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Prof. Steven Hall, Director – s. hall@aims.gov.au

The article Dr. Hall mentioned: Judith L. Anderson. 1998. Embracing uncertainty: The interface of Bayesian statistics and cognitive psychology. Conservation Ecology [online] 2(1): 2. Available from the Internet. URL: http://www.consecol.org/vol2/iss1/

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My questions for this visit

- How complementary are NOAA and AIMS?
- Can we add genuine value to each others business?
- If we can, how might an effective strategic alliance be realised?

Objectives

- Introduce AIMS
  - Purpose, Funding, Philosophy, Structure, Current Research Program
- An example of AIMS research in more detail

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What is AIMS?

A Commonwealth Statutory Authority with a mission to:

"generate [and transfer] the knowledge to support the sustainable use and protection of the marine environment through innovative, world-class scientific and technological research."

Australian Institute of Marine Science

Funding

Government appropriation	$16.7m
Asset replacement	$2.7m
External Revenue	~$4-5m

External Revenue Breakdown

Royalties & Licenses	*$500K*
Grants and Contracts	*$4-4.5m*

155 Staff, 55 PhD Students

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Infrastructure

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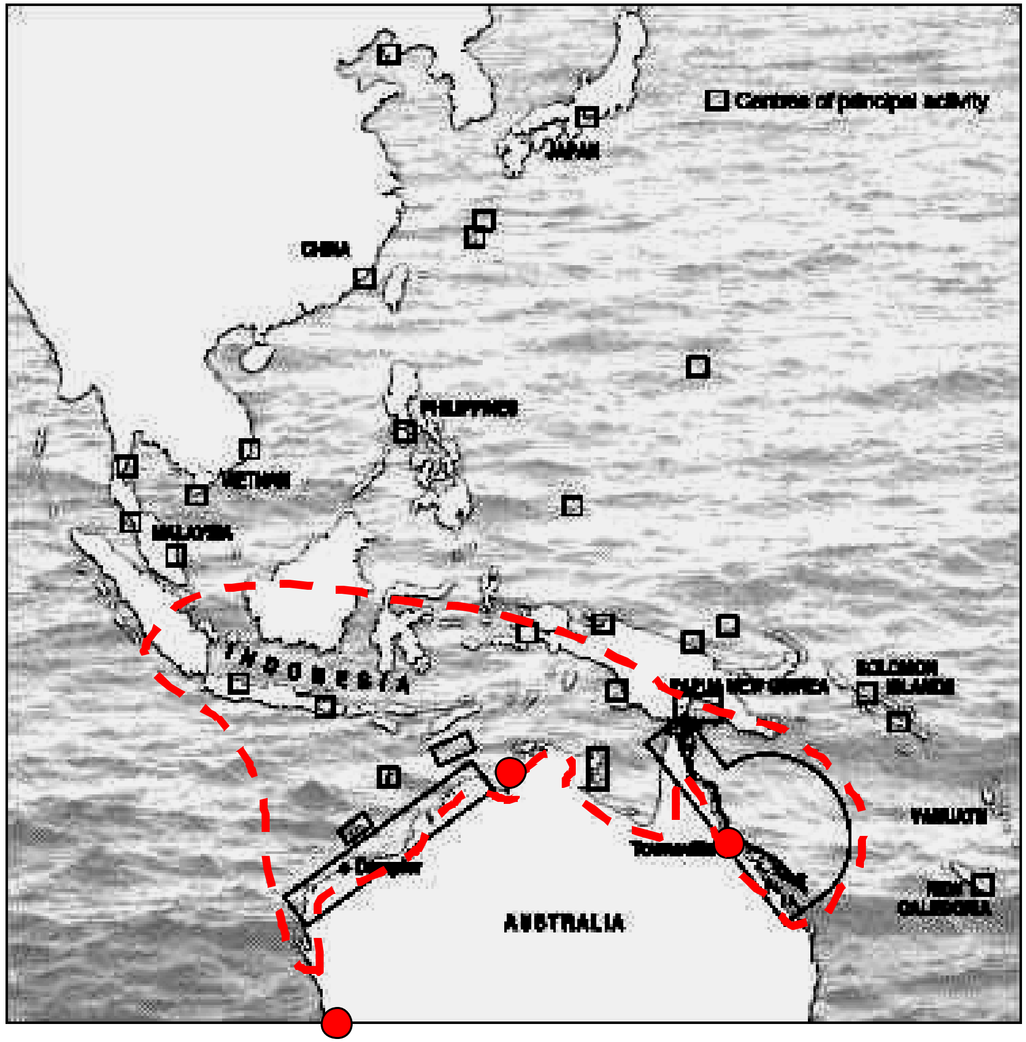
Scope of Operation



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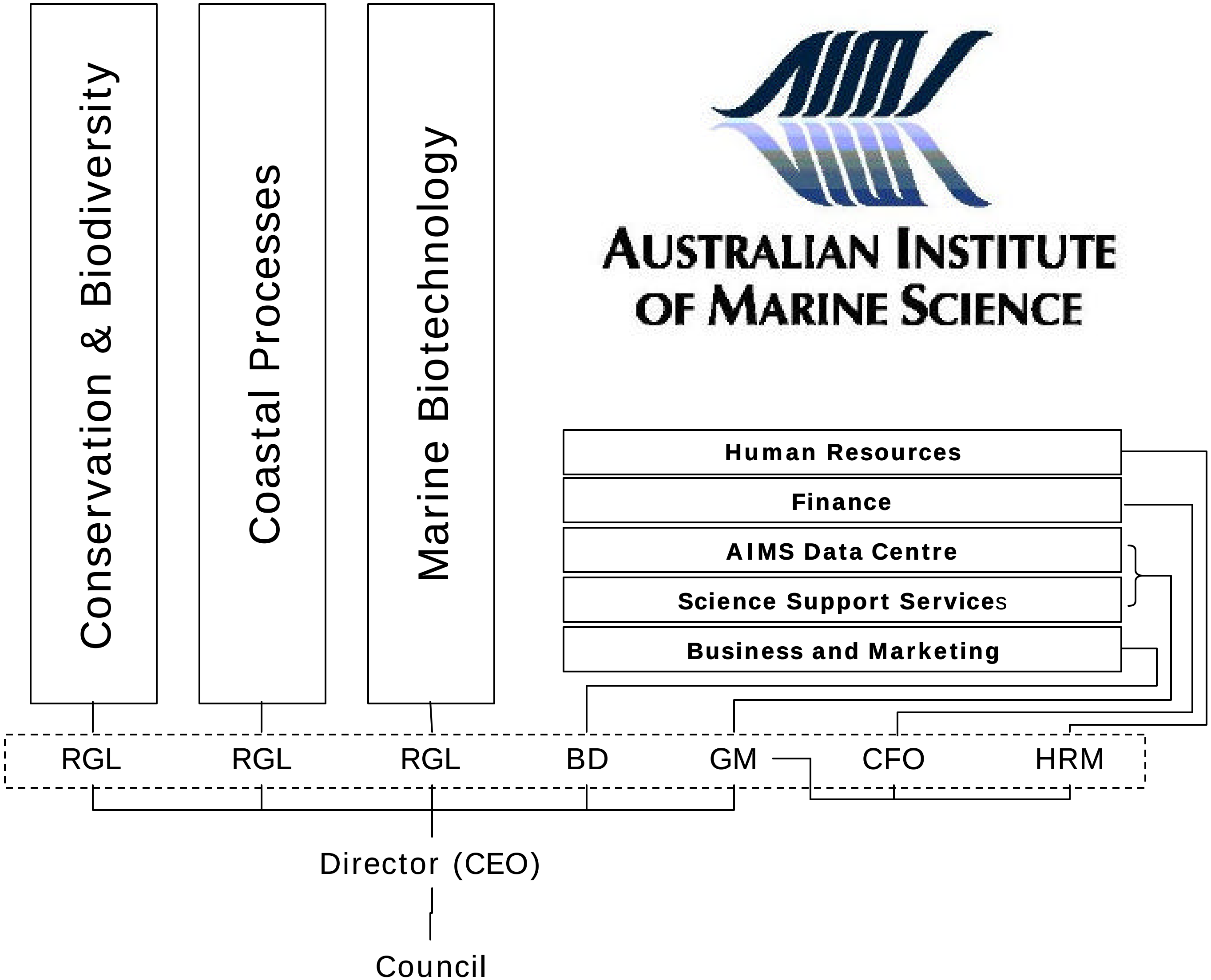
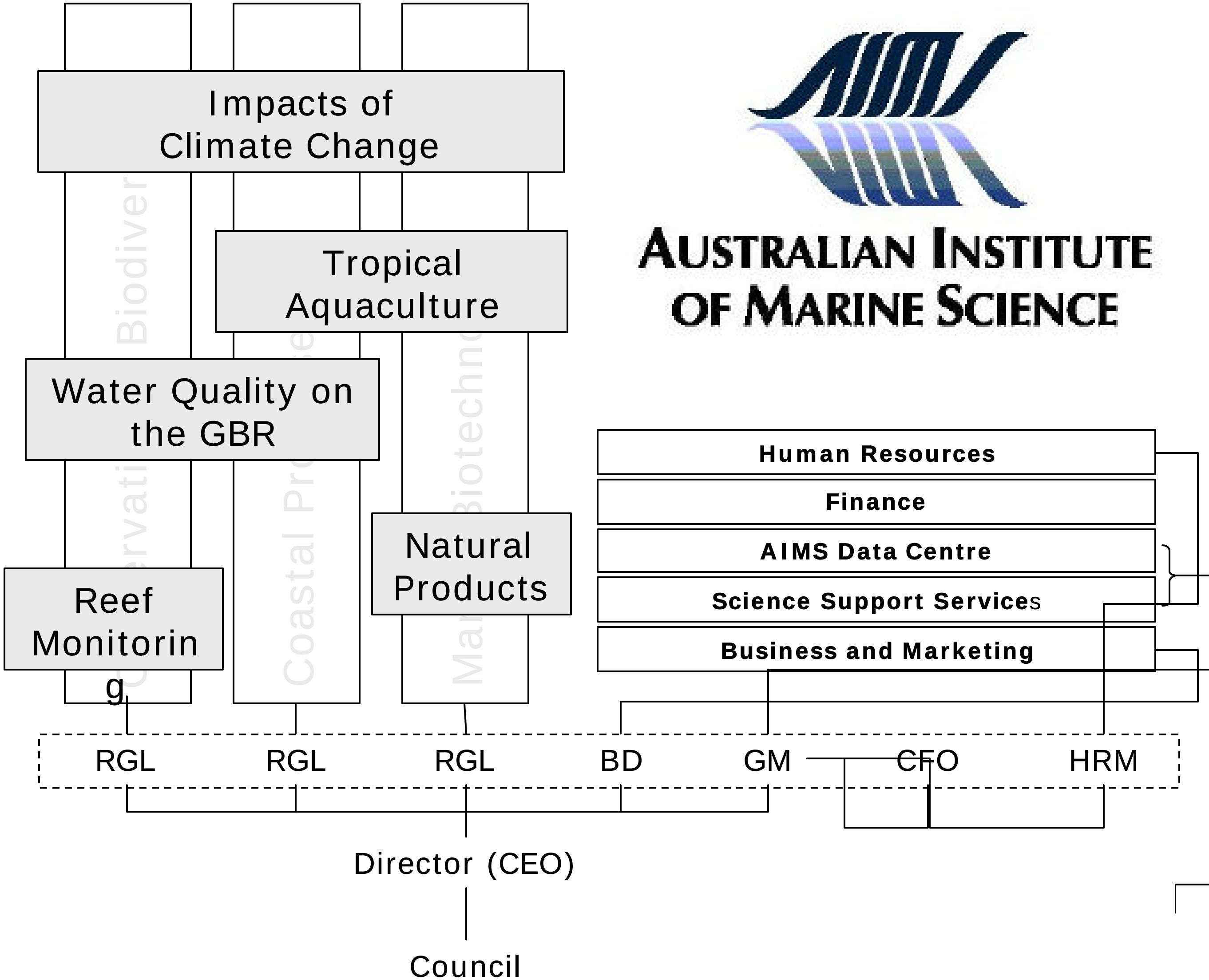
Australian Institute of Marine Science



Australian Institute of Marine Science



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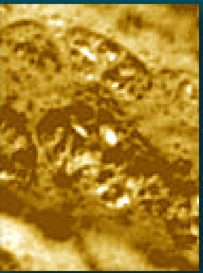
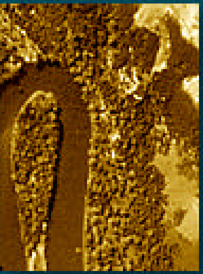
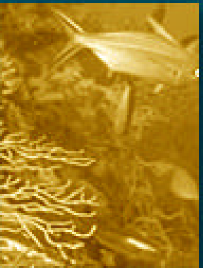
What do we do?

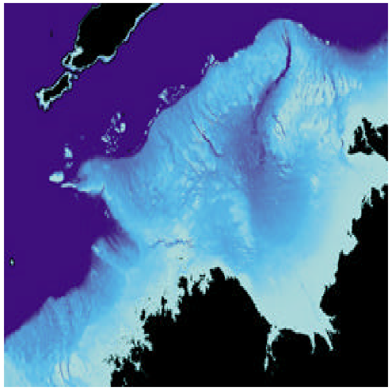






Conservation & Biodiversity

Julian Caley

Resource surveys for regional marine planning



Sea floor biodiversity

Evolution and biogeography of marine biota

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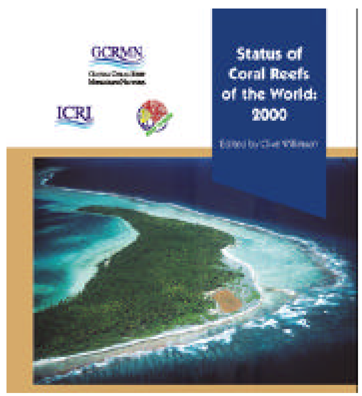
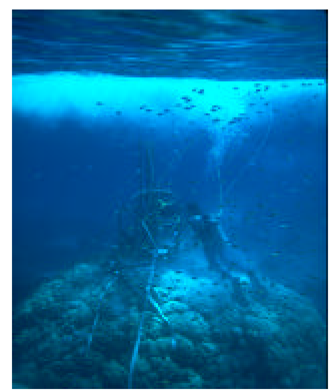
Conservation & Biodiversity

Status and trends on coral reefs

Global coral reef monitoring network



Coral reefs and climate change



Decision support for marine resource managers

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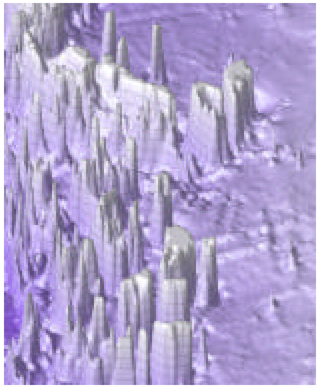
Coastal Processes

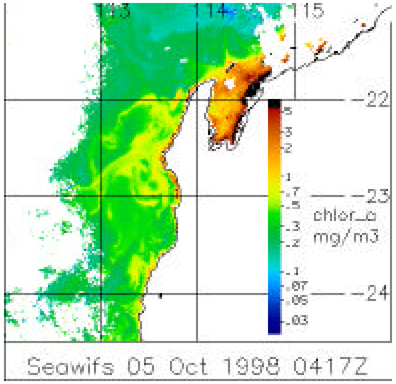
Frank Tirendi

Terrestrial run-off into coastal receiving waters

Transport models for water, sediments and propagules



Biological oceanography of the North West Shelf



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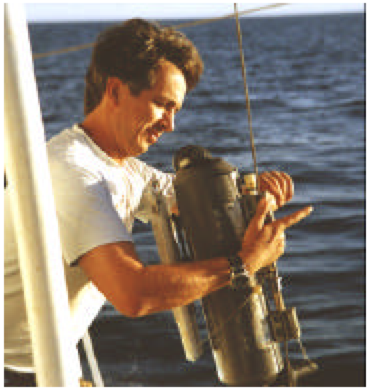
Coastal Processes

Biological impacts of excess nutrients in marine ecosystems



Biogeochemistry of estuaries

Bioindicators of sublethal stress in marine organisms

Marine Biotechnology

Chris Battershill

Marine environmental biochemistry and chemical ecology

Bioactive molecules from the marine environment

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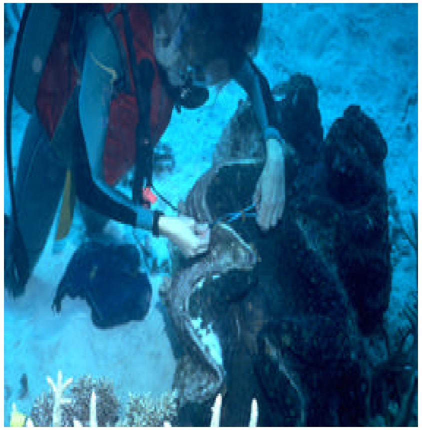
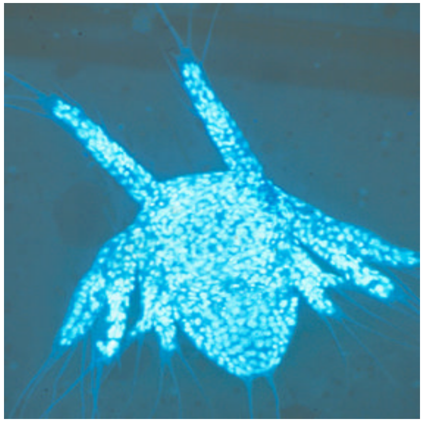
Marine Biotechnology

Population genetics and marine protected areas



Tropical Aquaculture



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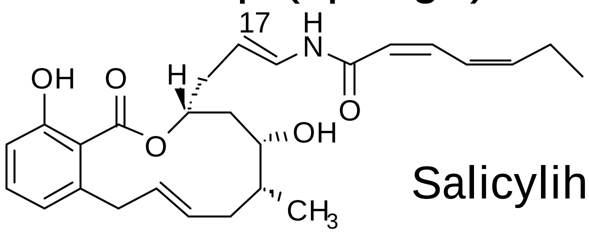
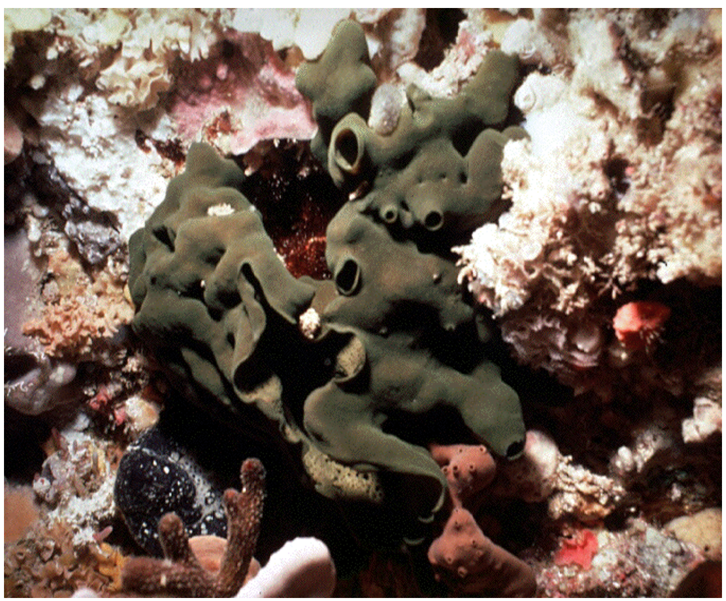
Biodiscovery

Anti-Cancer Compounds

Haliclona sp (sponge)



Salicylihamide



Lissoclinum lobatum
(tunicate)

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Some marine natural products presently sold as research tools

(Source: Calbiochem)

Compound	Present source	Retail price (US$) Per milligram
Bastadin 5	*Ianthella basta* (sponge)	9,040
Bastadin 19	*Ianthella basta* (sponge)	6,870
Bastadin mixture	*Ianthella basta* (sponge	5,800
Okadaic acid	*Halichondria okadai* (sponge)	4,070
Manoalide	*Luffariella variabilis* (sponge)	20,360
Saxitoxin	algae, toxic shellfish, crabs	3,322
Neosaxitoxin	algae, toxic shellfish,crabs	21,400
Tetrodotoxin	Bacteria (maybe) and puffer fish	316
Brevetoxin	Dinoflagellates	6,740
Anatoxin	Cyanobacteria	864
Palytoxin	*Palythoa toxica* (zoanthid)	14,240

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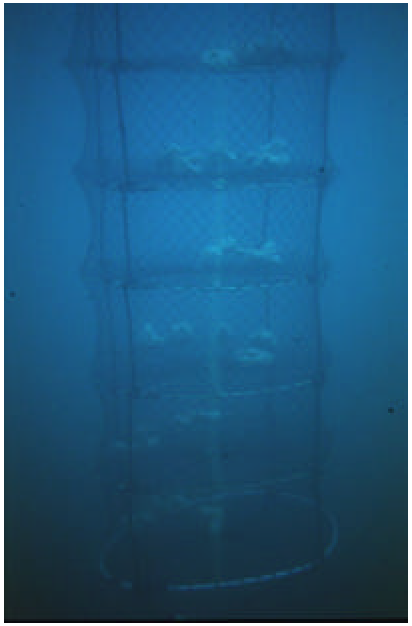
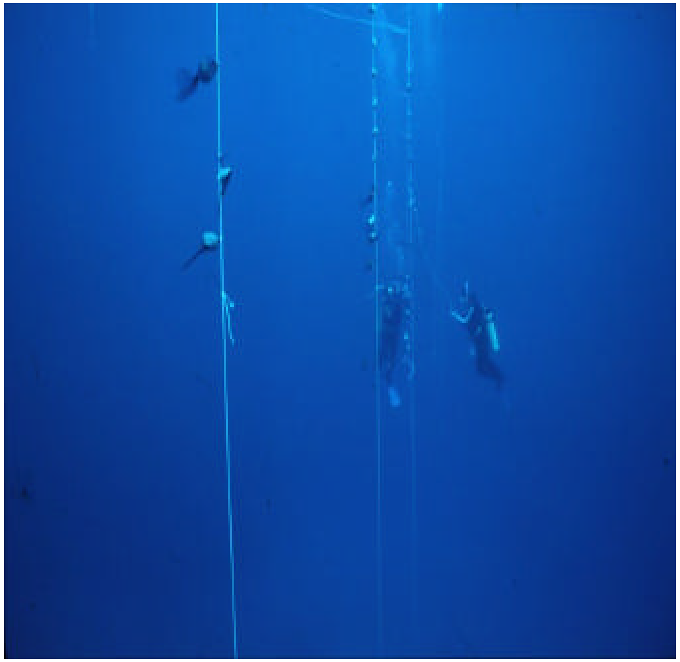
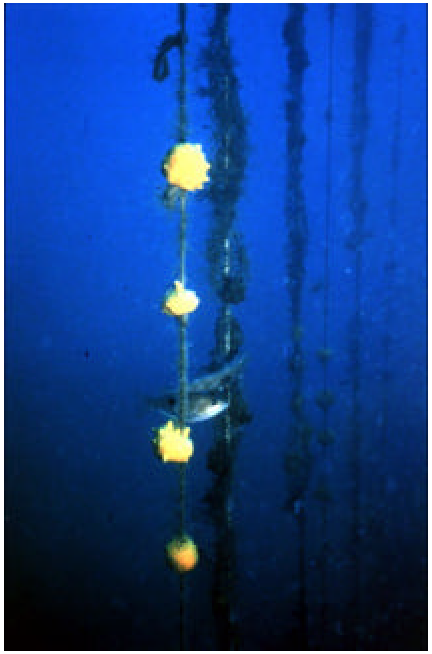
Low-technology aquaculture







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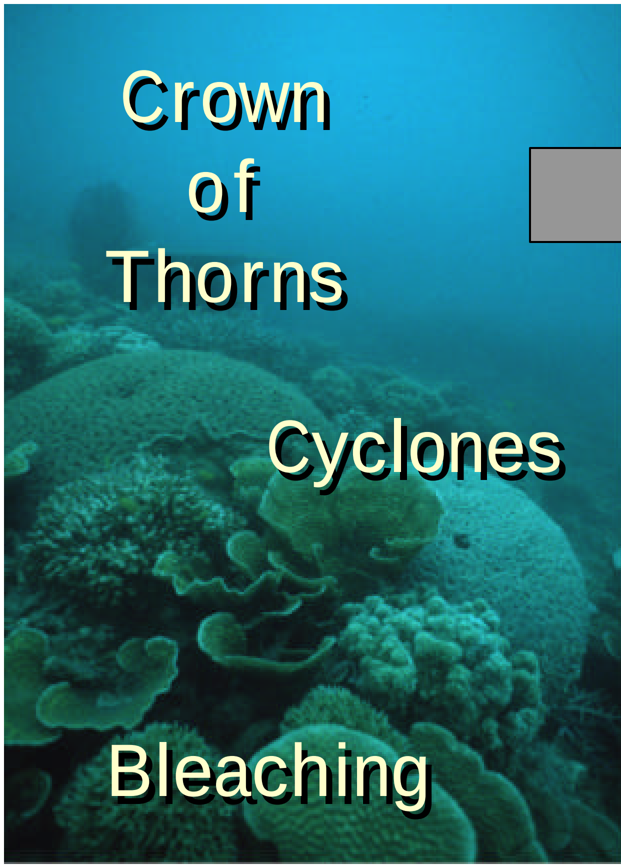
An example of AIMS research

Threats are real and must be managed



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Reef Futures

- Overarching Purpose:

To synthesise information and develop tools to improve understanding of coral reef systems, predict their future states and inform decision-making for their management.

Structure

- Knowledge Discovery and Data Mining
  Glenn De'ath
- Options analysis
  Scott Wooldridge & Terry Done
- Information Management System & GIS
  Stuart Kininmonth & Steve Edgar
- Working Groups and Synthesis
  www.reef.crc.org.au
- Knowledge Exchange
  Vicki Harriott

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Options Analysis

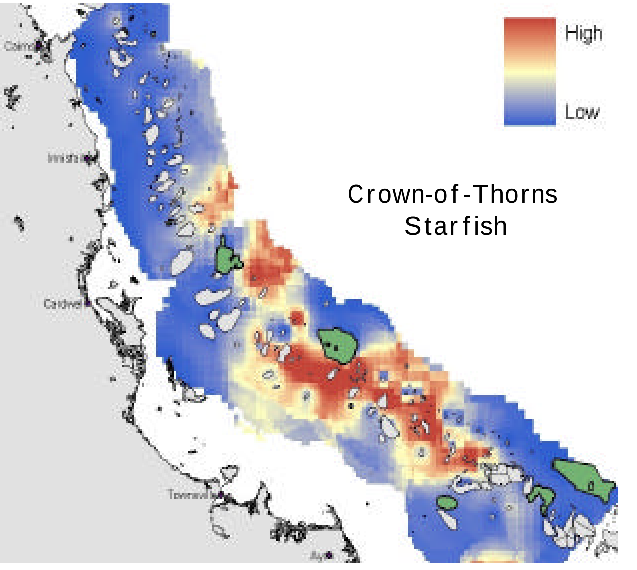
Scott Wooldridge

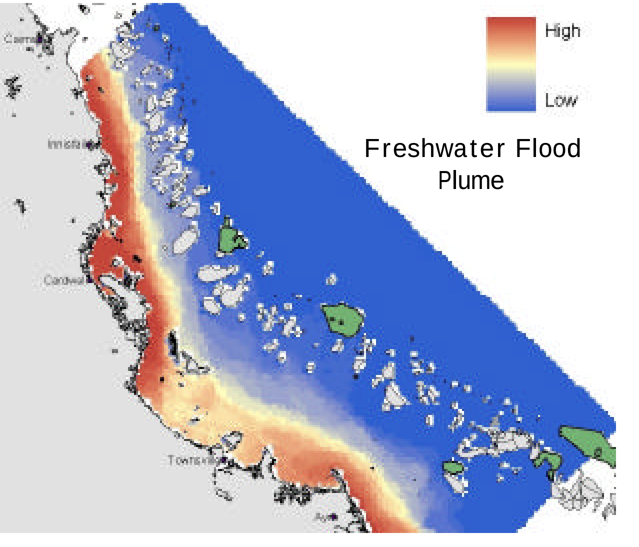
Research Objective

"To develop a modelling framework and tools to predict the future state of GBR coral reefs for a range of disturbance and management scenarios"

Used for modelling:

- Bleaching
- Crown-thorns-starfish
- Cyclone
- Water Quality
- Marine Reserve Design
- Flood Plumes





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The Traditional Approach

Deterministic Simulation Modelling

1. Attempt to describe and parameterise the functional form of key processes
2. Predict future states
3. Use predictions to support decision making

BUT

- Often complicated
- Hard to parameterise
- High uncertainty – esp with ecological models
- Predictions not well suited for decision making (don't deal with uncertainty well)

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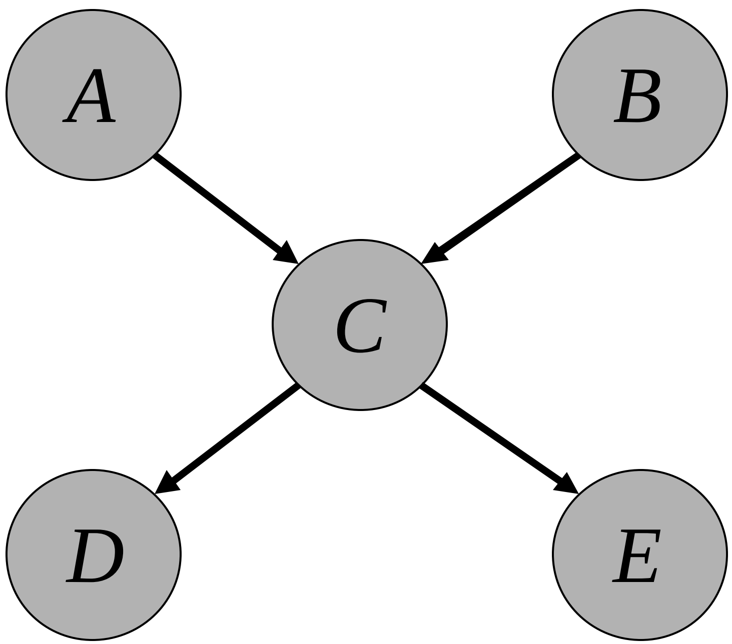
The right kind of answer

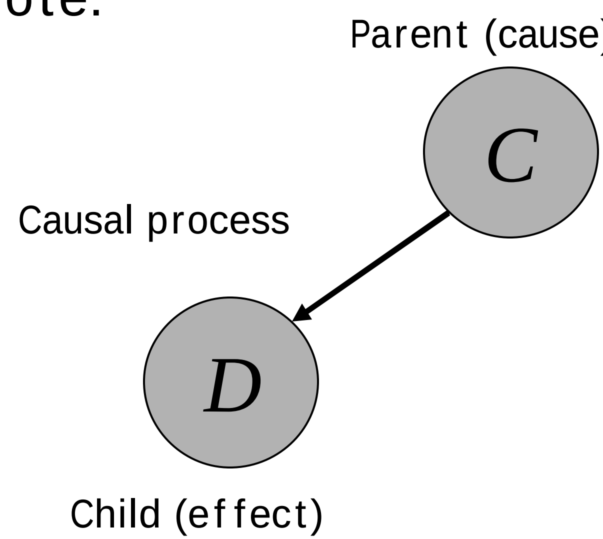
- "If you do [Management Action] x the probability that [Consequence] y will occur is $z\%$."
- Clear causal reasoning required to make such a statement.
- A framework needed to produce them.

Bayesian Belief Networks

- Describe causal relationships between variables



Note:



Parents can also be Children

Variables are independent if there is no link between them

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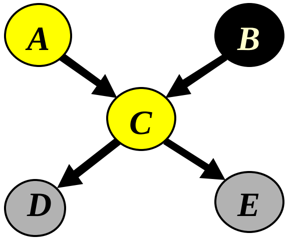
Conditional Probability Matrix

- The strength of a link is specified with a conditional probability eg. P(child| parent$_1$,...., parent$_n$)



- eg Assume 2 possible states ($\bullet$ & $\circ$)

$$M=\begin{bmatrix} m_1 & 1-m_1 \\ m_2 & 1-m_2 \\ m_3 & 1-m_3 \\ m_4 & 1-m_4 \end{bmatrix}=\begin{bmatrix} P\left(C=\bullet \middle| A=\bullet, B=\bullet\right) & P\left(C=\circ \middle| A=\bullet, B=\bullet\right) \\ P\left(C=\bullet \middle| A=\bullet, B=\circ\right) & P\left(C=\circ \middle| A=\bullet, B=\circ\right) \\ P\left(C=\bullet \middle| A=\circ, B=\bullet\right) & P\left(C=\circ \middle| A=\circ, B=\bullet\right) \\ P\left(C=\bullet \middle| A=\circ, B=\circ\right) & P\left(C=\circ \middle| A=\circ, B=\circ\right) \end{bmatrix}$$

Allows beliefs in the two states of C to be calculated

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With BBN's

- The structure of the network

and

- The conditional probability matrix

allows

1. The likelihood (marginal probability) of each node holding one of its states to be calculated
2. Propagation of effects throughout the network if a marginal probability is changed, thereby updating probabilities of variables of interest.

Bayes' Theorem
(for two hypotheses)

H_1: A coral reef will bleach
H_2: A coral reef will not bleach
Data: Variables that give us bleaching potential (high or low)

The probability that Hypothesis 1 is true, given the data

Prior probability of H_1

$$P\left(H_1 \middle| D\right) = \frac{P(H_1) \times P\left(D \middle| H_1\right)}{P(H_1) \times P\left(D \middle| H_1\right) + P(H_2) \times P\left(D \middle| H_2\right)}$$

Probability of observing vulnerability when H_1 is true

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In other words

1000 Coral Reefs

50 bleached

950 did not bleach

Low bleaching potential observed: 4 reefs

High bleaching potential observed: 46 reefs

High bleaching potential observed: 142 reefs

Low bleaching potential observed: 808 reefs

Of the 188 stands with high bleaching potential, the proportion of reefs that actually bleached is 46/188 = 0.245

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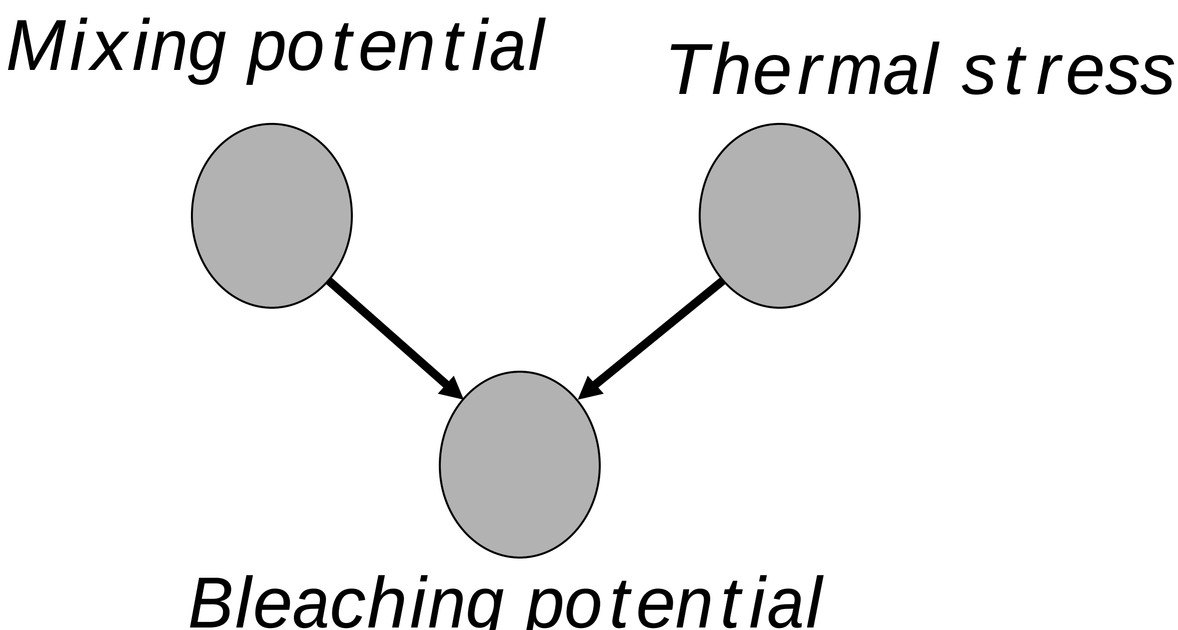
Coral Bleaching Potential

Objective

To predict the likelihood of bleaching under various scenarios



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Coral Bleaching Potential

Bleaching surveys + Remote sensed SST + Mixing conditions from expert opinion

↓

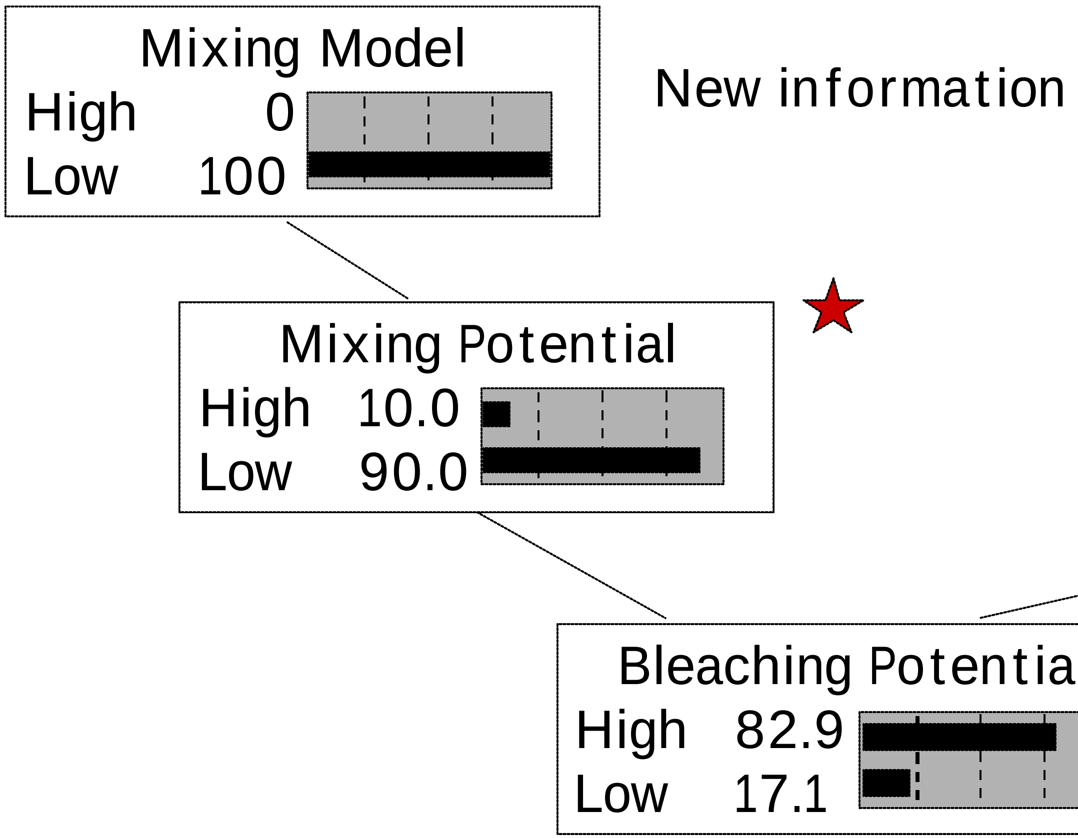
Frequency of bleaching states for each combination of mixing and thermal stress

↓

Conditional Probabilities for Bleaching Potential

		Bleaching potential	
Mixing	Thermal	High	Low
high	high	0.40	0.60
high	low	0.05	0.95
low	high	0.95	0.05
low	low	0.05	0.95

An example: Coral Bleaching



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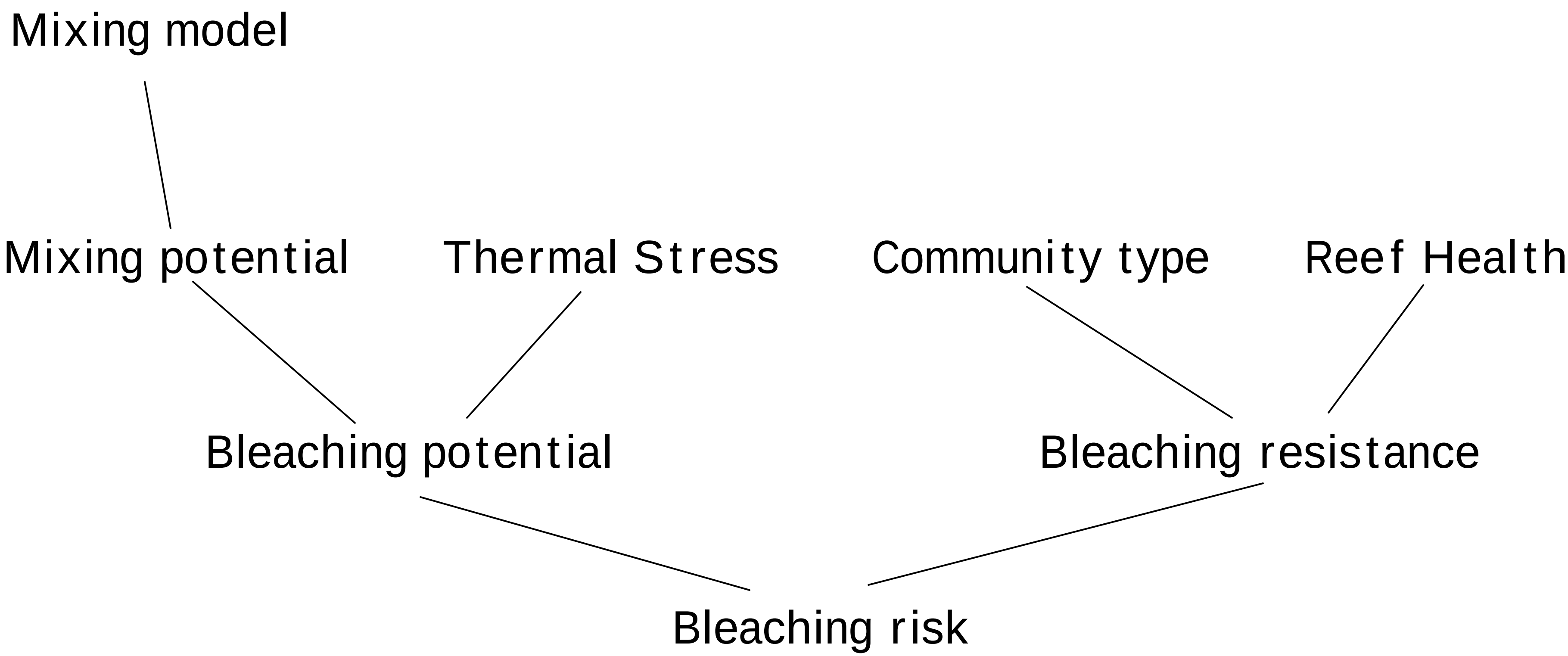
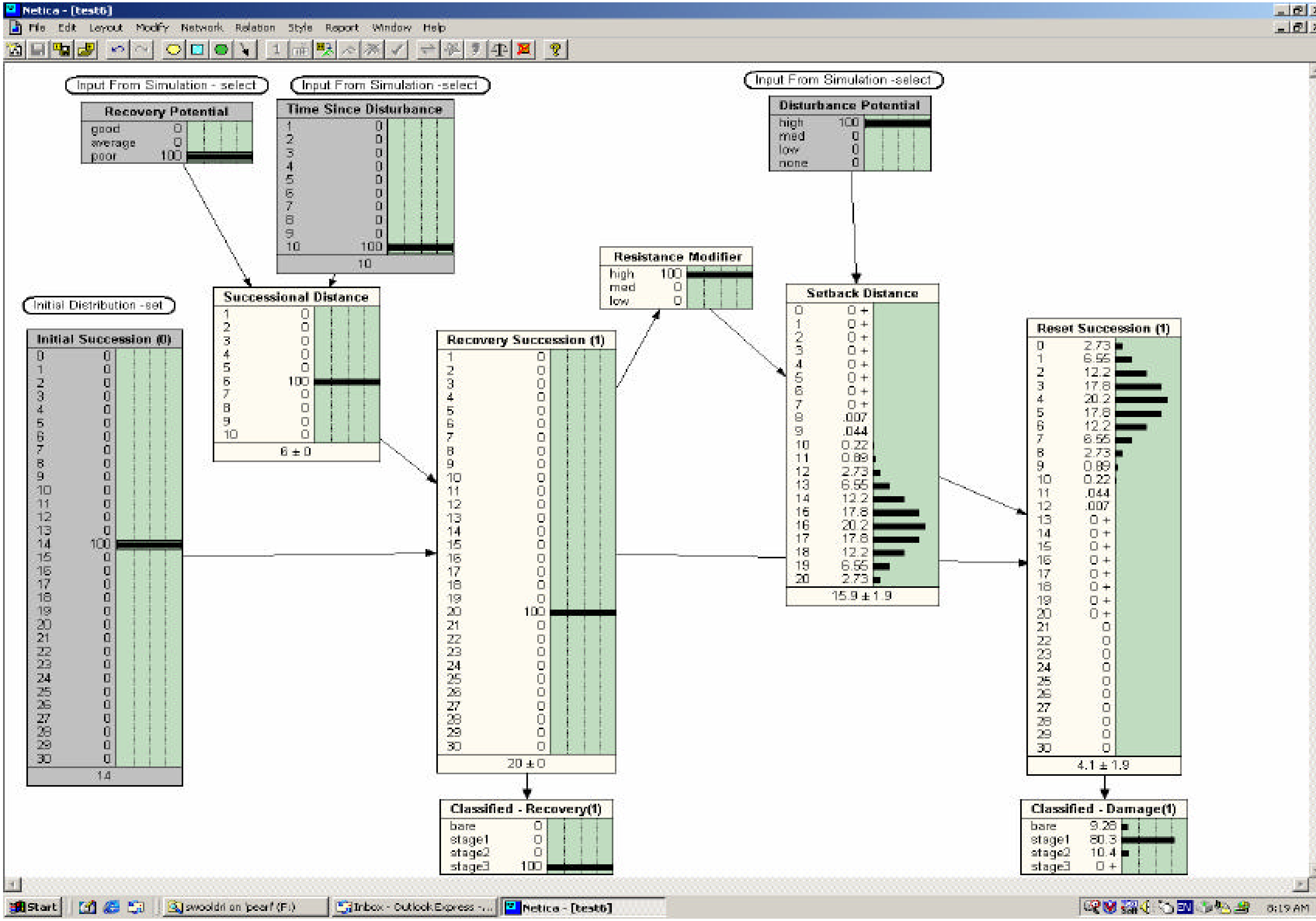
An example: Coral Bleaching





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Bayesian Belief Ne[illegible]rks

- Allow different kin[illegible]ormation to be easily comb[illegible]
- Formally stru[illegible]nderstanding
- Allows inf[illegible]ecision making with in[illegible]e scientific info[illegible]
- P[illegible]ns amenable to risk analysis
- [illegible]e scenarios can be tested

Predictive capacity for risk analysis
for GBR to be delivered January 20

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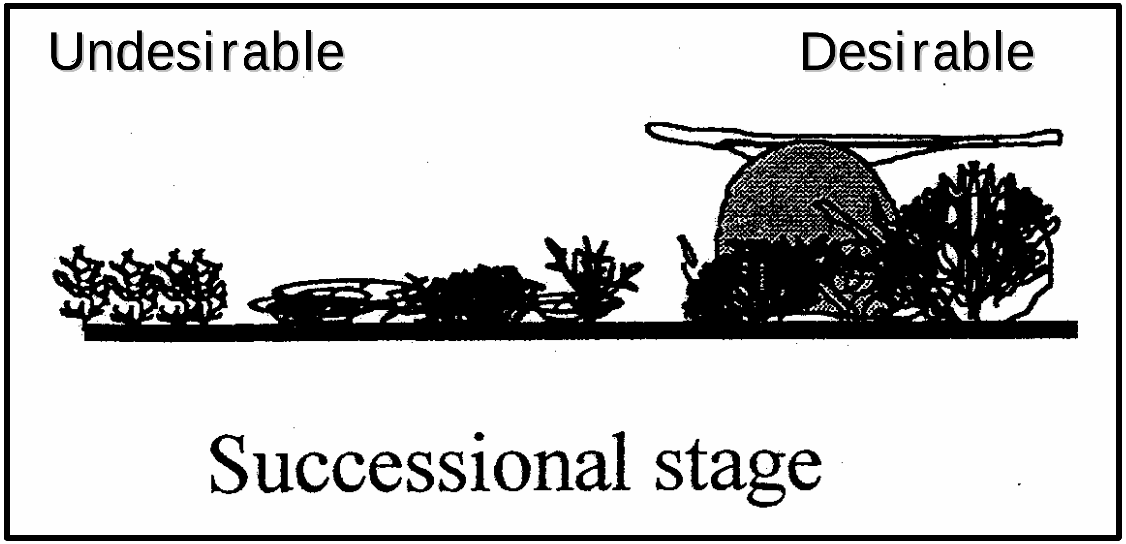
Recovery Dynamics

State (t) → State (t+1) → State (t+n)



Prob(transition) – *f* (initial state, time since disturbance, 'recovery' conditions)

- Bleaching
- Crown-thorns-starfish
- Cyclone
- Flood Plume

- Water Quality
- Marine Reserve Design

~ Management implications

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TRADER
(MPA Design Software)

- Statistical models (multivariate trees) + expert knowledge to determine ecoregions
- Smart algorithms based on trees and heuristics (grow, pick and peel) allow selection of a protective areas network
- Interactive tools refine the network through trading
- New tree-based data mining methods are being developed (knowledge discovery and data mining)

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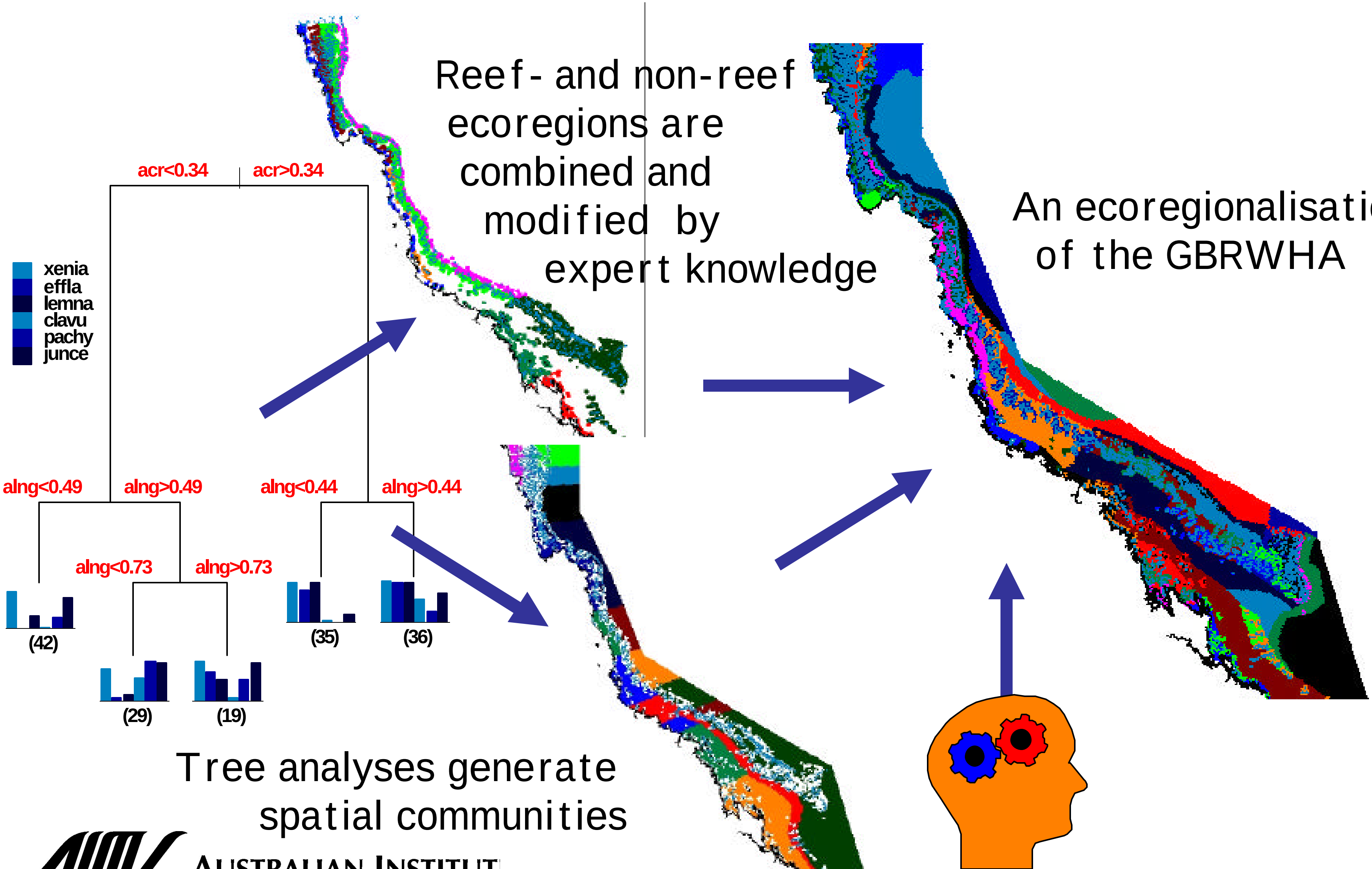
Data and knowledge to ecoregionalisation



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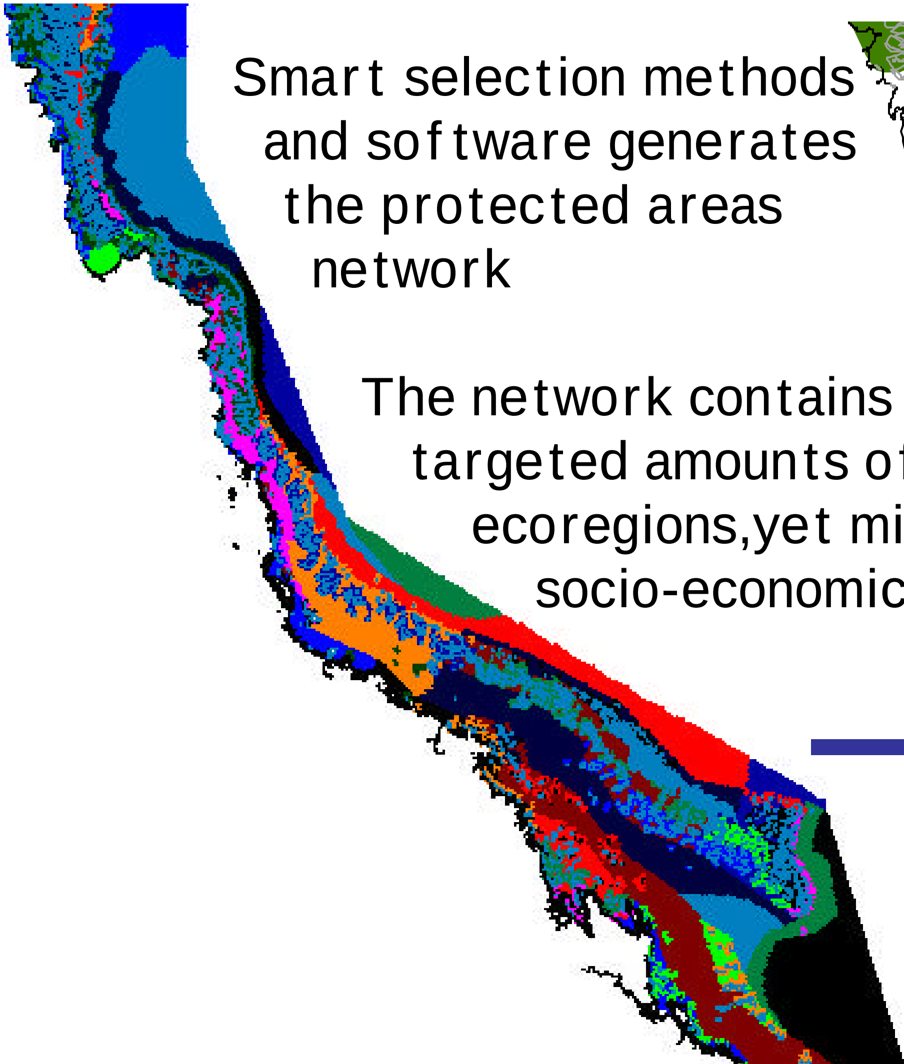
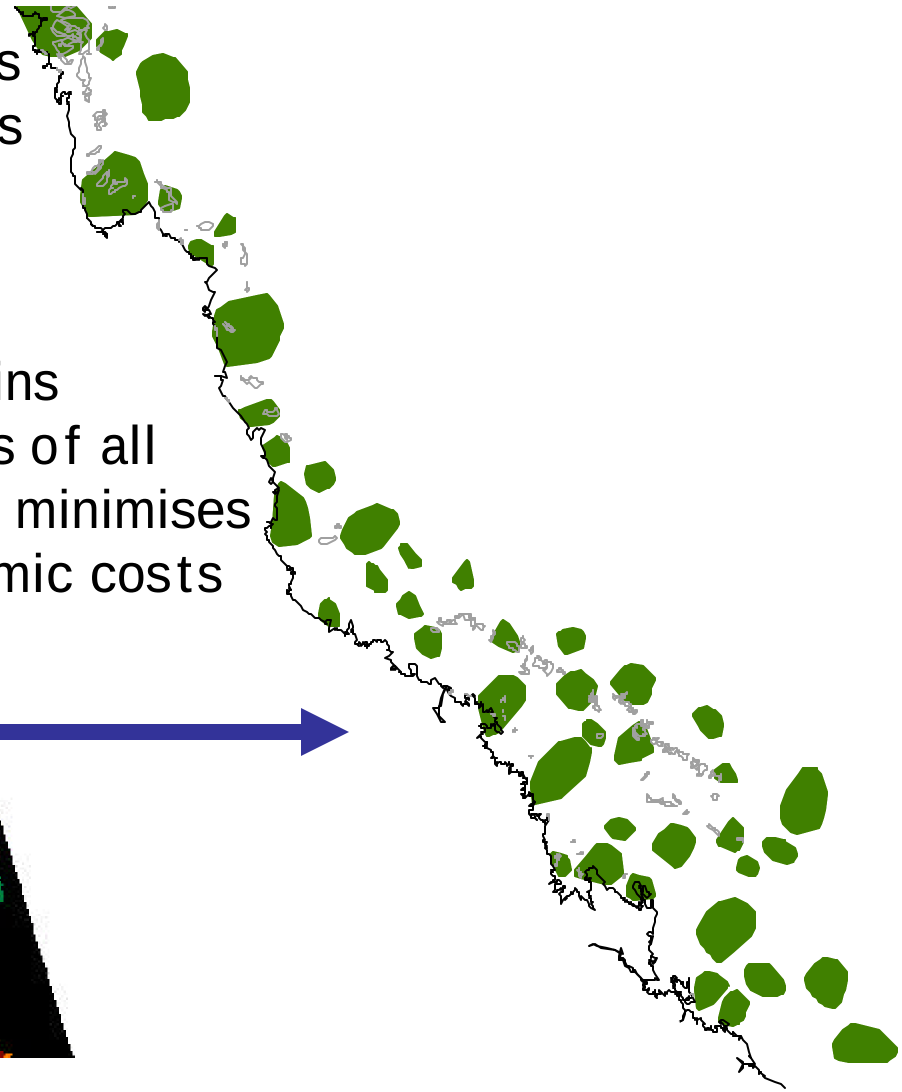
Ecoregionalisation to a Protected Areas Network

Smart selection methods and software generates the protected areas network

The network contains targeted amounts of all ecoregions,yet minimises socio-economic costs





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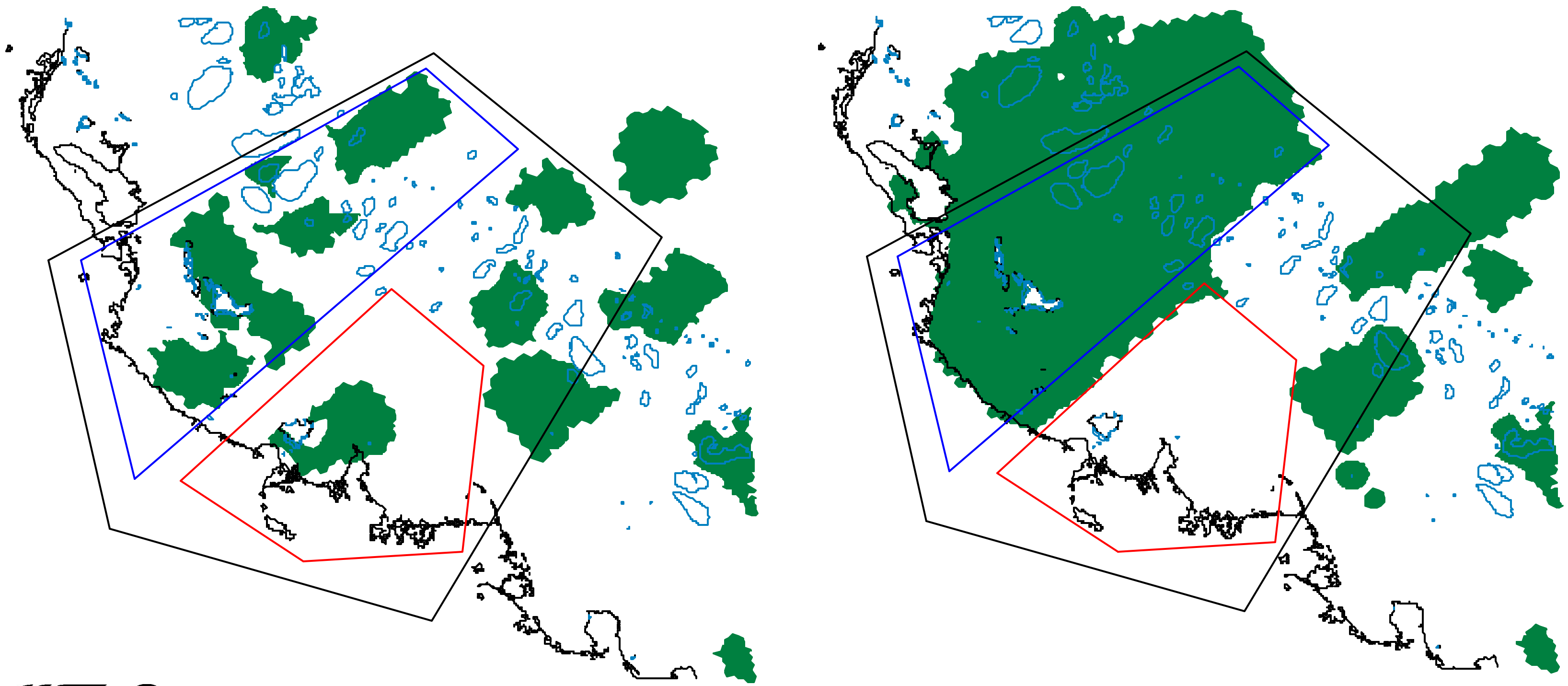
Trading

- Interactive local modifications to the network by including and excluding regions, and re-evaluating



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My questions for this visit

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- Can we add genuine value to each others business?
- If we can, how might an effective strategic alliance be realised?

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