What's easy and hard about modelling socioecological systems

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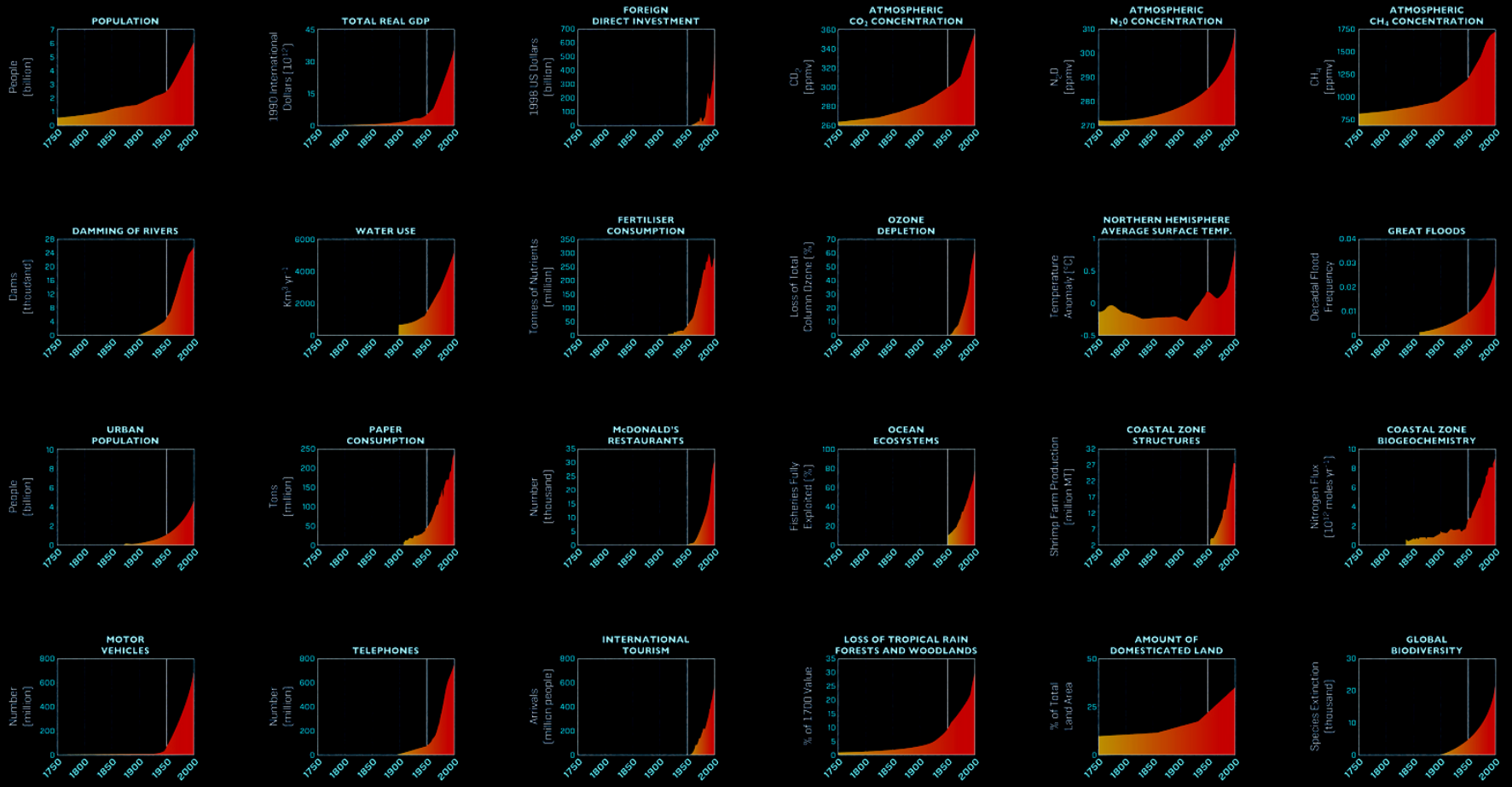
THE ANTHROPOCENE

The Anthropocene defines Earth's most recent geologic time period as being human-influenced, or anthropogenic, based on overwhelming global evidence that atmospheric, geologic, hydrologic, biospheric and other earth system processes are now altered by humans.

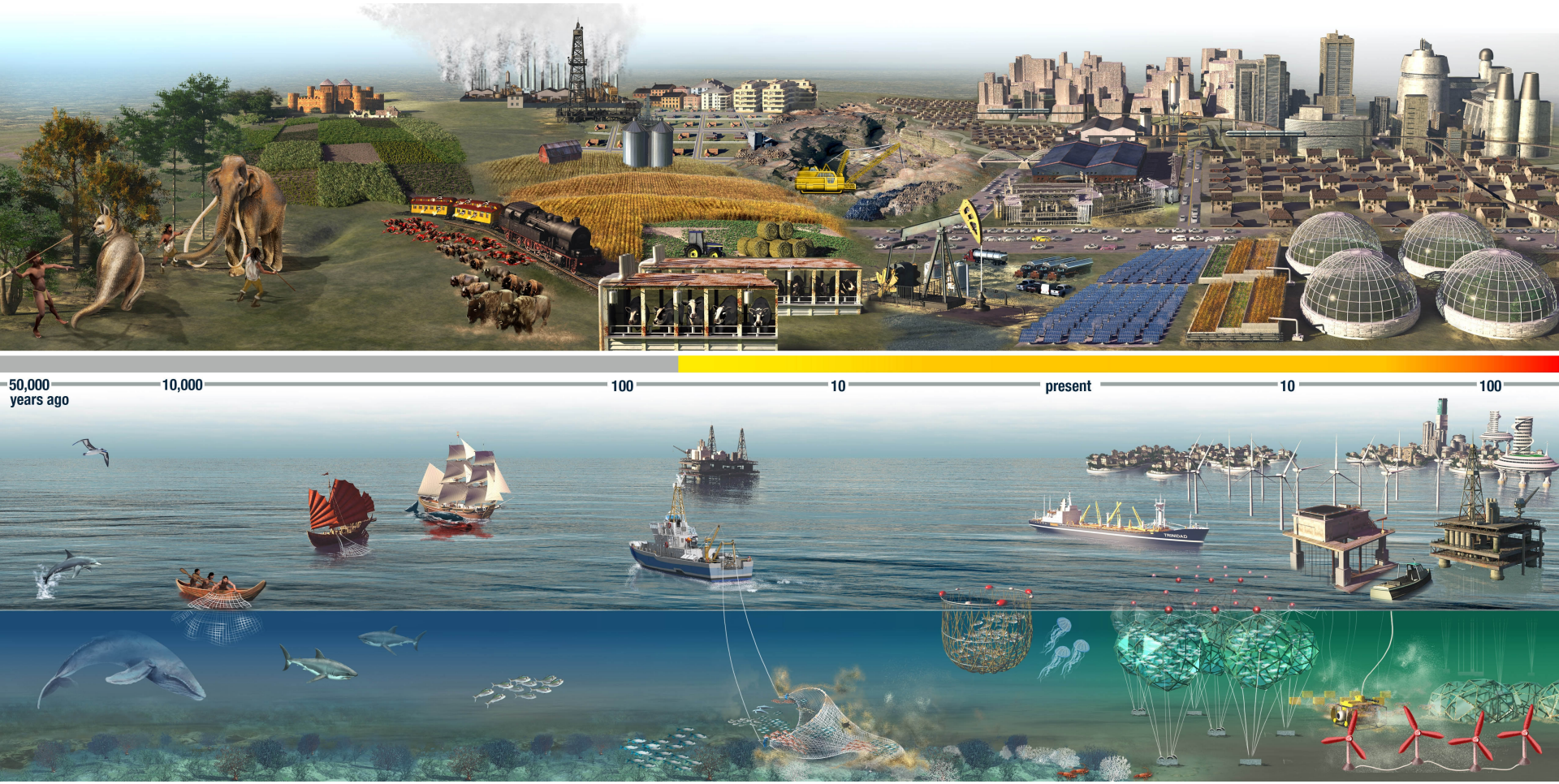
The line corresponding to 1950 highlights the **Great Acceleration**, the post-World War II worldwide industrialization, techno-scientific development, nuclear arms race, population explosion and rapid economic growth.

These graphs were compiled in a publication of the **International Geosphere-Biosphere Programme** (IGBP).



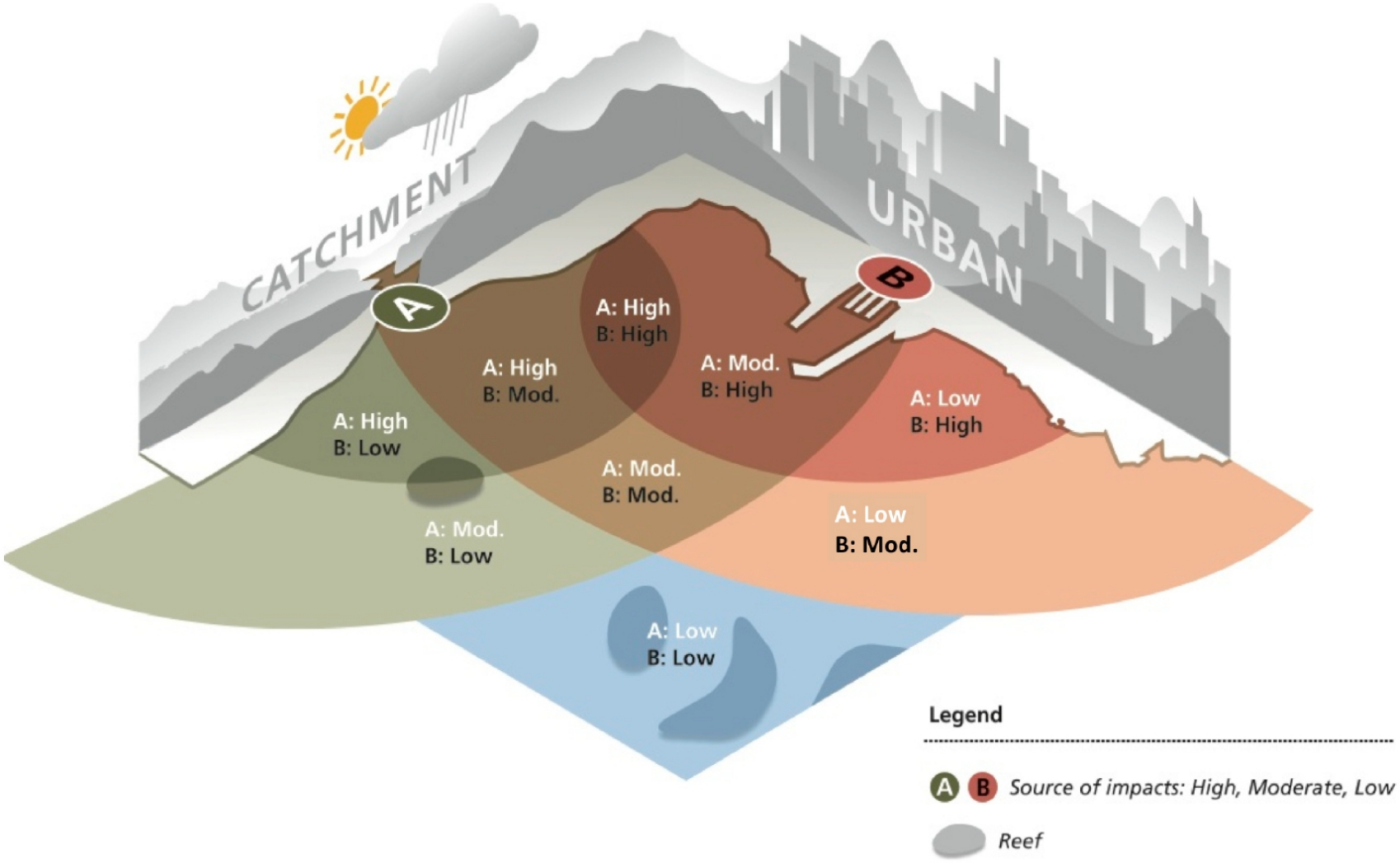
SOURCE: igbp.net | Steffen et al., 2005, Global Change and the Earth System, Springer, pp. 132-133
DESIGN: Globaia.org

Aquatic Revolution



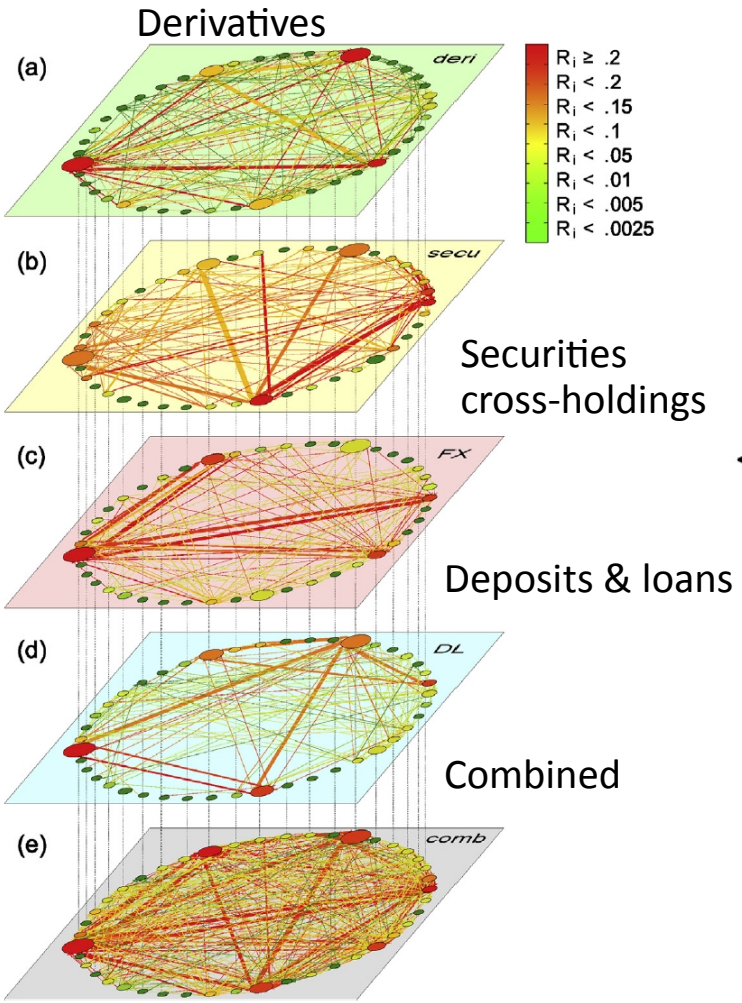
McCauley et al 2015 *Science*

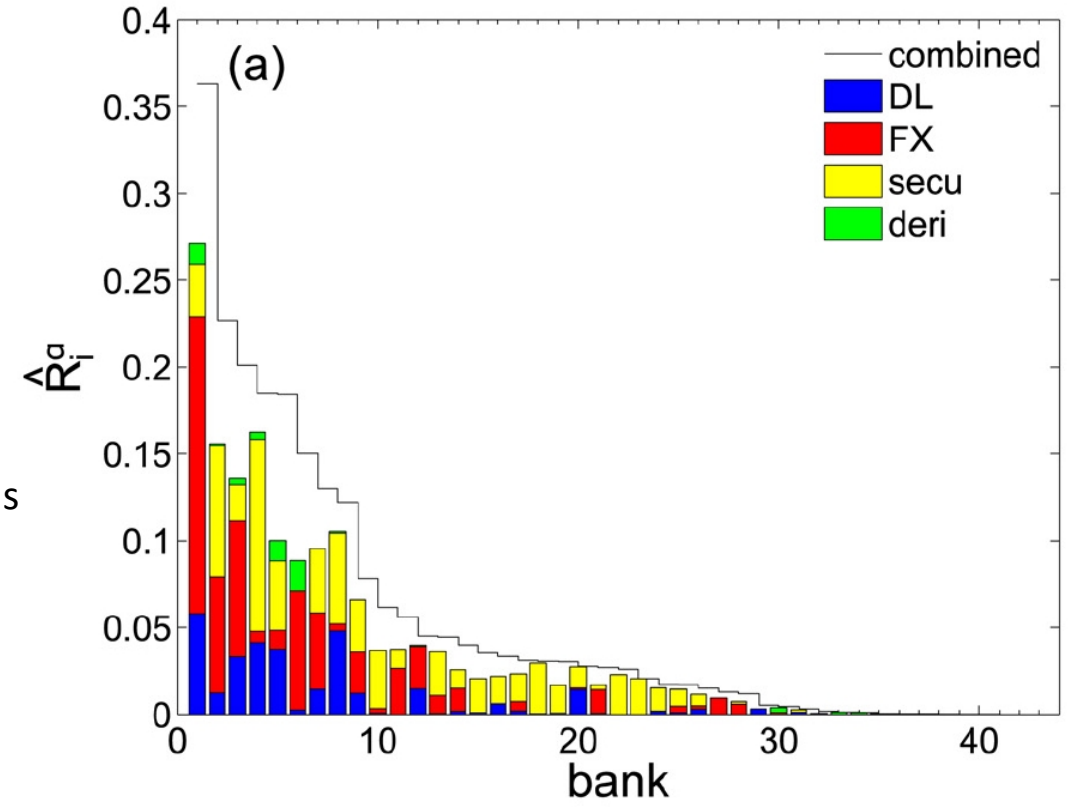
Looking at cumulative risk



Anthony et al 2013

Need for integrated assessments

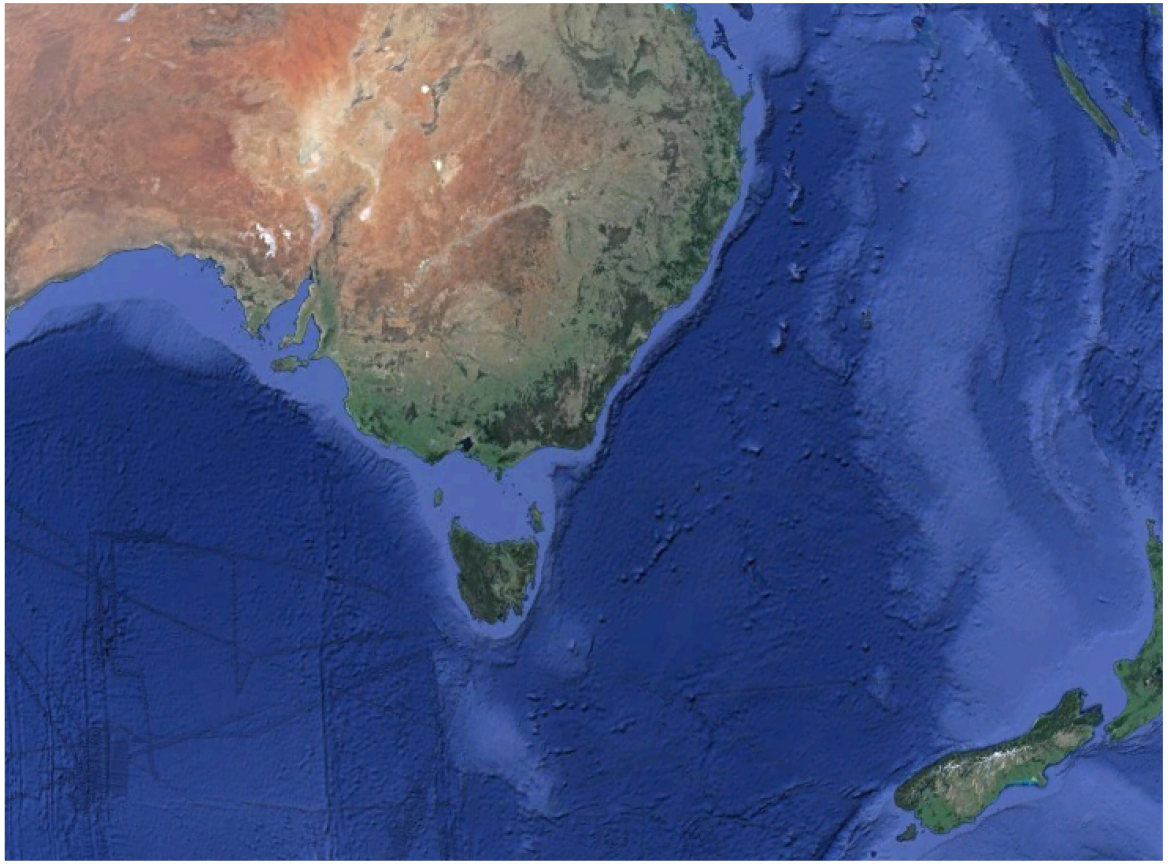


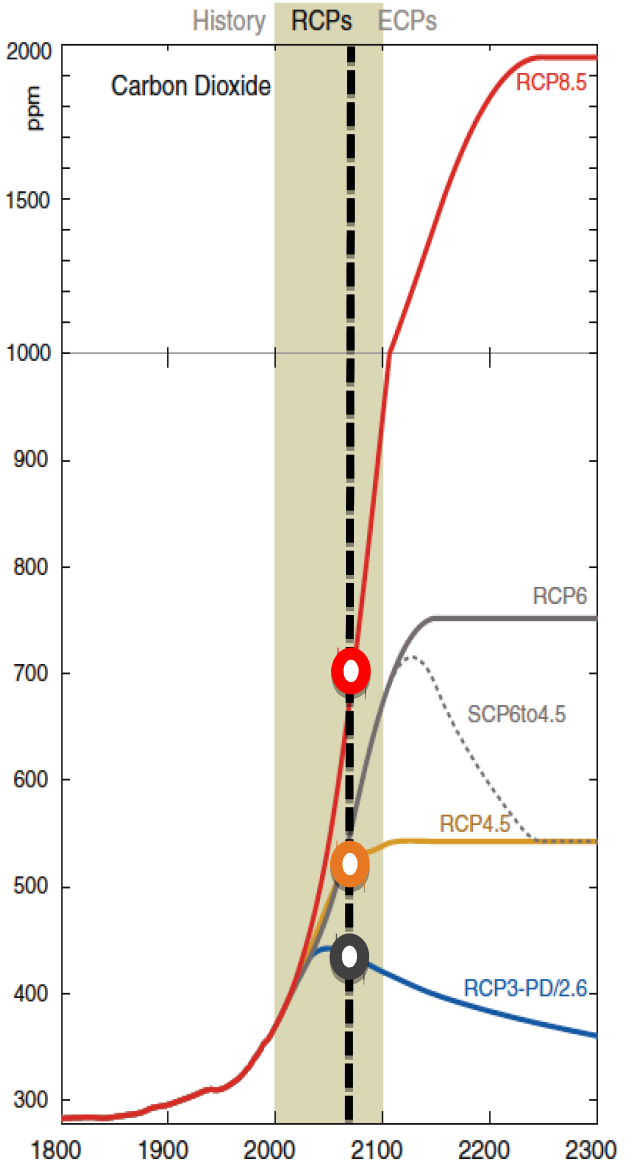


- **90% underestimate from single layer**

Integrated Projections

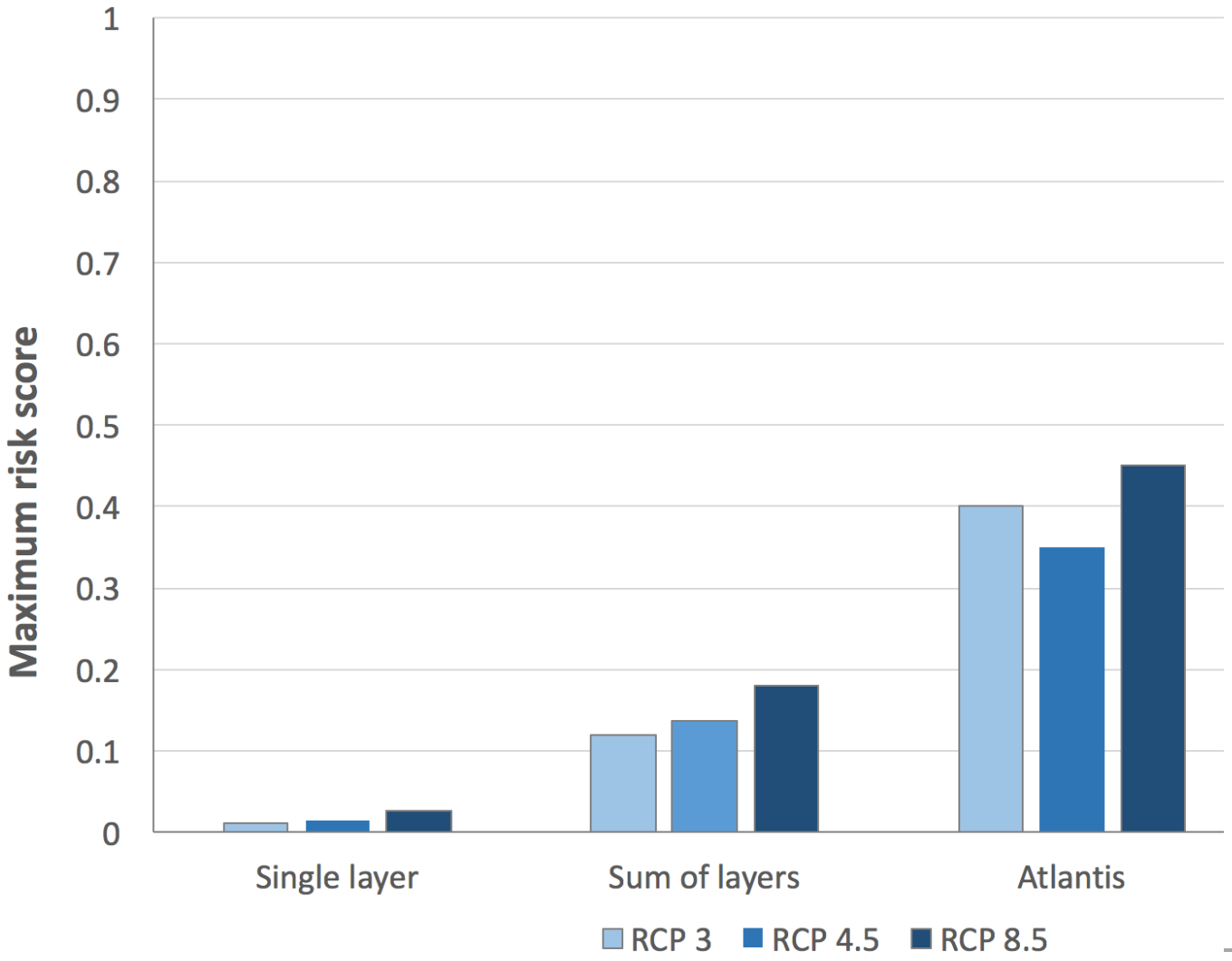
- Potential futures in SE Australia





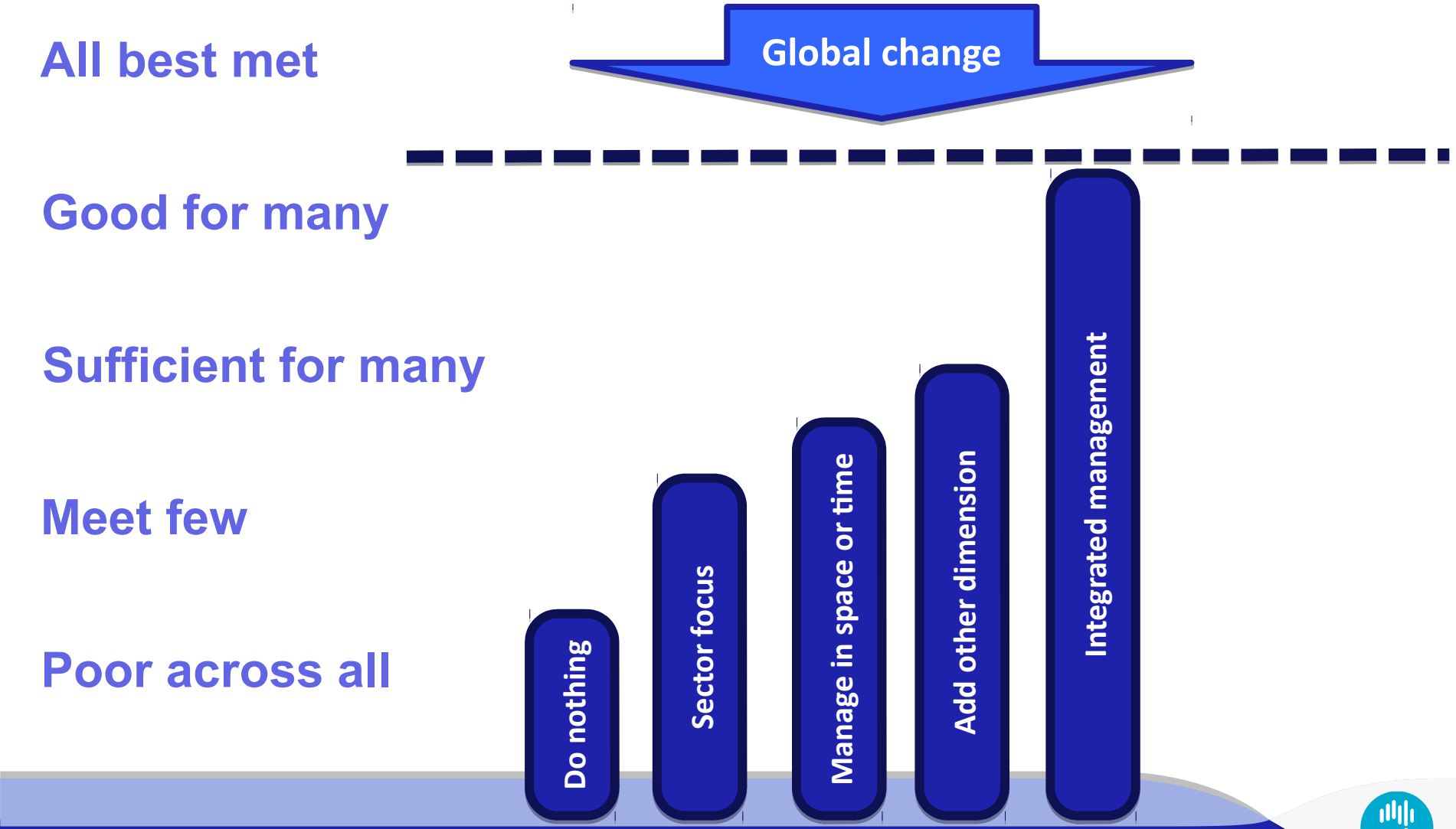
Meinshausen et al (2011)

Maximum Risk Scores



Need for integrated management

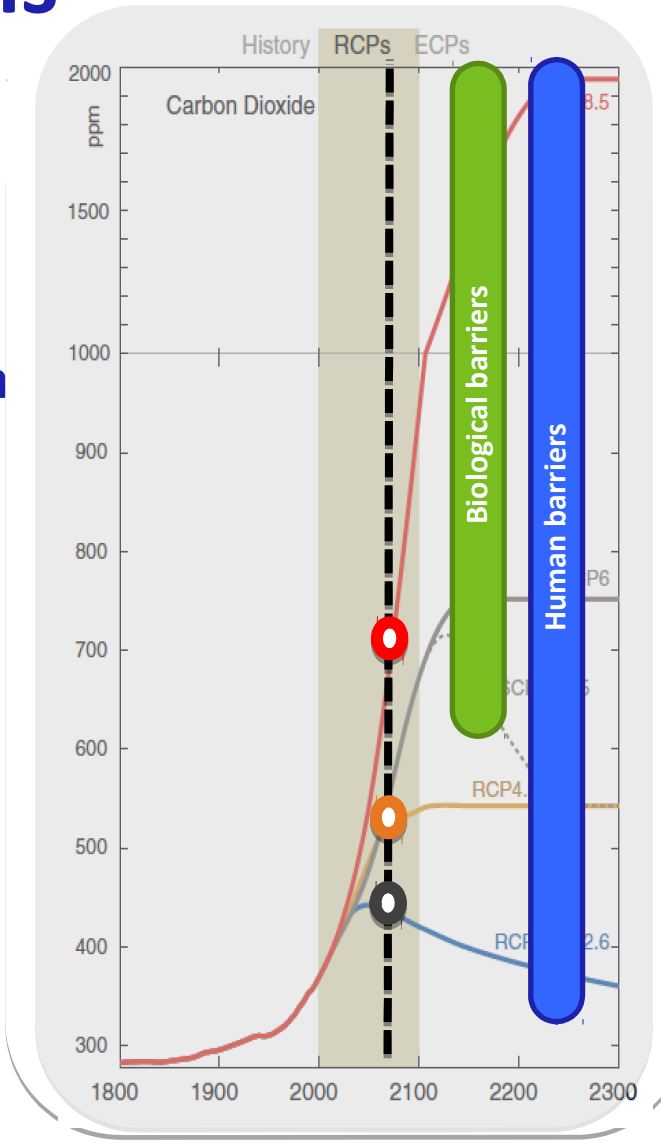
Ecological, Economic, Social objectives



Fulton & Gorton 2014

Role of the human dimensions

1. Biological and ecological
   - distribution, composition & productivity change; thresholds
2. Behavioural, cognitive and social
   - flexibility & personality; intuition & perception cultural influence
3. Governance and regulation
   - supportive vs constraints & delays (hardship potential)
4. Economic and markets
   - compound barriers; larger operators typically have more capacity
5. Technological
   - facilitate change vs lock in maladaptive behaviour; info access
6. Scientific



Fulton & Gorton 2014

Role of the humans

- Adaptation & innovation (in developing countries)
  - economic instruments
  - technology
  - institutions

(good governance

&

transparency)

Role of the institutions

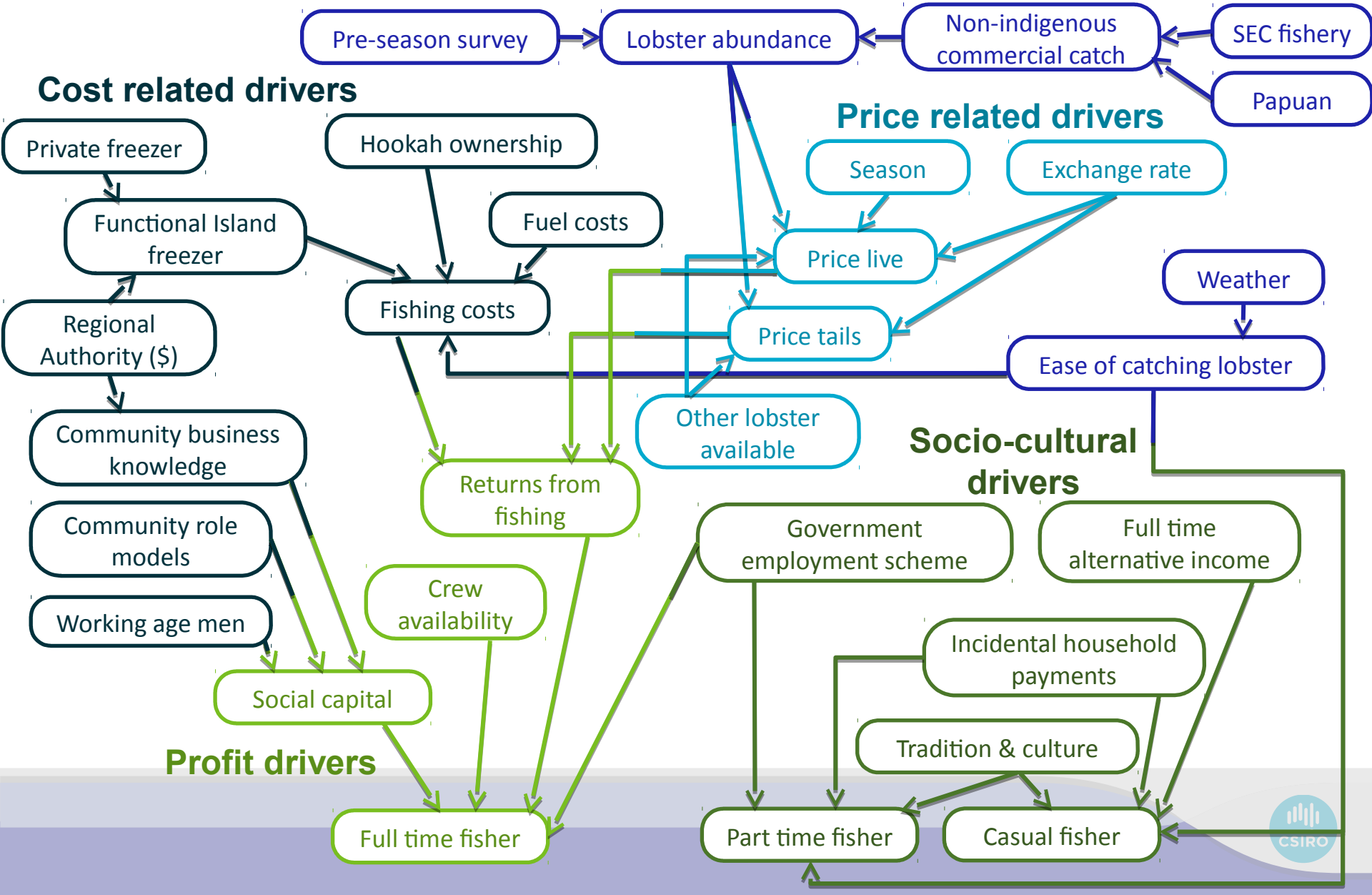
- Formal institutions shape:
  - economic growth & investment
  - risk-taking
  - innovation (constrain options, encourage

Aron 2000, Meye & Diez 2013, Dobinger et al 2015, Miranda et al 2015

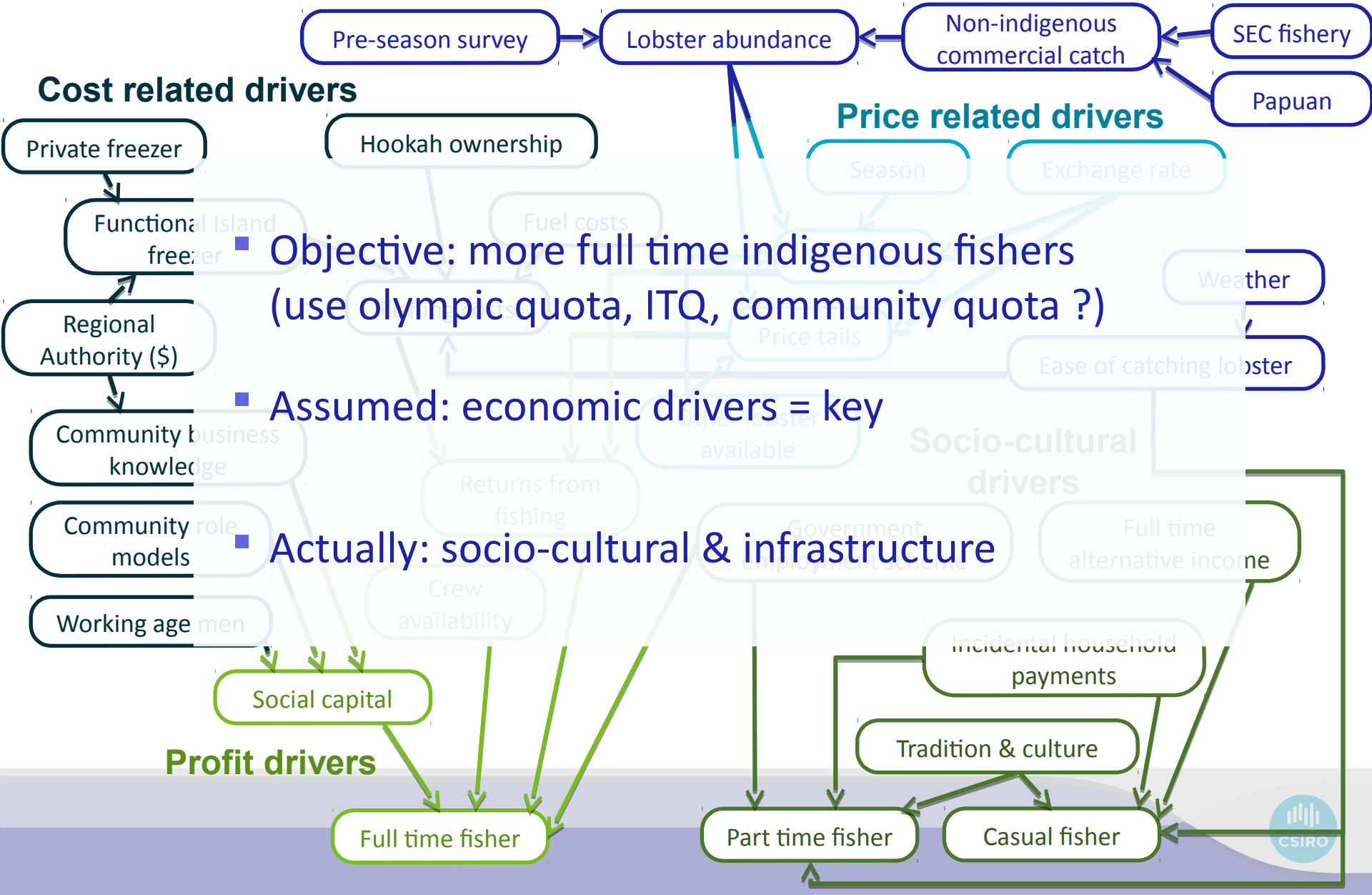
Australian Example - Torres Strait

Plagányi et al 2013, van Putten et al 2013

Australian Example - Torres Strait

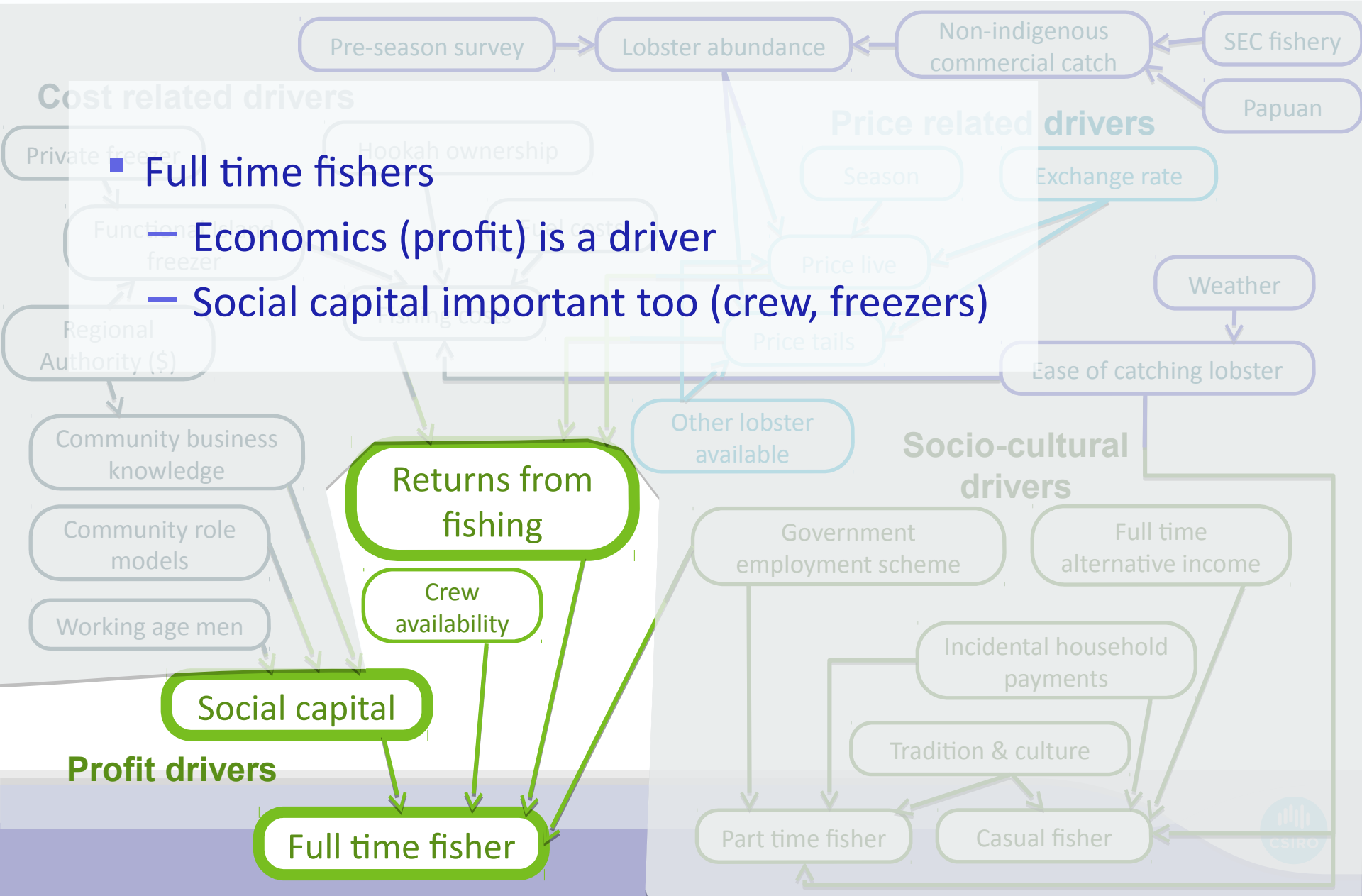


Australian Example - Torres Strait



- Objective: more full time indigenous fishers (use olympic quota, ITQ, community quota ?)
- Assumed: economic drivers = key
- Actually: socio-cultural & infrastructure

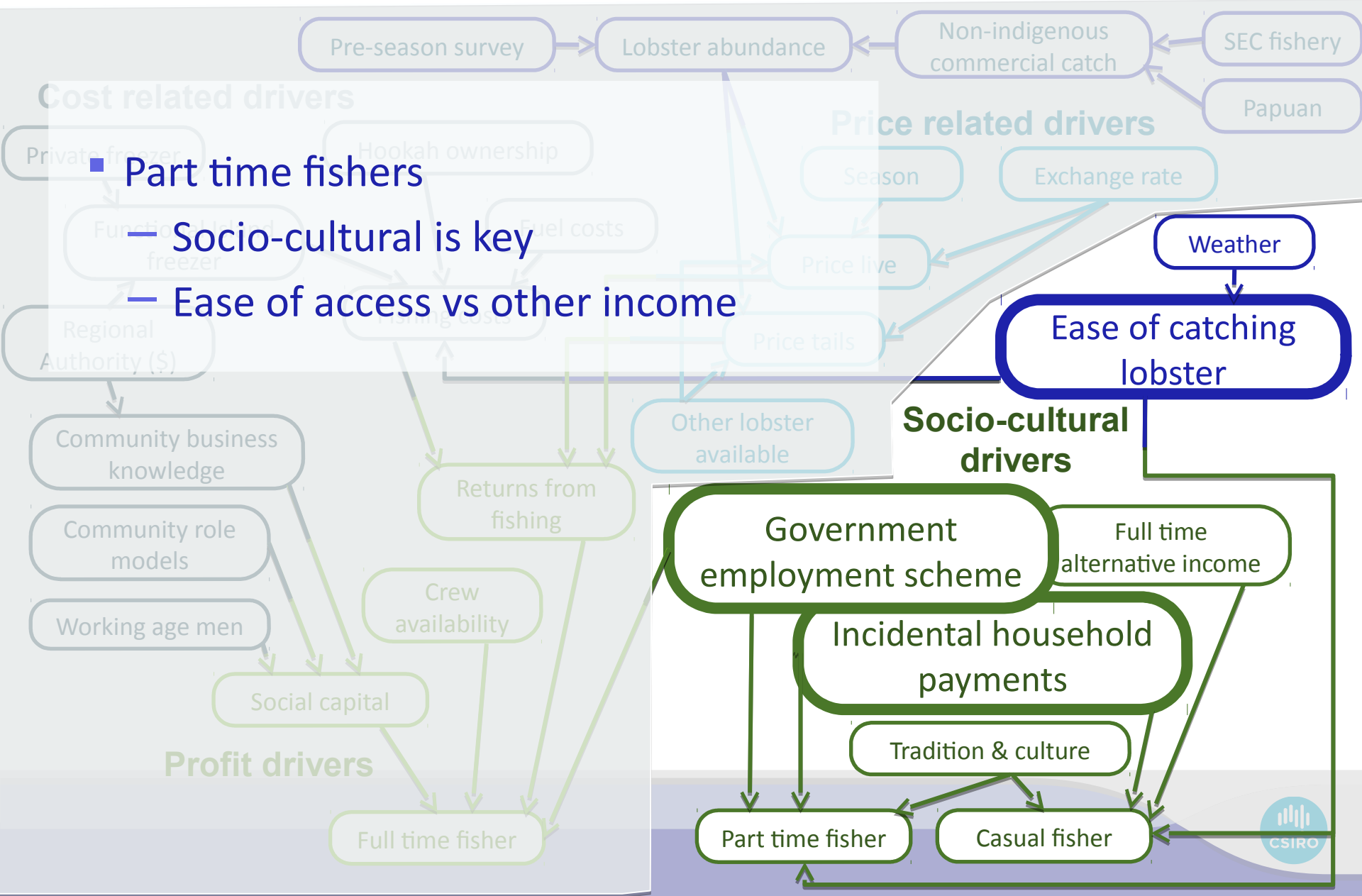
Australian Example - Torres Strait



- Full time fishers
  - Economics (profit) is a driver
  - Social capital important too (crew, freezers)

Australian Example - Torres Strait

- Part time fishers
  - Socio-cultural is key
  - Ease of access vs other income

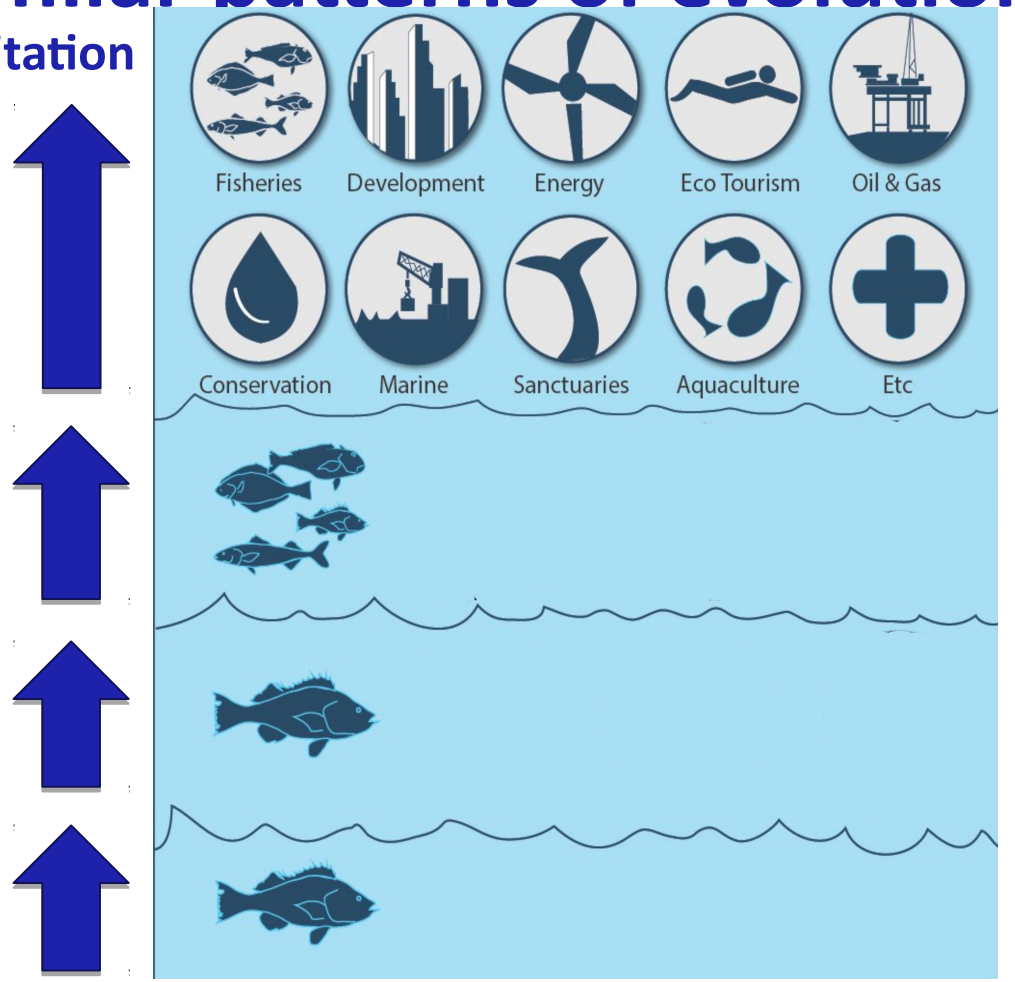


Other factors

- Mood
  - judgement severity
  - risk taking
- Gender
- Political leanings
- Culture
- Framing
- Personality (patience, optimism, ethics)

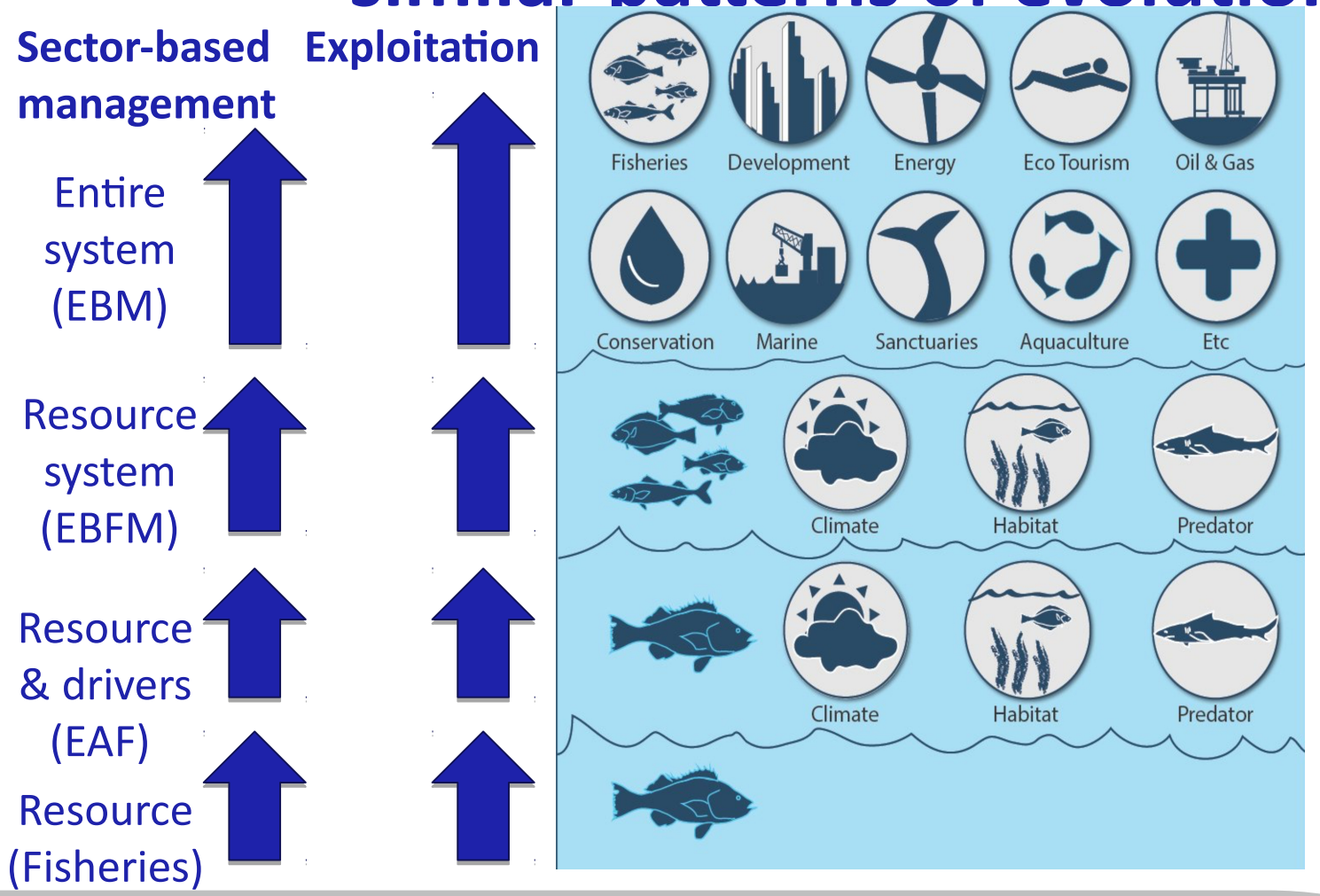
Cameron 2000, Ariely 2008, Kahneman 2011, Delis and Mylondis 2015

Use, management & modelling: similar patterns of evolution



Base figure: NOAA

Use, management & modelling: similar patterns of evolution



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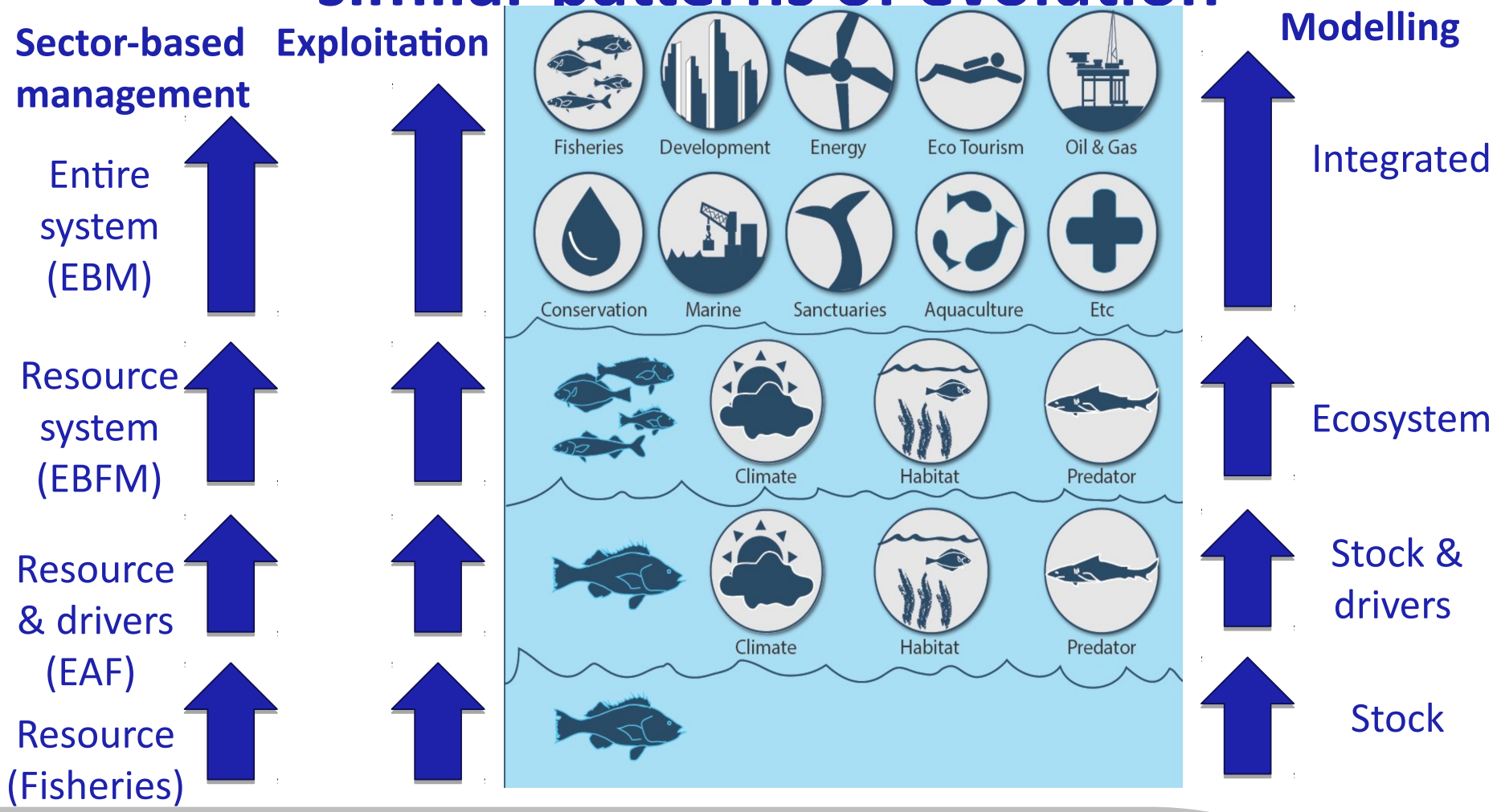
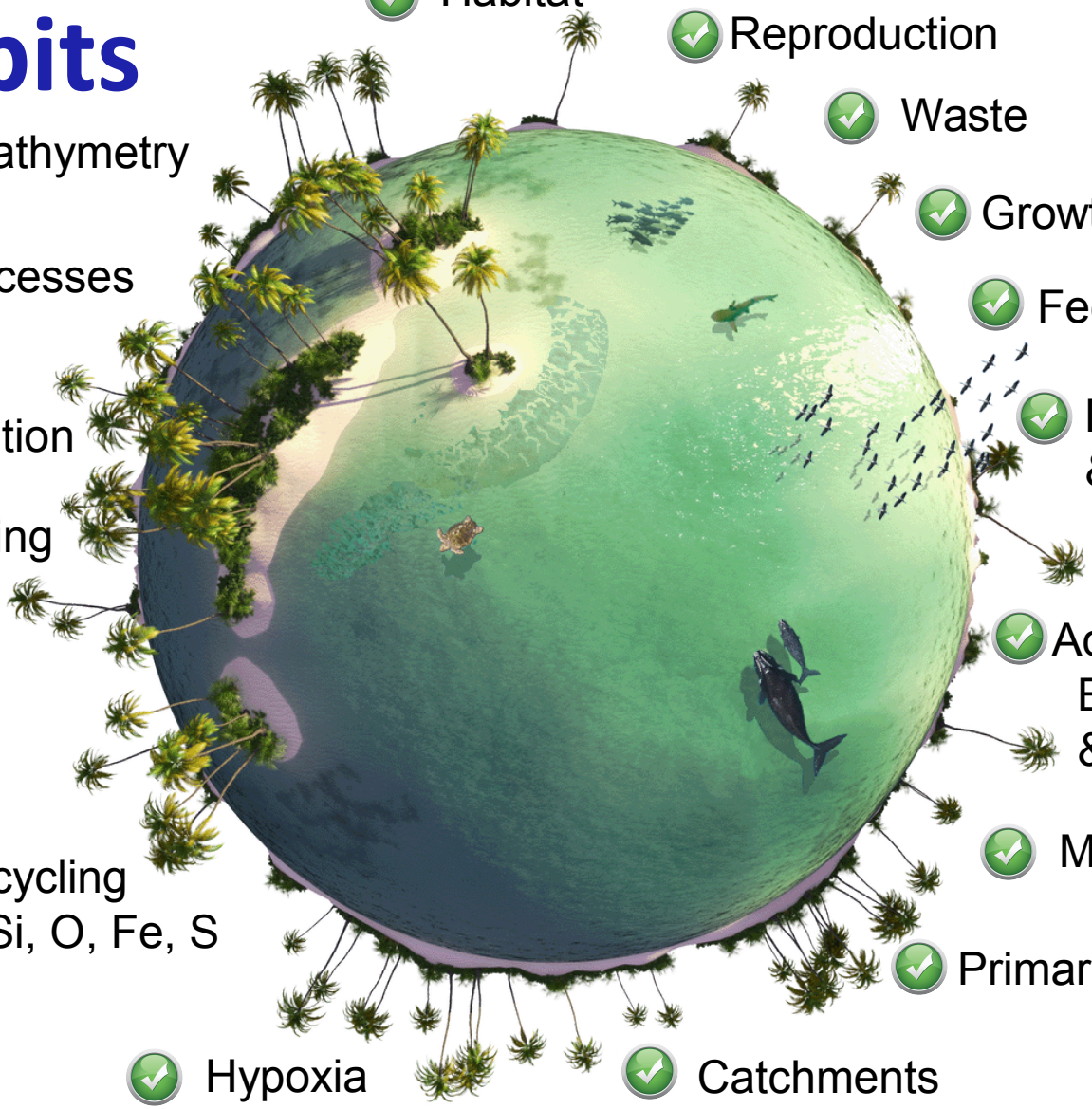


Base figure: NOAA

The eco bits



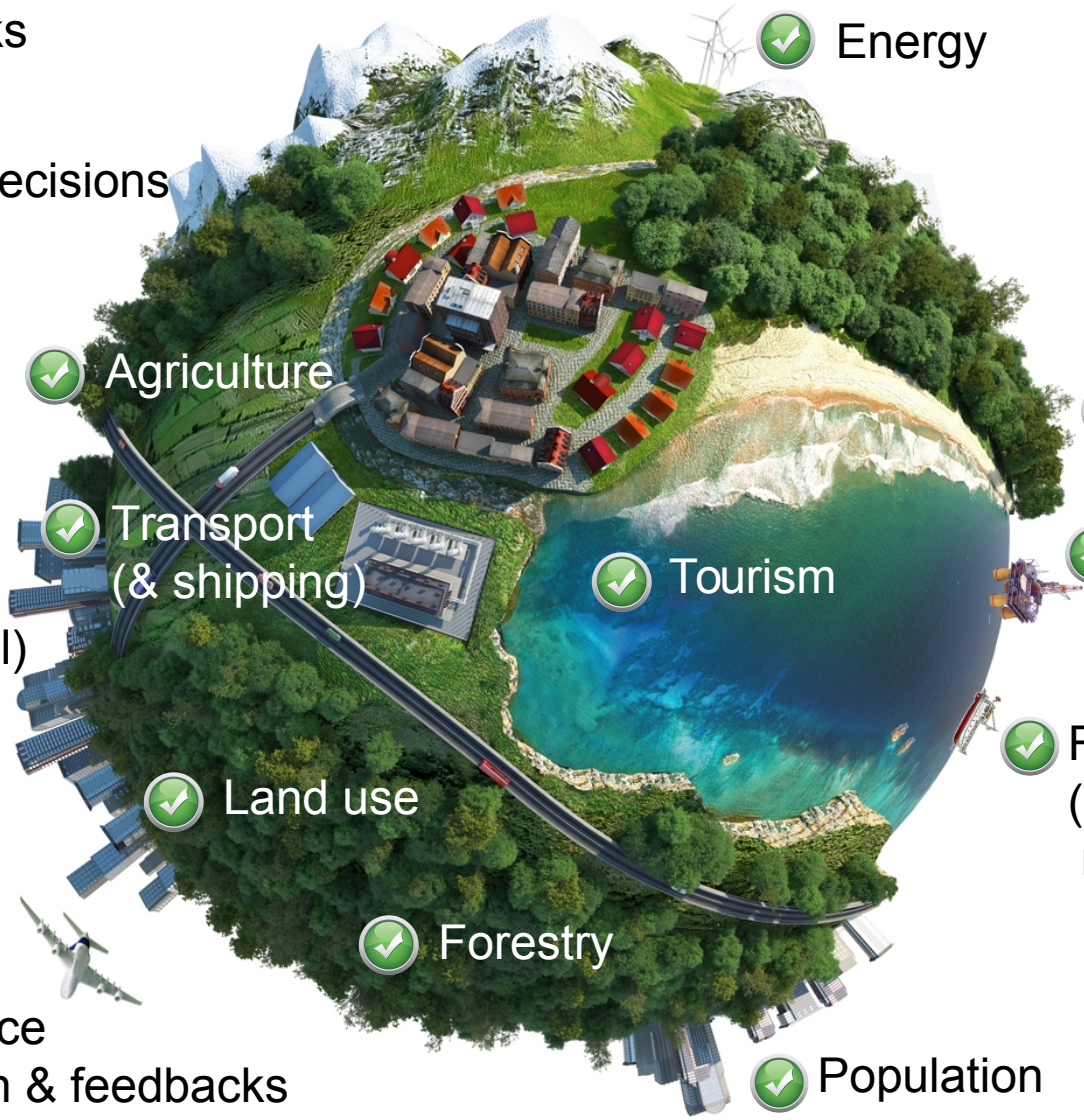
- Habitat
- Reproduction
- Waste
- Growth
- Feeding
- Movement & Migration
- Acclimation, Biodiversity & Evolution
- Mortality
- Primary production
- Catchments
- Hypoxia
- Nutrient cycling
  N, P, C, Si, O, Fe, S
- Environmental forcing
  - Temperature
  - Salinity
  - Alkalinity (pH)
  - Wind
- Currents, eddies, tides & stratification
- Sediment processes
- Bathymetry

End-to-end = the other bits

- Social networks
- Attitudes
- Behaviour & decisions

- Monitoring
- Assessments
- Control Rules
- Regulation

Urban (& residential) development & infrastructure (including ports)



- Economy
- Markets
- Trade
- Costs
- Revenue
- Investment

- Catchments
- Non-renewable Resources (oil, gas, mining)
- Fisheries (commercial & recreational)

Limits
Governance
Integration & feedbacks

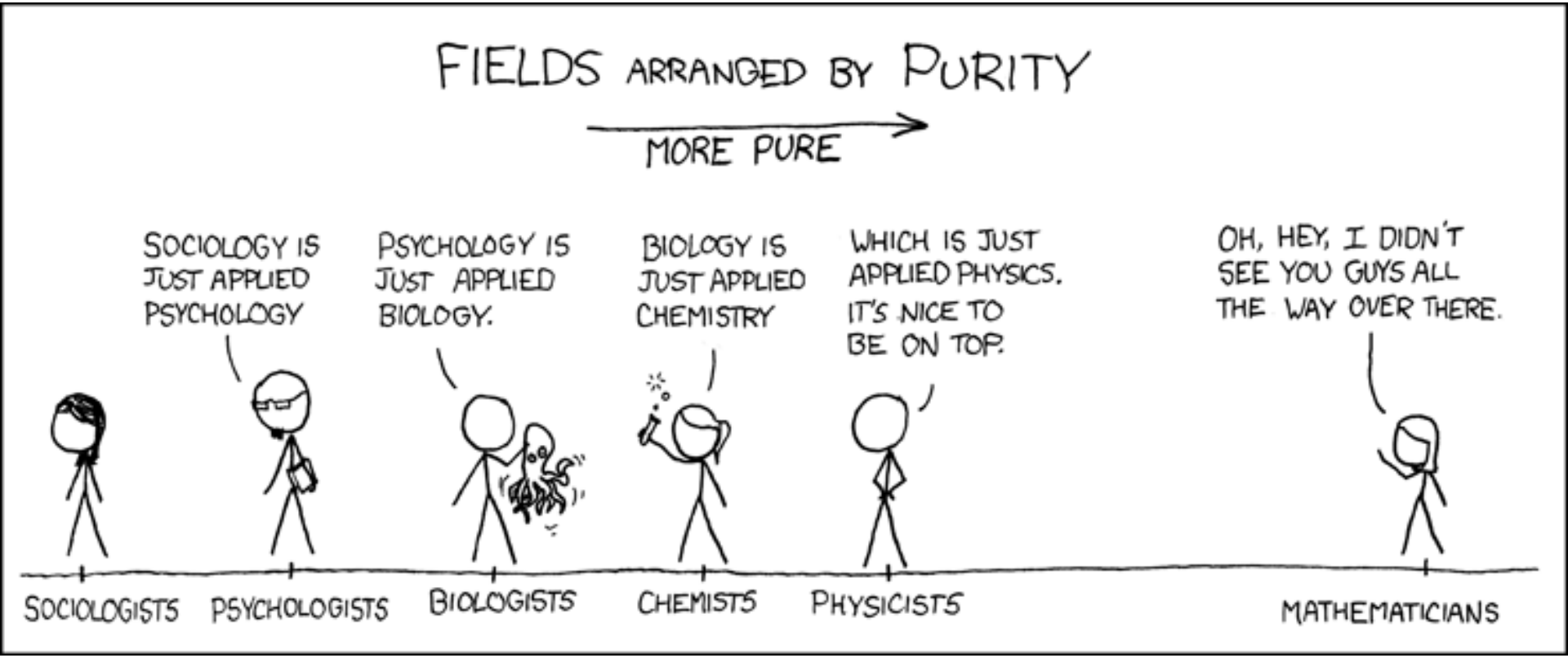
How to achieve integration?

- Desirable interconnection

How to achieve integration?

- Usual experience

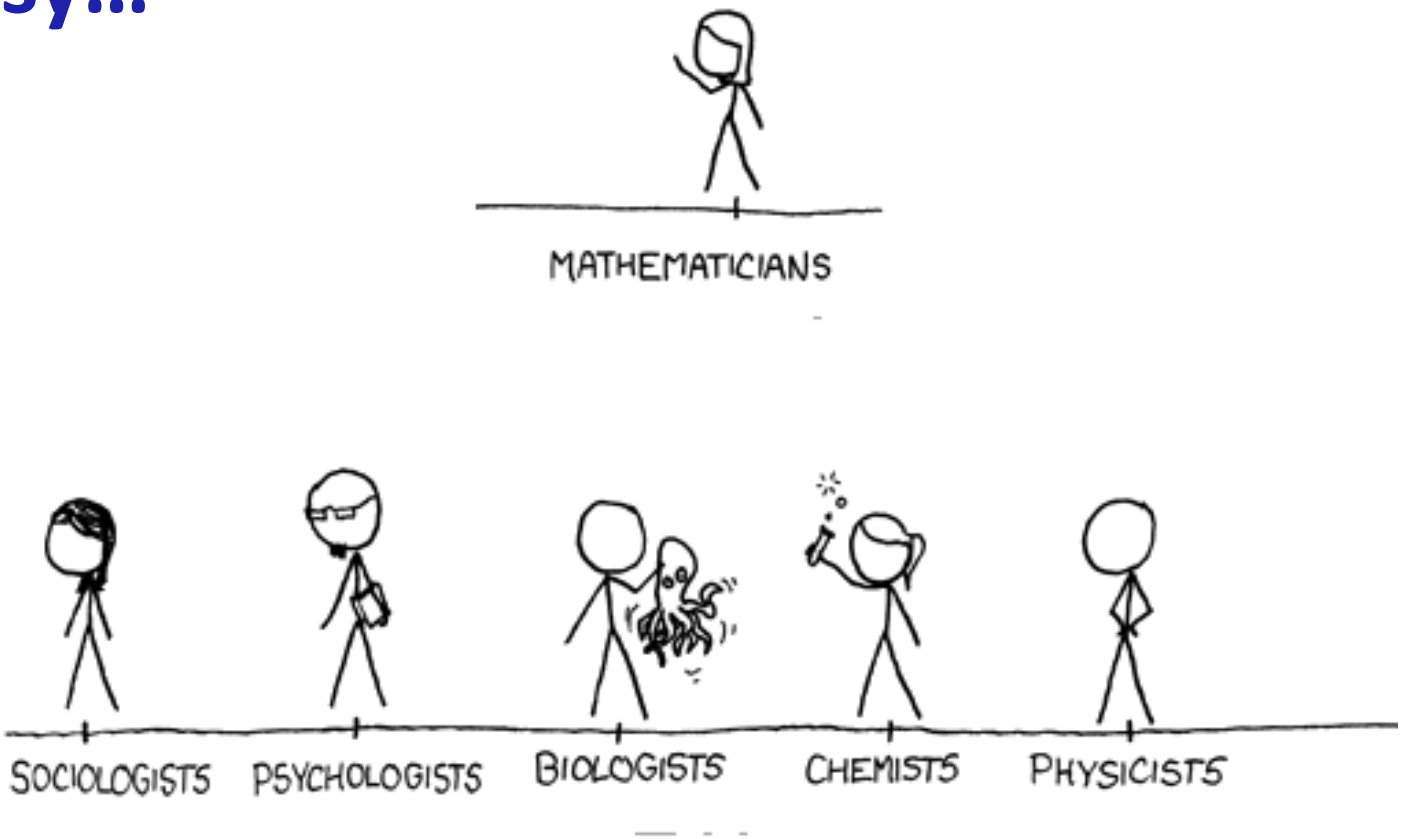
It Is Easy…



- Do not be frozen by fear
- Humans are not special
- We learn most from mistakes

xkcd.com

It Is Easy…



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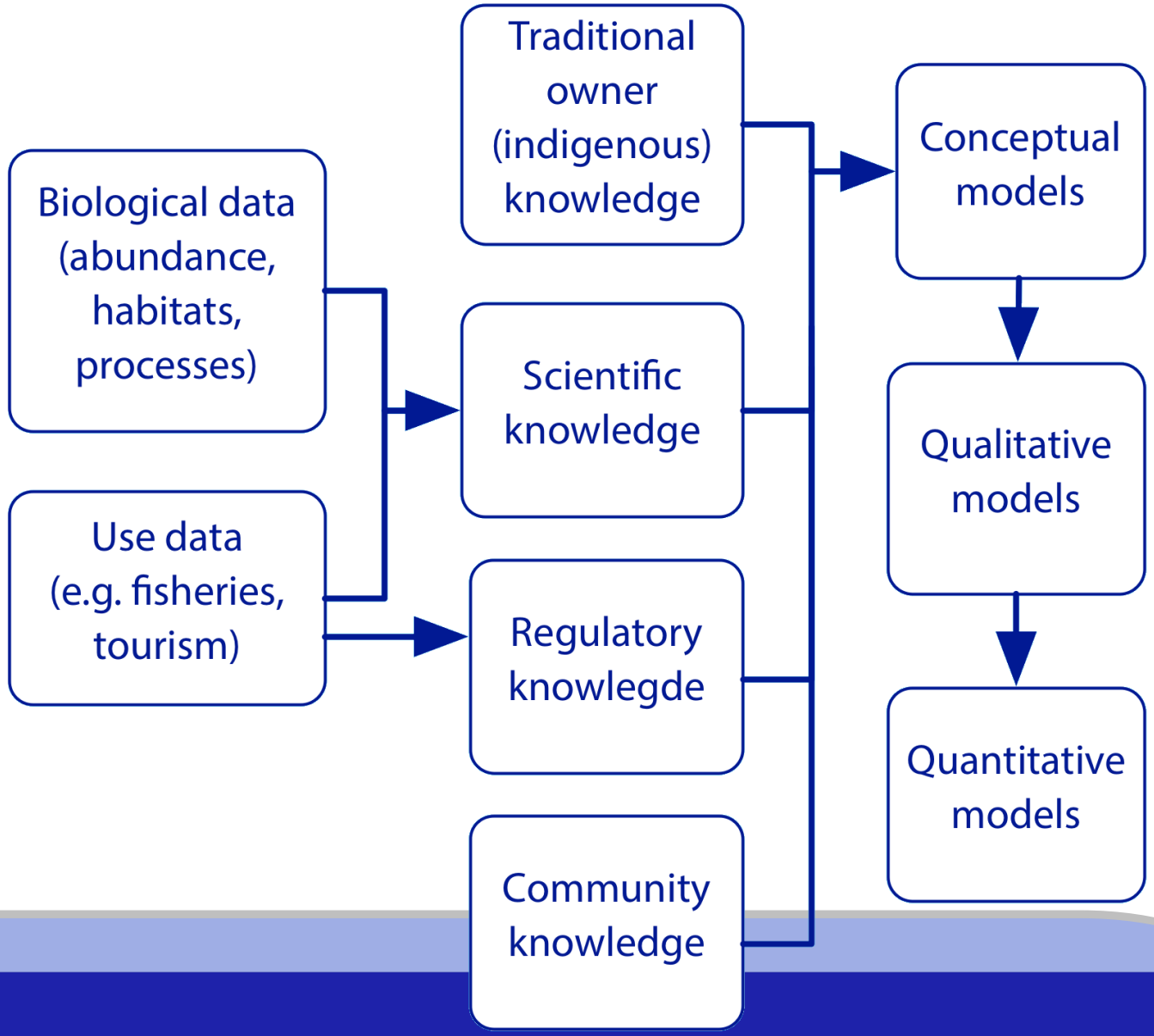
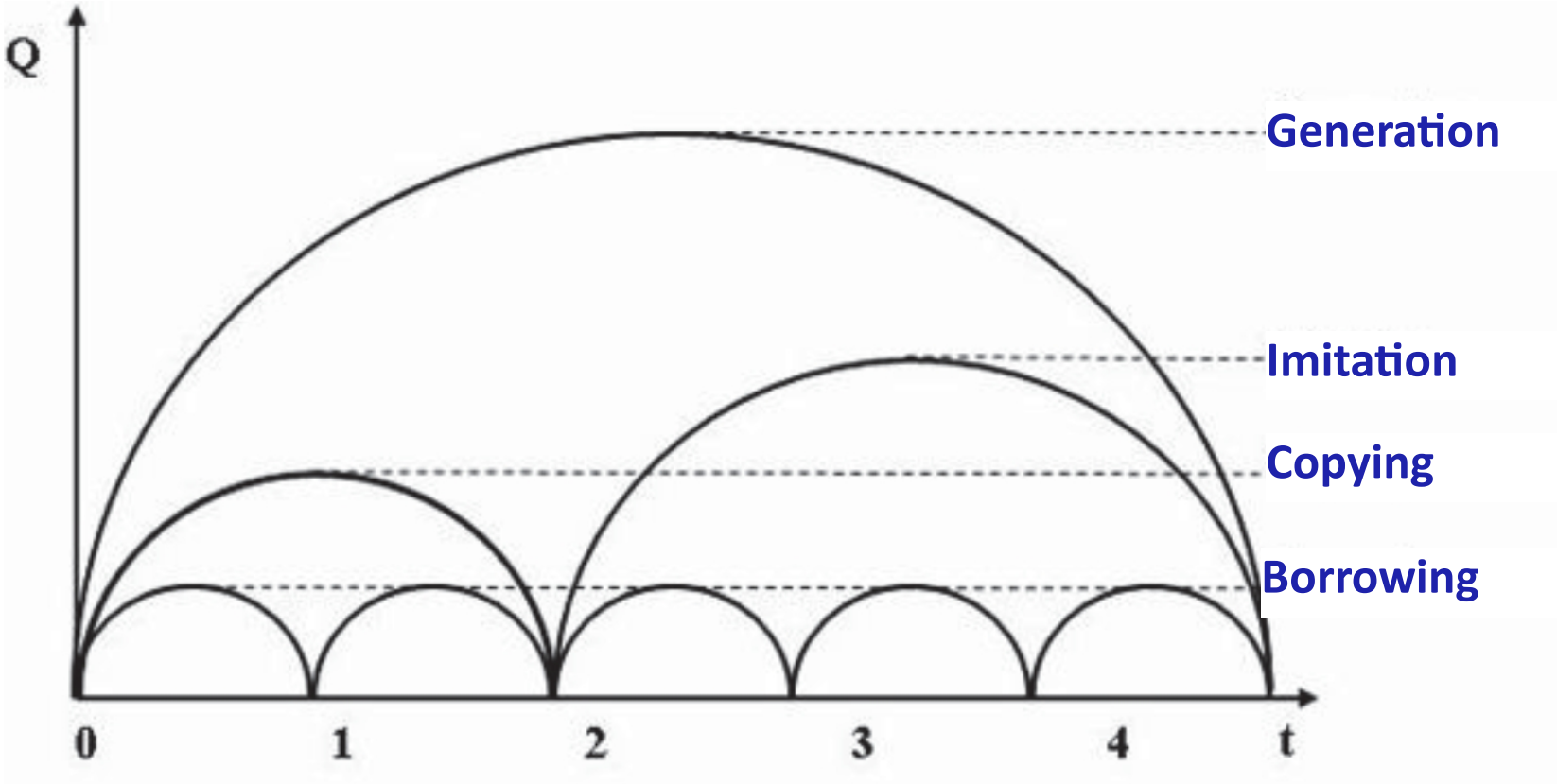
Models Bring Data & Ideas Together



Approaches

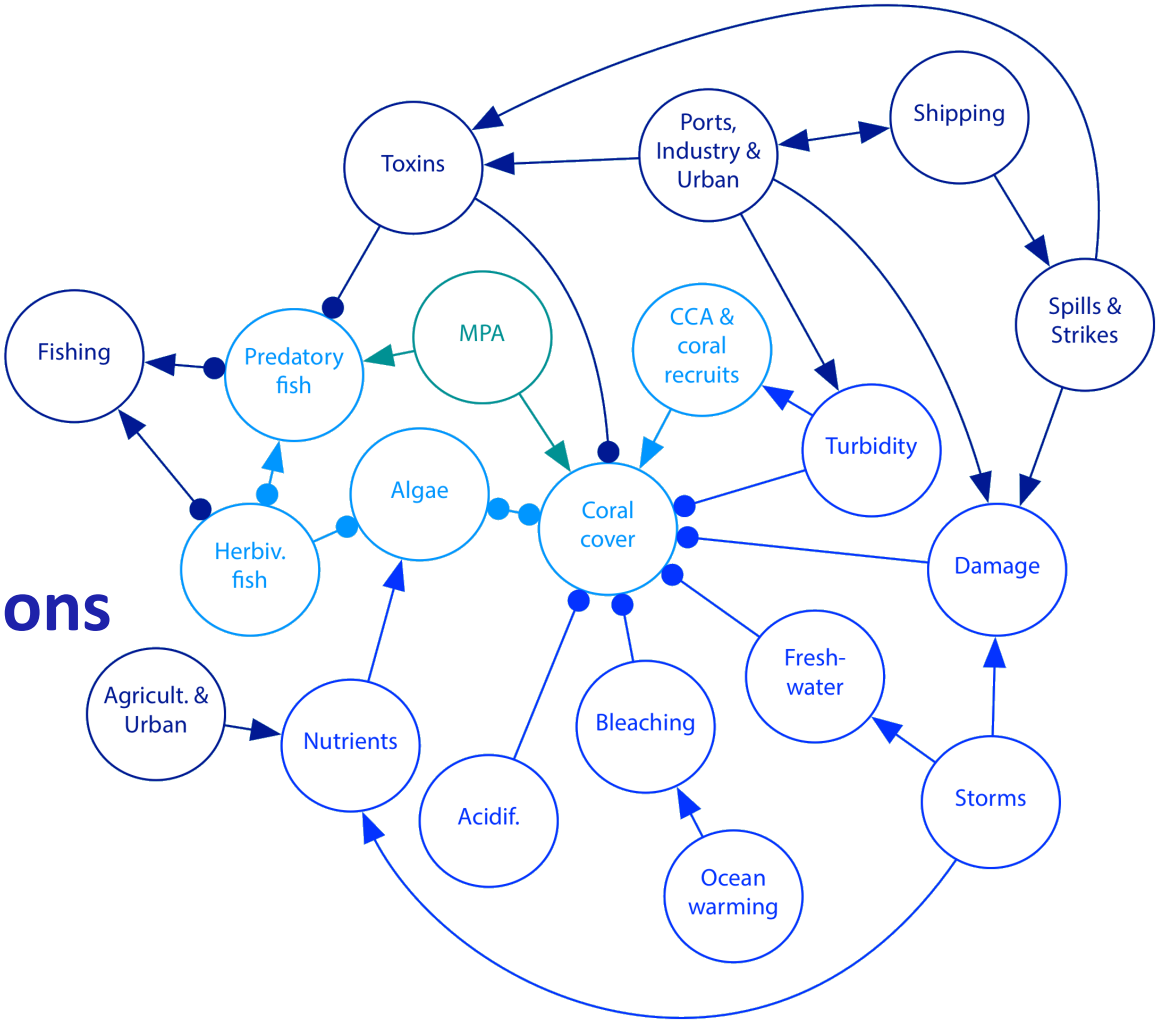
- Make use of innovation phases



Popov and Vlasov 2015

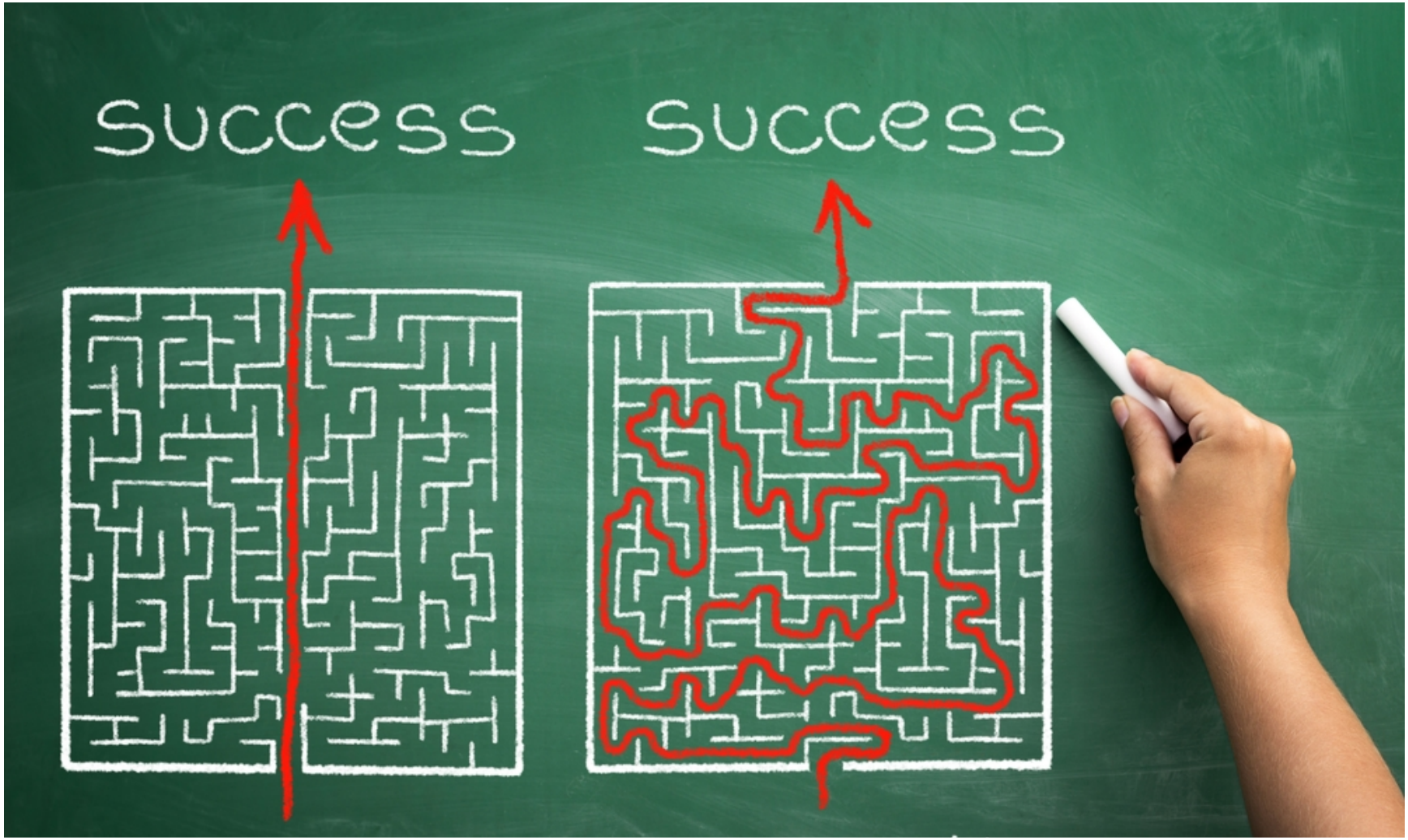
Approaches

- **Diversity of options**
  - qualitative
  - statistical
  - stocks & flows
  - differential equations
  - agent based (and hybrids)



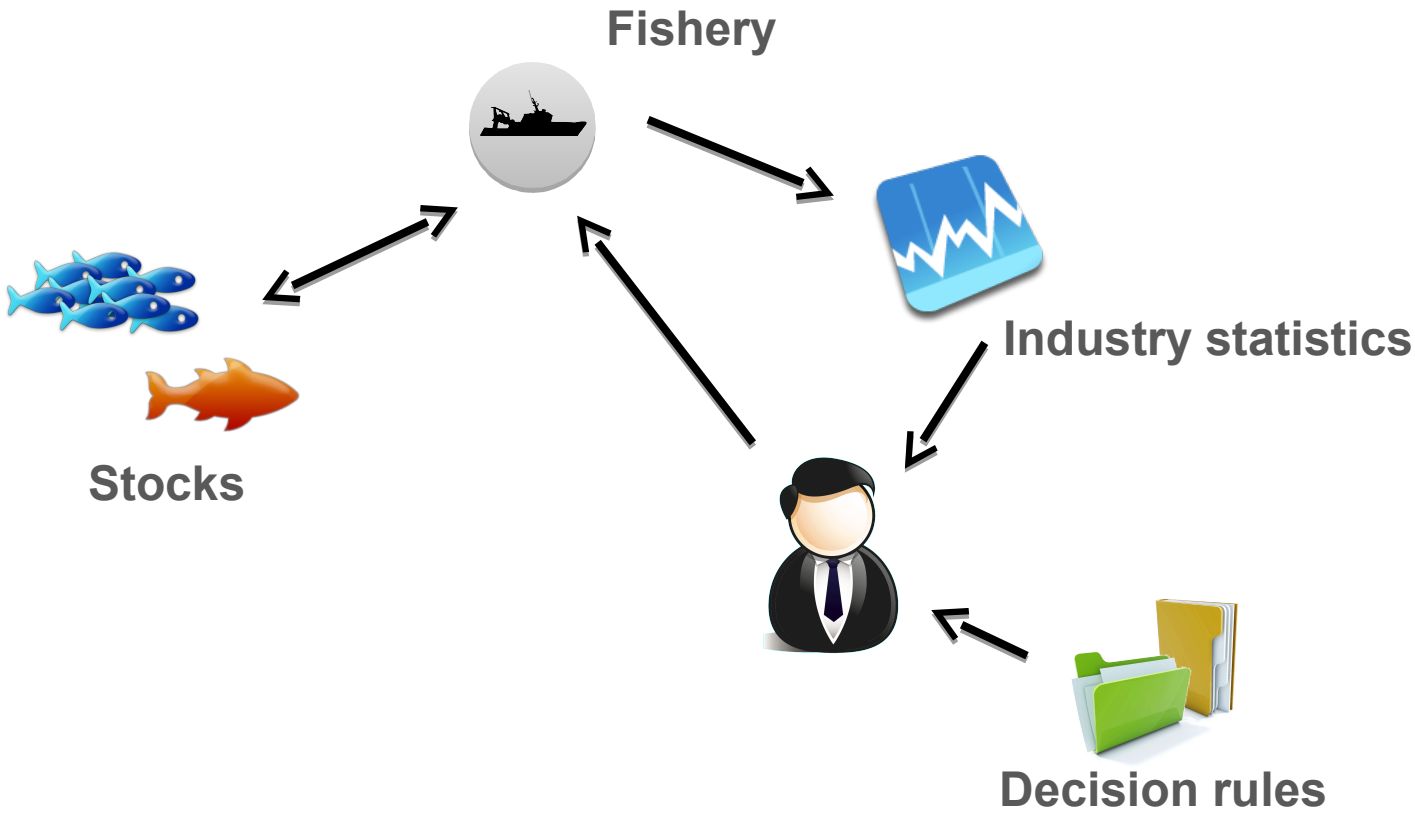
Model from: Anthony et al (2013)

Ok there are issues …



Linking the sub-systems

- One vs two way coupling



- Best management = quotas or economic levers (mostly)

Fulton et al 2014

Linking the sub-systems

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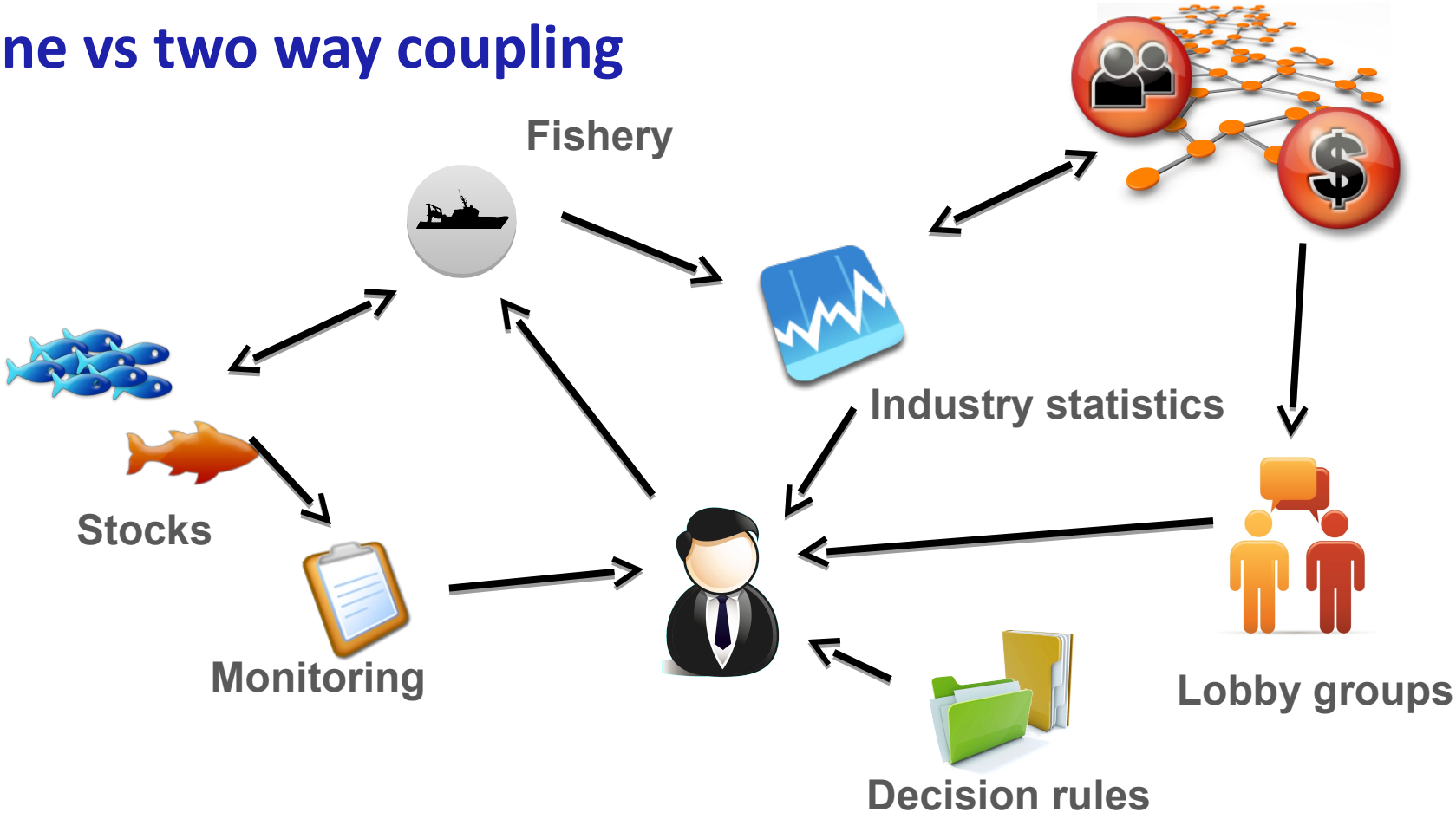
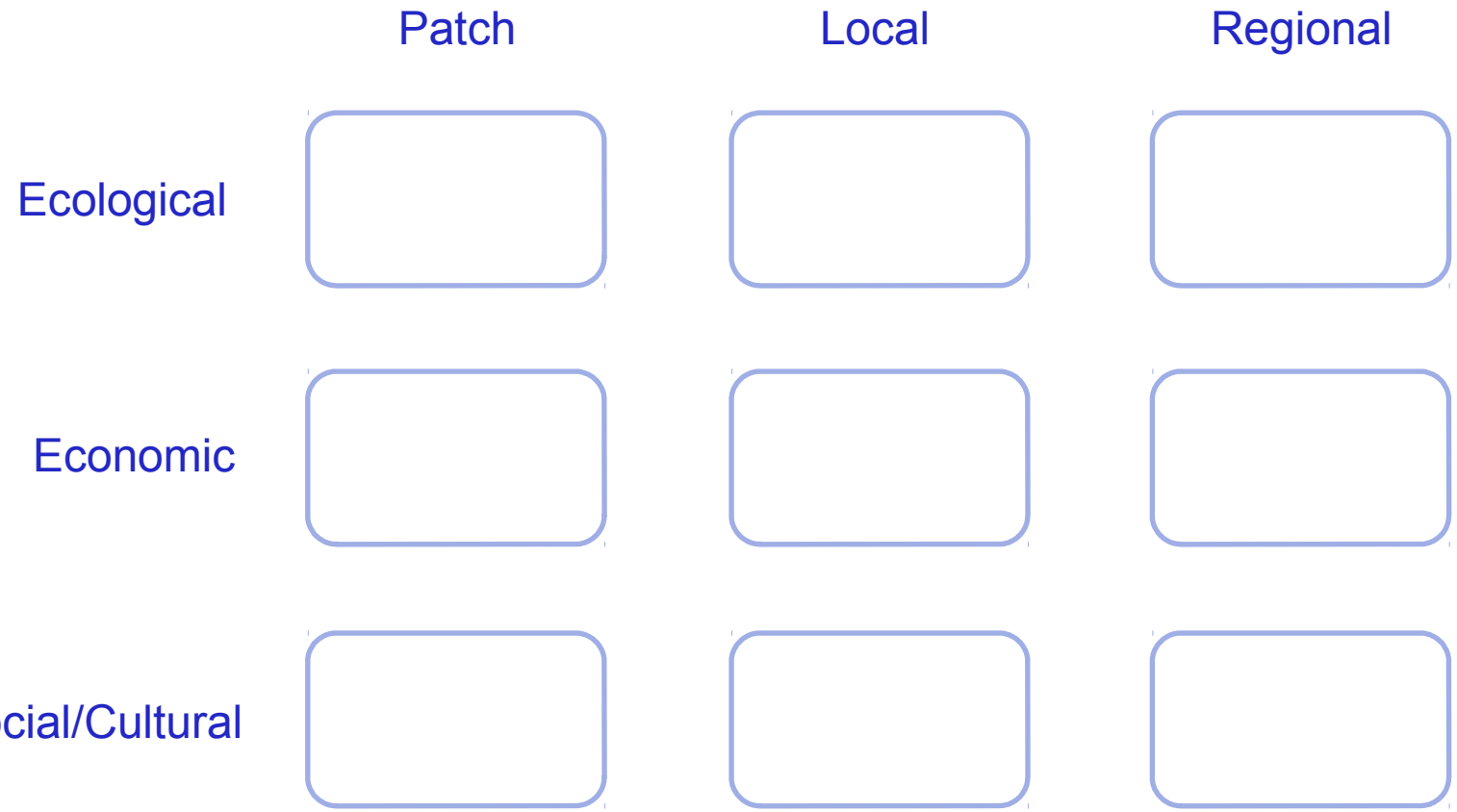


- Best management = quotas + spatial + gear (+ social)

Fulton et al 2014

Scale interactions

- Hierarchy of change (cross scale interactions)
- Path dependency

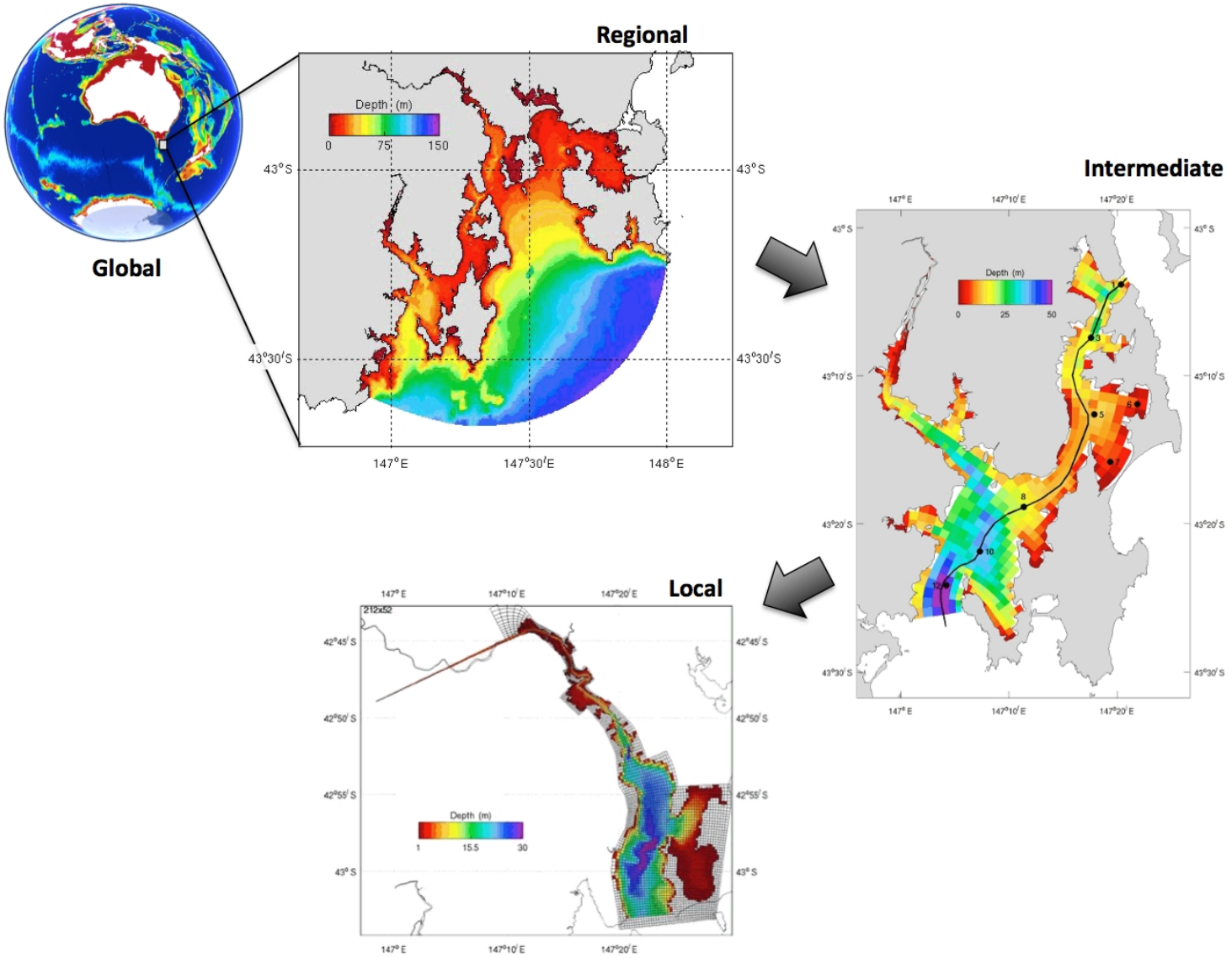


Kinzig et al 2006

Handling multiple scales

	Patch/Individual	Local	Regional	Global
Physical	**Stressors**	**Storm**	**Weather & Climate**	**Climate**
Ecological	**Feeding interaction**	**Connectivity**	**Productivity**	**Biogeo-graphy**
Economic	**Household income**	**Fishery**	**Economy**	**Trade**
Social/Cultural	**Families**	**Land use**	**Geography**	**Migration**
Management	**Regulation & Voting**	**Municipality**	**State Government**	**Conventions**

Physical and Chemical Models Span Most



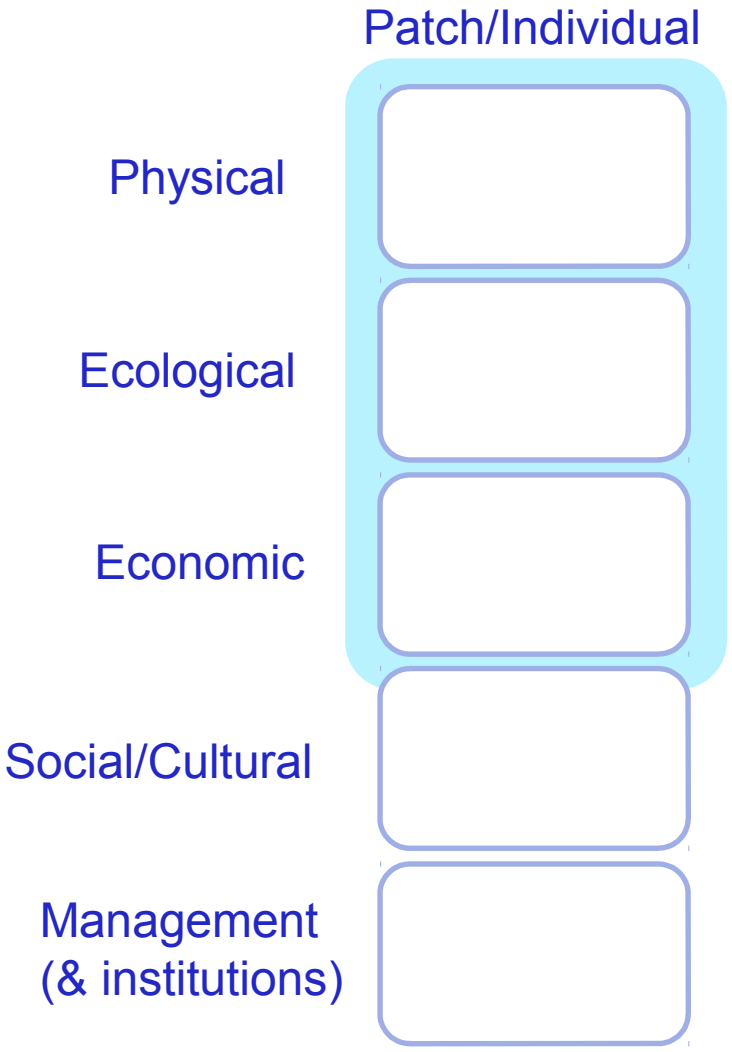
Handling multiple scales

The great challenge for the next several decades will be to advance understanding of social systems in the same way that the past century has advanced understanding of the physical world.

Jay Forrester (1987)

- Modelling weakest at intermediate scales & for socially related

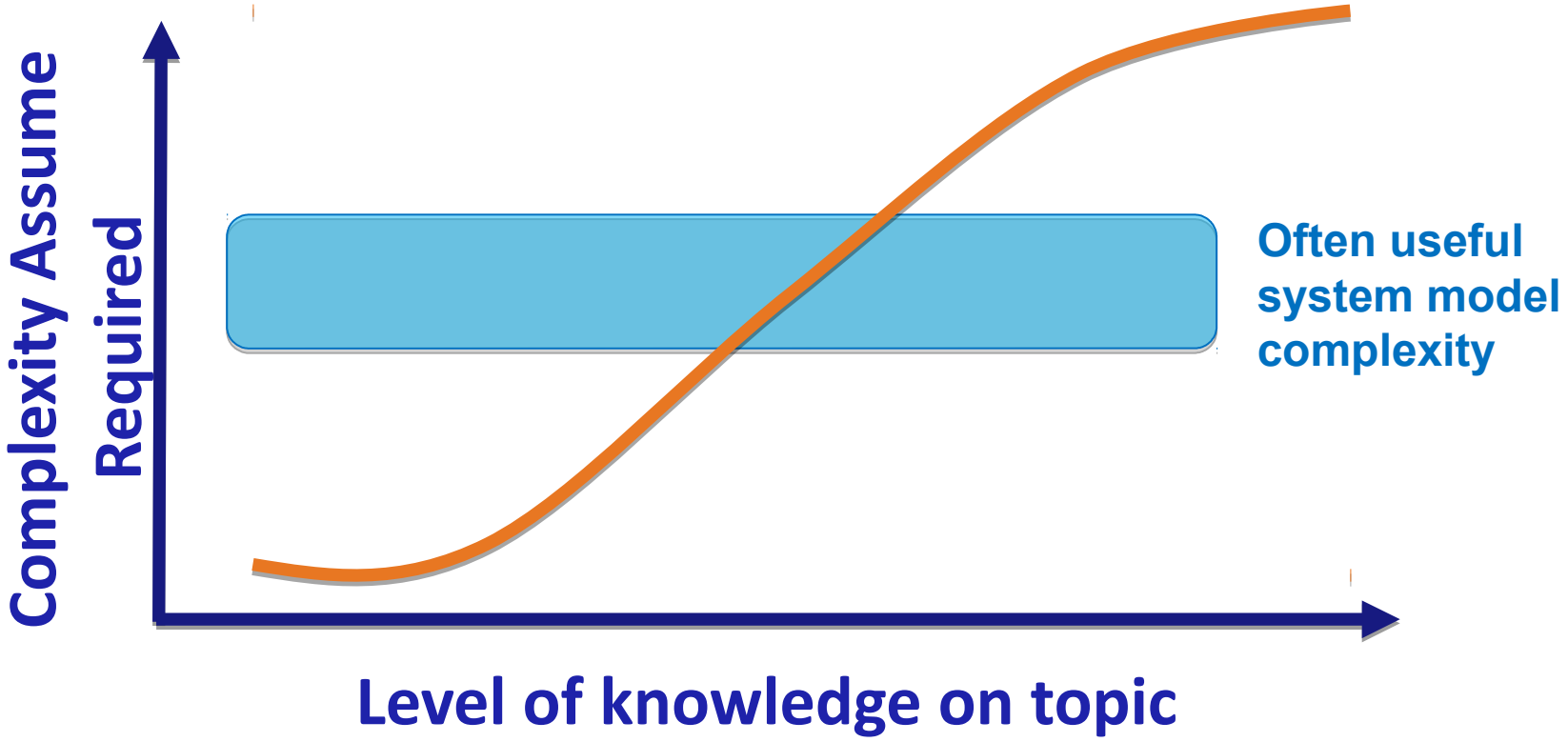
Handling multiple scales



- **Growing capacity**
  - **especially biophysical**
- **Data poor**
- **Noisy**
  - **model & data**
  - **process overlap**
  - **management success**
- **Cross-scale hard to do well**
  -

Modelling people

- Greeted with suspicion (considered too complex)



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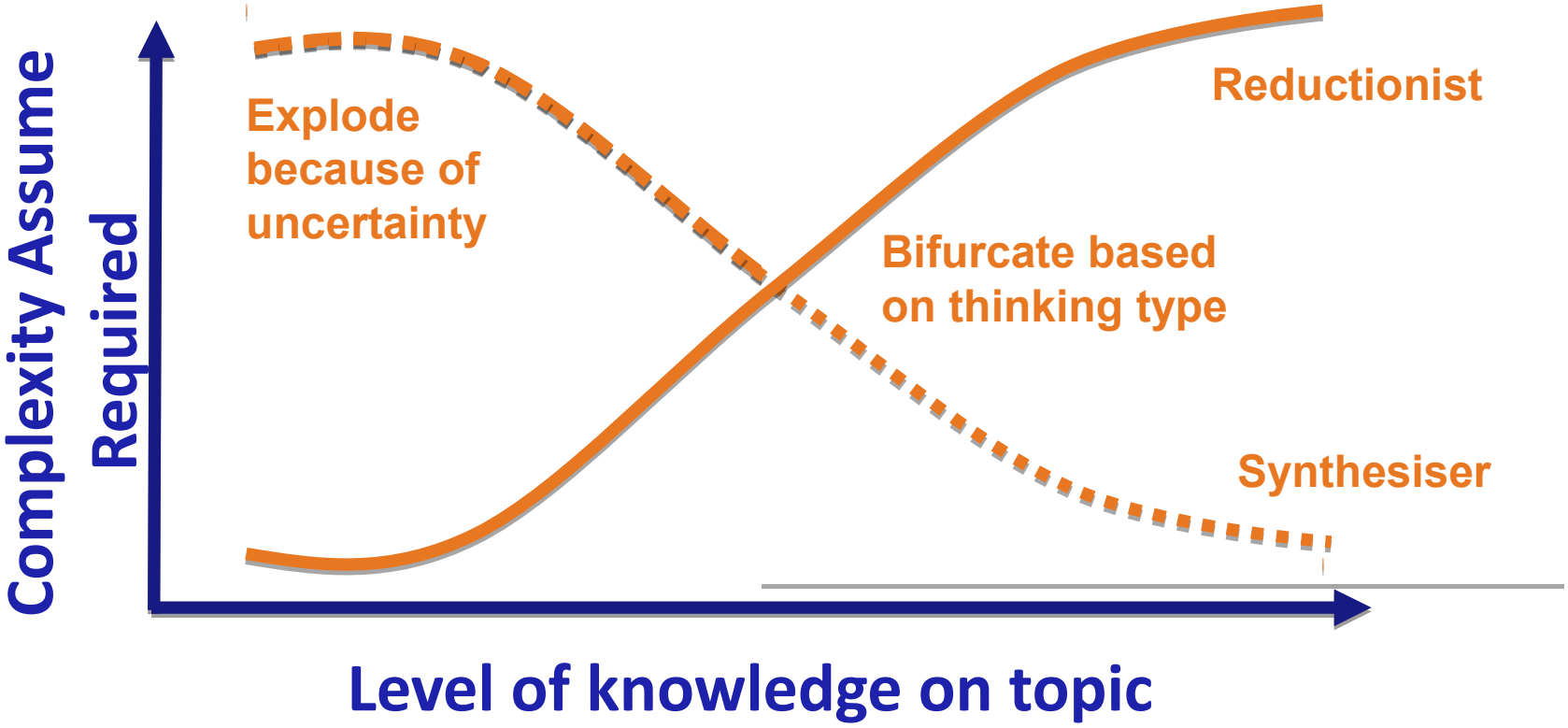
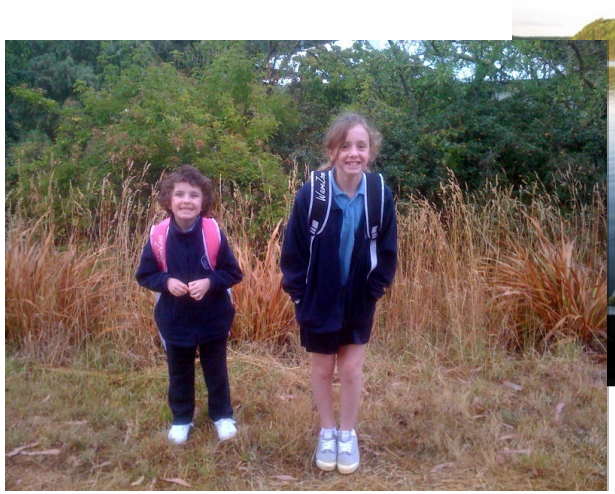


Modelling people

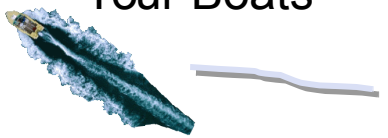
- **It is possible (or advertising wouldn't work)**

Basic human collective needs + Actor (or location) contextual needs + Meta-impacts (uncontrollable) = Experience and response



Agent based models of behaviour

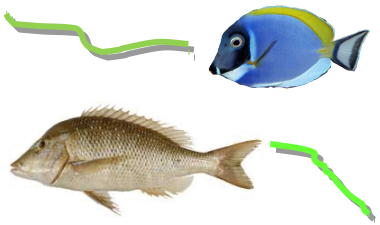
Tour Boats



Tourists

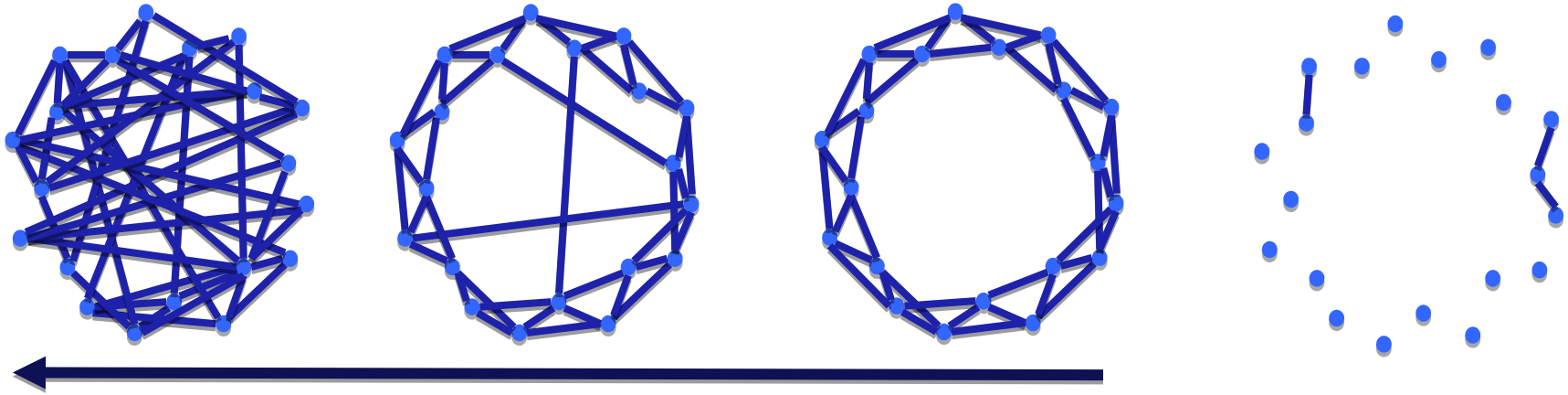
Residents

Fish schools



Fulton et al 2011

Capturing Human Behaviour



- Too efficient = clump & poor performance
- Some inefficiency = sustainable & at target
- Lesson = Mistrust undoes everything

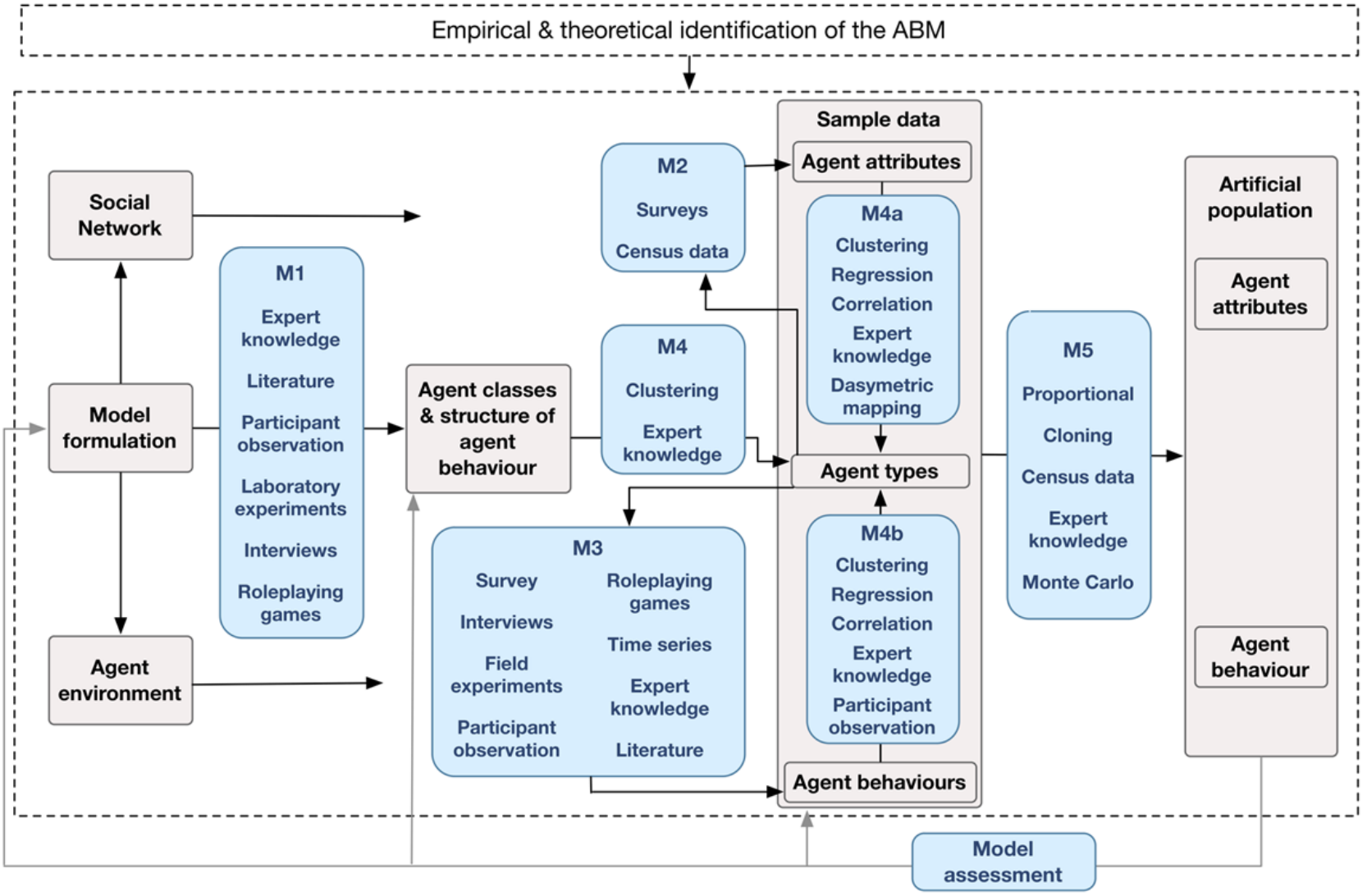
Modelling people

- Business world is paying attention
  - network economics (models) exposing cascade failure
  - ABM model saved Proctor & Gamble $300 mill USD
  - health & defence etc to

Shawn Brown (psc.edu)

Modelling people

- Multiple methods and data sources useful



Modelling people

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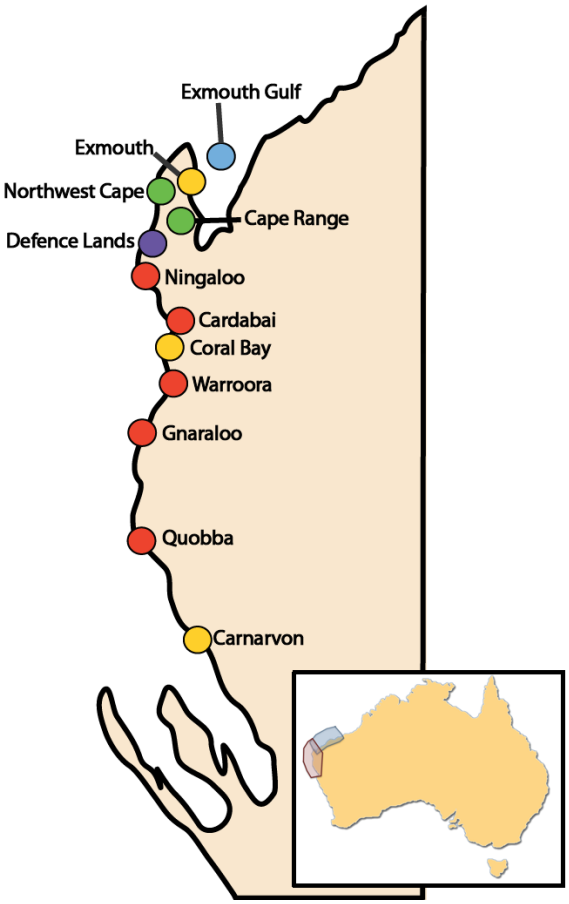
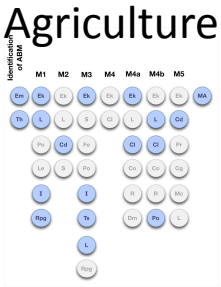
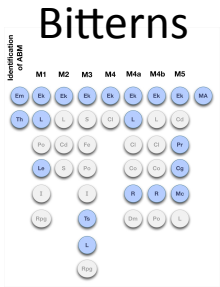
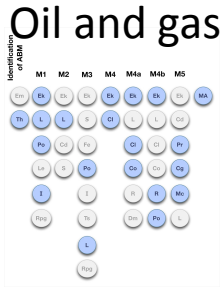
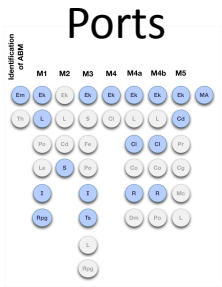
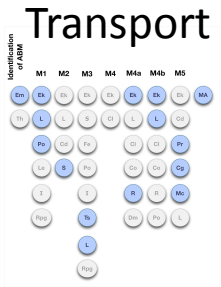


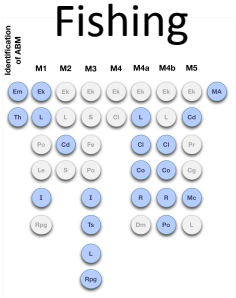


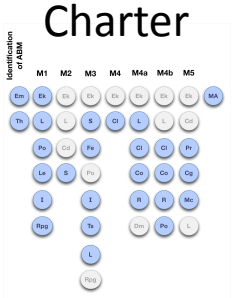


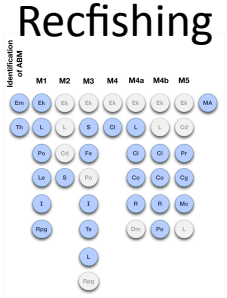


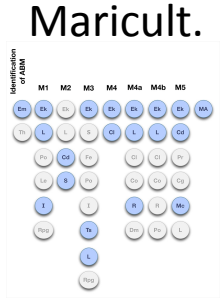


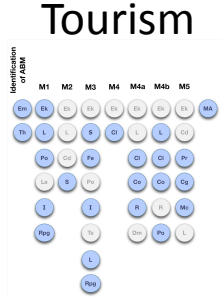


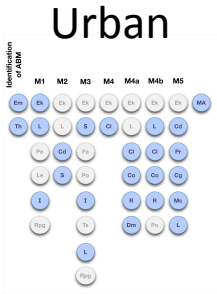


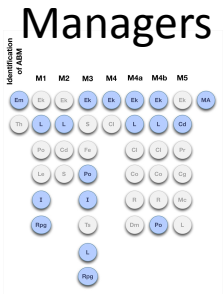


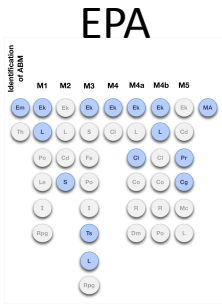


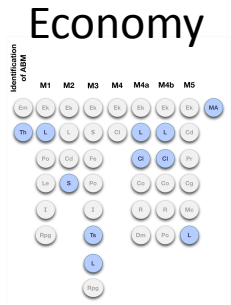








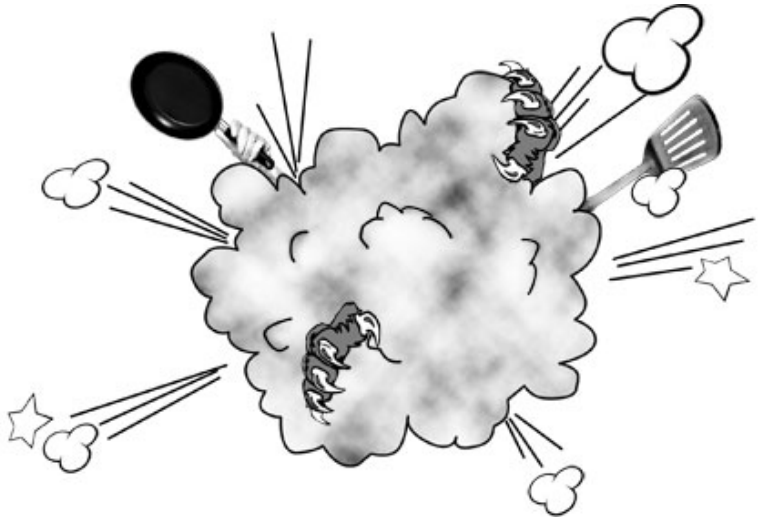




Gray et al 2013

Modelling institutions

- Hard as mix many ‘fuzzy’ human aspects & data poor
- Important for considering adaptive capacity of institutional arrangements
  - explore management options given current institutions
  - highlight when institutional change needed



Modelling institutions

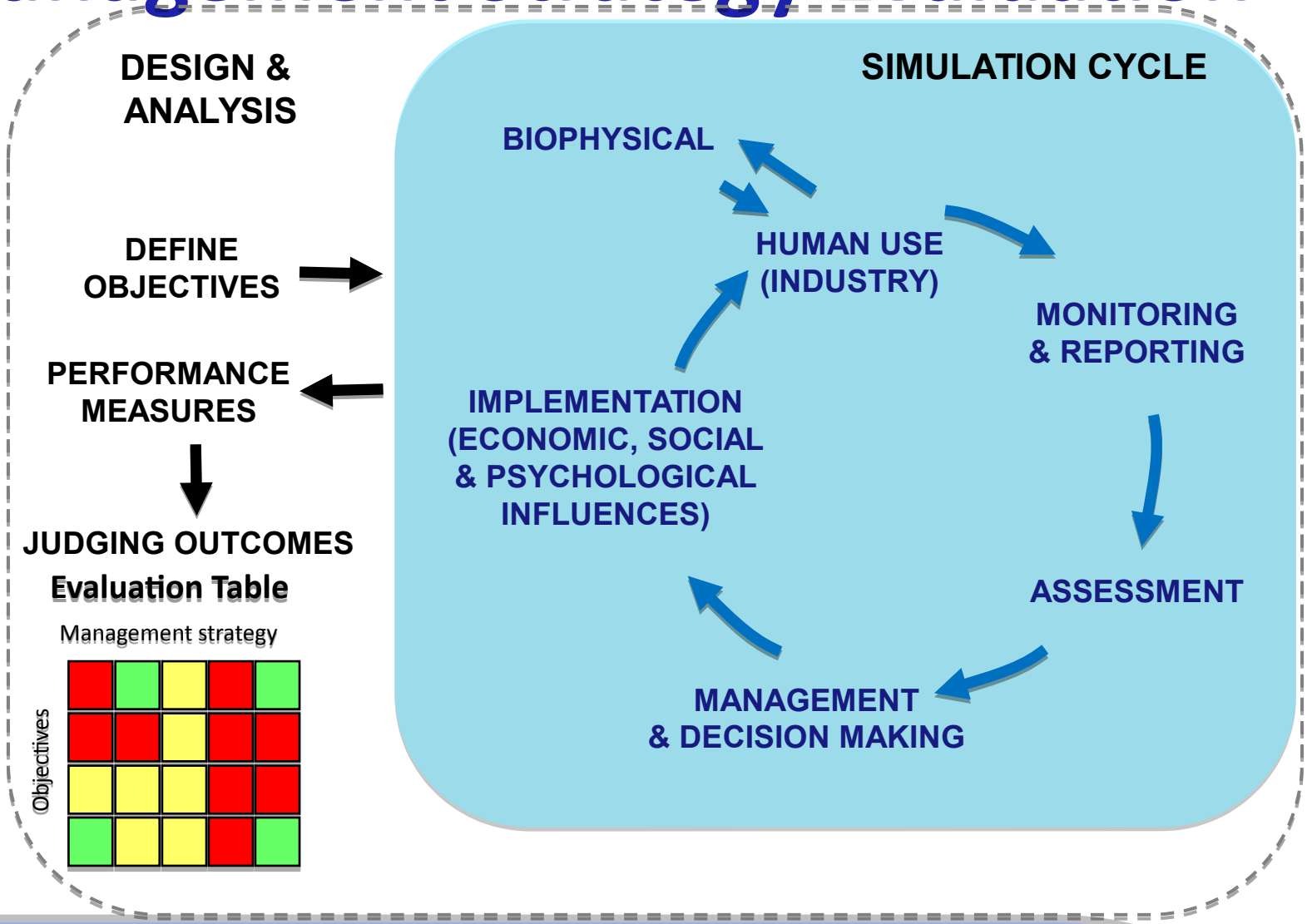
- Hard as mix many ‘fuzzy’ human aspects & data poor
- Important for considering adaptive capacity of institutional arrangements
  - explore management options given current institutions
  - highlight when institutional change needed
  - warn of change barriers

Uncertainties - Extreme events & Variability

- Lots of kinds of uncertainty
  - parametric, structural, “known unknowns”
- Hardest = step-change, extreme events
  - “Amistics” (Neal Stephenson)

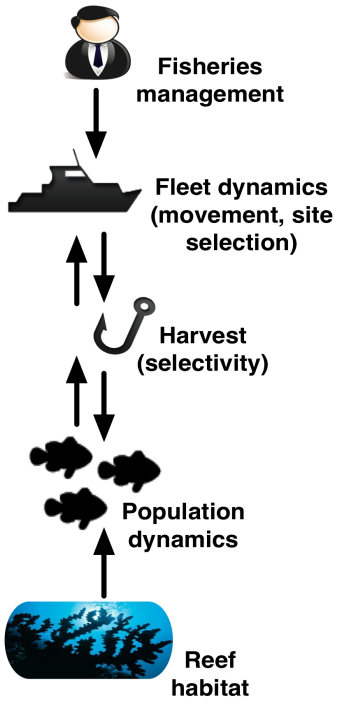
- combined role of models and scenarios

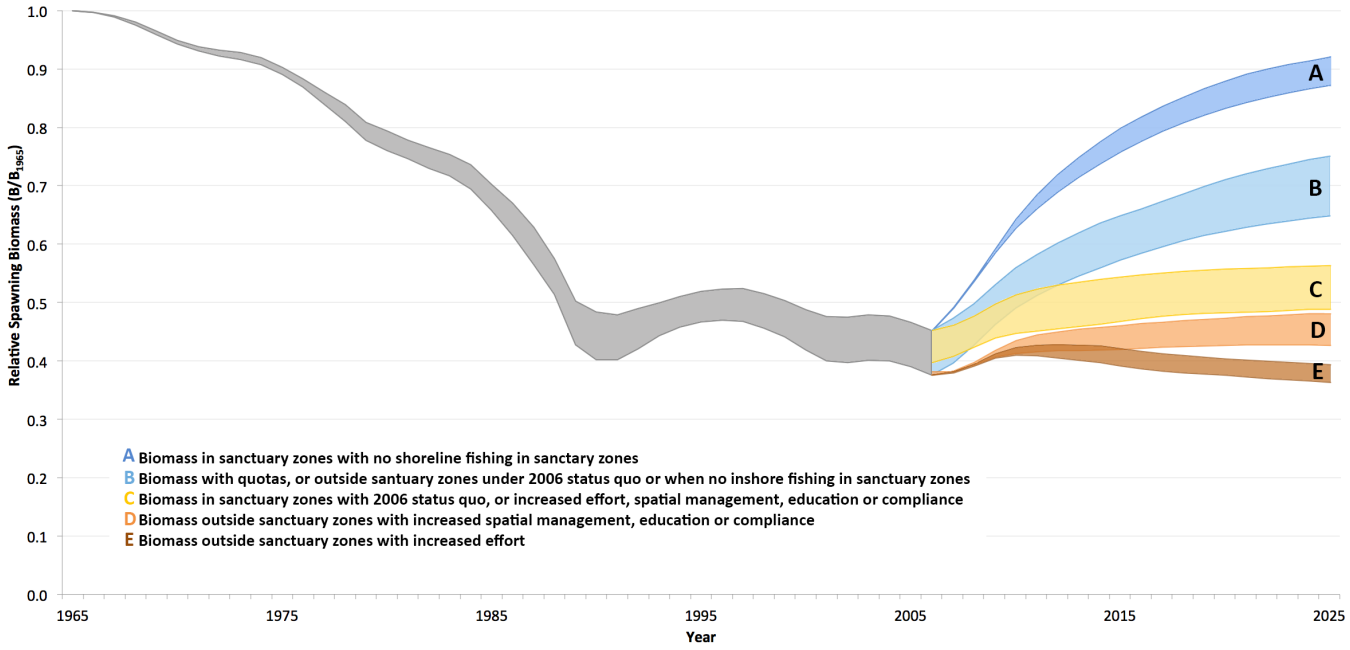
Management Strategy Evaluation



- Systems perspective + Adaptive Management Cycle

Management Strategy Evaluation





- A tool useful for exploring uncertainty
  - tests for the primary uncertainties
  - includes robustness tests for more unlikely scenarios

Little et al 2007, Fulton et al 2015

Pragmatic reality

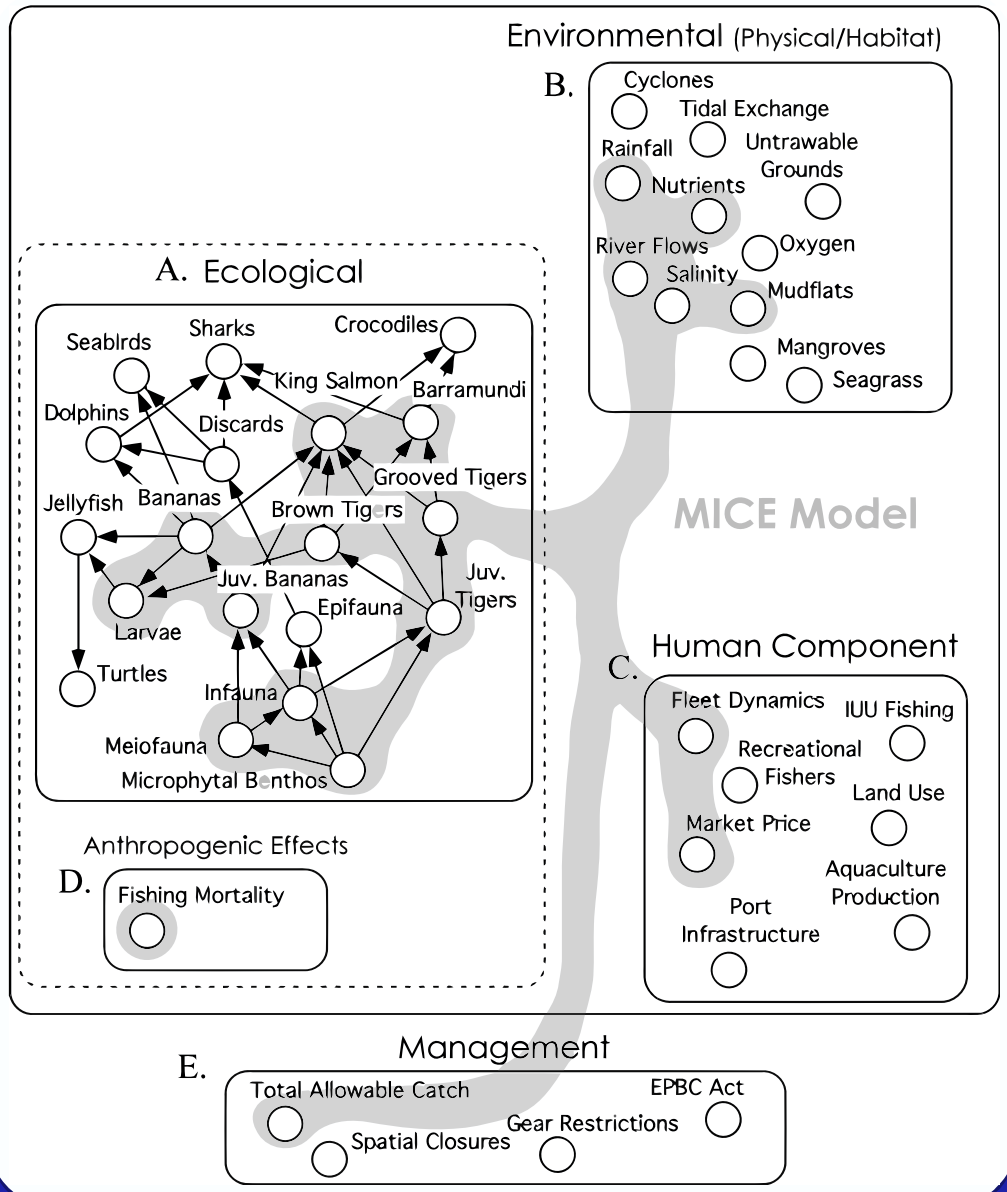
- Multiple model uses
  - forecast & understanding
  - different roles in different situations (tactical, strategic, simple, complex)
- Multidisciplinary approach overcomes individual pitfalls
  - no one true model, embrace multiple perspectives

England 1993, Orrell & McSharry 2009, about a gazillion modelling papers…

Keeping your sanity

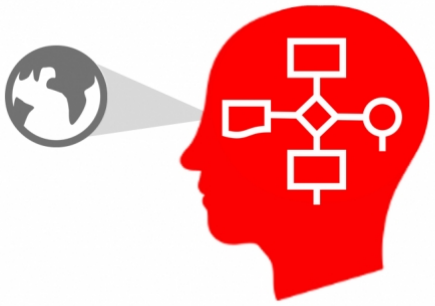
- “Minimum realistic” a good option

System thinking (regardless of final method)



- Think broadly
  - useful for many models (not just system models)
  - Key players
  - Light touch on all
- Intermediate complexity
- Tactical & strategic models

Uptake - the REALLY hard bit



- Lack of Time (& resources)
- Inappropriate trust
  - too much, too little
  - trust mental models (mix of emotions & function)
  - multiple (inconsistent) models held simultaneously
  - question model value before own assumptions
  - static past, now, future rather not a dynamic view

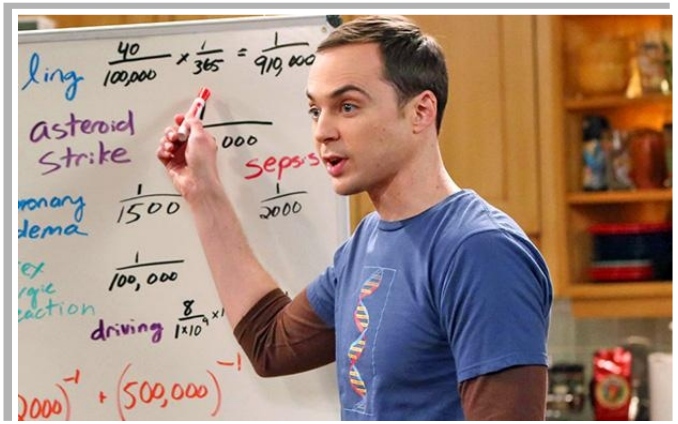
Image: pitstop@theasggroup.com

Distrust of models

- Familiarity & trust (competency, integrity, warmth)
- Easy to blame the modeller (nerds still aren't cool)
- Science = one voice (how much relative trust to place in it?)
- Honest broker and participatory approach misunderstood

You're in the pocket of…

‹insert disliked group of choice›



Summary

- Crowded space & conflicting objectives
- Maths = universal language across socioecological
- Models for synthesising information & providing options)
- New challenges
  - Modelling new scales & components
  - Alternative (e.g. hybrids) required
  - Building trust & resources

- **No right model so have a go!**

Thank you

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