Satellite and machine learning for monitoring our coastal environments

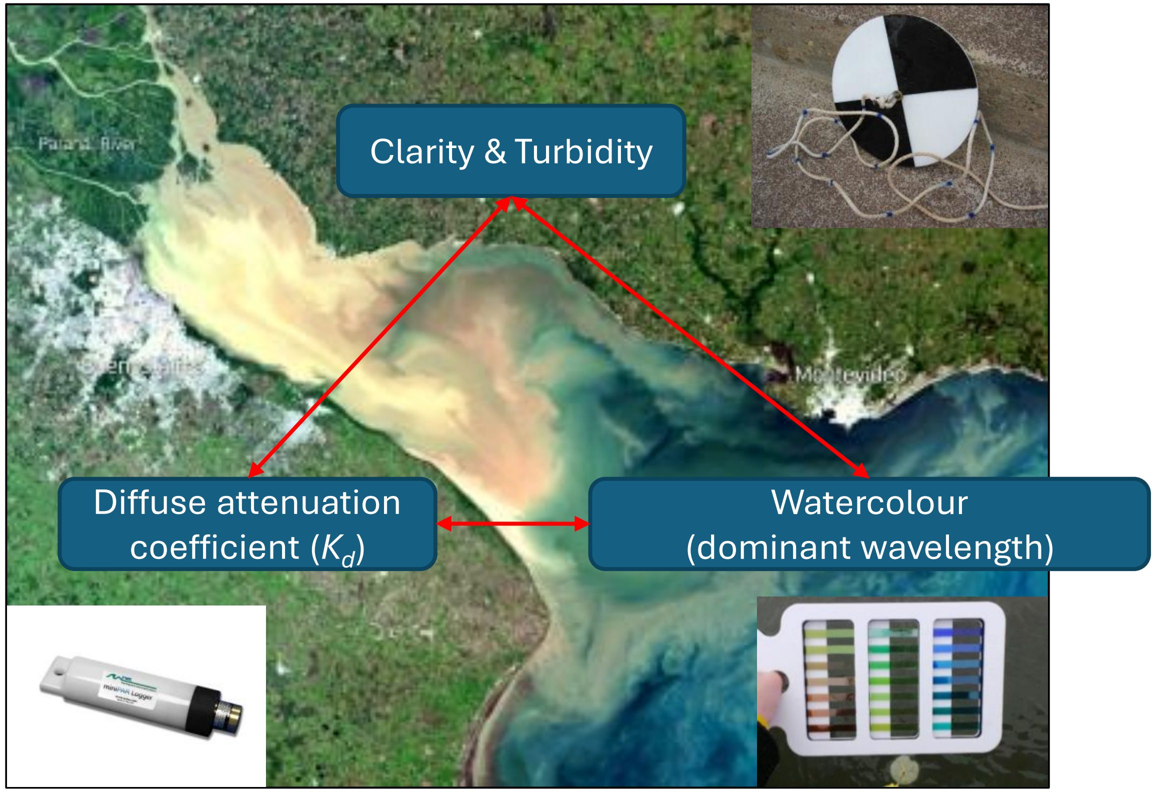
- Zhanchao Shao

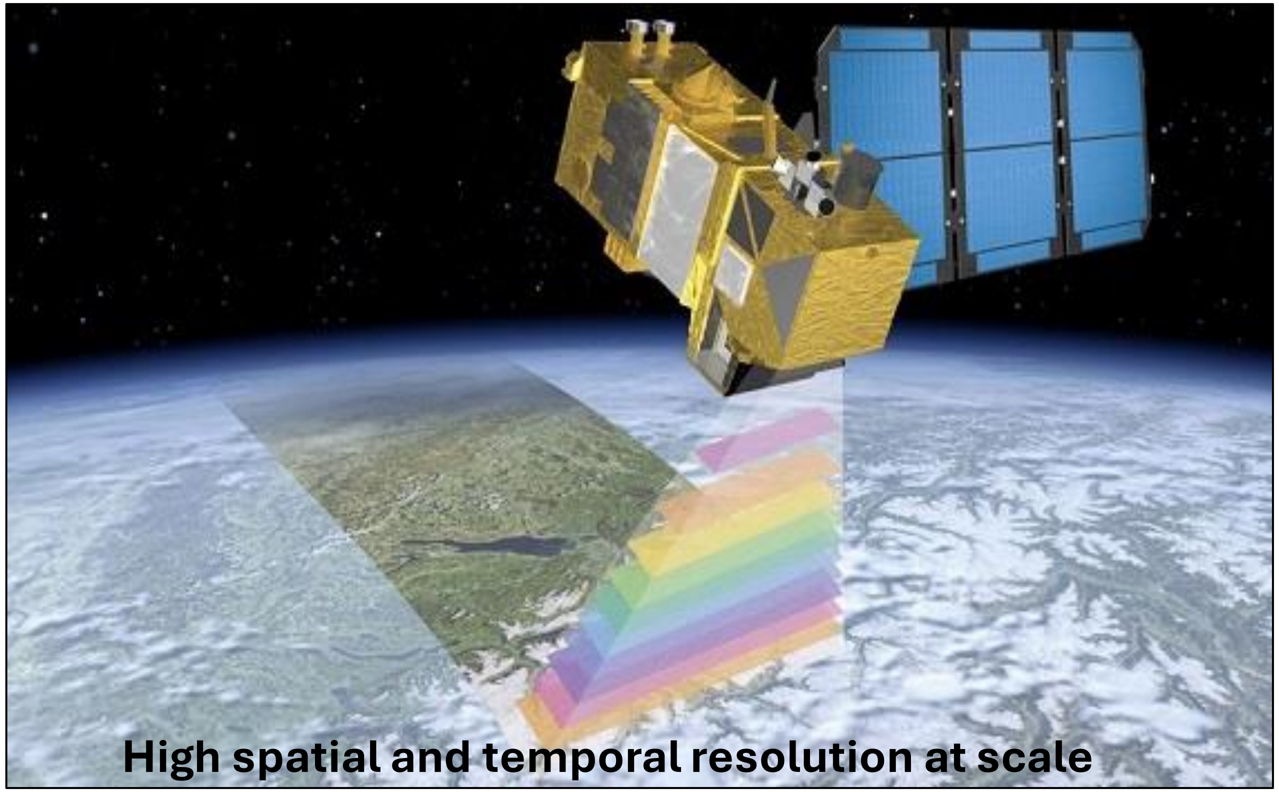
Prof. Karin Bryan, Dr. Dana Clark, Prof. Conrad Pilditch

- 📪z.shao@waikato.ac.nz

PART 1: Estuarine water health

Water Optical Properties





A comprehensive monitoring system needs less labour-intensive and more efficient techniques.

Based on the long-term water optical results from the satellite monitoring, classify estuaries with similar conditions for consistent management.

Image source: DOC, LAWA & Gorgeous with Attitude

Methods
Flowchart

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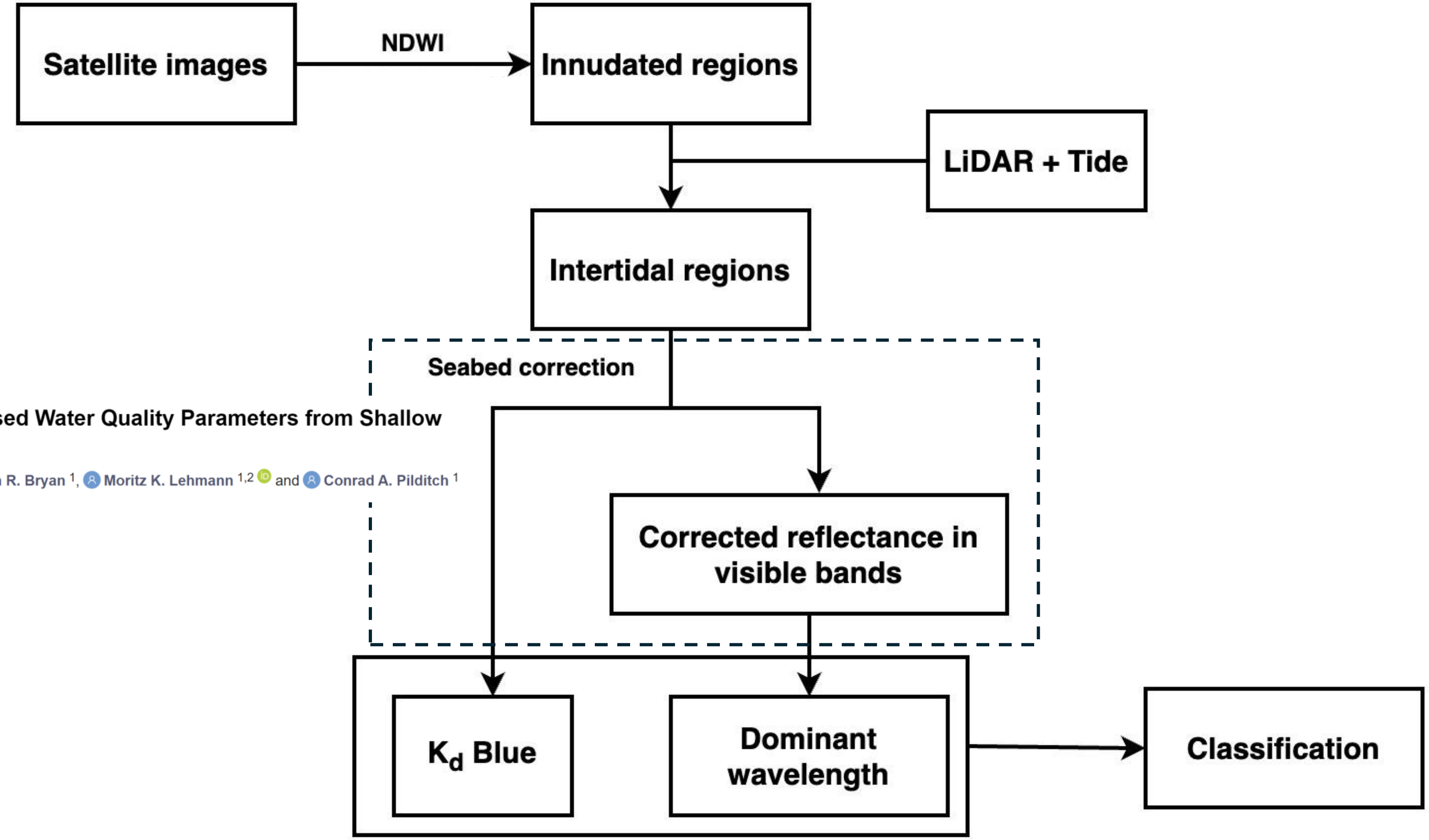


Extracting Remotely Sensed Water Quality Parameters from Shallow Intertidal Estuaries

by Zhanchao Shao [1,*], Karin R. Bryan [1], Moritz K. Lehmann [1,2] and Conrad A. Pilditch [1]

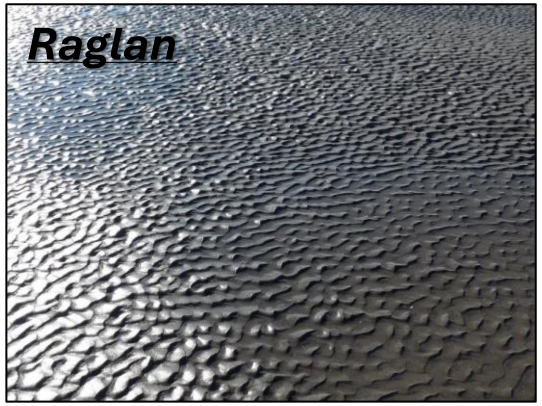
Shao et al., 2023

Methods

Sites

PART 1: Estuarine water health

- 13 sites in total.
- Ranging from relative pristine ecosystems (Mahurangi) to urban-influenced estuaries (Manukau).
- The sediment sources also vary (e.g. uniform black sands in Raglan and a mixture of rocky and sandy shores in Whangarei.



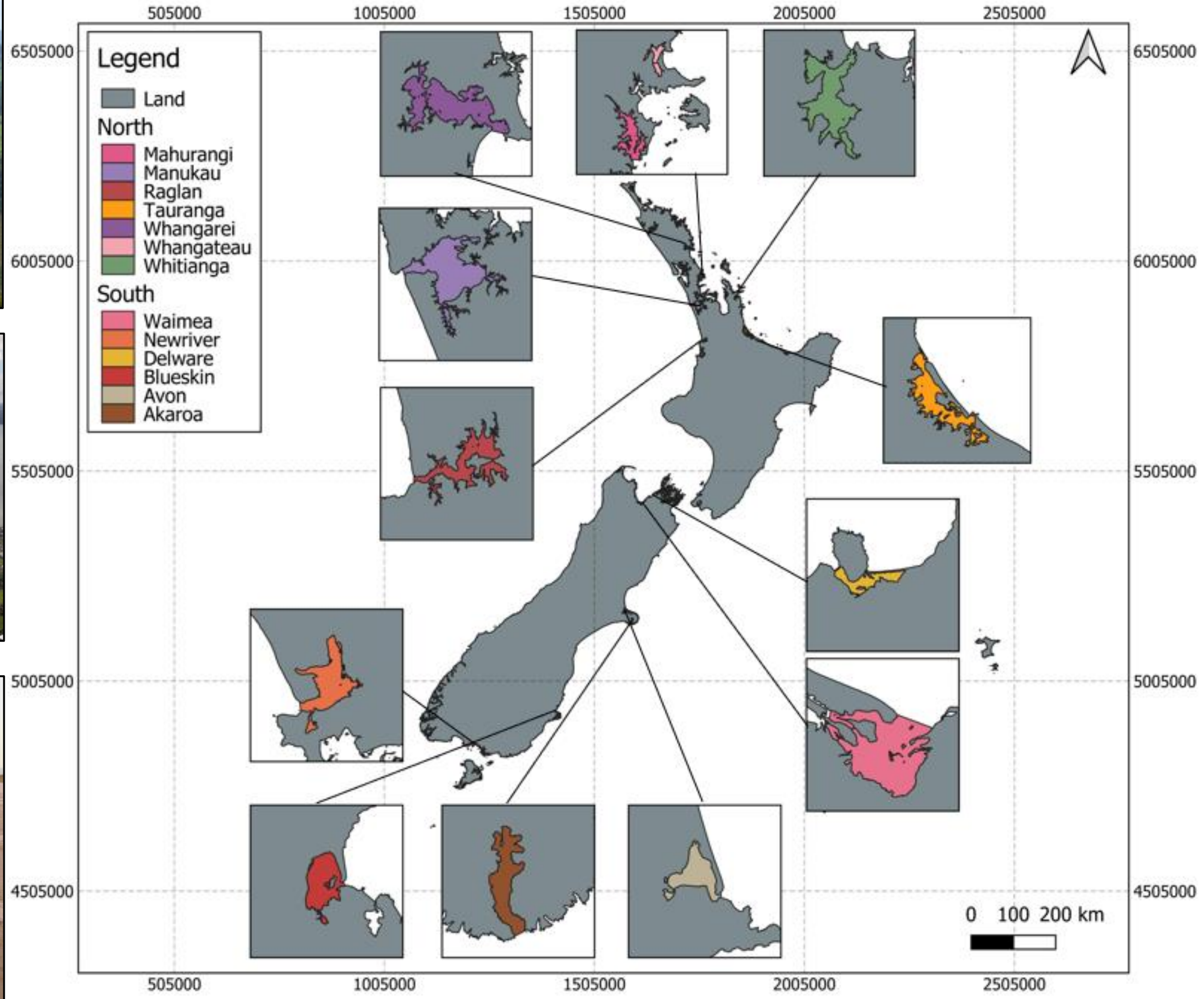


Image source: DOC, LAWA & Gorgeous with Attitude

Results

Classification

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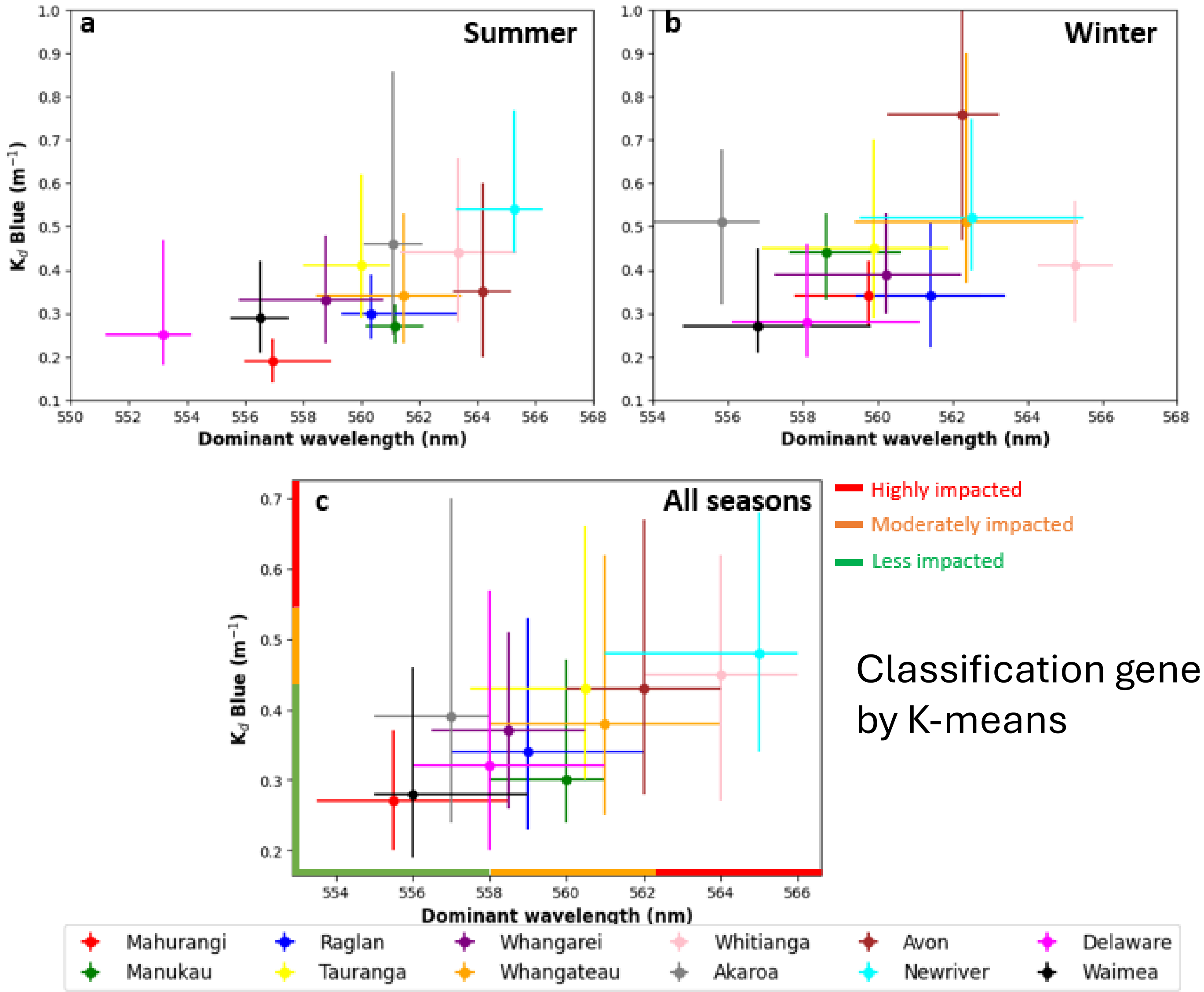
National Science Challenges



Classification generated by K-means

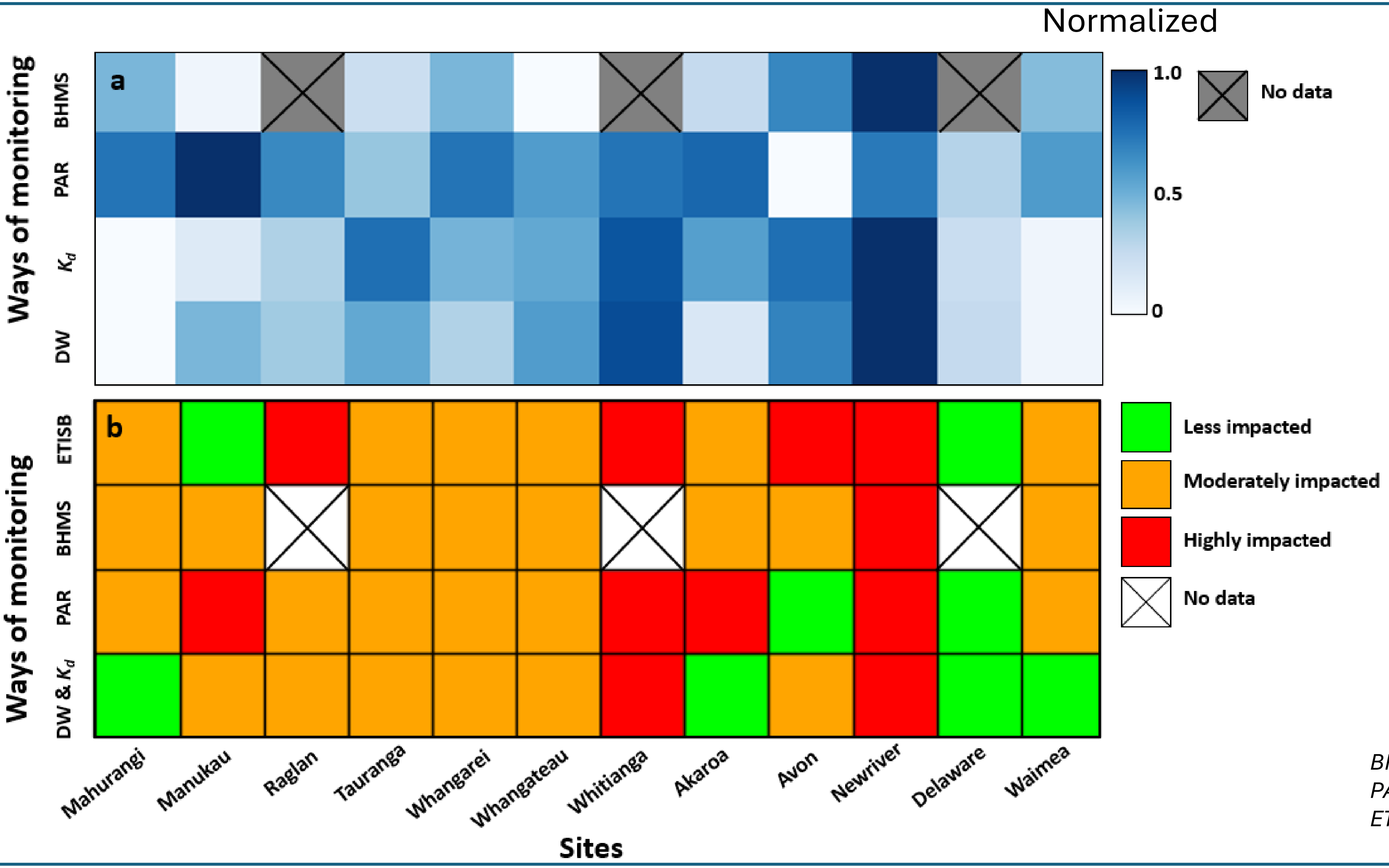
Three categories were classified: highly impacted, moderately impacted and less impacted;

We observed a strong correlation between dominant wavelength and K_d Blue.

Estimate K_d Blue values in deep waters where L's model is not applicable.

Results
Validation

PART 1: Estuarine water health



Findings:
High-level match up with other classification/score models.

The satellite derived dominant wavelength and Kd can be two useful indicators at scale to monitor estuarine health.

BHMS: Benthic health model scores
PAR: Photosynthesis active radiation light
ETISB: Estuary trophic index susceptibility bands

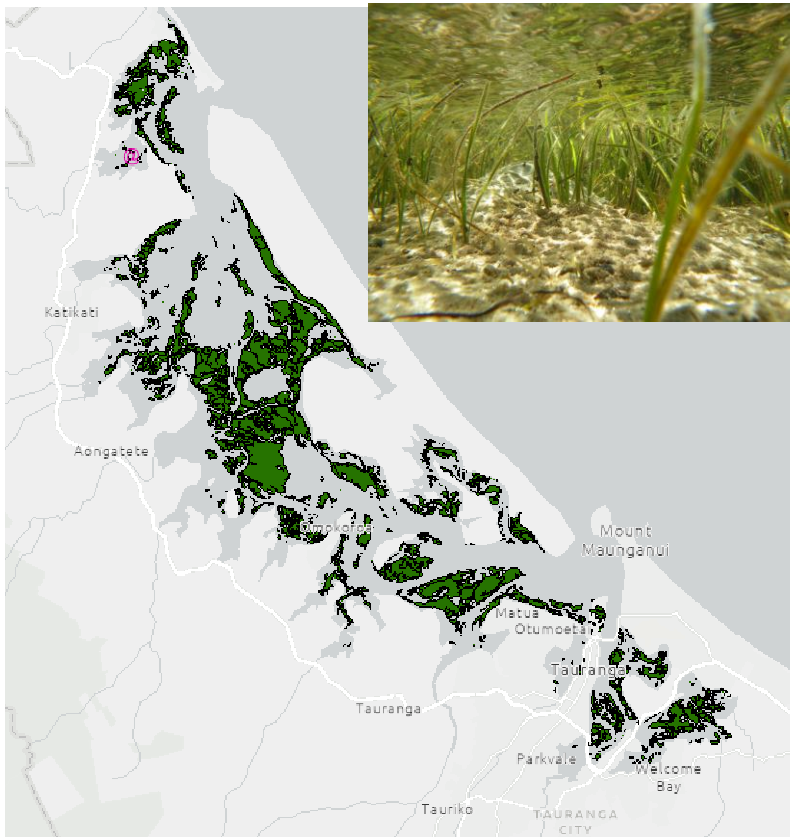
Clark et al., 2020; Mangan et al., 2020; Zeldis & Plew, 2022

Background & Objectives

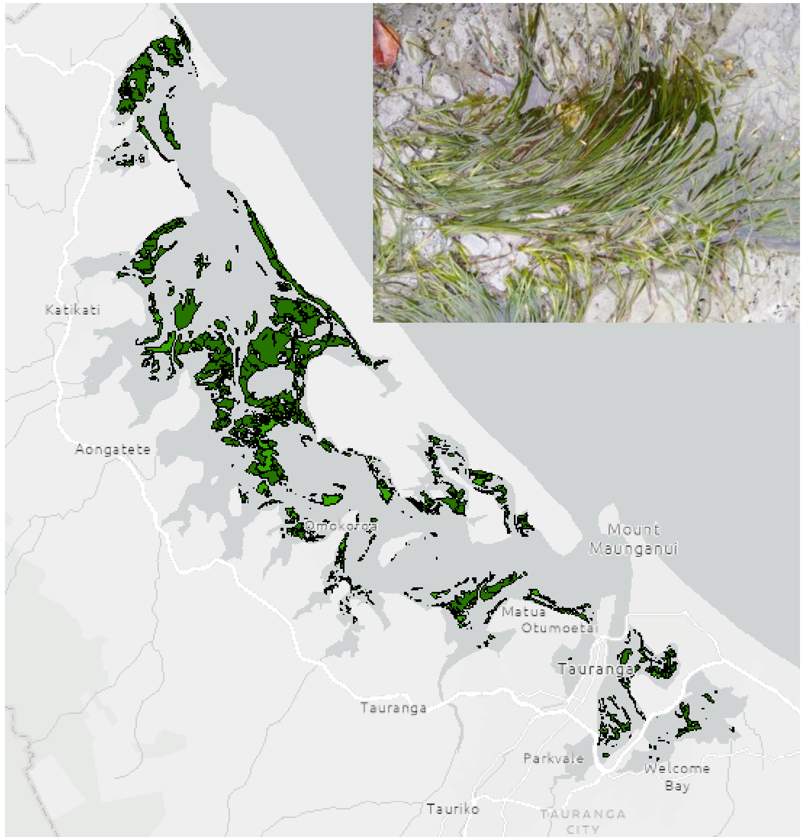
PART 2: Estuarine vegetation health

National Science Challenges

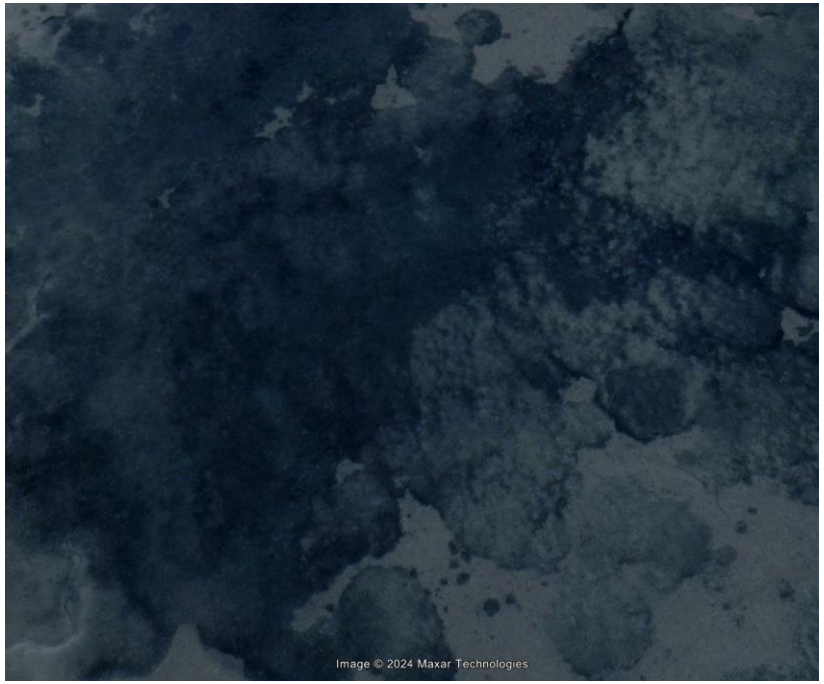
Distribution and monitoring (Zostera muelleri)



60 years ago

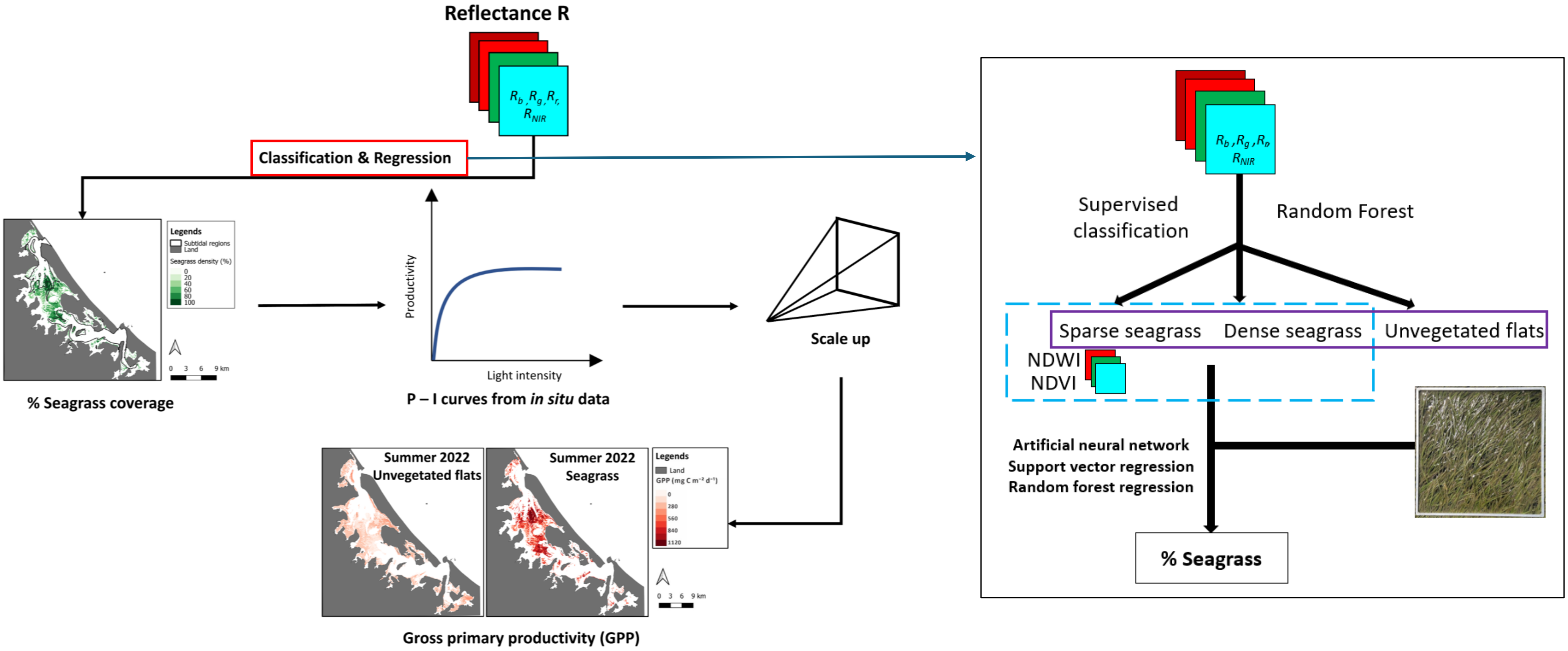


10 years ago



PART 2: Estuarine vegetation health

National Science Challenges



Results

Supervised classification with random forests

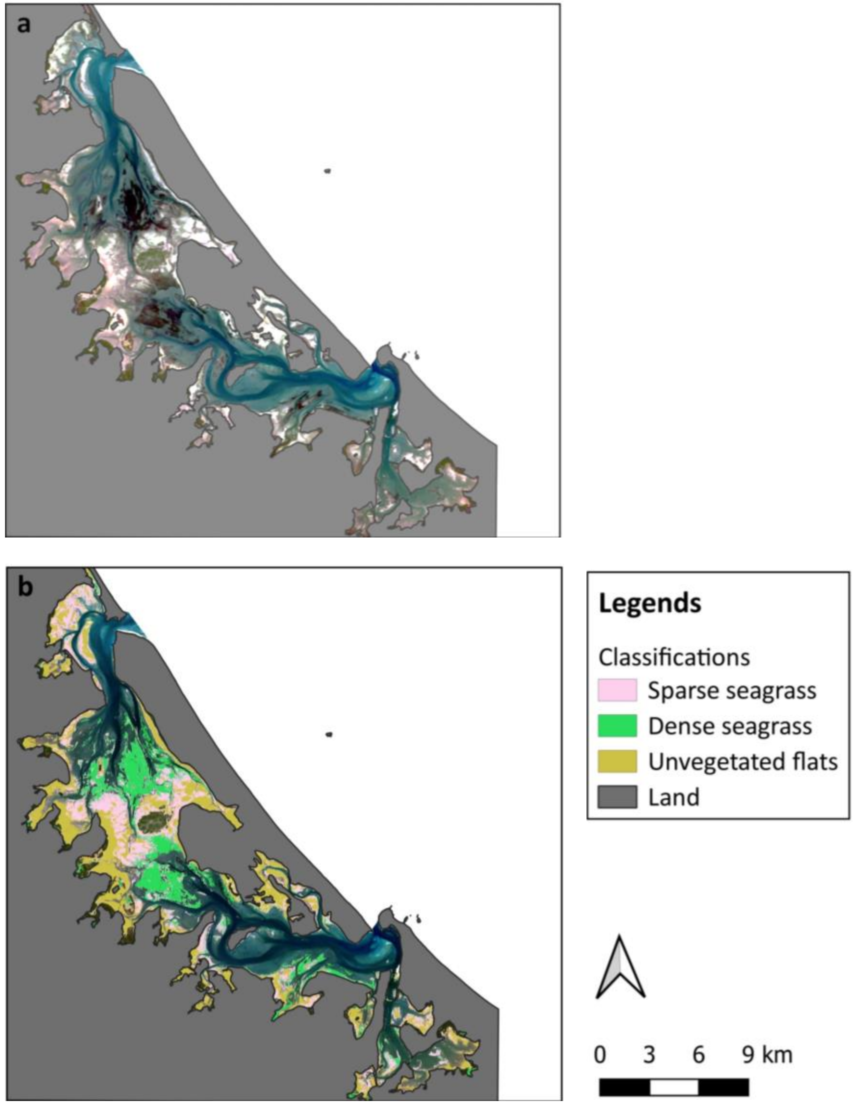
PART 2: Estuarine vegetation health

The optimal values for hyperparameters of random forests (validation with fivefold cross-validation):
Number of trees: 280; Min sample split: 4; Min sample leaf: 4; Max depth: 9

The classification report using random forests.

Class	Precision	Recall	F1-Score	Support (Sample numbers)
Sparse seagrass	0.86	0.91	0.89	20912
Dense seagrass	0.97	0.97	0.97	32301
Sandflats	0.92	0.94	0.93	16178

The overall accuracy is 0.96. 70% of pixels for training and 30% for testing.



Results

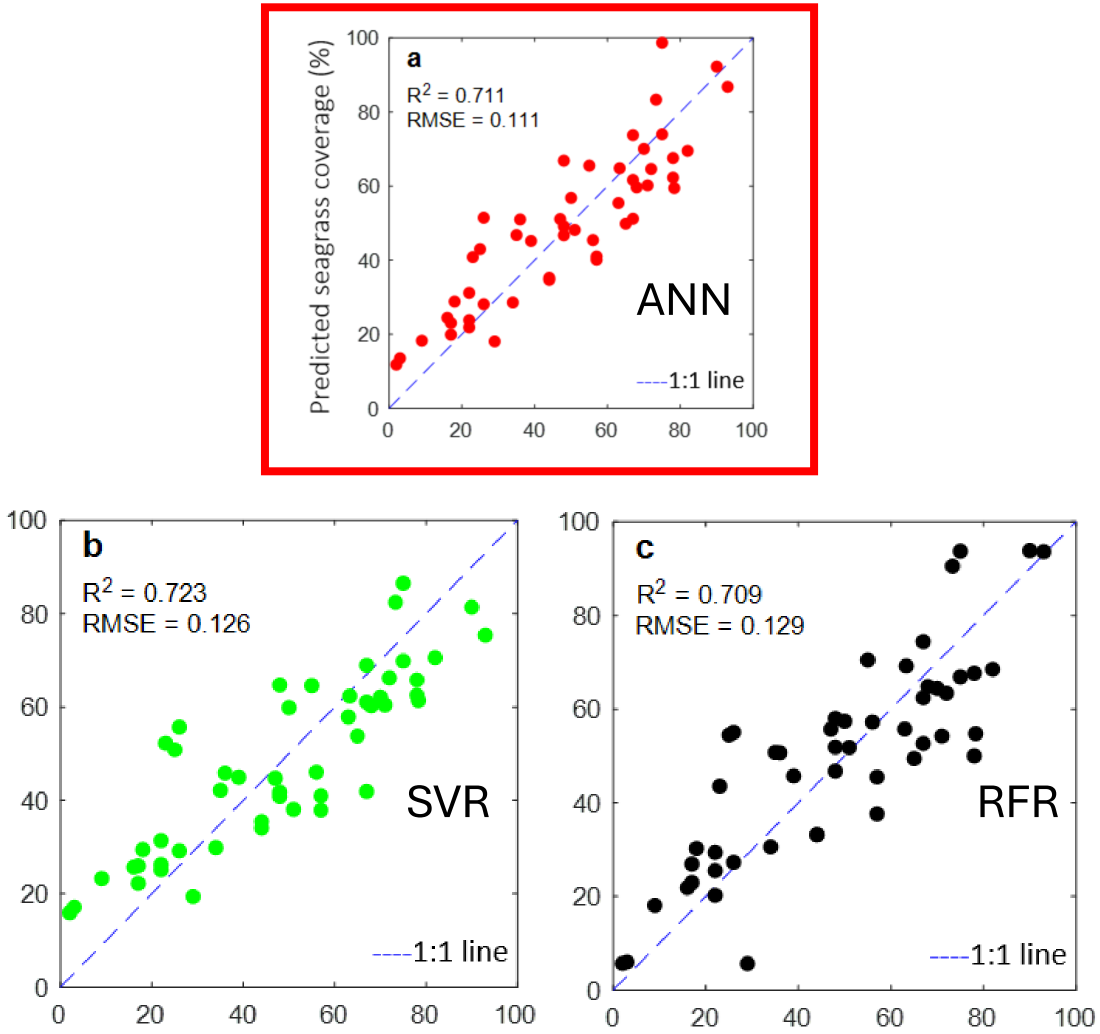
Machine learning regression (ANN, SVR & RFR)

PART 2: Estuarine vegetation health

Validation for optimal hyperparameters

80% (400) for training, 10% (50) for validation and 10% (50) for testing.

Model	Hyperparameters	Optimal values	Validation MSE	Validation R^2
ANN	Activation function	Relu	0.023	0.625
	Number of hidden layers	2		
	Number of neurons	10		
	Learning rate	0.01		
SVR	Kernel function	rbf	0.024	0.612
	Gamma	0.1		
	C	13		
RFR	Number of estimators	20	0.021	0.644
	Max depth	10		
	Min samples leaf	1		
	Min samples split	4		



Results

Seagrass coverage distribution

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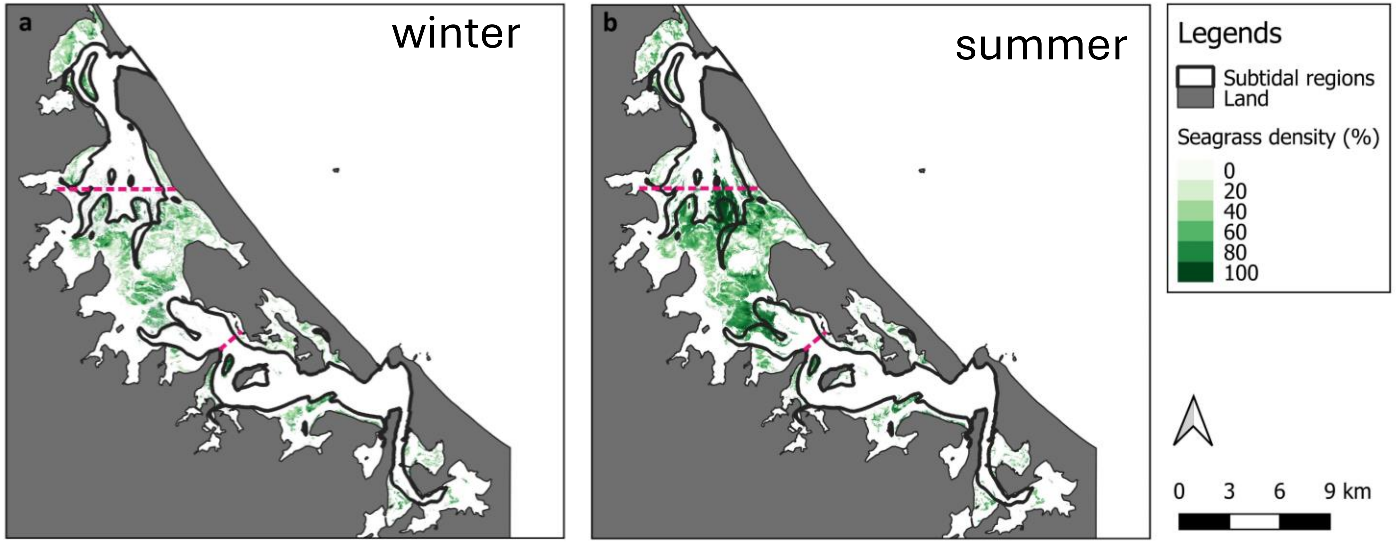

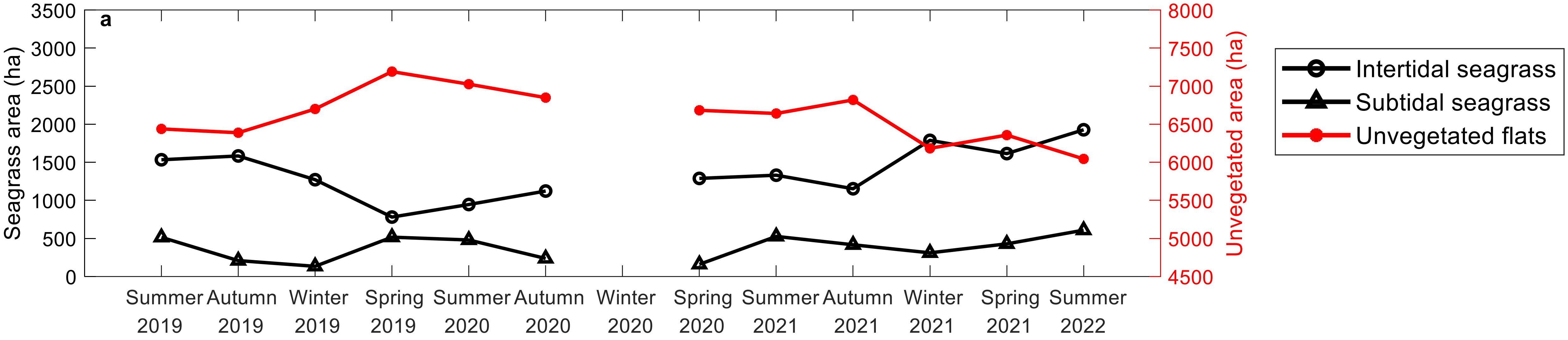

Results

Gross primary productivity of seagrass and MPB

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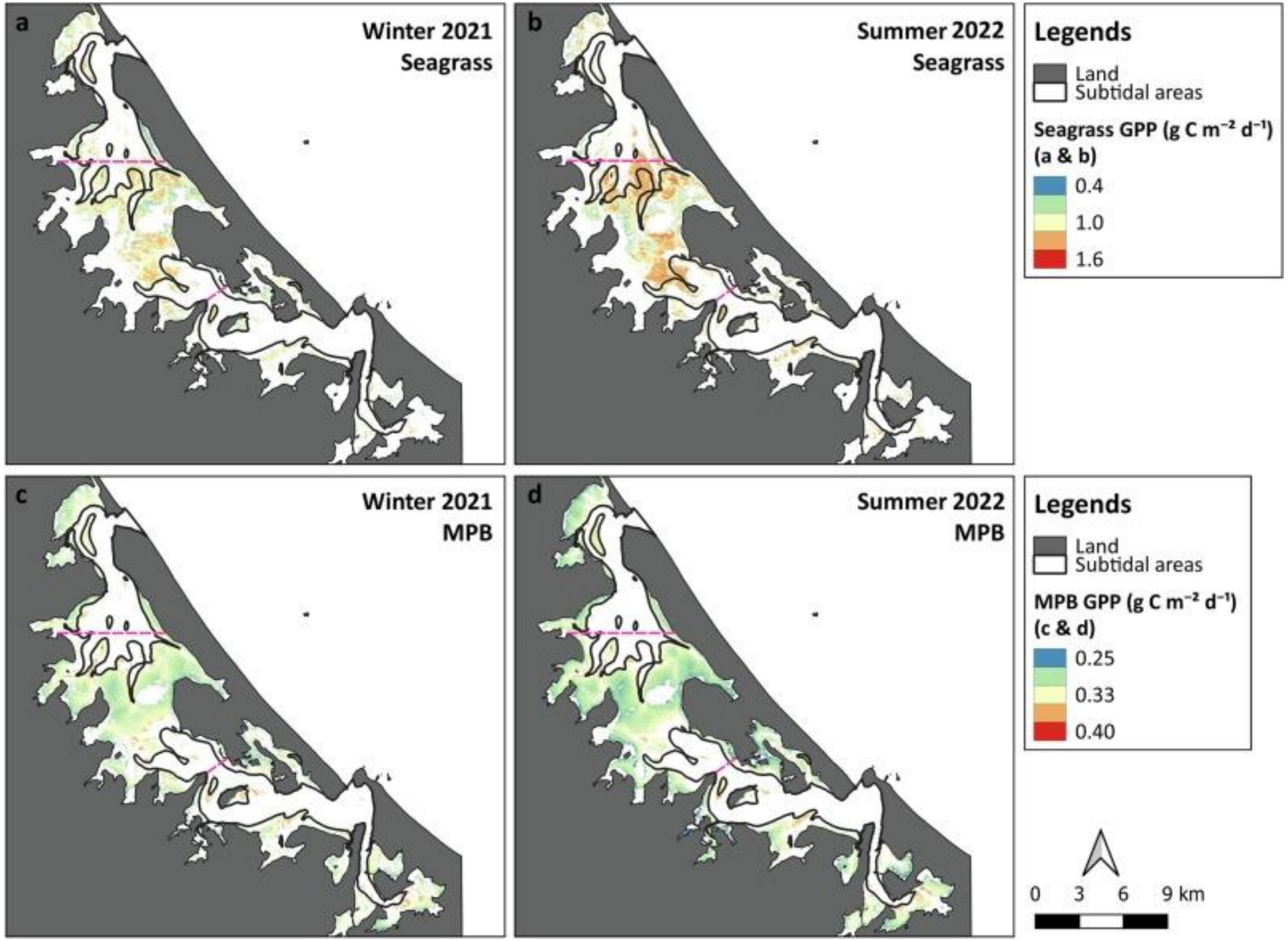

Results

Projection of sea level rise

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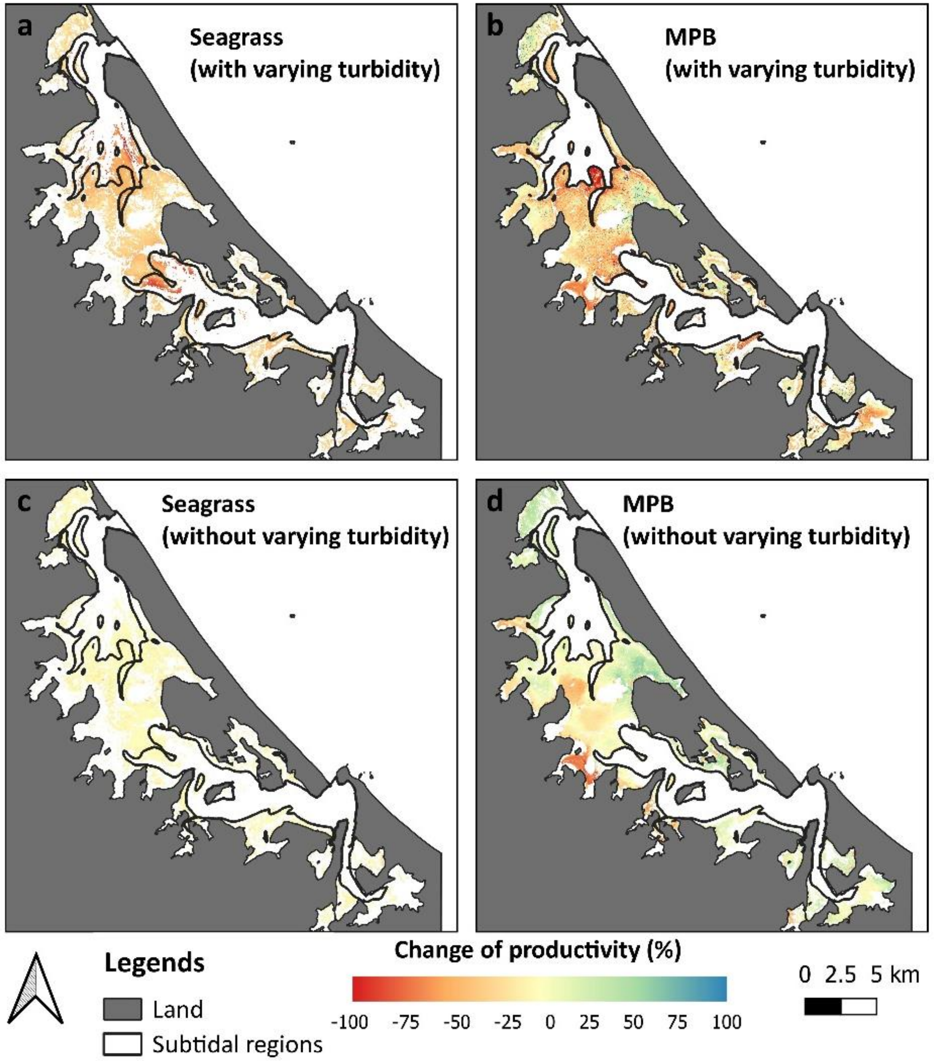
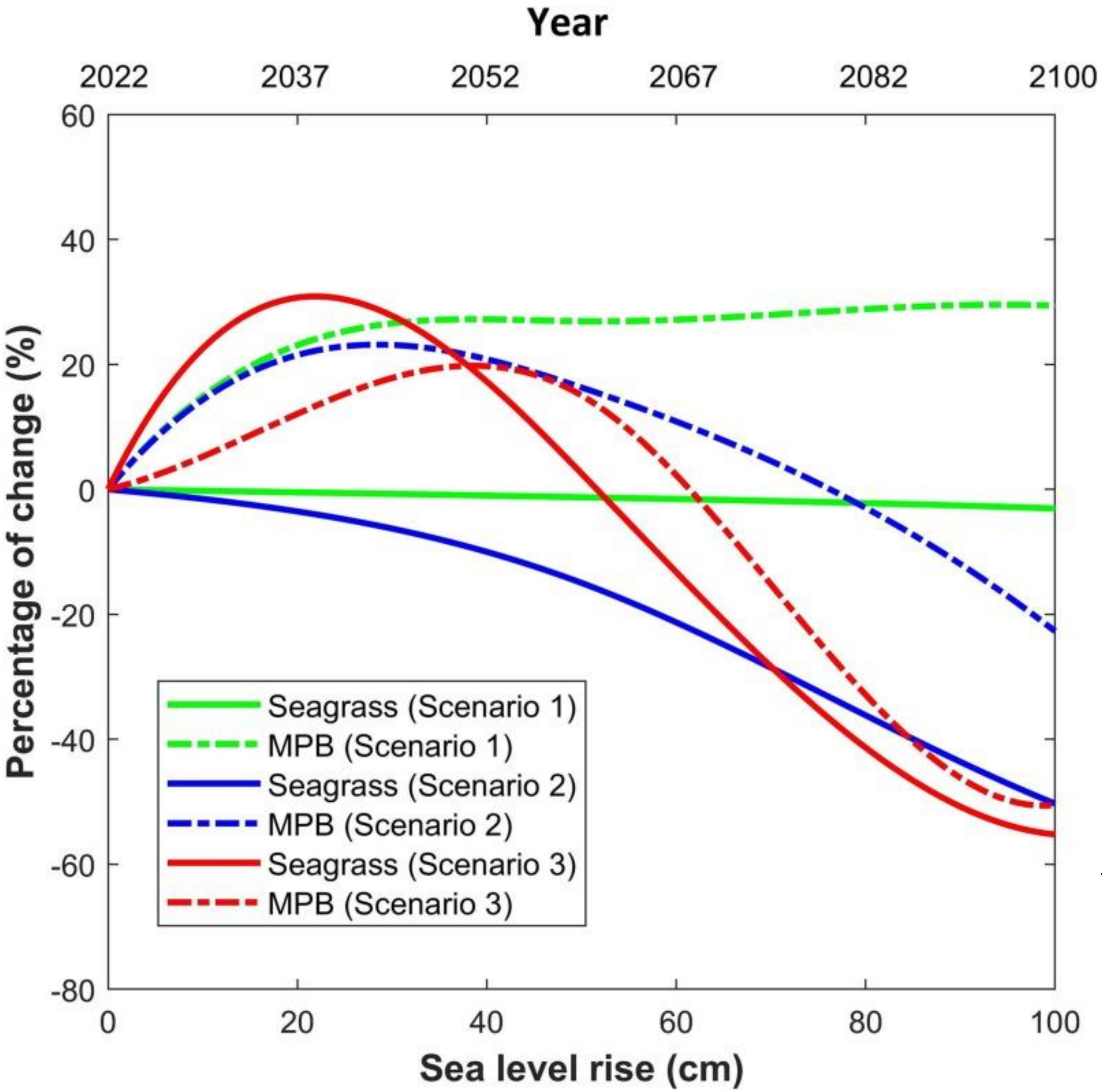
What happens in Year 2100?





Scenario 1: without increasing turbidity

Scenario 2: with increasing turbidity

Scenario 3: allowing expansion of seagrass meadows (including the varying turbidity)

Summary

What can we do with satellite data and machine learning?

- Monitor the estuarine water optical properties at scale in the long term;
- Manage the estuaries with similar conditions;
- Evaluate estuarine vegetation health based on their distribution and percentage cover;
- Predict the potential effects of sea level rise and climate changes on coastal environments;
- ……

National SCIENCE Challenges

Acknowledgements

Thanks!

Zhanchao Shao

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📪z.shao@waikato.ac.nz

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Data available: