



POLICY BRIEF

POLICY BRIEF | SEPTEMBER 2023

Using Remote Sensing Data to Monitor Primary Production in Cabo Verde: A Step Towards Smarter Ocean Management

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MAIN HIGHLIGHTS

- This study shows seasonal variability in Chlorophyll-a, peaking in winter and spring, and declining in summer and autumn. Significant years were 2015 and 2018, correlating with high fish catch in Cabo Verde. A notable shift in Chlorophyll-a levels started in 2013, showing a consistent rise.
- Monitoring Chl-a helps therefore understand the productivity and distribution of fish species in the region.
- A surveillance team trained in remote sensing must be set up to monitor primary production on a regular basis.

1. Background

More than 70% of the Earth's surface is covered by the ocean, making it the largest expanse (Costanza, 1999). The relationship between ocean ecosystems and global climate change is attracting much attention in recent years (Spring, 2019; Siswanto et al., 2020). As the base of the marine food web, phytoplankton plays a fundamental role in the biogeochemical cycling of elements by converting inorganic elements into organic components. Phytoplankton are advected microalgae and therefore dependent on marine currents. They can photosynthesize using light and nutrients such as NO₃ (Nitrate), PO₄ (Phosphate), Si (Silicate), Fe (Iron) and carbon dioxide (CO₂) available in the water to produce oxygen and organic matter. As primary producers, many marine organisms, in-

cluding fish, depend on them for their nutrition. They also contribute also to roughly half of the fixed carbon on the planet by absorbing atmospheric CO₂ and producing 50% of dioxygen (O₂) essential for life on the earth's surface (Martin, 2014). In the current scenario of climate change, a noticeable decrease in primary production on a larger scale has been observed. (Boyce et al., 2010).

Chlorophyll-a (Chl-a) is a pigment found in algae and other photosynthetic organisms. Of all the types of chlorophyll, it is Chl-a that serves as a key indicator of phytoplankton biomass in the ocean (Behrenfeld & Falkowski, 1997).

While estimating microscopic phytoplankton numbers and associated primary productivity is a

significant challenge for ships (Dierssen & Randolph, 2012), satellite remote sensing of ocean color has become a reliable tool to study phytoplankton dynamics over various timescales (Vantrepotte & Mélin, 2009; Krasnopolsky et al., 2016).

The Cabo Verde (CV) archipelago, our study focus, experiences diverse hydrographic conditions (Figure 1) due to the convergence of ocean currents and coastal upwelling. Positioned primarily between the oligotrophic and mesotrophic zones near the African coast, the islands are influenced by the Canary Current (CC) and the North Equatorial Current (NEC). Furthermore, the southern side of the islands is seasonally affected by the North Equatorial Counter Current (NECC) due to the movement of the Intertropical Convergence Zone (ITCZ), leading to changes in wind patterns (Ramos et al., 2012).

Existing literature indicates a substantial decrease in Chl-a levels around CV from 1992 to 2005, particularly during 2000-2004. However, the precise spatio-temporal variability and trends of Chl-a remain unclear, creating a knowledge gap regarding its dynamics in this region.

This study centers on the significance of Chl-a

2. Approach and findings

The study relied on monthly Chlorophyll-a (Chl-a) data obtained from Aqua-MODIS Level 3, with a 4 km spatial resolution beginning from 2002 to 2022. Satellite imagery of Chl-a was employed to create monthly and yearly surface maps. These images were also used to generate time series for temporal variability analysis. To evaluate the influence of Chl-a variability on fish catch, annual data from the National Institute for Fisheries Development CV, was utilized. This data specifically focuses on the comparative evolution of artisanal and industrial fisheries landings by species group from 1999 to 2022 (in tons).

The satellite images were analyzed using Python programming language. They were calculated (for the whole 2003 - 2022 period, as well as for each month in the same multi-annual period) using the

levels in the ocean as an indicator for fishery yields. It aims :

- to characterize the seasonal and interannual variability and trends of Chl-a around the Cabo Verde Islands.
- to investigate the relationship between Chl-a and fish landing from 2003 to 2022.

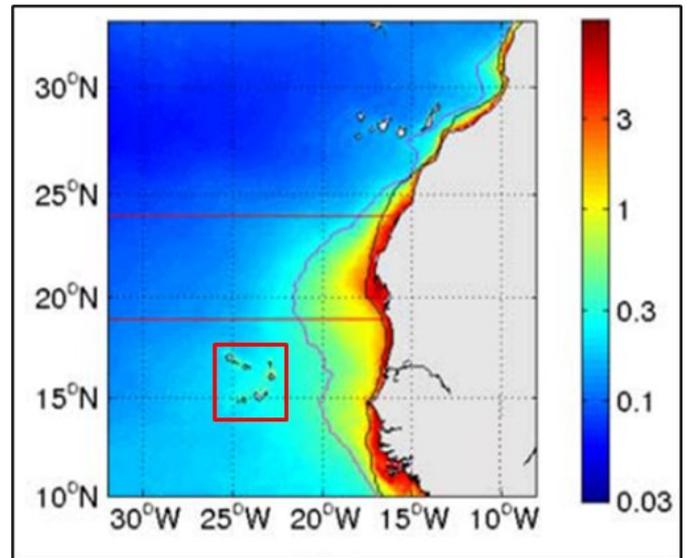


Figure 1 : Surface Chl-a (mg/m^3), derived from SeaWiFS (Lathuilière et al., 2008).

following equation:

$$\bar{X}(x, y) = \sum_{i=1}^n X_i(x, y, t_i) \quad (\text{Eq1})$$

$\bar{X}(x, y)$ is the monthly mean value or monthly climatology value at position (x, y) . $X_i(x, y, t)$ is the t^{th} value of the data at (x, y) position. n is the number of monthly data used to calculate the monthly climatology and annual climatology. If X_i is an empty pixel, that pixel is not considered. The correlation analyses were carried out using the Pearson correlation.

The analysis provided insights into the seasonal variability of Chl-a in CV.

From the monthly climatologies, the results show that the maximum Chl-a values were recorded in

January, reaching approximately 0.32 mg/m^3 . In contrast, the minimum values were observed in August, with concentrations around 0.15 mg/m^3 . This indicates an increase during winter and Spring and a decrease during summer and Autumn. Studies in the region (Pradhan et al., 2006) have linked this enrichment during winter to processes like convection and advection from upwelling, which have a coherent relationship with Chl-a. However, the influence of these processes might be regional, with sporadic upwelling occurrences.

2015 and 2018 show higher Chl-a with January 2018 depicting an important signal from the satellite image (Figure 2). Moreover, the Chl-a concentration surpassed 0.5 mg/m^3 for the same

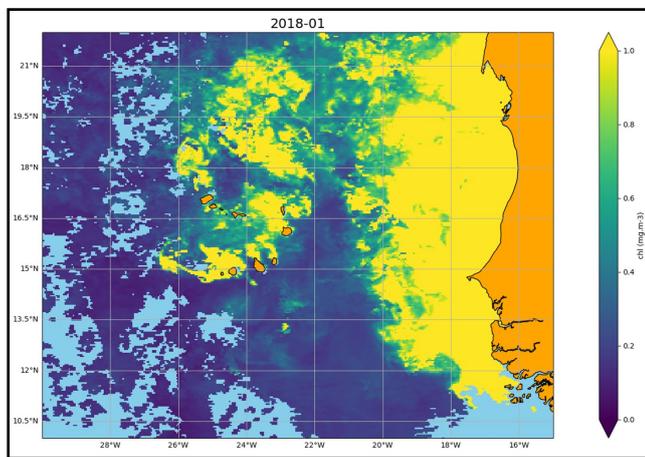


Figure 2: Surface mean Chl-a map for January 2018

3. Conclusions

- Seasonal analysis of Chl-a concentrations indicates peaks in January and lows in August, signifying increased levels during winter and spring, and a decrease in summer and autumn.
- Notable regime shifts in Chl-a dynamics are observed, with a consistent upward trend in values from 2013 onwards.
- High Chl-a years in CV correspond with periods of abundant fish catches, while years of low Chl-a productivity align with reduced fish catches, indicating a strong correlation between Chl-a levels and fishery yields.

month. Furthermore, the analysis of interannual Chl-a variability reveals a regime shift from 2013 onwards, with increasing Chl-a values over time.

The analysis of Chl-a variability and total fisheries landing in CV reveals a notable similarity in their patterns. High Chl-a years align well with years of large fish catches in CV (Figure 3), while low productivity years correspond to years of low fish catches. For example, the years 2015 and 2018, which were characterized by high fish catches, also exhibited high Chl-a.

Overall, Chl-a showed a strong positive correlation with the catch of small pelagic fish and tuna, with respective correlation coefficients of 0.72 and 0.78.

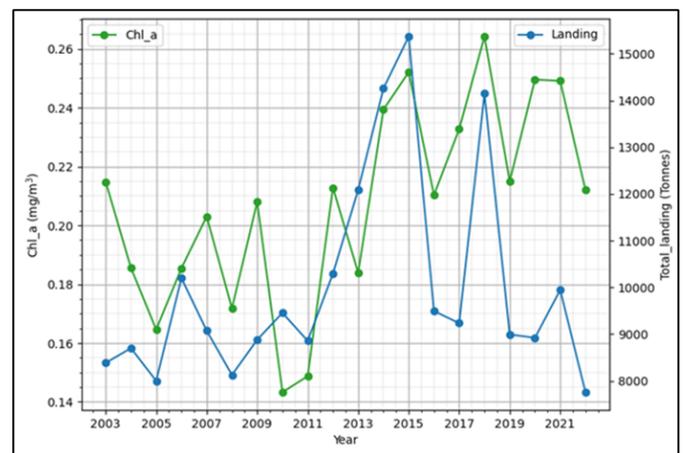


Figure 3: Interannual variability of Chl-a and Total fisheries landing

4. Policy Recommendations

- Implement seasonal monitoring programs to capitalize on the peak Chl-a concentrations observed in January, ensuring sustainable fishing practices during periods of increased phytoplankton abundance.
- Establish adaptive management strategies that account for the observed regime shifts in Chl-a dynamics, emphasizing the need for flexibility in response to changing environmental conditions.
- Strengthen fisheries management policies during years of high Chl-a, focusing on sustainable harvest quotas and ensuring adequate enforcement to prevent overfishing during periods of abundant fish populations.

5. Implications

1. Understanding the seasonal variability of Chl-a allows for more precise planning of fishing activities.
2. Recognizing the regime shift in Chl-a dynamics from 2013 onwards provides a valuable indicator of potential long-term changes in marine productivity.
3. The strong correlation between Chl-a levels and fishery yields highlights the interconnectedness of marine ecosystems.
4. Implementing measures that align fishing activities with periods of higher phytoplankton abundance can lead to more sustainable and productive fisheries, benefiting both the environment and local economies.

6. Reference list

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ACKNOWLEDGEMENT

This policy brief presents research funded by the German Federal Ministry of Education and Research (BMBF) in the framework of the West African Science Service Centre on Climate Change and Adapted Land Use (WASCAL) through WASCAL Graduate Studies Programme in Climate Change and Marine Sciences at the Institute for Engineering and Marine Sciences, Atlantic Technical University, Cabo Verde.



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Source: Kodjo Olivier ASSOKPA, Master's thesis in Climate Change and Marine Sciences, "Assessing the spatio-temporal variability of Chlorophyll-a across Cabo Verde using remote sensing data", September 2023.

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