

The logo for the National Oceanography Centre, featuring a white square with a black border. The text "National Oceanography Centre" is written in black, stacked vertically within the square.

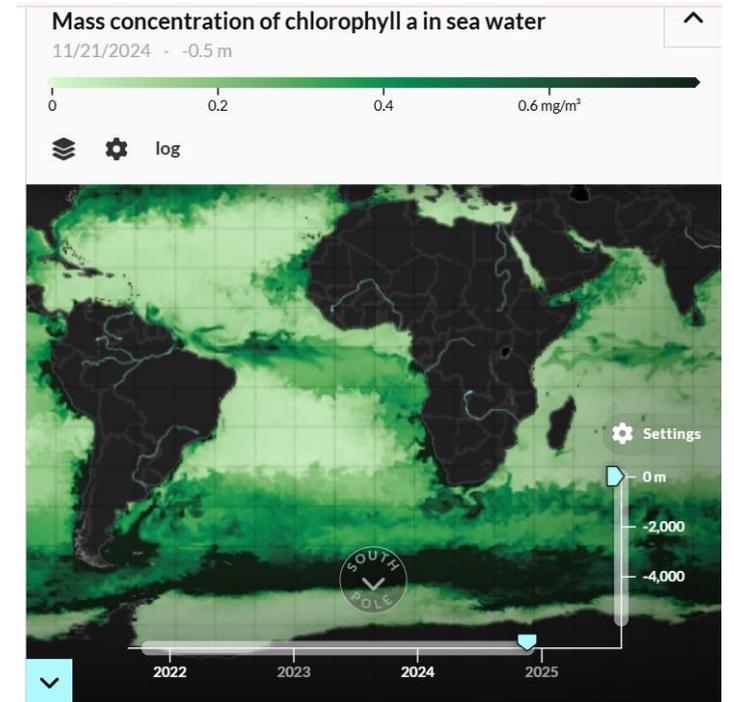
National
Oceanography
Centre

**INTEGRATING MARINE BIOGEOCHEMISTRY MODELS WITH
SOCIO-ECONOMIC INFORMATION:
BRIDGING RESEARCH AND HUMAN NEEDS FOR EFFECTIVE
OCEAN PREDICTION SYSTEMS**

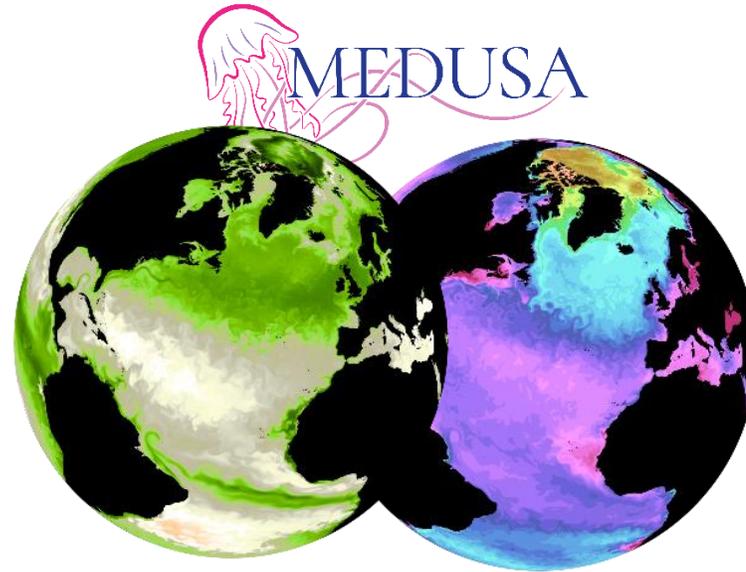
K.POPOVA, Z.JACOBS, A.YOOL, A.LOVERIDGE, S.PATEL

A 3.5-DECADE JOURNEY OF 3D GLOBAL BIOGEOCHEMICAL MODELS

Global Ocean Biogeochemistry Analysis and Forecast



1/4 resolution in global operational forecast



1/12 resolution in hindcasts and projections

- Regional realism
- Emergent dynamic CC indicators
- Extremes rather than gradual changes
- Abrupt and irreversible changes (Tipping Points)

Annual mean: Vertical Mean (0 - 123 m)
 $d(\text{nitrate})/dt$ in $\text{mmol-N/m}^3/\text{yr}$

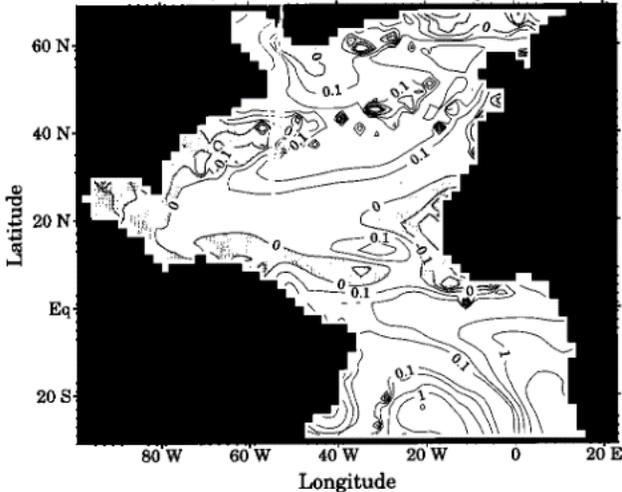
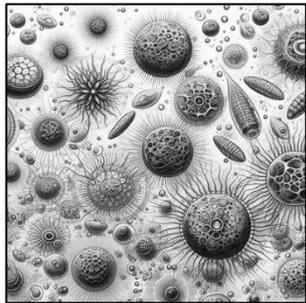


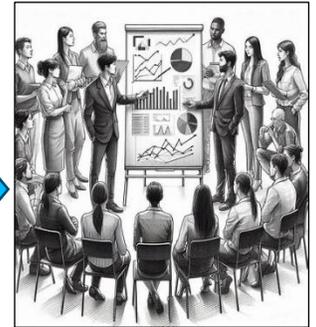
Fig. 4. Map of the change in nitrate concentration during year 3 of the simulation. Contour interval is 0, ± 0.1 , ± 0.2 , ± 0.5 , ± 1.0 , ± 2.0 , etc.

Sarmiento et al., 1993

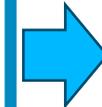
KEY TYPES OF SOCIO-OCEANOGRAPHIC MODELS



BGC Models

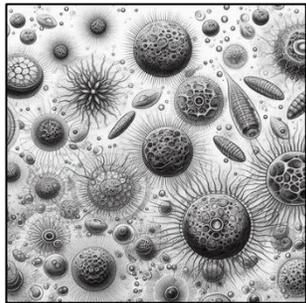


Participatory and
co-management
Models and
Actions

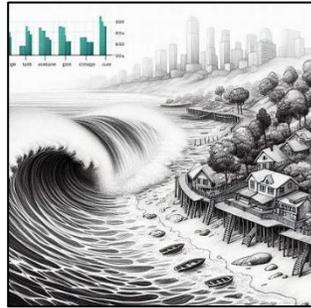


KEY TYPES OF SOCIO-OCEANOGRAPHIC MODELS

← Detail and realism of environmental indicators



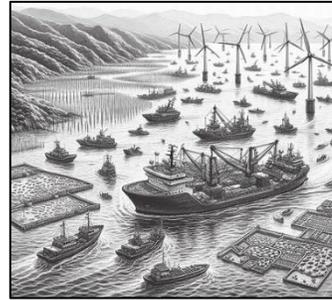
BGC Models



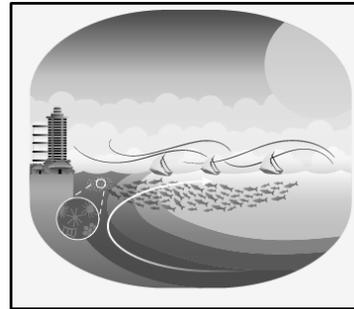
Climate Change Risk and
Vulnerability Models



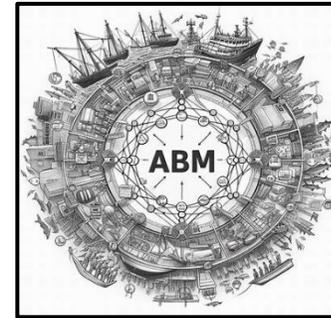
mCDR Models



MSP Models



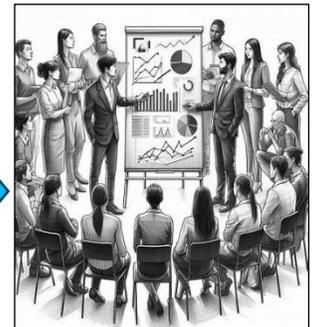
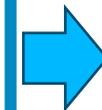
Coupled Human-Natural
Systems Models



Agent-based
Models



Economic Models

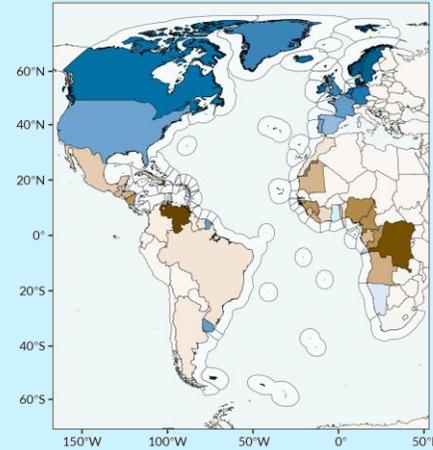


Participatory and
co-management
Models and
Actions

EXAMPLES OF ADDING HUMAN DIMENSIONS TO BGC MODELS

Risk/Vulnerability Modelling approach

Vulnerability of Marine Ecosystem Services of the Atlantic rim countries to Climate Change Impacts



A Storyline Approach

Navigating the Waters of Marine Carbon Dioxide Removal: From Promise to Practice

(Ocean Alkalinity addition)



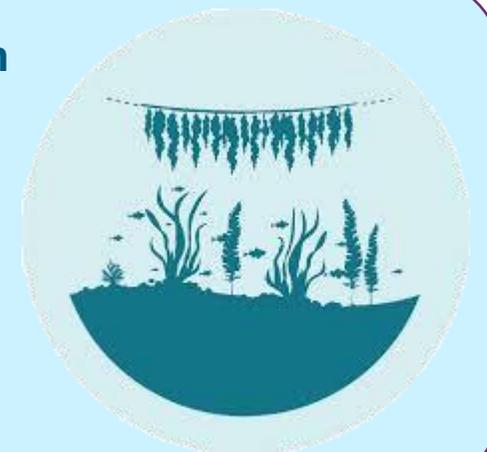
Towards a global “Upwelling Watch” system

Focus on small-scale seasonal upwelling systems and their socio-economic impacts



Environmental Digital Twin with socio-economic components

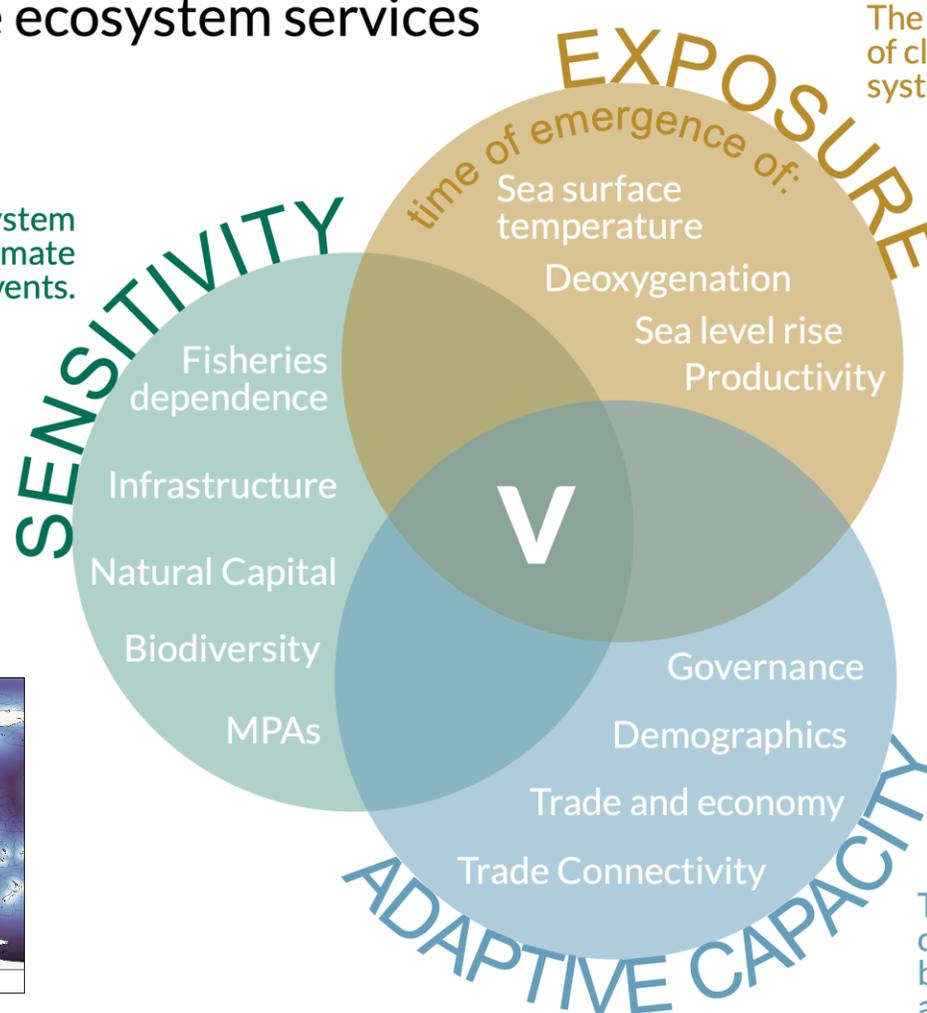
Macroalgae for carbon dioxide removal
(Scaling up experiments)



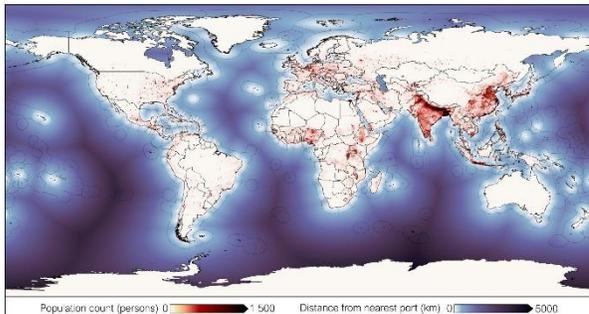
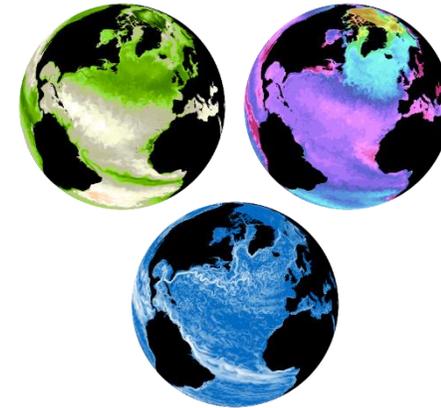
VULNERABILITY OF MARINE ECOSYSTEM SERVICES OF THE ATLANTIC RIM COUNTRIES TO CLIMATE CHANGE IMPACTS

Vulnerability (V) Index framework for Atlantic marine ecosystem services

The degree to which an ecosystem service is affected by the climate related stress or extreme events.



The magnitude and duration of climate stresses to which a system is exposed.



The ability of a country to withstand or recover from extreme events, based on the level of social capital and the effectiveness of governance.

TYPES OF DATA DESCRIBING HUMAN DIMENSIONS OF GLOBAL-SCALE SOCIO-OCEANOGRAPHIC SYSTEMS

Population and demographics

(e.g. coastal population density, age structure)

Economic activities

(e.g. employment in blue economies, revenue, GDP)

Social data

(e.g. education, cultural practices)

Management, governance and policy

(e.g. MPAs, pollution regulation)

Land and sea use and infrastructure data

(e.g. cost of fisheries infrastructure)

Political data

(e.g. strength of political institutions, level of corruption)

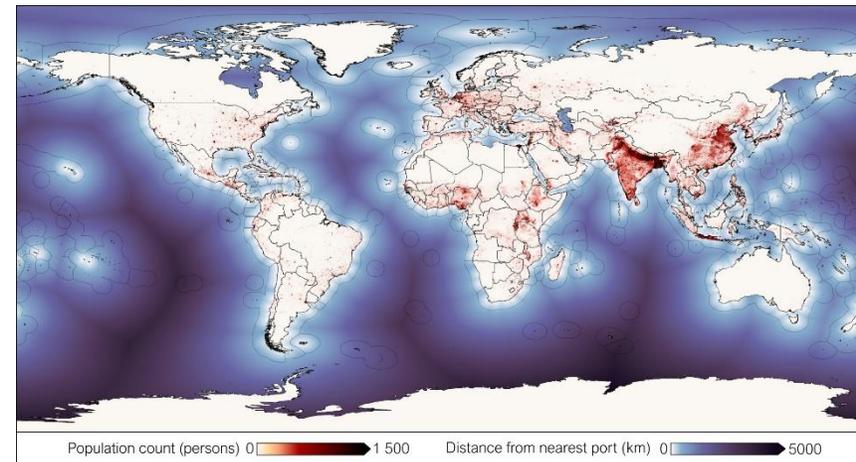
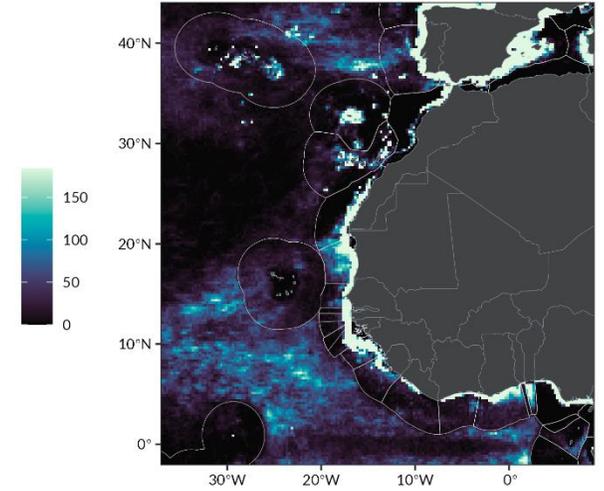
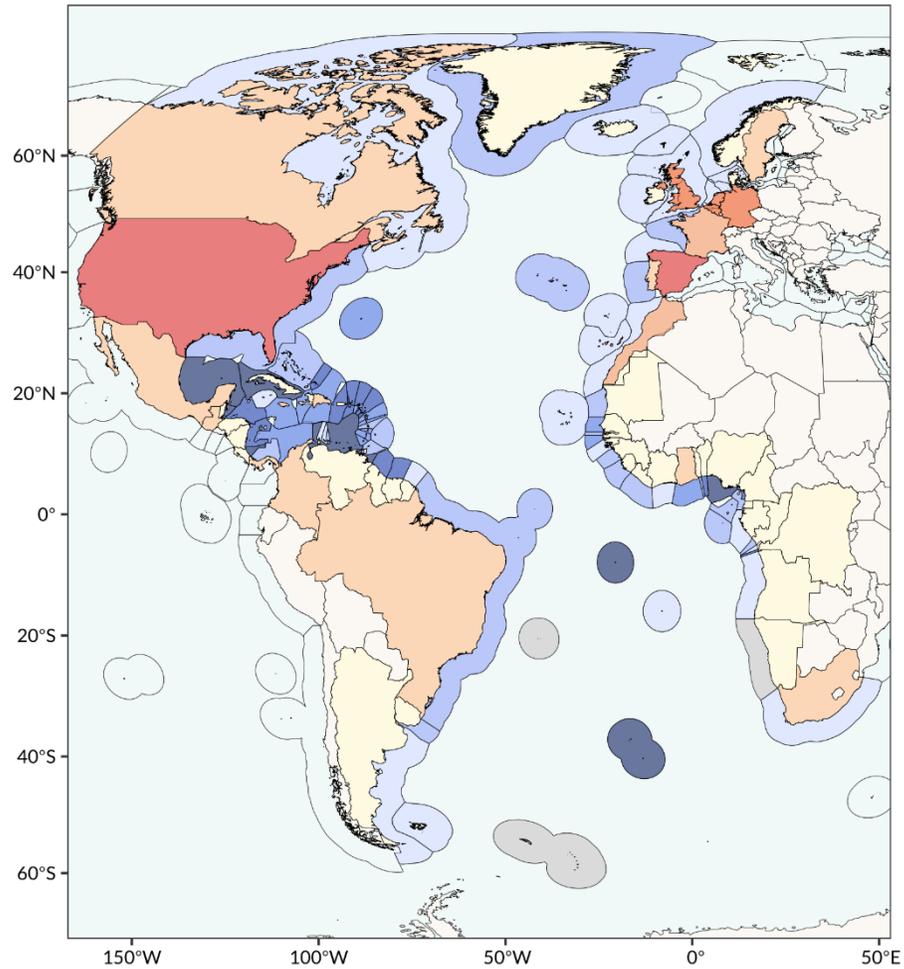
Health data (human and environmental)

(e.g. human health index, levels of pollution)

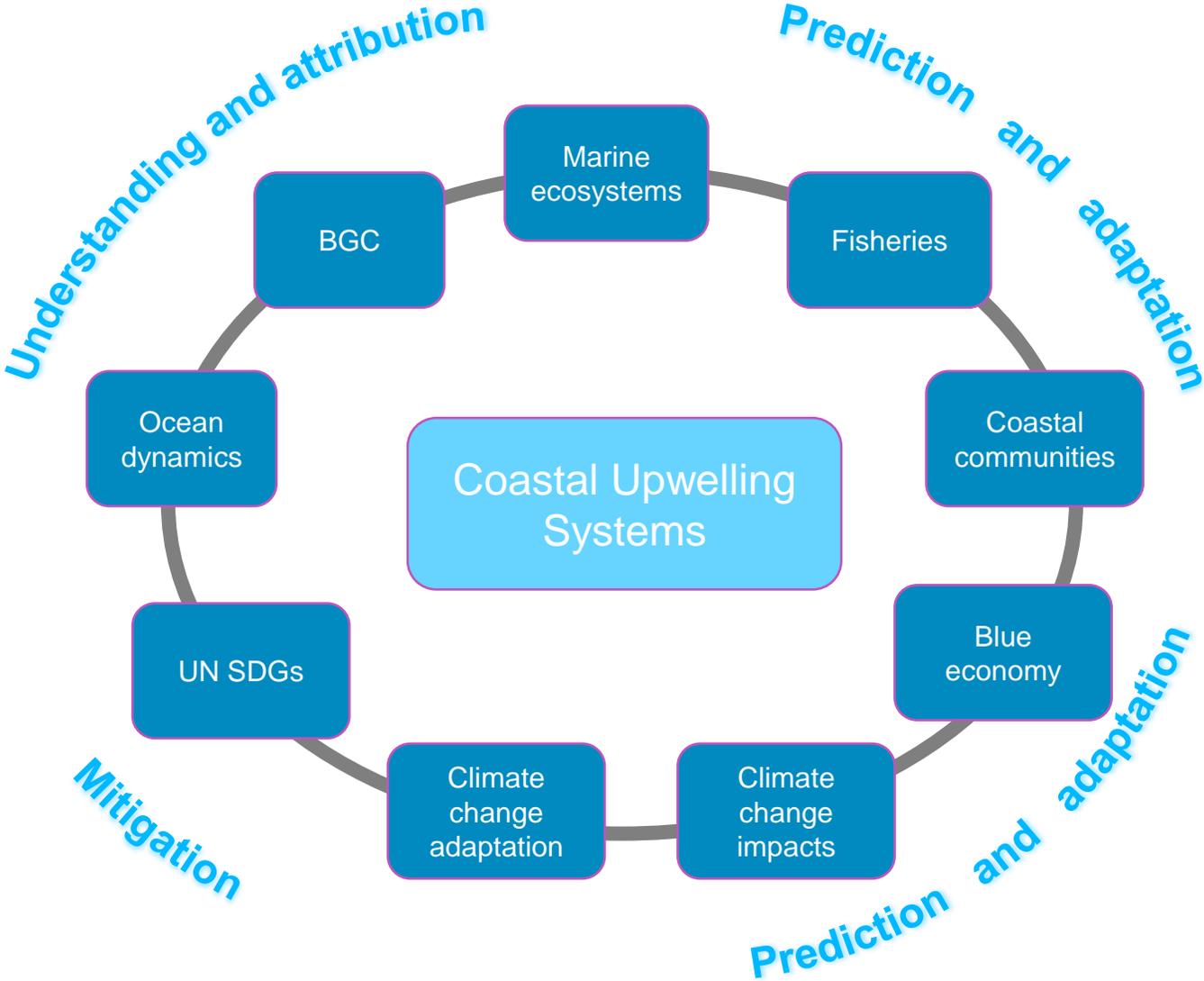
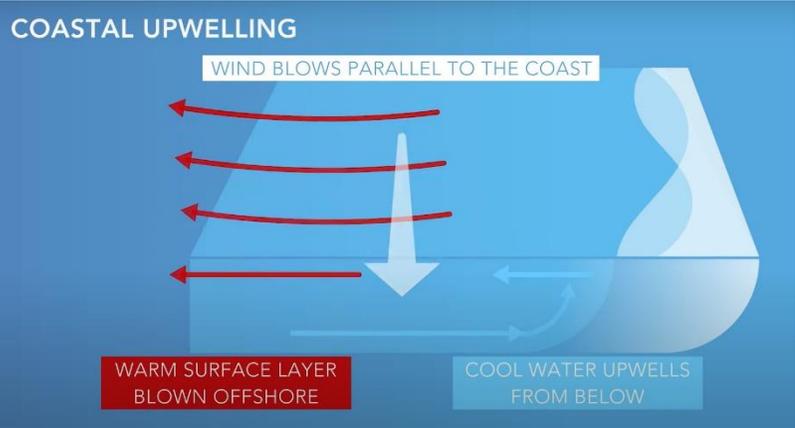
Access to marine resources

(e.g. distribution of key habitats; marine natural capital)

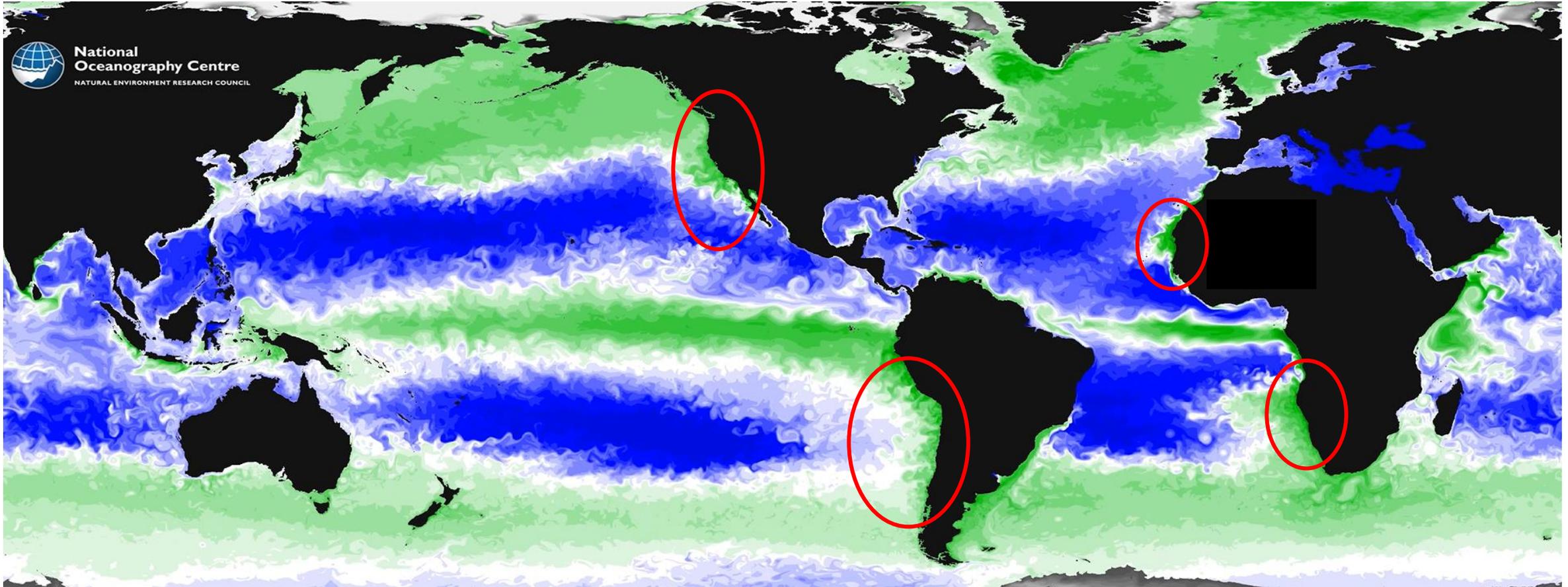
RESOLUTION OF SOCIO-ECONOMIC DATA



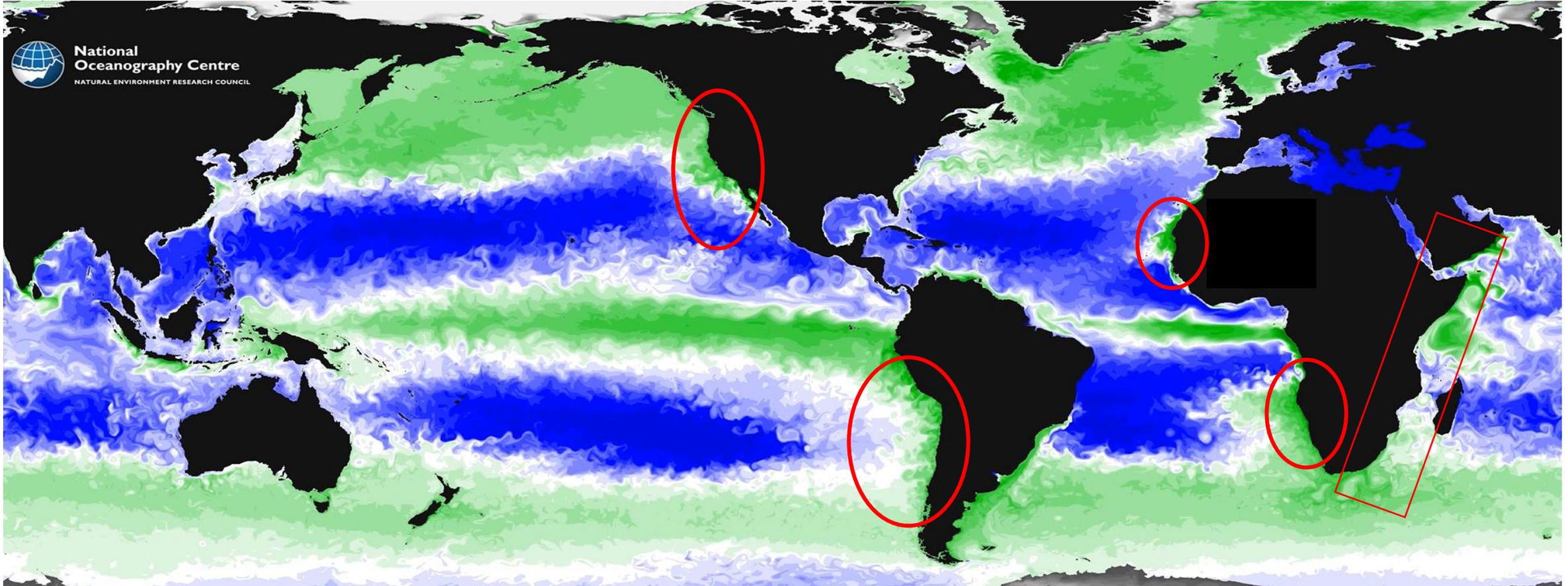
COASTAL UPWELLINGS: AT THE CROSS ROADS OF OCEAN DYNAMICS AND SOCIO-ECONOMICS



“UPWELLING WATCH”



“UPWELLING WATCH”



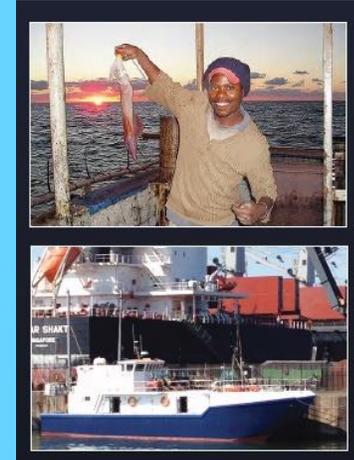


EAST AFRICAN UPWELLING-DRIVEN SYSTEMS AND THEIR ROLE IN FOOD SECURITY

Kenya: Sustainable development of the emergent north Kenyan Banks fishery as the next frontier of food security



South Africa: What has caused collapse and recovery of the squid fishery and can we predict its future?



Tanzania: upwelling as a driver of the small pelagic fishery underpinning food security of the coastal population



Somalia: What is the future fate of the strongest seasonal upwelling on Earth?





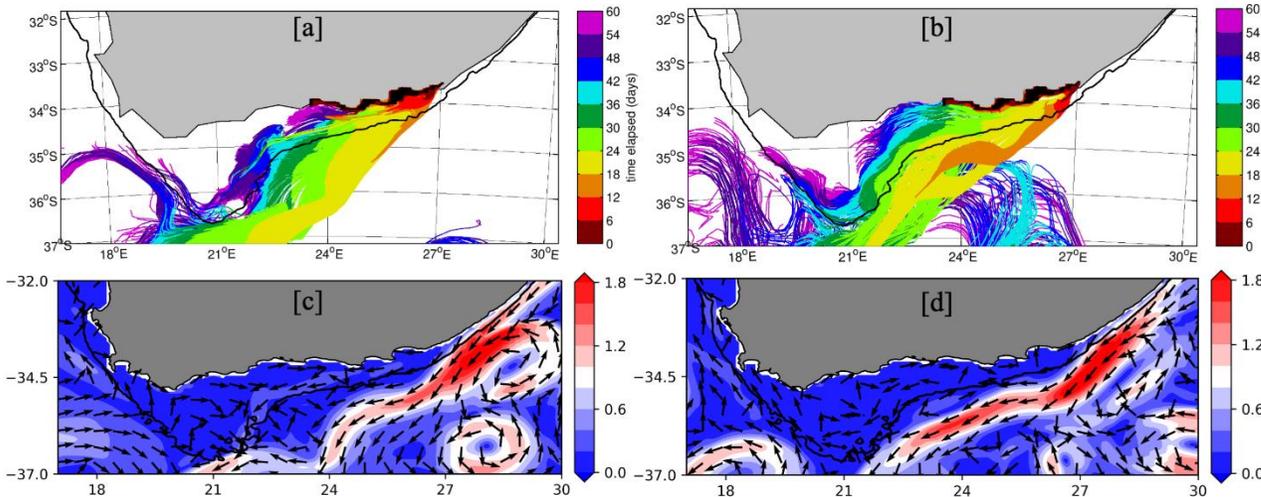
AGULHAS UPWELLING AND COLLAPSE OF THE CHOKKA SQUID FISHERY



The collapse of the Chokka squid fishery in 2013 had a devastating effect on the Eastern Cape, one of the poorest provinces in South Africa. The reasons for the collapse were tightly linked to the dynamics of the Agulhas Bank upwelling.



THE chokka industry will go into a voluntary closed season from next week, leaving more than 2000 Eastern Cape already battling fishermen without a source of income.



Publication highlights: Jacobs et al., 2022. Drivers of productivity on the Agulhas Bank and the importance for marine ecosystems.

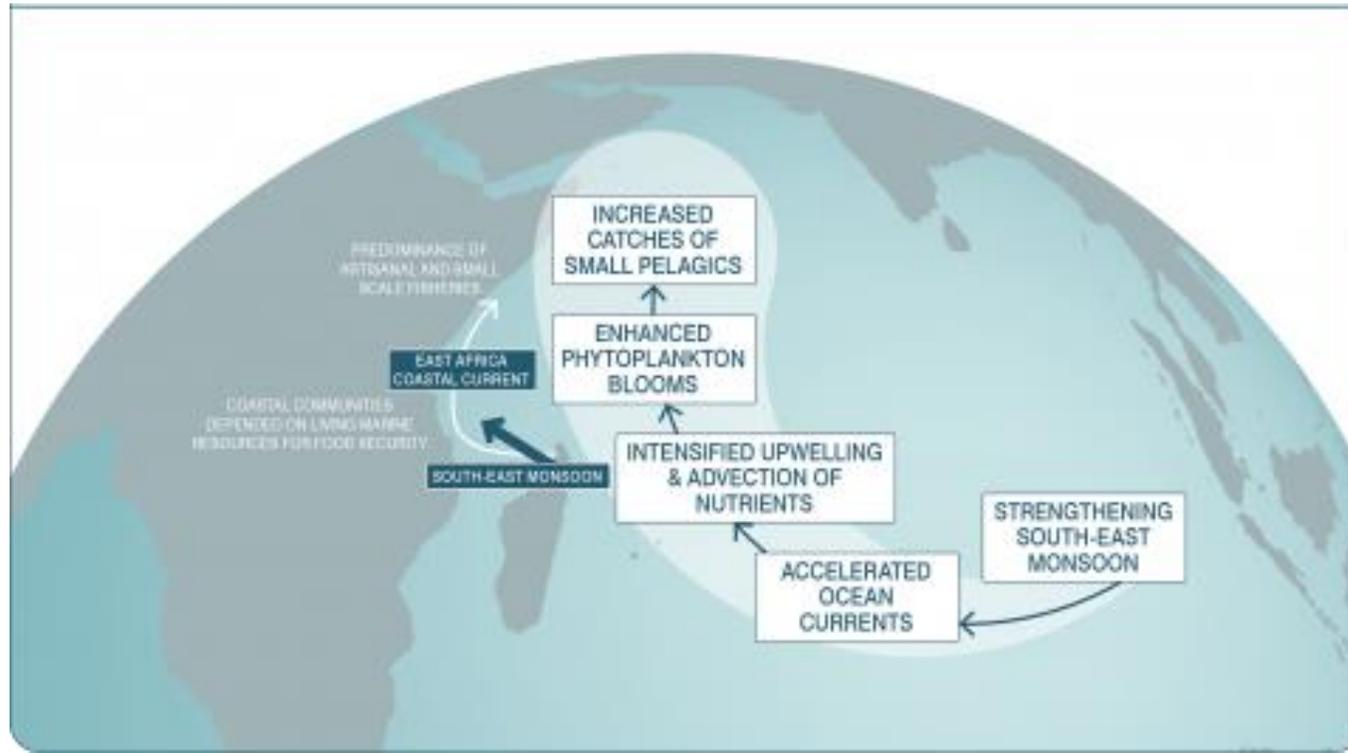
Jacobs et al., 2023. Retention properties of the Agulhas bank and their relevance to the chokka squid life cycle



EAST AFRICAN COASTAL UPWELLING

Interannual monsoon wind variability as a key driver of East African small pelagic fisheries

- Small pelagic fisheries provide food security, livelihood support and economic stability for East African coastal communities—a region of least developed countries.
- Using remotely-sensed and field observations together with modelling, we address the biophysical drivers of this important resource.



Fatma Jebri^{1,*}, Zoe Jacobs¹, Dionysios E. Raitsos^{2,3}, Meric Srokosz¹, Stuart C.





NORTH KENYAN BANKS UPWELLING



The North Kenya Bank fishery is expected to spur economic growth for local communities. If well managed, it could help achieve national development goals, including poverty alleviation and wealth creation. Sustainability requires informed management interventions, but there is only scant information on the ecological status and drivers of the fishery.

ROTTING AWAY

Lamu fishermen stuck with tonnes of tuna for lack of market

A kilo is selling for as low as Sh100

In Summary

- There is no ready market for the fish leaving the fishermen reeling in losses.
- Twalib said they have been forced to sell their catch to local fish mongers at throwaway prices.

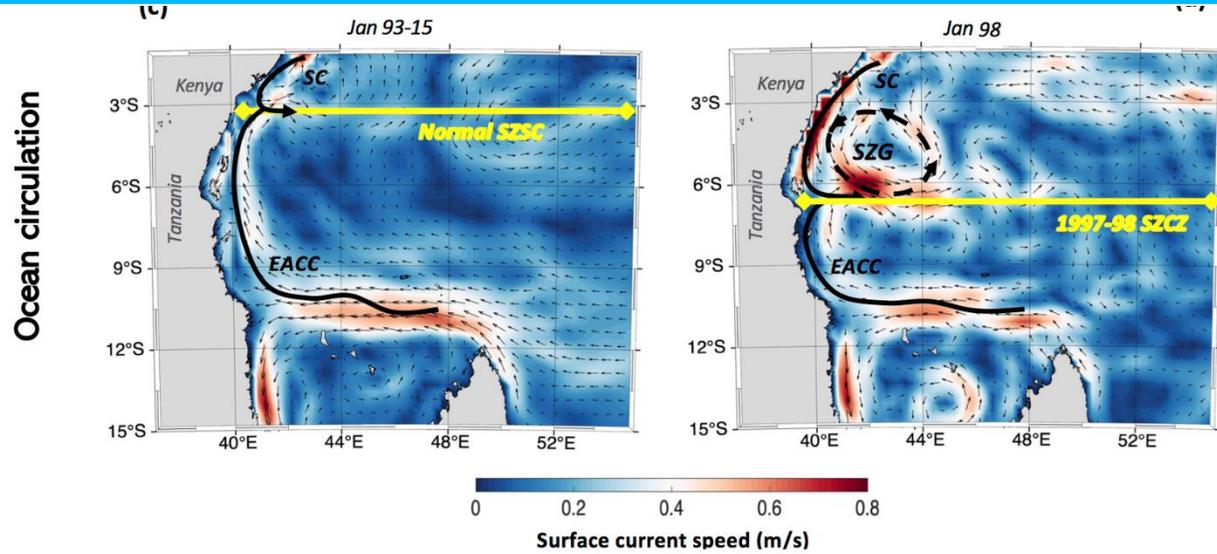


Tonnes of tuna fish rot in Lamu due to lack of market

Thursday, February 07, 2019 – updated on June 29, 2020



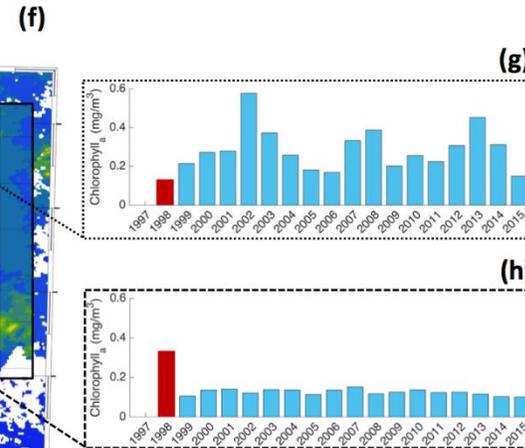
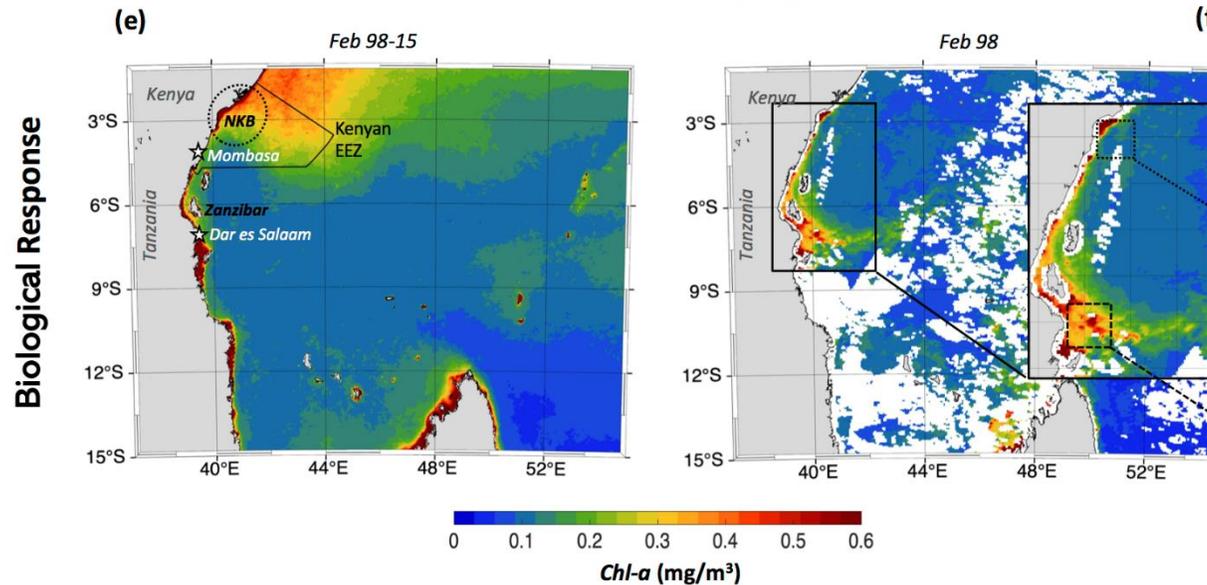
UPWELLING PUBLICATIONS HIGHLIGHTS



Open Access Feature Paper Article

A Major Ecosystem Shift in Coastal East African Waters During the 1997/98 Super El Niño as Detected Using Remote Sensing Data

by [Zoe L. Jacobs](#)^{1,*}, [Fatma Jebri](#)^{1,†}, [Meric Srokosz](#)¹, [Dionysios E. Raitsos](#)^{2,3}, [Stuart C. Painter](#)¹, [Francesco Nencioli](#)³, [Kennedy Osuka](#)^{4,5}, [Melita Samoilys](#)⁴, [Warwick Sauer](#)⁶, [Michael Roberts](#)^{1,7}, [Sarah F. W. Taylor](#)¹, [Lucy Scott](#)⁸, [Hellen Kizenga](#)⁹ and [Ekaterina Popova](#)¹

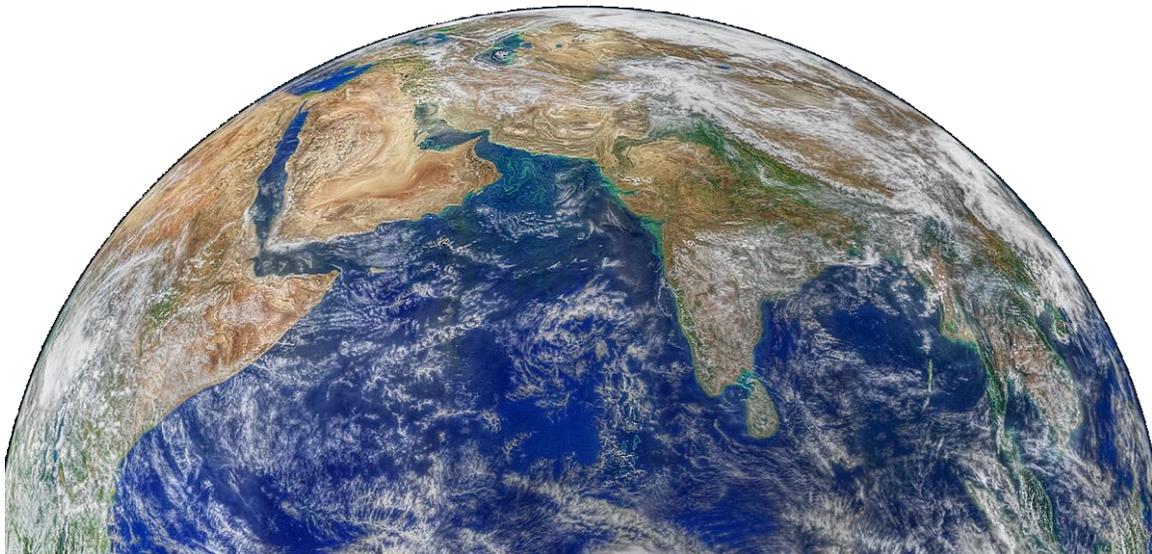




THE FUTURE FATE OF SOMALI UPWELLING ECOSYSTEMS



A series of reports to the World Bank based on the NOC future ocean projections and remote sensing analysis underpinning 50M investment into fisheries infrastructure



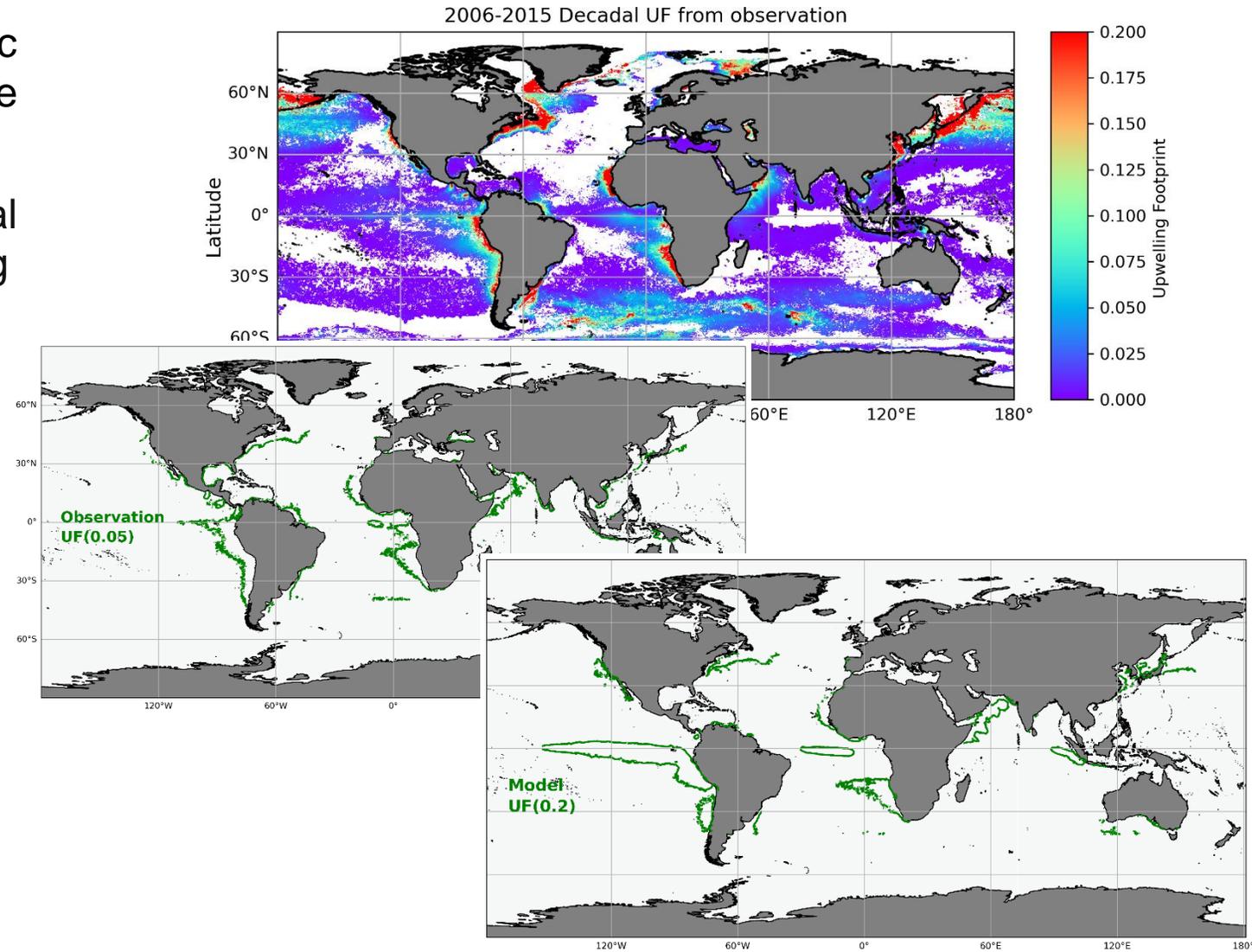
DEVELOPING A GLOBAL “UPWELLING FOOTPRINT” METRIC

- Combined SST metric and Chl-a metric delineates coastal upwelling systems where lowest SST coincides with high Chl-a.
- “Upwelling footprint” refers to the spatial extent or impact area of the coastal upwelling

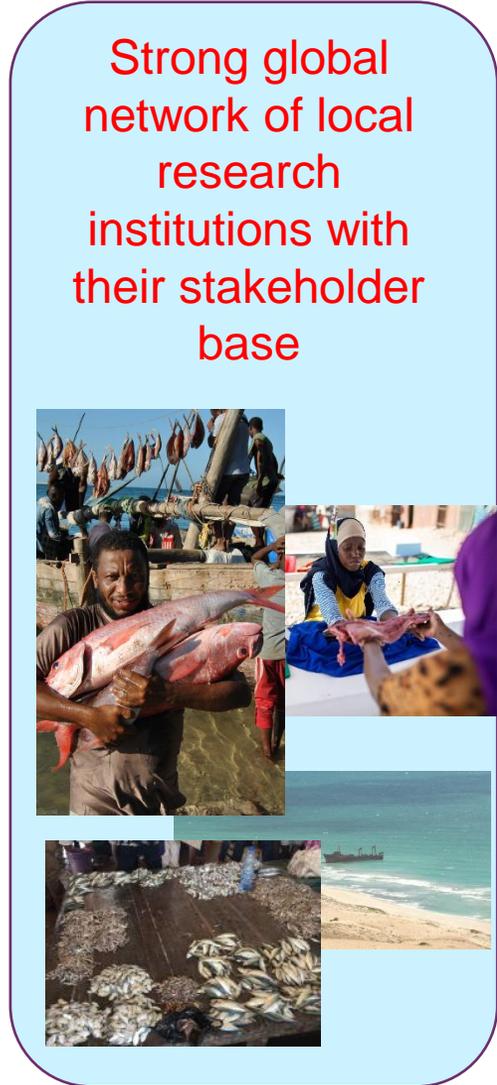
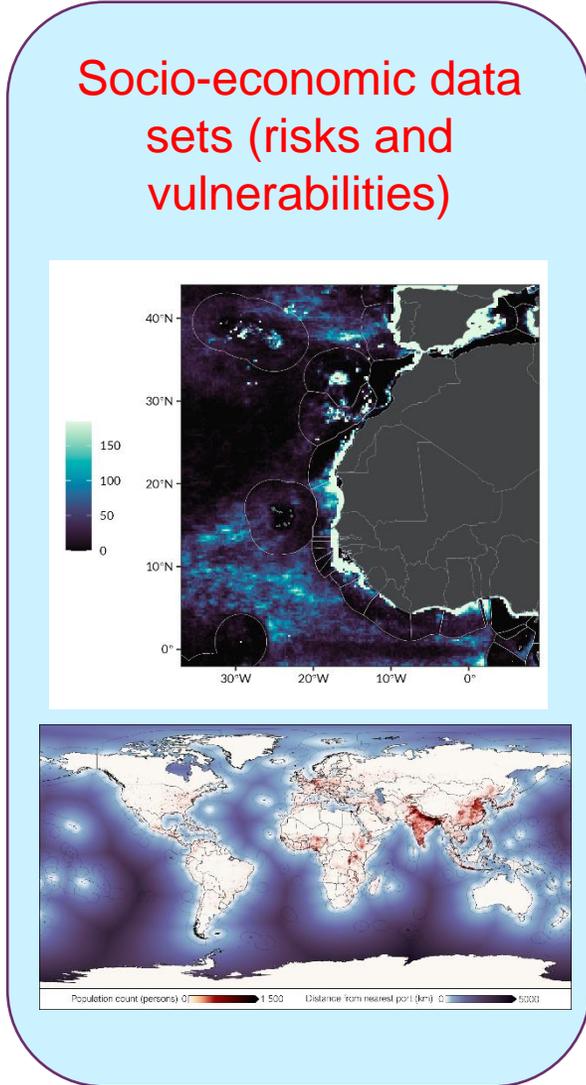
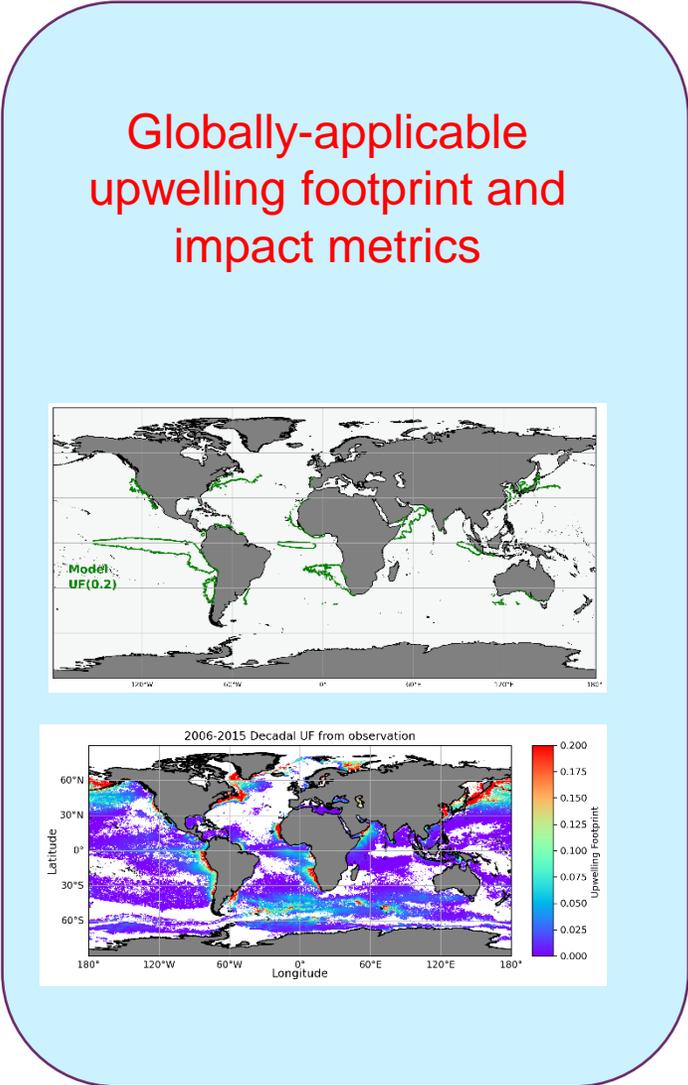
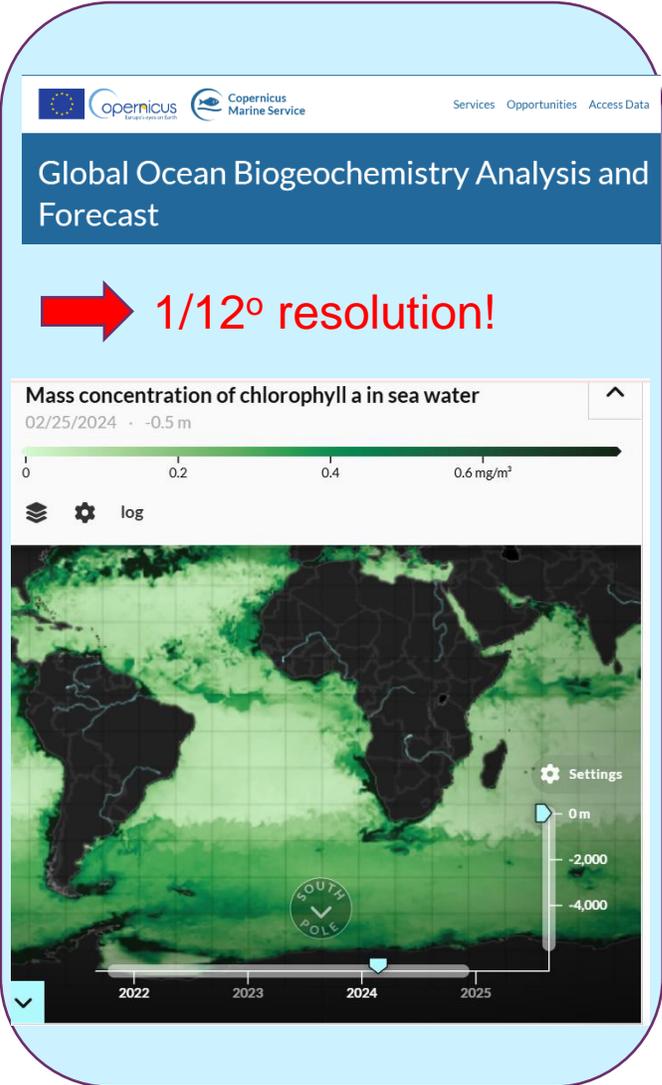
Upwellings captured by model

- ✓ California
- ✓ Humboldt
- ✓ Canary (Iberian)
- ✓ Benguela
- ✓ Somalia and Oman
- ✓ Guinea
- ✓ Java-Sumatra
- ✓ Indian Peninsula
- ✓ Augulas
- ✗ South China sea
- ✗ Arafura sea

Shailee Patel et al, in prep



TOWARDS A GLOBAL “UPWELLING WATCH” SYSTEM



CONCLUSIONS AND RECOMMENDATIONS



For Biogeochemical Modellers:

- Don't hesitate to incorporate human dimensions into your models.
- Act Now: Don't wait for a perfect end-to-end fully coupled model! Utilise available approaches: qualitative, quantitative, two-way coupled, and one-way coupled.

For Socio-Economic Scientists, Impact Experts, and Interdisciplinary Researchers:

- Embrace complexity of ecosystem risk indicators.
- Collaborate with BGC Modellers: There is much more to impacts than just SST and Chl-a!