Complexity Science in Action

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Nested Scales
Scales

- Bacteria
- Phytoplankton
- Zooplankton
- Fish
- Mixed-layer depth
- Largest whale
- Mean depth of ocean
- Internal Rossby radius
- Ocean Basin
- Ningaloo process scales
- Ningaloo management scales

Scales range from 1 mm to 10^10 km:
- 10^{-6} km
- 10^{-4} km
- 10^{-2} km
- 10^0 km
- 10^2 km
- 10^4 km
- 10^6 km
- 10^8 km
- 10^{10} km
Regulatory Jigsaw
Regulatory Focus
Northwest – Multiple Use
Marine multiple use management

- Conservation
- Ports & Coastal Developments
- Recreation & Tourism
- Transport & Shipping
- Fisheries & Aquaculture
- Mining, Oil & Gas
- Renewable Energy
- Catchments & Outfalls
Decision Processes

Goals → Situation → Problem → Decision → Results → Assumed

Decision Processes

 Goals (drivers) of others

 Decisions

 Environment

 Goals

 Action of others

 Side Effects

 Potential

 truth

Mis-judging feedback

Under steer

Over steer
Training (brain)
1. Participatory Modelling

- Classical approach
  - Problem
  - Analysis
  - Solution

- Participatory approach
  - Problem
  - Analysis
  - Solution
2. Complexity science

- Systems Theory
- Nonlinearity
- Networks
- Pattern Hierarchy
- Agent Based Models

Integrated Approach
Multiple models

- All individually useful
- Don’t always need the set

- Toy
- Focused
- Conceptual
- Large (full) models
- Shuttle
System Spanning

Environment

Industry

Economy

Infrastructure

Society

Foodwebs

Reporting

Monitoring

Governance

Lobbying
Qualitative

ECOSYSTEM

INDUSTRY

GOVERNANCE

ECONOMY & SOCIETY

Conceptual
Empirical & Focused

- **Species & Habitats**
- **Reporting**
- **Monitoring**
- **Industry**
- **Economy**
- **Governance**
Toy models

ECONOMY

GOVERNANCE

INFRASTRUCTURE

ECOSYSTEM

INDUSTRY
Minimum realistic (shuttle ideas)
Full quantitative

Environment

Foodwebs

Industry

Economy

Society

Infrastructure

Lobbying

Governance

Reporting

Monitoring

Large model
Full quantitative

Environment
- Grided data
- Lagrangian ocean
- Habitat Metapopulation
- Schools of fish
- Individual top predators

Industry
- Large model

Economy

Infrastructure

Lobbying

Society

Reporting

Governance

Monitoring

Foodwebs
Full quantitative

Environment
- Gridded data
- Lagrangian ocean
- Habitat Metapopulation
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Foodwebs

Industry
- Sector models
- Stocks & flows
- Agent based
- Empirical

Economy
- Input-Output
- Empirical
- Agent based

Infrastructure
- Stocks & flows

Reporting
- Statistical

Monitoring
- Statistical

Governance
- Rule-based

Lobbying

Society
- Agent based
- Networks
- Matrices

Large model
Multiple models

Full study (and model development)

Learning
- Conceptual
  - Single focus
  - Toy models

Problem definition
- Conceptual

Skill training
- Toy models
  - Shuttle models

Showcase + model refinement
- Single focus
  - Shuttle models

Implement + set scenarios
- Single focus
  - Shuttle models

Full system model
- Full model
Australian Example: SE Fishery

- Multi-everything fishery
- Highly diverse and variable
- Solutions needed
Find small interventions with large returns

Avoid large interventions with small returns
Expert Assumptions

- Each concentrate on focus topic
  - Stock assessments, economics
  - Assumed linear relations
  - Miss interactions
  - Miss dynamic human behaviour

Gross Value Product

Fish Size
Scenarios

- Status quo (quota management & not that effective)
- Quotas on everything of value
- Integrated management (zoning; gear restrictions; quotas)
- Conservation driven (open paddocks, closed world)
Assumed vs Reactive Responses

- Qualitative analysis
  - pessimistic
  - optimistic

- Quantitative analysis

Status quo (2006)
Assumed vs Reactive Responses

- Qualitative analysis
- Quantitative analysis

Lots of quotas

Diagrams showing comparison between assumed and reactive responses in various contexts such as industry, certainty, social, management efficiency, and broader ecosystem.
Assumed vs Reactive Responses

- Qualitative analysis
- Quantitative analysis

Conservation

- Industry
- Certainty
- Social
- Broader ecosystem
- Management efficiency

Target species

- Industry
- Certainty
- Social
- Broader ecosystem
- Management efficiency

Target species
Assumed vs Reactive Responses

- Qualitative analysis
- Quantitative analysis

Integrated

- Target species
- Industry
- Certainty
- Social
- Broader ecosystem
- Management efficiency

Integrated

- Target species
- Industry
- Certainty
- Social
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- Management efficiency
Disciplinary Focus

- Best management = quotas (mostly)
Cross-disciplinary Links

- Best management = quotas + spatial + gear restrictions
- Similarly for coastal zone management

Decision rules
Industry statistics
Lobby groups
Monitoring
Stocks
Fishery
General Finding & Outcomes

- Trade-offs
  - Sectors (small and large)
  - Timescales (short-term costs vs long-term risk)
  - Conservation vs economic objectives

- Fishery restructured
Conclusions

- Integrated adaptive management = most effective management option

- Coasts & oceans (& society of users) = complex systems

- Complexity science-based toolbox
  - explore alternative futures (feedbacks & uncertainty)
  - can be transformative
  - industry & biophysical usage becoming more common
  - inclusion of social aspects rarer (often critical though)
  - transdisciplinarity is key (especially being participatory)
Agent based modelling

Networks

Chaos

Systems Theory

Complexity

Self-organisation

Emergence

Non-linearity

Bayes
Taking a systems approach to systems
Thank you

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