When are models good enough? Assumptions and uncertainty in forecasts of ecosystem state and service supply

Edward J. Gregr, Kai M.A. Chan, Villy Christensen

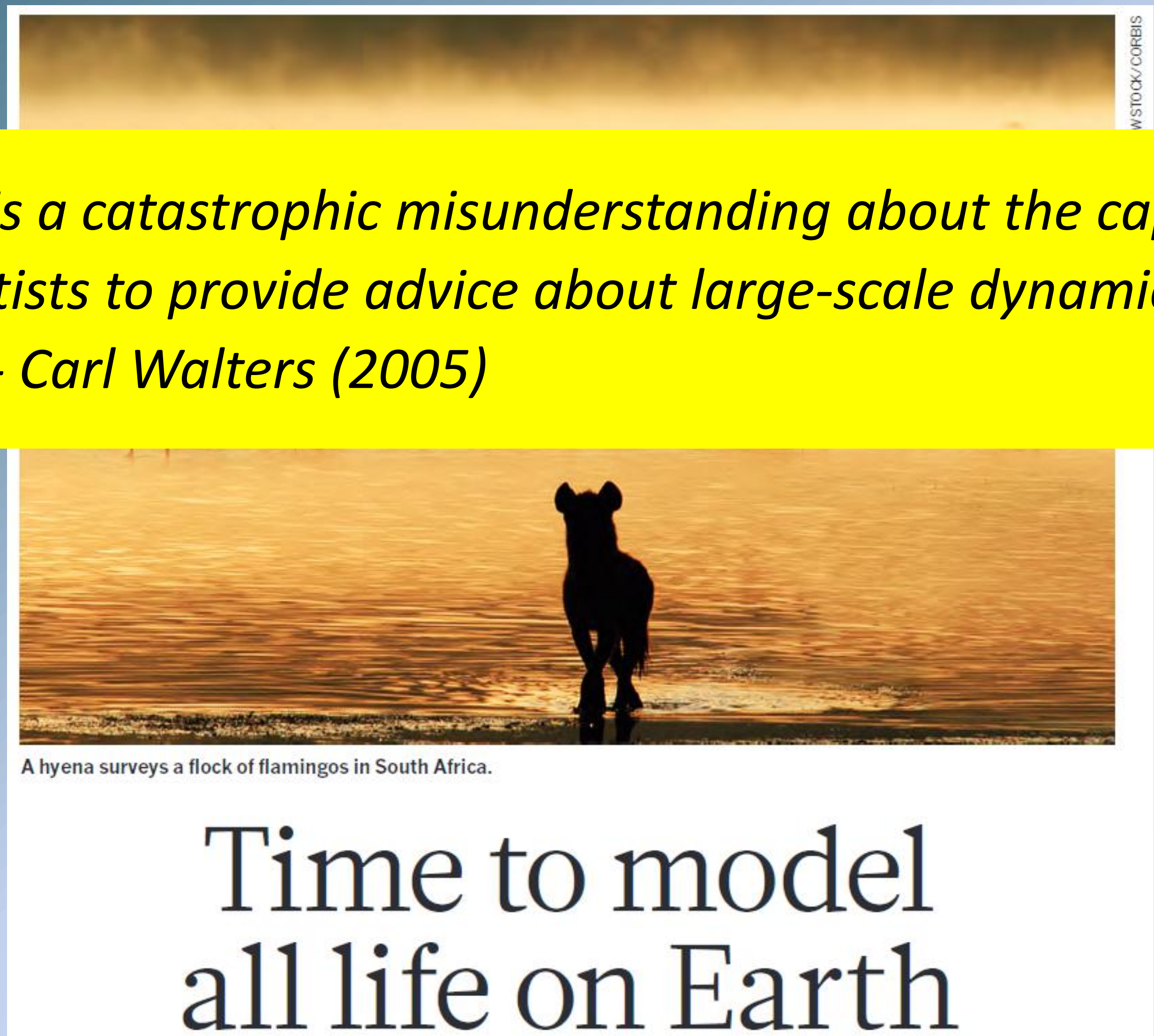
Institute for Resource and Environmental Studies, UBC

Communicating forecasts, uncertainty and consequences of ecosystem change
Nanaimo, BC, October 2013

Funding:
The Nature Conservancy
NSERC
Hampton Fund
BRITE

Ecosystem models & decision making

“There is a catastrophic misunderstanding about the capability of scientists to provide advice about large-scale dynamics.”
- Carl Walters (2005)



A hyena surveys a flock of flamingos in South Africa.

Purves et al. 2013, Nature

The problem with uncertainty

- Models use assumptions to reduce scope, creating implicit uncertainties
- If assumptions are implicit, uncertainties are hidden
- Its complicated, and not sexy
- Overconfidence in model results

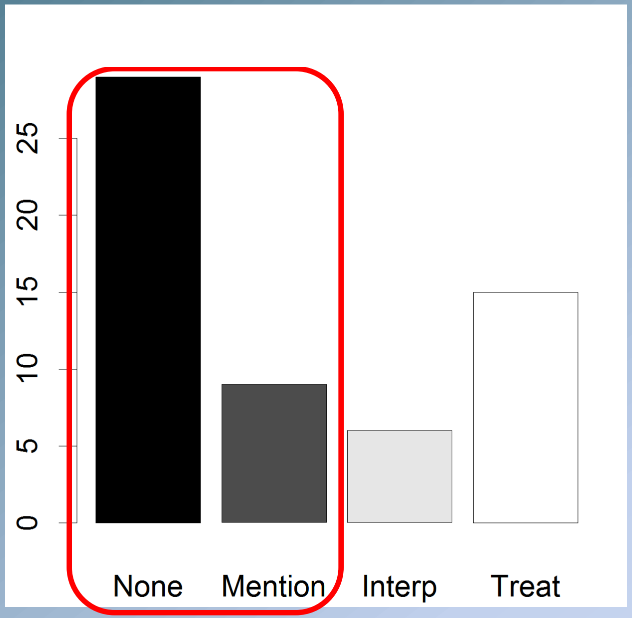
How implicit assumptions compromise the utility of ecosystem models for decision making

Gregr & Chan (in prep)

- Extracted EBM-related literature (1990-2012) (n=560)
- Selected the most popular based on citation rate (n=60)
- Reviewed stated policy relevance, treatment of uncertainty, and design assumptions

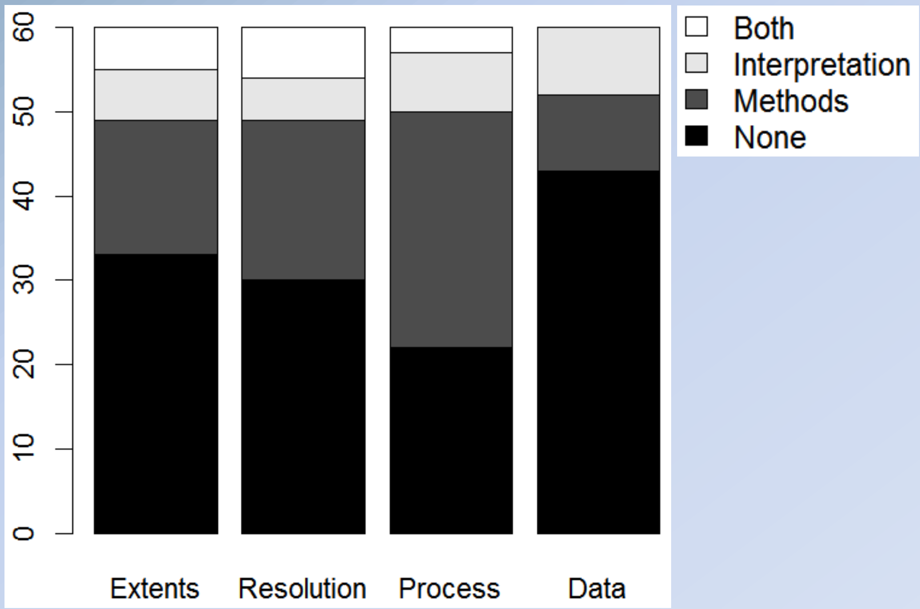
Popular papers treat uncertainties and assumptions poorly

Uncertainty



(n=60)

Assumptions



- Over half largely ignored uncertainty
- Model design assumptions were mostly implicit
- < 10% described a relevant mgmt application

Implications

Not addressing assumptions & uncertainties:

- Compromises uptake of results
- Can lead to misunderstandings & bad decisions
- Cripples the building of coupled-models

- Good work on uncertainty being done, but papers are not being read

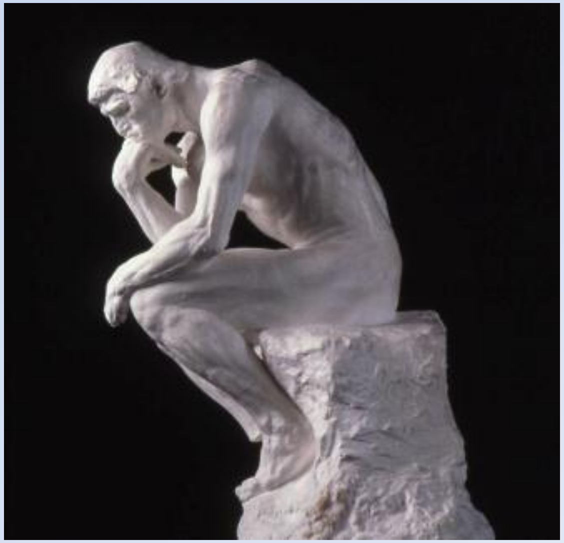
Fawcett and Higginson 2012 (PNAS)

Clarity is (part of) the solution

To improve understanding:

- A clear research question, objectives
- Describe uncertainties
- Articulate design decisions
  (Extents, resolution, process, data)

- Is the pursuit of
  understanding sufficient?

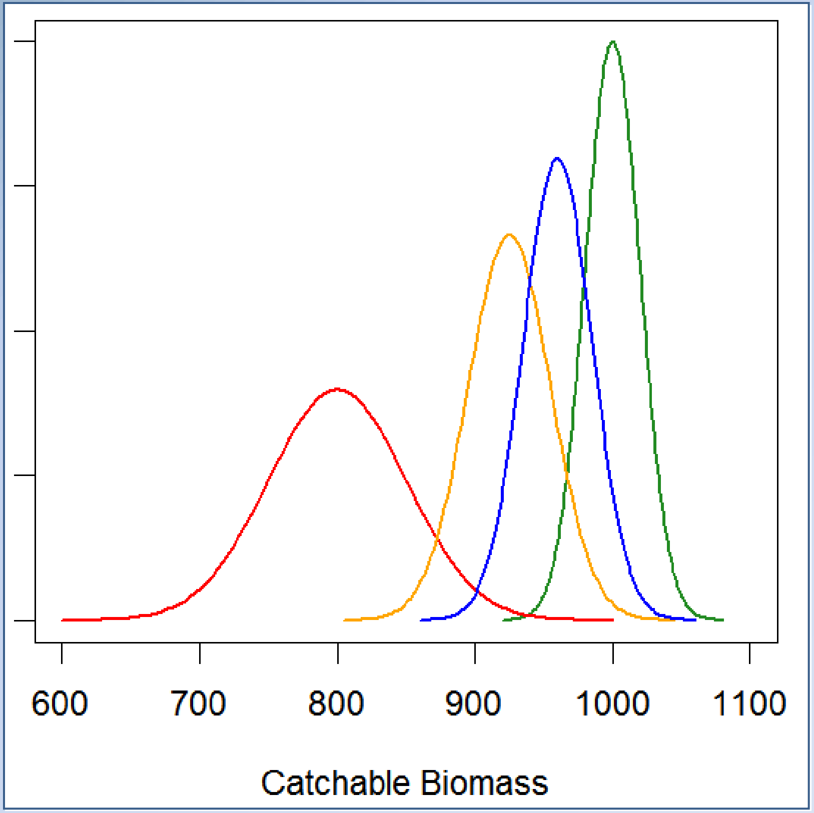


Spiral of complexity

- Adding information to a model assumed to improve accuracy and precision
  - New, improved data
  - Improved resolution
  - New, improved processes

- Costly
- Can lead to unresponsive, overly complex models
- Unclear decision relevance

- ***No clear end point …***



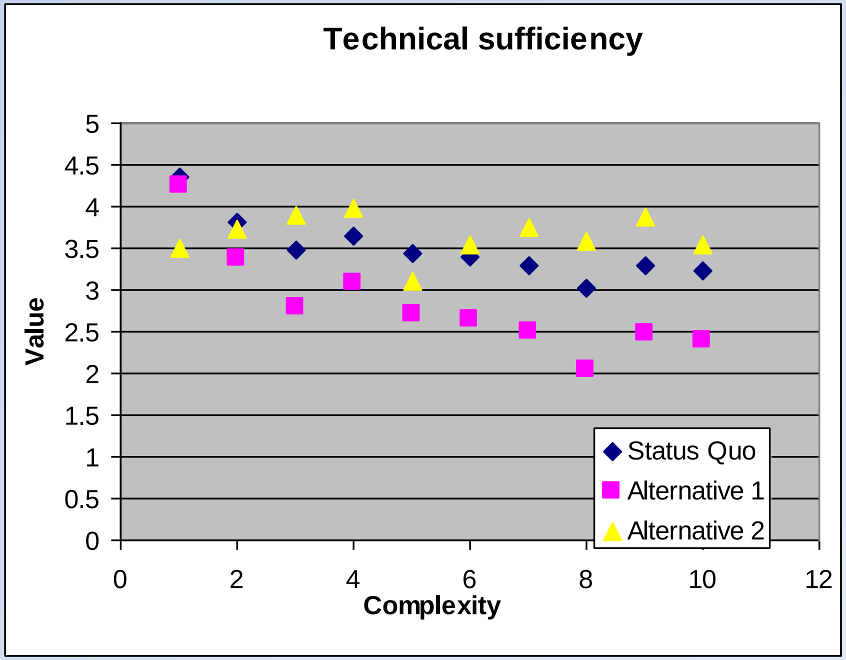
Sufficiency

A model is sufficient when additional information will not change the decision (Phillips 1984)

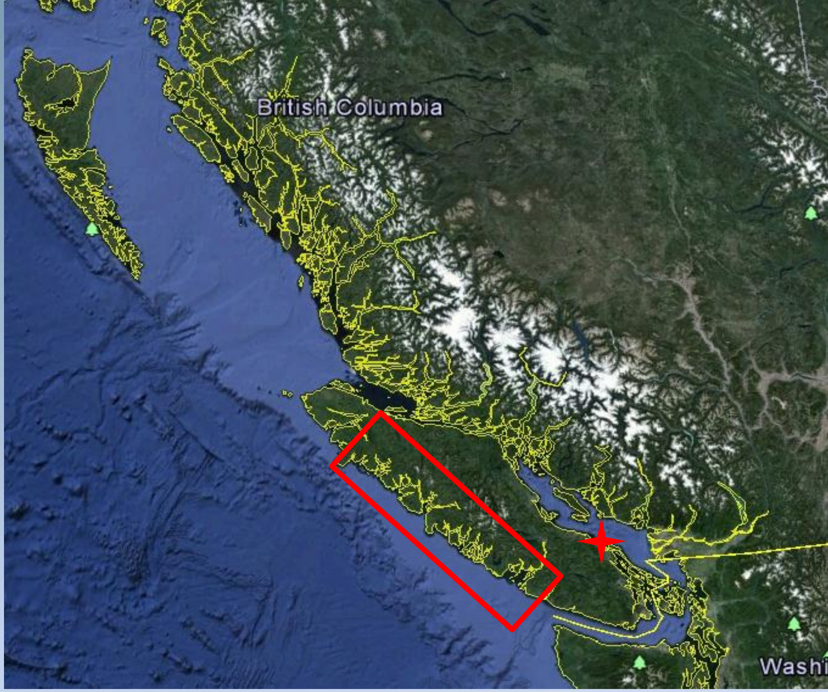
- Requires decision context
  (Alternatives, objectives, risk tolerance)

- Contextual sufficiency:
  All model assumptions credible

- Technical sufficiency:
  Predicted difference between alternatives within risk tolerance



Case study



- Sea otter trophic cascade
- Conflict between otters & fisheries
- Management problem:

How to manage a listed species that consumes valuable fisheries resources?

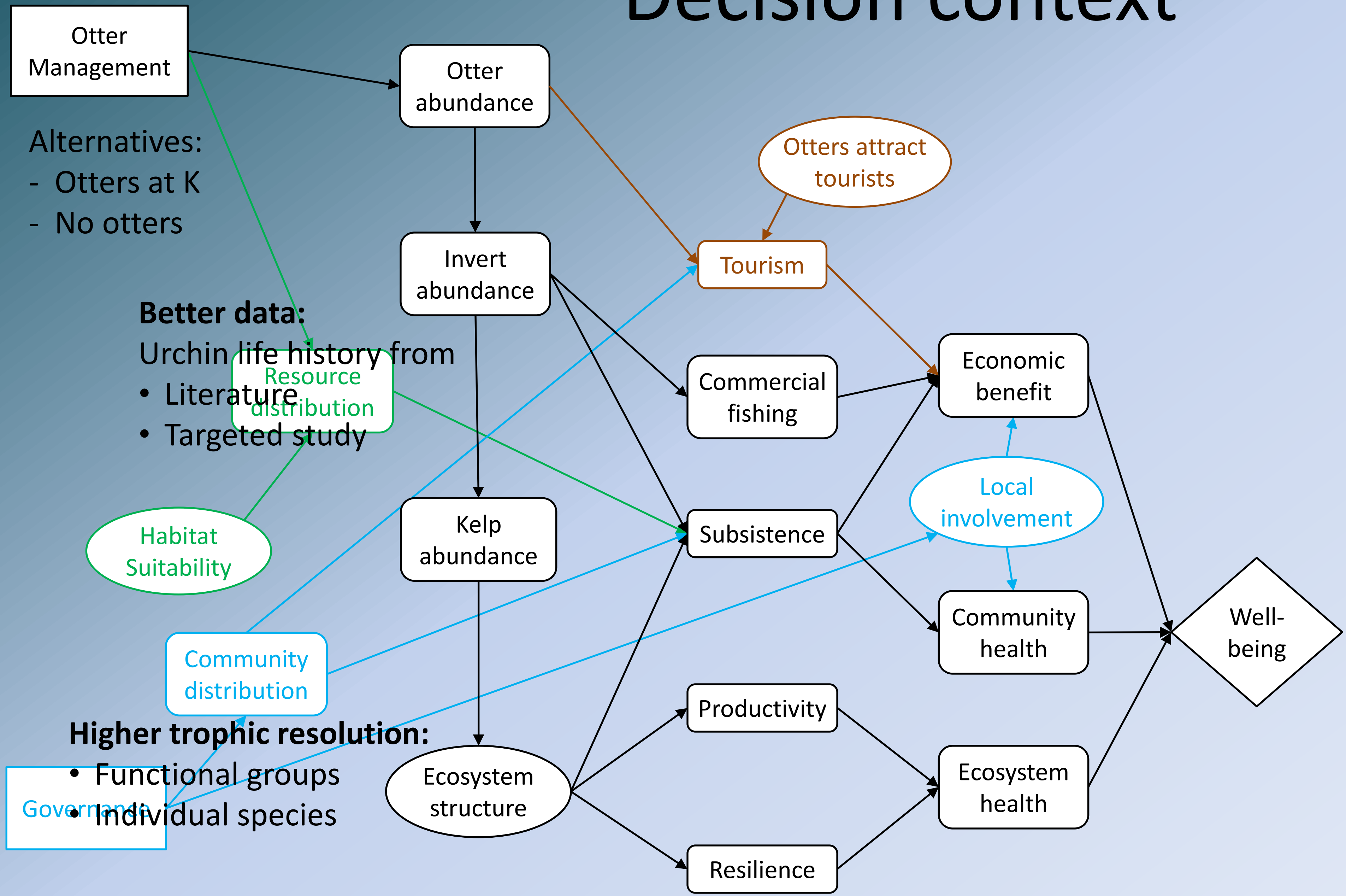
Sea otters → Urchins → Kelp

Decision context

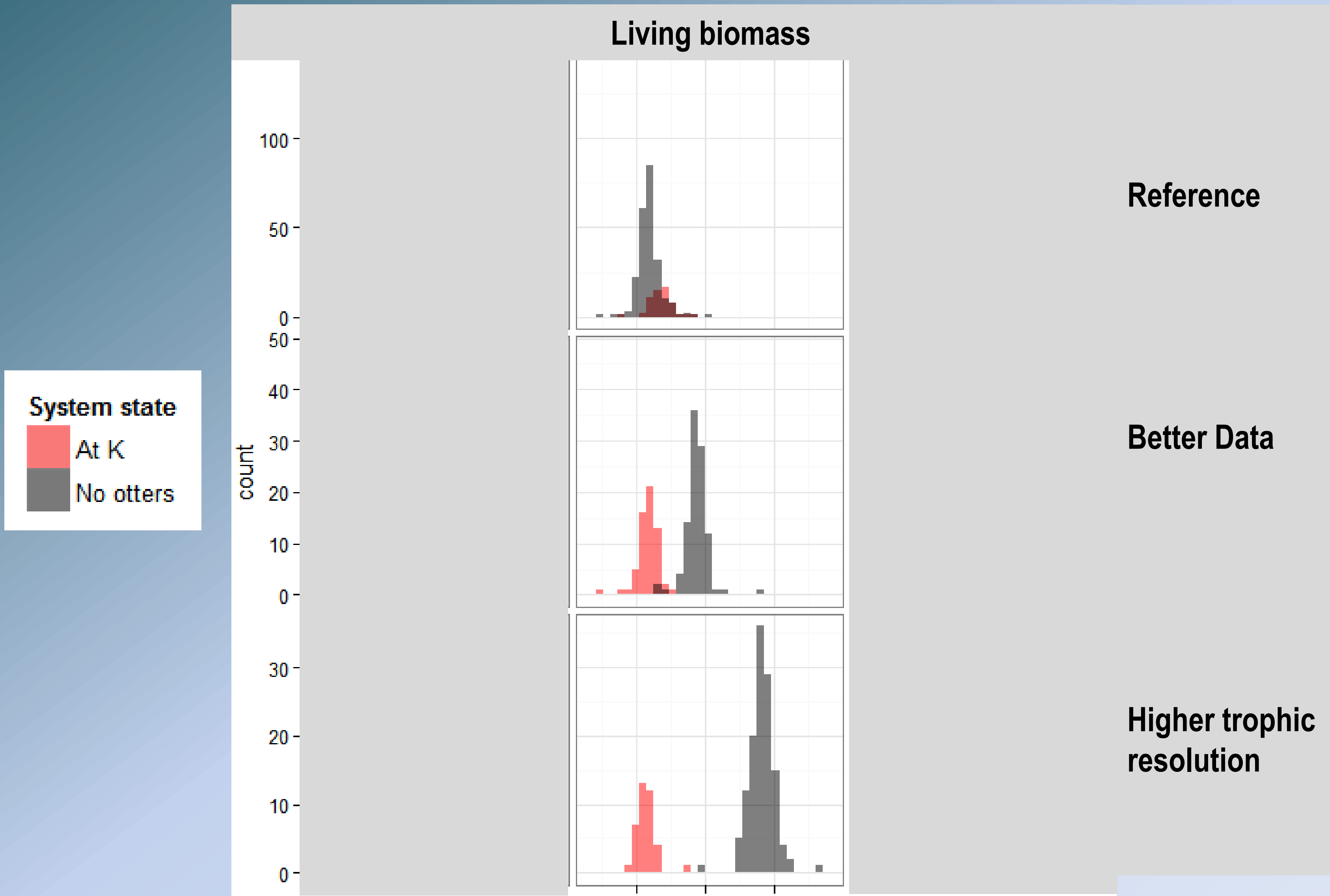
Alternatives:
- Otters at K
- No otters

Better data:
Urchin life history from
- Literature
- Targeted study

Higher trophic resolution:
- Functional groups
- Individual species



Model response to more information



Evaluating sufficiency

- Technical uncertainty can be quantified
  - Value of Information approach
- Contextual uncertainty reflects belief
  - Fundamental assumptions explicit
  - Consensus based
  - Bayesian Belief Network
  - Weight of Evidence
- Sufficiency needs to combine contextual and technical certainty

Conclusions

- Need to be better at articulating model assumptions & uncertainties
- Ecosystem models can be assessed for sufficiency in specific decision contexts
- PICES Open Science Meeting Workshop (April 2014):

Bridging the divide between models and decision-making: The role of uncertainty in the uptake of forecasts by decision makers

ejgregr@gmail.com