# Dealing with Uncertainty: implications for fisheries adaptation


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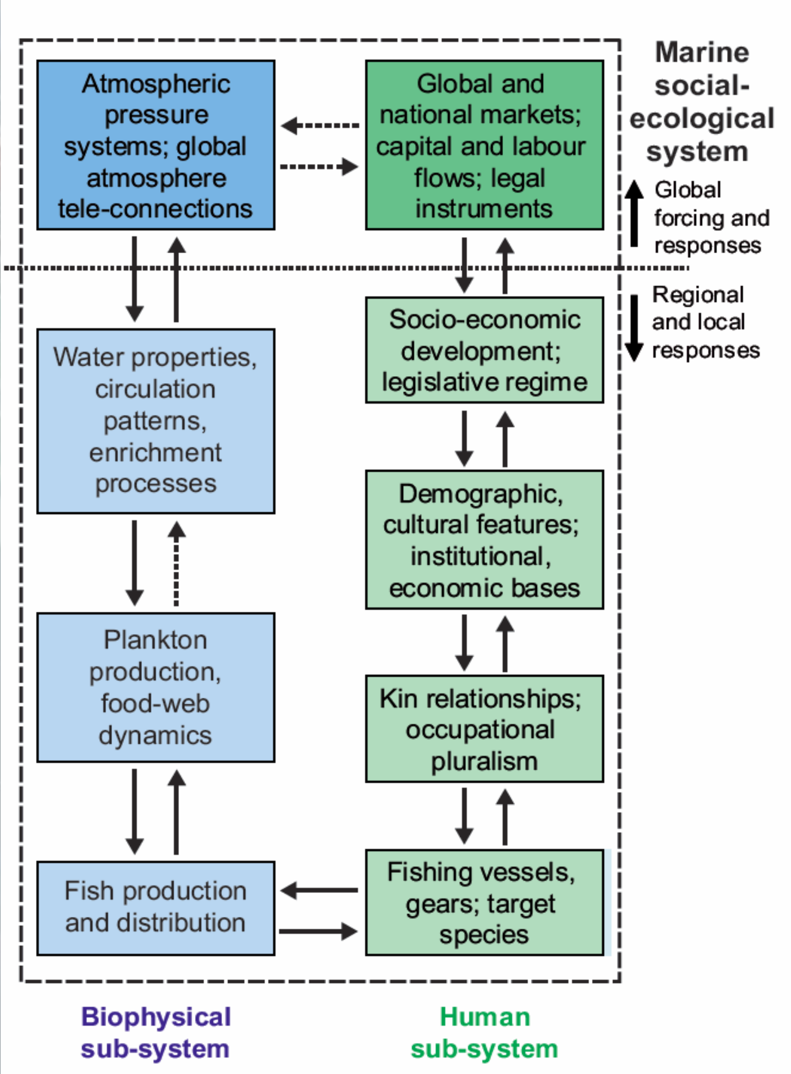
# Coupled marine social-ecological systems




Perry et al. 2010. In: Barange et al. Marine ecosystems and global change. OUP

## Social-ecological systems:

- complex adaptive systems including social (human) and ecological (biophysical) sub-systems in two-way feedback relationships
- integrated concept of humans-in-nature
- delineation between human social and ecological systems is artificial

Berkes. In Press. In: Ommer et al. World Fisheries: a social-ecological analysis. Wiley-Blackwell.

# Types of Uncertainty

1. Observation uncertainty (current state of the system is not completely known)
    - due to natural variability on a variety of time and space scales
    - difficulties in making accurate observations

2. Model uncertainty (models are not perfect)
    - due to wrong or incomplete systems and processes included in the models (or missing entirely)
    - lack of knowledge of parameter values

3. Process uncertainty (lack of understanding of the system)
    - lack of knowledge of how system is structured and functions
    - interacting effects of multiple drivers of change
    - uncertainty over human behavioural responses

4. Policy uncertainty (inadequate application)
    - Information not communicated clearly or policies not appropriate

# Expected impacts of climate change on marine ecosystems

1. Changes in species' distributions
   - model globally on the basis of "habitat envelopes"
   - one model predicts range shifts of 600 km for pelagic species and 220 km for demersal species, with 83% moving poleward

   (Cheung et al. Fish and Fisheries, 2009)

2. Changes in species' abundances
   - due to changes in recruitment, conditions exceeding physiological limits, etc.

3. Changes in productivity of marine ecosystems
   - expectation is for marine ecosystem productivity to decrease in low latitudes and increase in high latitudes
   - response of upwelling areas is unclear

(e.g. Barange and Perry. 2009. FAO Tech. Rept. 530)

# Several factors complicate predictions of climate change impacts

- local expressions of global-scale predictions
  - e.g. details of changes in fish distributions; threshold effects
- disruption of existing communities as species respond at different rates to warming conditions
- changes of seasonality – mismatch of life cycle timing
- uncertainties about how nutrient inputs and productivity will respond to warmer conditions
- declines in adaptive capacities of marine ecosystems to climate change due to effects of fishing and habitat loss, e.g. shorter life spans, loss of sub-populations

Result is: increased Model and Process uncertainty

# Drivers of change in marine social-ecological systems

**Biophysical drivers:**

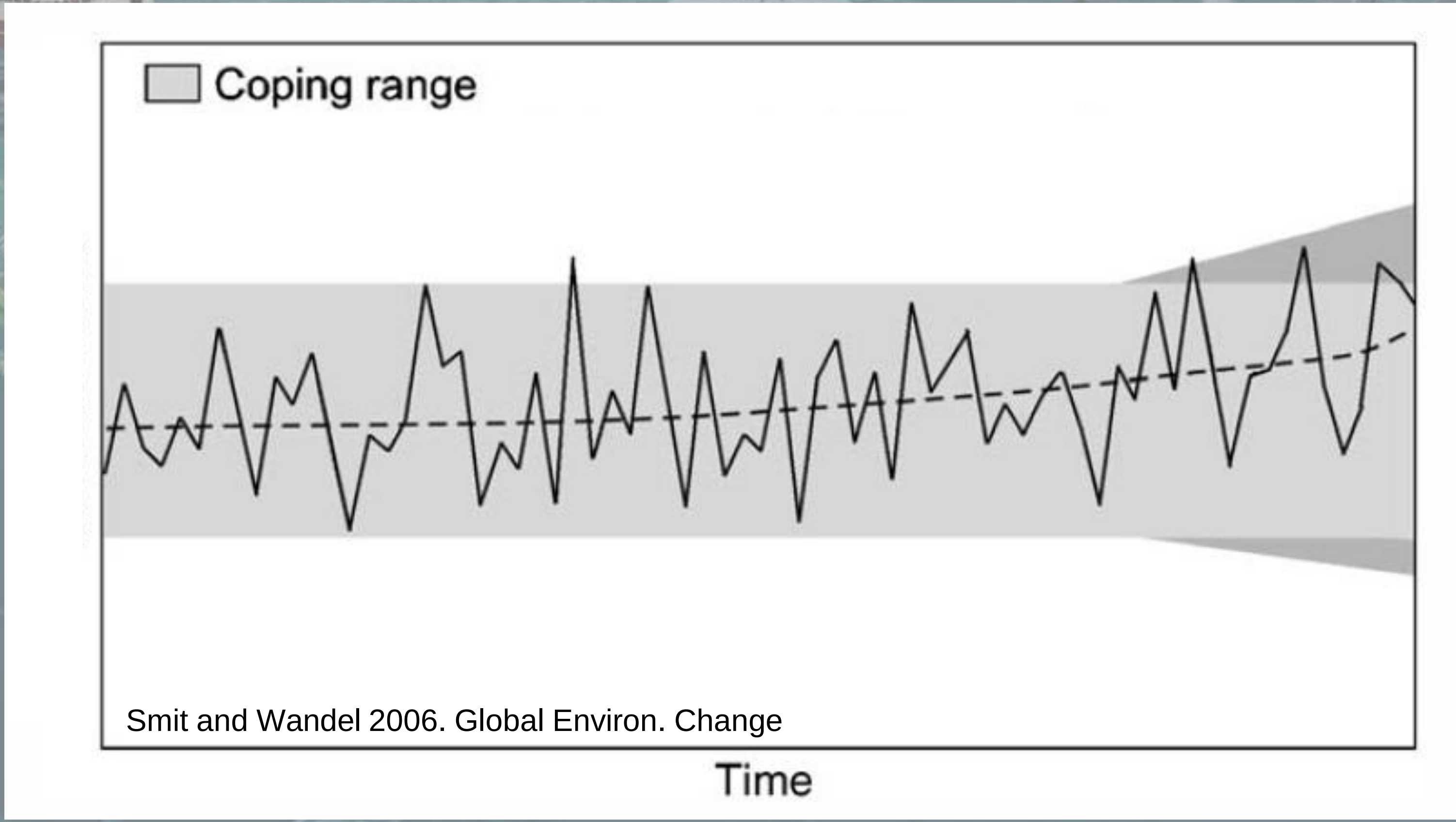
- environmental variability
- climate trends (change)
- acidification
- changes in oxygen concentration
- internal ecosystem dynamics (predator-prey; disease)

**Human drivers:**

- fishing
- habitat degradation
- contaminants
- introductions of exotic species
- mineral extraction

- demographic changes
- economic changes
- market / trade changes
- infectious diseases
- societal and international agreements
- law and property relations
- policy changes

# Human social systems cope with variability (uncertainty) within their "normal" range of experience, and adapt to variability beyond their "normal" range.




"Normal" range is therefore a scale issue, i.e. relative to the experience and adaptive capacities of the natural or human social systems

# Synthesis of responses of fishing-dependent human communities to global changes expressed locally

- at short time scales and in response to “small” changes (coping strategies – relatively quick to start, somewhat reversible):
  - intensify effort
  - diversify to other gears and species
  - migrate
  - “hibernate”

- at longer time scales, or in response to “big” changes (adapting strategies – slower to implement, difficult to reverse):
  - political reform
  - capacity building
  - restructuring
  - community closure

# Queensland east coast inshore finfish fishery

(Courtesy Renae Tobin and Steven Sutton, James Cook University, Cairns, Australia)


## Commercial fishery

- about 200 active vessels
- average experience 28 years
- target multiple species
- 7% of vessels depend on inshore

## Charter fishery

- about 230 vessels
- average experience 8 years
- target mostly (75%) Barramundi
- 70% of vessels depend on inshore

# Queensland east coast inshore finfish fishery

(Courtesy Renae Tobin and Steven Sutton, James Cook University, Cairns, Australia)

Explore potential adaptive capacities of these fisheries to a hypothetical scenario of warmer waters, barramundi move south and species composition changes in northern Queensland:

Commercial fishery

- can move
- can change species
- low investment and debt – good potential for restructuring

= good social-ecological resilience

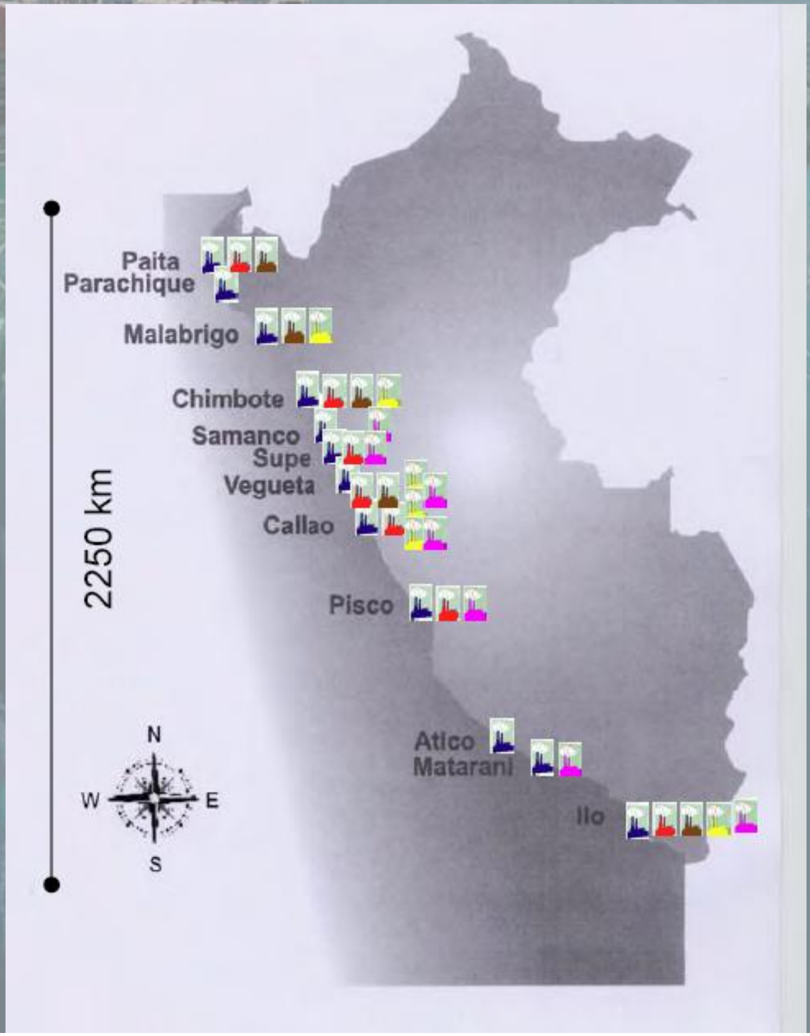
Charter fishery

- some can move
- most cannot change species
- high investment, difficult to restructure
- young, high education, previous experience elsewhere, low household dependence on fishing

= good social, but not ecological, resilience

# Peru – adaptations to interannual (ENSO) and multi-decadal variability

(Courtesy Milena Arias Schreiber, M. Ñiquen, M. Bouchon, IMARPE, Peru)




## 1. Decentralised processing plants

- but significant potential social consequences

# Peru – adaptations to interannual (ENSO) and multi-decadal variability

(Courtesy Milena Arias Schreiber, M. Ñiquen, M. Bouchon, IMARPE, Peru)


1. Decentralised processing plants
   - but significant potential social consequences

2. Low cost unloading facilities

3. An opportunistic industry
   - industry is able to substitute other species for fishmeal processing

4. Flexible formal institutions
   - lack of a management plan for the anchovy fishery avoids legal instruments that could restrict or delay rapid management decisions

5. Rapid response from management institutions
   - it takes two and a half days to close the anchovy fishery following written recommendations from the Peruvian Research Institute

# Enhancing adaptive capacities of marine social-ecological systems to variability and uncertainty
# - good step towards adapting to climate change

| Biophysical systems | Human social systems |
|---|---|
| Reduce overall fishing pressure | Adopt a livelihoods approach |
| Shift exploitation to functional groups (& new fishing opportunities) | Current policies may not be appropriate under climate change, e.g. management targets; subsidies |
| Do not focus on biomass alone: maintain life spans; sub-populations | Increased uncertainties require more monitoring |
| Do not decrease trophic level of fish communities | Governance: active communication and involvement with stakeholders |
| Adapt fishing and stock rebuilding to current productivity conditions | New agreements may be needed for problems (e.g. migratory stocks) |

# Analogy with explicit inclusion of uncertainties into weather forecasting

| Old Paradigm | vs. | New Uncertainty Paradigm |
|---|---|---|
| Focus only on reducing uncertainty | → | Focus on reducing & quantifying uncertainty |
| Single value "most likely" forecast | → | Most likely value and probabilities of other values |
| Decisions based only on "most likely" scenario | → | Decisions based by weighing costs and impacts of each possible scenario |
| Status quo socio-economic losses due to forecast error | → | Risk mitigation, socio-economic enhancements due to factoring forecast error in decision making |

NOAA. 2009. State of the Science Fact Sheet. Weather Forecast Uncertainty.

# Recommendations for dealing with uncertainty

1. Observation uncertainty
   - invest in monitoring (of critical components of the social-ecological system)
   - statistical modelling of near-future conditions rather than long-term projections
2. Model uncertainty
   - develop multiple models, and which are robust to model uncertainties (i.e. use a model ensemble approach)
3. Process uncertainty
   - invest in research to
     - improve understanding of critical processes,
     - identify highly sensitive components, and
     - identify important processes not included in models
4. Policy uncertainty
     - prior planning with stakeholders
     - monitoring implementation, and periodic review of policies

# Dealing with uncertainty: implications for fisheries adaptation

- Climate change is but one of many drivers of change in marine social-ecological systems
- Fisheries systems have capacities to adapt to uncertainties due to environmental and human variability
  - these can be enhanced or suppressed by management and policy actions
- Recognise the inherent uncertainties of observations, models, underlying processes, and the application of policies
  - requires risk-based decision making
- No matter how good the predictions, there will always be uncertainties and, consequently, `surprises`
  - need to build capacities in both the `natural` and human social systems which support adaptation to surprises

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