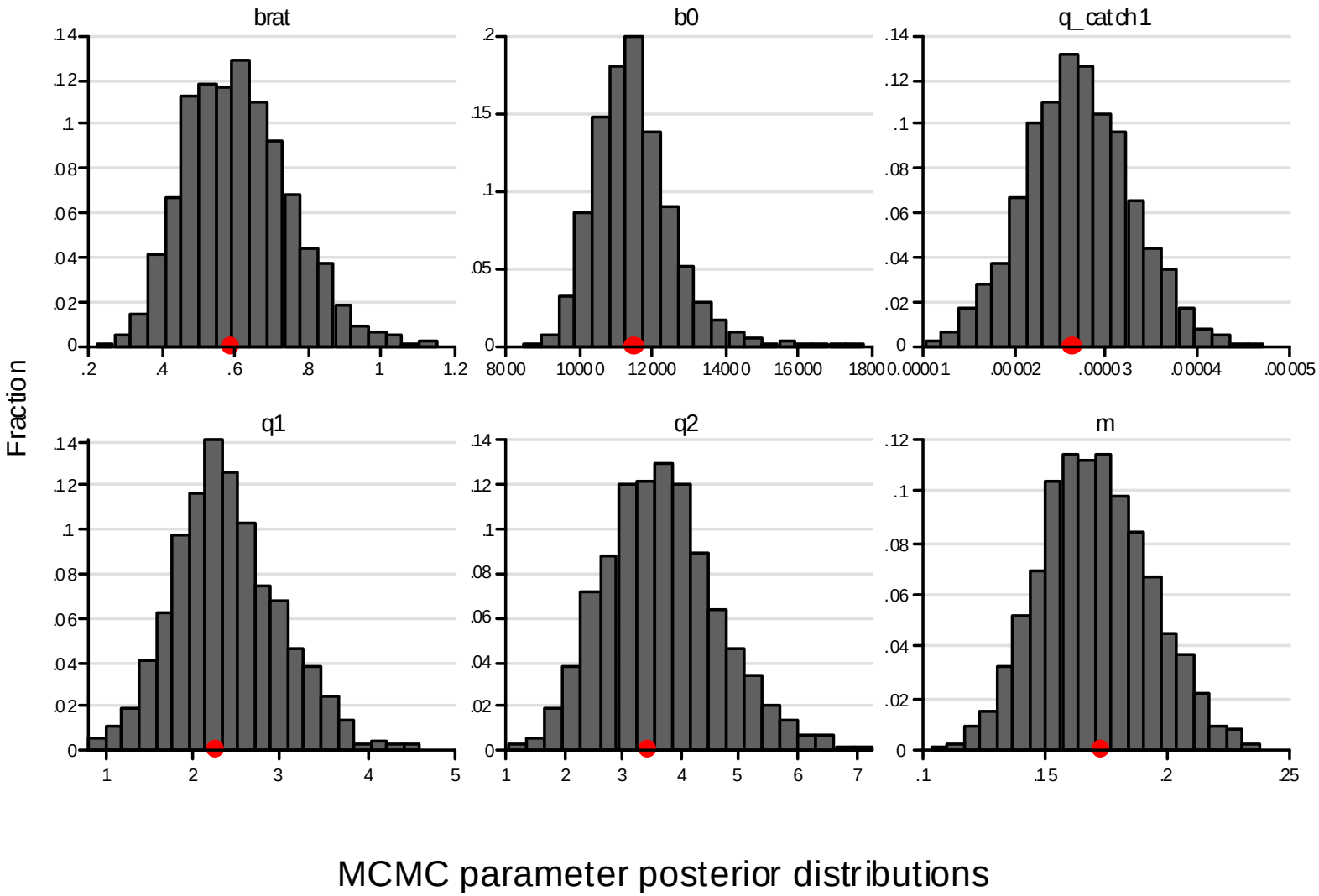
The next step

- But we don’t stop there
  - the “best” fit which minimises the negative log likelihood is just one of many plausible fits
  - for instance, suppose we have a model where the -LL=1000
    - what about a fit where the -LL=1001?
    - or -LL=1010?
  - close, but they are not selected because it is not the minimum

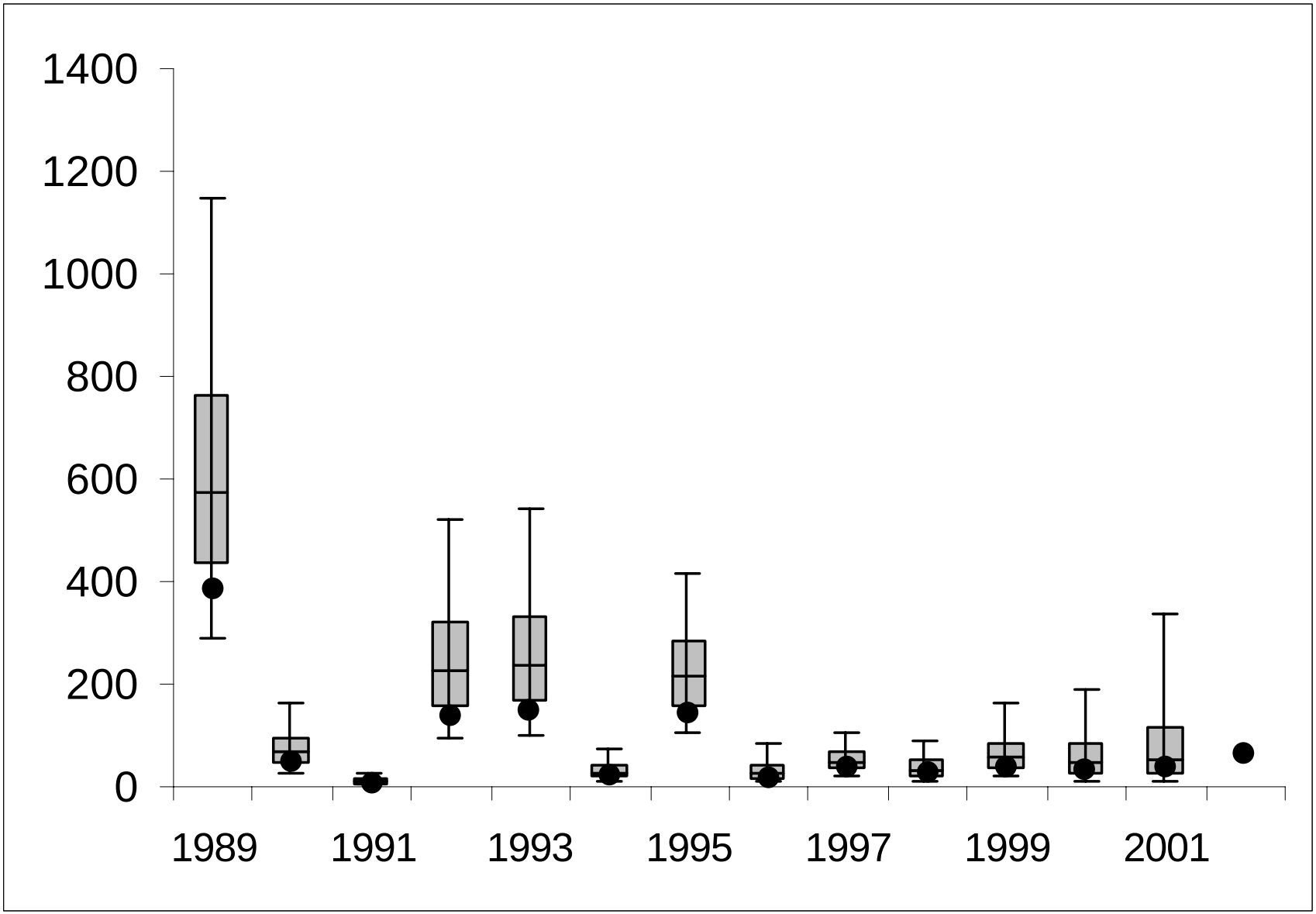
The next step (2)

- An approach to this problem is to use Bayesian methods:
  - explicitly state prior “beliefs” or understanding of every model parameter
  - obtain “best fit” to the data, taking into account the “priors”, as a starting point
  - search the likelihood surface across all parameter combinations, weighting each “solution” by its likelihood
    - “good” solutions get high likelihoods
    - “not so good” are lower

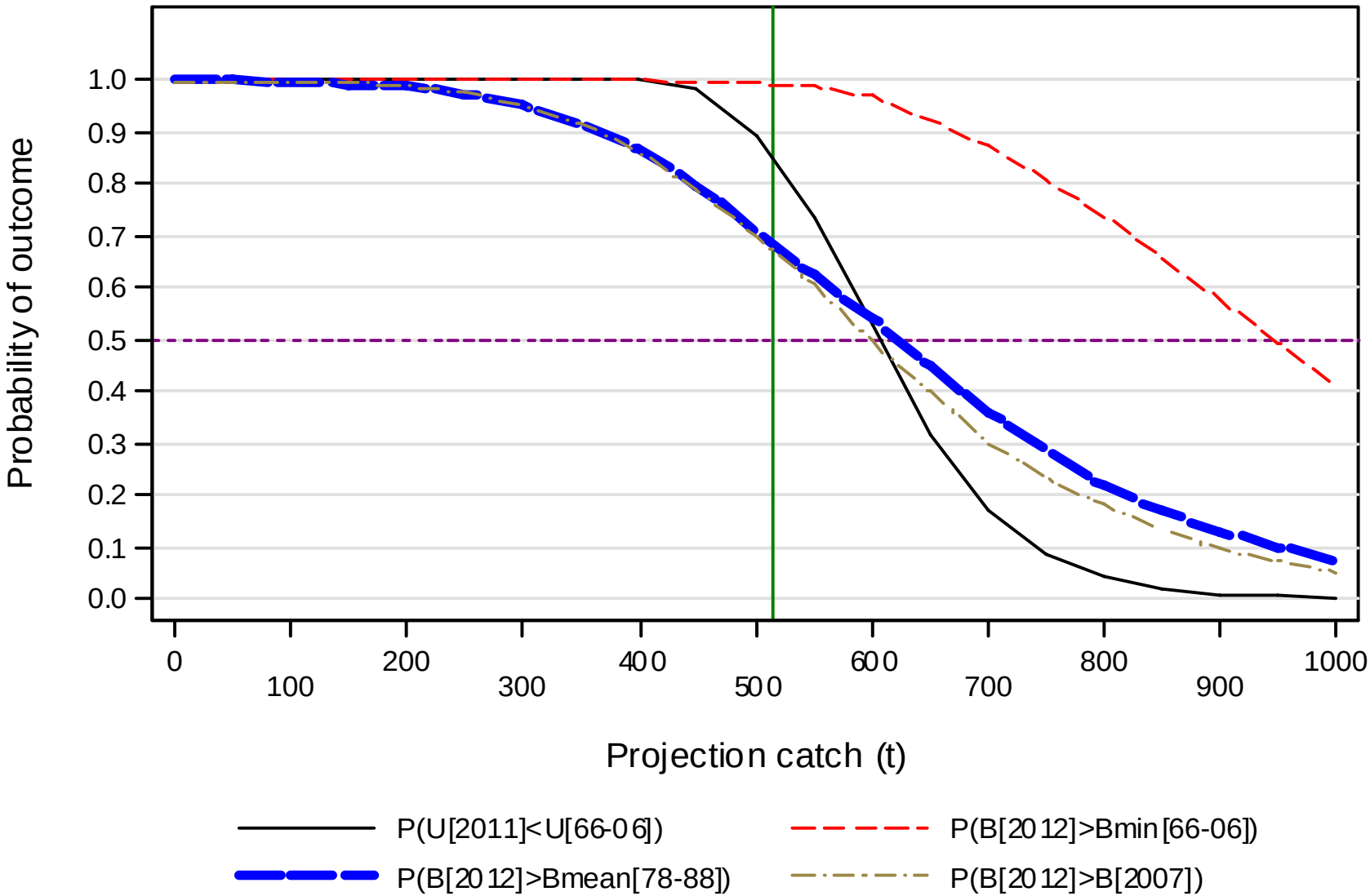
Result is a probability distribution for every parameter and derived parameter:



Another example:

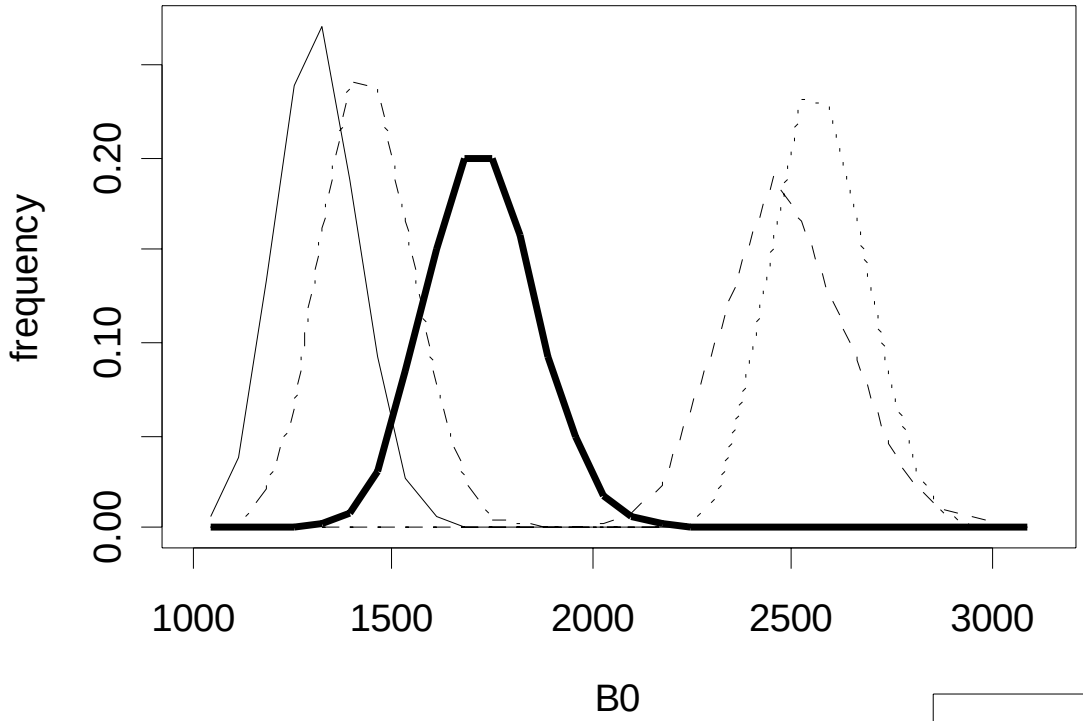


Application to management:

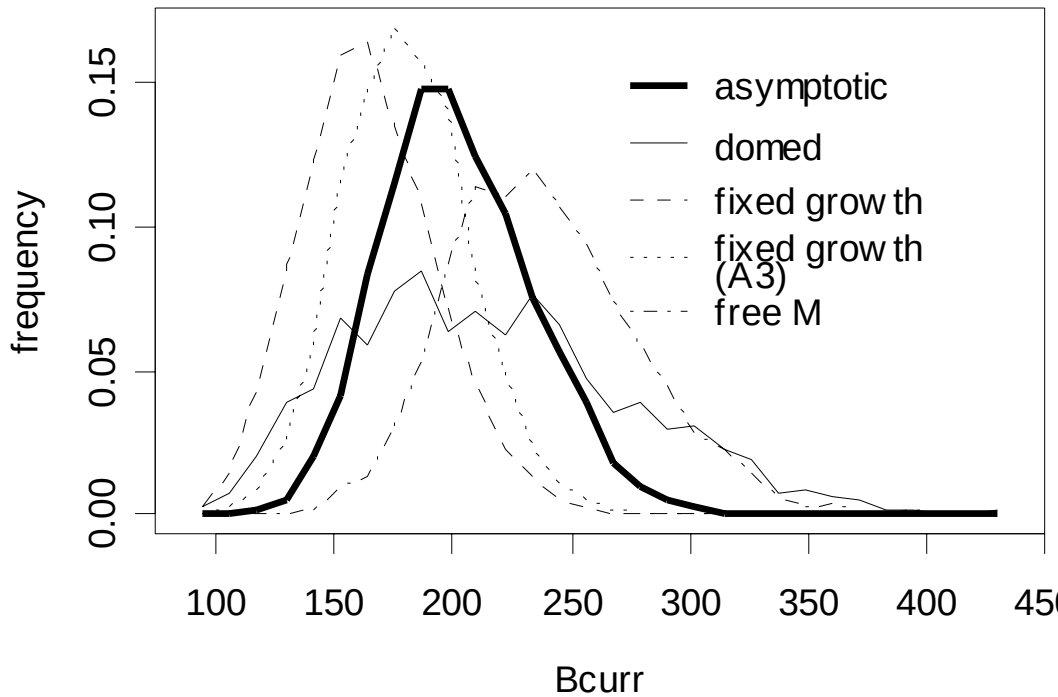


But there's more!

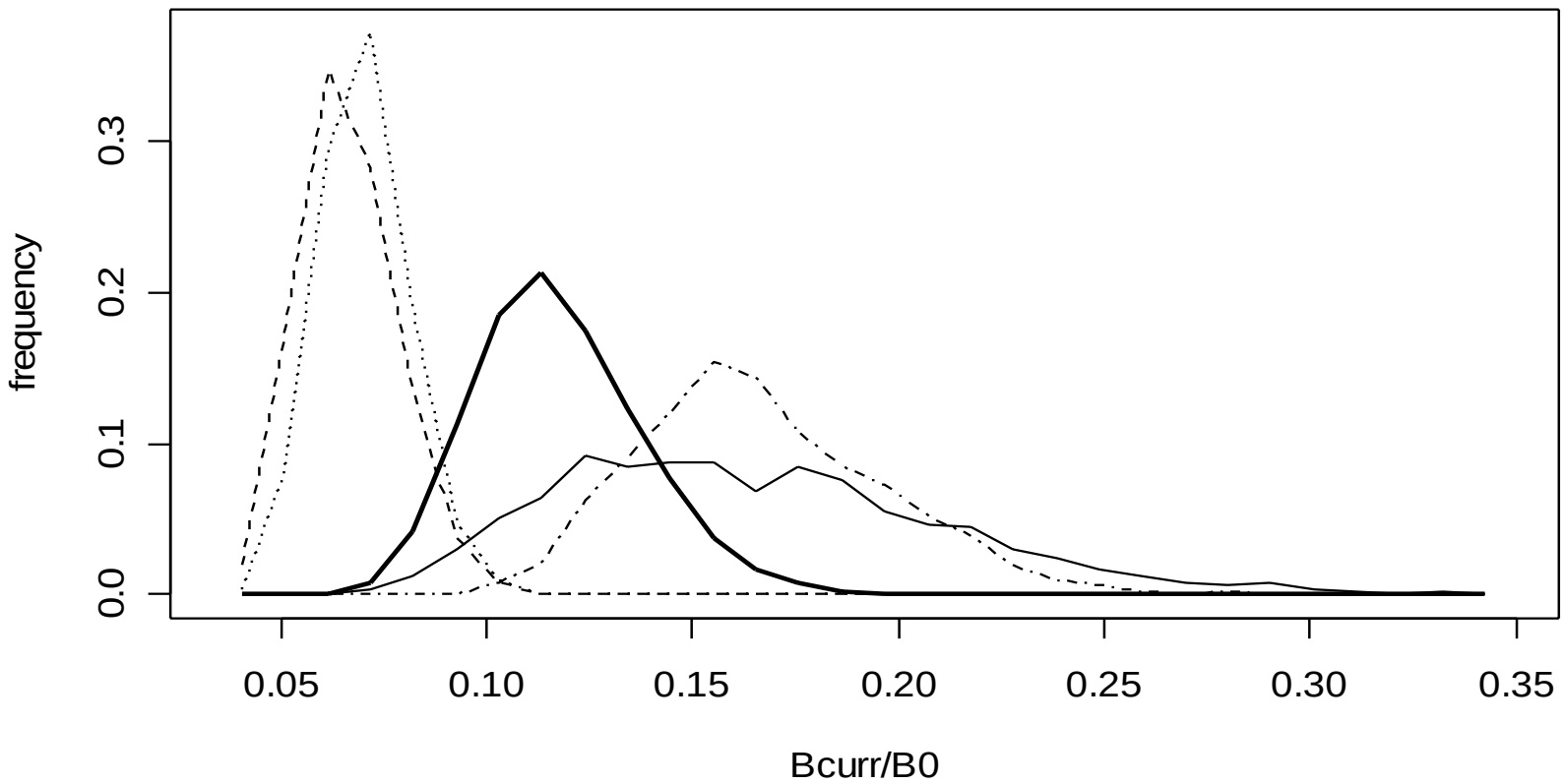
- Decision tables (as in the previous graph) often criticised for making simplistic assumptions about management response
  - assume constant catch even if stock is declining (ie. no feedback mechanism)
  - done in the context of a limited range of stock hypothesis
    - what about multiple hypotheses?



Example of alternative multiple model hypotheses



Alternative model hypotheses: Bcurrent/B0:



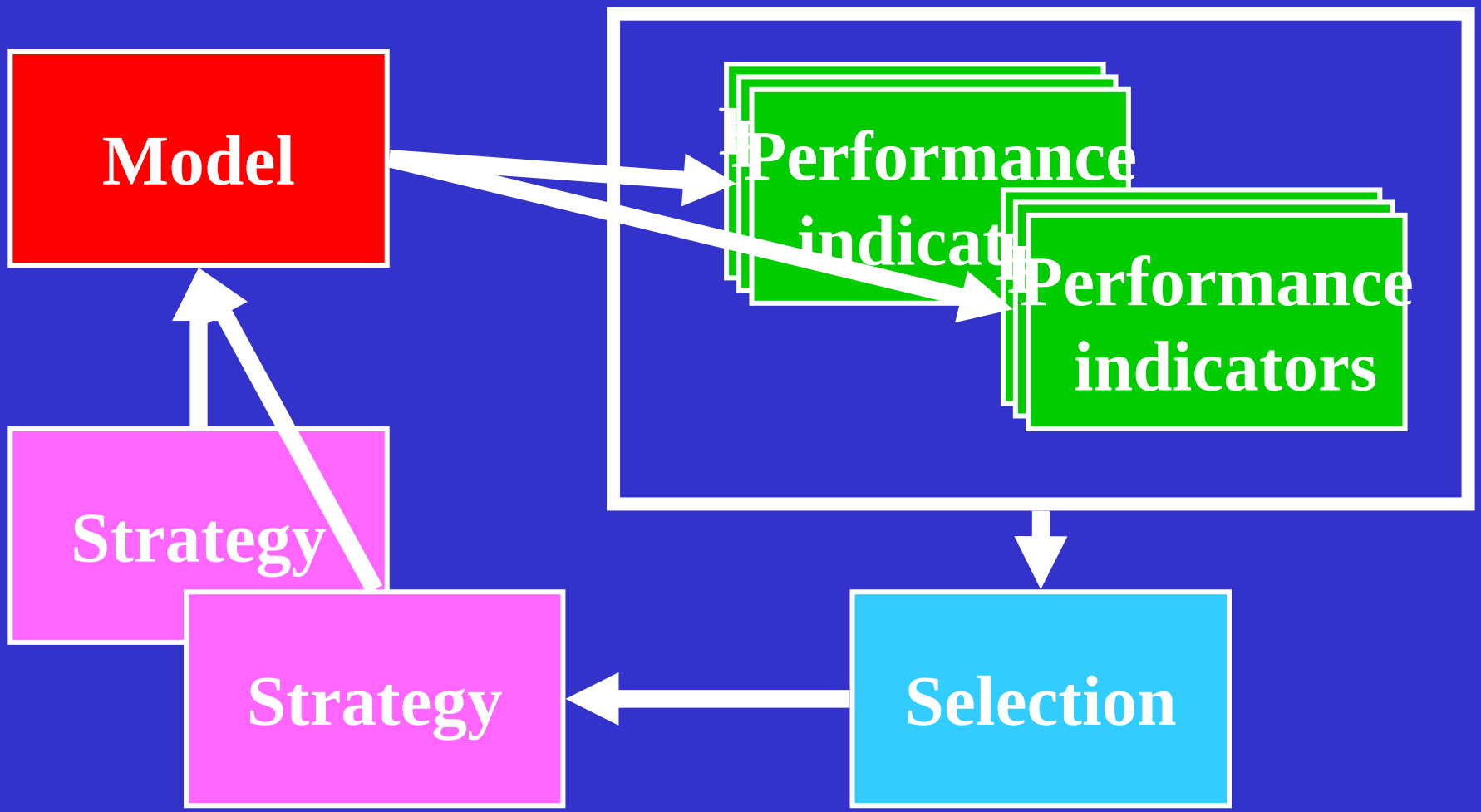
What can be done in these situations?

- Currently favoured approach is “Management Strategy Evaluation” (MSE)
- Developed initially by Doug Butterworth at Univ of Cape Town and taken up by the International Whaling Commission
- Now considered to be best way to provide management advice in the face of uncertainty

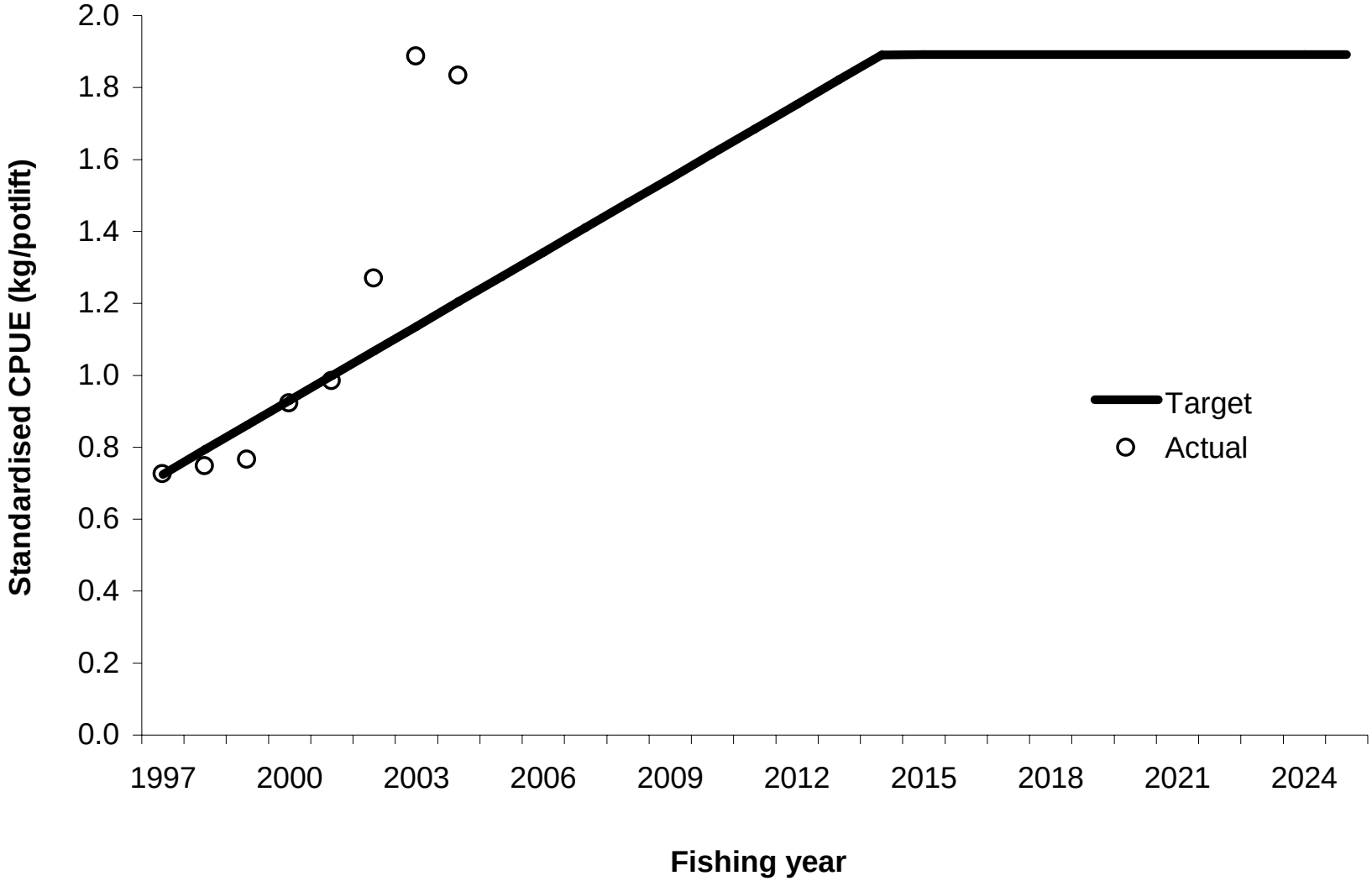
MSE: what is it?

- Simulation of a feed-back control system under a range of hypotheses, especially in terms of model structure, as well as the usual sampling and process error uncertainties
- Requires agreement from all parties to set up rules and targets against which the simulation can be run
  - logical continuation from earlier modelling approaches

Management strategy evaluation



NZ Southern Rock Lobster



NZ Southern Rock Lobster (2)

Summary of changes

April 1999	Drop 20%: 888 t => 711 t
April 2001	Drop 20%: 711 t => 568 t
April 2004	Raise 6%: 568 t => 603 t
April 2006	Raise 25%: 603 t => 755 t
April 2008	another 25% ???

Advantages of Management Procedures

- Explicit strategies to stay at or near reference points while achieving harvest goals
- Look for strategies that perform well across a range of hypotheses and levels of uncertainty
- Brings the stakeholders (=interested parties) together to discuss goals and strategies

Advantages of Management Procedures (2)

- Harvest strategies are the main indicator of a well managed system
- Fundamental requirement for external certification (e.g. Marine Stewardship Council)
- Provides a degree of certainty to the users
- Defines how data are collected and used

Disadvantages of Management Procedures

- Intensive work: requires more time and effort than traditional stock assessments
- Often difficult to reach agreement amongst users
  - lots of subjective steps
  - hard to get everyone together at once

Disclaimer & Final Comment

- I have glossed over a lot of very big problems and issues in this presentation
  - necessary given the scope of the topic and amount of time available
- I think the next logical step is for salmon models to adopt the stock synthesis approach
  - this is being explored explicitly for chinook at this time
  - there is a published paper on this in the CAJ (Quinn & ?) (Copper R chinook)

Disclaimer & Final Comment (2)

- The potential is to place both GSI and CWT data into the same model, allowing the model to compare its predictions with the observations
  - this would be very complex because movement and multiple stocks are such a large component of salmon population dynamics
  - confounded with other important parameters such as natural mortality and selectivity
  - not an easy task