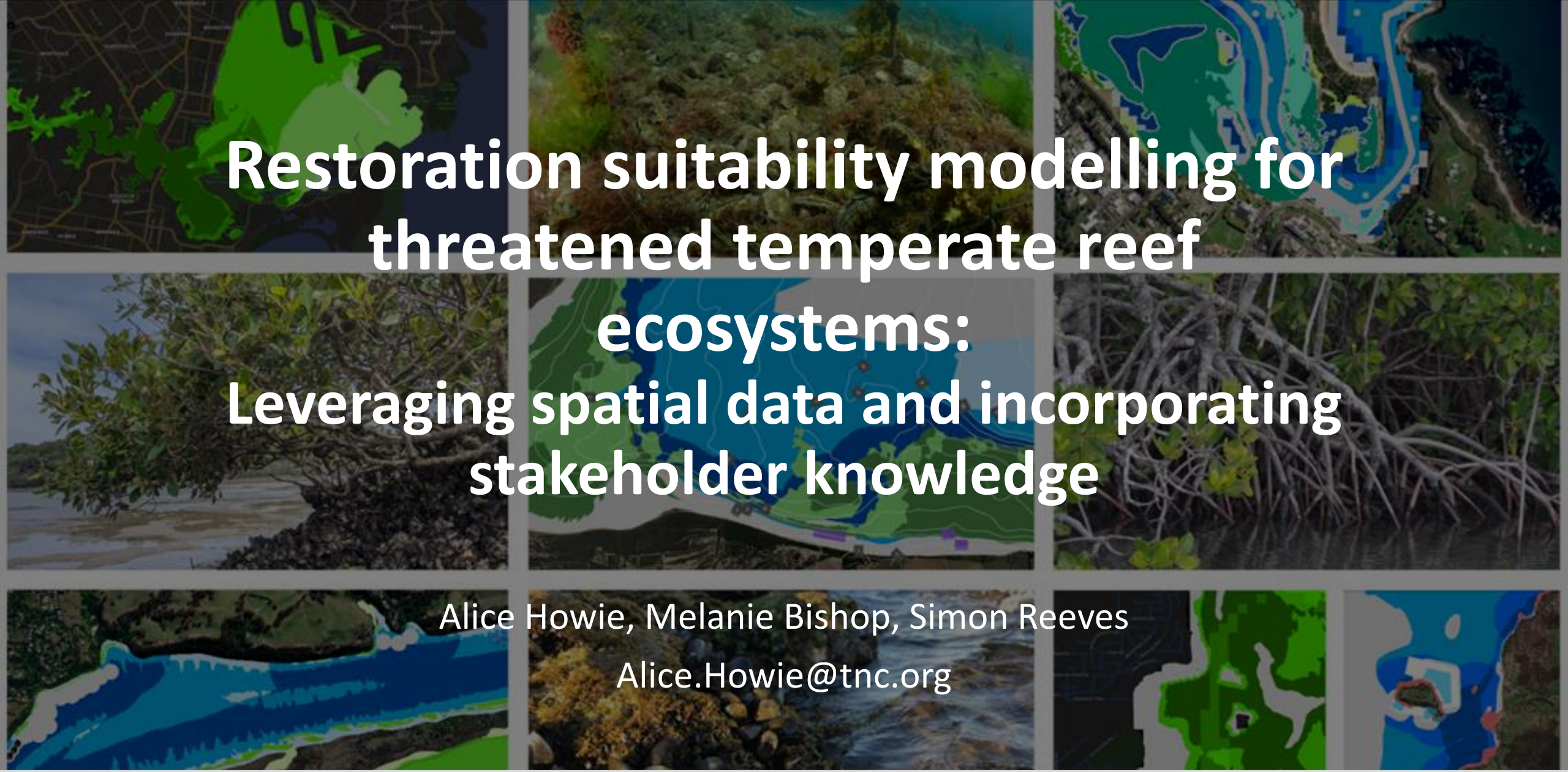

Restoration suitability modelling for threatened temperate reef ecosystems: Leveraging spatial data and incorporating stakeholder knowledge

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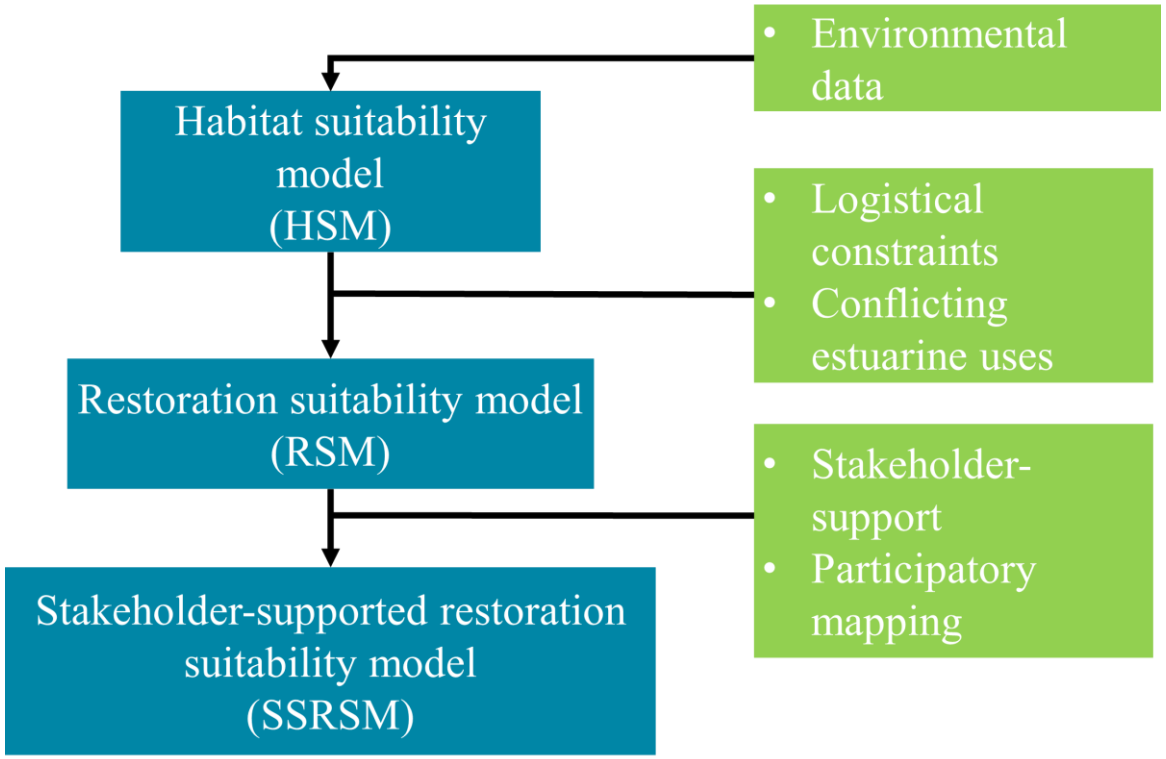
The Nature Conservancy Australia

MACQUARIE University

Credit: Francisco Martínez-Baena, The Nature Conservancy

F. MARTINEZ



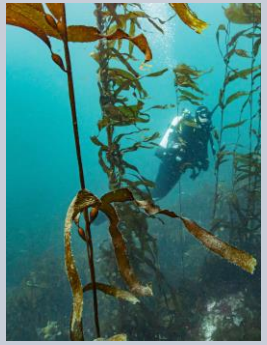
What is suitability modelling

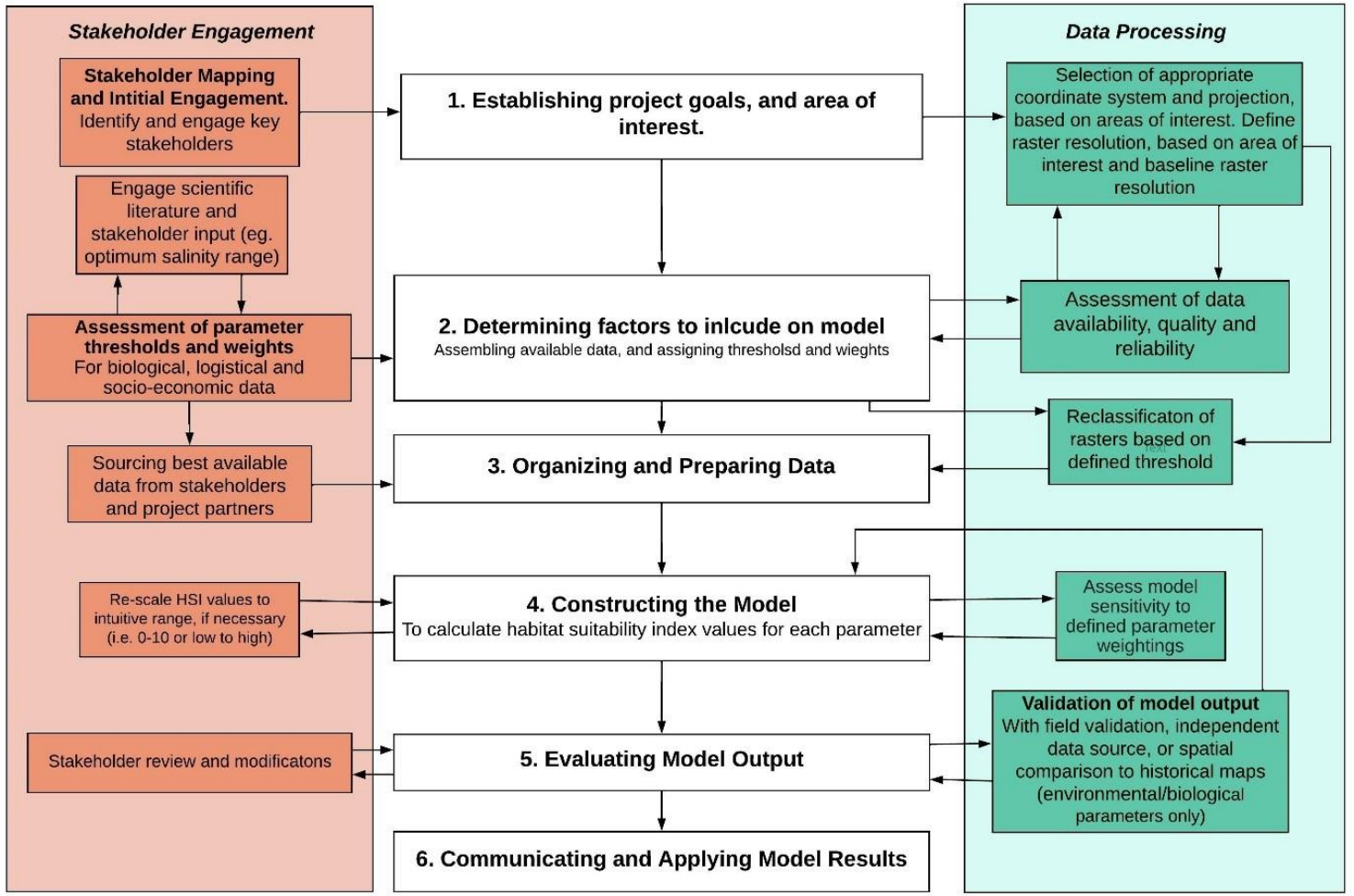
- ArcGIS/QGIS/R/Python
- Historic habitat distribution data may be sparse

Around Australia

- Focused on three shellfish species and more recently, giant kelp
- Supporting TNC's Reef Builder rollout
- Stakeholders to assist informing sites selection

Restoration suitability modelling





Hanns *et al. (in prep)*

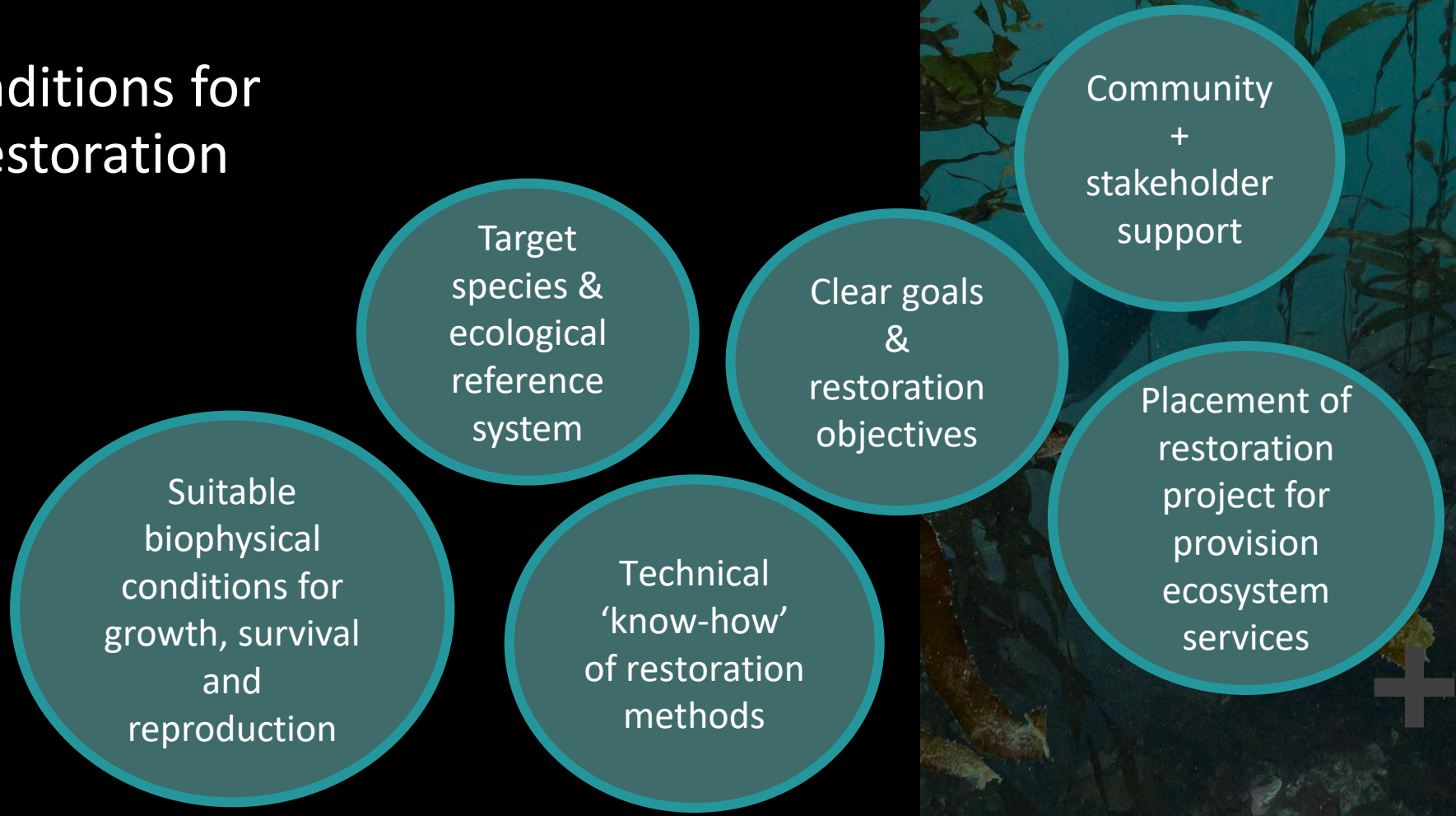
1. Establishing **project goals and area of interest**

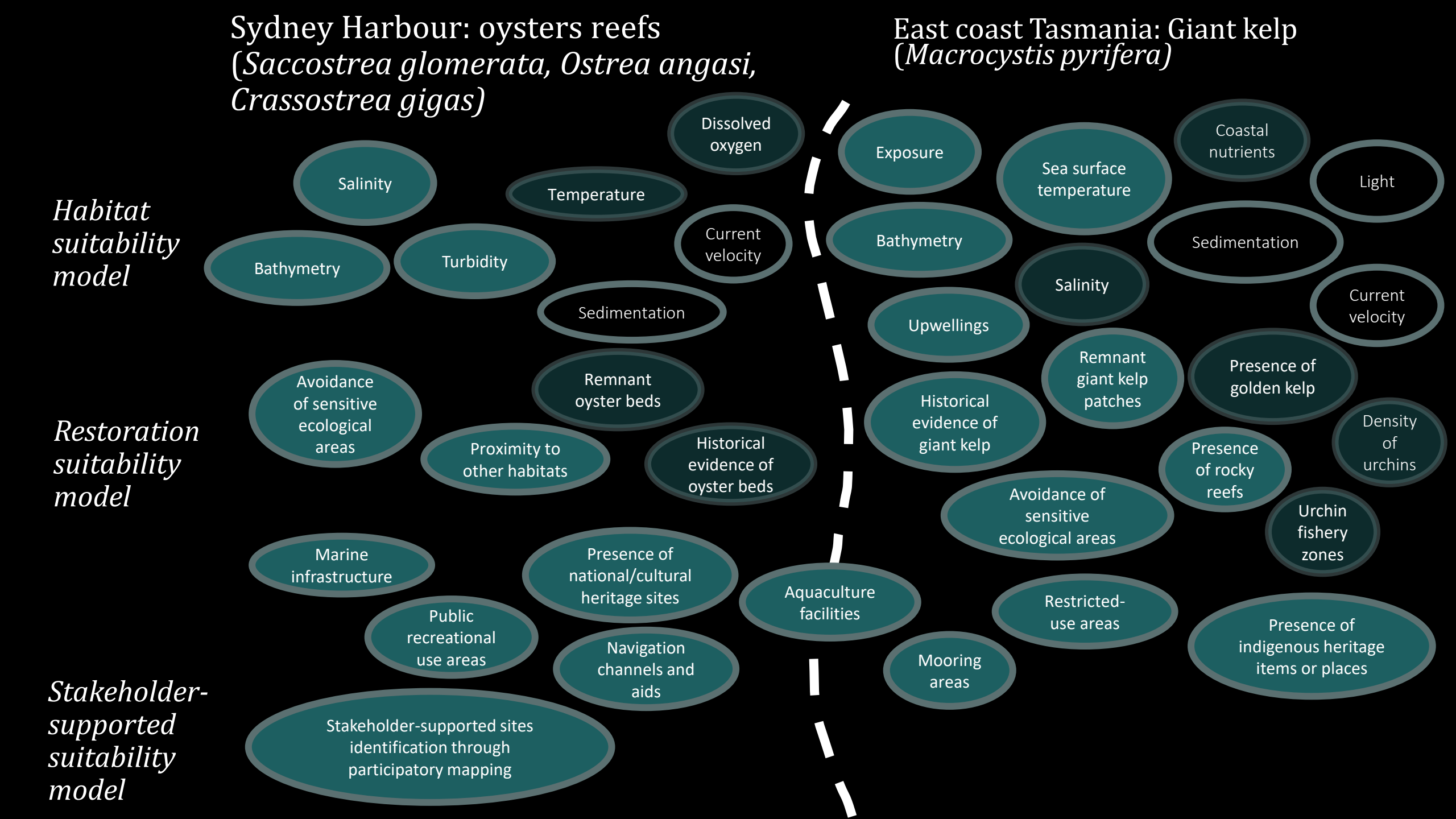
- Defining an ecological reference system

Credit: Francisco Martínez-Baena, The Nature Conservancy

2. Determining **parameters to include in model**

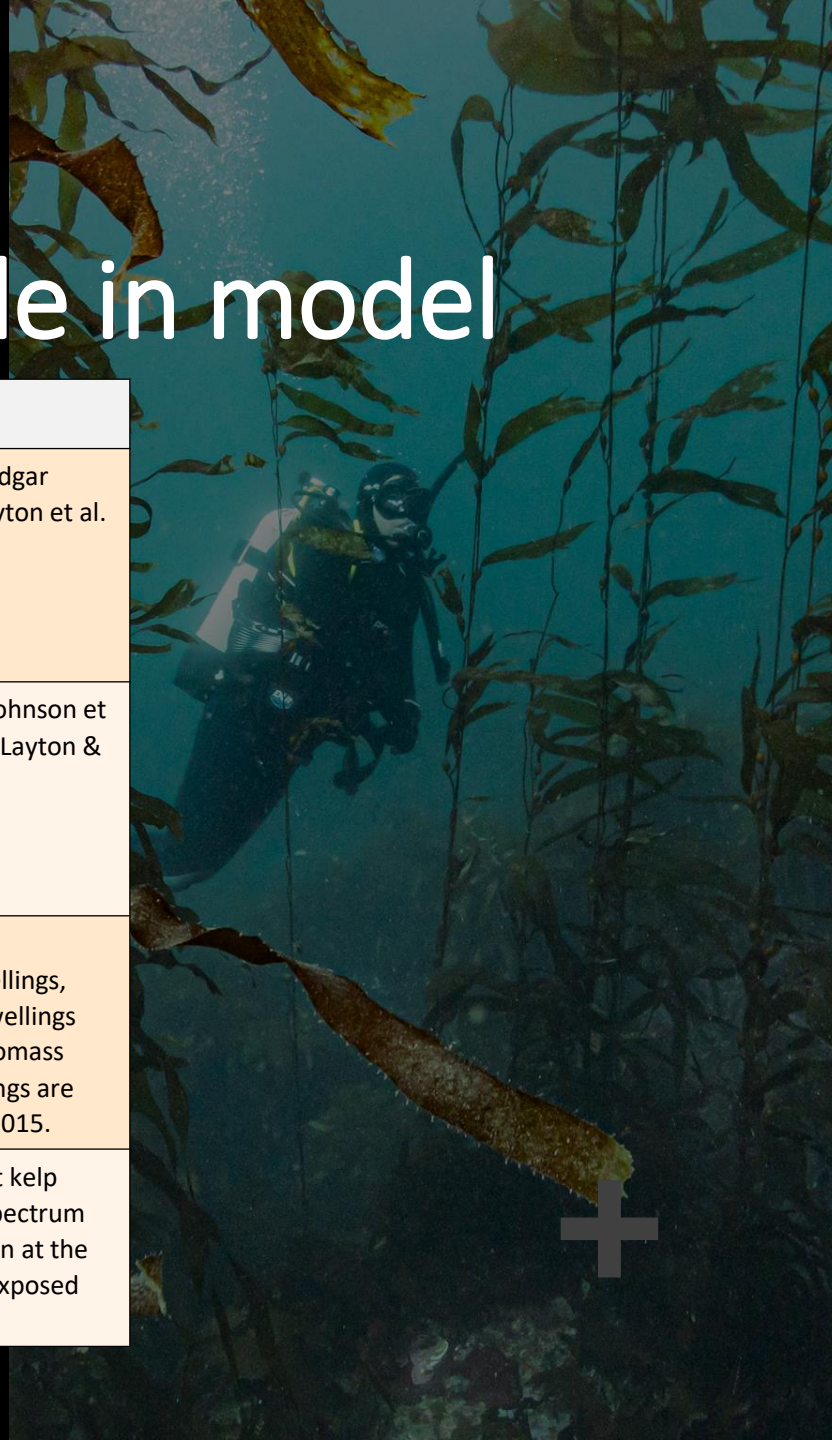
- Enabling conditions for successful restoration projects




Sydney Harbour: oysters reefs (*Saccostrea glomerata, Ostrea angasi, Crassostrea gigas)*
East coast Tasmania: Giant kelp (*Macrocystis pyrifera)*
Habitat suitability model
Restoration suitability model
Stakeholder-supported suitability model
Dissolved oxygen
Salinity
Temperature
Current velocity
Bathymetry
Turbidity
Sedimentation
Avoidance of sensitive ecological areas
Remnant oyster beds
Proximity to other habitats
Historical evidence of oyster beds
Marine infrastructure
Presence of national/cultural heritage sites
Public recreational use areas
Navigation channels and aids
Stakeholder-supported sites identification through participatory mapping
Exposure
Sea surface temperature
Coastal nutrients
Light
Bathymetry
Sedimentation
Salinity
Current velocity
Upwellings
Remnant giant kelp patches
Presence of golden kelp
Historical evidence of giant kelp
Density of urchins
Presence of rocky reefs
Avoidance of sensitive ecological areas
Urchin fishery zones
Aquaculture facilities
Restricted-use areas
Mooring areas
Presence of indigenous heritage items or places

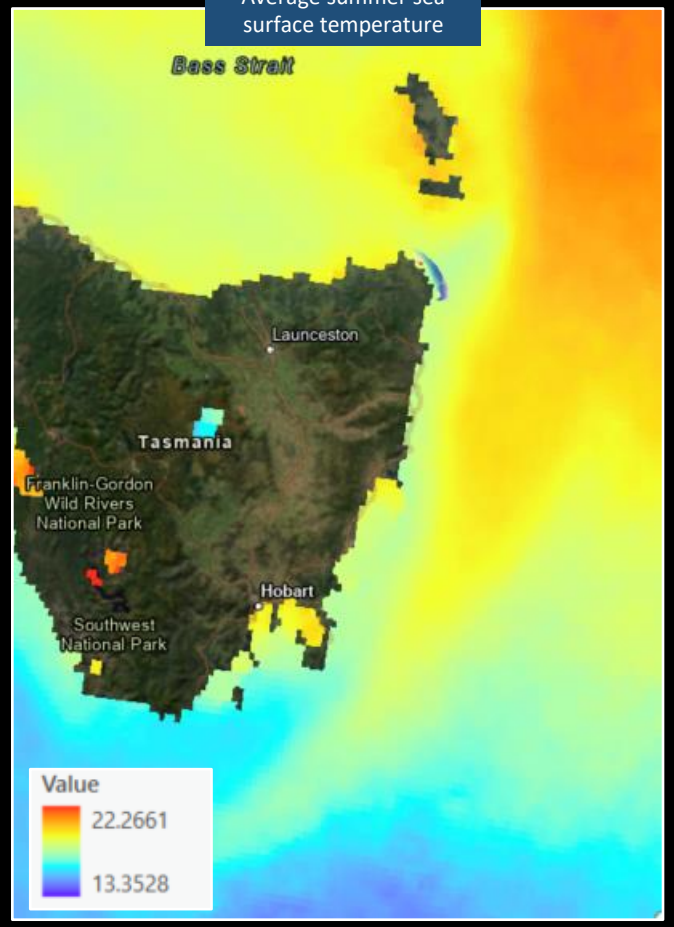
2. Determining **parameters to include in model**

	Parameter	Envelope	Criteria/suitability score	Rationale
Habitat suitability	**Depth (metres, AHD)**	1 – 28 m	• 0-1 m = 0.0 • 1-5 m = 2.5 • 5-15 m = 4.0 • 15-20 m = 2.5 • 20-28 m = 2.0 • >28 m = 0.0	Within ecological tolerances. Edgar 2012; Schiel & Foster 2015; Layton et al. 2020.
	Mean summertime water temperature (°C)	7 – 24 (°C	• <7 = 0.0 • 7-16 = 4.0 • 16-18 = 3.0 • 18-20 = 2.0 • 20-24 = 1.0 • >24 = 0.0	Within ecological tolerances. Johnson et al. 2011; Schiel & Foster 2015, Layton & Johnson 2021.
	Frequency of upwelling		• < 10% (unlikely) = 1.0 • 10 – 30% (occasional/semi-seasonal) = 2.0 • 30 – 50% (seasonal) = 3.0 • 50 – 70% (semi-persistent) = 4.0 • > 70% (persistent) = 4.0	Natural variation in nutrient concentrations driven by upwellings, with higher frequencies of upwellings showing greater macroalgal biomass than those areas were upwellings are less frequent. Schiel & Foster 2015.
	Fetch-based openness index	< 0.4	• 0-0.01 = 1.0 • 0.01 - 0.05 = 3.0 • 0.05 - 0.25 = 4.0 • 0.25 – 0.4 = 3.0 • > 0.4 = 0.0	Historically and currently, giant kelp occurs across almost the full spectrum of coastal exposures, other than at the most sheltered and the most exposed locations.



3. Organising and **preparing data**

Average summer sea surface temperature



NASA Goddard Space Flight Center, Ocean Ecology Laboratory, Ocean Biology Processing Group. Moderate-resolution Imaging Spectroradiometer (MODIS) Aqua Data; NASA OB. DAAC, Greenbelt, MD, USA.

Frequency of upwellings

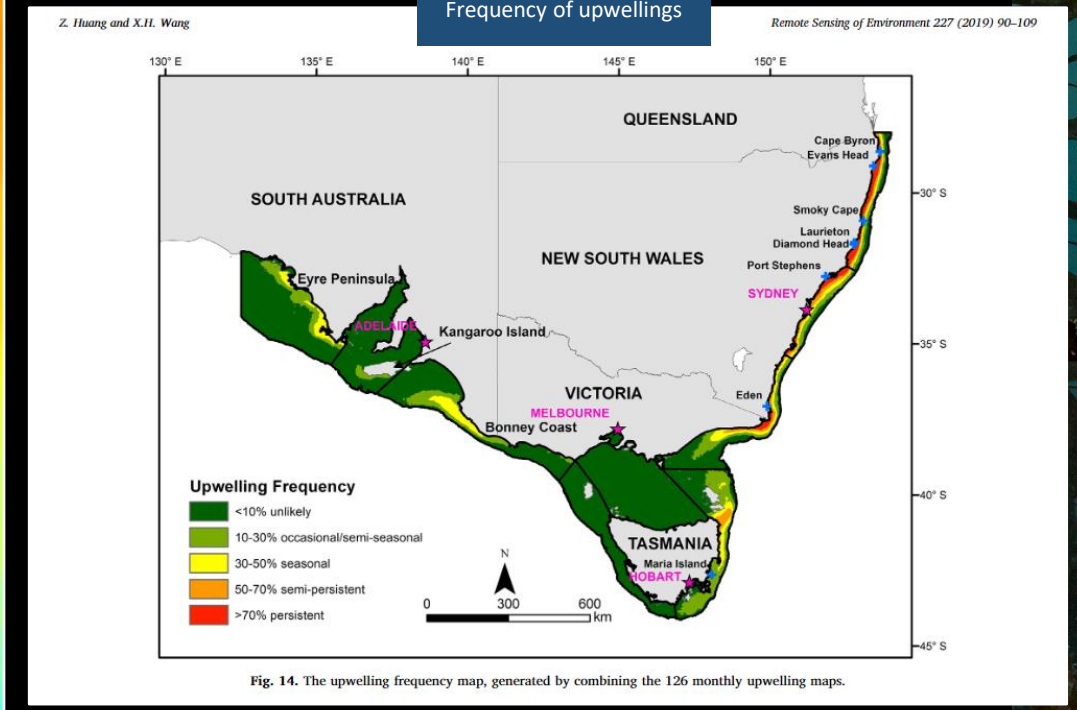
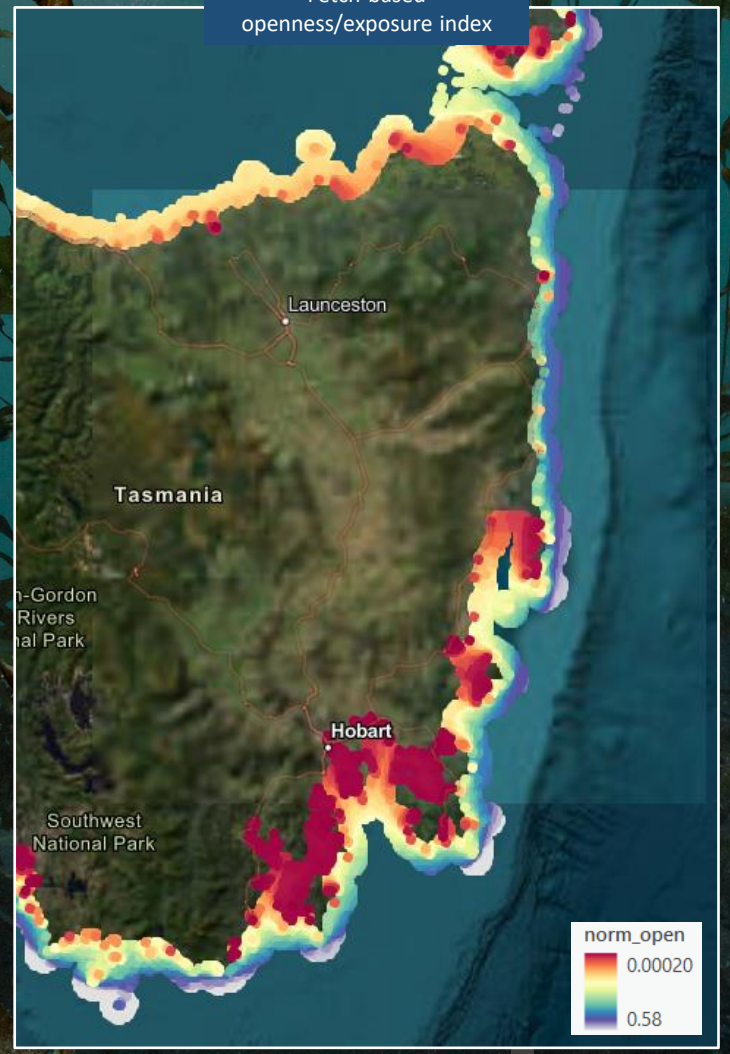


Fig. 14. The upwelling frequency map, generated by combining the 126 monthly upwelling maps.

Huang, Z. and Wang, X.H., 2019. Mapping the spatial and temporal variability of the upwelling systems of the Australian south-eastern coast using 14-year of MODIS data. *Remote sensing of environment*.

Fetch-based openness/exposure index



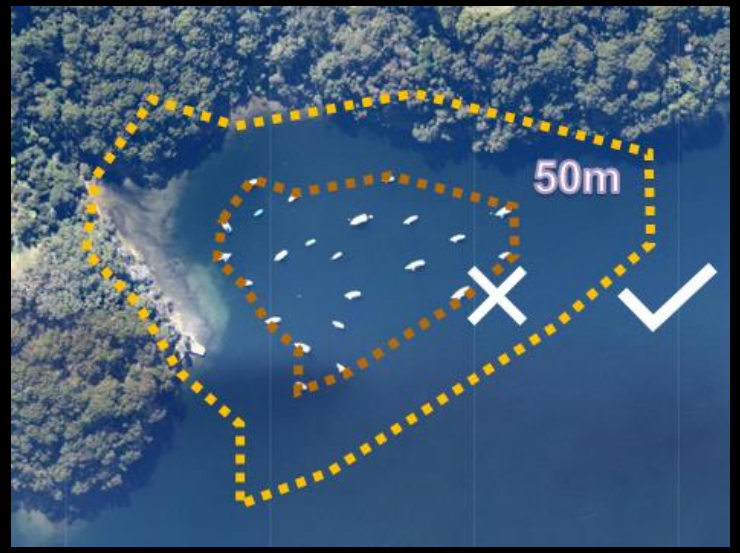
Hill, Nicole; Barrett, Neville; Pepper, Austen; Hulls, Justin (2013): Fetch-based exposure indices for temperate Australia.

Restoration suitability modelling

Credit: Chris Gillies, The Nature Conservancy

Identify parameters of interest

Conflicting estuarine uses



Other complex habitats

4. Constructing the **model**

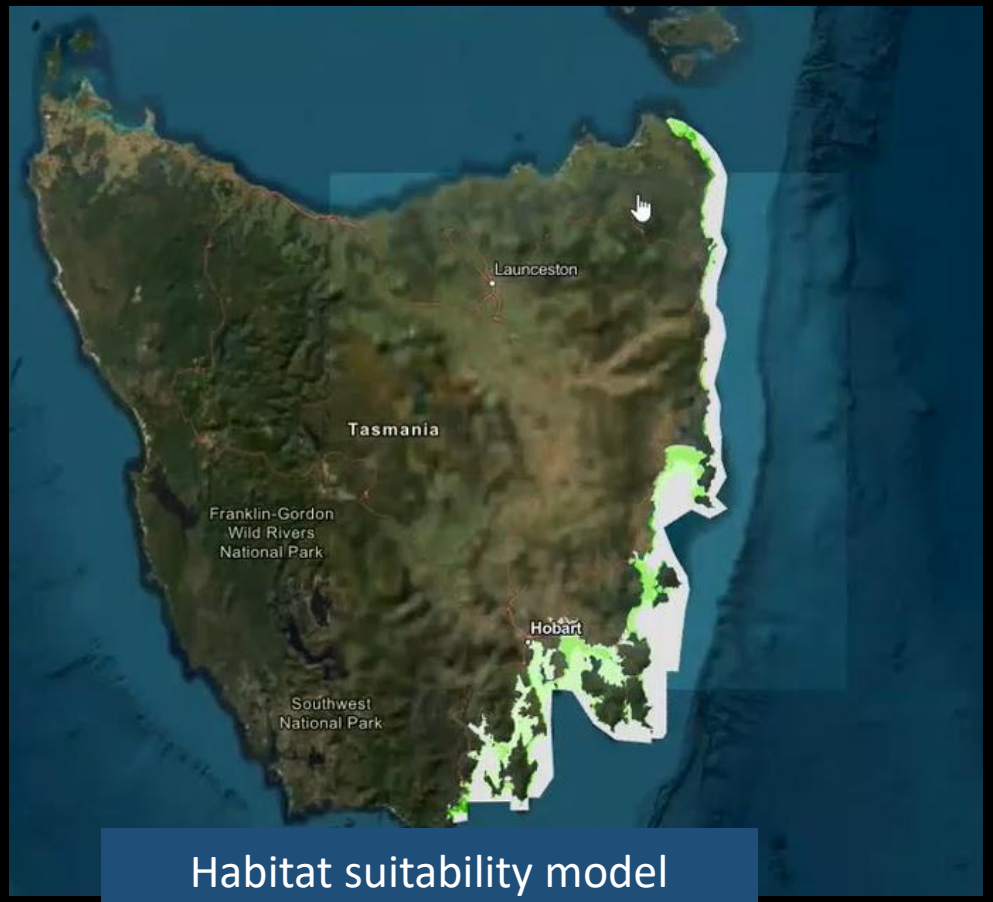
Habitat suitability model

↓

Restoration suitability model

↓

Stakeholder-supported restoration suitability model



Habitat suitability model

Restoration suitability model

Sydney Harbour case study

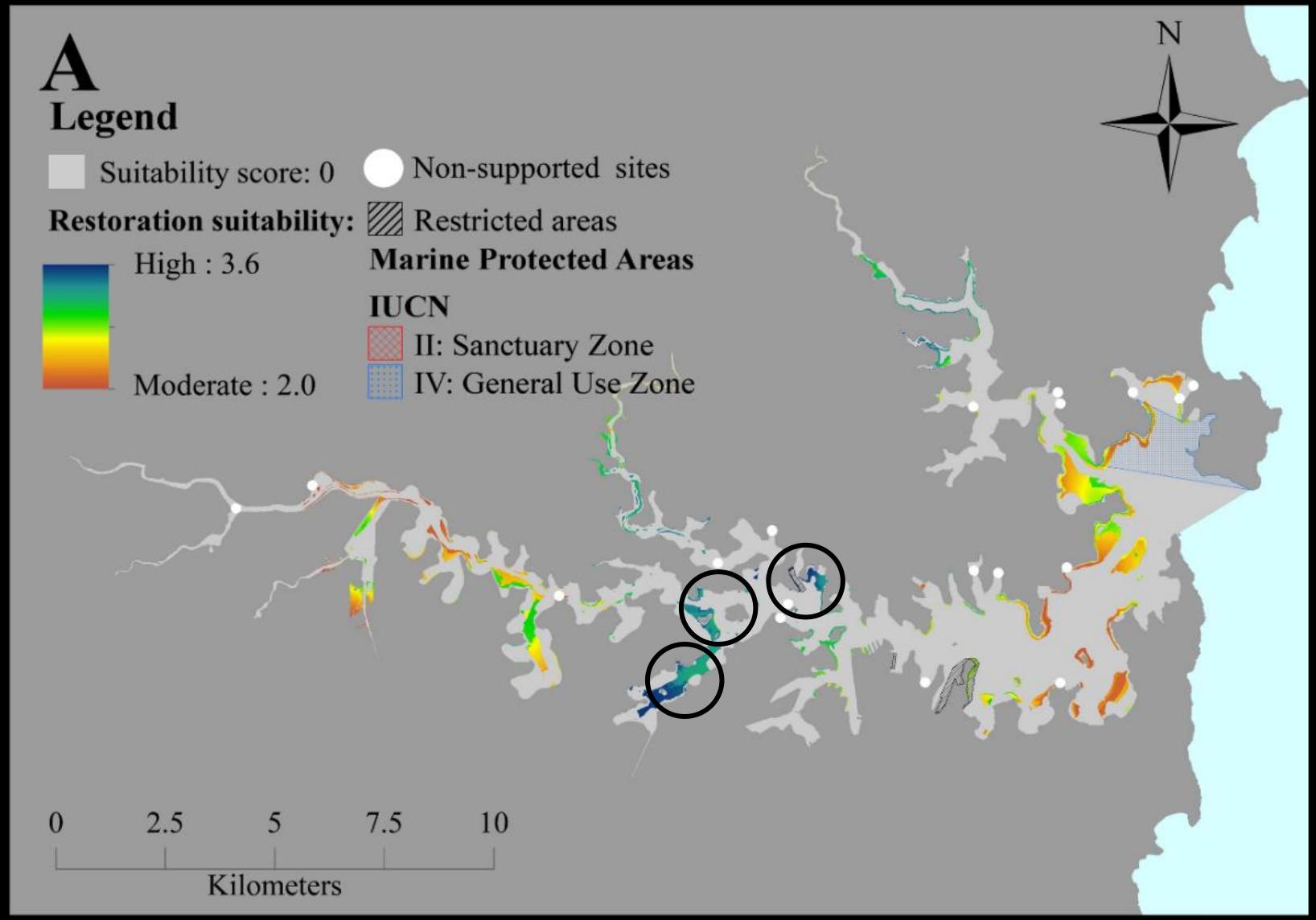
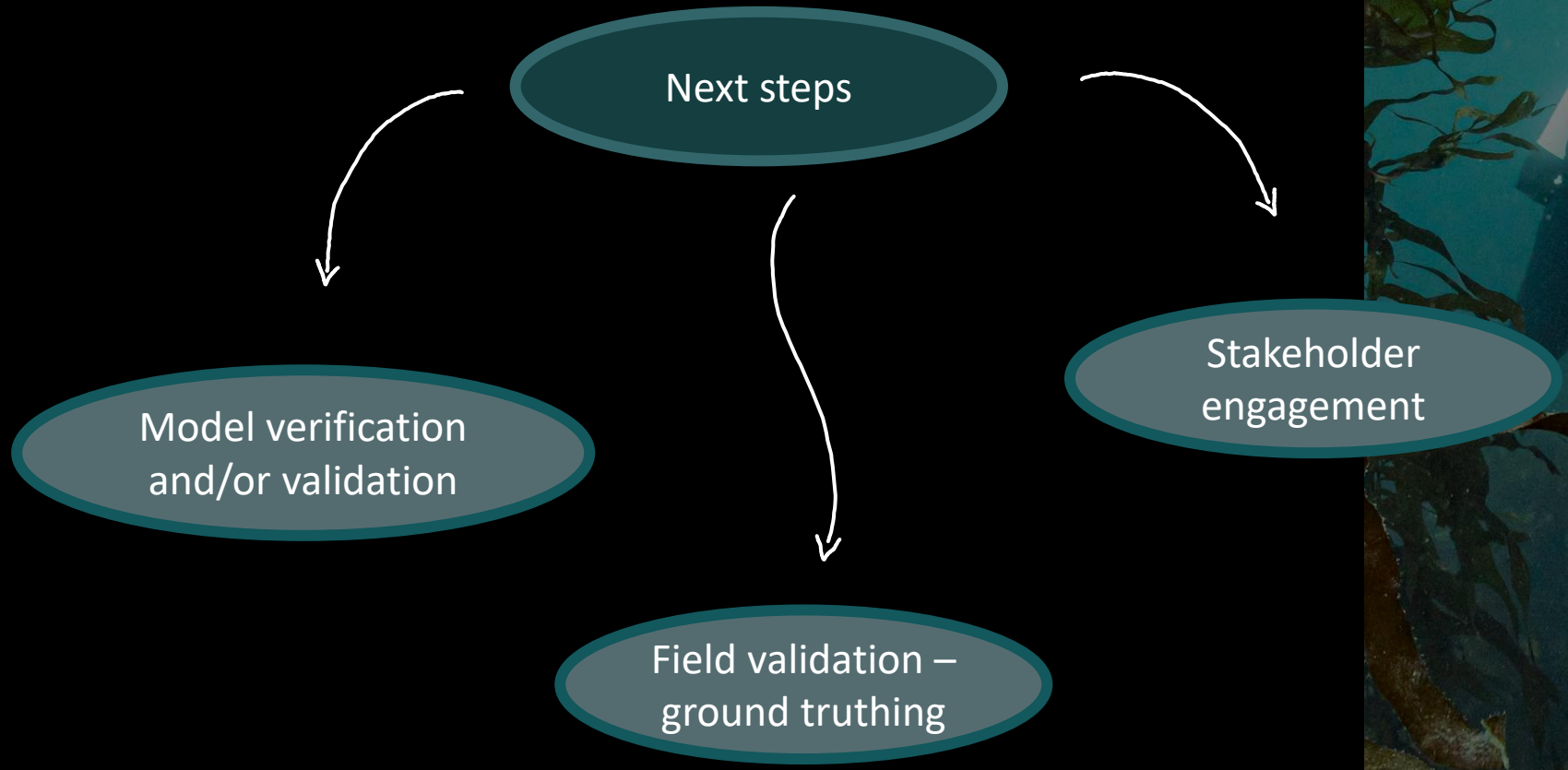


Figure Stakeholder-supported restoration suitability models (SSRSMs) for Sydney Harbour estuary.

5. Evaluating **model output**



6. Communicating and **applying model outputs**

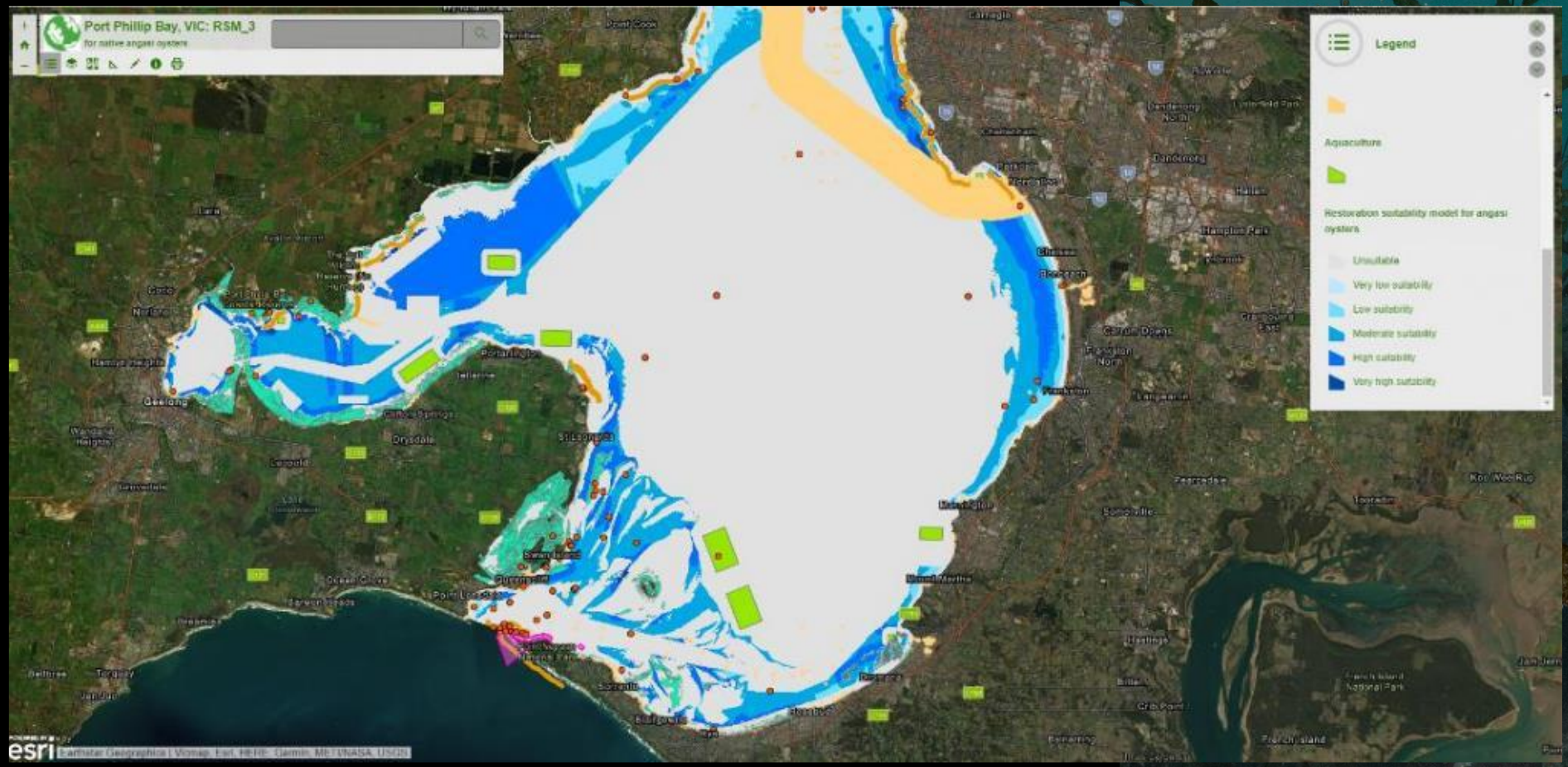


Figure Example of ArcGIS Online web map app showing the restoration suitability model for Port Phillip Bay.

Future **Directions**

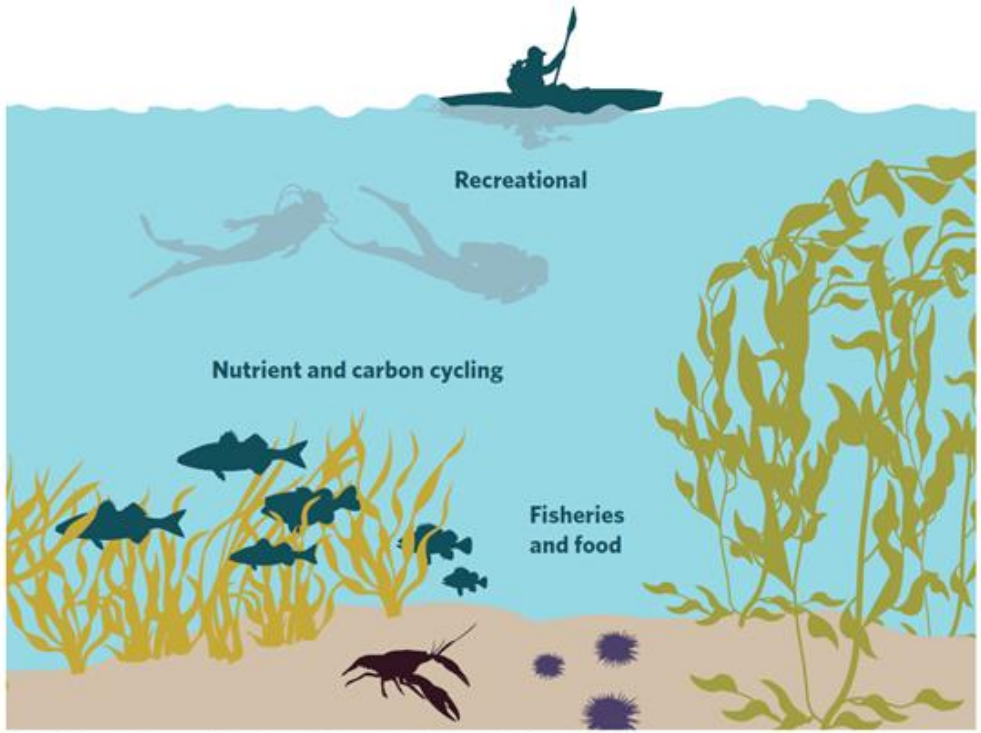
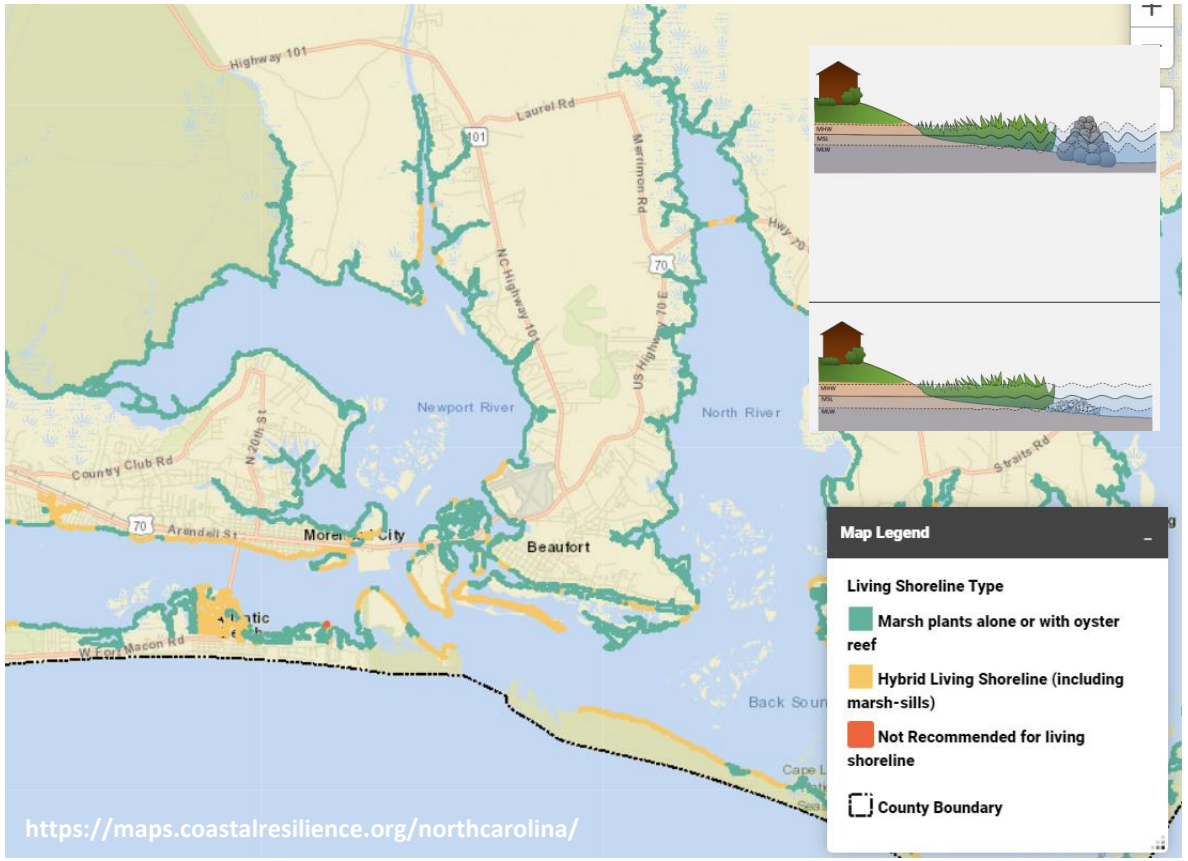


Figure 1.3 Ecosystem diagram of kelp forests, including services: illustration by Jon Ferland



Acknowledgments: Melanie Bishop (MQ), Simon Reeves (TNC), Cayne Layton (UTAS), Carleisha Hanns (TNC), Kate Longley-Wood (TNC), Seth Theuerkauf (BOEM)

Questions?