Reef and wild fishery conservation through exploiting satellite remote sensing of the marine carbonate system

Website: https://esa-oceansoda.org/
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Background
Since the beginning of the industrial revolution humans have released approximately 500 billion metric tons of carbon into the atmosphere. About 30% of this carbon dioxide (CO2) has been taken up by the oceans, largely by the dissolution of this CO2 into seawater and subsequent reactions with the dissolved carbonate ions present in seawater. The long-term uptake of carbon dioxide by the oceans is reducing the ocean pH, a process commonly known as ocean acidification, and altering the ocean chemistry and ecology, impacting marine ecosystems on which we rely.

Recent work has begun to investigate the use of satellite Earth Observation (Land et al. 2015; Land et al. 2019), especially focusing on satellite surface salinity and sea surface temperature data, exploiting empirical methods to monitor surface-ocean carbonate chemistry. These techniques complement in situ approaches by enabling the first synoptic-scale observation-based assessments of the global oceans and are particularly well suited to monitoring large episodic events. The Satellite Oceanographic Datasets for Acidification (OceanSODA) project will further develop the use of satellite Earth Observation for studying and monitoring marine carbonate chemistry.

Large river inputs to the global ocean
Satellite observations will be used to characterise the real influence and variability of the river carbonate inputs into the Atlantic. The analysis of these time series data (downstream studies), designed in collaboration with coral reef researchers NOAA and WWF, will identify reef regions that favour higher calcification rates (more likely resilient to ocean acidification).

Eastern boundary upwelling systems
Upwelling events can be associated with episodic ocean acidification and low oxygen. These regional-scale dynamics are not well represented in climate models (Small et al., 2015, Di Lorenzo, 2015). OceanSODA will characterize two upwelling systems to identify their synoptic scale and temporal extent and investigate linkages between upwelling driven changes in the carbonate system and fishery catches. These downstream evaluation will be designed in collaboration with WWF and NOAA.

Global analysis of extreme ocean acidification and compound events
We will develop new methods based on observations from space and in synergy with in situ and model data to detect extreme events from space observations. This will provide the first global-scale assessment of the occurrence, distribution, and severity of these events. Of particular interests are the events that co-occur with other stressors (compound events). Downstream impact studies will be performed (in partnership with WWF and NOAA) to assess impact on reef health, fishery catch and recruitment.

Study regions showing eight geographic regions (solid boxes) used within OceanSODA. These include areas of river plumes (large freshwater discharge) in the Amazon and Orinoco (A), Congo (B), Mississippi (C), St. Lawrence estuary and outflow (D), and vulnerable eastern boundary upwelling systems, in the Benguela (E), Canary (Mauritanian, F) upwelling systems, Californian coast (G) and Barents Sea (H).

Summary of prominent recent marine heat waves. The figure shows the maximum sea surface temperature anomaly in regions where temperature exceeds the 99th percentile using NOAA’s daily optimum interpolated sea surface temperature dataset. The 99th percentile is calculated over the 1982-2016 reference period. Source: Frolicher and Laufkotter, 2018.

Case studies: science and downstream studies

Outs: Planned publically available data products
The project will identify the optimal algorithms and inputs for each study region and their combined uncertainties. These optimal approaches will be used to calculate spatial time series data for the downstream impact studies. All data will be made available on an open access FTP server. The data for each geographic region will include:
- Total sea surface alkalinity (TA)
- Sea surface partial pressure of CO2
- pH
- Sea surface aragonite saturation state

Outputs

Preliminary results showing total alkalinity for the Amazon Plume
(a) (b)

Example optimal time series results for the Amazon Plume
(a) (b)

Preliminary results showing total alkalinity for the Amazon Plume using Aquarius salinity (monthly mean), World Ocean Atlas 2014 nitrate and the TS13 algorithm from Pathfinder-OA. (a) Derived surface total alkalinity for April 2012. Overlaid circles show in situ observations collected in April and May 2012 from the GLODAPv2 dataset. (b) Derived observations of total alkalinity between August 2011 and June 2015. Source: Land et al. 2019.

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(c) (d) (e) (f) (g) (h)

Scientific management
The project will be managed by the University of Exeter, UK, with collaboration with WWF and NOAA. The project will be delivered in collaboration with an international steering committee and an expert technical steering group. The project will be delivered in collaboration with the European Space Agency, NASA and the European Space Agency, including the implementation of satellite Earth Observation-based mission through ESA’s OceanSODA project.

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