The New Zealand Estuary Trophic Index (ETI) Tools

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'Nationally consistent assessment and prediction of estuary eutrophication'

ETI Project Background

Why was the ETI needed?

Nutrient enrichment threatens many NZ estuaries, but guidance on assessing estuary health was limited.

It has been difficult to:

- Determine current estuary trophic state,
- Assess effects of land-use on trophic state,
- Gauge consequences of FW nutrient limit-settings, relative to estuary health objectives,
- Achieve priorities of the NPSFM (2014), NZCPS (2010) and RC RS&T Strategy (2016).

ETI Project Background

How did the ETI happen?

Regional Councils sought advice *via* the MBIE Envirolink Tools scheme, to develop estuary assessment and predictive tools.

Funding:

- ✓ NIWA/MBIE – two years (Mar 2015-Feb 2017), $250K

Contributors:

- ✓ NIWA: Marine ecology and modelling, Tool coding
- ✓ Wriggle Coastal Management: Estuary assessment science, Tool design
- ✓ Regional Councils: Envirolink Tools project champion, water quality science
- ✓ Hume Consulting Ltd: Typology assessment

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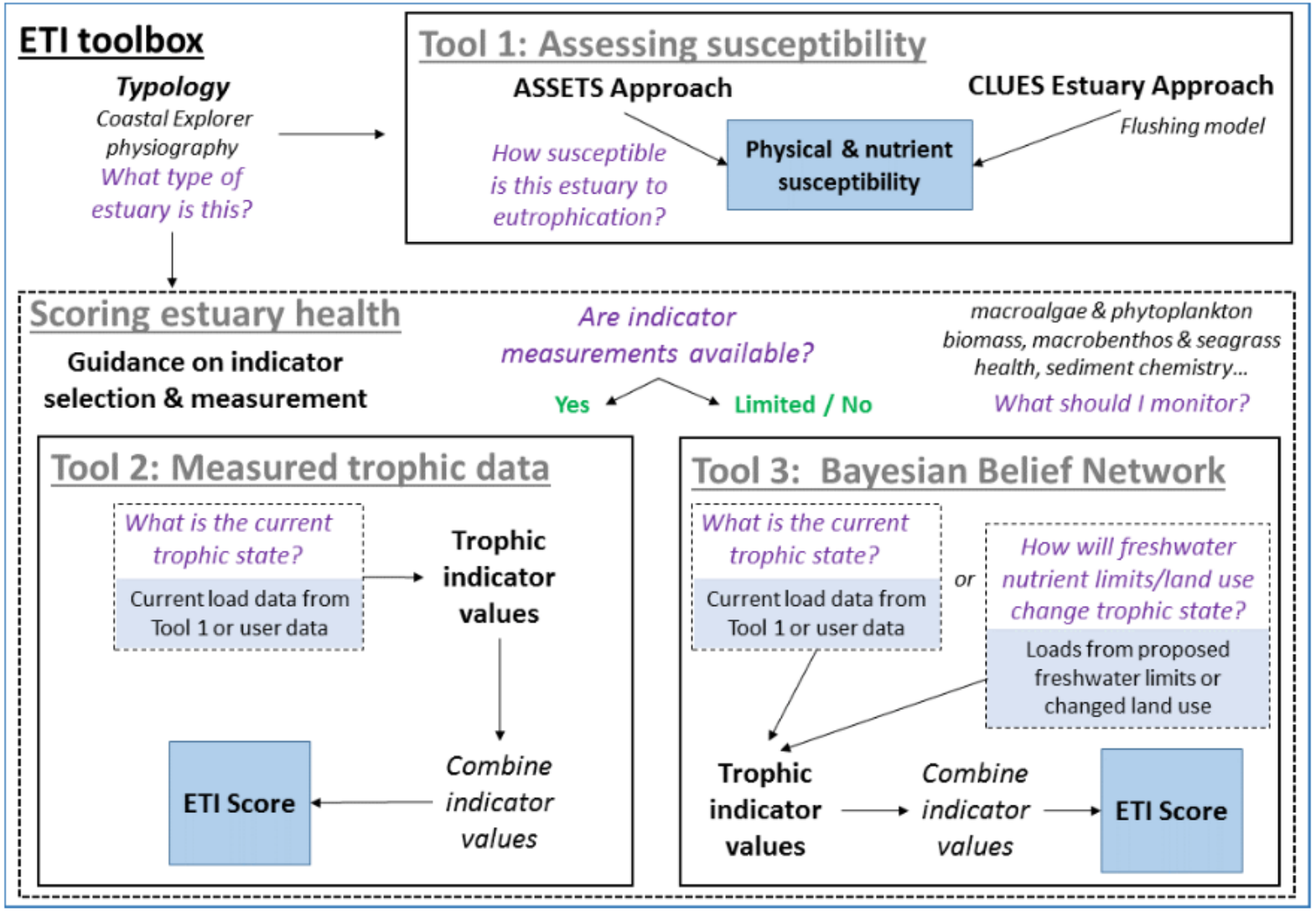
Wriggle coastalmanagement

The ETI has 3 web-based tools

1. Predicts susceptibility of estuaries to eutrophication
2. Scores current estuary trophic state using monitored indicators
3. Scores trophic states in data-limited or scenario-testing situations



ETI Estuary Typology

- Lagoon and rivers types have the subtype **ICOE** – intermittently closed and open estuaries

Robertson et al. (2016 a). **NZ ETI Screening Tool 1. Determining eutrophication susceptibility using physical and nutrient load data.** *Envirolink Report*

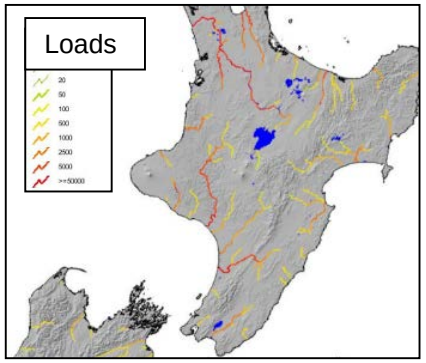
Hume, T. (2016). **Fit of the ETI trophic state susceptibility typology to the NZ coastal hydrosystems classification.** *NIWA Client Report*

ETI Tool 1: Estuary susceptibility using CLUES-Estuary

'CLUES Estuary':

- Developed by NIWA
- Uses CLUES nutrient loads, a national estuary database and simple hydraulics
- Predicts estuary potential nutrient concentrations and flushing times
- Works across all estuary sizes and types

CLUES



Nutrient loads,
River flows

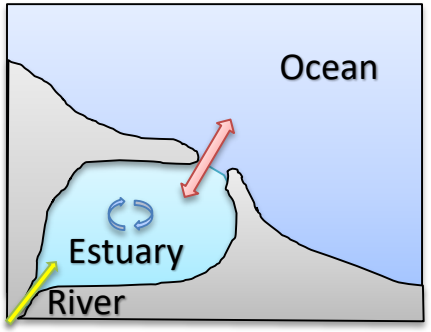
+

Coastal Explorer

Volume,
Tidal prism
(450 estuaries)

+

Estuary Dilution Models

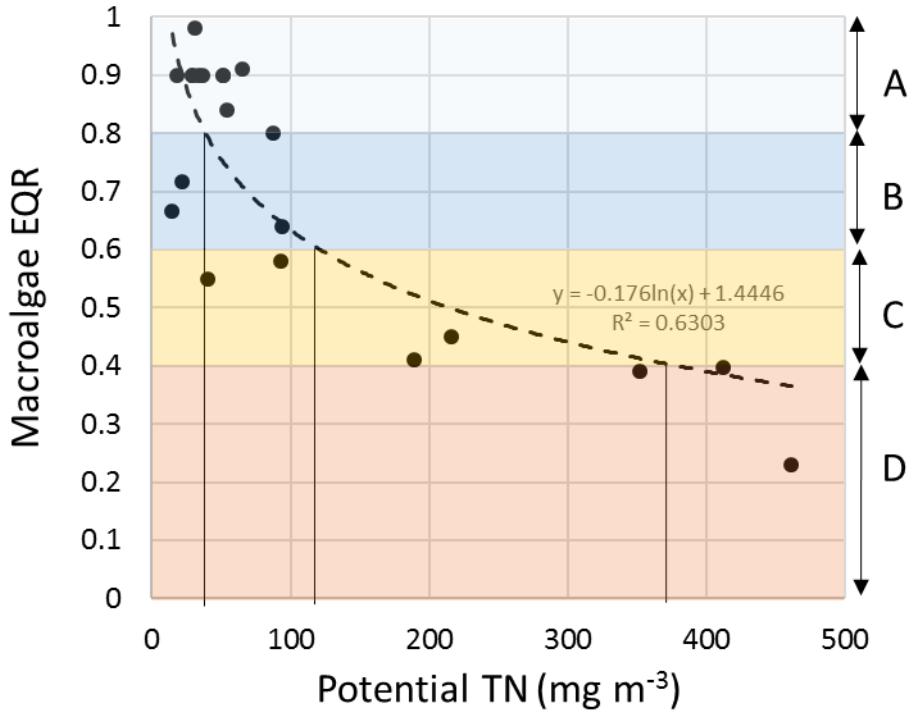


Dilution
-> concentration
Flushing time

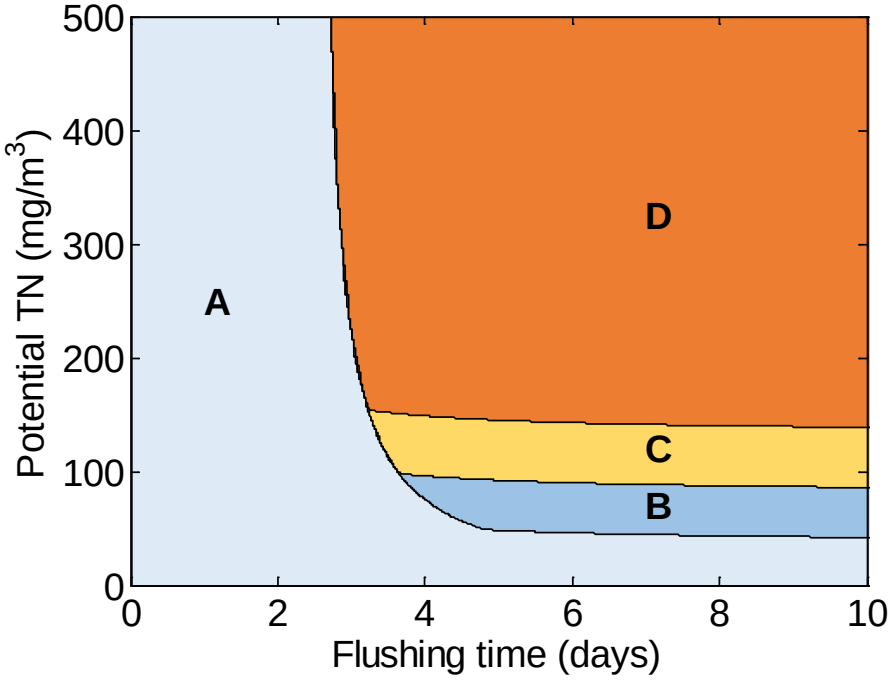
Plew et al. (2017 in review). **CLUES-Estuary: a GIS-based tool for predicting estuarine water quality in New Zealand.** *Coasts and Estuaries*

ETI Tool 1: Estuary susceptibility using CLUES-Estuary

Macroalgae susceptibility



Phytoplankton susceptibility



Band	A	B	C	D
TN (mg/m^3)	< 40	40-120	120-380	> 380

Band	A	B	C	D
Chl-a (µg/l)	< 5	5-10	10-16	> 16

ETI Tool 1: Estuary susceptibility using ASSETS

'ASSETS': Assessment of Estuarine Trophic Status

- Estuary dilution and flushing = 'physical susceptibility'
- Physical susceptibility + nutrient loads = 'combined nutrient and physical susceptibility'
- Developed for large estuaries in USA - applicable to deep NZ river and bay estuaries only

Dilution / Flushing

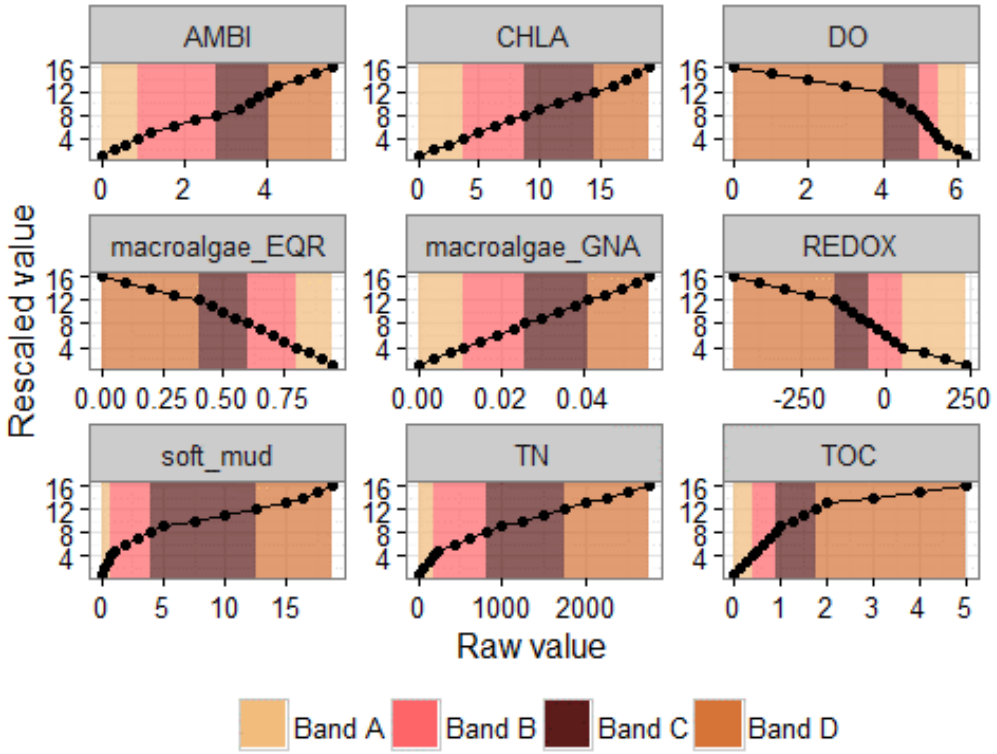
Physical susceptibility	N load (mg/m²/d)			
	Very High > 250	High 50-250	Moderate 10-50	Low <10
High	Very High	High	High	Moderate
Mod	Very High	High	Moderate	Low
Low	High	Moderate	Moderate	Low

Robertson et al. (2016 a). **NZ ETI Screening Tool 1. Determining eutrophication susceptibility using physical and nutrient load data.** *Envirolink Report*

ETI Tool 2: Scoring trophic state using indicators

- Identifies appropriate trophic indicators to monitor
- Gathers international and local knowledge on indicator states that describe ecological condition
- Combines indicator states to create a banded score

- *Primary indicators*: growth responses of primary producers (macroalgae, phytoplankton)
- *Secondary indicators*: 'symptoms' of primary effects (e.g., macrobenthos health, oxic state, sediment N&C, chlorophyll)



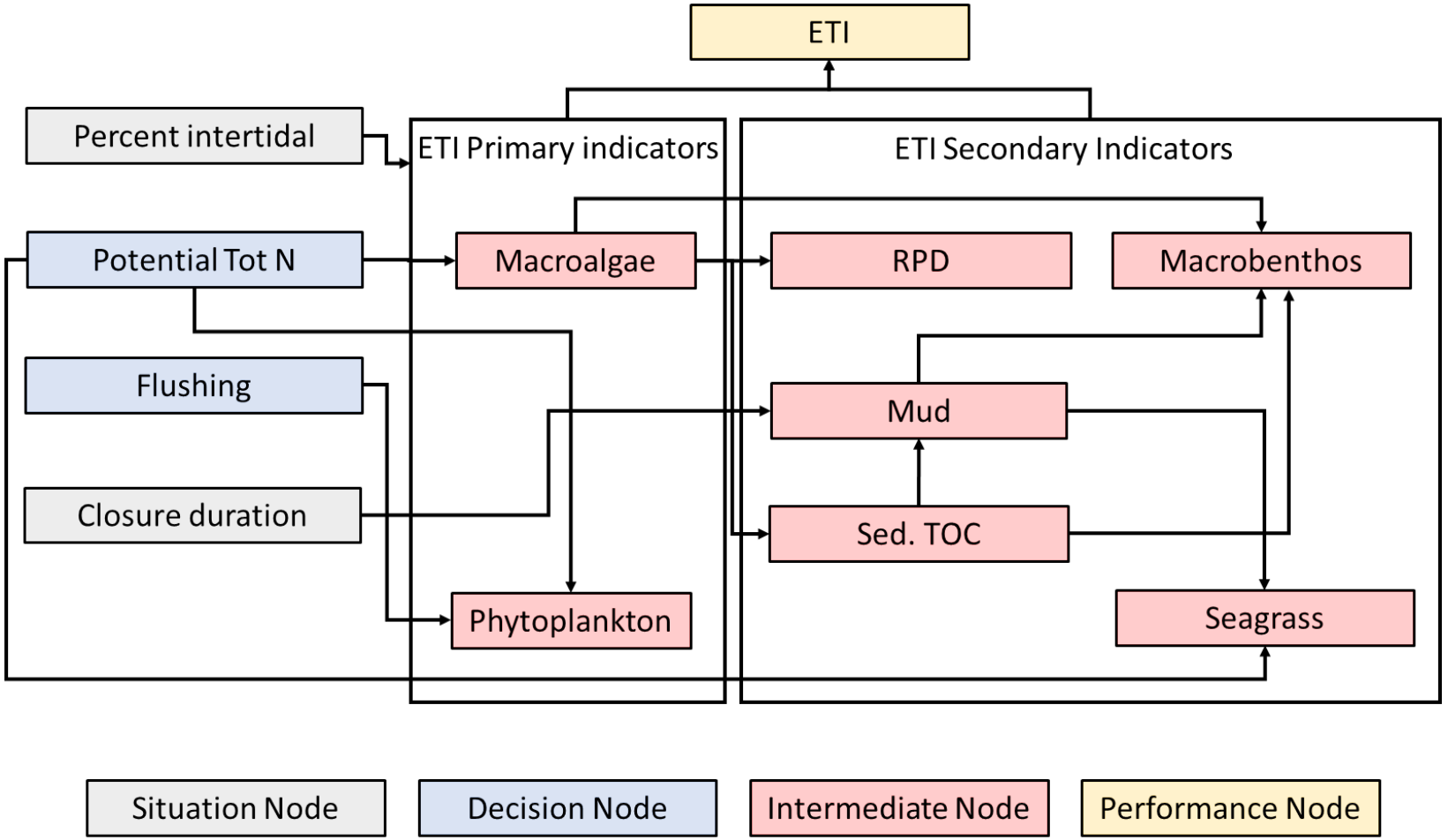
Robertson et al. (2016 b). **NZ ETI Screening Tool 2. Determining Monitoring Indicators and Assessing Estuary Trophic State.** *Envirolink Report*

ETI Tool 3: Scoring trophic state using Bayesian network

Links drivers of estuary trophic condition with responses of indicators to calculate ETI score

The BBN is useful when:

- There are few or no indicator measurements
- Testing scenarios, e.g., changed land use or point sources
- Testing effects of upstream load limit-setting scenarios

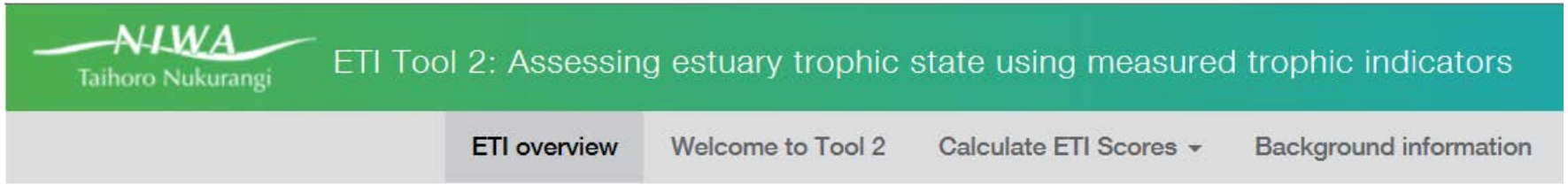


ETI Tool 3: Bayesian network knowledge

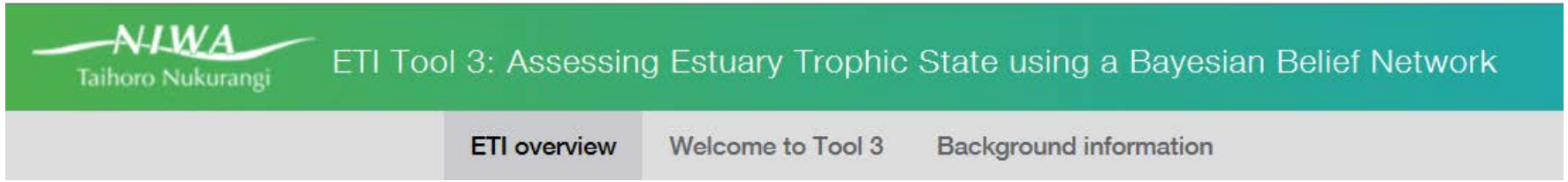
Node linkage	Description	Data sources	References
Potential N/Macroalgae	Empirical functional relationship	CLUES-Estuary, Wriggle EQR database	(Plew et al. 2015, Elliott et al. 2016)
Potential N/Phytoplankton	Modelled functional relationship	CLUES-Estuary, literature values for phytoplankton growth	(Eppley 1969), (Plew et al. 2015, Elliott et al. 2016)
Flushing/Phytoplankton	Modelled functional relationship	CLUES-Estuary, literature values for phytoplankton growth	(Plew et al. 2015), (Elliott et al. 2016)
Closure state/Mud	Expert opinion	Coastal Explorer	(Hume et al. 2016)
Macroalgae/RPD	Empirical functional relationship	Wriggle EQR database, California estuaries	(Sutula et al. 2014)
Macroalgae/Sed TOC	Empirical functional relationship	Wriggle EQR, TOC databases, California estuaries	(Robertson et al. 2016 b), (Sutula et al. 2014)
Sed TOC/Mud	Empirical functional relationship	US East Coast estuaries, Wriggle TOC database	(Pelletier et al. 2011), (Robertson et al. 2016)
Macroalgae/Macrobenthos	Empirical functional relationship	California estuaries	(Green et al. 2012), (Sutula et al. 2014)
Mud/Macrobenthos	Empirical functional relationship	Wriggle TOC/Mud/Macrobenthos database	(Robertson et al. 2016)
TOC/Macrobenthos	Empirical functional relationship	Wriggle TOC/Mud/ Macrobenthos database	(Robertson et al. 2016)
Potential N/Seagrass	Literature values	NZ, US field results	(Robertson et al. 2016 b), (Matheson and Wadhwa 2012), (Burkholder et al. 1994)
Mud/Seagrass	Literature values	NZ field results	(Robertson et al. 2016 b), (Matheson and Wadhwa 2012)

ETI Apps to be demonstrated next!

- Assesses estuary physical and nutrient susceptibility to eutrophication



- Scores estuary state using measured values of indicators



- Scores estuary state by linking indicators; tests scenarios using a BBN