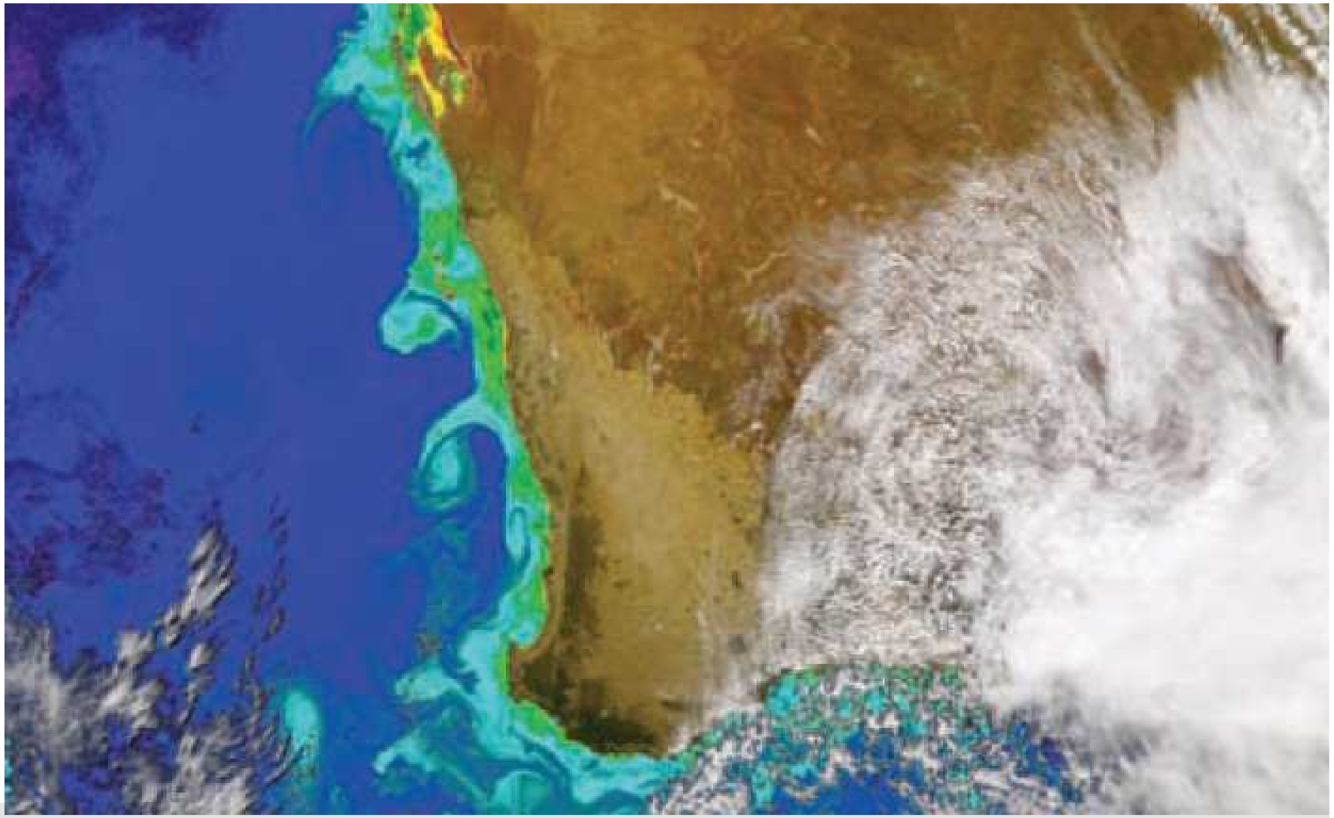

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Ecosystem health monitoring

Keith Hayes, Jeff Dambacher, Dave Clifford, Mark Palmer, Chris Moessender and Tom Taranto

16th November 2010, Canberra

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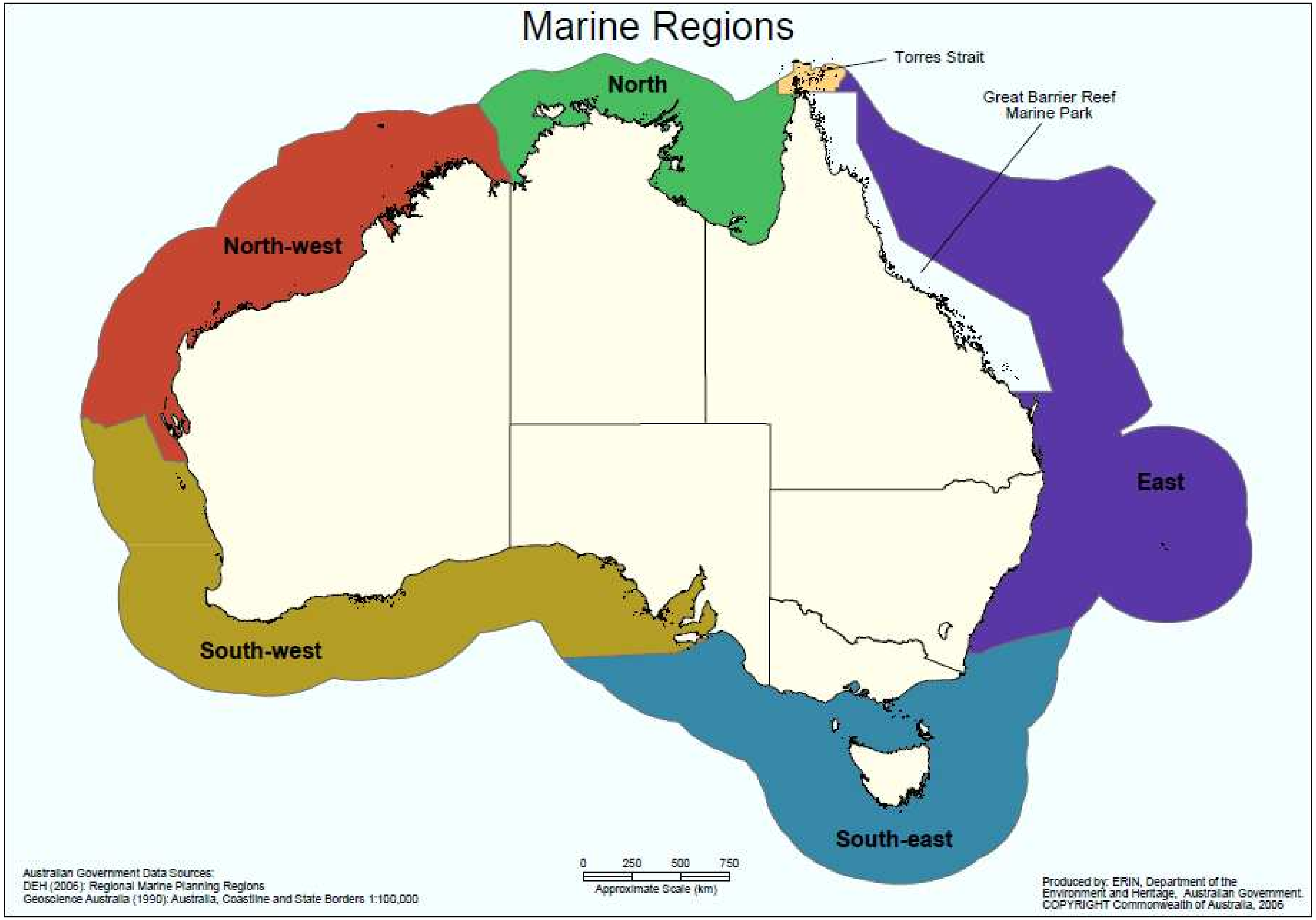
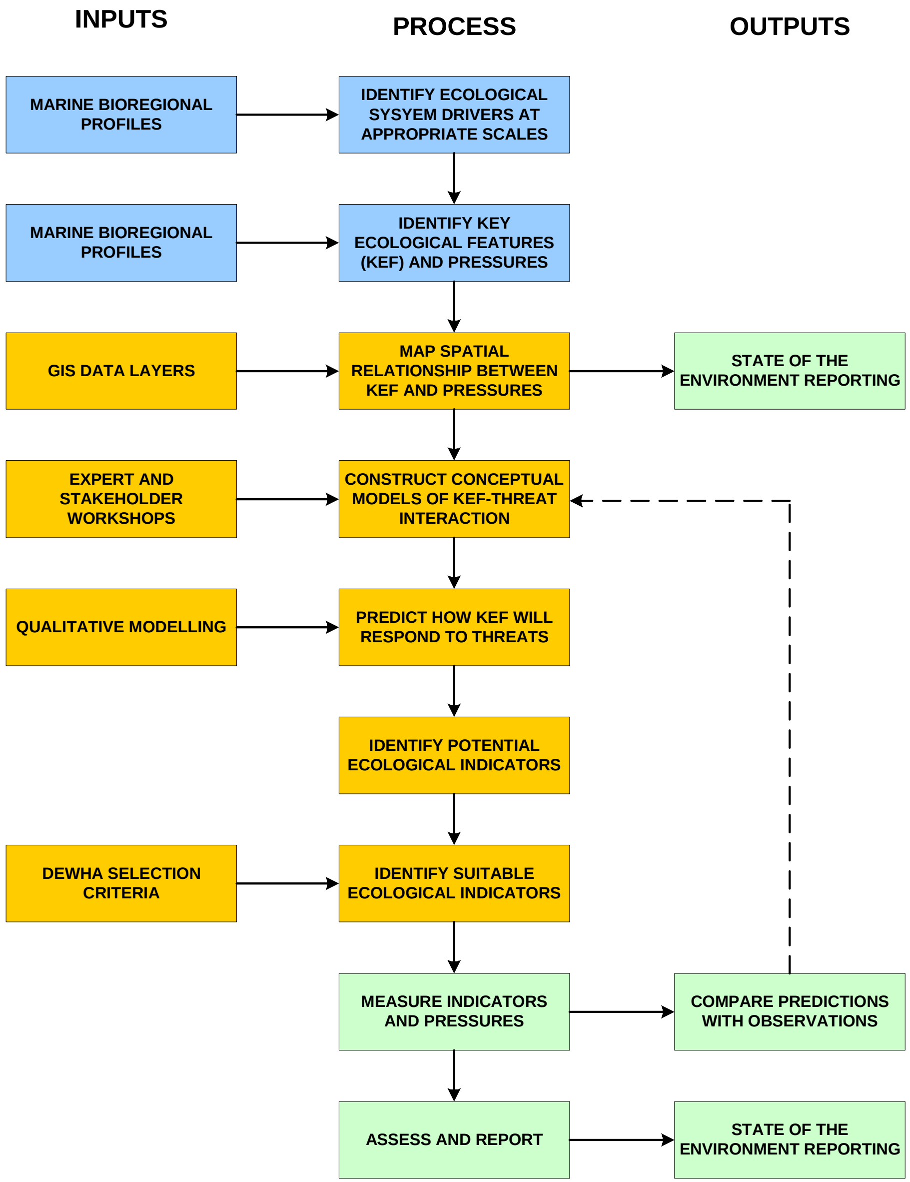
DEWHA Marine planning regions



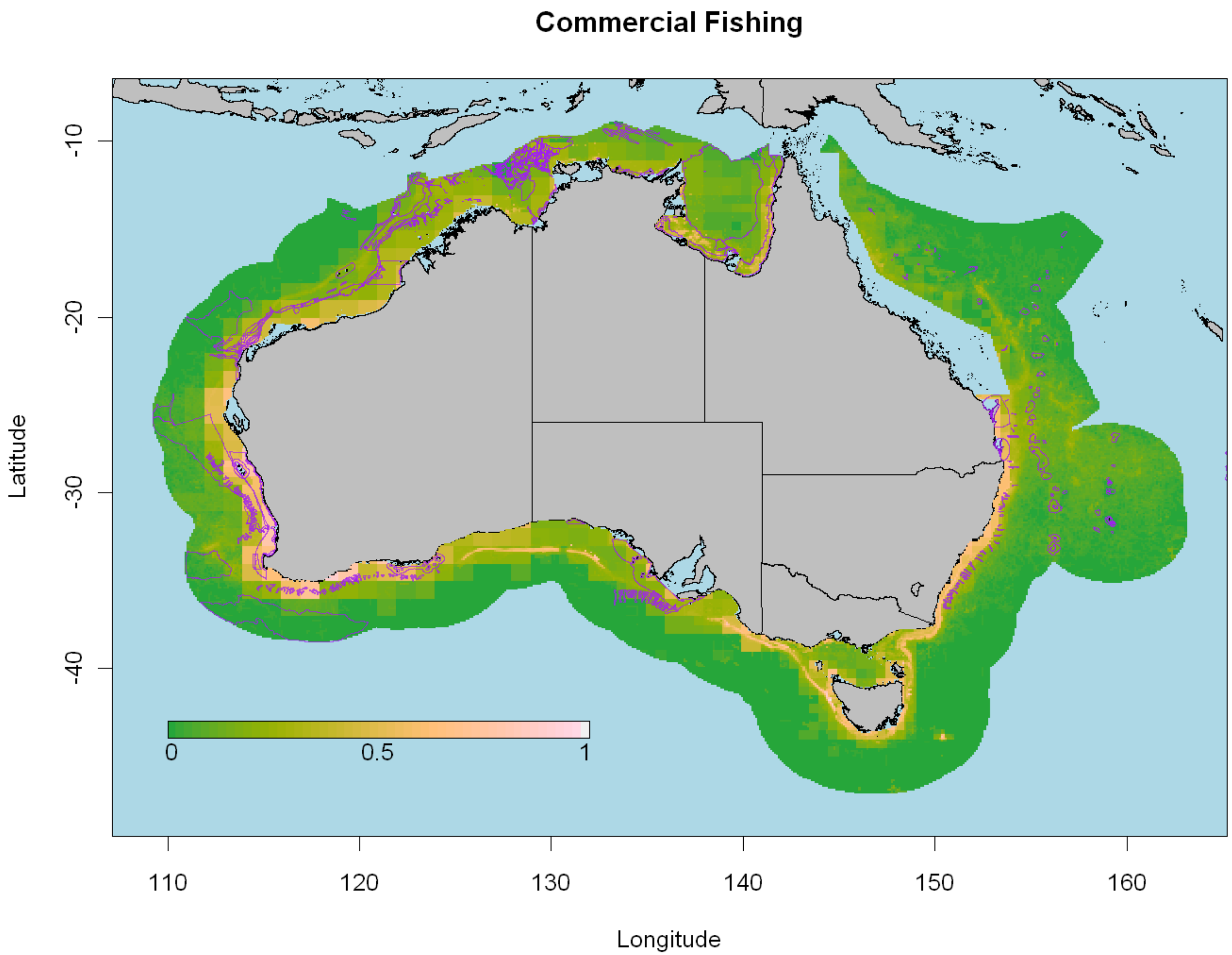
Identifying ecological indicators

- Empirical approaches
  - reference site methods: statistically compare the biological and physical conditions of “pristine” sites to “impacted sites”
  - stress gradient methods: statistically identify ecosystem responses to sustained anthropogenic activity
- Theoretical approaches
  - seek to understand the cause and effect mechanisms that link anthropogenic activity and ecosystem response
  - nowadays usually couched within the DPSIR framework
  - many methods

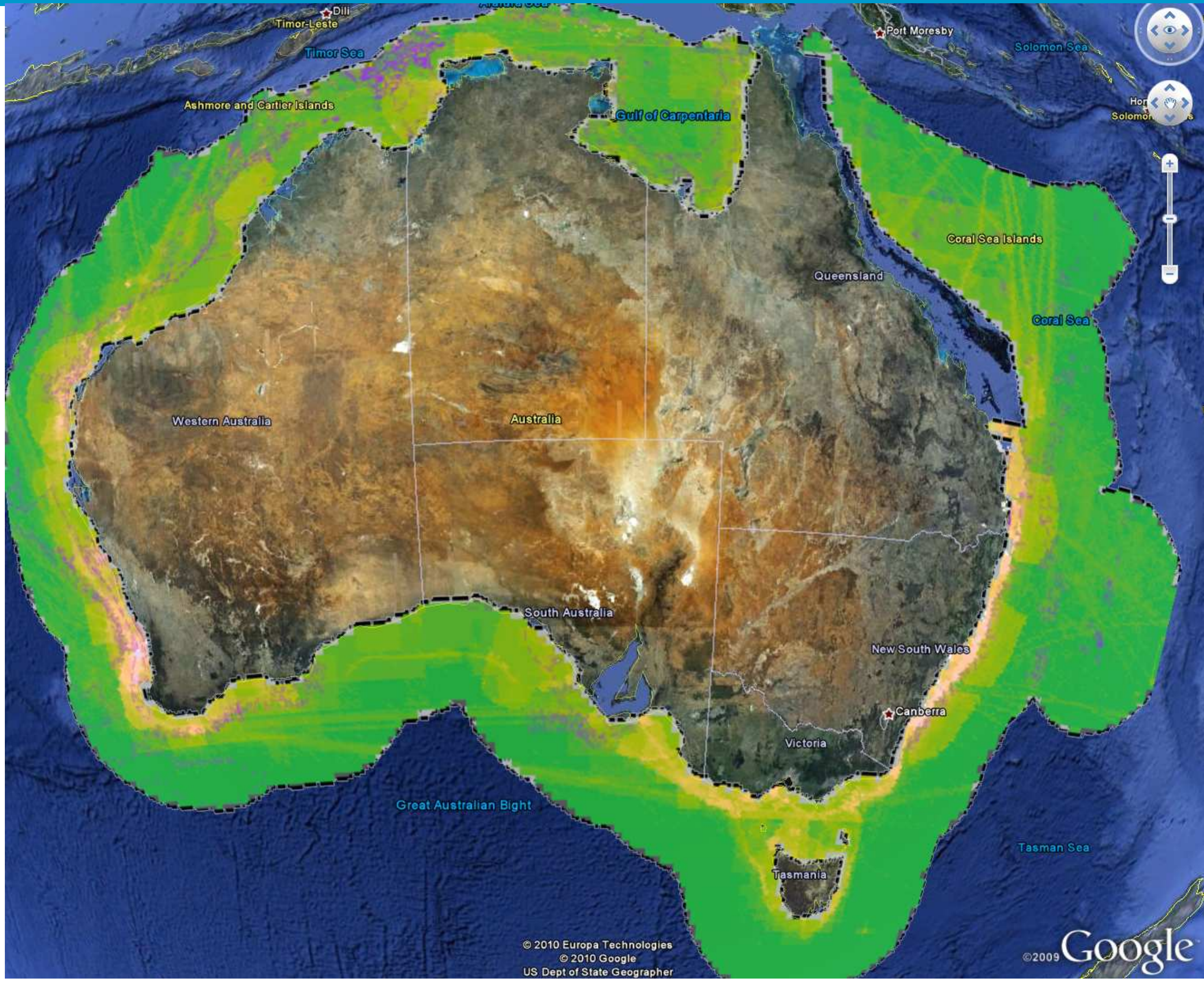
Basic framework



Mapping threats: commercial fishing



Mapping the spatial (and temporal) relationship between KEFs and pressures



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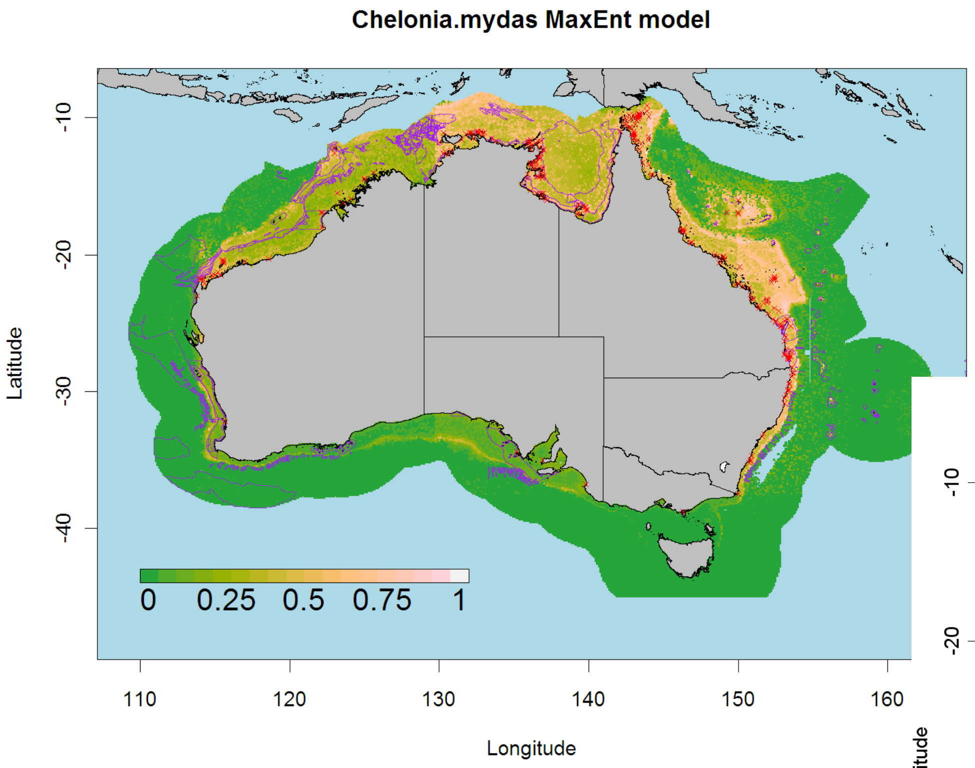
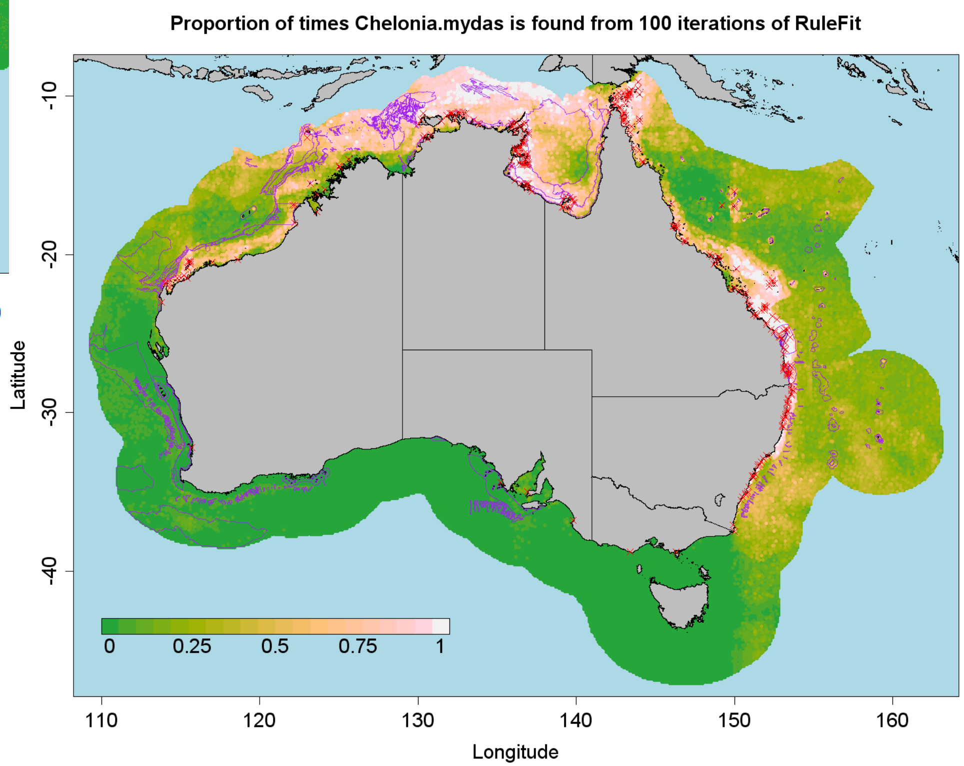
Mapping assets: TEPS (*Chelonia mydas*)





Why is the mapping important?

- Roles
  - monitor pressures trends (required by the DPSR framework)
  - constrains pressure scenarios by identifying relevant anthropogenic activities and valued ecosystem components
  - helps identify the domain of the model
  - helps identify future monitoring locations
  - helps identify hotspots
  - SoE reporting

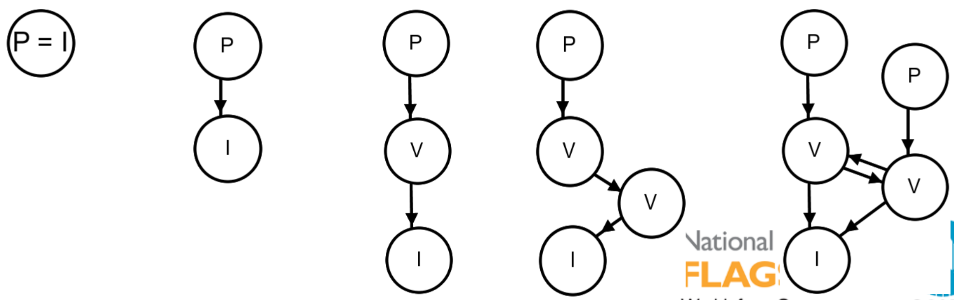
- Key challenges
  - considerable scope for methodological improvement
  - need to develop explicit interaction models – e.g. building on the Ecological Risk Assessment for the Effects of Fishing

Construct conceptual model of KEF-pressure interactions: sufficiency of methods

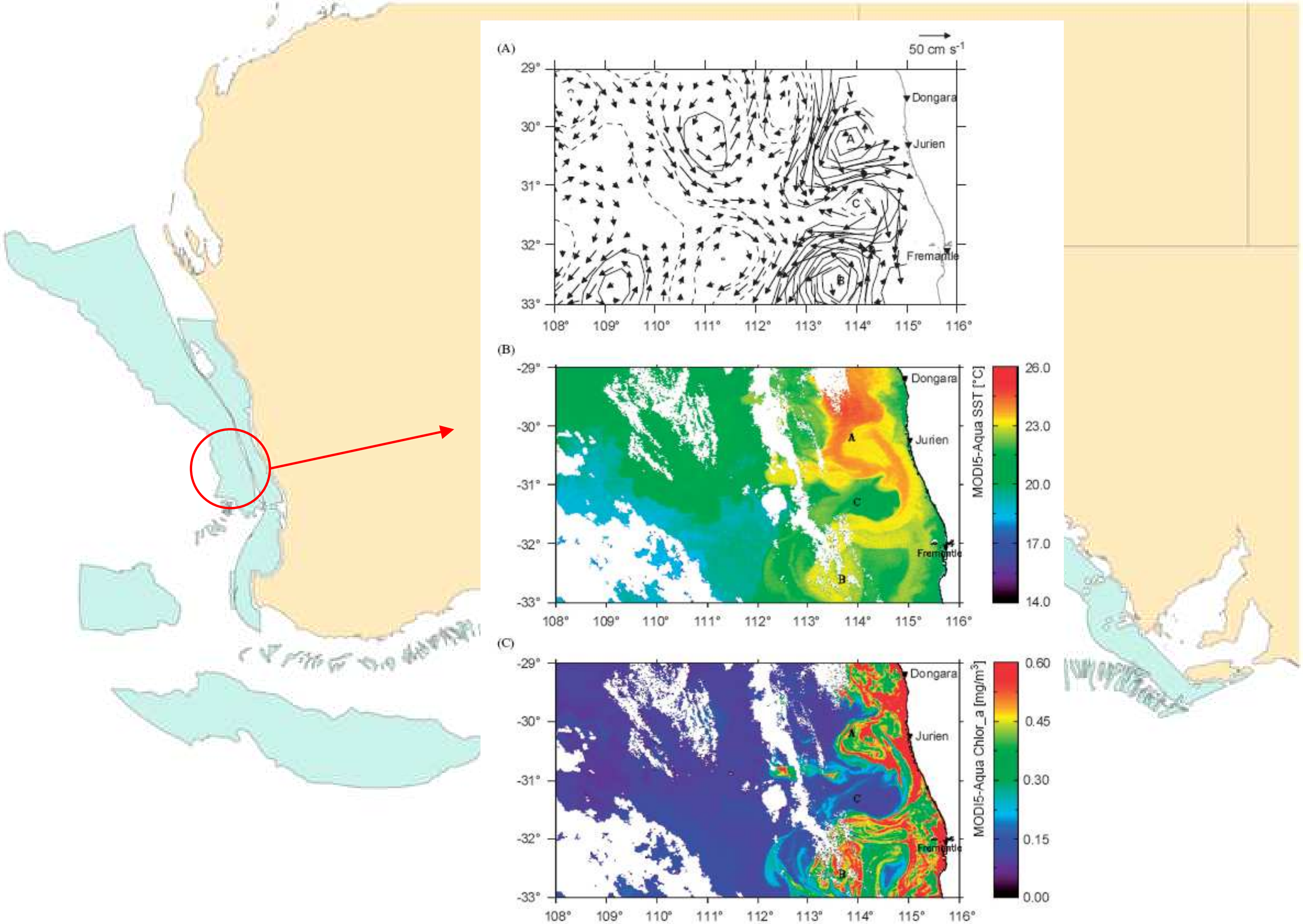
	Complexity of cause-effect relationship				
Method	**None**	**Simple**	**Direct**	**Diffuse**	**Feedback**
1. Unstructured list	**X**				
2. Objective-indicator matrix		**X**			
3. Cartoon		**X**	**X**		
4. Influence diagram		**X**	**X**	**X**	
5. Fuzzy cognitive map		**X**	**X**	**X**	
6. Bayesian belief network		**X**	**X**	**X**	**X**[†]
7. Qualitative process model		**X**	**X**	**X**	**X**
8. Quantitative process model		**X**	**X**	**X**	**X**

[†] With difficulty

P: pressure
V: variable
I: indicator



SW KEFS: Meso-scale eddies



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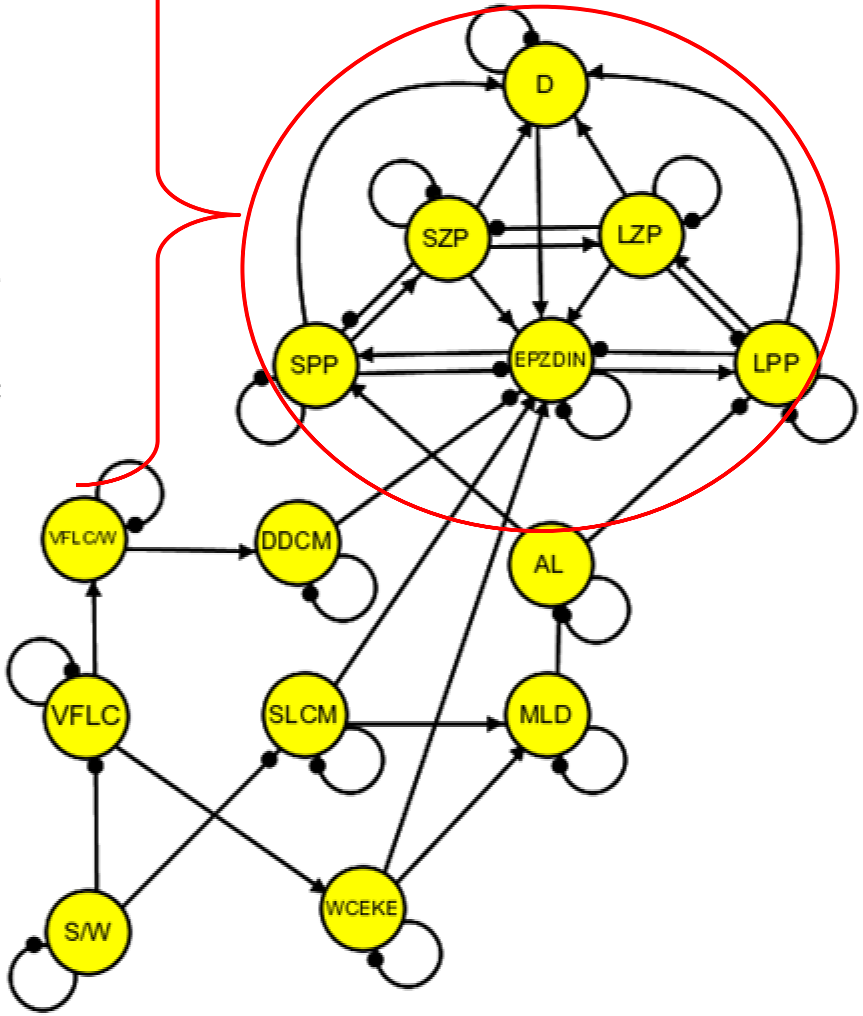
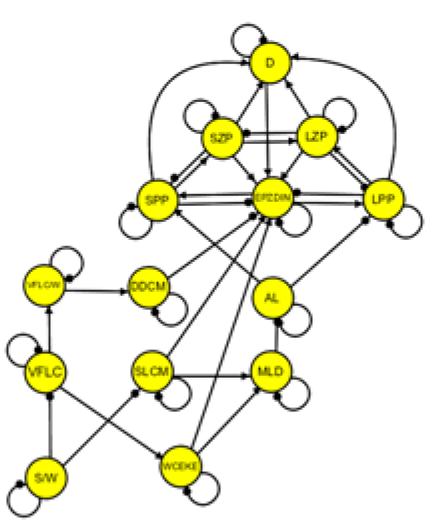
Predict how the KEF will respond to pressures: Qualitative model of (warm core) meso-scale eddy

State variable	Rate equations
Phytoplankton N (mmol N m^{-3})	$\frac{\delta P}{\delta t} = \frac{\delta}{\delta z}\left(K_z \frac{\delta P}{\delta z}\right) - \omega_{\mathrm{p}} \frac{\delta P}{\delta z} + R_{\max} P_{\min}\left[\frac{\mathrm{DIN}}{\mathrm{DIN} + ks_{\mathrm{P}}}, 1 - \exp(-\alpha\,\mathrm{PAR}/R_{\max})\right] - m_{\mathrm{p}} P - G$
	$R_{\max} = P_{\max} \frac{\mathrm{ChlN}}{(\mathrm{CN\,mw\,C})} \exp(k_t T)$
Zooplankton N (mmol N m^{-3})	$\frac{\mathrm{dZoo}}{\mathrm{d}t} = \frac{\delta}{\delta z}\left(K_z \frac{\delta \mathrm{Zoo}}{\delta t}\right) + \gamma G - m_{\mathrm{zoo}} \mathrm{Zoo}^2 - r\mathrm{Zoo}$
	$G = G_{\max} \mathrm{Zoo}\left(\frac{P}{P + ks_{\mathrm{zoo}}}\right), \quad r\mathrm{Zoo} = k_{\mathrm{resp}} \mathrm{Zoo} + k$
Detritus (mmol N m^{-3})	$\frac{\delta D}{\delta t} = \frac{\delta}{\delta z}\left(K_z \frac{\delta D}{\delta z}\right) - \omega_{\mathrm{D}} \frac{\delta D}{\delta z} + (1-\gamma) G + m_{\mathrm{zoo}} \mathrm{Zoc}$
DIN (mmol N m^{-3})	$\frac{\delta \mathrm{DIN}}{\delta t} = \frac{\delta}{\delta z}\left(K_z \frac{\delta \mathrm{DIN}}{\delta z}\right) - R_{\max} P_{\min}\left[\frac{\mathrm{DIN}}{\mathrm{DIN} + ks_{\mathrm{P}}},\right.$

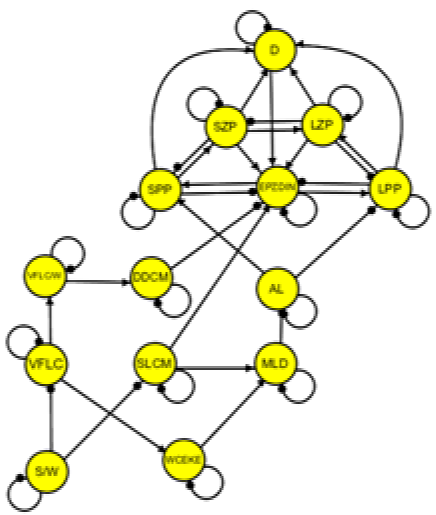
Source: Greenwood *et al*, 2007



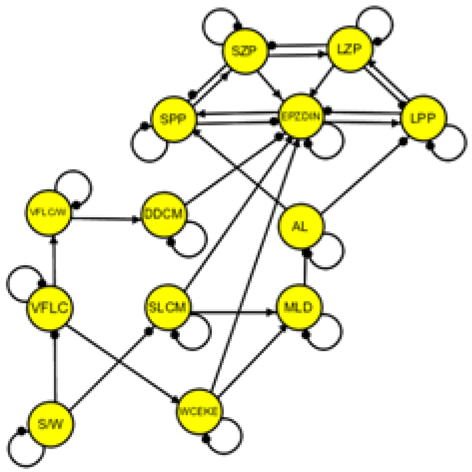
Model structure uncertainty: capturing knowledge via signed digraphs



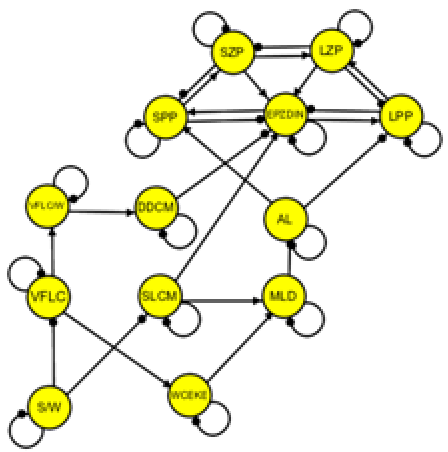
Meso-scale eddy1



Meso-scale eddy2



Meso-scale eddy3



Meso-scale eddy4

Potential indicators: Meso-scale eddy and climate change

Reference	Qualitative model	Season	Volume flux of the Leeuwin Current	Summer wind stress
A	Meso-scale eddy 1	Winter	Small decrease	No change
B	Meso-scale eddy 1	Summer	Small decrease	No change
C	Meso-scale eddy 1	Summer	Small decrease	Increase
D	Meso-scale eddy 4	Winter	Small decrease	No change
E	Meso-scale eddy 4	Summer	Small decrease	No change
F	Meso-scale eddy 4	Summer	Small decrease	Increase

a) Pressure scenario Model variable	A	B	C	D	E	F
EPZDIN[a]	–	+	+	–	+	+
Detritus	–	+	+	Na	Na	Na
Small phytoplankton	+	+	+	–	+	+
Large phytoplankton	–	+	+	+	–	–
Small zooplankton	+	–	?	–	+	+
Large zooplankton	–	+	+	–	+	+
Average light	–	+	+	–	+	+
Mixed Layer Depth	+	–	–	+	–	–
Surface Layer Convective Mixing	+	–	–	+	–	–
Warm Core Eddy Kinetic Energy	+	–	–	+	–	–
Depth of Deep Chlorophyll Maximum	+	–	–	+	–	–
Ratio of VFLC/WDU	+	–	–	+	–	–
Volume Flux of the Leeuwin Current	+	–	–	+	–	–

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Thank you