Identifying metocean drivers of turbidity using 18 years of MODIS satellite data: Implications for marine ecosystems under climate change.

Paula Cartwright[1], Peter Fearns[2], Paul Branson[1], Michael Cuttler[1], Ryan Lowe[1], Nicola Browne[2], Michael O'Leary[1].

1. The University of Western Australia

2. Curtin University

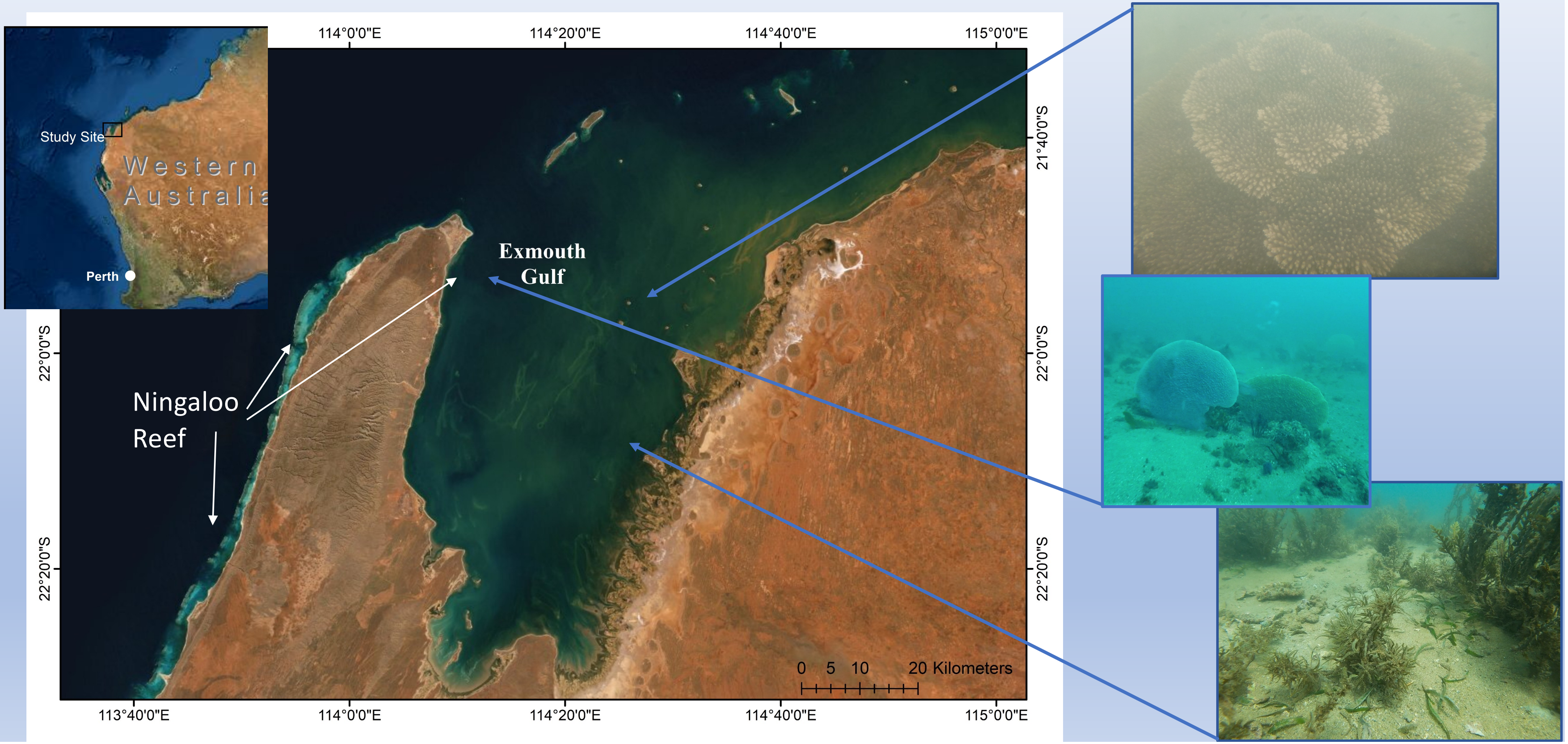
Curtin University

ARC CENTRE OF EXCELLENCE Coral Reef Studies

THE UNIVERSITY OF WESTERN AUSTRALIA

REIF REEF ECOLOGY & ISLAND FUTURES

Ecosystems and benthic habitats of the Exmouth Gulf



Methods - 1. Remote sensing of turbidity

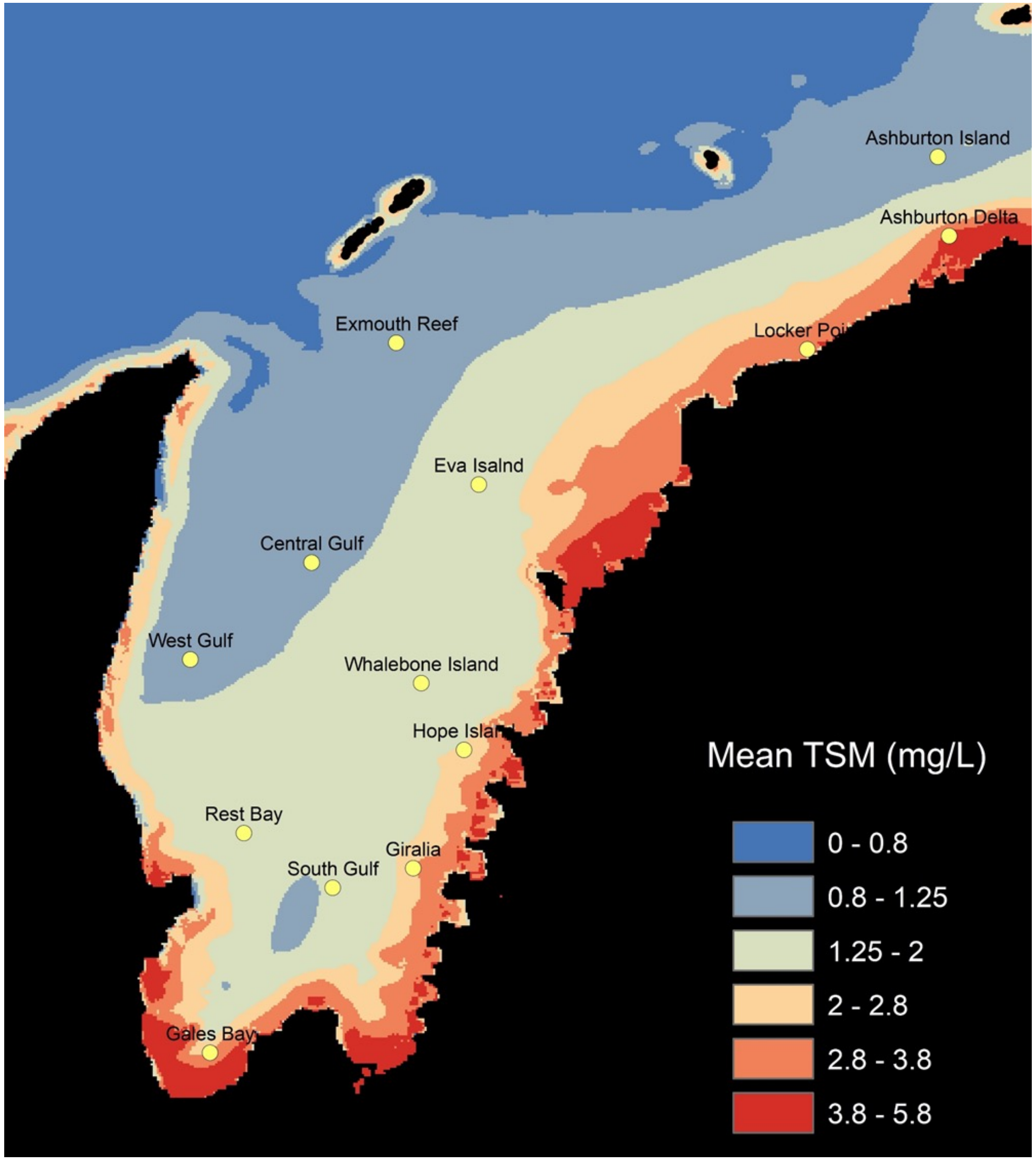
1. MODIS-aqua daily satellite data from 2002-2020 (7,640 scenes)
   - ~ 10 terabytes data

2. Apply robust turbidity algorithm

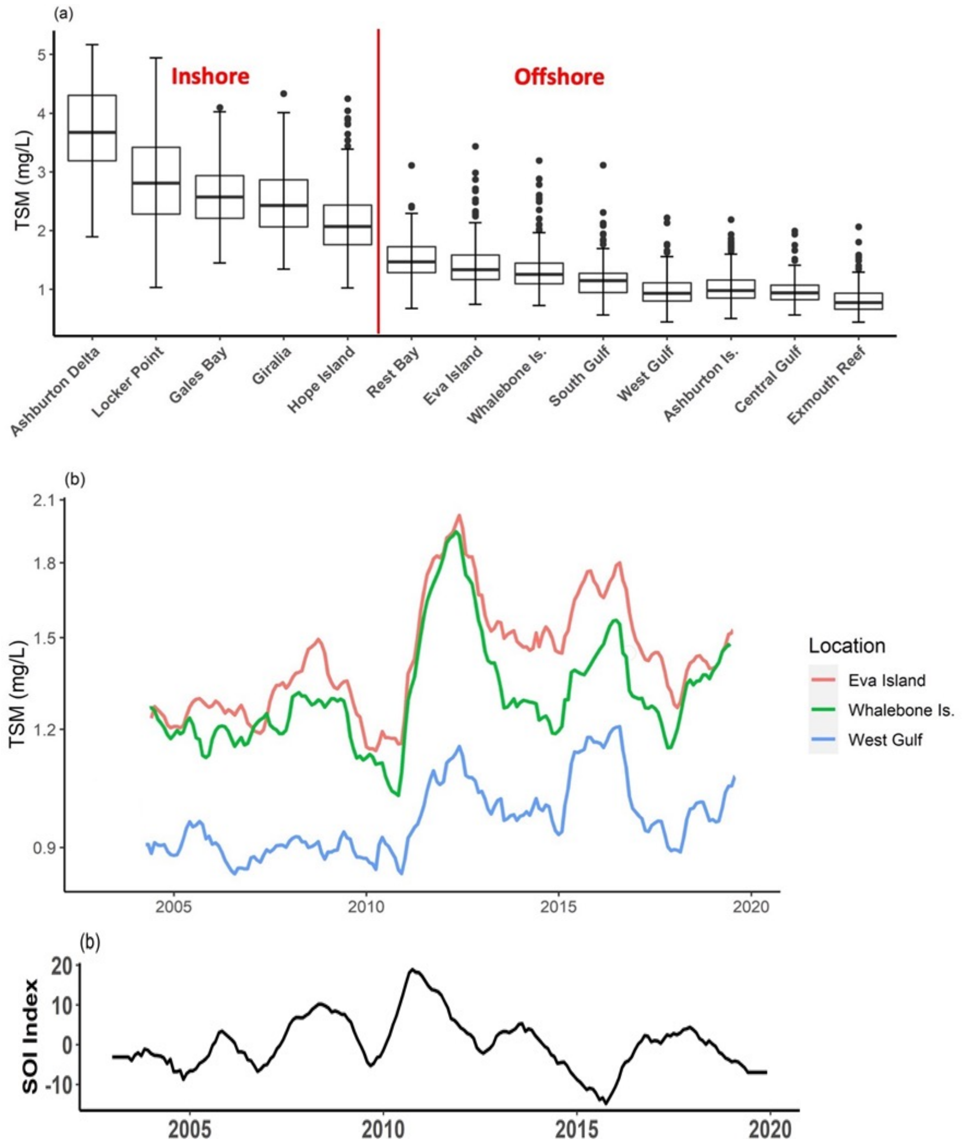
Dorji, P.; Fearns, P.; Broomhall, M. A Semi-Analytic Model for Estimating Total Suspended Sediment Concentration in Turbid Coastal Waters of Northern Western Australia Using MODIS-Aqua 250 m Data. *Remote Sens.* **2016**, *8*, doi:10.3390/rs8070556

3. Analyse Turbidity Regime - *Analyse mean turbidity, anomalies, time series trends, and spectral (frequency) analysis*

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

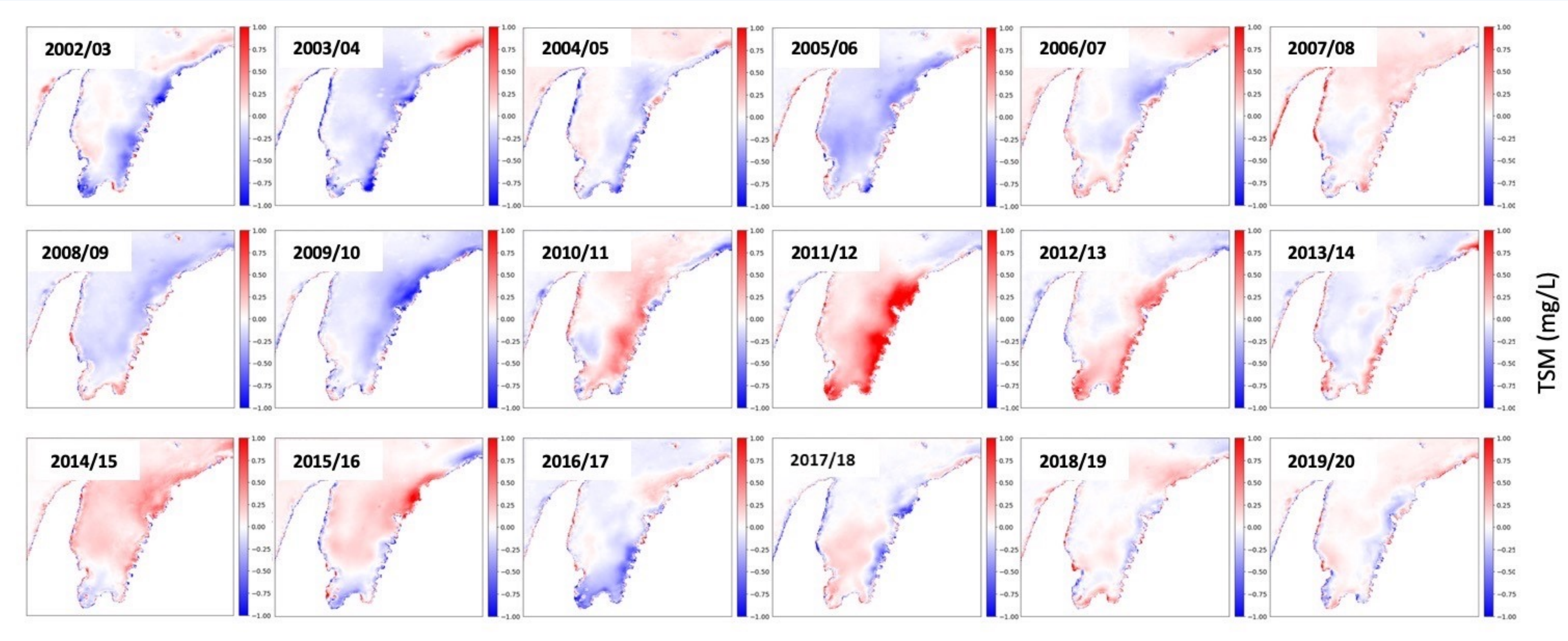


Ashburton Island
Ashburton Delta
Exmouth Reef
Locker Poi
Eva Isalnd
Central Gulf
West Gulf
Whalebone Island
Hope Islan
Rest Bay
Giralia
South Gulf
Gales Bay
Mean TSM (mg/L)
0 - 0.8
0.8 - 1.25
1.25 - 2
2 - 2.8
2.8 - 3.8
3.8 - 5.8

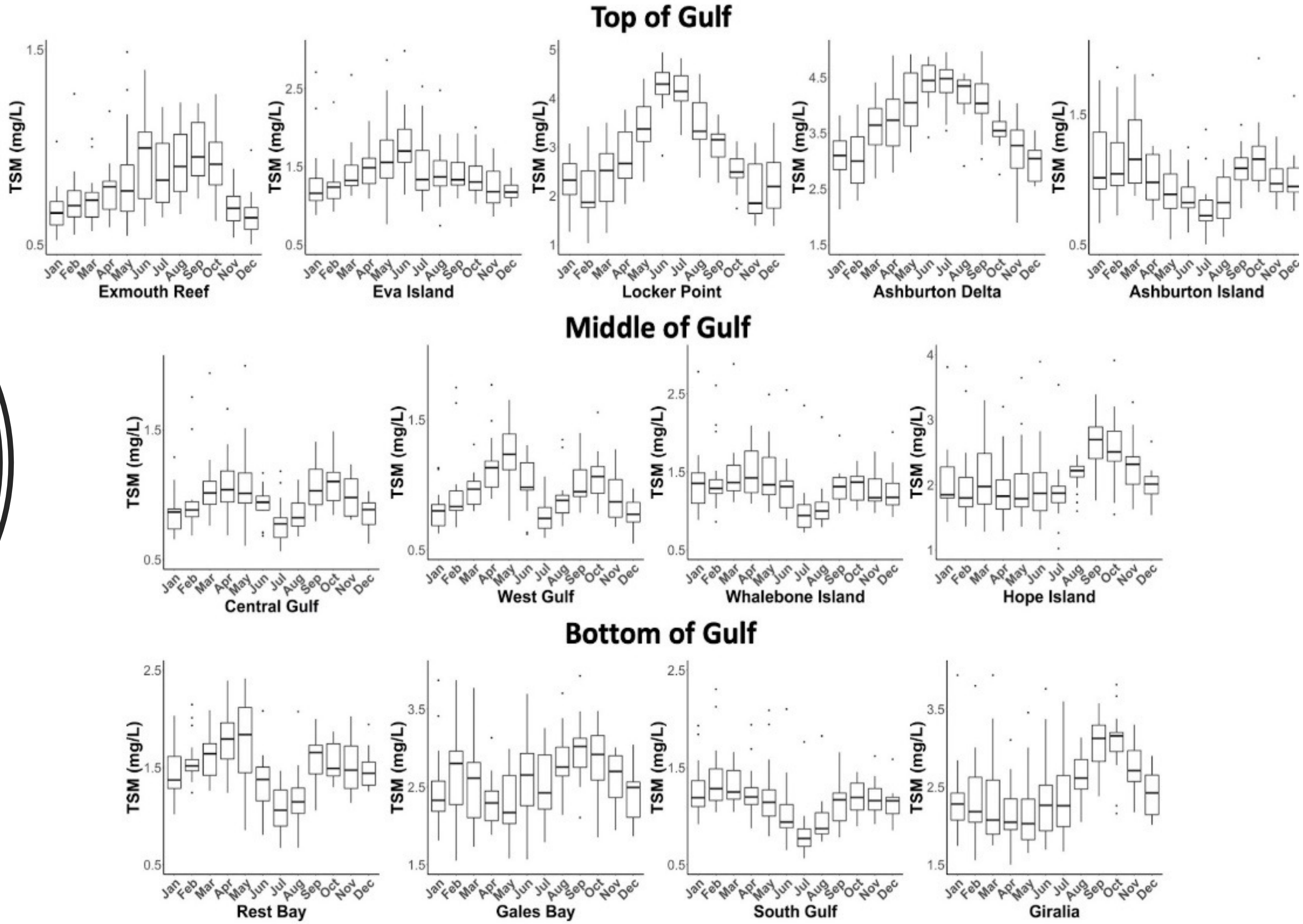


(a)
Inshore
Offshore
TSM (mg/L)
Ashburton Delta
Locker Point
Gales Bay
Giralia
Hope Island
Rest Bay
Eva Island
Whalebone Is.
South Gulf
West Gulf
Ashburton Is.
Central Gulf
Exmouth Reef
(b)
TSM (mg/L)
Location
Eva Island
Whalebone Is.
West Gulf
(b)
SOI Index

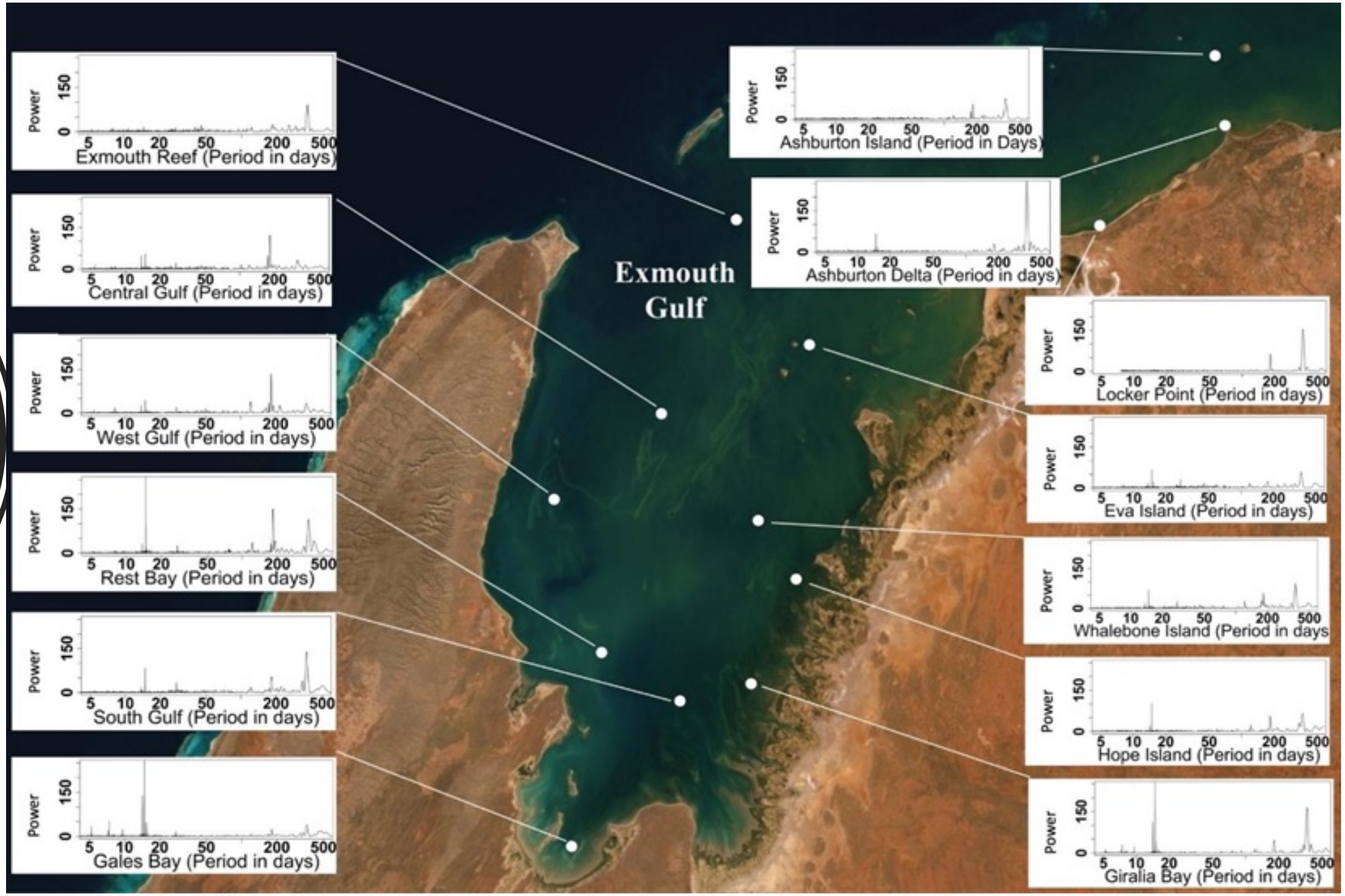
Annual turbidity anomalies



Seasonal variability



Spectral Analysis



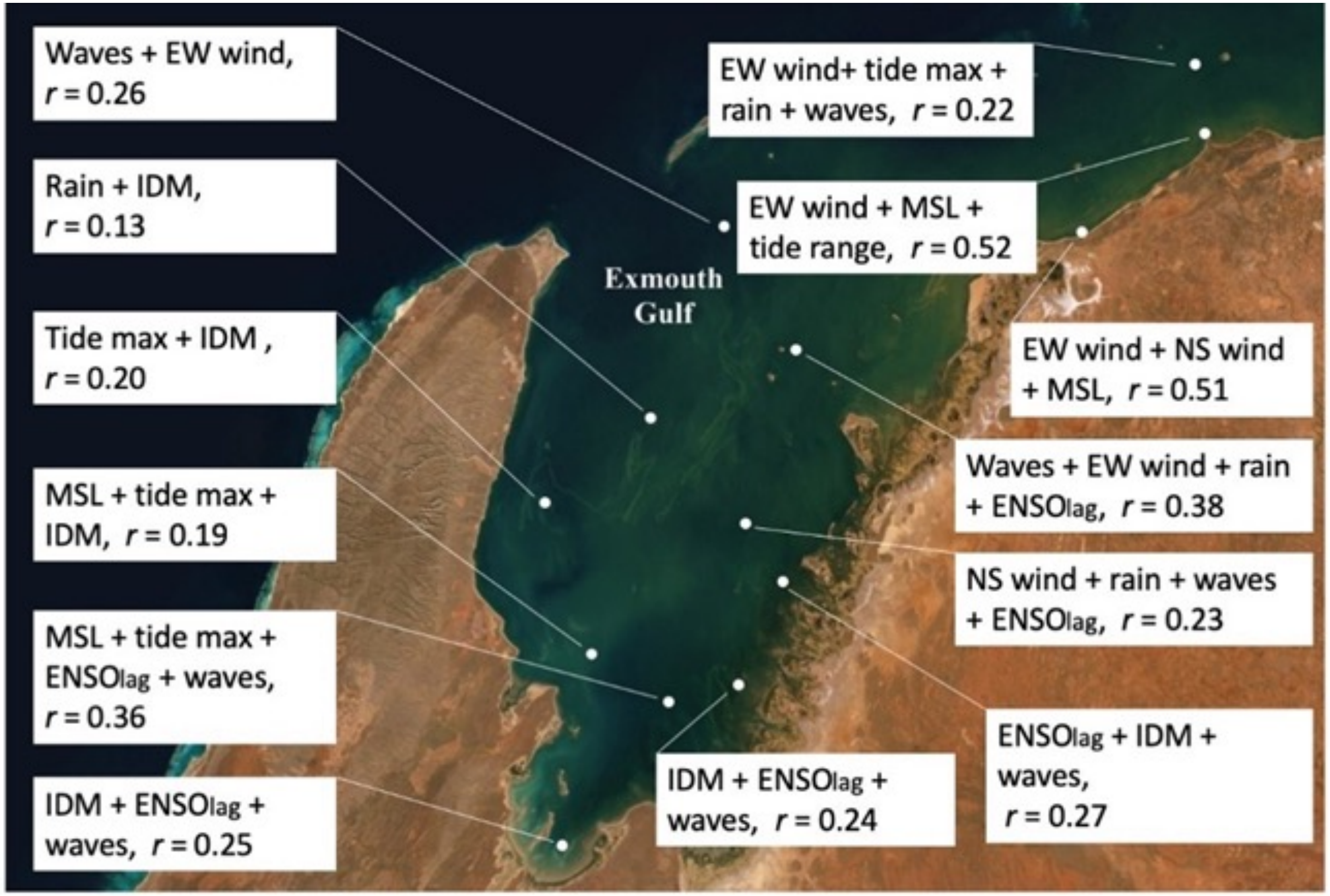
Methods 2 - Analyse metocean drivers of turbidity

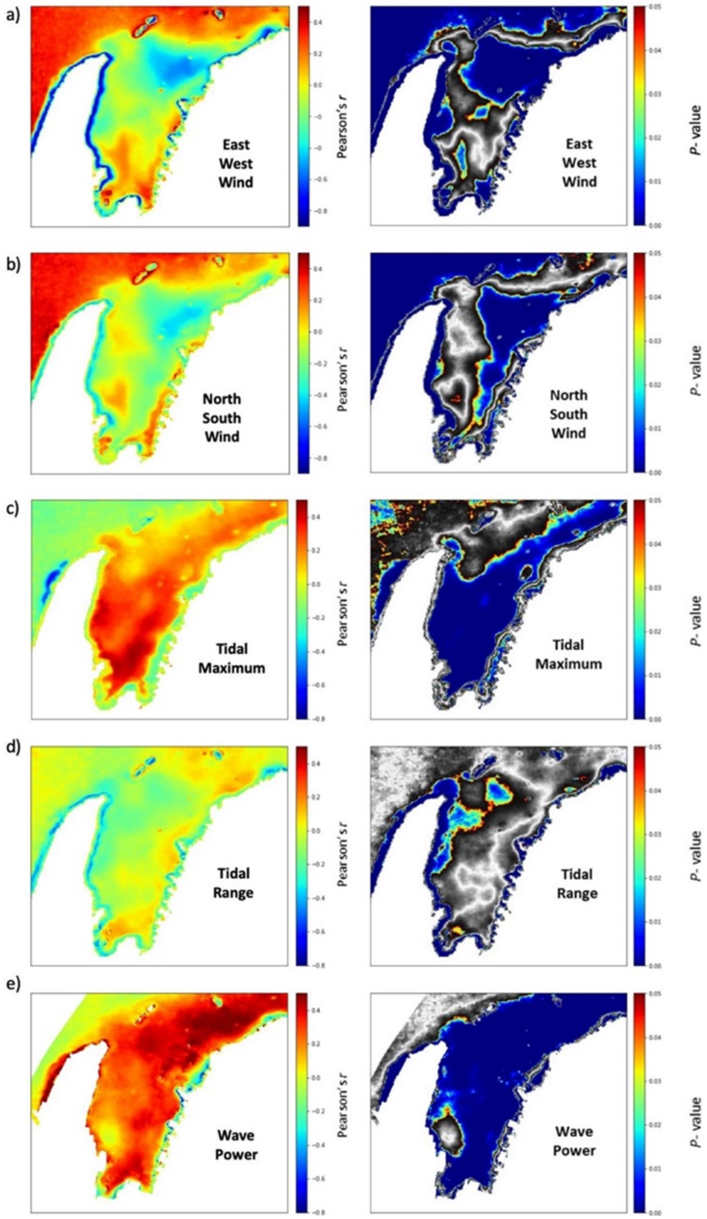
Met-ocean factors for same period as turbidity data – Analyse with correlation & regression analyses and principal component analysis to find met-ocean drivers of turbidity

- *wind (u & v components)*
- *waves*
- *tides*
- *mean sea level*
- *rainfall*
- *ENSO*
- *Indian Ocean Dipole*

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Multiple Regression Analysis

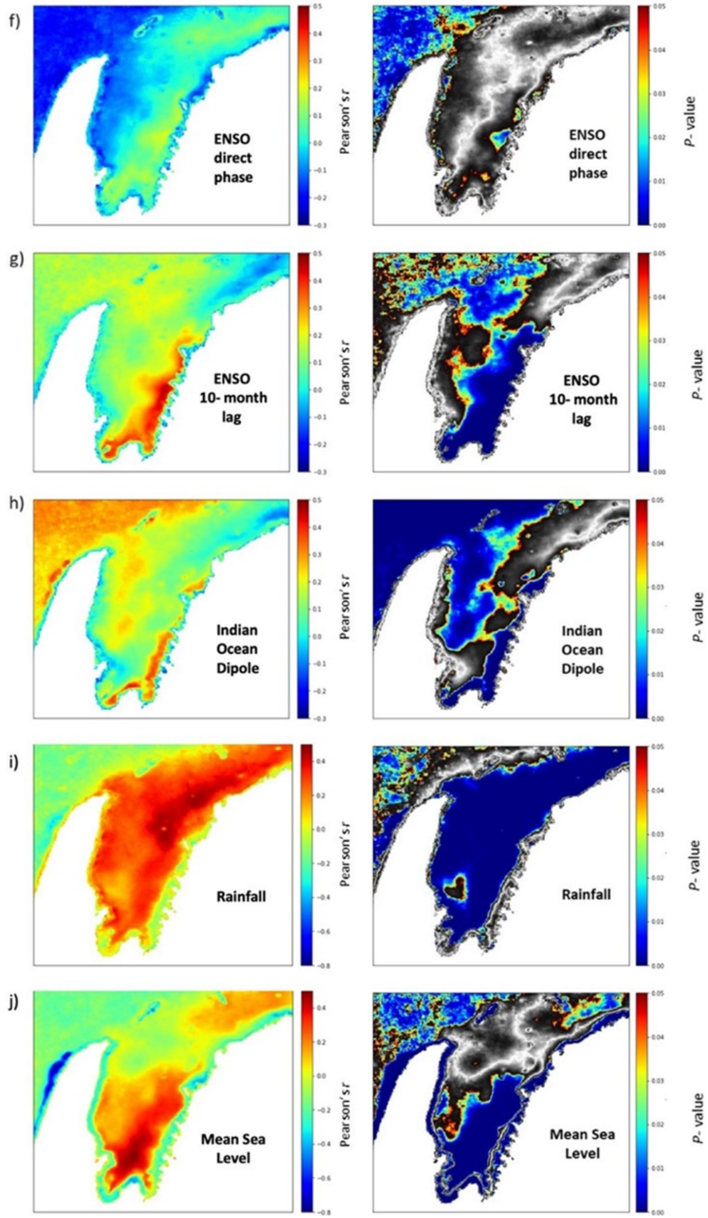


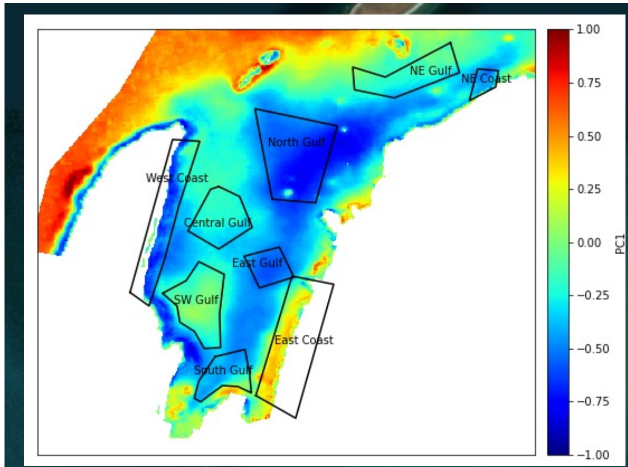


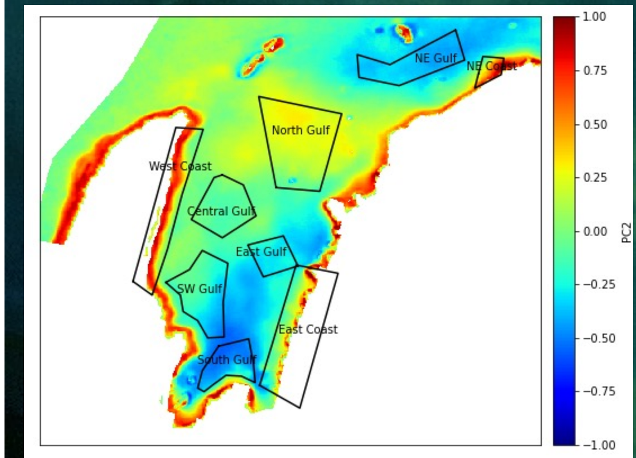
Pearson's *r* correlation maps

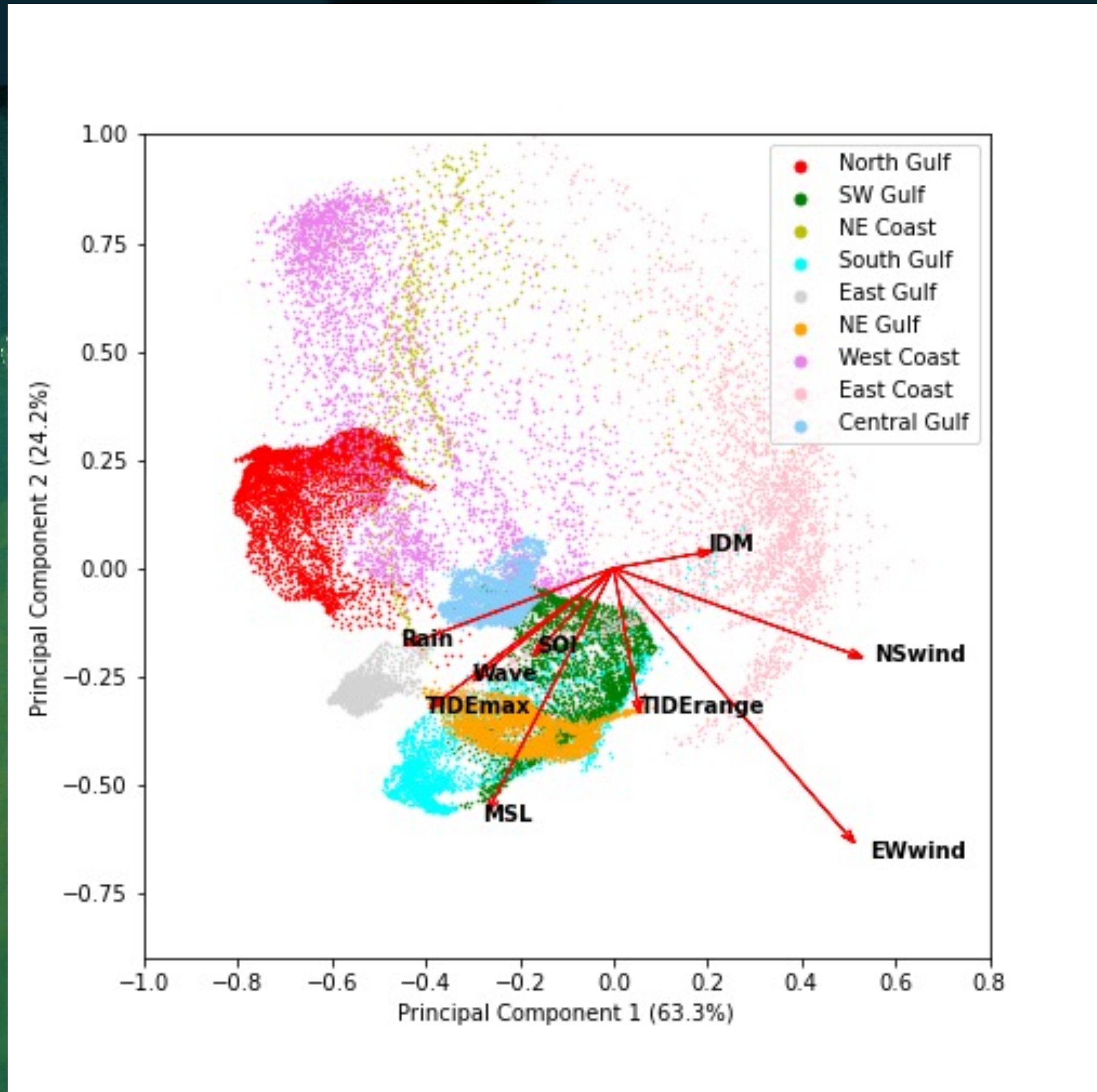
-between turbidity and environmental variables

-With corresponding *p*-value maps









	Waves	EW Wind	NS Wind	Tide Max	Tide Range	MSL	Rain	IDM	SOI
PC1	-0.27	0.49	0.50	-0.37	0.05	-0.26	-0.41	0.18	-0.15
PC2	-0.24	-0.61	-0.20	-0.30	-0.31	-0.53	-0.17	0.03	-0.18
PC3	-0.85	-0.03	-0.07	0.34	-0.11	0.36	-0.08	0.00	-0.05

Loadings from principal component analysis of met-ocean drivers of turbidity in the Exmouth Gulf.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Conclusions

- This study has analysed 18 years of remotely sensed turbidity data to find the met-ocean processes that drive seasonal and interannual turbidity fluctuations in Exmouth Gulf
- We find that while variability in turbidity is high, there has been a systematic upward trend in turbidity in some regions of the Gulf.
- The significant coupling of ENSO and IOD to turbidity reveal pathways where climate change could further impact water quality to ecologically critical habitats into the future.
- This highlights how important a better understanding of the relationship between global climate cycles, regional oceanographic processes and turbidity is to the future management of coastal environmental values

Recommendations

- **We recommend that future studies should :**

1. Utilise Google Earth Engine (or similar) for long time-series analyses instead of downloading large amount of satellite data and relying on supercomputers
2. Approach the quantification of climate change impacts to water quality by applying novel statistical methods (i.e. machine learning) to long term data (MODIS?), incorporating climate change circulation models and emission scenarios

remote sensing

Special Issue "Application of MODIS Data for Environmental Research"

MDPI

Article

Identifying metocean drivers of turbidity using 18 years of MODIS satellite data: Implications for marine ecosystems under climate change.

Paula Cartwright [1,2], Peter Fearns [3], Paul Branson[1,4], Michael Cutler [1,5], Michael O'Leary [1,6], Nicola Browne [7], Ryan Lowe [1,2,6]