InVitro (agents in glass): MSE modelling

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CSIRO Marine Research

Acknowledgements

InVitro MkII

Randall Gray

Roger Scott

Fabio Boschetti

InVitro Mk I

Rich Little

Brian Hatfield

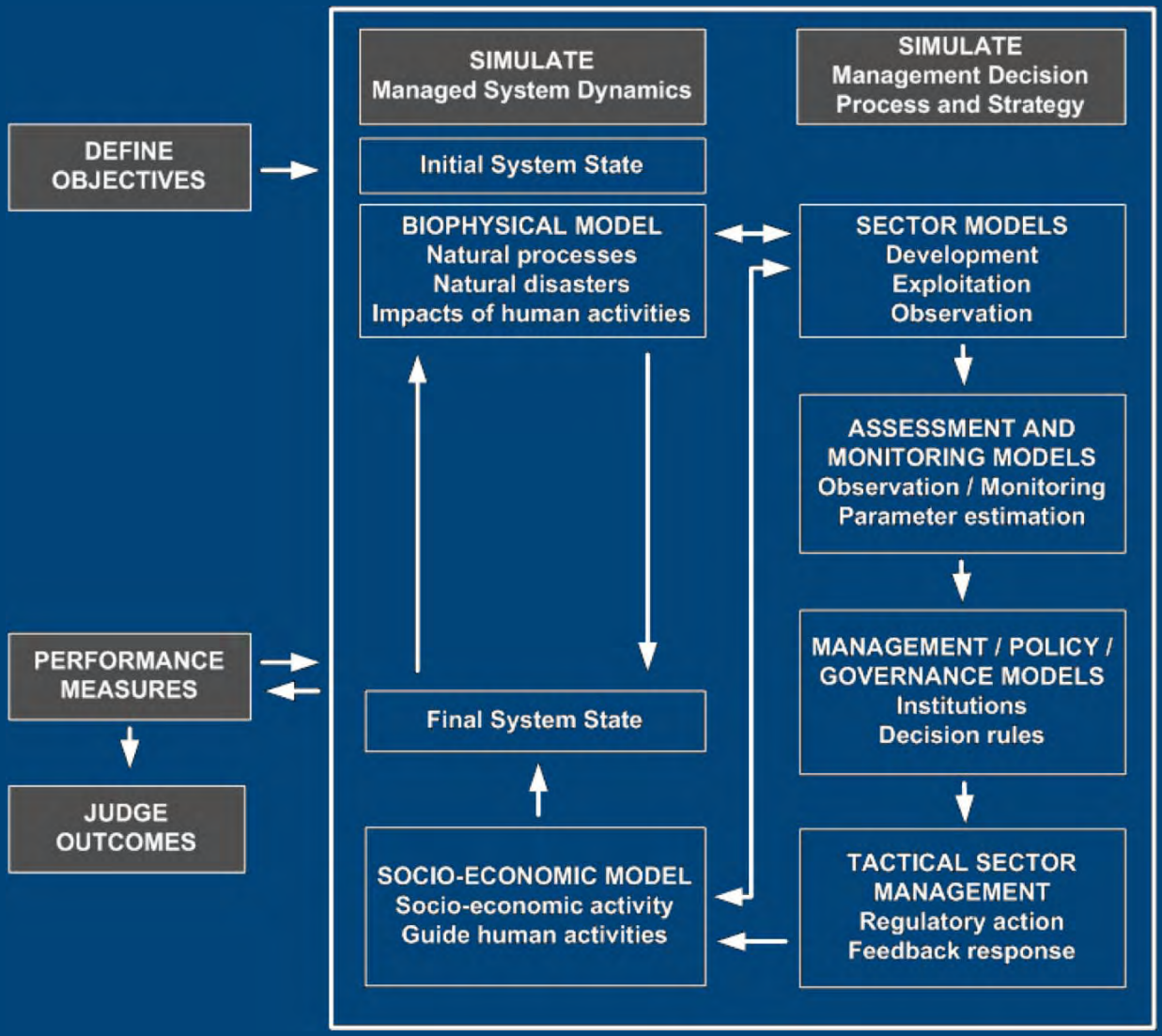
Keith Sainsbury

Vince Lyne

Motivation and Challenges

- Legislation requires assessment of environmental impacts
- Sustainable management & use across sectors = multiple use management
- Multiple stakeholders = multiple diverging interests and conflicting management objectives
- Uncertainty about managed resources, environment and interaction of sectors (response to management strategies)

Management Strategy Evaluation

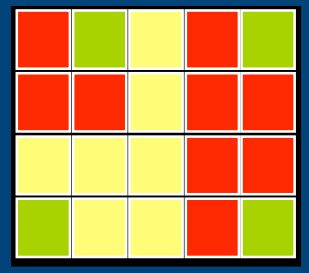


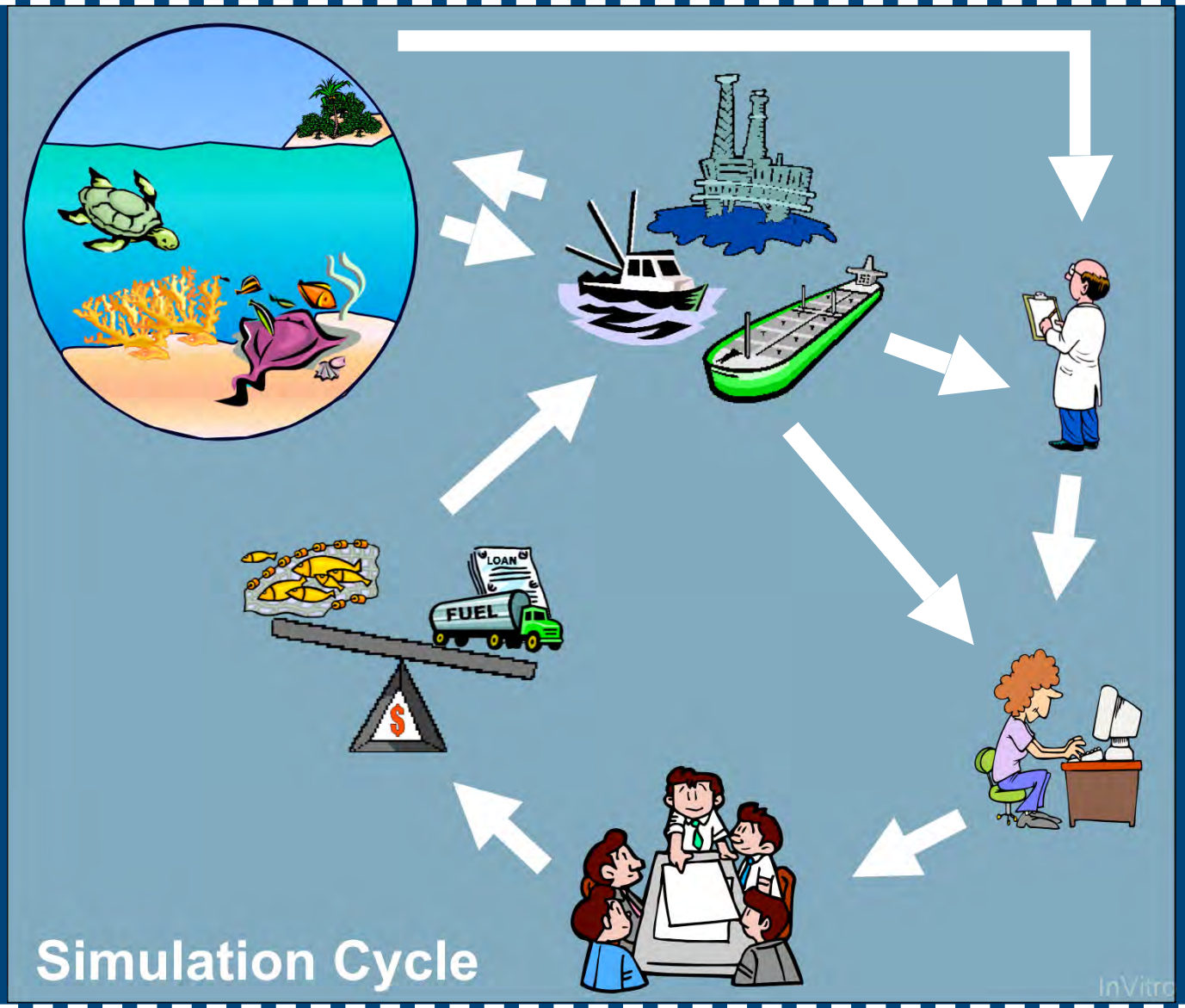
MSE framework

Design & Analysis

Define Objectives

Performance Measures





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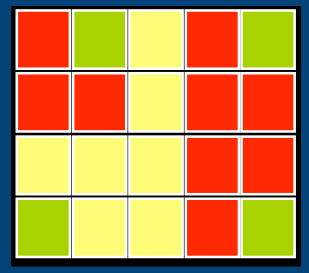
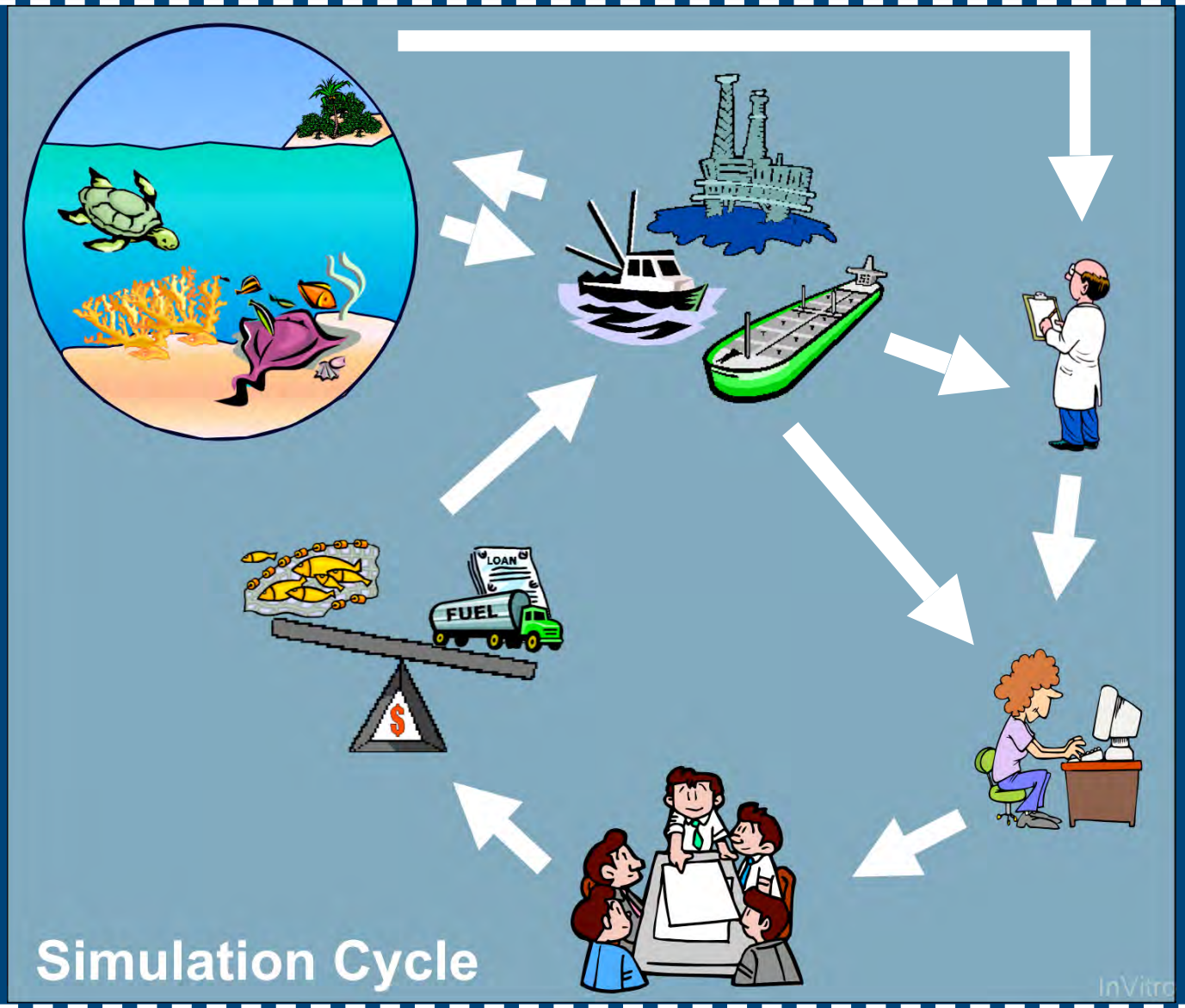
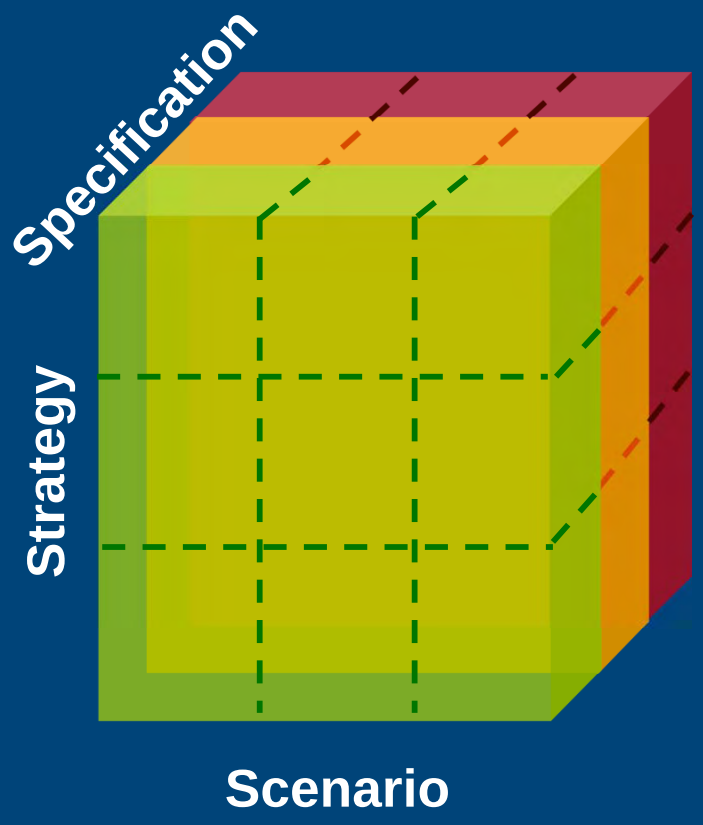




Handling Uncertainty



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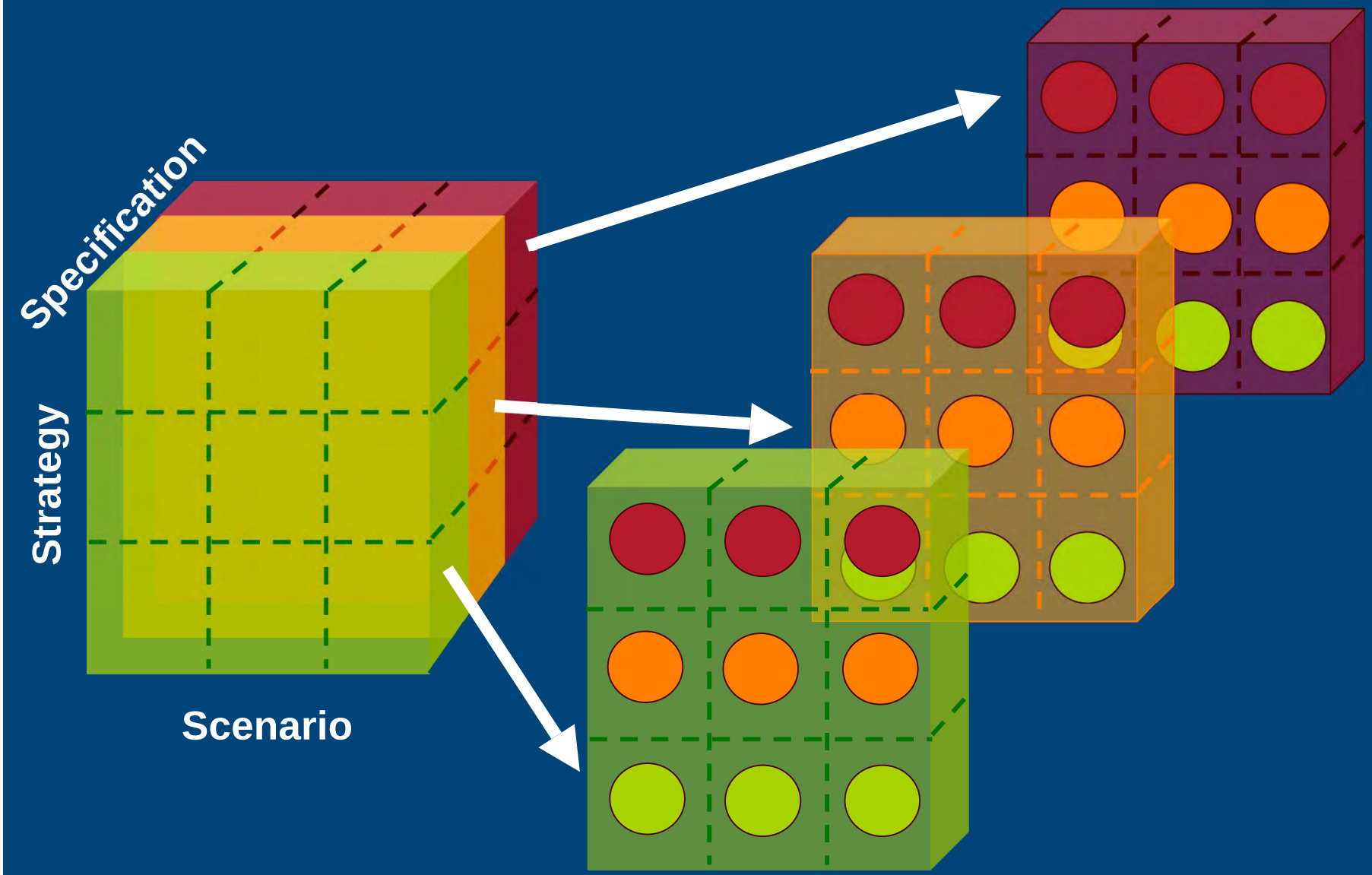
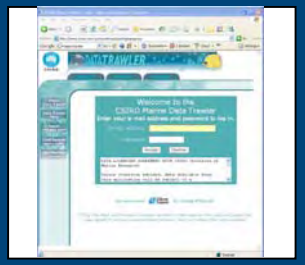
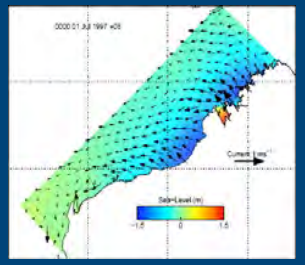
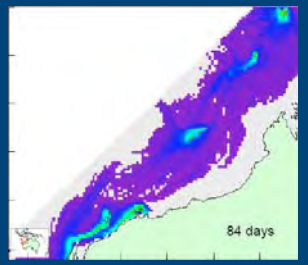


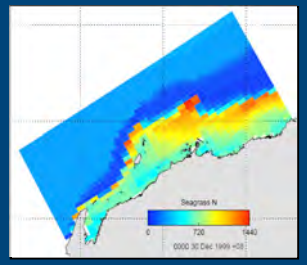
Building the Model

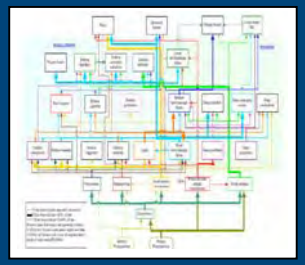
- Iterative information gain

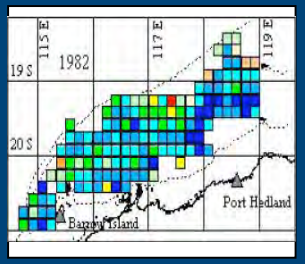


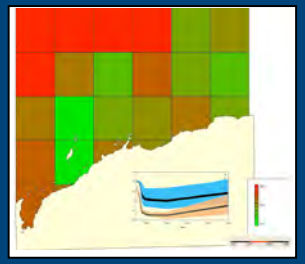


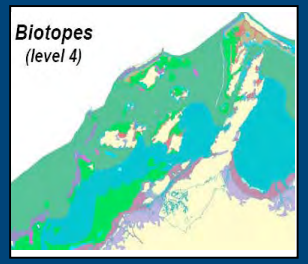


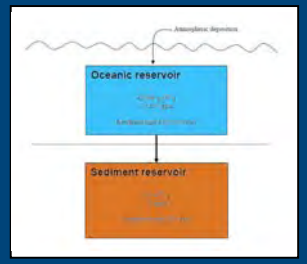


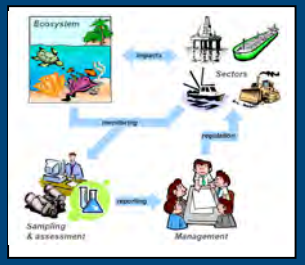


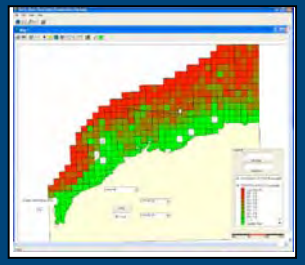




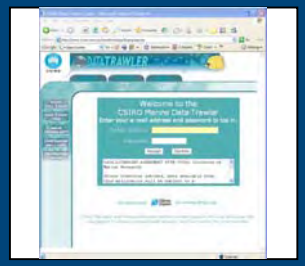


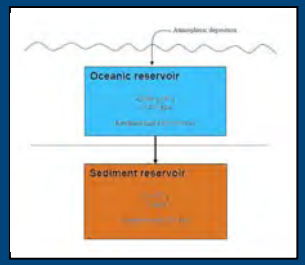


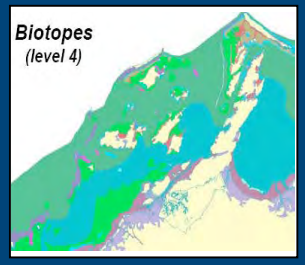


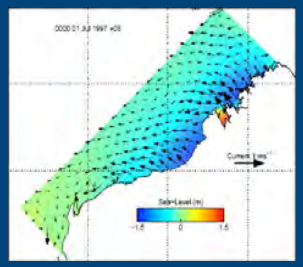


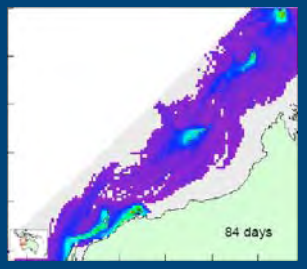
Building the Model

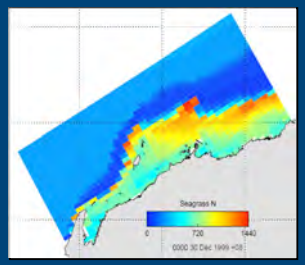


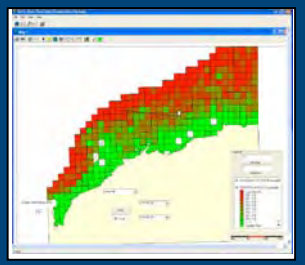






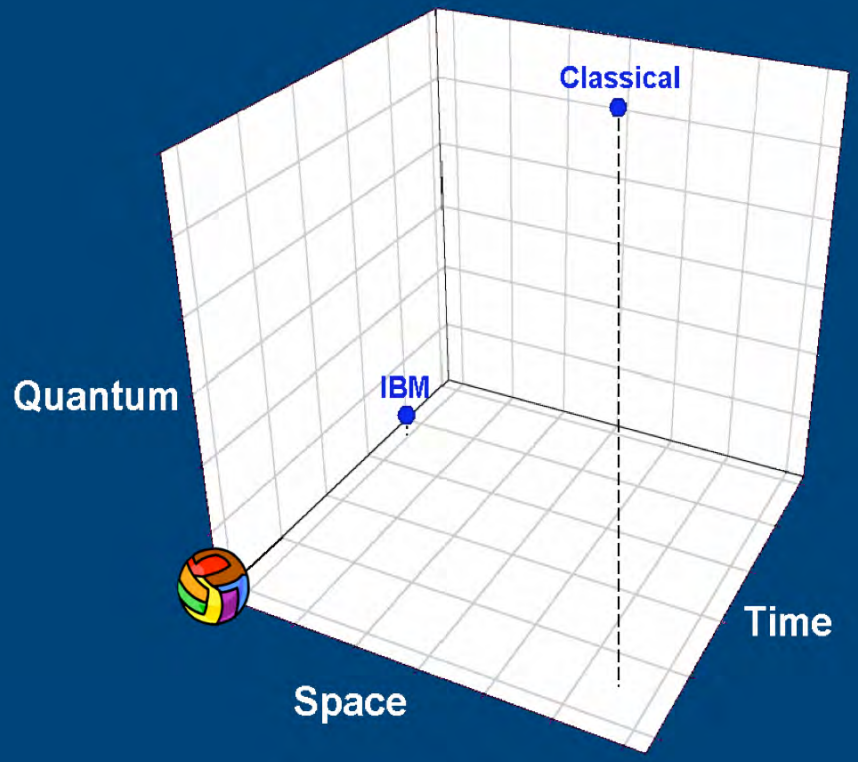






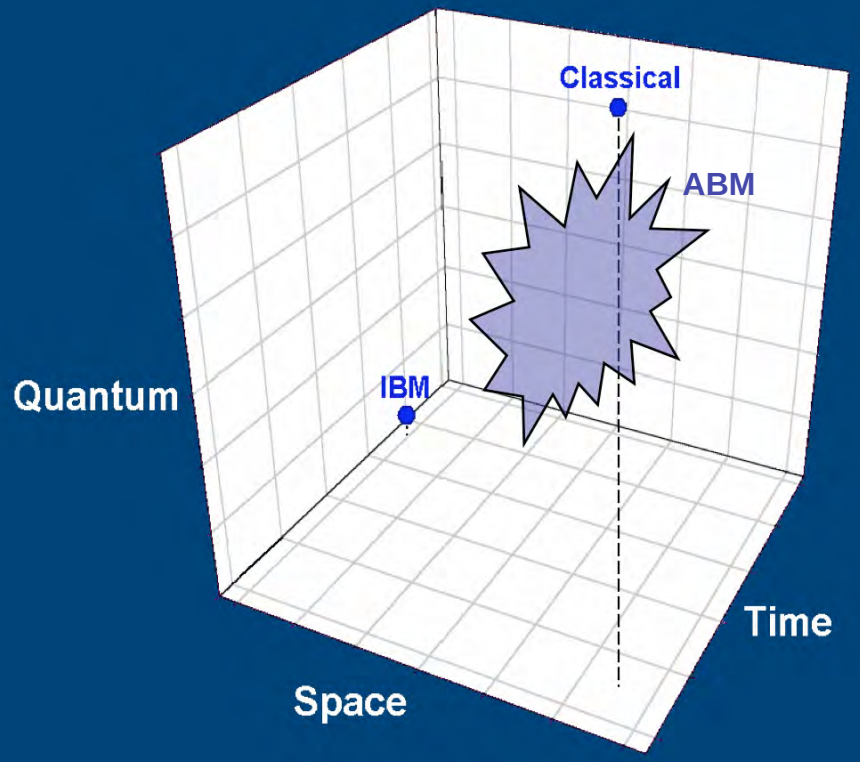
Data + analysis **Process models** **MSE** **View**

InVitro



- Targeted agent-based behaviour model
  - mix of differential equations and decision trees

InVitro



- Targeted agent-based behaviour model
  - mix of differential equations and decision trees

Agent Based

- Basic structure = behaviour / process decision tree
  - process based
  - alternate formulations dependent on resolution

differential equations ⟷ individual-based

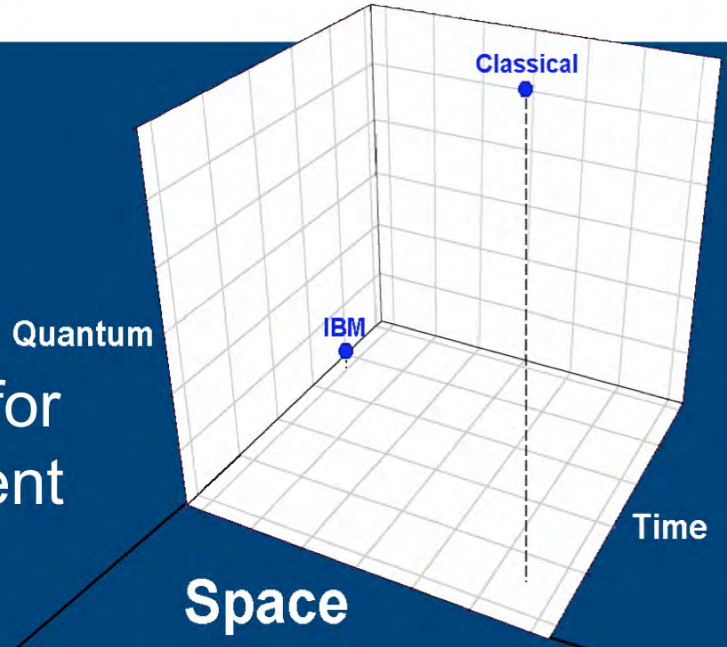
high ⟵ group membership ⟶ low

low ⟵ trophic level ⟶ high

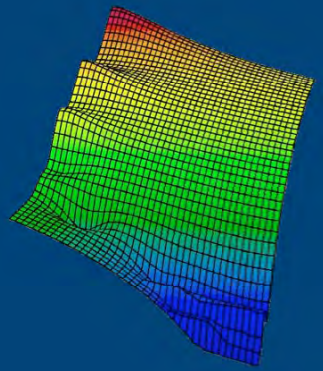
coarse ⟵ scale (space, time) ⟶ fine

Resolution

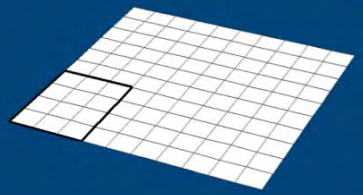
- 3D spatially explicit
- Variable time step
- Best resolution used for each system component



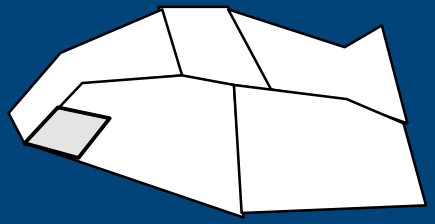
continuous



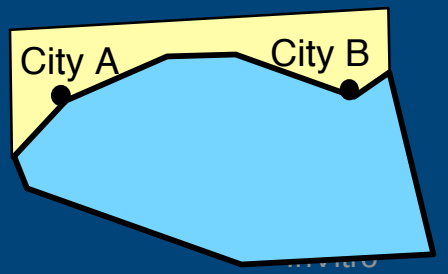
gridded



regional

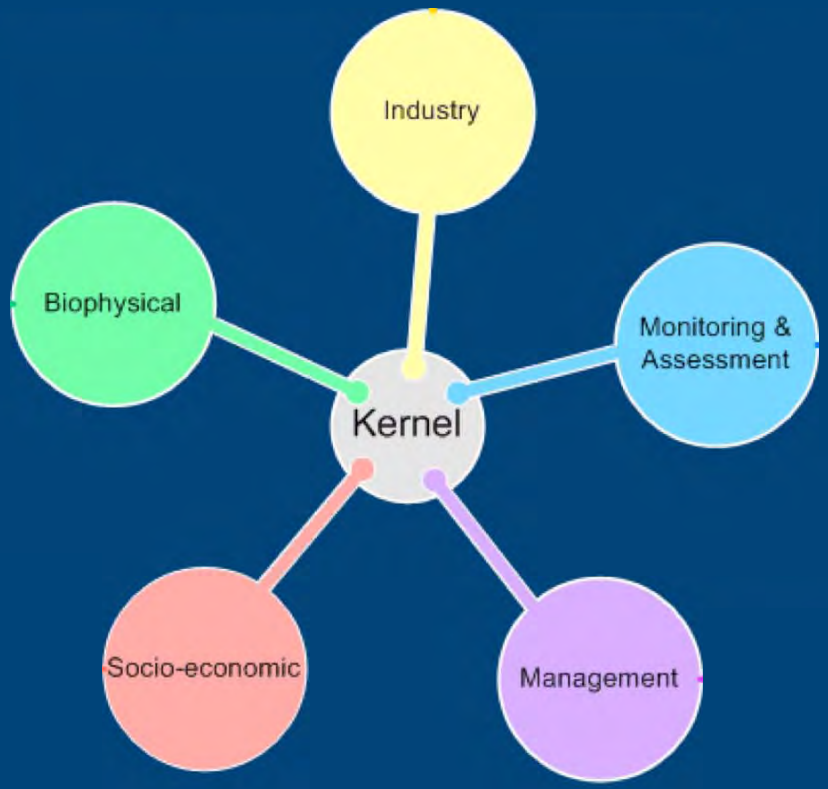


global

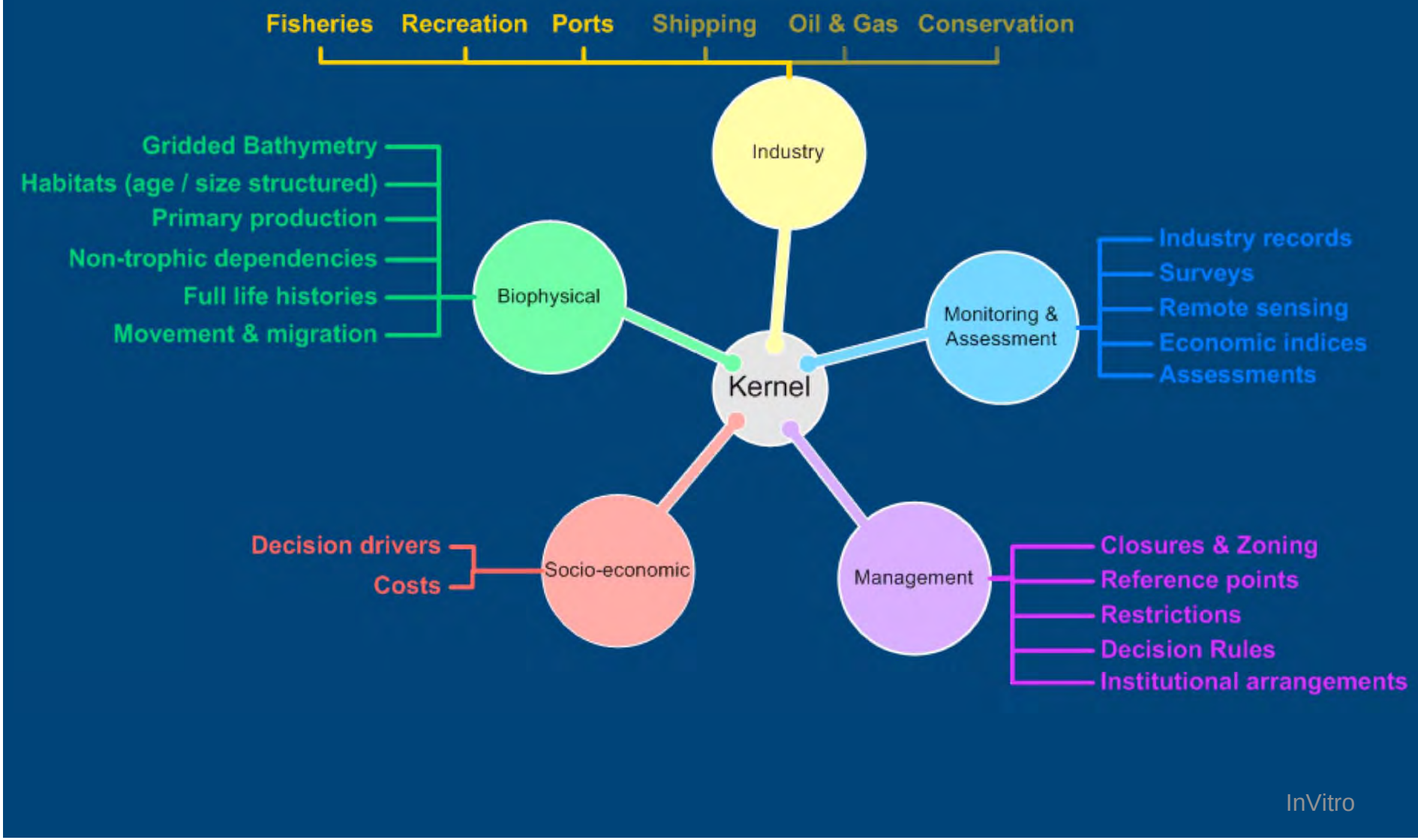


Modular Structure

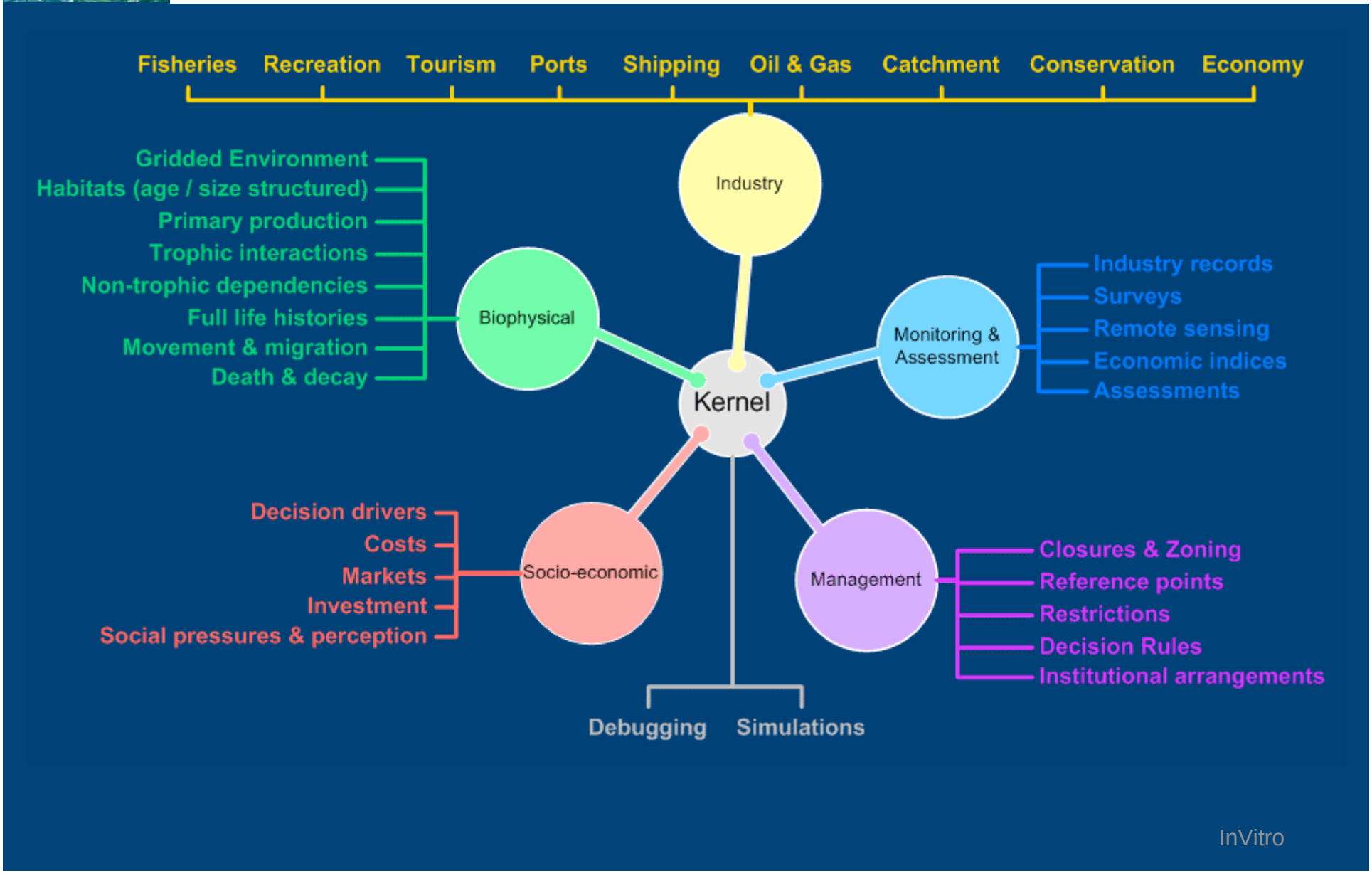
Capability


Industry
Biophysical
Monitoring &
Assessment
Kernel
Socio-economic
Management

Dynamic vs Forced

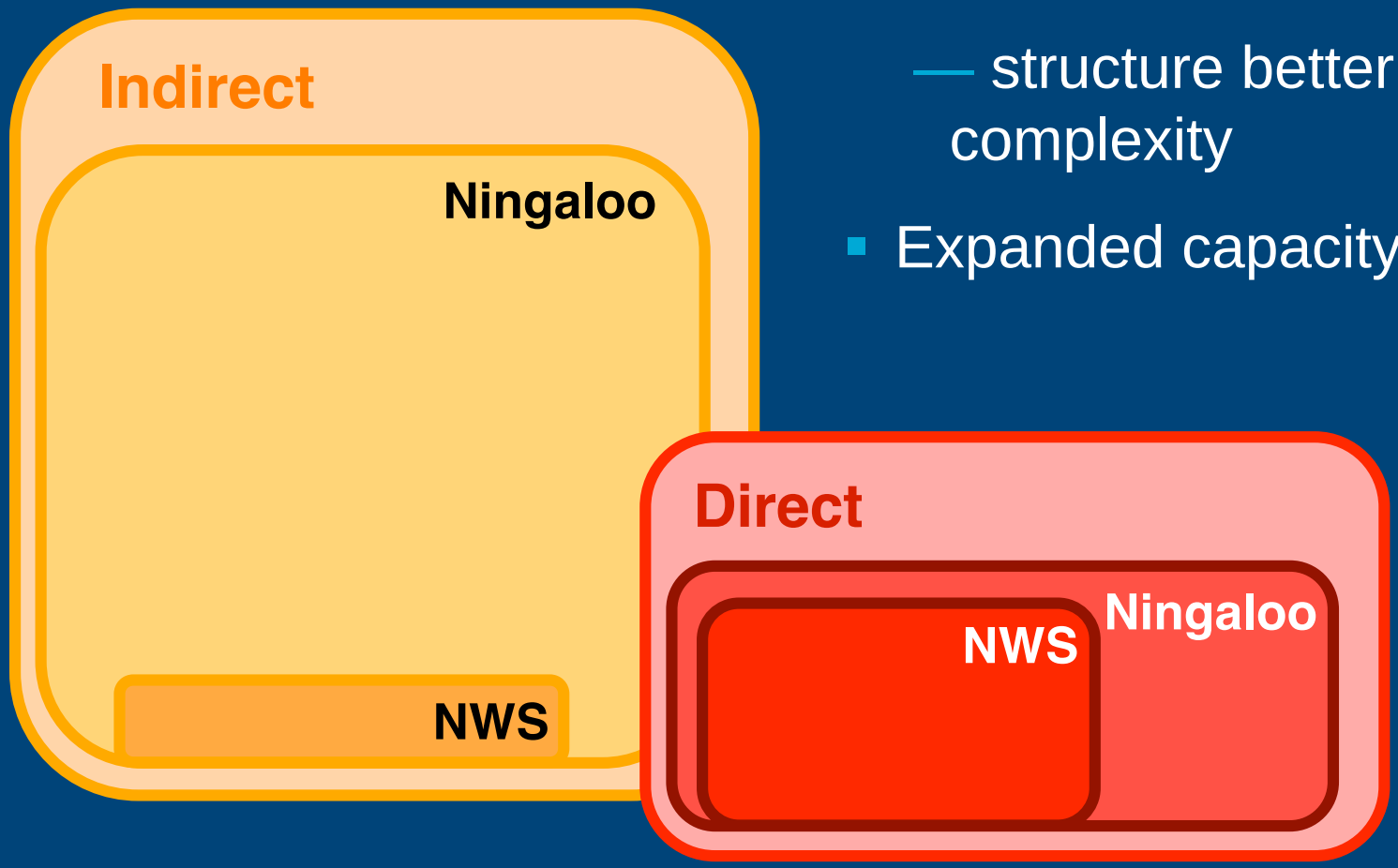


Then vs Now

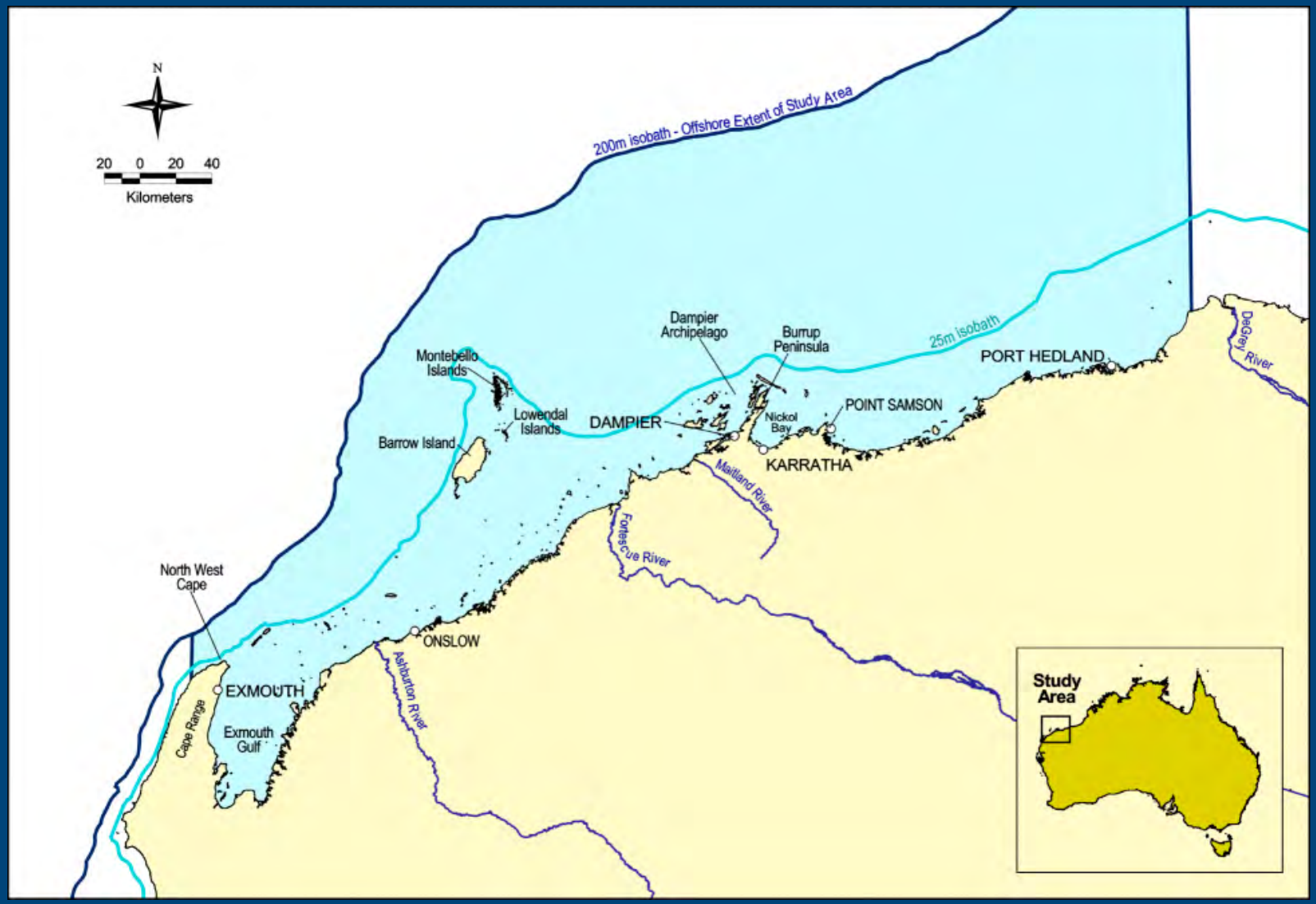

Fisheries
Recreation
Tourism
Ports
Shipping
Oil & Gas
Catchment
Conservation
Economy
Industry
Gridded Environment
Habitats (age / size structured)
Primary production
Trophic interactions
Non-trophic dependencies
Full life histories
Movement & migration
Death & decay
Biophysical
Kernel
Monitoring & Assessment
Industry records
Surveys
Remote sensing
Economic indices
Assessments
Decision drivers
Costs
Markets
Investment
Social pressures & perception
Socio-economic
Management
Closures & Zoning
Reference points
Restrictions
Decision Rules
Institutional arrangements
Debugging
Simulations

Lessons Learnt

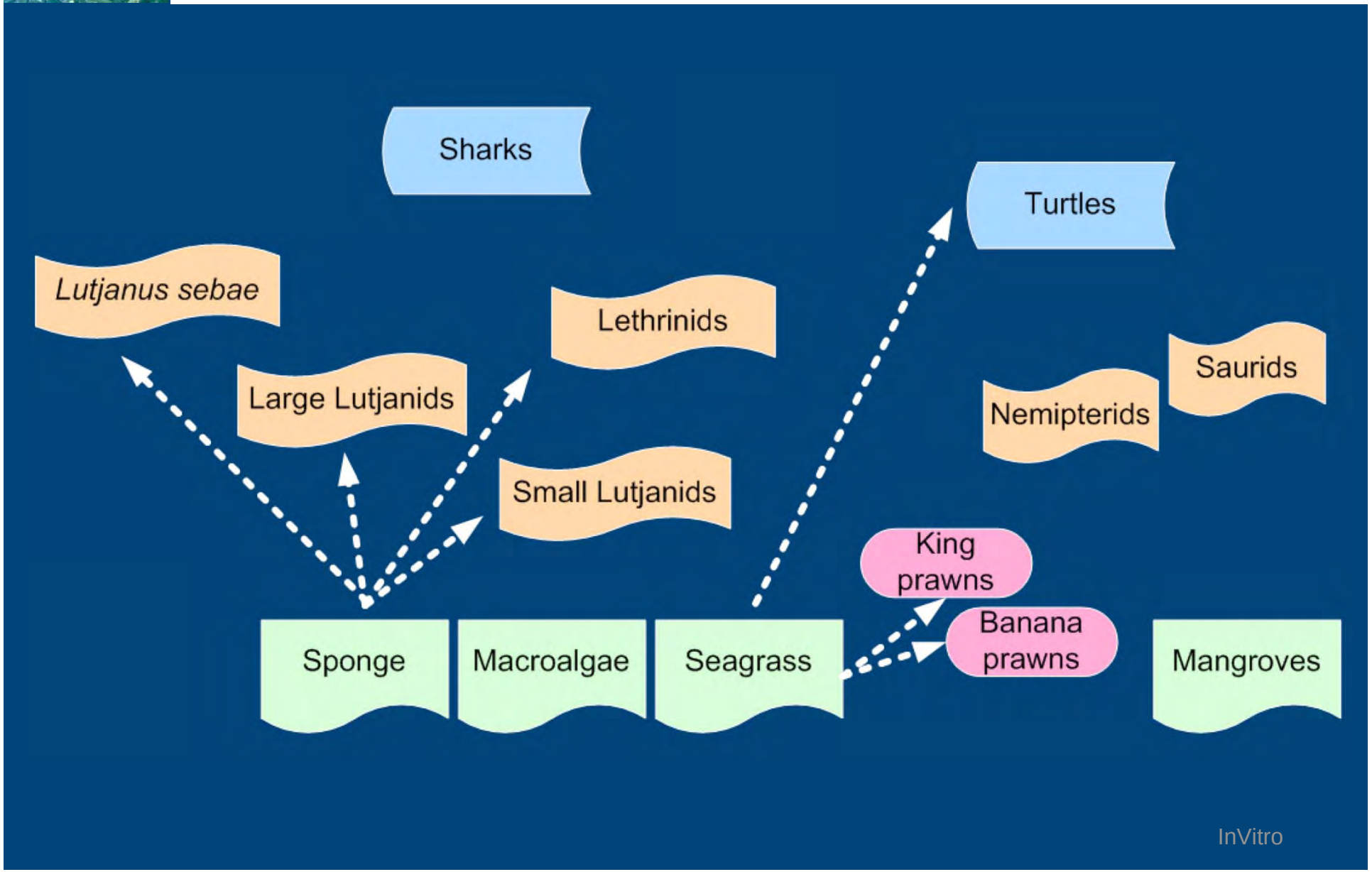
- Lessons well learnt
  - structure better than complexity
- Expanded capacity



Model Domain

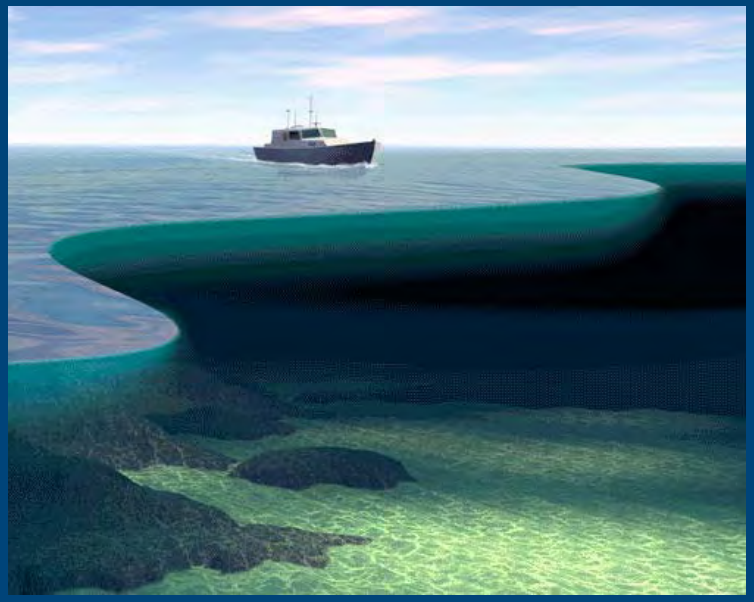


Biological Groups

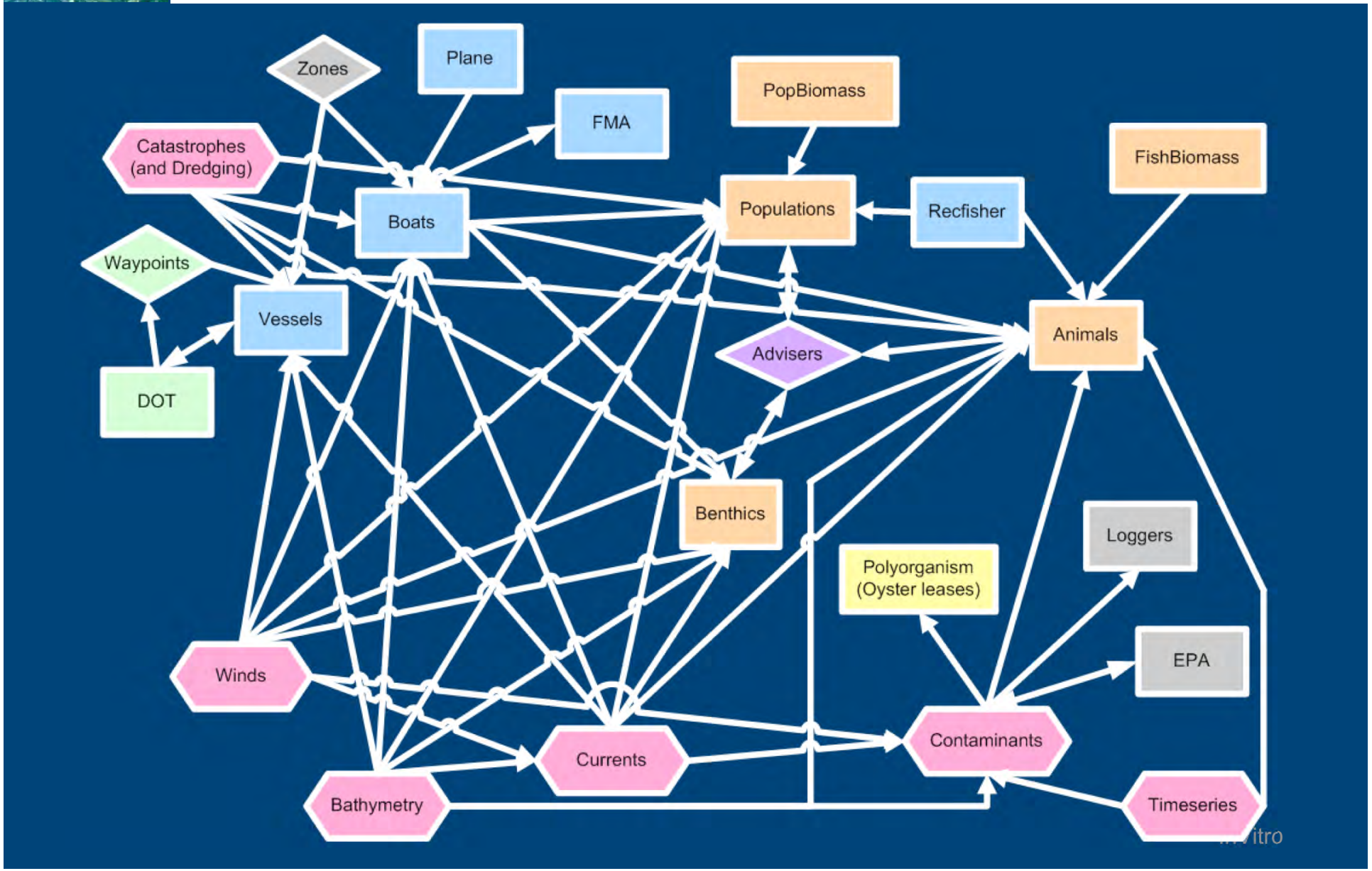


Human Sectors

- Fisheries
  - commercial
  - recreational
  - surveys
- Ports
- Shipping
- Coastal development (and leaching)
- Plumes
- Oil and Gas
- Conservation



All together



Strategies

- **Status Quo**: **Continue as in 2000**
  - not much to recommend it (for most sectors)
  - state declines, economics follows eventually
  - possible for a single sector to overwhelm
- **Enhanced**: **Best practice per sector**
- **Integrated**: **All sectors together**

Strategies

- **Status Quo**: **Continue as in 2000**
- **Enhanced**: **Best practice per sector**
  - strong returns (especially short-medium & good conditions)
  - less variability
  - doesn’t help regional state (juggling local recoveries)
  - can’t help in poor conditions
  - management costs & tension
- **Integrated**: **All sectors together**

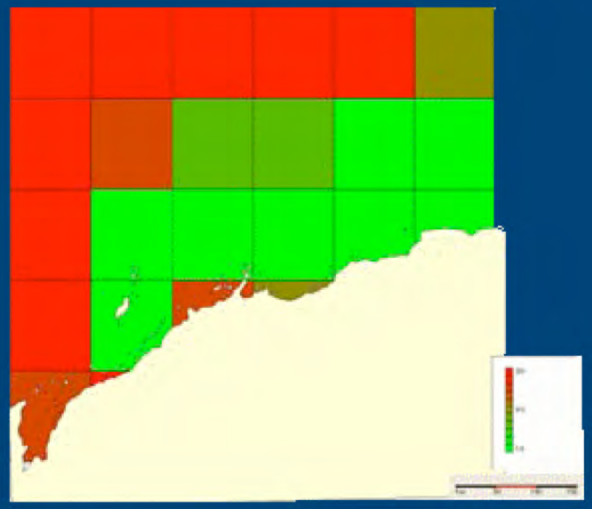
Strategies

- **Status Quo**: **Continue as in 2000**
- **Enhanced**: **Best practice per sector**
- **Integrated**: **All sectors together**
  - improved system state
  - higher rates, lower absolute yields
  - sensitive to how implemented (costs & objectives)

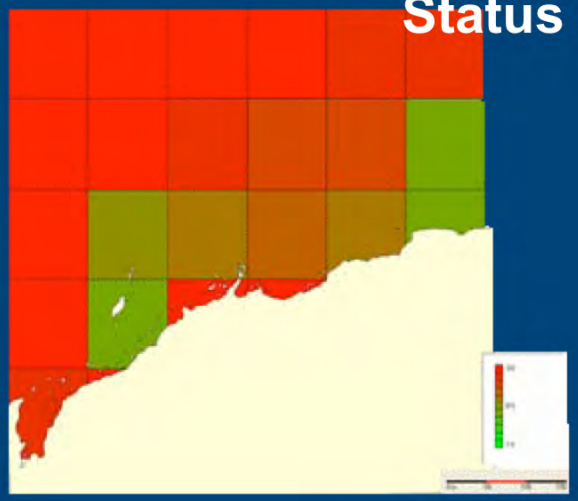
- **Biggest differences under poor conditions**
  - need to determine baseline productivity?

General Distributions

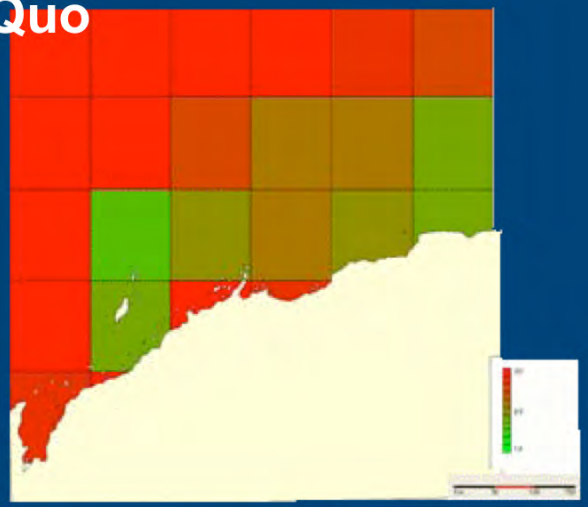
Status Quo



1970

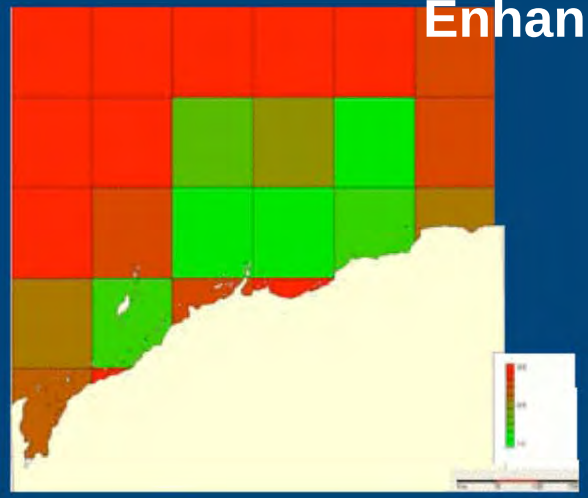


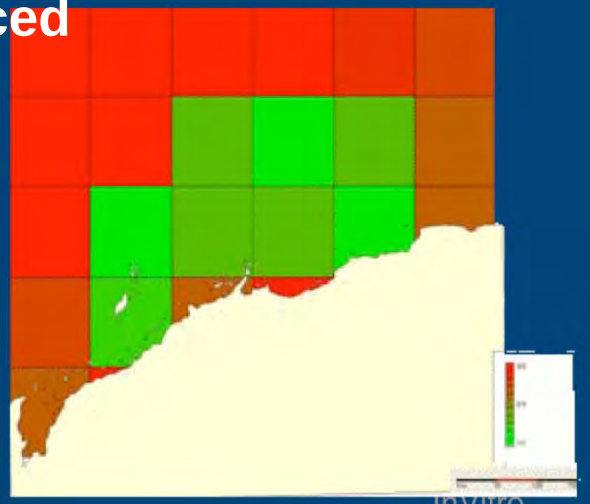
2000



2016

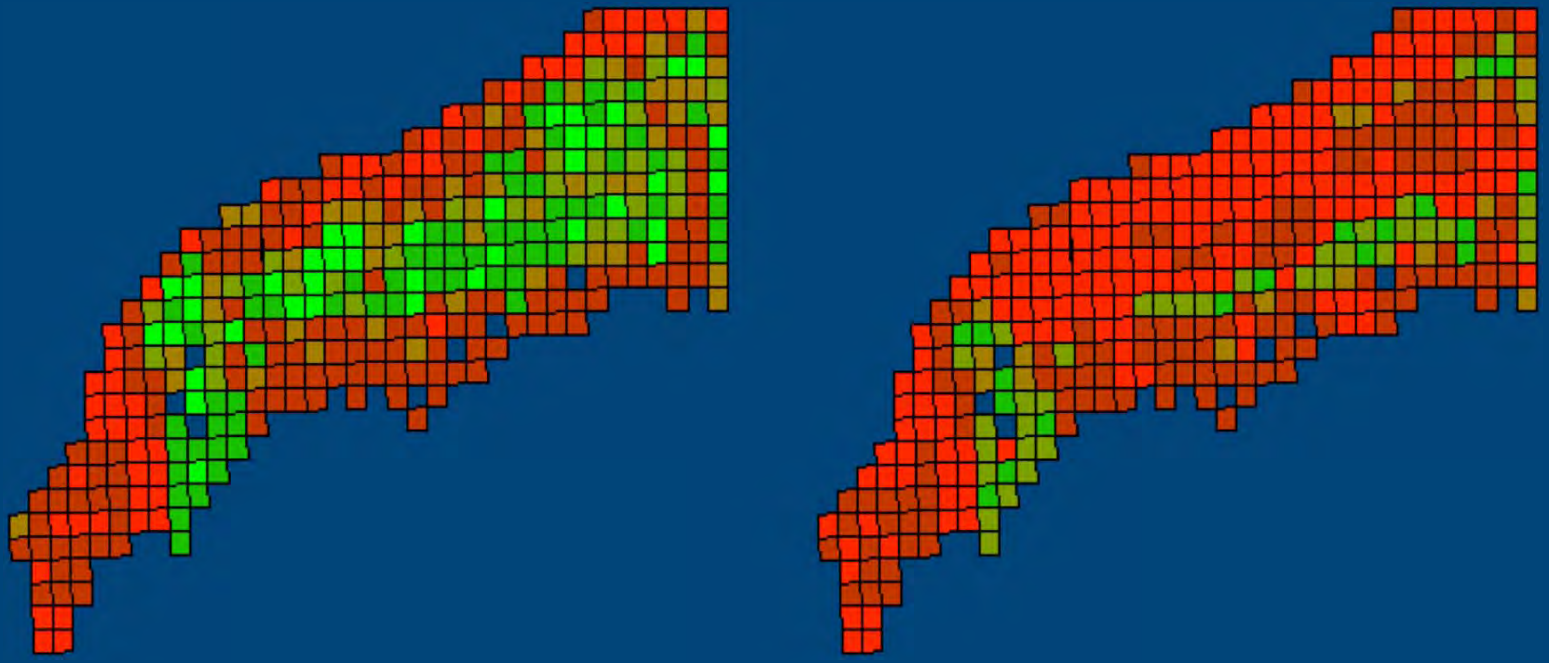
Enhanced





Historical Impacts & Context

- System still recovering from past events (60s-70s)
- Benthic habitat and trawling

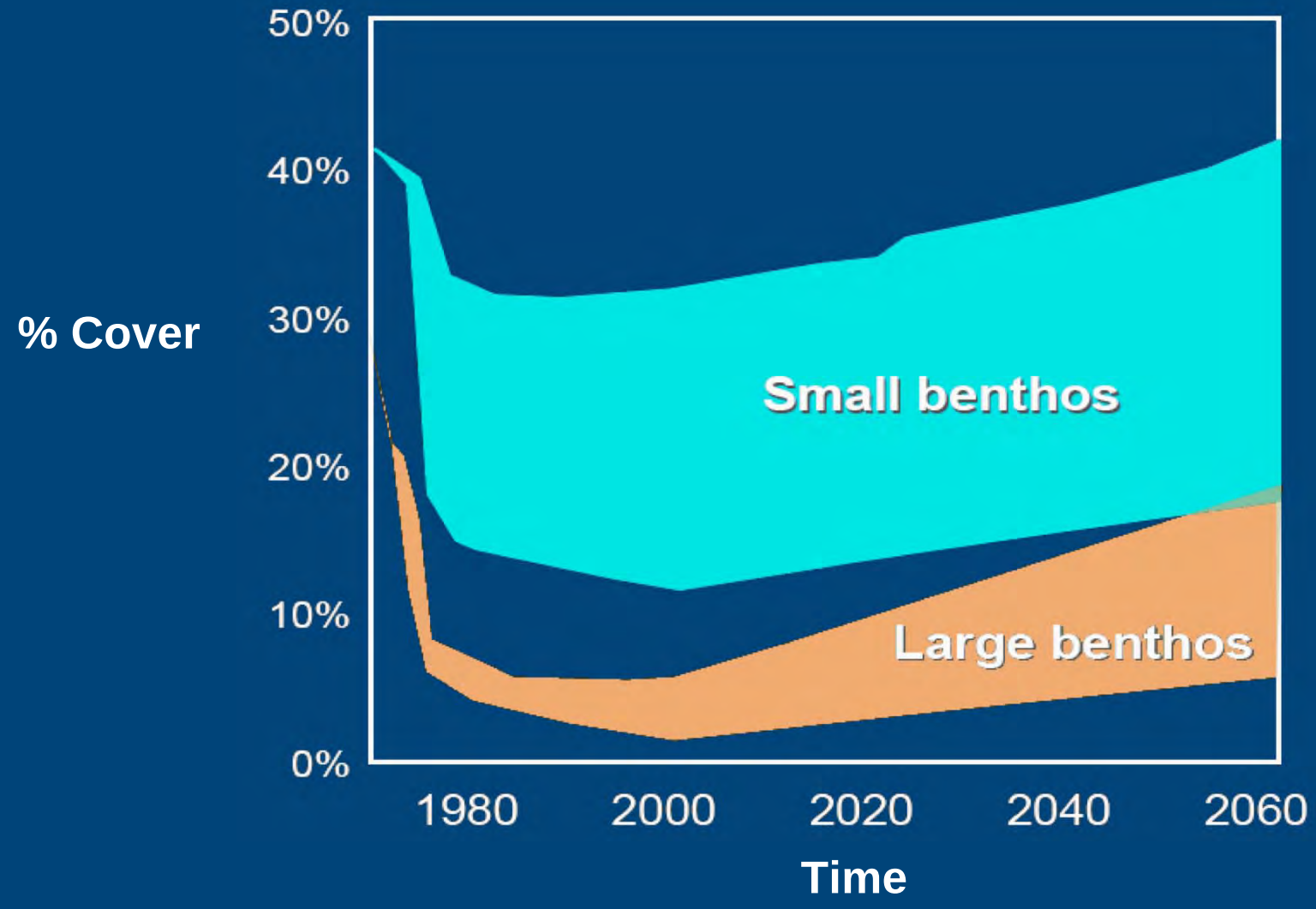


1969
(Before)

2001
(After)

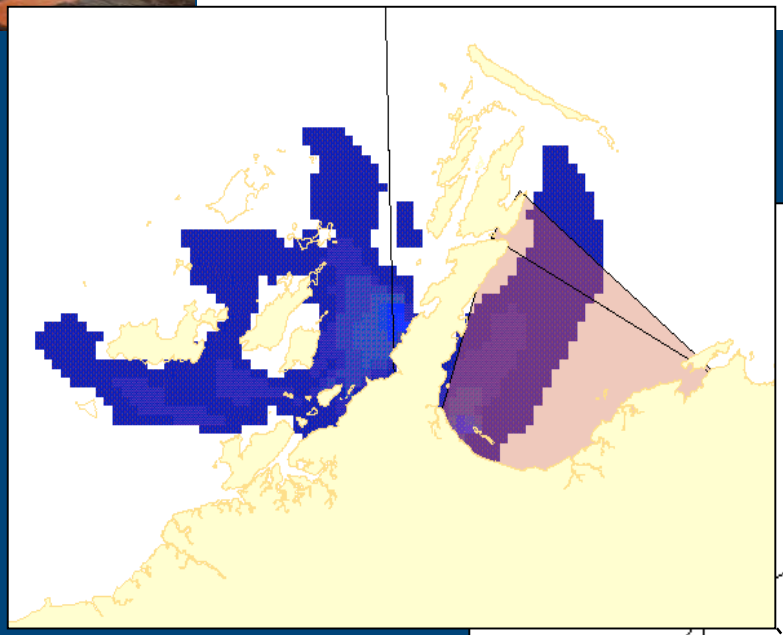
Slow recovery

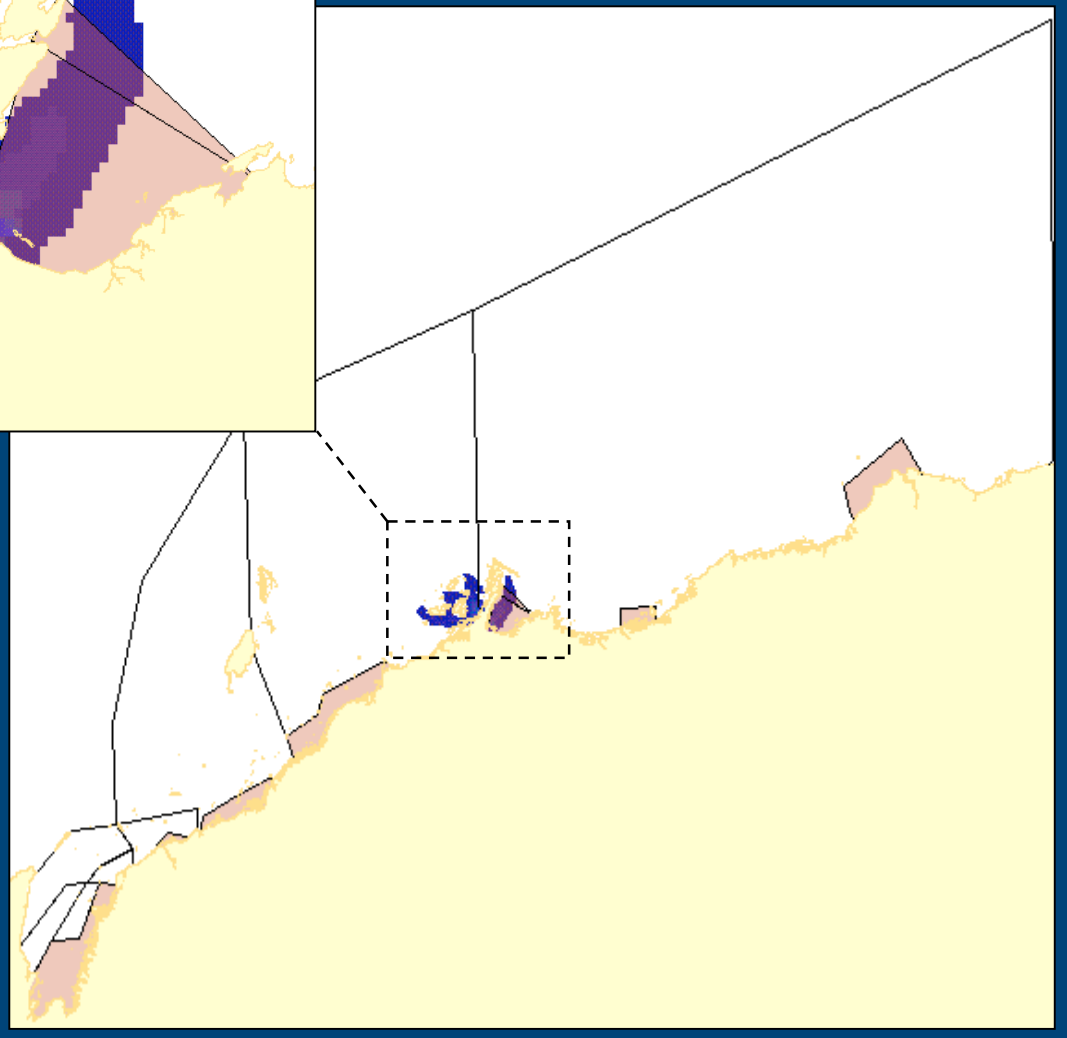
- Regional rates very slow



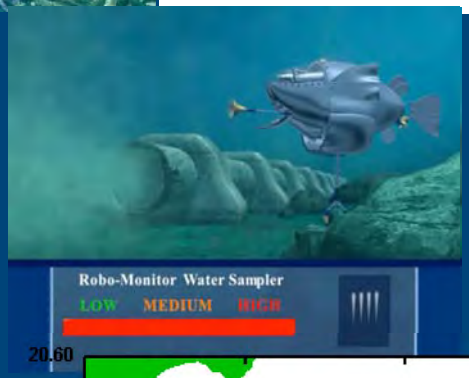
Outfalls and Prawns

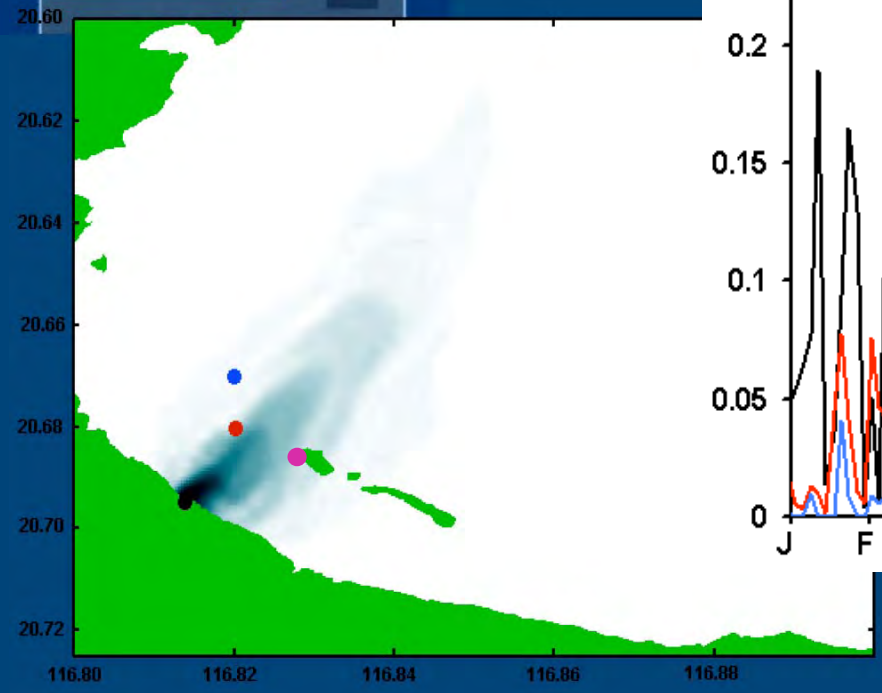
- Potential cross-sector interactions

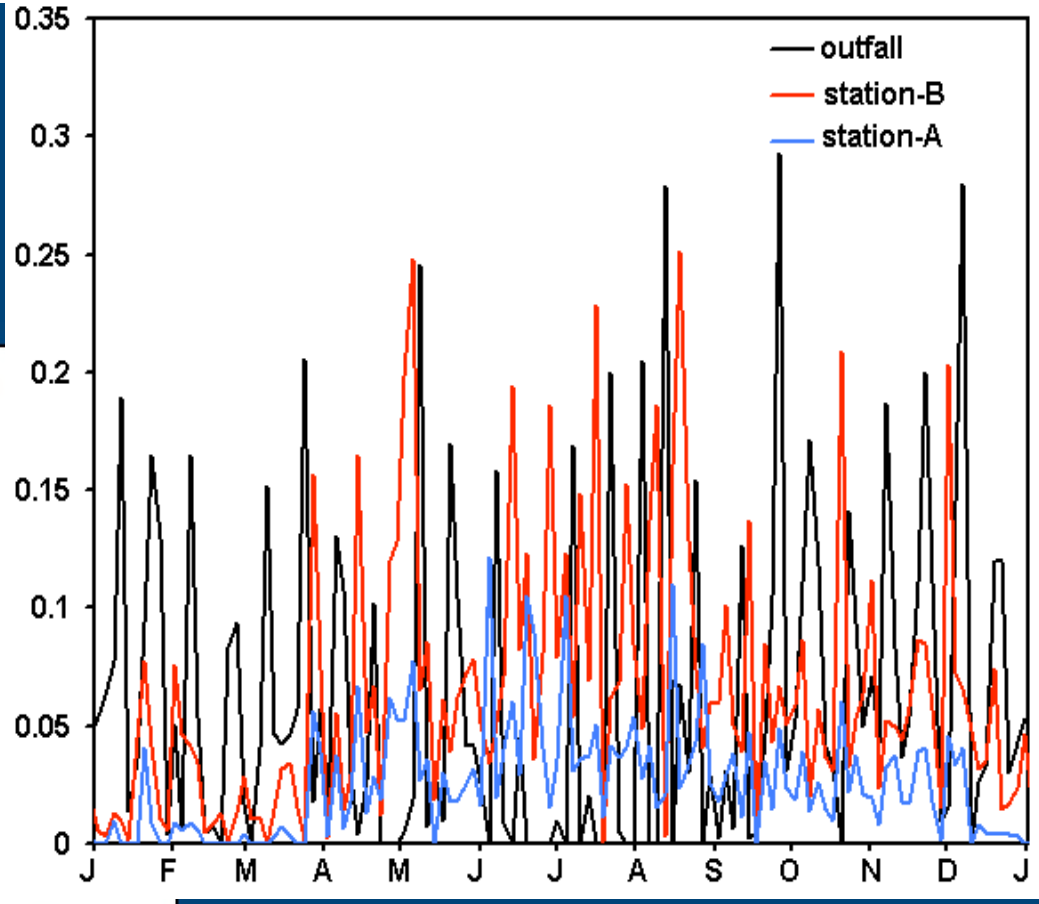




Monitoring Sites



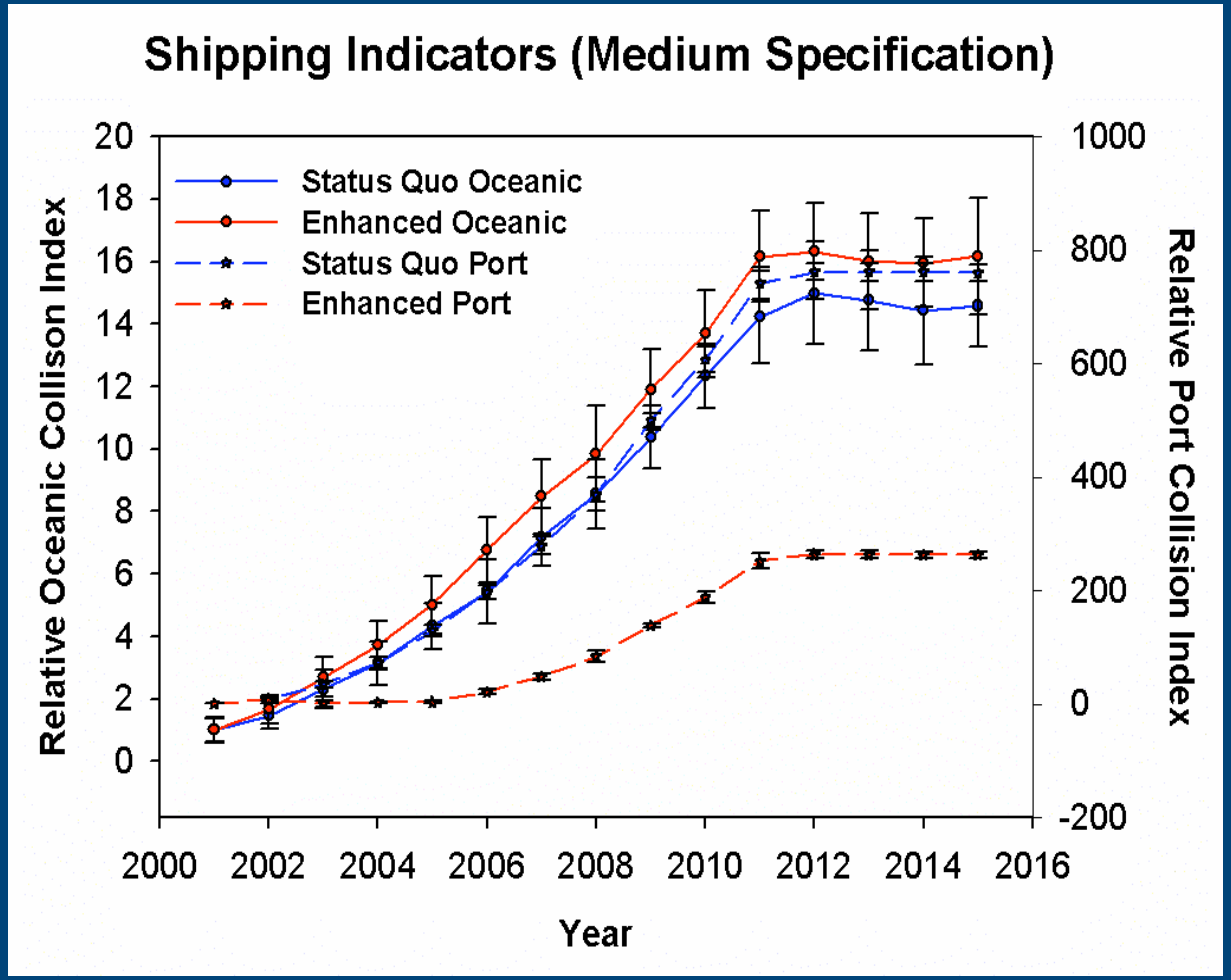




- Effective vs ineffective monitoring

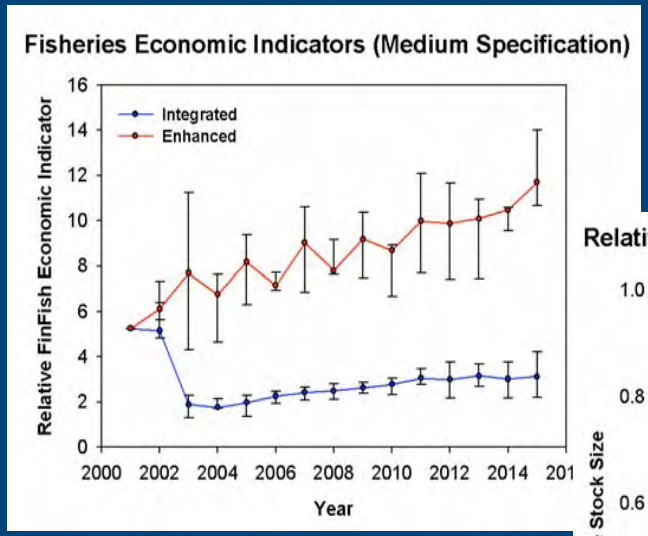
Short vs Long-term Risk

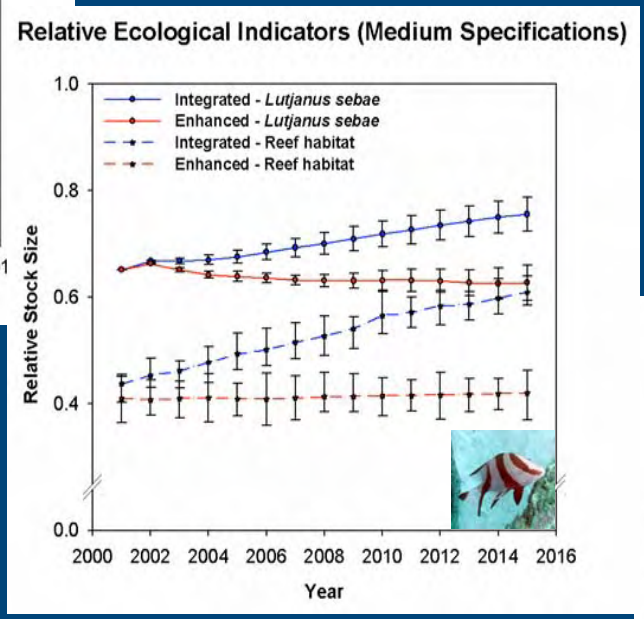
- Benefits (and tradeoffs) identified

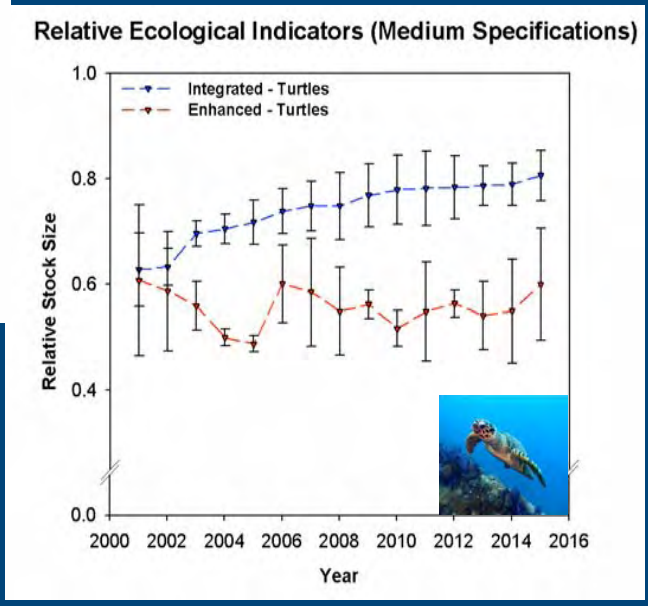


Economics & Conservation

- Decisions have costs



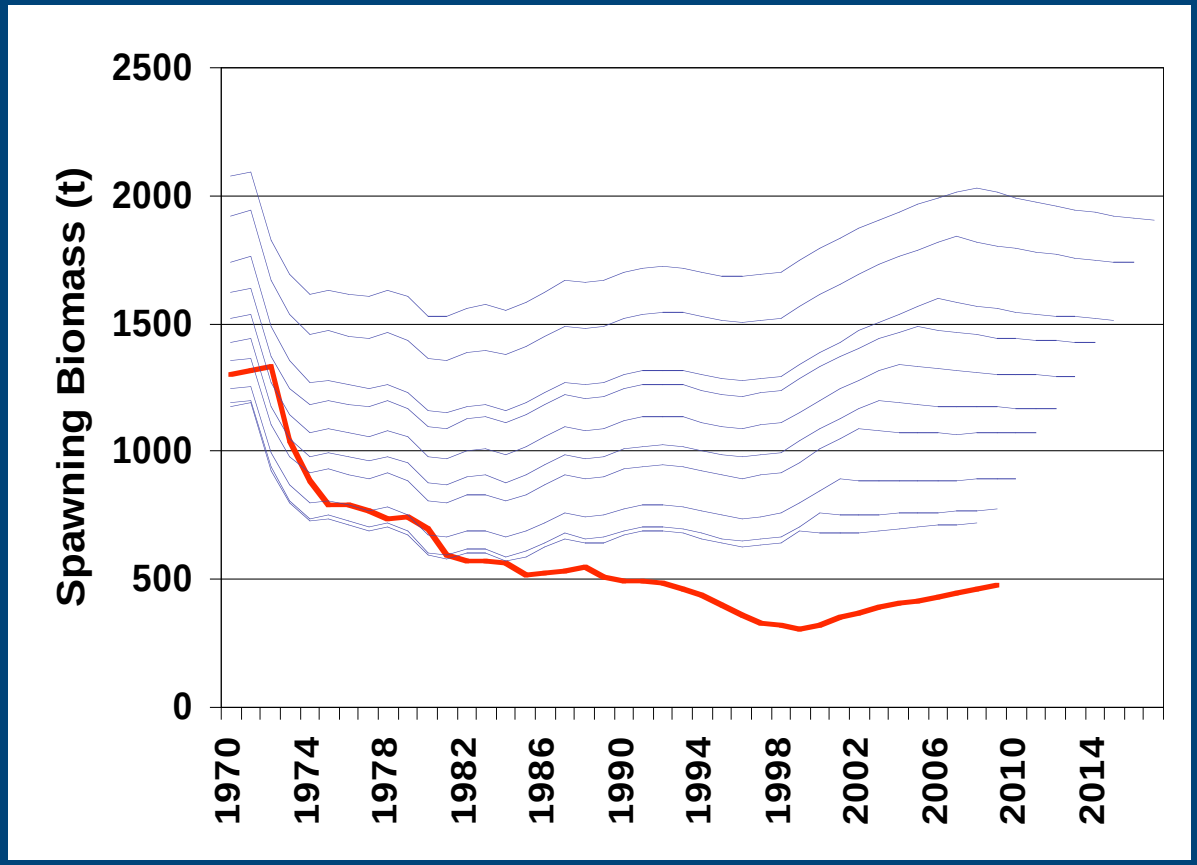




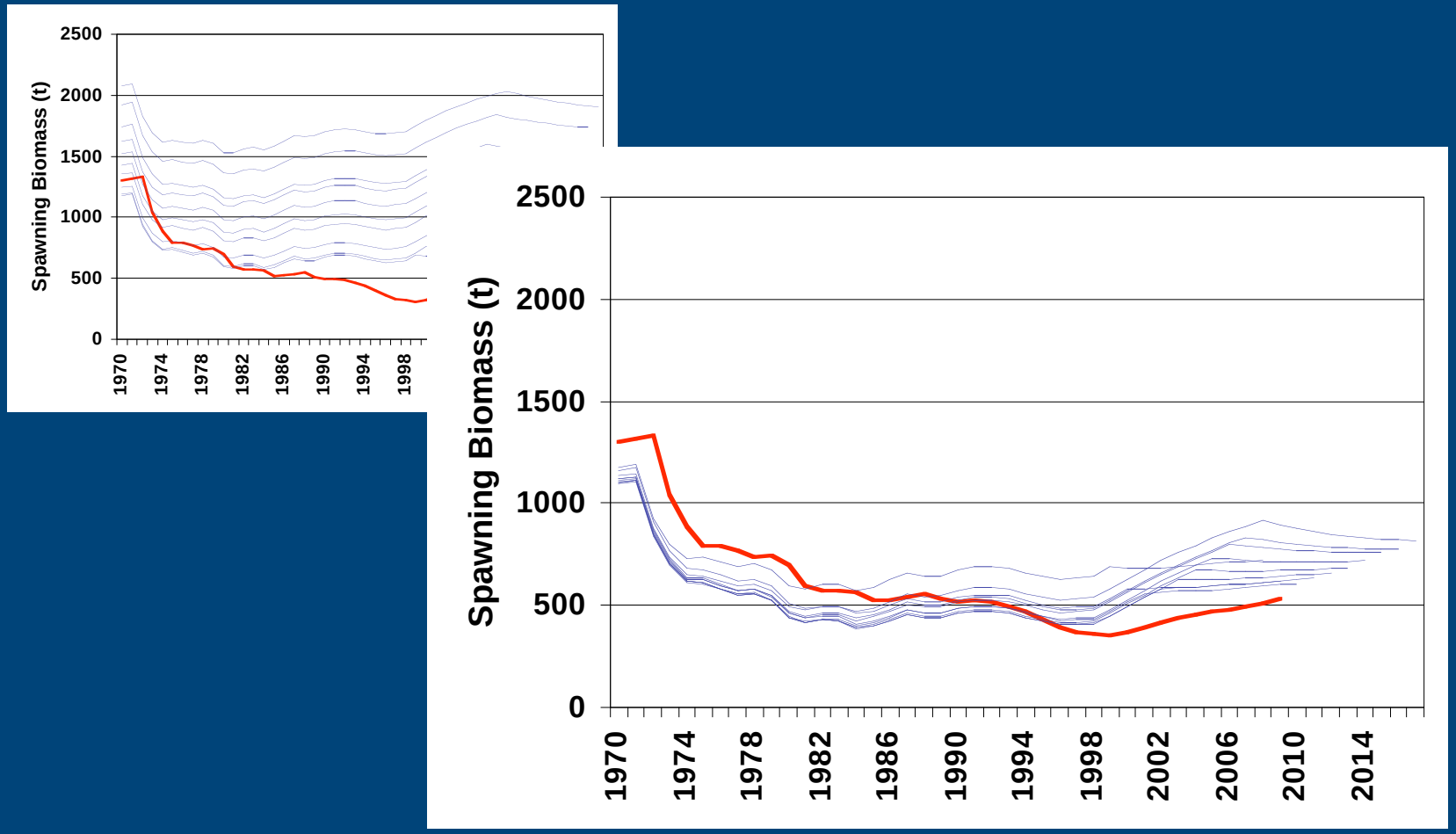
- Thought leads to less cost

Assessment Checks

- Verify assessment models



Value of Independent Surveys



- Pessimistic system state

Other Results

- Dominated by direct effects
- Naturally highly disturbed
- Human impacts limited (spatially constrained)
- Impacts grow dangerously if:
  - widespread growth
  - poor system state
  - development cycles coalesce

National and international adoption of NWSJEMS modelling approaches

Arctic

Puget Sound

California Current

Northeast USA

InVitro

Conclusions and The Future

- Direct effects strongest on NWS, yet integrated still the best management approach

- Quantitative MUMSE is possible
  - harder than anticipated for NWS, lessons learnt
    - ⇨ NWS-InVitro proved concept
    - ⇨ now modular with expanded capacity
  - ‘best practice’ (but need link to management response)

ViewNWS

- How to