espa
ecosystem services for poverty alleviation

GLORIA
Global Learning Opportunities for Regional Indian Ocean Adaptation




Activity/*Activité* 4: Key Ecological Assets
Ressources écologiques essentielles

Conceptual models of key ecological assets, processes and drivers

Convenor/ *Présidente*: Éva Plagányi and Ingrid van Putten, CSIRO (Australia)
Tom Chaigneau, Exeter University (United Kingdom)
Team member: David Obura (Kenya)

OCEANS & ATMOSPHERE
www.csiro.au

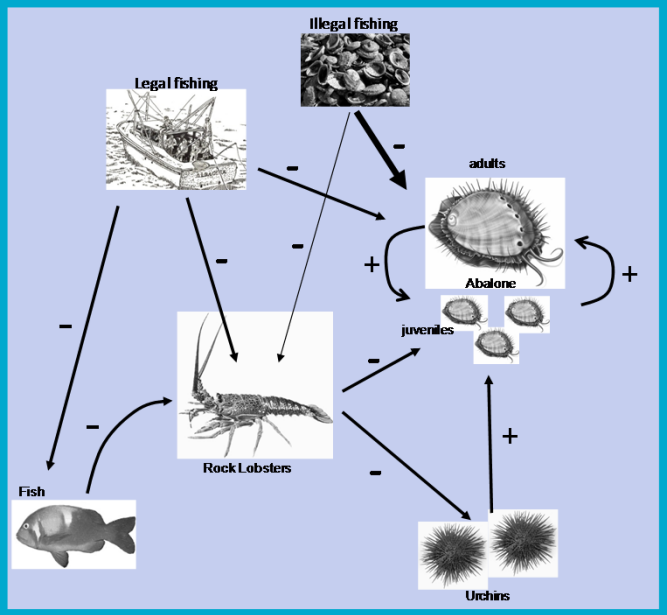
14-16 June 2016

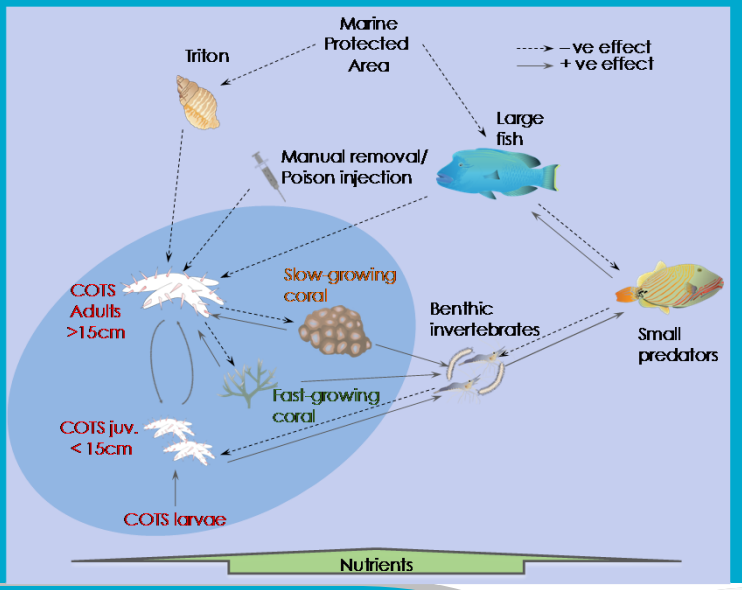
CSIRO

AIMS

1. Conceptual models of key ecological assets and processes
2. Collaborative development of conceptual models

Model results can inform monitoring and management





Climate change and people

Livelihoods

Social wellbeing

Cultural

Traditional fishers

Artisanal fishers

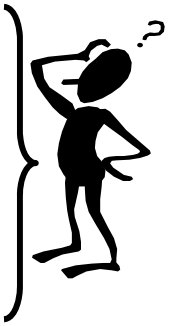
WHY MODELS?

- Representation of a system that can be used to synthesize understanding and make predictions
- Can simulate alternative scenarios (cf flight simulator), predictions and impact of management actions – difficult to do this in the real world

Need to road-test climate-smartness of management strategies

Objectives for Ecological Models

- **Conceptual/Conceptuel:** of the structure, functioning and interactions of the ecosystem. May not be used explicitly in decision-making or scientific advice. Forms **underlying context** for any detailed management planning and decision-making

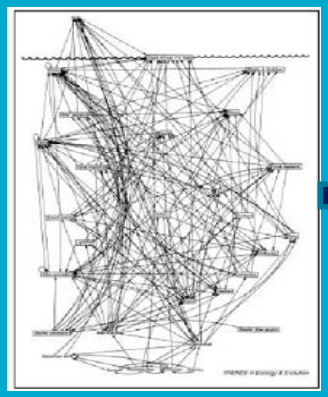


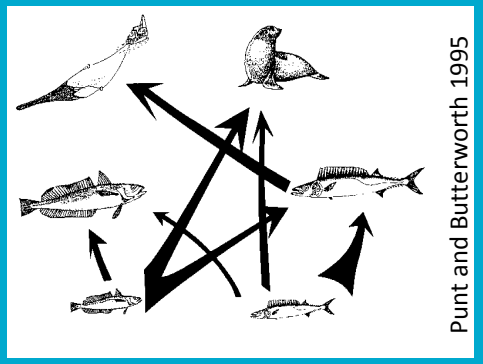
- **Strategic/Strategique decisions**: linked to **policy goals** and are generally long-range, broadly-based and inherently adaptable

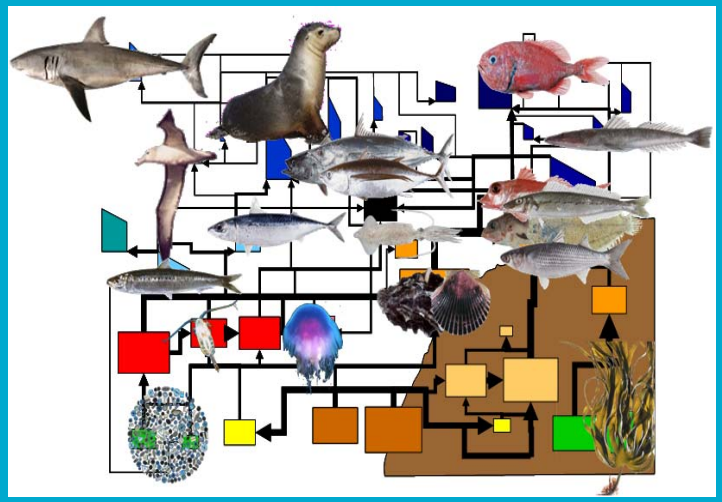
- **Tactical/Tactique decisions:** aimed at the short-term (e.g. next 3-5 years); operational objective in the form of a rigid set of instructions e.g. **tactical decision** tc

MODEL TYPES

1. Simple vs complex
2. Qualitative (descriptive, conceptual drawing) vs quantitative (numbers, statistics)
3. Mechanistic understanding vs dynamic process models fitted to data using statistical theory

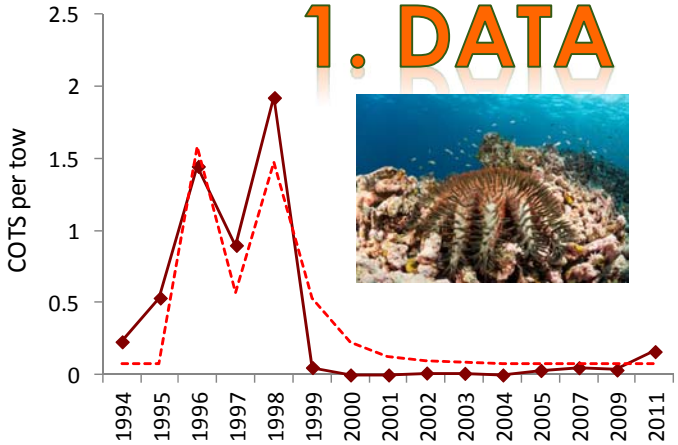






TOOLBOX

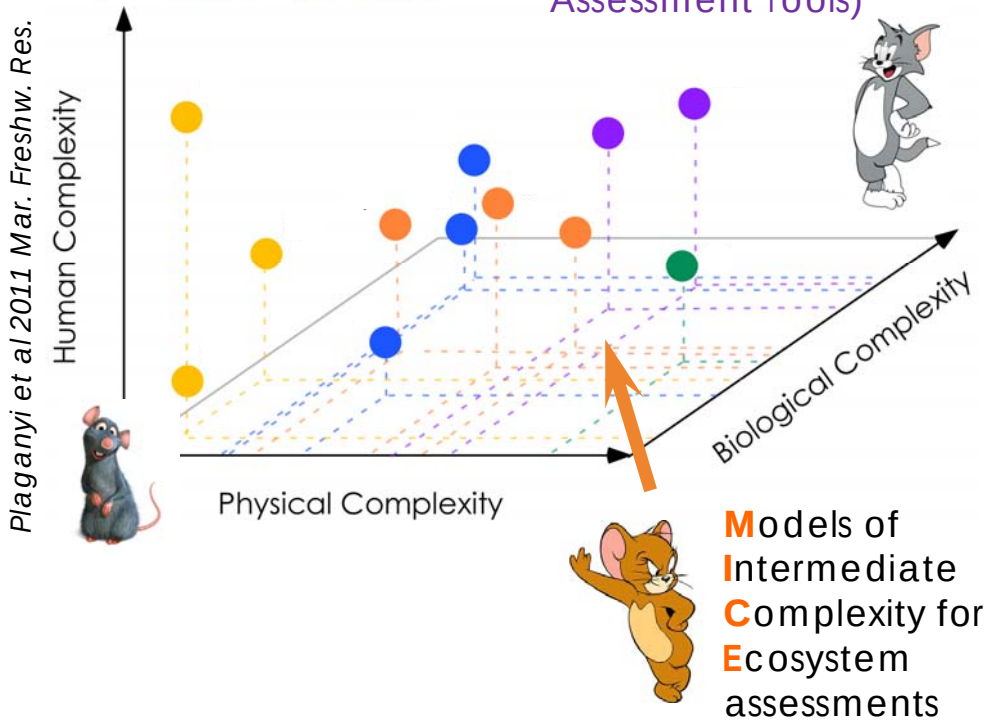
1. DATA



Courtesy: AIMS

2. MODEL

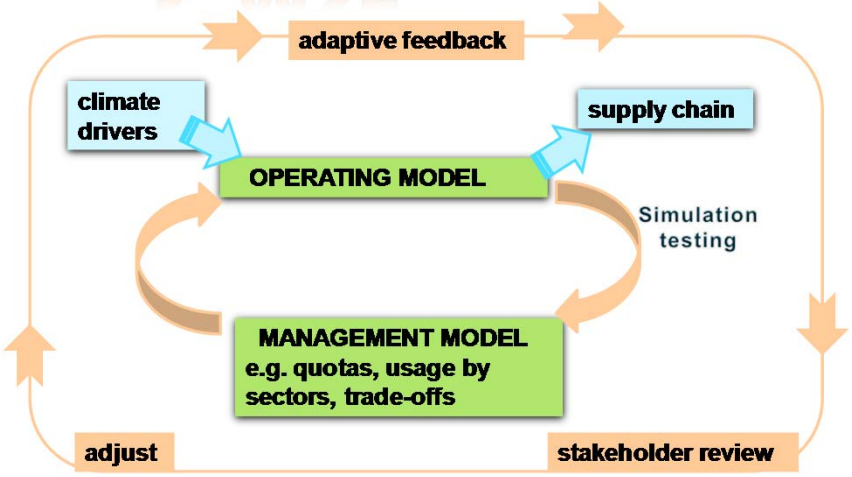
CATS (Complex Assessment Tools)



Models of **I**ntermediate **C**omplexity for **E**cosystem assessments

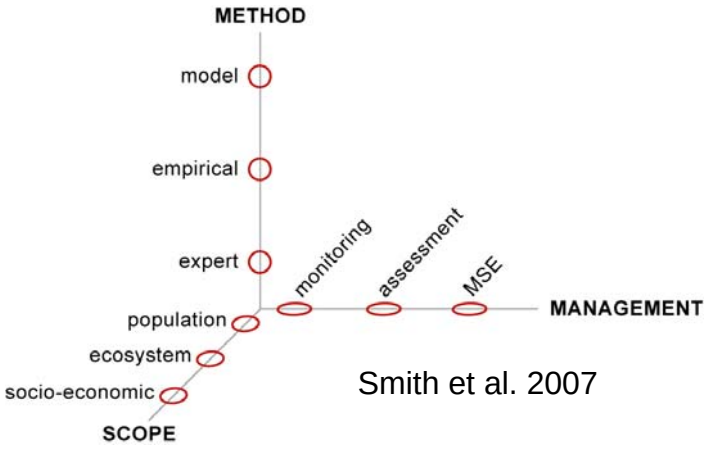
3. MSE

Management **S**trategy **E**valuation

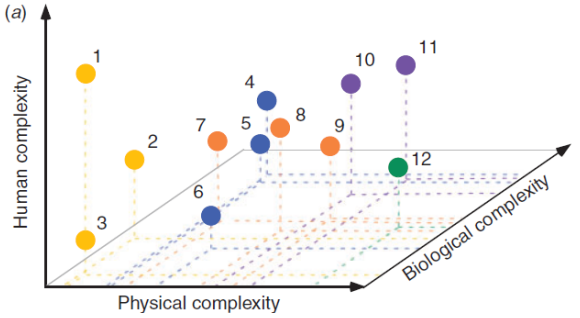


Ecosystem-based fisheries management in Australia

- Range of tools, from simple to complex, qualitative through semi-quantitative to fully quantitative
- Multiple models of same system considered ideal where feasible
- EAF has very broad focus – multiple sectors, industry, mining etc
- Increasing incorporation of economic and social factors
- Coming to grips with merging fisheries and conservation science
- Use of MSE* is key

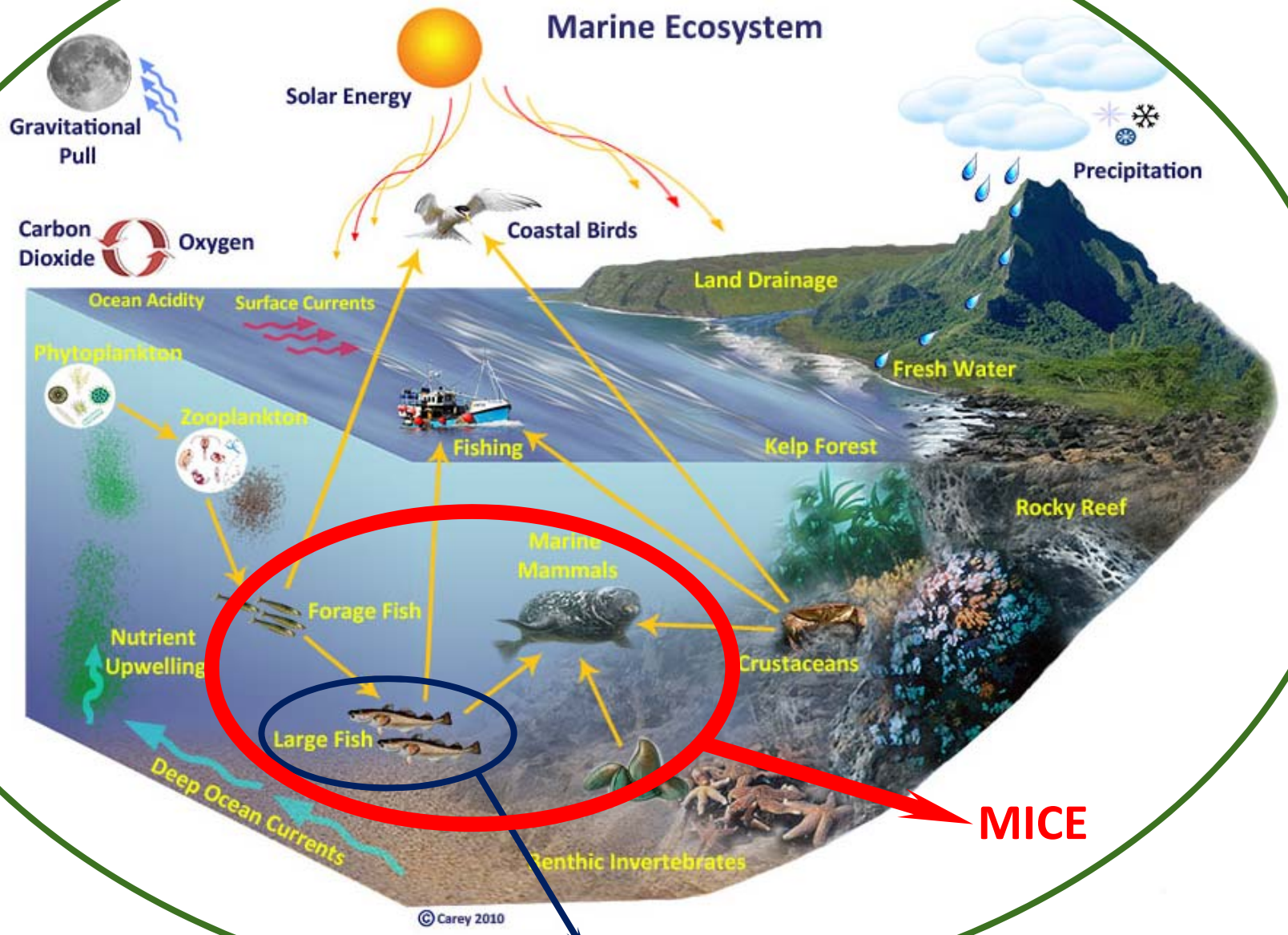


Smith et al. 2007



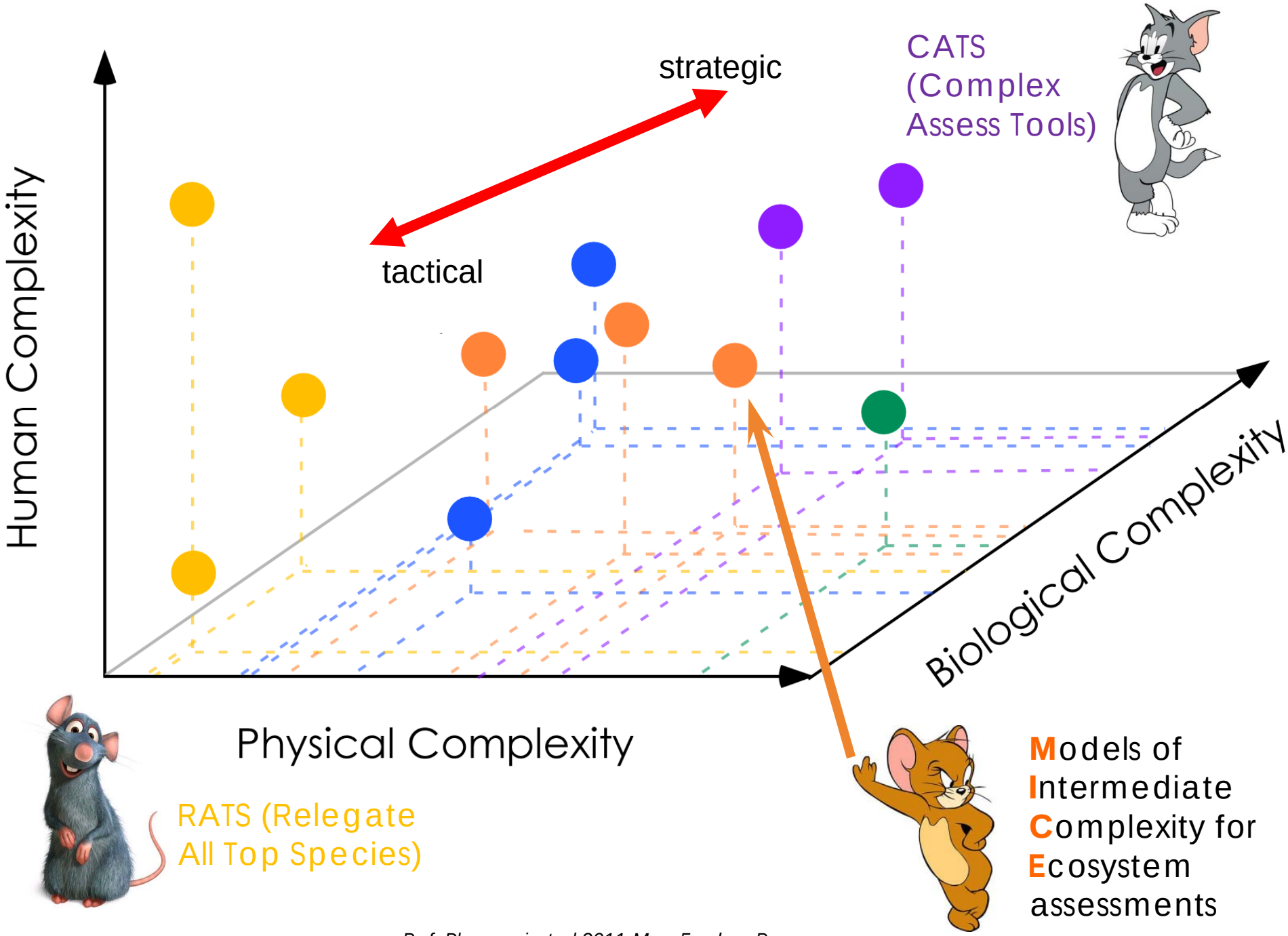
*MSE – Management Strategy Evaluation

Whole of Ecosystem models



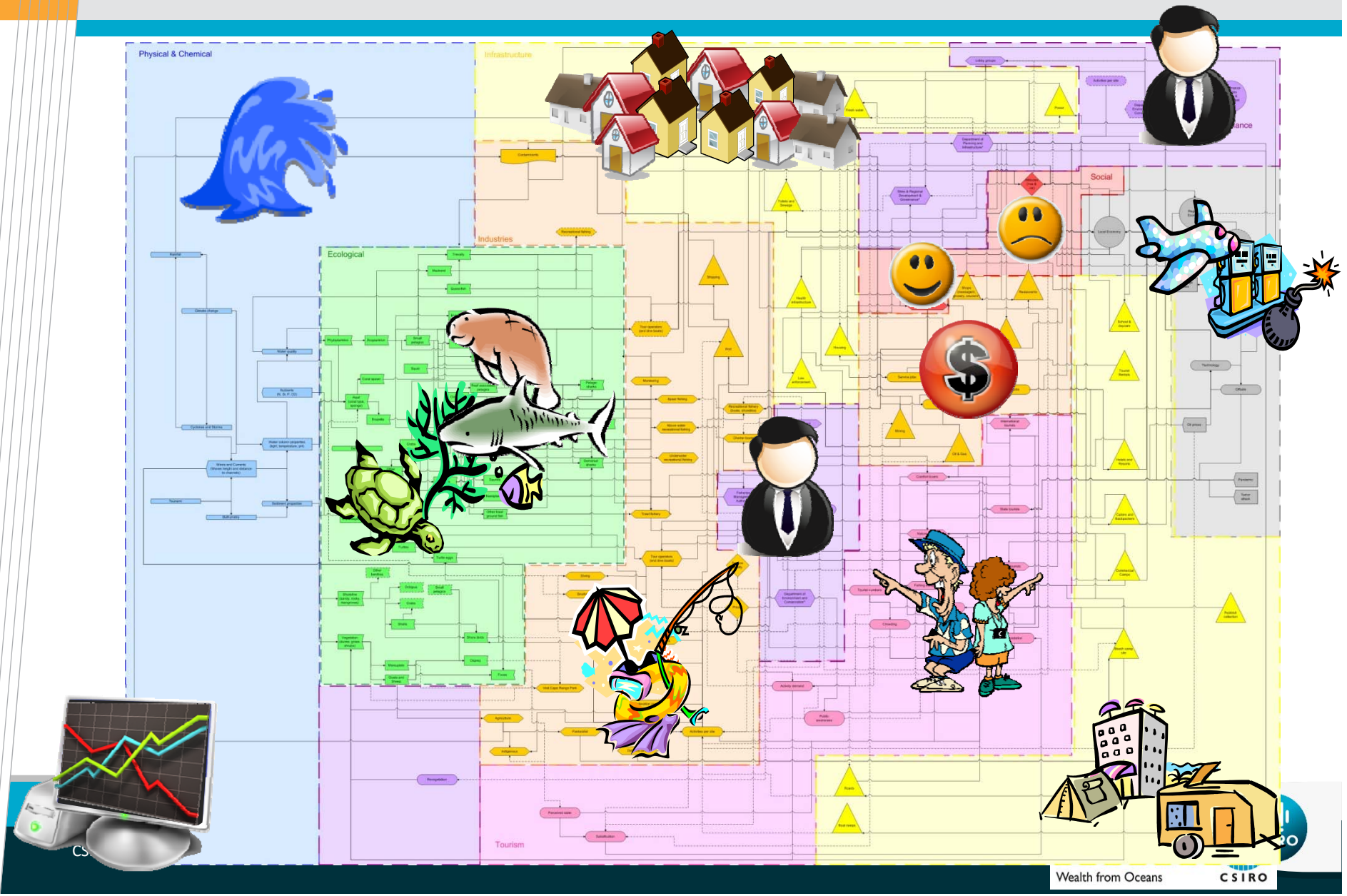
MICE

ESAM (Extensions to Single-Species Assessment models)



Ref: Plaganyi et al 2011 Mar. Freshw. Res.

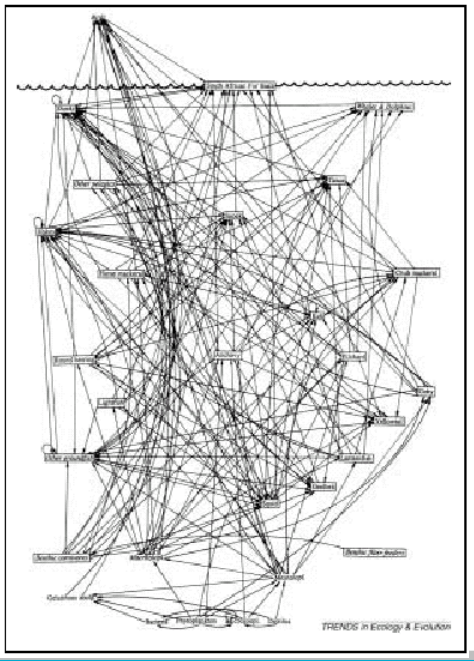
End-to-End Models (Atlantis)

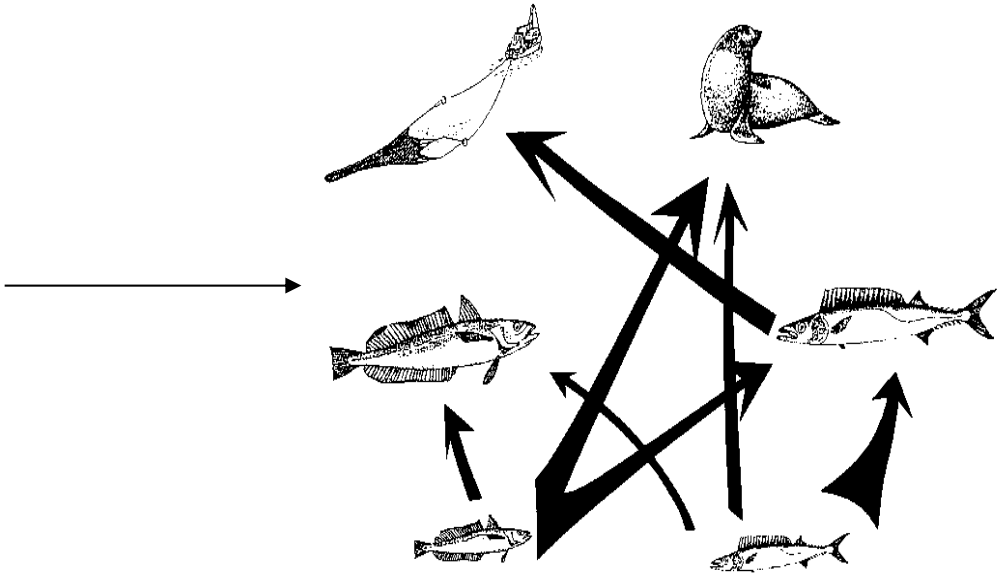


Intermediate complexity models
Modele de complexite intermediaire

- Models that bridge the gap between stock assessment and end-to-end or “whole of system” models - reduce complex system to key focus species, interactions and components

Models of
Intermediate
Complexity for
Ecosystem
assessments

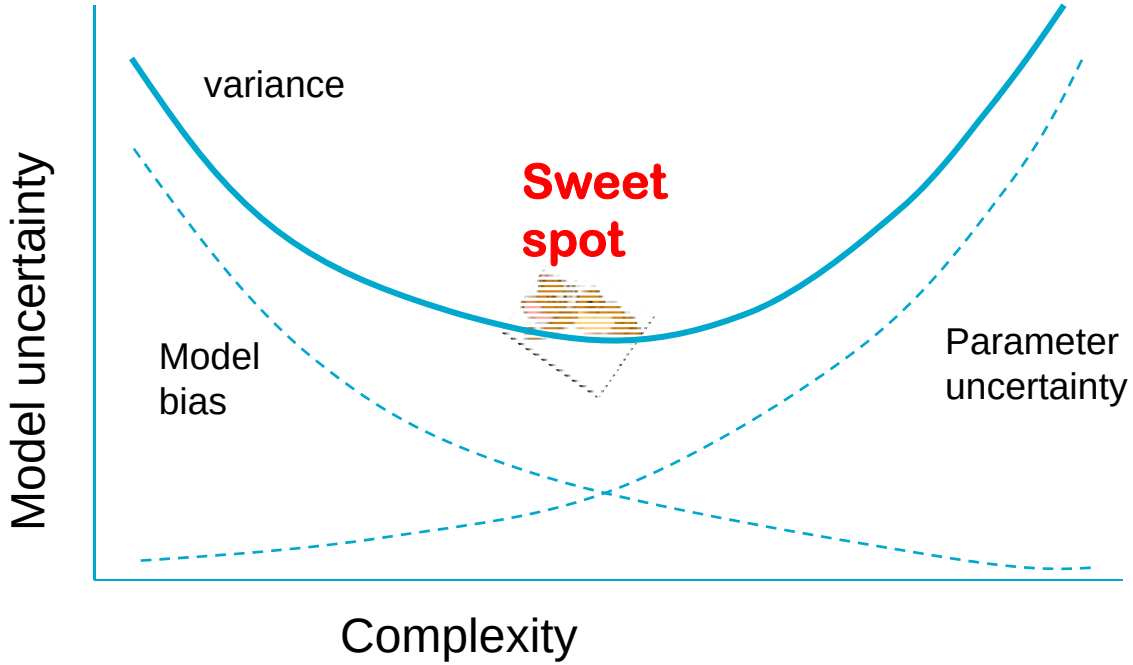




Punt and Butterworth 1995

Finding the sweet spot where uncertainty is reduced and the usefulness of these models to fishery management is maximised (Collie et al., FaF, 2014)

Variance – complexity trade-off



Models of
Intermediate
Complexity for
Ecosystem
assessments

MICE in a nutshell

1. Ability to address tactical questions
2. Intermediate complexity
3. Focus on subset of the ecosystem
4. Address specific management question
5. Are fit to data
6. Account for major uncertainties
7. Can include linked physical and human dimensions
8. Based on extensive expert/stakeholder consultation

Plagányi, É., et al. (2012) Models of intermediate complexity for ecosystem assessment to support tactical management decisions in fisheries and conservation. *Fish Fisheries*

LIZARD ISLAND, AUSTRALIA

CORAL BLEACHING
Blanchiment des coraux

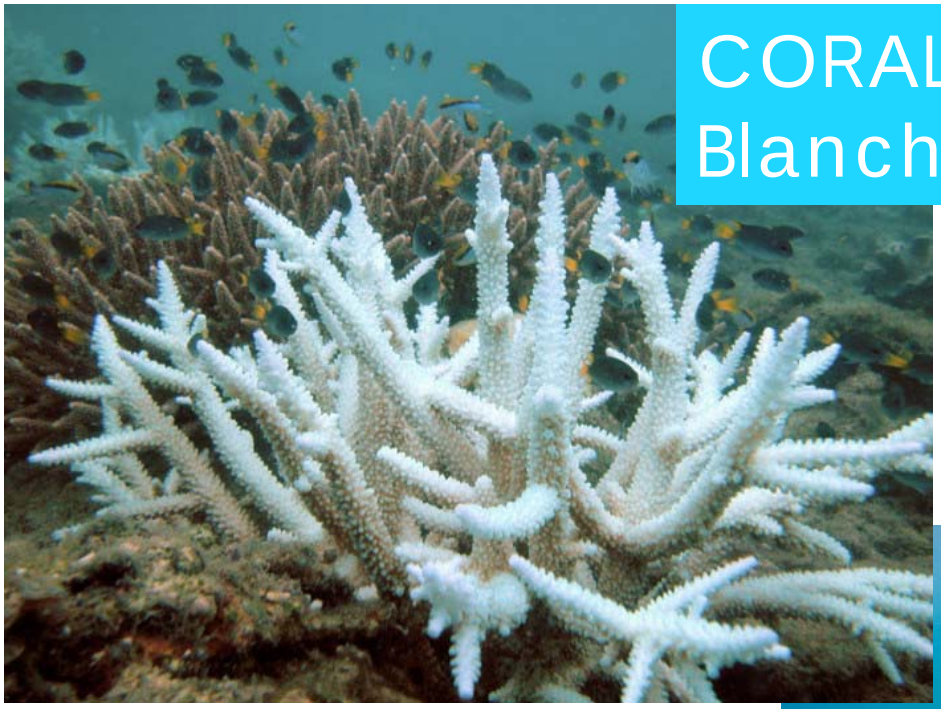
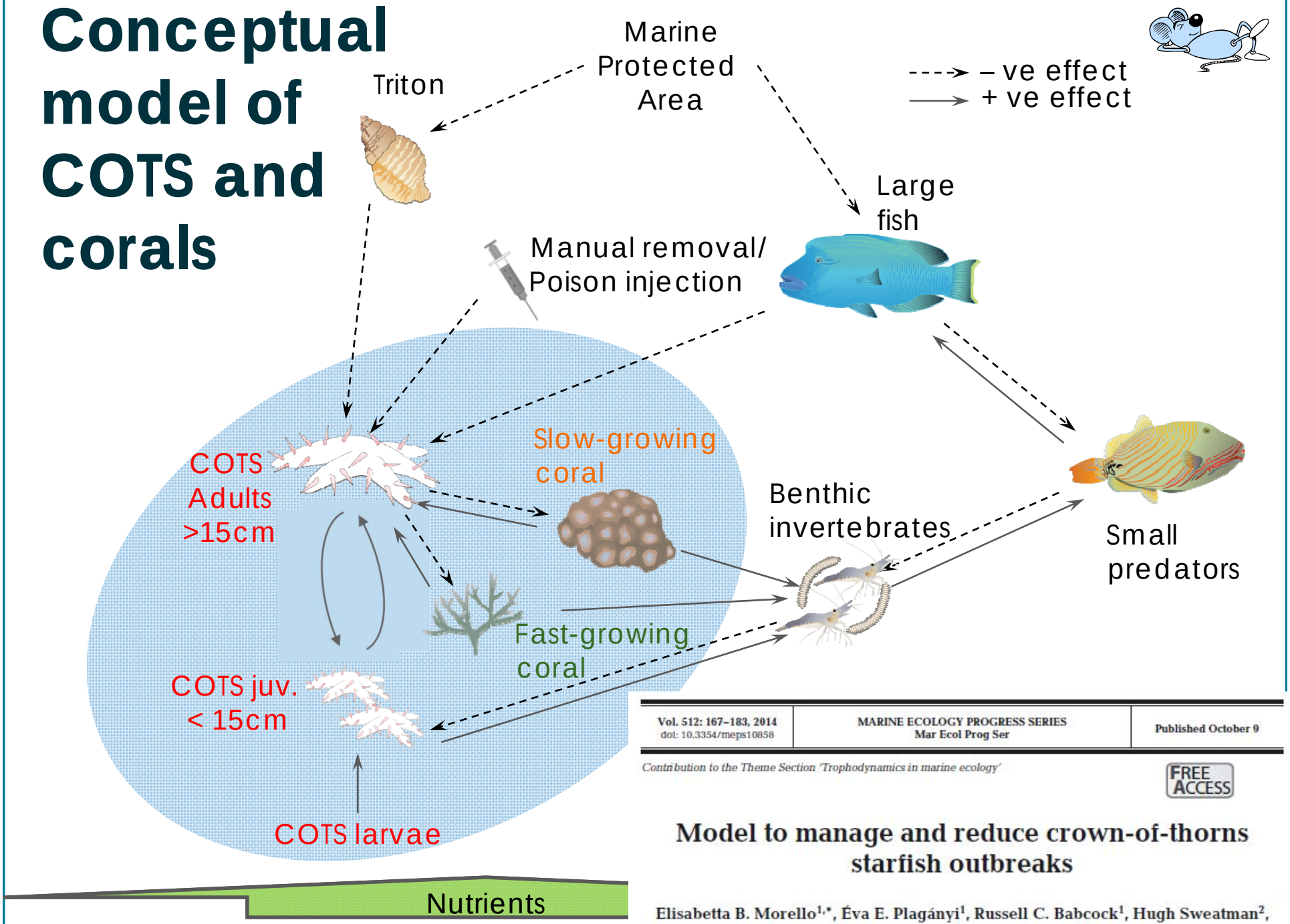


Image credit:http://www.theguardian.com/environment/2016/jun/07/the-great-barrier-reef-a-catastrophe-laid-bare

MICE - Crown of Thorns Starfish (COTS)

Acanthaster planci

Conceptual model of COTS and corals



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Published October 9

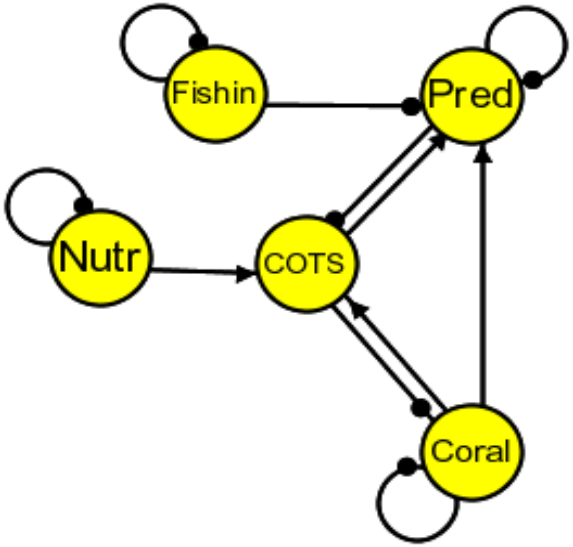
Contribution to the Theme Section 'Trophodynamics in marine ecology'

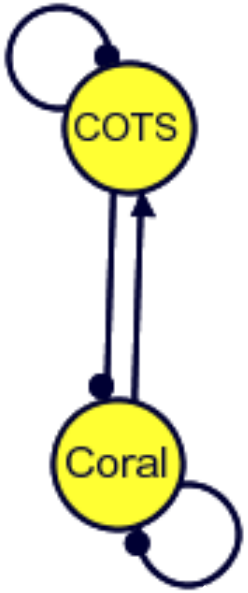
FREE ACCESS

Model to manage and reduce crown-of-thorns starfish outbreaks

Elisabetta B. Morello[1,*], Éva E. Plagányi[1], Russell C. Babcock[1], Hugh Sweatman[2], Richard Hillary[3], André E. Punt[3,4]

Qualitative Modelling





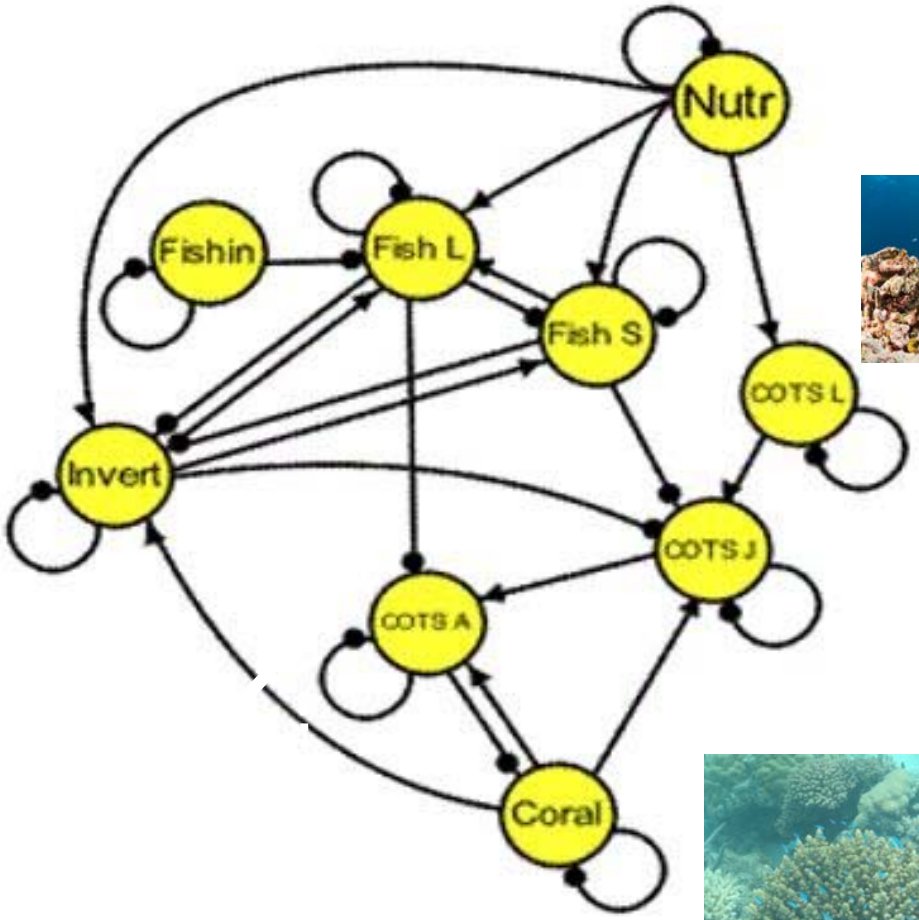
	Coral	COTS
Coral	+	-
COTS	+	+

Babcock et al. In review, based on approach of Dambacher et al. 2010

Dambacher, J. M., Gaughan, D. J., Rochet, M.-J., Rossignol, P. A., and Trenkel, V. M. (2009). Qualitative modelling and indicators of exploited ecosystems. *Fish and Fisheries* **10**, 305–322. doi:10.1111/J.1467-2979.2008.00323.X

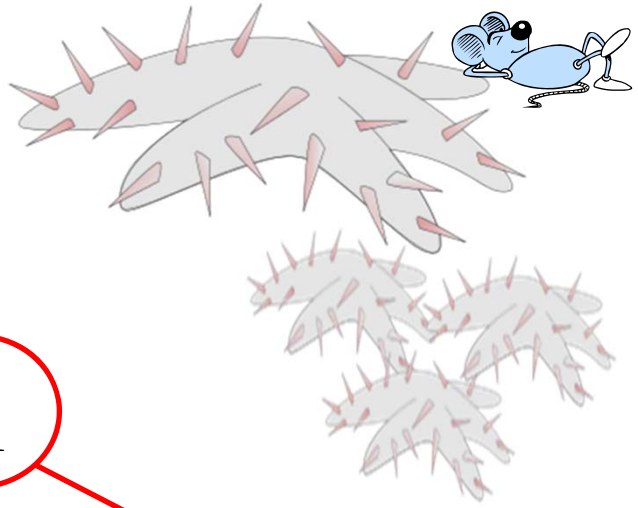
Qualitative Modelling

EXAMPLE RESULT:
Starfish outbreaks may be caused by multiple factors, rather than by single proximal cause (such as runoff), hence need a combination of management responses



Babcock et al. in review

CoT adults and juveniles



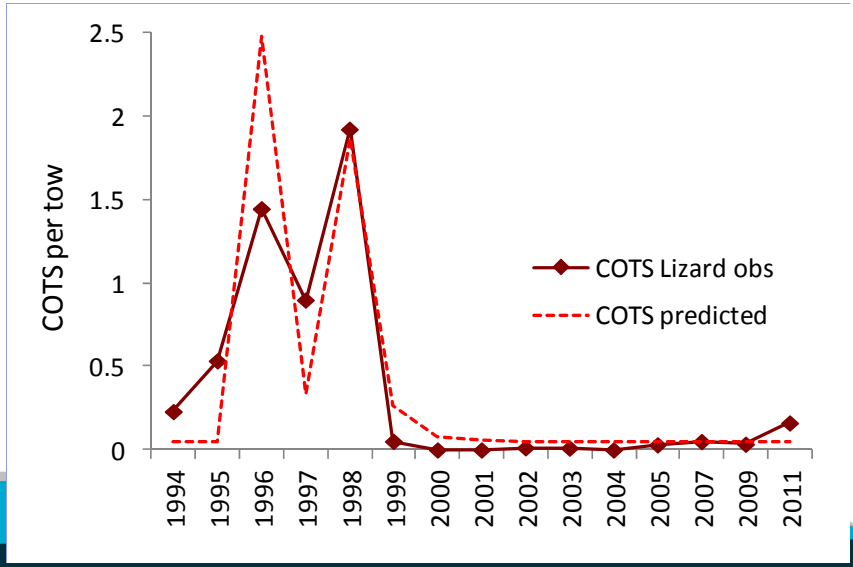
Age-structured model

$$N_{y+1,1,0} = R_{y+1} + I_{y+1}$$

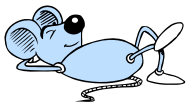
Recruitment

Immigration

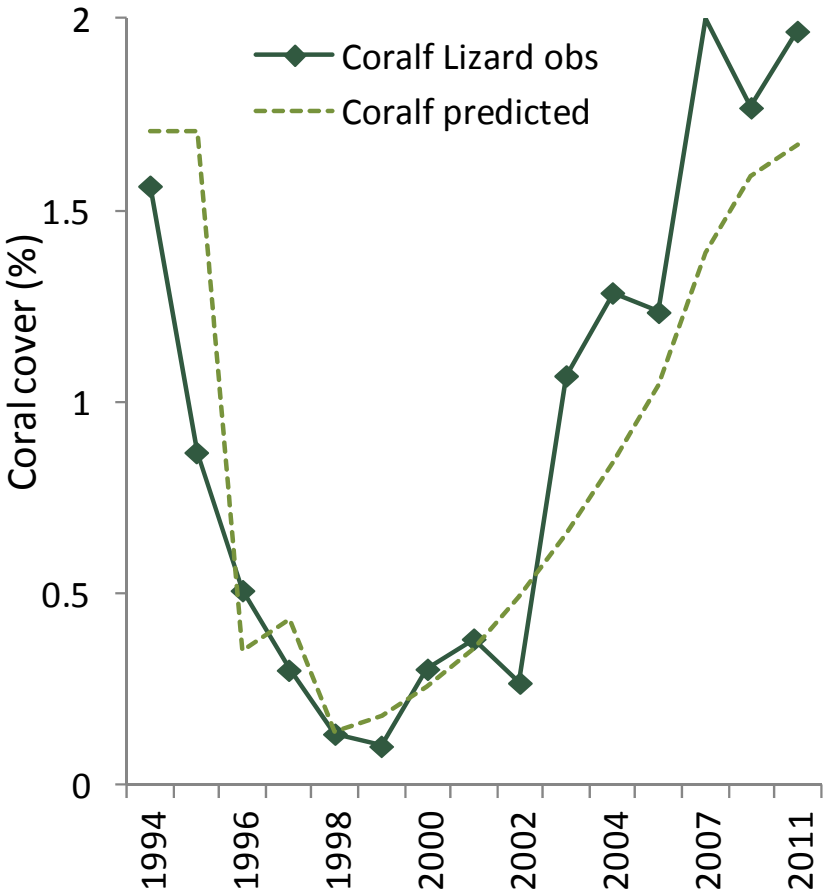
$$N_{y+1,a+1} = N_{y,a}\, e^{-f(Coral(t))*M_a} - Q_{y,a}$$



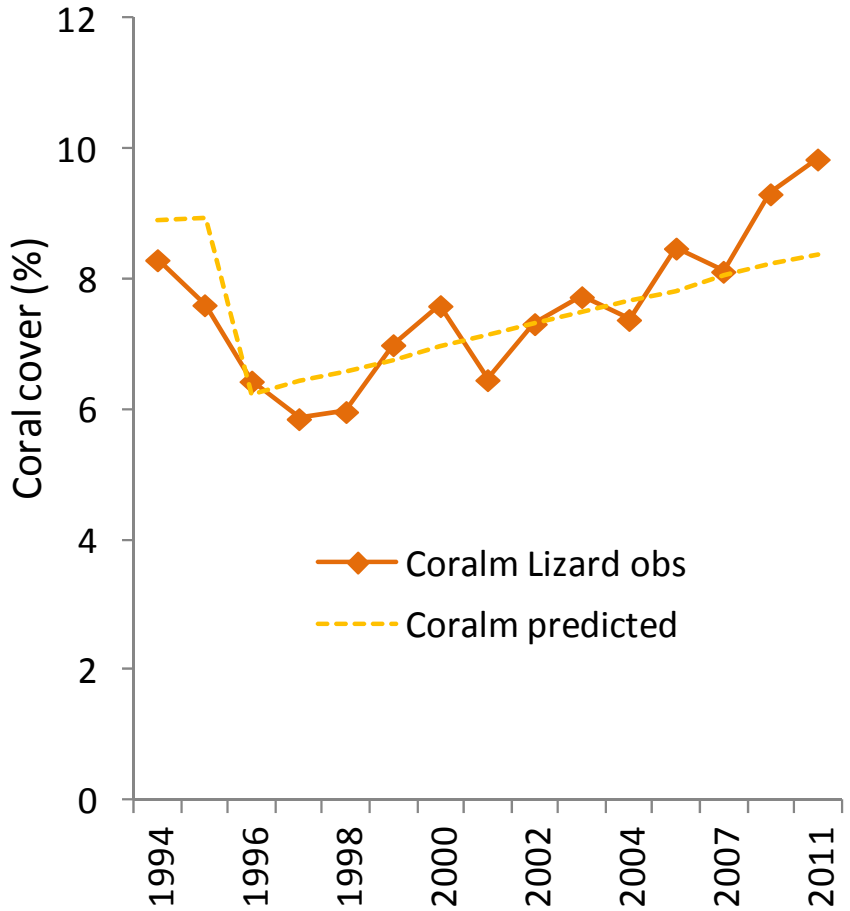
FITTING TO LIZARD ISLAND DATA



Fast-growing coral

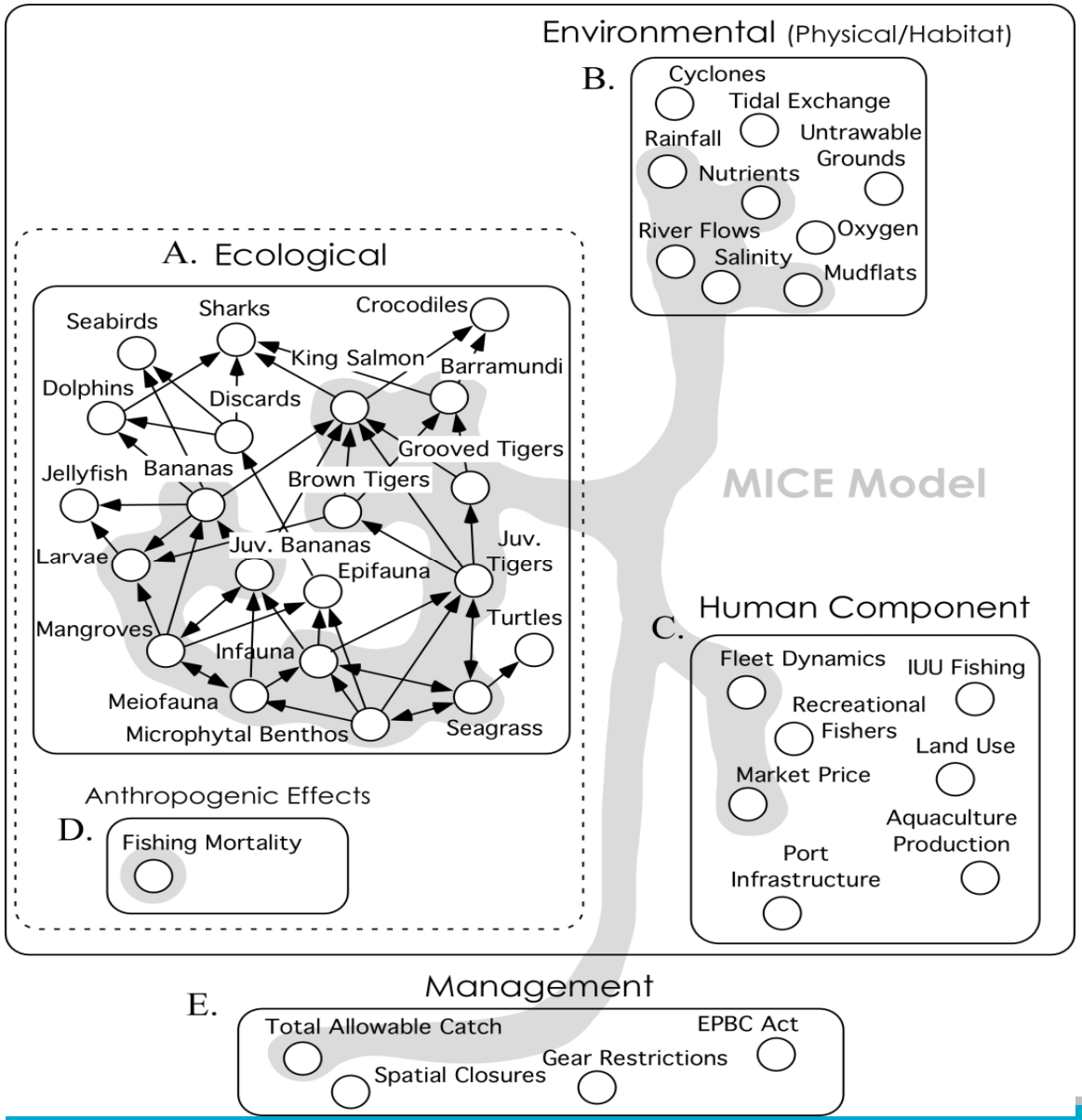


Slow-growing coral



Key output of most recent research: computation of THRESHOLD levels for infestation versus amount of coral

Gulf of Carpentaria

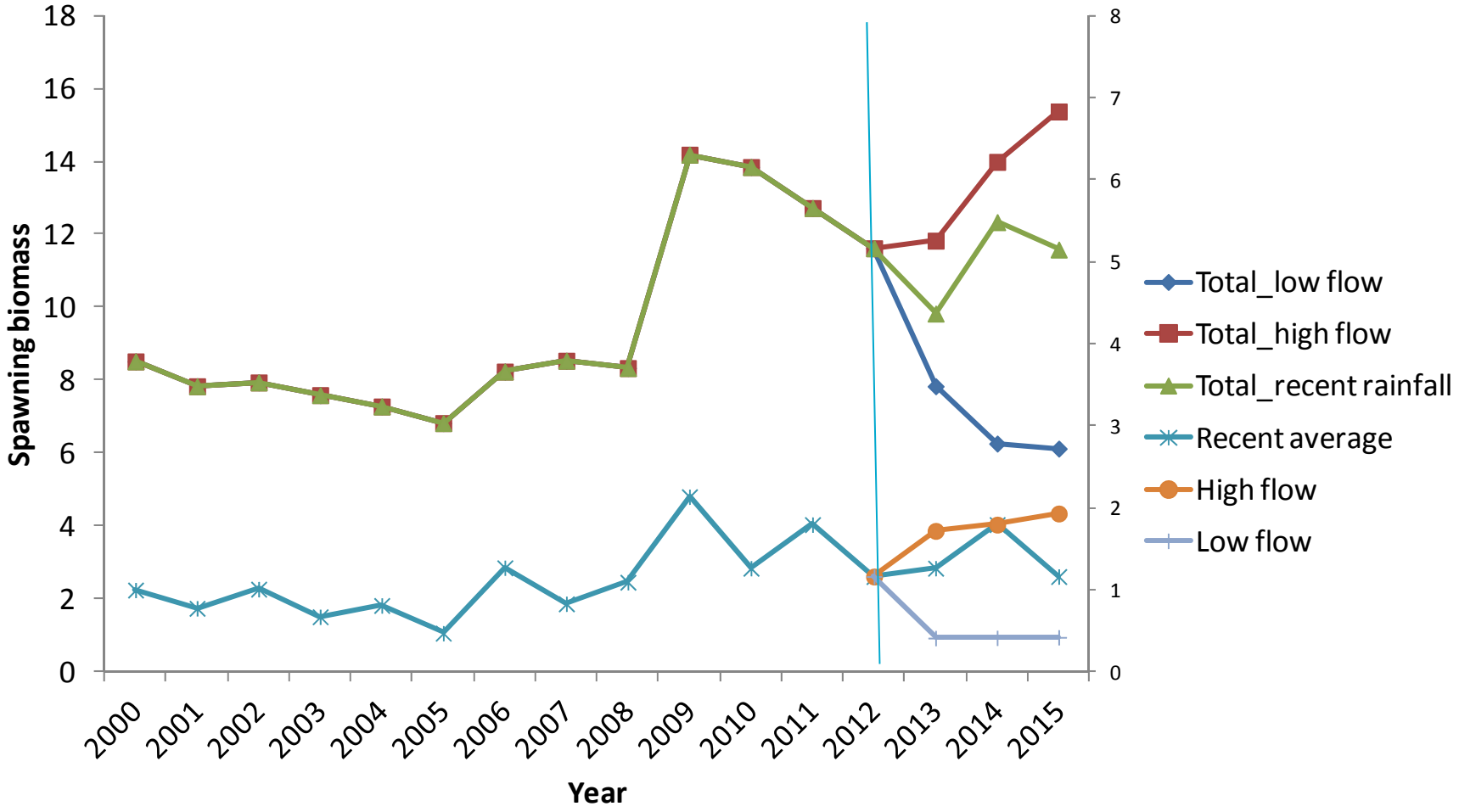


5 species

1. brown tiger prawns (*P. esculentus),*
2. grooved tiger prawns (*Peneaus semisulcatus)*,
3. white banana prawns (*Penaeus merguiensis*),
4. barramundi (*Lates calcarifer)*
5. a generic shark group.

The model domain is the GoC in northern Australia

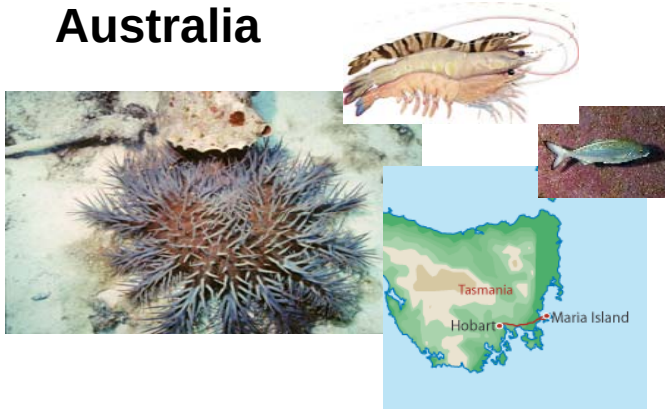
Example of projected banana prawn biomass under future high/low rainfall scenarios (preliminary runs of model)



MICE Examples

Models of Intermediate Complexity for Ecosystem assessments
Modele de complexite intermediaire

Australia



Antarctic (Viv Tulloch)

India (GULLS, Belmont)

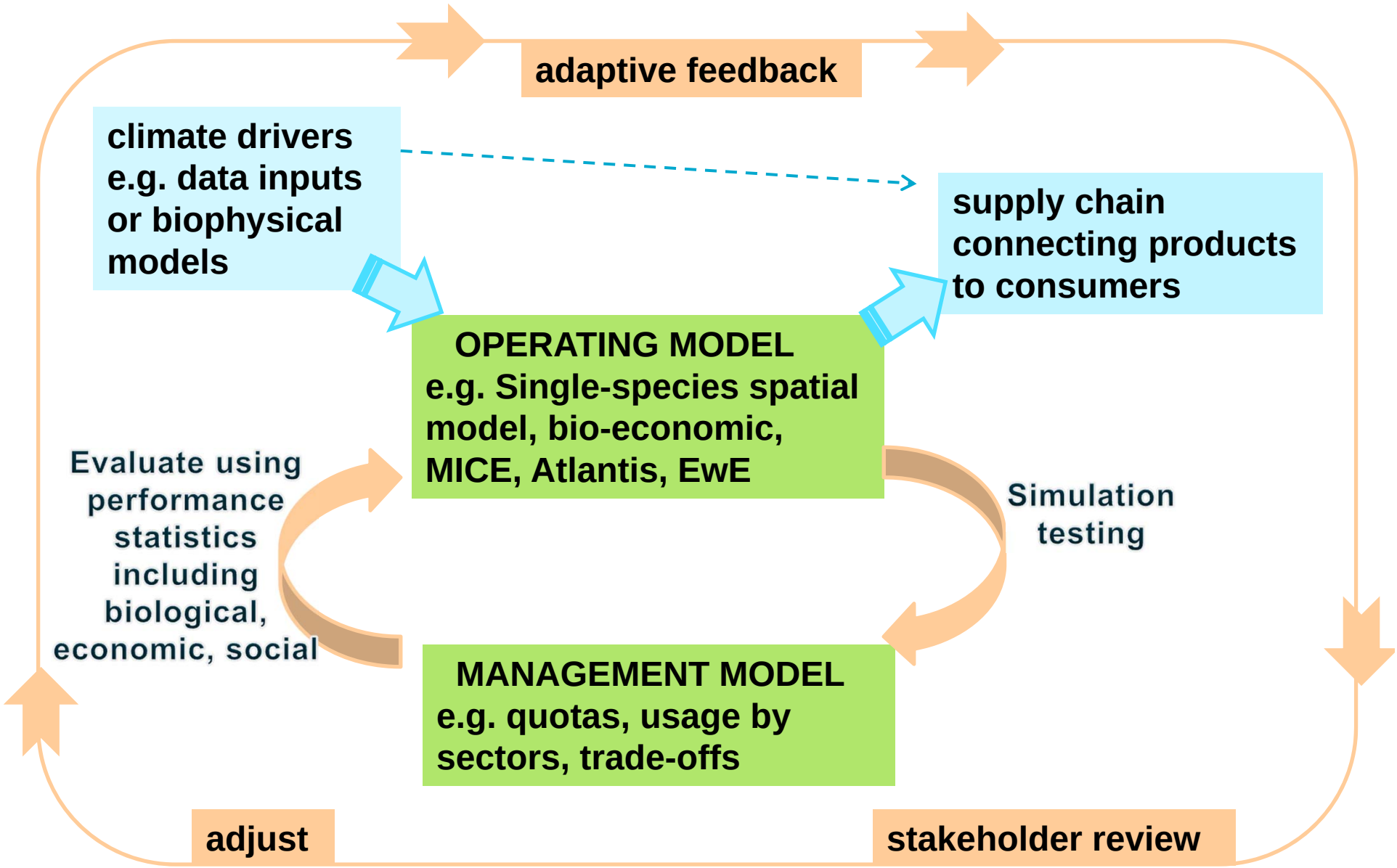
Brazil (GULLS)

South Africa (Blamey et al. 2013, 2014)

Italy (Angelini et al. 2015)

Madagascar (GULLS; GLORIA)

Photo credits: abalone – Rob Tarr; Indian mackerel - Dr Alex Tattersall, National news & pictures



Plaganyi (2015)

Common system model for hotspots: SEA-MICE

(Socio-Ecological Adaptations Model of Intermediate Complexity for Ecosystems)

Number of a species in an area each year

Net production (eg carrying capacity K can vary)

Compliance index I - accounts for IUU

$$\#N_{sp,a,t+1} = N_{sp,a,t} + r_{sp,a,t} e^{(\varsigma_{y,s} - (\sigma_R)^2/2)} \cdot N_{sp,a,t}\left(1 - \left(\frac{N_{sp,a,t}}{K_{sp,a,t}}\right)^{\mu}\right) - \sum_s \left(q_{sp.s,a.t} E_{sp.s,a.t}\right) \cdot I_{sp,a,t} \cdot N_{sp,a,t} + IM_{sp.a.t} - EM_{sp.a.t}$$

Net growth rate (eg vary with temperature); X recruitment residual

No. caught = catchability x effort (eg hrs fished) - test future changes

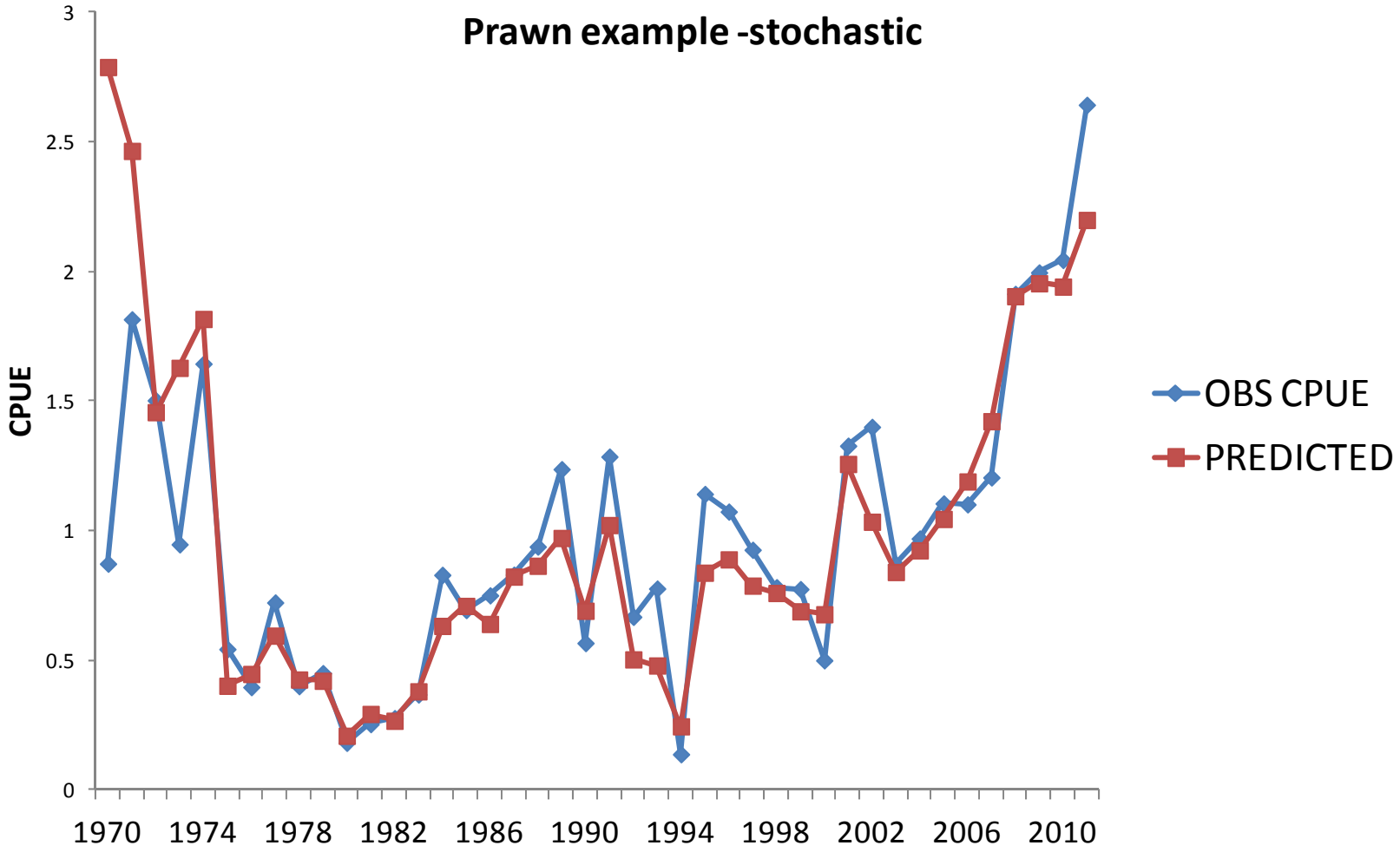
Immigration /Emigration

www.marinehotspots.org

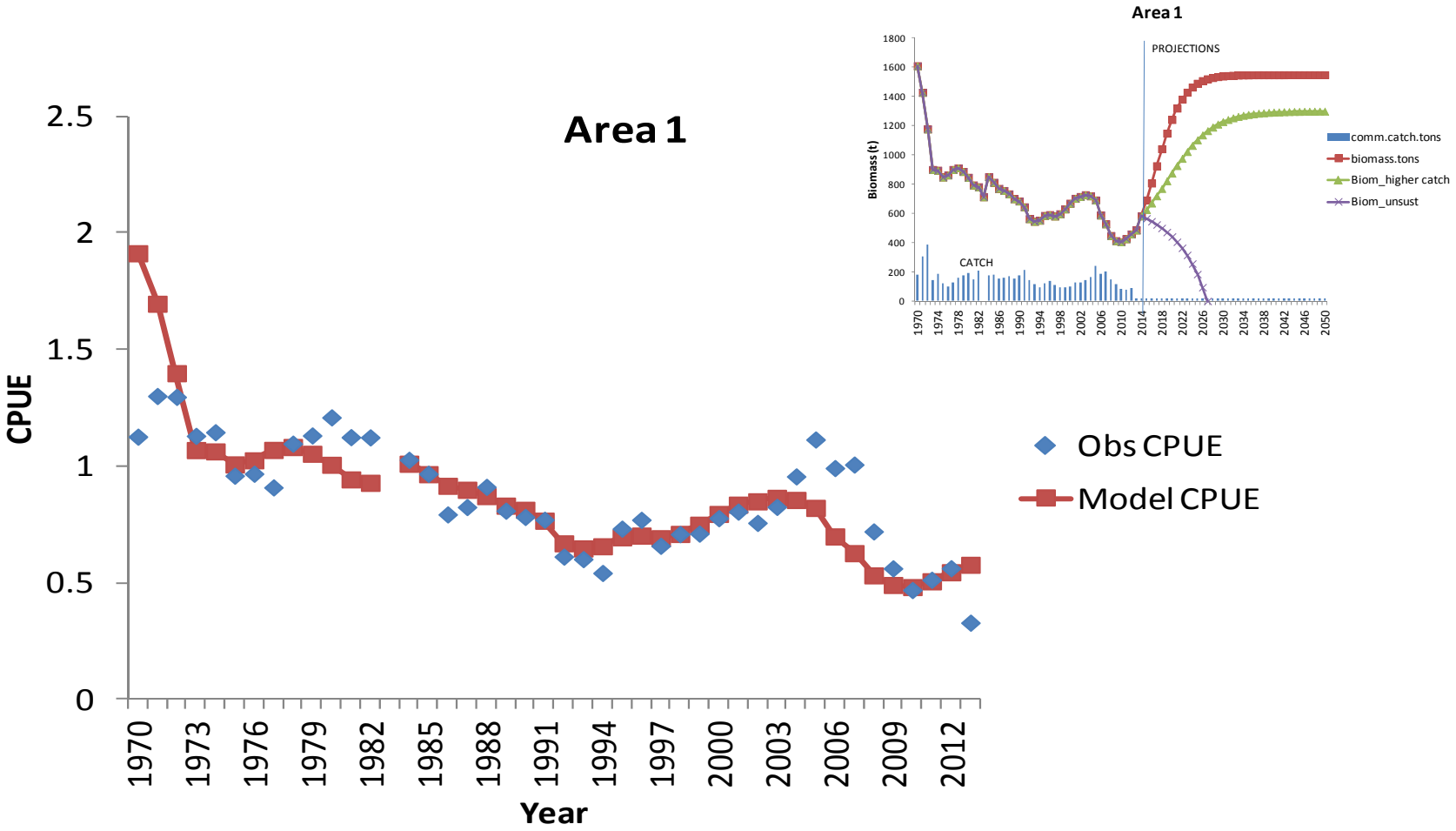
A Belmont Coastal Vulnerability Theme Project

Global Understanding for local solutions: Reducing vulnerability of marine-dependent coastal communities (GULLS)

Testing the model - Australian banana prawn fit to data



Tasmanian lobster – fit to data

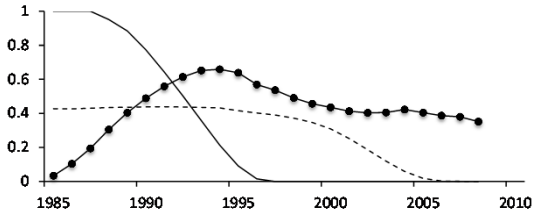


Data: Stewart Frusher (UTAS)

Simple Population Dynamics Schaefer model

Getting going with the model:

1. Choose values for *r, K*
2. Input Catch data for each year
3. Assume $N_1 = K$
4. Calculate $N_2 \ldots N_{i+1}$ from equation:



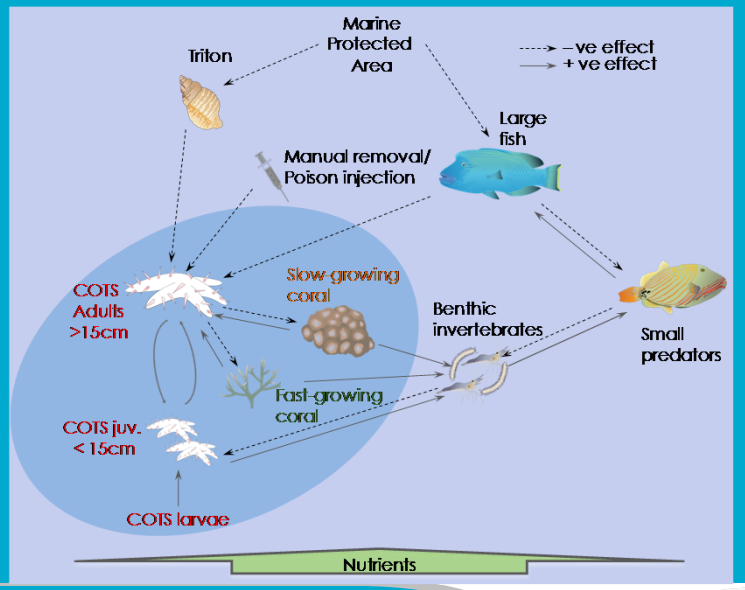
$$N_{t+1} = N_t + r_t e^{(\varsigma_t - (\sigma_R)^2/2)} N_t \left(1 - \left(\frac{N_t}{K_t}\right)\right) - C_t \cdot I_t$$

5. Refine choice of model parameters such as *r* and *K* by comparing with past observations/data or formally fitting the model to the data (also called conditioning the model)
6. Use model to project into the future under alternative scenarios

AIMS

1. Conceptual models of key ecological assets and processes
2. **Collaborative development of conceptual models**

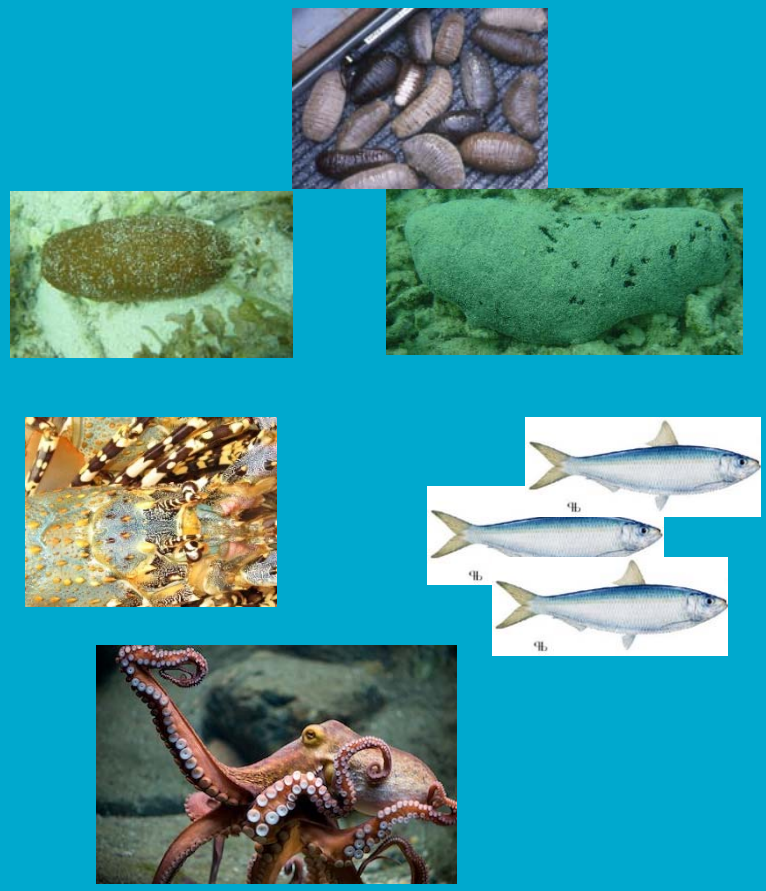
Model results can inform monitoring and management



Morello et al. 2014

KEY SPECIES, CLIMATE DRIVERS, LINKAGES AND DEPENDENCIES

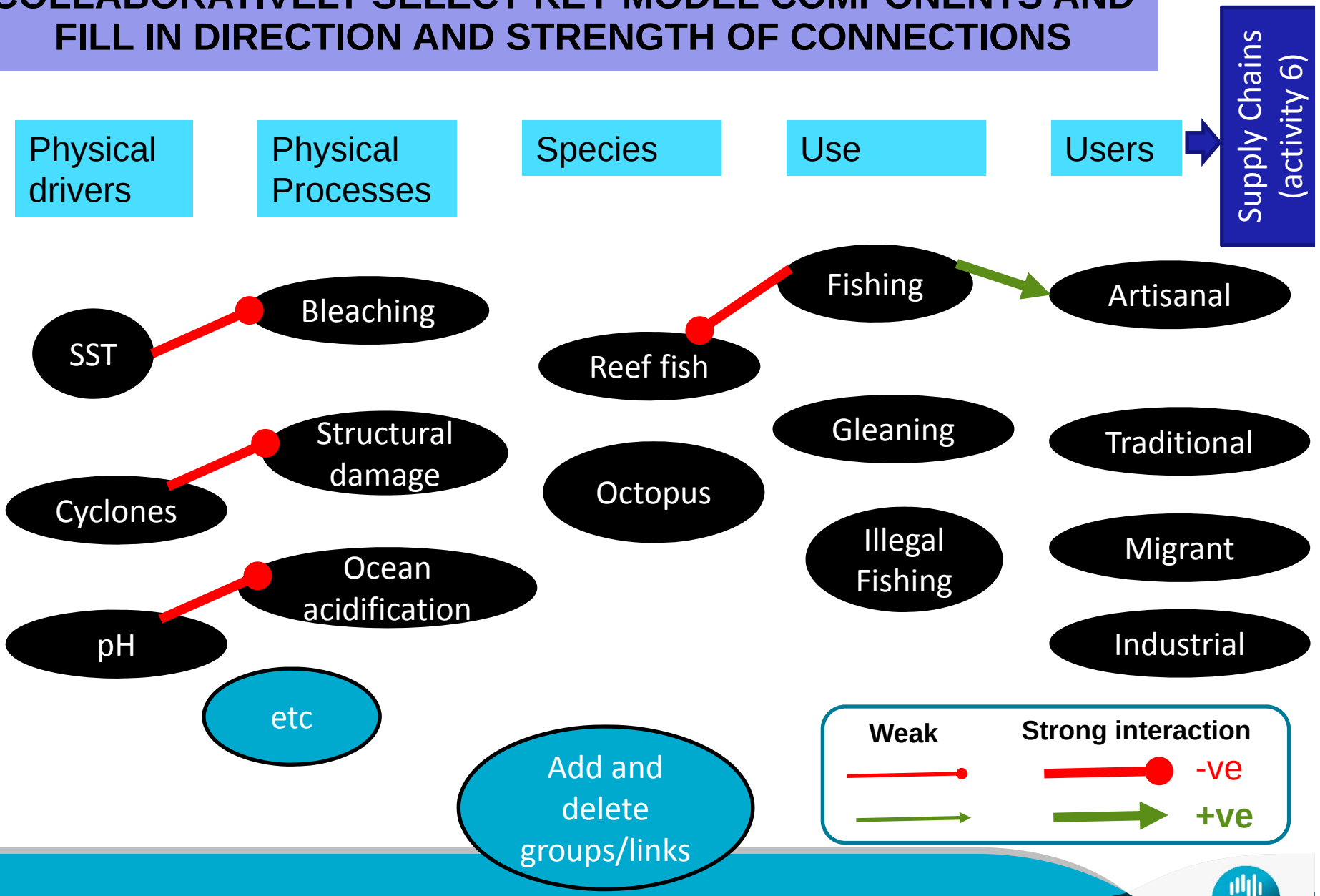
1. Octopus, sea cucumbers, lobsters, reef fish, seaweed….
2. Climate drivers
3. Social/Economic dependencies
4. Supply Chains



Models to test the performance of alternative marine monitoring and management strategies to detect and respond to ecological changes caused by climate change

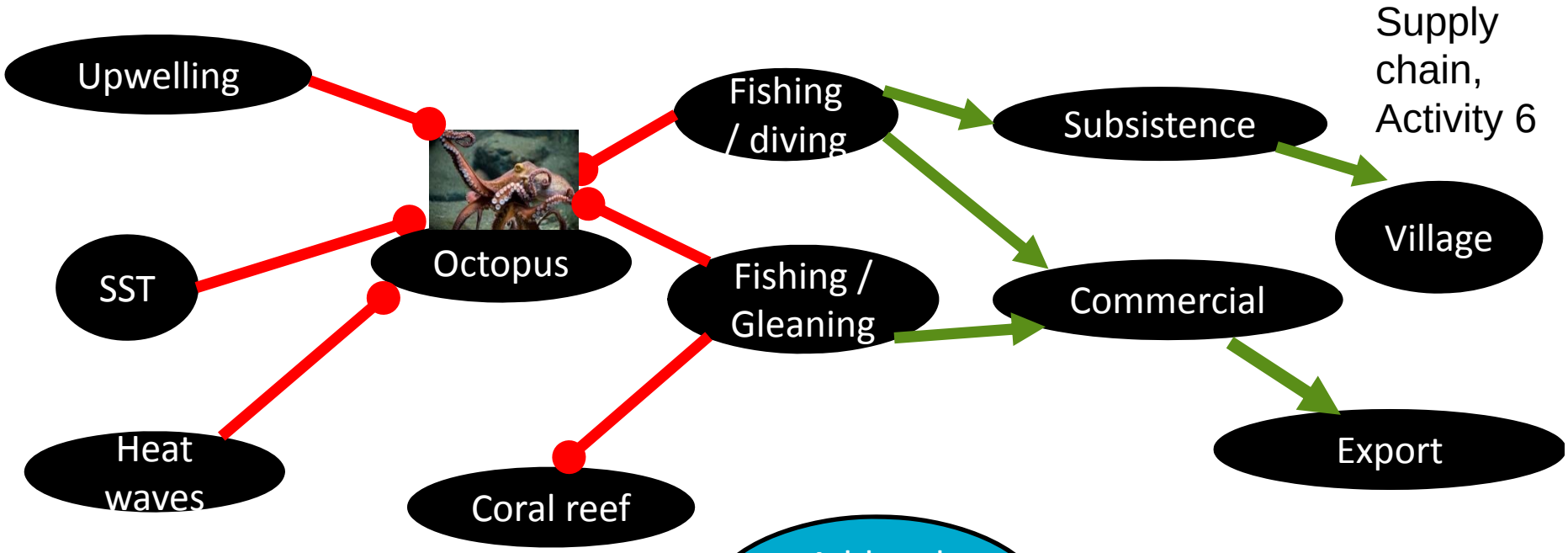
Octopus image: blogs.scientificamerican.com

COLLABORATIVELY SELECT KEY MODEL COMPONENTS AND FILL IN DIRECTION AND STRENGTH OF CONNECTIONS



EXAMPLE 1 – KEY ASSET - OCTOPUS

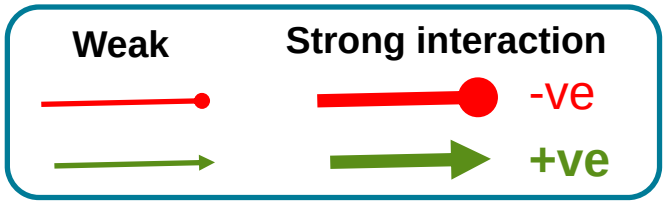
Role of climate vs role of fishing?



Use climate drivers and info from vulnerability analysis, eg. rising temperatures, causing increased growth rates and possible vertical changes in the distribution ; if SST rises beyond the thermal tolerance levels octopus may migrate to cooler, deeper waters which could result in reduced catches for gleaners Harding (2013) Blue Ventures

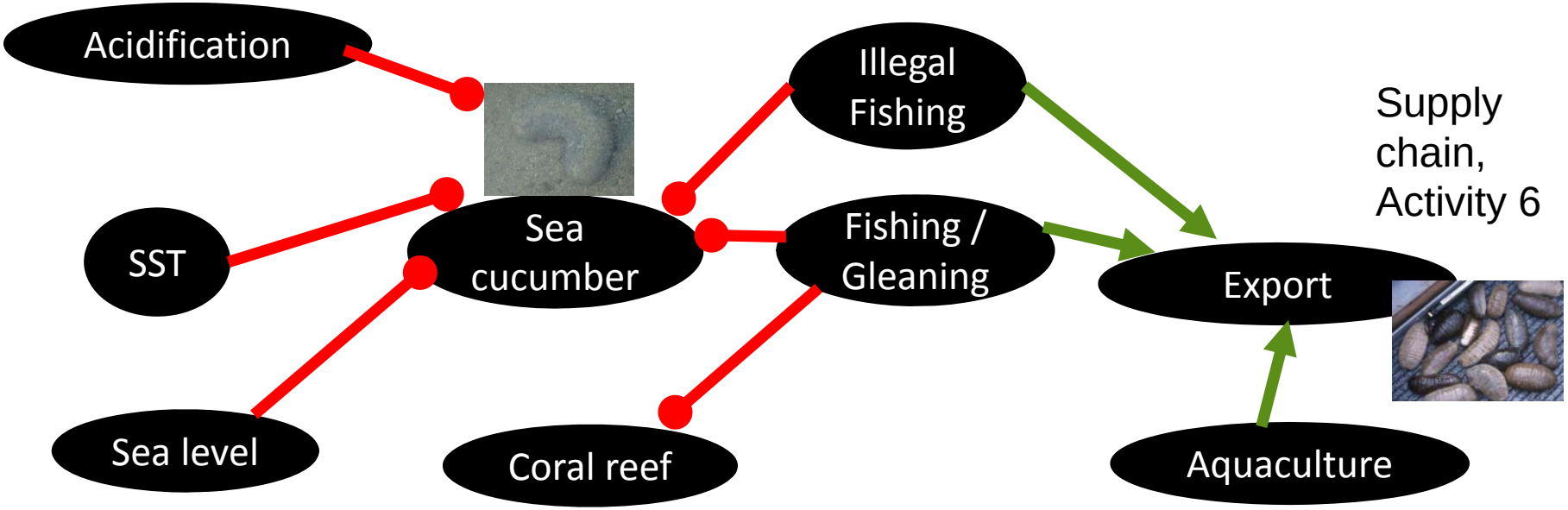
habitat degradation through trampling and the use of spears to break up coral heads

Add and delete groups/links

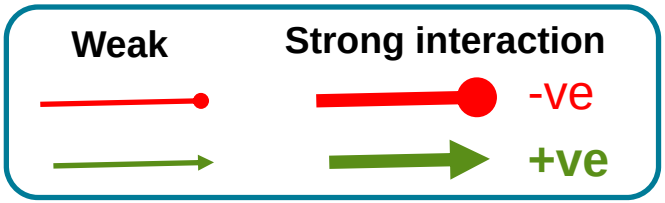


EXAMPLE 2 – KEY ASSET – SEA CUCUMBER

Role of climate vs role of fishing?



Add and delete groups/links



OBJECTIVES

Use models to:

1. Identify major challenges caused by climate change
2. Help identify options for adaptation to the climate challenges
3. Use models to facilitate communication
4. Develop recommendations for an action plan
5. Make recommendations for priorities for future research

espa ecosystem services for poverty alleviation

GLORIA

Global Learning Opportunities for Regional Indian Ocean Adaptation

Thank you
Merci beaucoup

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Acknowledgements
GLORIA team