This study aimed to investigate patterns in upwelling events at different distances from the coastline and to test whether the same patterns exist in the various datasets. As seawater temperature is known to have a large influence on species distribution and productivity (Bolton 2010; Smit et al. 2013), the benguela upwelling system is distinct in that it is one of four most productive regions in the world thus it is important to understand not only how temperatures vary at different distances from the coastline but to what intensity these events have varied at different distances from the coastline. In this way, the proximal causes of environmental change might be understood in terms of its relevance in affecting these important regions. Sinnett and Feddesen (2014) showed that various environmental factors such as solar radiation, air temperature, humidity and wave energy are responsible for temperature variation within the coastal region. Here, however, we examine if the same upwelling patterns exist at local and broader-scale SST fields.

Our results clearly show that upwelling events detected in different ocean sea surface temperature datasets showed different durations and intensities at different times. Some patterns were dominant and persistant throughout the datasets. It is also found that less upwelling events are occuring at a distance furtherest away from the coastline. In the satellite dataset often a distance of 10000km and 20000km from the coastline tend to show similar upwelling events. This difference appear to be related to nature and the variability of physical oceanographic processes at broad and loacal scales and other processes that could be playing a role. These findings illlistrate how dis similar satellite data is from in situ collected datasets.

The difference between the in situ and satellite derived data were striking. We anticipated a large degree of coupling in the datasets on local and broad scale, however instead the OISST satellite derived data yield a more intense events compared to the SACTN collected data. The CMC dataset shows that events are less intense throughout the various sites and more closely match with the in situ data. Events obtained from the OISST satellite data were also more frequent and represented a longer duration. The larger intensities from the in situ dataset may be an artifact of the innability of remotely sensed data to record maximum and minimum temperatures that in situ instruments are capable of detecting (Smale and Wernberg, 2009). The in situ collected data shows very few events detected at Port Nolloth, similarly, the CMC and OISST dataset also shows fewer upwelling events recorded at a distance of 10km within this region. Upwelling events recorded in Sea Point match closely with the events detected in the OISST dataset at a distance of 10km. The CMC dataset shows much different detected events with no major events. It is observed that the SACTN in situ collected temperature data shows similar patterns to the OISST dataset at a distance of 10km. Saldanha Bay shows the most frequent upwelling events detected throughout the datasets. However, the in situ and OISST dataset at a distance of 10km once again shows similar detections with CMC dataset at a distance of 10km from the coastline does not representing these detected events. At a distance of 30km – 50km the in situ detected events differ greately compared to the satellite derived temperature data.

Previous studies suggest that a longer time series containing more data would have greater accuracy indetecting subtle changes in temperature differences obtained from variable coastal regions such as the South African coastline. Schlegel and Smit (2016) suggested that having a time series of greater than 30 years for sites with a low variance results in increased ability to detect changes. They showed that high quality time series datasets have frequent measurements with minimal missing (NA) values present. Furthermore, low quality datasets (i.e. those with more than 5% of NA values) have a higher chance of detecting variation where none exists.

We would be amiss to point out some weaknesses inherent in the SACTN dataset. Temperature

measurement along the South African coastline started in the 1970s, and has been inconsistent in

terms of instruments used, modifications to styles and methods, calibration, and site locations (Smit et al. 2013; Schlegel and Smit 2016). Additionally, older records within some datasets, such as the

SACTN dataset, may have been lost or are unreliable since the metadata for these are unavailable.

These metadata are essential as their absence prevents the understanding of the influence that the

instruments had on temperature recordings. Some measurements may therefore not represent accurate or well-validated temperatures due to the instrumentation used; however, we mitigated these effects by selecting only the most reliable and longest duration data, which other studies (Williamson et al.,in progress) have suggested are most suitable for the problem at hand.

Data in the SACTN are comprised of multiple sources, acquired by various means, and efforts are

currently underway to homogenise these datasets (Williamson et al., in progress). The underwater

temperature recorders (UTRs) used to collect data in the SACTN dataset expressed a lower number of NA values compared to the data collected with hand thermometers. As such, this may have influenced the overall time series dataset (Schlegel and Smit 2016). The level of precision at which data were collected also influenced the length of the time series needed. Time series in which temperature was collected at a precision of 0.5oC may require another 24 months of recordings to precisely detect long term variation (Schlegel and Smit 2016). The average length of the thermometer time series component of the SACTN dataset was 346 months whereas the average length of UTR time series was less than half of that. With the extent of these differences in length being so severe, even once correcting for potential negative effects on the measurement precision of the thermometer collected time series, it was clear that thermometer data were more useful than that of UTRs. These influences may be expected to affect trend estimates of change derived from the data, but we do not anticipate that they have affected estimates of the variability in time and between sites in the way that they were used in this current study.

Satellite-acquired SST records are useful to modern marine scientists. These data are often used to

model and predict a wide range of oceanic and biological processes in the open ocean, but have only recently been used to study temperature variations influencing benthic organisms (Pearce, Faskel, and Hyndes 2006). SST data acquired by satellites deviate from coastal in situ collected seawater temperatures for a variety of reasons (Smit et al. 2013). The SST data presented the broader-scale situation along the coast, and we use it here as a forcing boundary that we hypothesise influence the coastal temperatures. Our analysis shows that the offshore SSTs (various sources) at a distance between 30km and 50km often do not match the detected events present within the in situ dataset along the west coast of South African.

EBUS, such at the benguela upwelling system are known to be highly variable across a wide spectrum of spatial and temporal scales, in both the forcing and response of the system. In some cases, a climate event can force large, temporary changes in overall productivity or community composition; these effects were seen during the large 1997-98 El Niño event and the delayed upwelling in 2005 in the California Current. EBUS are therefore be characterized as both resilient (quick recovery from disturbances) and robust (maintenance of ecosystem function and relatively high productivity) to natural climate variability, maintaining an abundance of species of high commercial and conservation value. However, the scale of future responses to anthropogenic climate change may be beyond the historical scales of variability , making forecasting the response of EBUS to climate change difficult.

The importance of understading the contributions of variation of upwelling on a local and broad scale relate to how productive these regions are but also indicated that upwelling found at a distance of 50km does not imply that the same upwelling events are present within the nearshore. Thus in order to detect coastal upwelling it is better to make use of coastal data. Within marine environments, coastal temperature variation allows for a variation in the spatial arrangements of marine biodiversity. Whilst wind and wave action may not be directly affecting ocean temperatures, Blamey and Branch (2009) have found that wave action has a profound influence on species distributions along the coastline. The presence or absence of marine species are determined by a variety of factors and whilst those factors may not be influencing each other as was the case here, they collectively play important roles in affecting the marine life of the South African coastline, and identifying those roles can aid in improving our understanding of nearshore dynamics, thereby providing greater knowledge to be used for conservation.