

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

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# A 3.5-DECADE JOURNEY OF 3D GLOBAL BIOGEOCHEMICAL MODELS

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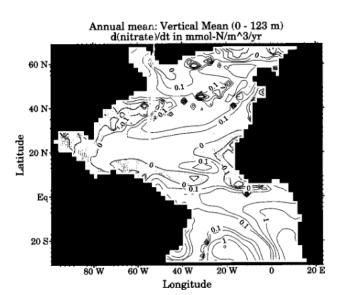


Fig. 4. Map of the change in nitrate concentration during year 3 of the simulation. Contour interval is  $0, \pm 0.1, \pm 0.2, \pm 0.5, \pm 1.0, \pm 2.0$ , etc.

#### Sarmiento et al., 1993



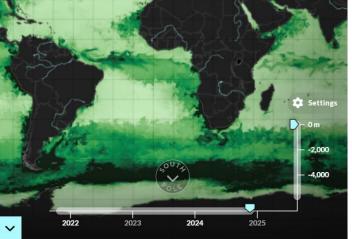
1/12 resolution in hindcasts and projections

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

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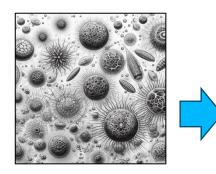
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1/4 resolution in global operational forecast

## **KEY TYPES OF SOCIO-OCEANOGRAPHIC MODELS**



**BGC Models** 

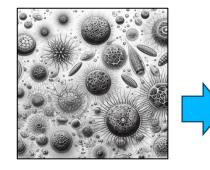


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Participatory and co-management Models and Actions

# **KEY TYPES OF SOCIO-OCEANOGRAPHIC MODELS**





**BGC Models** 



Climate Change Risk and Vulnerability Models



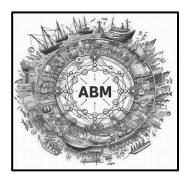
mCDR Models



MSP Models

Coupled Human-Natural

Systems Models



Agent-based Models



Economic Models



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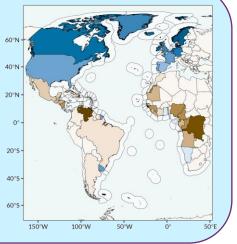
Participatory and co-management Models and Actions

# **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)



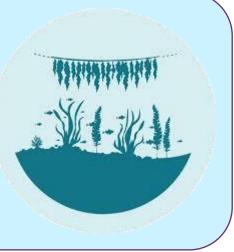
#### Towards a global "Upwelling Watch" system

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



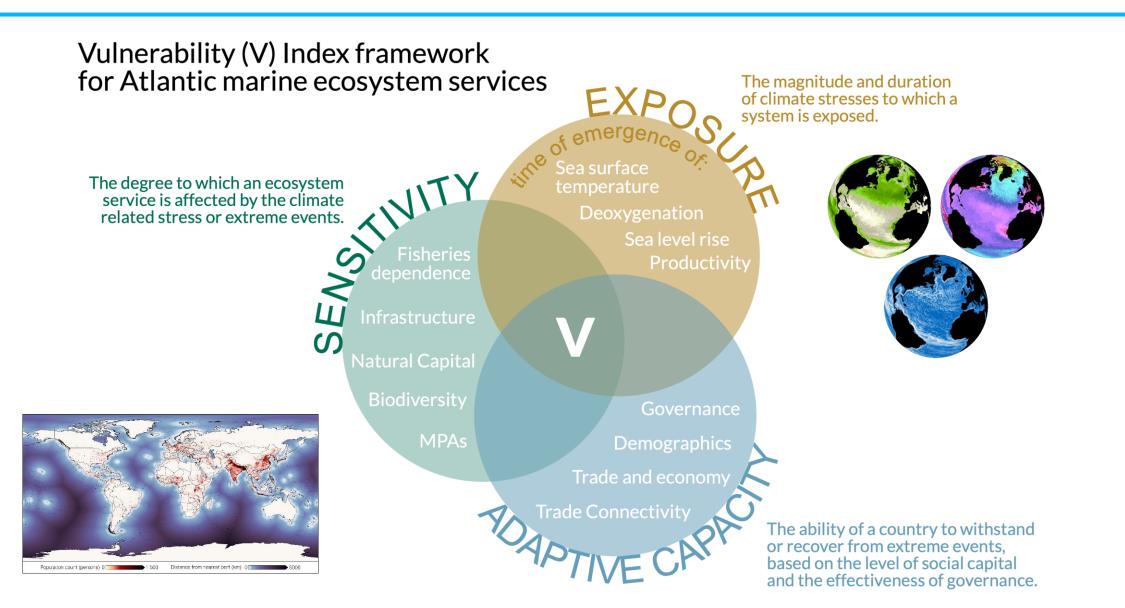
Environmental Digital Twin with socio-economic components

Macroalgae for carbon dioxide removal (Scaling up experiments)



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

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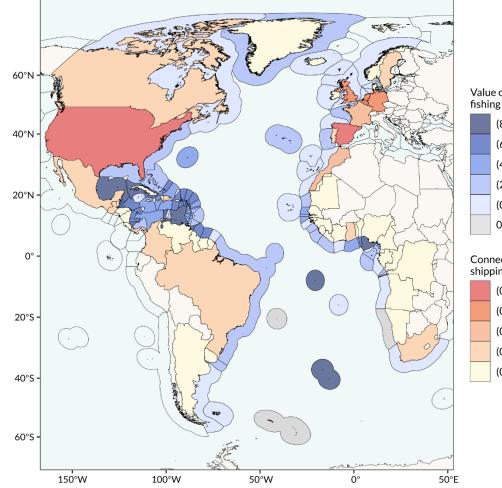
## TYPES OF DATA DESCRIBING HUMAN DIMENSIONS OF GLOBAL-SCALE SOCIO-OCEANOGRAPHIC SYSTEMS

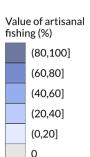


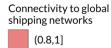
Population and demographics (e.g. coastal population density, age structure)	Economic activities (e.g. employment in blue economies, revenue, GDP)	Social data (e.g. education, cultural practices)	Management, governance and policy (e.g. MPAs, pollution regulation)
Land and sea use and infrastructure data (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**

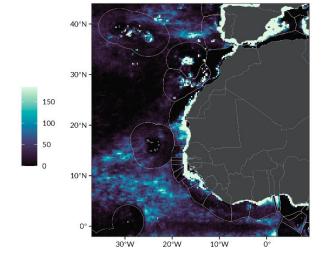


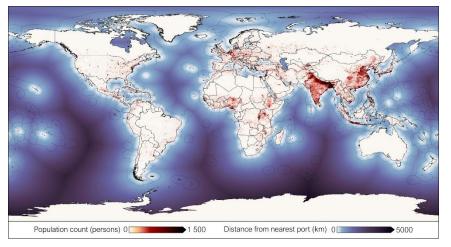






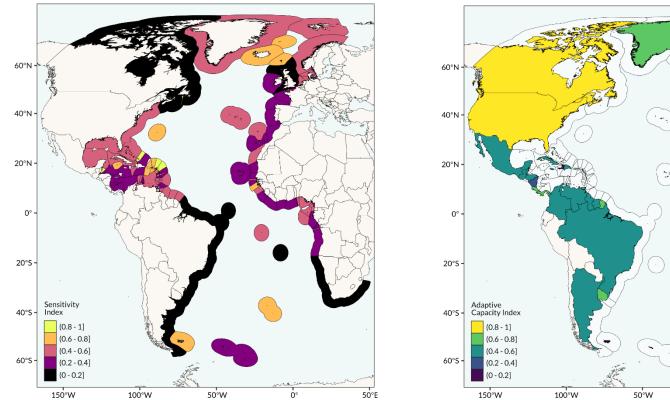


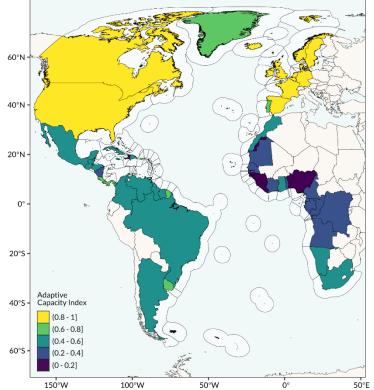




## **VULNERABILITY OF MARINE ECOSYSTEM SERVICES OF THE ATLANTIC RIM COUNTRIES TO CLIMATE CHANGE IMPACTS (PRELIMINARY RESULTS)**







#### Socio-economic indicators

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#### Sensitivity index

Adaptive capacity index



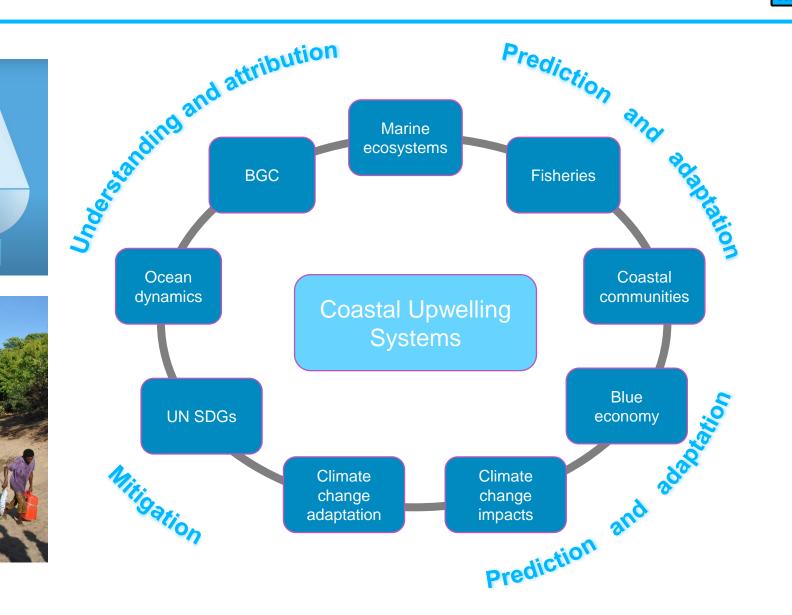




# COASTAL UPWELLINGS: AT THE CROSS ROADS OF OCEAN DYNAMICS AND SOCIO-ECONOMICS

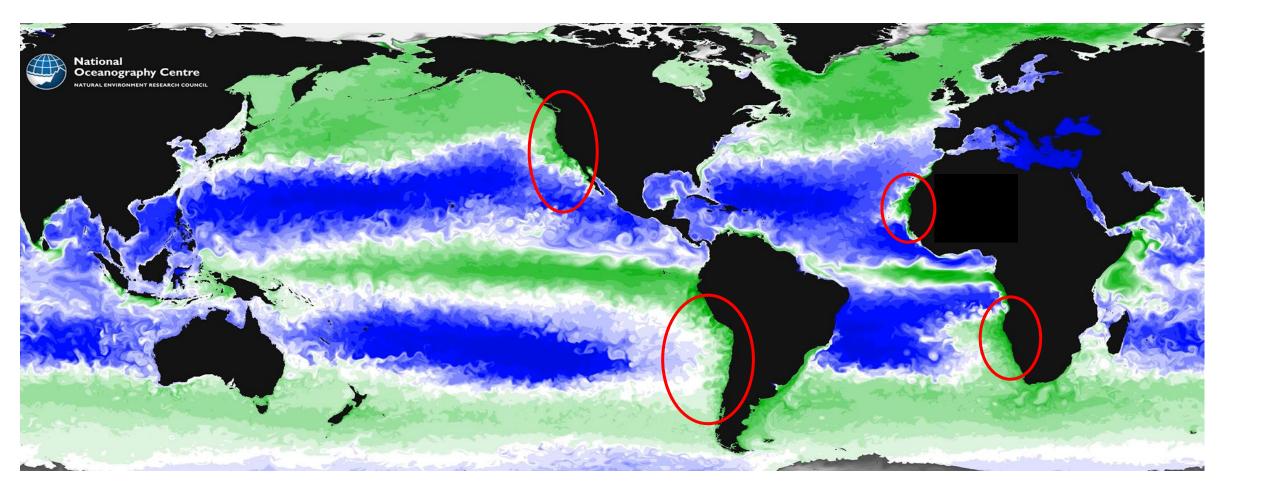






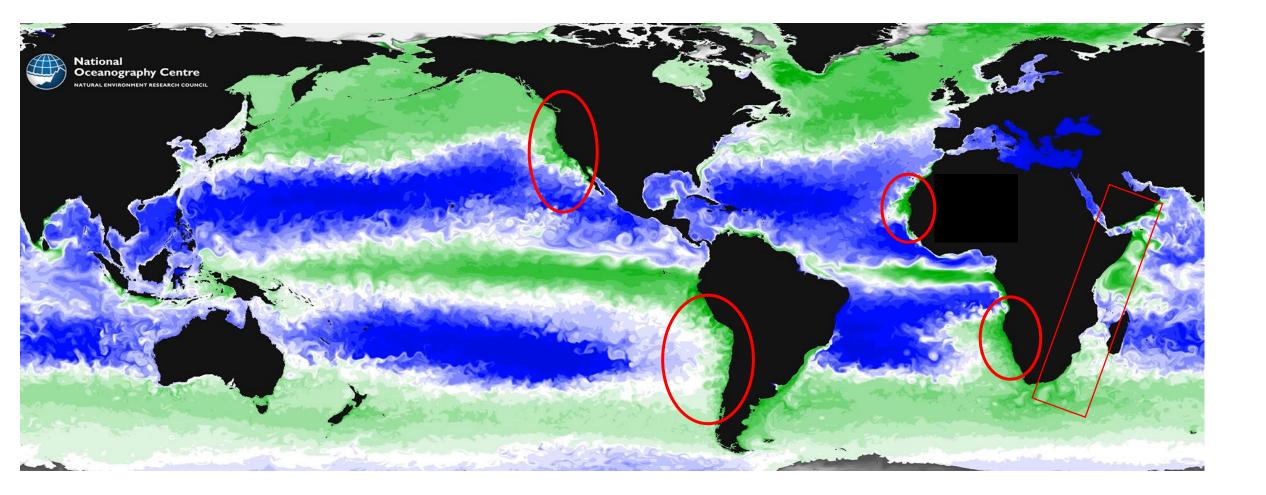
## **"UPWELLING WATCH"**





## **"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?

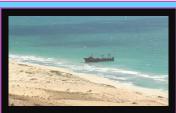




**Tanzania:** upwelling as a driver of the small pelagic fishery underpinning food security of the coastal population



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







## AGULHAS UPWELLING AND COLLAPSE OF THE CHOKKA SQUID FISHERY

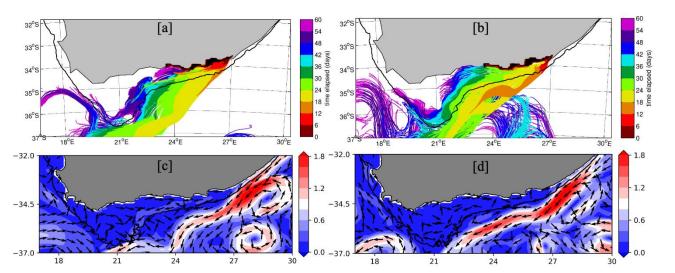


The collapse of the Chokka squid fishery in 2013 had a devastating effect on the Eastern Cape, one of the poorest provinces in South Africa. The reasons for the collapse were tightly linked to the dynamics of the Agulhas Bank upwelling.











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

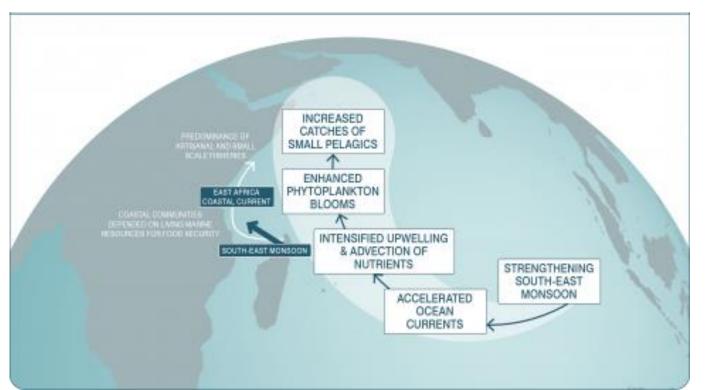


# EAST AFRICAN COASTAL UPWELLING



## 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<sup>1,\*</sup>, Zoe Jacobs<sup>1</sup>, Dionysios E. Raitsos<sup>2,3</sup>, Meric Srokosz<sup>1</sup>, Stuart C.





# NORTH KENYAN BANKS UPWELLING

National Oceanography Centre

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.





Nairobi Metro Coast Mountain Lake Region Rift Valley Northern

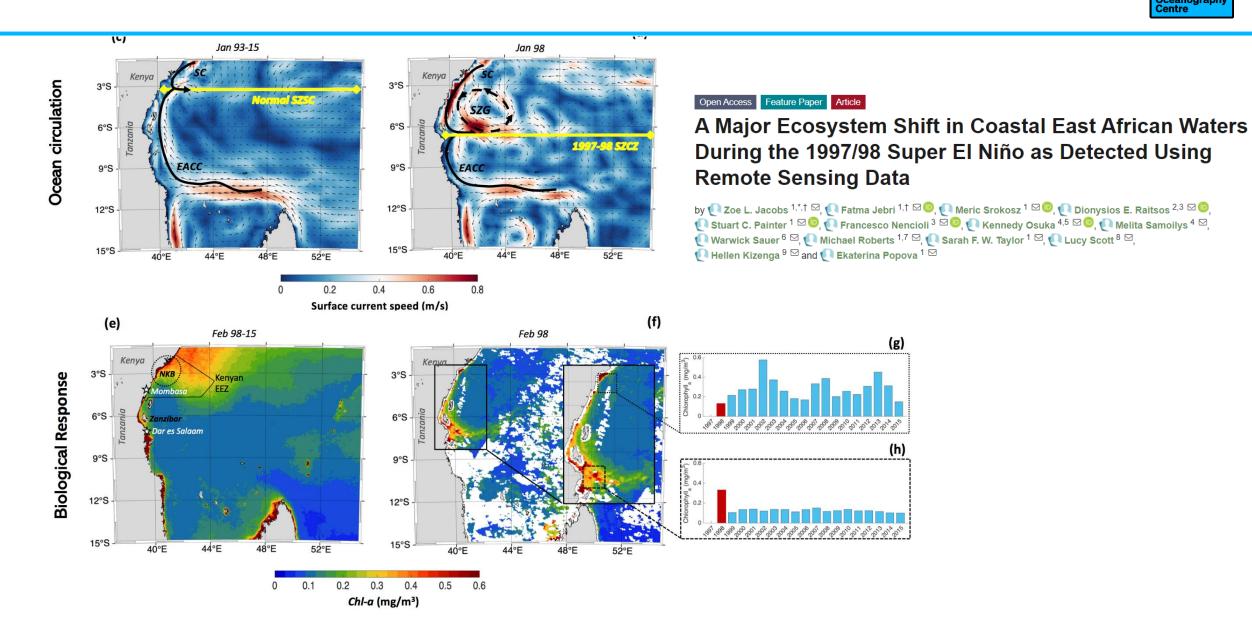
# Tonnes of tuna fish rot in Lamu due to lack of market

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



## **UPWELLING PUBLICATIONS HIGHLIGHTS**





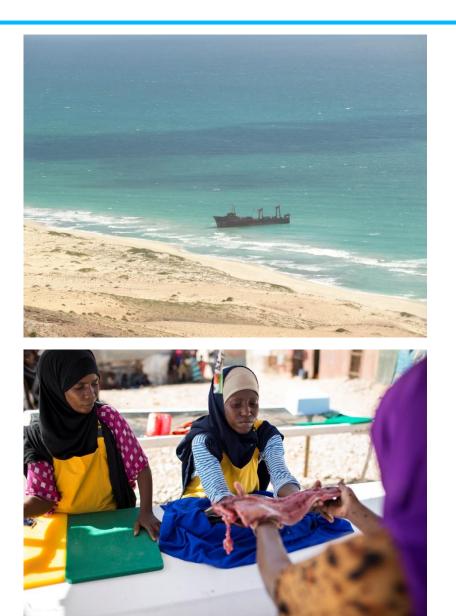


# THE FUTURE FATE OF SOMALI UPWELLING ECOSYSTEMS



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

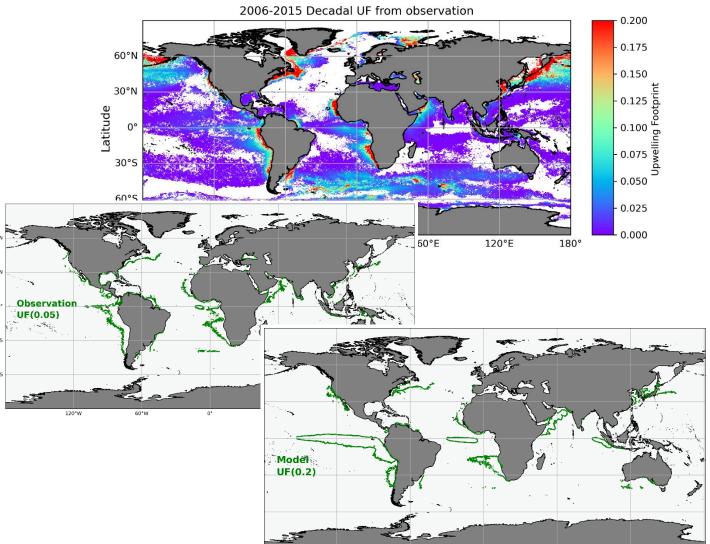
- Combined SST metric and Chl-a metric delineates coastal upwelling systems where lowest SST coincides with high Chl-a.
- "Upwelling footprint" refers to the spatial extent or impact area of the coastal upwelling

#### Upwellings captured by model

<ul> <li>California</li> </ul>	
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- Humboldt
- Canary (Iberian)
- Benguela
- Somalia and Oman
- Guinea
   Java-Sumatra
   Indian Peninsula
- Augulas
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  - × Arafura sea

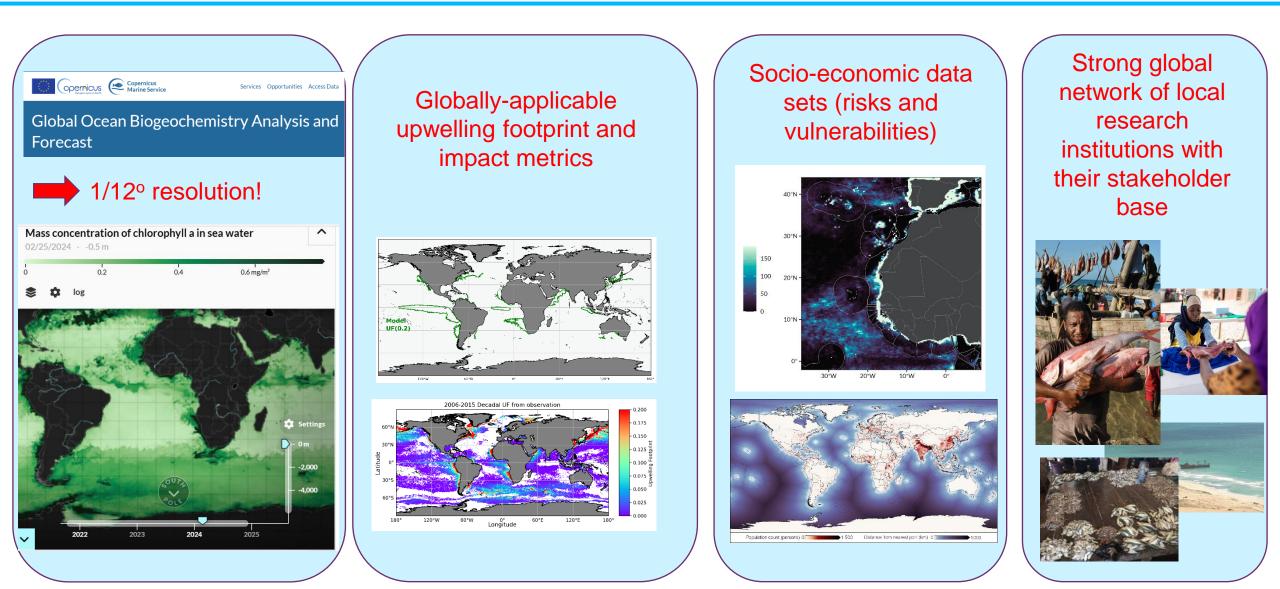
#### Shailee Patel et al, in prep





# TOWARDS A GLOBAL "UPWELLING WATCH" SYSTEM





## **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!