Use of HICO in the Southern Benguela: Saldanha Bay case study

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Introduction

Saldanha Bay is a partially enclosed bay located on the west coast of South Africa approximately 100 km north of Cape Town (figure 1). The sheltered nature of the embayment and its proximity to the productive Benguela upwelling system has led to it being a key mariculture site in South Africa. Nearly the entire black mussel (*Mytilus galloprovincialis*) industry is located here and it is one of four sites used for the culture of Pacific oysters (*Crassostrea gigas*) in South Africa.

Saldanha bay is located close to St Helena Bay, a site of extremely high productivity in the Benguela current large marine ecosystem (BCLME). This region frequently suffers from Harmful Algal Blooms (HABs) which, upon entering Saldanha Bay, can have a negative biological and economic impact on the shellfish farms. Ocean colour remote sensing offers a platform for monitoring HABs near and inside of the bay and could also potentially aid in the estimation of the carrying capacity for the bay for mariculture. HICO imagery specifically offers the opportunity to acquire information about the phytoplankton biomass distributions within the bay at a higher spatial resolution than with the use of previous methods (e.g. MERIS FR data).

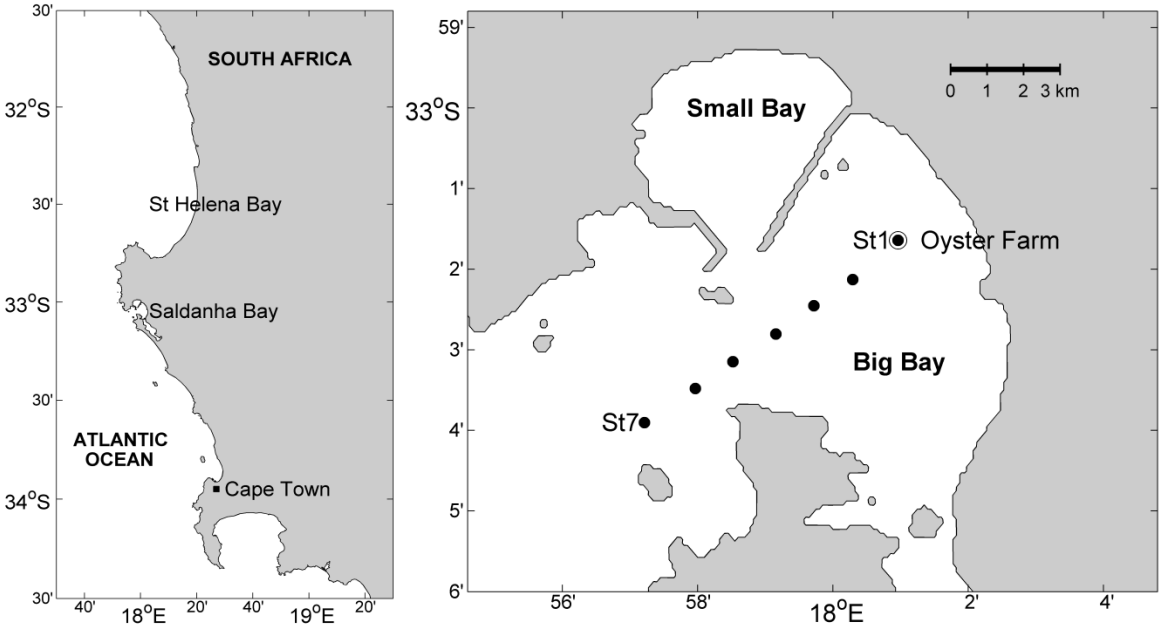

Figure 1. The left image indicates the location of Saldanha Bay relative to Cape Town and St Helena Bay. The right image shows the layout of Saldanha Bay and gives the locations of the transect sampling stations in Big Bay; station 7 is near the mouth of the bay and station 1 is at the oyster farm.

Methods

In situ data collection

Data were collected in a transect of seven stations (figure 1) that extended from the oyster farm (station 1) to the mouth of the bay (station 7). Each station included a CTD cast as well as surface water collection for Chl-a analysis. Chl-a samples were extracted in 90% acetone and analysed fluorometrically with correction for phaeopigments (Holm-Hansen et al 1965).

HICO data

The HICO satellite match-up data were collected during November 2012 and January 2013. HICO L1b data were obtained from NASA and processed through SeaDAS v7 to get the Level 2 chlor_a product.

A fluorescence line height (FLH) type approach (Gower et al 1999) was also applied to raw top of atmosphere (TOA) radiance data to assess phytoplankton biomass:

$$\mathrm{FLH} = \mathrm{Lt2} - \mathrm{Lt1} - (\mathrm{Lt3} - \mathrm{Lt1})\frac{(\lambda_2 - \lambda_1)}{(\lambda_3 - \lambda_1)}$$

where Lt1, Lt2 and Lt3 represent the TOA radiance at 661.7, 679.02 and 719.12 nm respectively. The regression equation of in situ Chl-a versus the HICO FLH variable was used to create a Chl-a product for comparison with the SeaDAS product.

Results and Discussion

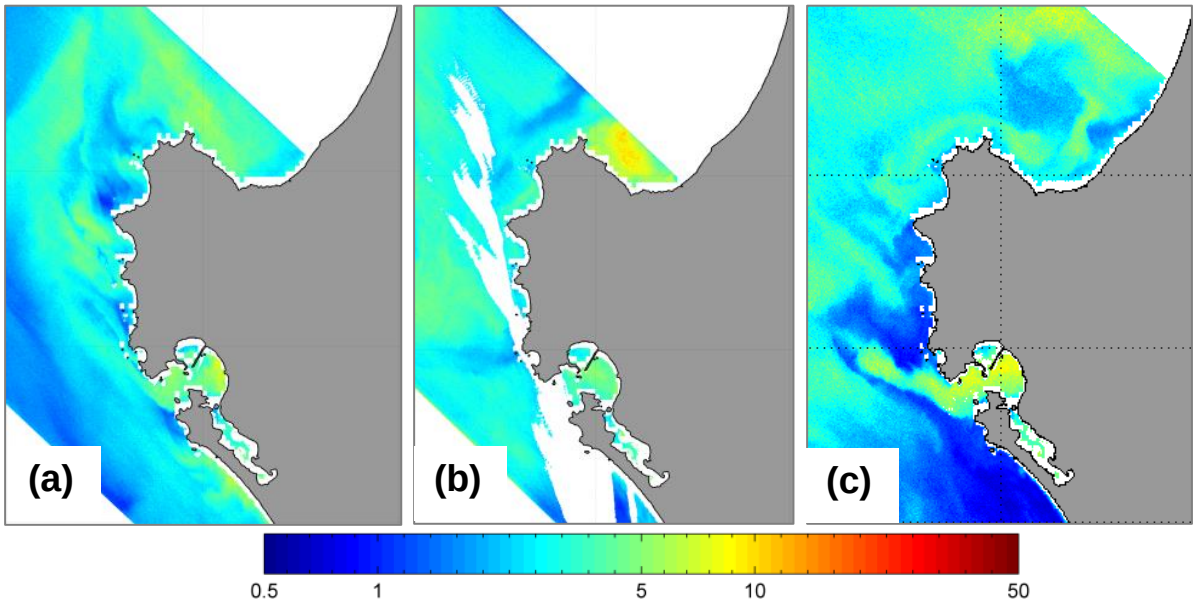

Figure 2. The HICO chlor_a product (mg m^{-3}) for (a) 21 November 2012, (b) 17 January 2013 and (c) 20 January 2013

During January 2012 to January 2013 the surface Chl-a measurements inside Saldanha Bay ranged from 3.54 to 29.33 mg m^{-3}, whilst concentrations of up to 54.95 mg m^{-3} were measured at the mouth of the bay. The chlor_a images processed with

SeaDAS can be seen in figure 2; the Chl-a concentration appeared to be lower than expected for Southern Benguela during the summer months. This was confirmed in figure 3 where the chlor_a product tended to underestimate chl-a values inside Saldanha Bay by an average of 363% and showed a poor correlation with in situ data.

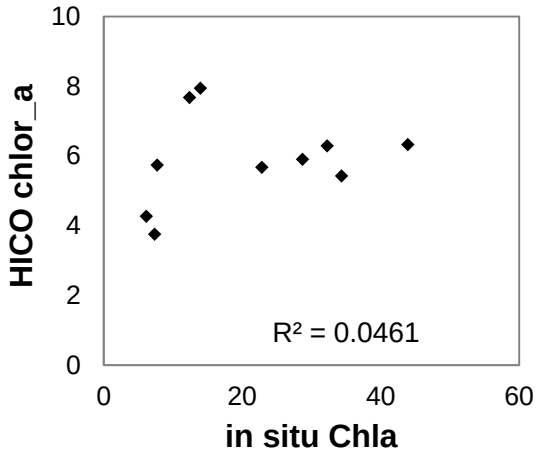

Figure 3. HICO chlor_a product versus in situ Chl-a

Due to the high biomass of the Southern Benguela, the correction for atmospheric aerosols over the region has always been prone to large errors. As a result, algorithms based on the blue or green regions of the spectra (such as the chlor_a product) have a tendency to fail under these conditions.

The high biomass of the Southern Benguela provides a strong fluorescence signal in the red and NIR in L1b radiance data. Within Saldanha Bay, where concentration of Chl-a are generally lower than the adjacent Benguela region, an FLH type approach could provide an estimate of phytoplankton biomass. Figure 4 shows a good relationship between the HICO FLH and in situ Chl-a.

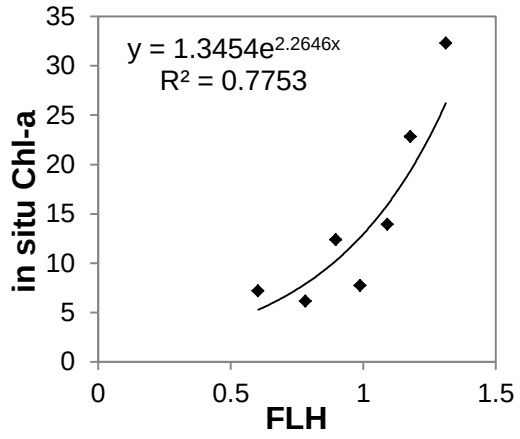

Figure 4. Chl-a versus the HICO FLH variable for Saldanha Bay

The exponential regression equation of figure 4 was used to derive the Chl-a concentration for the three HICO images in figure 5. The Chl-a concentrations in figure 5 are generally higher than the SeaDAS chlor_a product, and closer to what would be expected for the Southern Benguela.

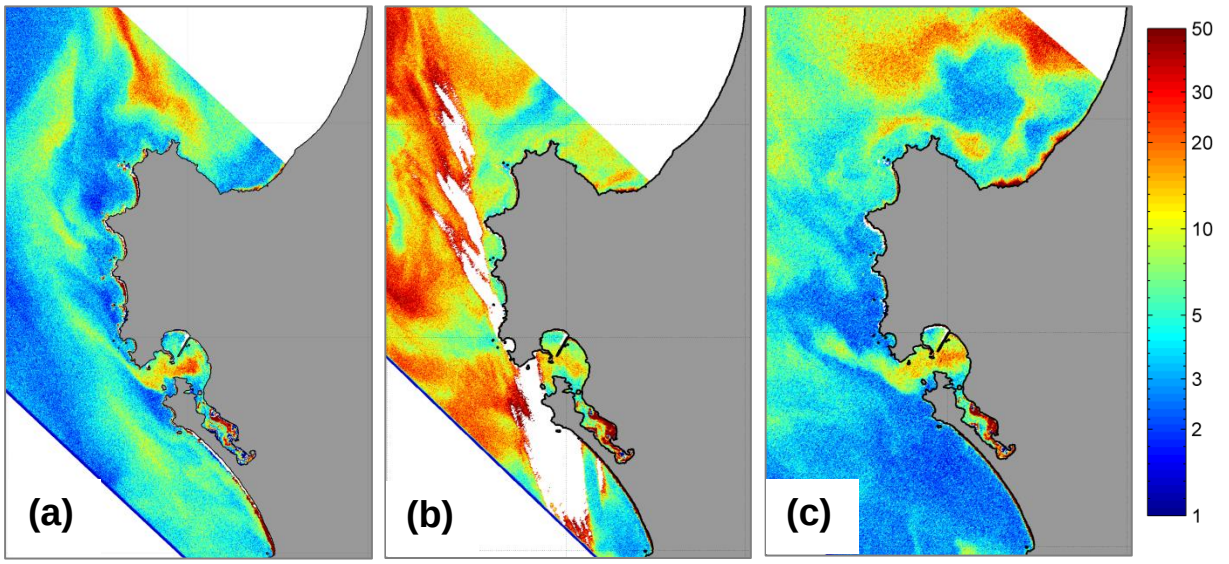

Figure 5. The Chl-a product derived from the fluorescence line height of HICO L1b TOA radiance data for (a) 21 November 2012, (b) 17 January 2013 and (c) 20 January 2013

This FLH algorithm provides a qualitative estimate for the Chl-a in the region and is not expected to provide accurate results under all conditions. Some of the flaws of the current algorithm include:

- No correction for gaseous absorption or Raleigh scattering
- The fluorescence peak is known to shift towards the NIR during high biomass events which could lead to negative FLH values and failure of the algorithm.
- Small sample size of match-up data

Future work will endeavour to correct for gaseous absorption and Raleigh scattering. New algorithms for the Southern Benguela will use approaches such as the maximum peak-height (MPH) algorithm (Matthews et al 2012) or the adaptive reflectance peak height (ARPH) algorithm, which would enable the algorithm to handle the fluorescence peak shift during high biomass events. In situ data collection will take place throughout 2014 in St Helena Bay to increase the HICO match-up database. Specific focus will be on obtaining data during high biomass events.

References

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