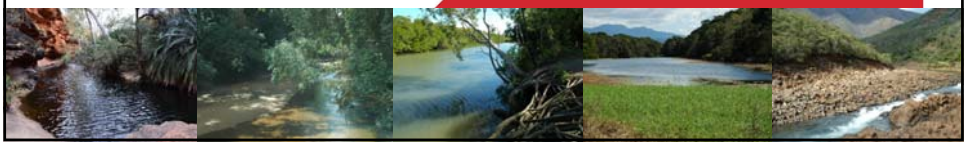
OPUS

Predicting Cumulative Impacts in Freshwater Systems

Peter Gehrke

November 2014



"Over the past 50 years, humans have changed ecosystems more rapidly and extensively than in any comparable period of time in human history. This has resulted in a largely irreversible loss in the diversity of life on Earth."

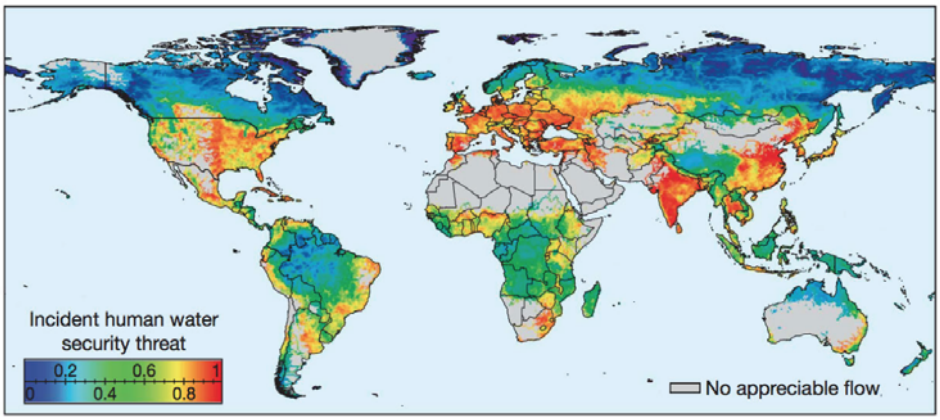
Millennium Assessment, 2005

Use of world environmental resources

- In **2014** there will be ...
  - **250 km³** water used
  - **275 km³** water evaporated from dams
  - **62 m** cars made
  - **100 m** televisions made
  - **365 m** computers made
  - **5 m ha** forest lost
  - **12 m ha** desertification (larger area than NZ North Island)
  - **10 m t** toxic chemicals produced

Threats to global water security and river biodiversity

~80% of the world's population lives in areas where the level of threat for water security and river biodiversity exceeds 0.75



Vörösmarty et al. 2010. Nature. Global threats to human water security and river biodiversity

Australian water wars

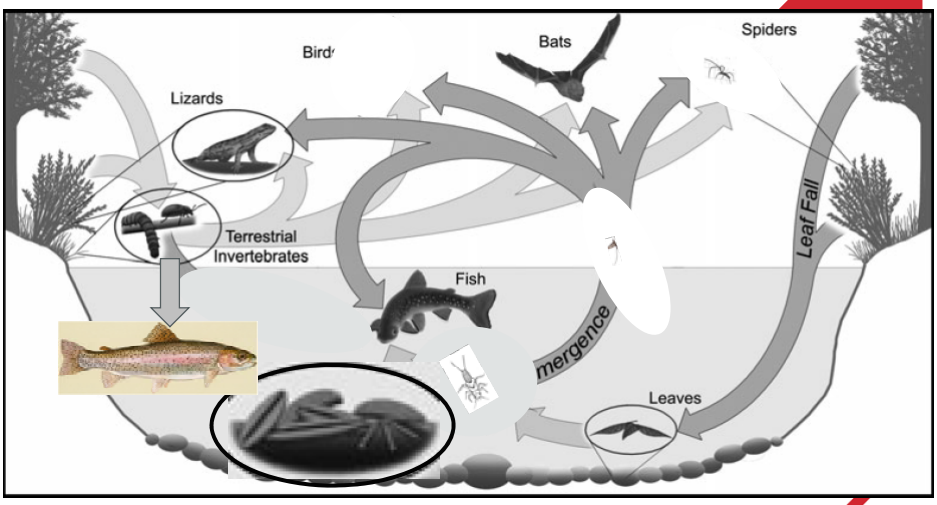
Cumulative impacts – expecting the unexpected

- Strong evidence quantifying historical cumulative impacts of existing developments
- Predictive capability in ecology is weaker by comparison, in part because of our limited ability to identify future scenarios

Hypothetical scenario:

What impacts would you expect following the introduction of a non-native species?

Cumulative impacts of introduced species

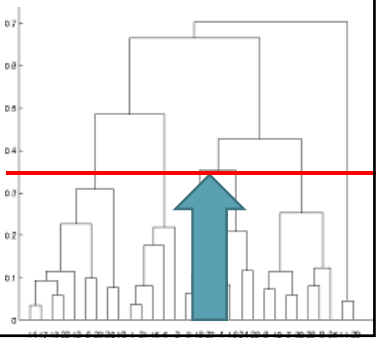


Baxter et al (2005) *Freshwater Biology* **50,** 201-220

Reductionist v systems approaches

Reductionist approach:

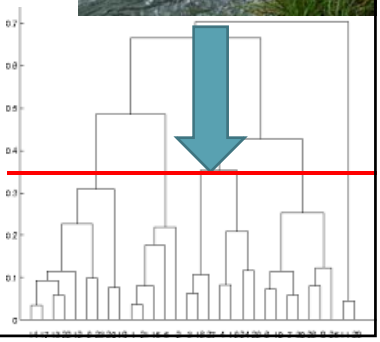
- Ecosystems are the sum of their components; cumulative impacts assessed by combining individual impacts
- Cumulative impact assessment ***requires*** knowledge of cause and effect responses to each development
- Mandates "bottom-up" approach to measure fine detail to identify significant impacts (= inefficient)
- Potentially useful for projects with few ecosystem components
- Risk of failing to predict emergent ecosystem properties and associated large-scale impacts



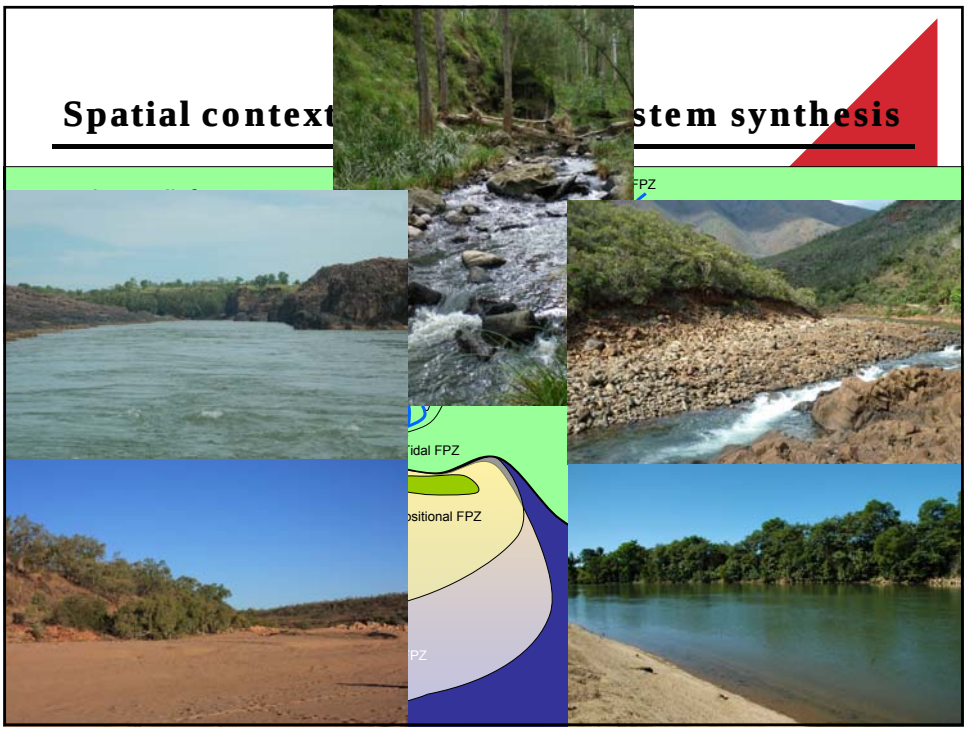
Reductionist v systems approaches

Systems approach:

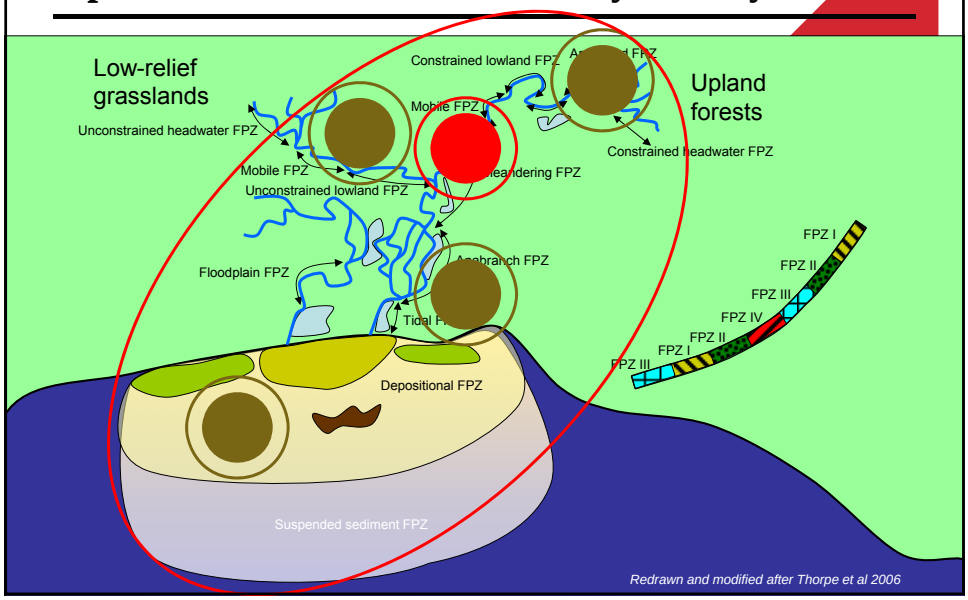
- Ecosystems have emergent properties beyond sum of components; cumulative impacts ***not*** assessed by combining individual impacts
- Cumulative impact assessment ***requires*** knowledge of emergent ecosystem properties; cause and effect responses to development
- Uses "top-down" approach; measures down to level required to identify impacts (= efficient)
- Useful for projects with many components
- Risk of failing to predict significant "small" impacts [e.g. threatened species]



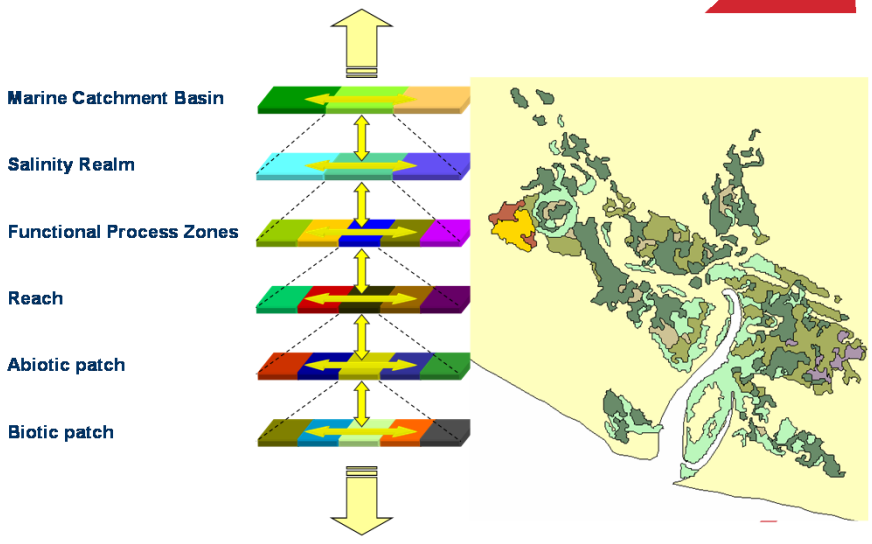
Spatial context … stem synthesis



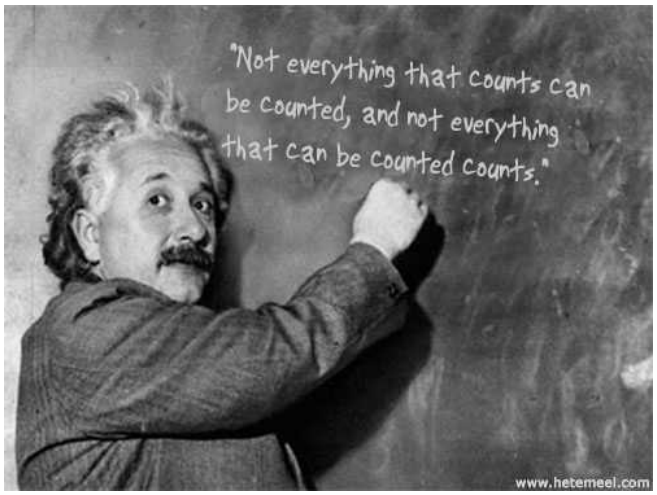
Spatial context: Riverine ecosystem synthesis



Scale dynamics of cumulative impacts



Focus on important impacts



Prof William Cameron

Terms of Reference

"predict** the **cumulative impact** of a project on environmental values over time and in combination with impacts ...* [of other developments] *... – as **detected** by **baseline monitoring"

- Implies ability to ***predict cumulative impacts*** based on ***existing detected impacts***. Expected impacts may not have yet occurred (future), and not detected by baseline monitoring (past and present)
- ToR preclude consideration of expected future impacts that have not yet been detected by ***baseline monitoring***
- ***Baseline monitoring*** refers to reference condition of unimpacted environment, not impacted condition
- Under ToR, prediction of cumulative impact is restricted to assessments based solely on pre-existing impacts, and precludes all other impacts

Typical impacts

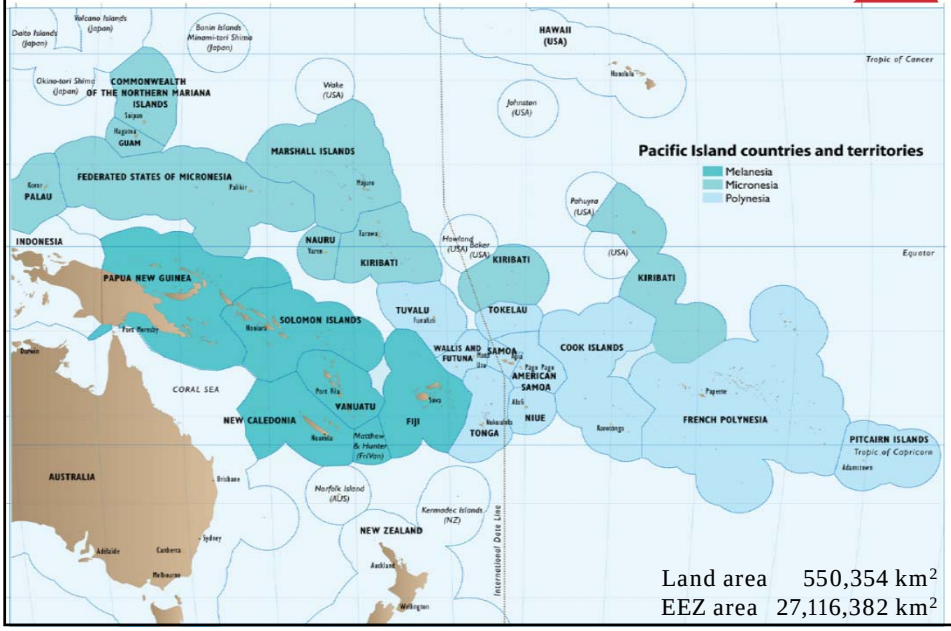
- Climate change and extreme events
- Catchment vegetation
- Surface-groundwater interactions
- Runoff and infiltration
- Water quality
- Water quantity (timing, magnitude, frequency, variability
- Riparian and channel habitats
- Material transport and transformations
- Biota
- Biological connectivity, barriers
- Ecological interactions (food webs etc)
- Pests and disease

- Predicting combined effects of these impacts from multiple projects, is technically challenging

Vulnerability of Tropical Pacific Fisheries and Aquaculture to Climate Change

A systems approach to cumulative impact assessment

Pacific Island Countries and Territories



Land area 550,354 km^2
EEZ area 27,116,382 km^2

Fish, Food Security and Climate Change

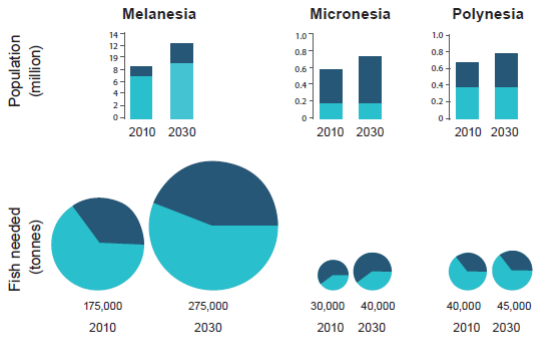
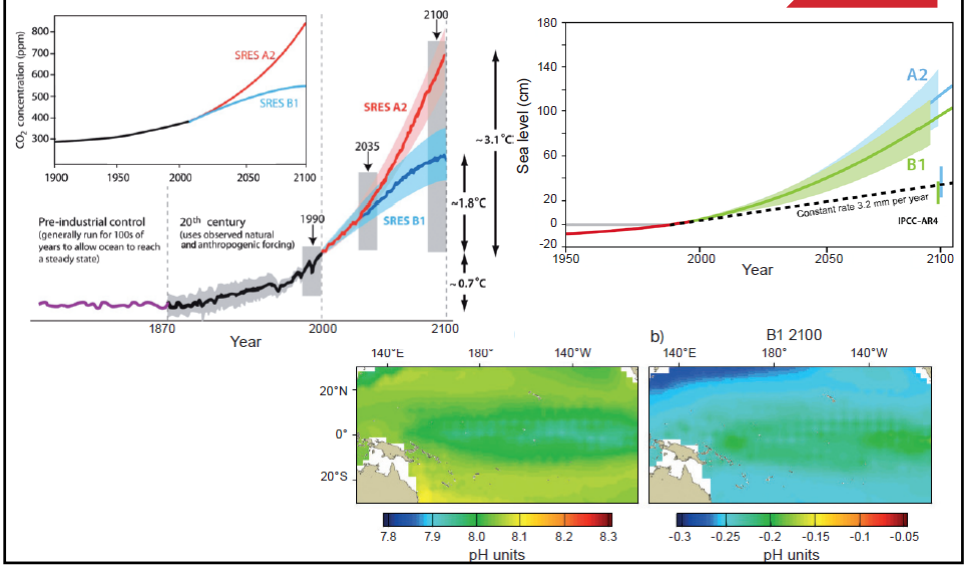


Figure 1.8 Forecasts of population growth, and the fish needed for food security in rural (■) and urban (■) areas of Melanesia, Micronesia and Polynesia in 2030 (source: SPC).

Another 115,000 tonnes of fish per year is needed just to meet diet requirements of population growth by 2030

Climate change effects on fish production?



Systems approach

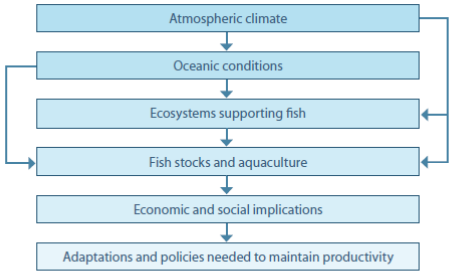
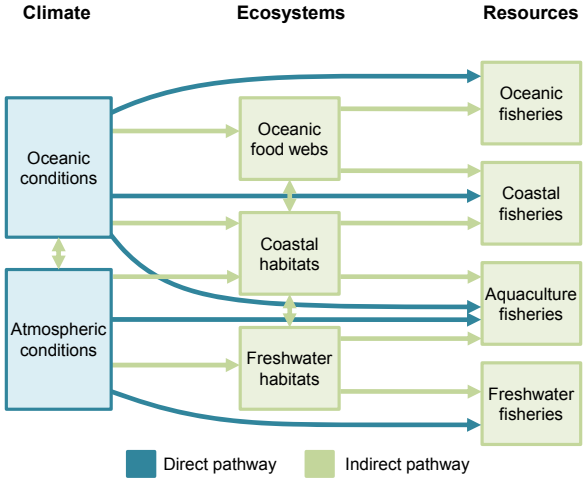


Figure 1.12 Summary of the approach used to assess the vulnerability of tropical Pacific fisheries and aquaculture to climate change. The approach is applied separately for oceanic, coastal and freshwater fisheries, and aquaculture.

System components



Vulnerability assessment framework

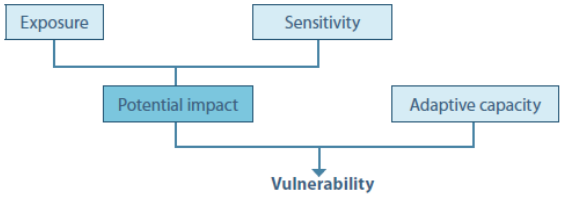
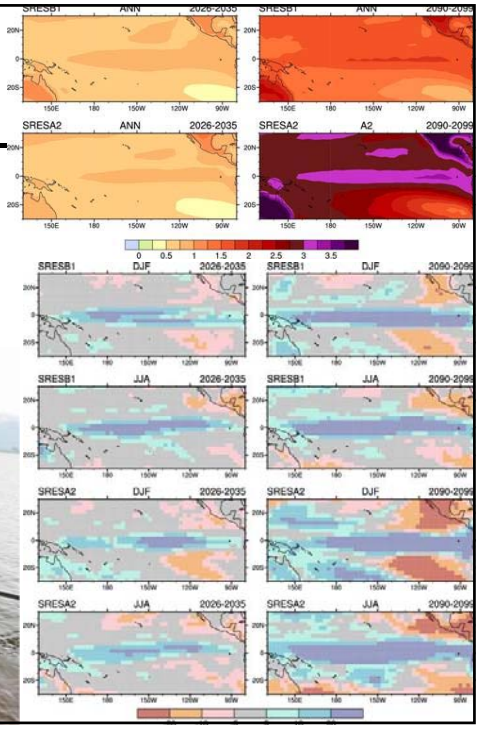


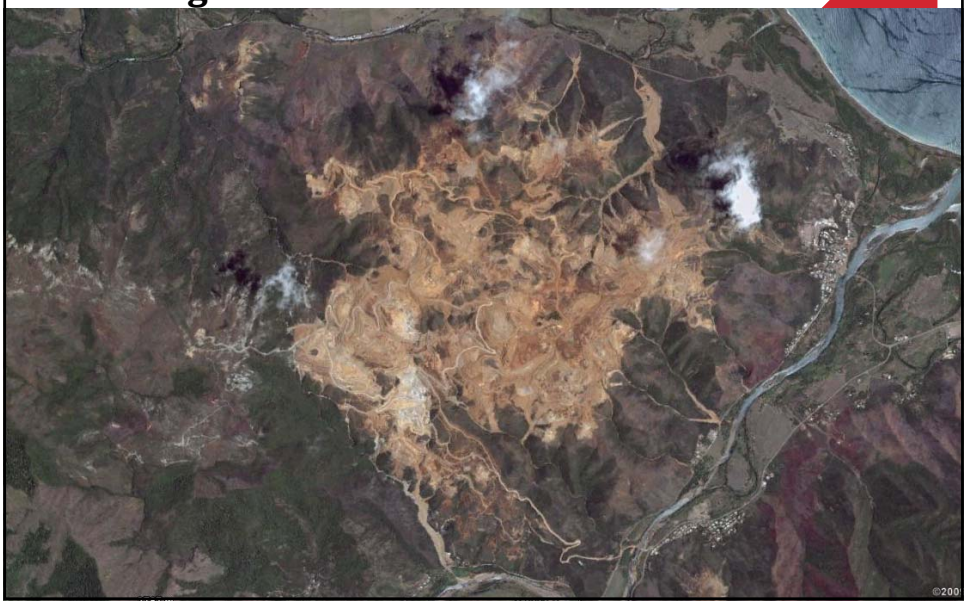
Figure 1.15 Framework used for assessing vulnerability of tropical Pacific fisheries and aquaculture to climate change. Adapted from Schroter and the ATEAM Consortium (2004)[106].

Freshwater and estuarine habitats and fisheries

- 10% to >20% rainfall increase = more habitat
- Temperature and other effects largely masked by rainfall
- Est. 5 – 12.5% increase in fish production

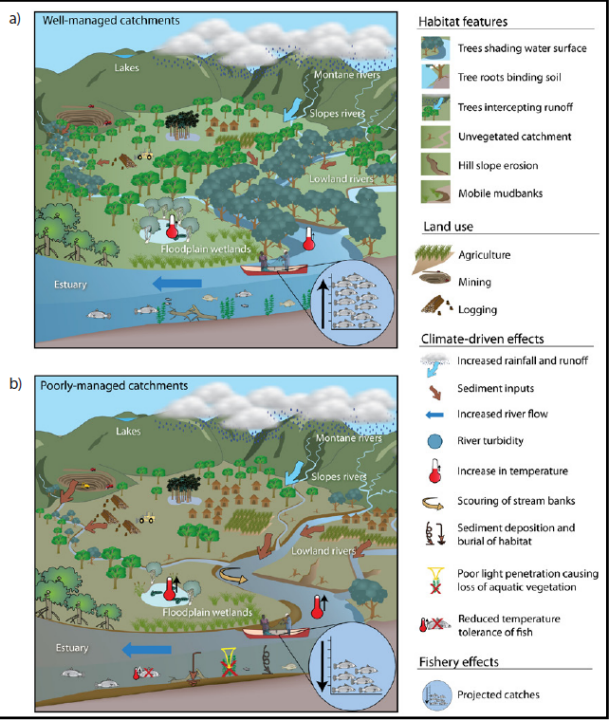


Mining and deforestation

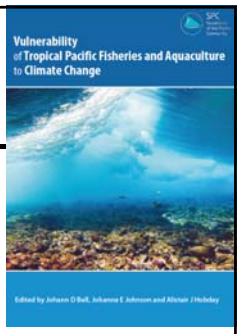


Communicating outcomes

- Technical detail
- Simple messages
- 10 – 20 page summaries for each country, cross-referenced to main document



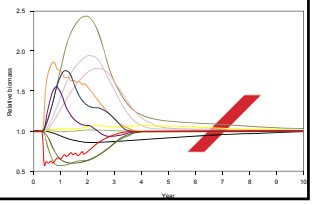
Cumulative findings

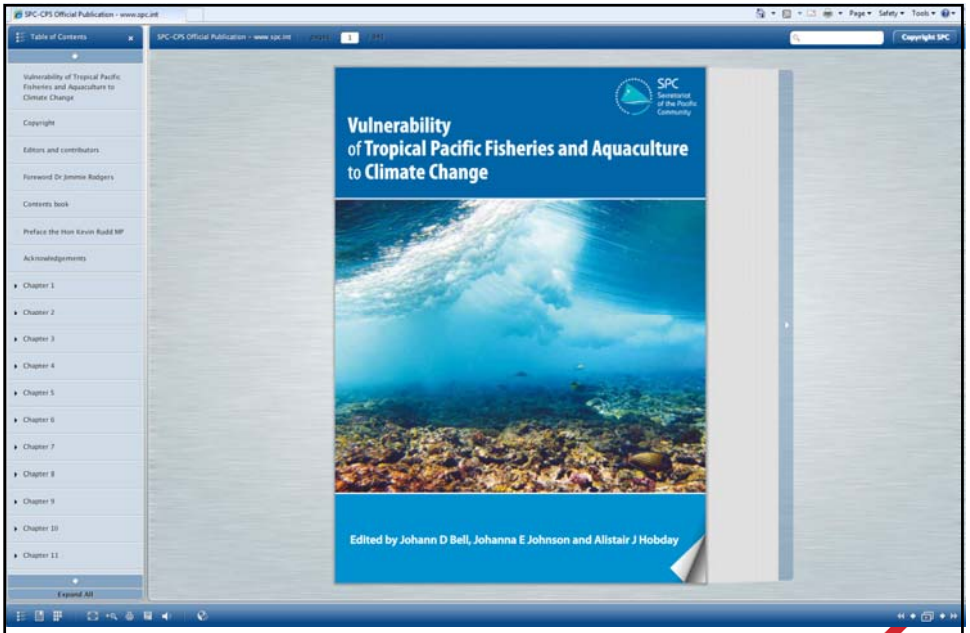


- There will be winners and losers from climate change
- Losers will include people who depend on coral reef fisheries
- Coastal communities will have to find new sources of food
- Winners will include freshwater fisheries and pond aquaculture in PNG, Fiji, Vanuatu and Solomon Islands; subject to ability to manage cumulative impacts of mining, forestry, agriculture and urban development
- Need greater reliance on tuna for food, income, and livelihoods for growing population

A way forward

- Outcome focus – Government policy
- Think BIG – our clients are – and focus on holistic, systems-scale approaches
- Acknowledge the fine detail (e.g. threatened species), but don't get bogged down in reductionist thinking
- Critical need to understand how systems work, and roles of key species and processes (robust conceptual models)
- Work with agencies to resolve nonsensical requirements
- Promote conceptual and quantitative tools and models that allow systems thinking





http://www.spc.int/climate-change/fisheries/assessment/e-book/