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# South African Kelp Moving Eastwards: the Discovery of Ecklonia Maxima (Osbeck) Papenfuss at De Hoop Nature Reserve on the South Coast of South Africa

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*Short Communication*

# South African kelp moving eastwards: the discovery of *Ecklonia maxima* (Osbeck) Papenfuss at De Hoop Nature Reserve on the south coast of South Africa

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**Historical and recent evidence is documented to demonstrate that the eastern limit of the major kelp-bed forming seaweed *Ecklonia maxima* has moved c. 73 km eastward along the south coast of South Africa since 2006, after remaining unchanged for almost 70 years. A significant population has established at Koppie Alleen, De Hoop Nature Reserve, which has been monitored from 2008 to 2011. It is hypothesised that the eastward spread is limited by aspects of the inshore water temperature regime, and recent evidence suggests that gradual cooling along this coast may have caused the change in distribution. It seems likely that if a cooling trend continues along the South African south coast, kelp beds and their associated species will move farther eastward in future decades, affecting the ecology and livelihoods along this coast.**

**Keywords:** biogeography, climate change, Laminariales, temperature



## Introduction

*Ecklonia maxima* is the dominant kelp on the west coast of South Africa, forming large beds in the southern portion of the Benguela region. The total biomass of surface-reaching kelp is estimated at around 530 000 t fresh weight (Anderson et al. 2007). This species, together with *Laminaria pallida* (a shorter kelp, which in the southern Benguela occurs as a sub-canopy species) and other smaller macrophytes, drives a major coastal ecosystem, being responsible for more than 50% of energy input into these kelp bed ecosystems (Field and Griffiths 1991). Up to 6 000 t per annum of these kelps have been harvested over the past decade for use as fresh feed in the abalone aquaculture industry (Anderson et al. 2003, Troell et al. 2006). Any change in the distribution of this ecosystem engineer species could have major effects on coastal ecology and livelihoods. From a review of the literature and from regular visits by the current authors around the coastline, we have recently observed that *E. maxima* has extended its distribution c. 73 km farther east (measured in straight lines around Cape Agulhas), onto a coastline considered to be part of the south coast or Agulhas Marine Province. This contribution records this potentially important finding.

## Results and discussion

### *The historical distribution of* Ecklonia maxima

*Ecklonia maxima* grows to 15 m in length (Stegenga et al. 1997), with a long, hollow stipe and a float holding its fronds at or near the surface in shallow water at low tide. A negative consequence of its great size is that, unlike other seaweeds, it is not possible to gather much information on its distribution from herbarium records. It has been recorded from north of Lüderitz in Namibia (Anderson et al. 2007) to a position just west of Cape Agulhas (the southernmost tip of Africa) in the south. This point was specified by Papenfuss (1942) as Papenkuilsfontein (a site c. 11 km west of Cape Agulhas (Figure 1), where it was growing in abundance in 1937. The only record east of this point is reported in Stephenson (1948), who stated that 'a colony of rather small but stout plants' was found by MA Pocock about 2 miles (3 km) east of Cape Agulhas. Pocock was a major collector of South African seaweeds (Bolton 1999) and this is the only published report of *E. maxima* east of Cape Agulhas, although Stegenga et al. (1997) thought it 'possible that these were a form of the variable *E. radiata*'. Cape Agulhas is a major biogeographical break in the distribution of coastal benthic organisms, considered by Stephenson (1948) to be the dividing line between the 'Western Overlap' and South Coast biogeographical regions. There is a major change in seaweed vegetation on either side of Cape Agulhas, most marked by the loss of kelp beds to the east, but also in intertidal communities (Stegenga et al. 1997, Bolton and Anderson 1997, Anderson et al. 2009).

### *The recent distribution of* Ecklonia maxima

In 1987, JJB and RJA conducted a commercial seaweed survey by helicopter, which included a low flight over the intertidal zone at low spring tide from Cape Town to Cape Agulhas lighthouse. Notes were made on 1 in 50 000 maps during the flight, and the map of this region has a written comment by RJA; '*Ecklonia* seen (indiv. plants)'. This comment is written close to the settlement of Suiderstrand (Figure 1), with nearby coastal features Bloubaai and Vlei se Bank, at the coast below the farm of Paapekuilfontein (sic). This was the easternmost surface kelp seen from the helicopter and was clearly the same place as that recorded (with slightly different spelling) by Papenfuss (1942). Since the 1980s, JJB and RJA have made many seaweed collections and other visits on low spring tides along the coastline between Cape Agulhas and De Hoop Nature Reserve (Figure 1), and at many sites farther west and east. They never previously observed *E. maxima* east of Cape Agulhas. A smaller, solid-stiped relative, *E. radiata*, has a distribution that may overlap slightly with *E. maxima*; drift plants of the former being observed just west of Cape Agulhas at Die Dam (Stegenga et al. 1997). Attached shallow-water plants of *E. radiata*, however, have not been observed west of De Hoop Nature Reserve (Bolton and Stegenga 1990), although Stegenga et al. (1997) suggested that plants with solid stipes in deep water (c. 20–30 m) in False Bay near Cape Town may be *E. radiata*. In laboratory culture, it was possible to produce small hybrid sporophytes between *E. maxima* and *E. radiata*, which have intermediate temperature tolerances to those of the parent kelp species (Bolton and Anderson 1987). The longer-term survival capabilities of hybrid sporophytes, however, is not known.

### Ecklonia *in De Hoop Nature Reserve*

Bolton and Stegenga (1990) recorded only *E. radiata* in the shallow, subtidal and intertidal rocks pools at Koppie Alleen, De Hoop Nature Reserve, and most plants were an unusual smooth-bladed form, with very few plants being of the more familiar spinose morphology. Intertidal pools some 3 km east of Koppie Alleen had only more typical spinose plants (see Figure 2b). This pattern of morphologies of *E. radiata* is still present along the De Hoop shoreline. In January in a number of years during the past decade, JJB supervised a student field course on the intertidal aeolianite ledges at Koppie Alleen, De Hoop Nature Reserve (Bolton and Stegenga 1990), to carry out surveys of biotic communities at spring low tide. It can thus be verified that *E. maxima* was not present at this site in January 2004, 2005 or 2006, and was not observed on a number of other visits between the mid-1980s and 2006. In August 2008, RJA and JJB led a seaweed collecting trip to the same shore at Koppie Alleen and observed significant populations of clearly hollow-stiped *E. maxima* plants, which were lining the walls of many low-shore gullies and in the immediate subtidal (Figure 2a). The larger plants were mature (fertile with sori). We visited the site again in January 2009, 2010 and January and February 2011, and the species is still present and thriving. So far we have only observed them within about 2 km of Koppie Alleen, and the species was not observed at Noetsie (De Hoop Nature Reserve; Figure 1) in April 2011. Our evidence thus strongly suggests that the species became obvious at Koppie Alleen between January 2006 and August 2008.

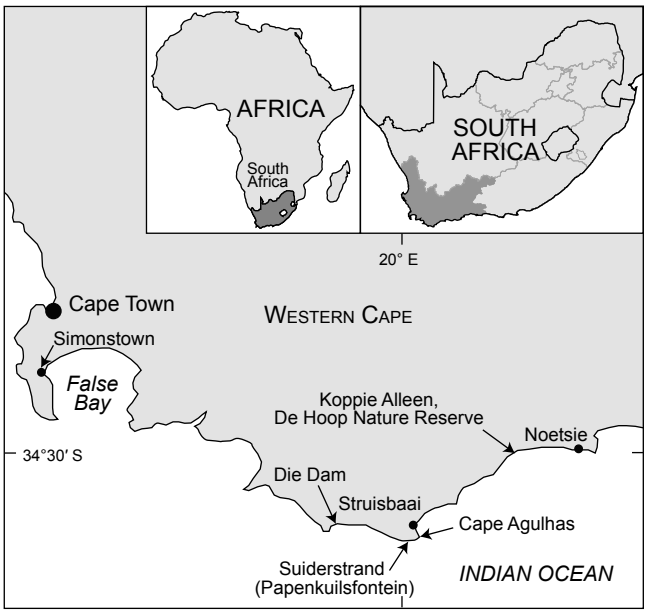


**Figure 1:** Map of the south coast of South Africa showing the Cape Agulhas region and locations mentioned in the text

### *What limits the eastward spread of* Ecklonia maxima*?*

A large body of distributional field and experimental information demonstrates that the limits to the biogeographical distribution of seaweeds are controlled overwhelmingly by seawater temperature (Lüning 1980, 1990, Van den Hoek 1982, Bolton 1986, Breeman 1988, Bolton and Anderson 1990, Bolton 2010). However, there are a few cases where other factors such as photoperiod (Lüning 1980, 1990) are limiting. Distribution can be controlled in various stages of the life history, either by limits to survival, growth or reproductive ability (Breeman 1988). Other ecological factors limit species dominance on a shore (e.g. wave action, grazing, and other biotic effects McQuaid and Branch 1984), but temperature correlates with total distribution on a biogeographic scale, of intervals of 50 km or more (Bolton and Anderson 1990, Bolton and Stegenga 2002). Nutrients may also be involved (particularly with a large species such as *E. maxima* that has a high ratio of storage to photosynthetic tissue). The major nutrient, i.e. nitrogen, is linearly inversely correlated with seawater temperature from 10 to 18 °C along the temperate coastline of South Africa (Waldron and Probyn 1992). Thus, seawater temperature is also a surrogate for nutrient concentration along this coast.

*Ecklonia maxima* has often been described as a 'cold water kelp' (e.g. Stephenson 1948, Griffiths and Mead 2011). In fact, it is better described as a warm temperate kelp as the genus *Ecklonia* does not occur where monthly mean temperatures fall below 10 °C (Bolton and Anderson 1994), and *E. maxima* grows in False Bay where monthly mean temperatures reach over 18 °C (e.g. at Simonstown; Bolton 1986). These are warm temperate conditions *sensu* van den Hoek (1975). Gametophytes and small sporophytes of *E. maxima*


**Figure 2:** (a) *Ecklonia* plants from Koppie Alleen, De Hoop Nature Reserve, in August 2008 (photo: Rheinhardt Scholtz); (b) two forms of *Ecklonia radiata* at Koppie Alleen: smooth-bladed form on the left and more typical spiny-bladed form on the right (photographed in February 2011). Scales are approximate

grow well in temperatures up to 22 °C, so apparent temperature limits closer to 18 °C must act on another phase of their life history, such as survival, growth or reproduction of the large sporophyte. At Struisbaai, immediately east of Cape Agulhas, summer monthly mean temperatures of over 21 °C have been reported by Bolton (1986), but De Hoop temperatures are not available except for measurements taken monthly over a one-year period by Bolton and Stegenga (1990). These were at least as high as those at Struisbaai. Populations of *E. maxima* about 160 km west of Cape Agulhas, in False Bay, have increased considerably between 1986 and 2007, which may be linked to lower recent temperatures in the bay (Griffiths and Mead 2011). The lack of *E. maxima* along the northern and the greater

part of the western shores of False Bay was considered by Papenfuss (1942) to be 'owing no doubt to the high sea temperatures that prevail there during the summer months'.

### *Seaweed distribution and climate change*

If, as we hypothesise, that the seawater temperature regime is limiting the eastward spread of *E. maxima*, we need to look for evidence of cooling in the region immediately east of Cape Agulhas. Warming of sea surface temperature (SST) regimes is experienced worldwide (Müller et al. 2009), and there is strong evidence for rapidly changing kelp distributions associated with temperature changes (e.g. Edwards and Estes 2006, Kirihara et al. 2006). Kelps only have very short dispersal distances by means of spores, but fertile plants of floating kelp like *E. maxima* can disperse rapidly. Washed up drift plants of the species have often been observed east of the distribution of attached populations, as far east as Port Alfred, 625 km east of Cape Agulhas (RJA pers. obs.). The establishment of this kelp along the South African south coast is clearly limited by environmental conditions, not dispersal.

Models of possible future SST regimes made by the International Panel for Climate Change are beginning to be used to predict future seaweed distributions, including kelps (Müller et al. 2009). Early data suggest that South Africa may be anomalous in this regard. There is evidence that coastal temperatures on the west and south coasts of South Africa have not increased, but have dropped slightly (but significantly) in the past two decades. Analysing satellite SST data from 1982 to 2009, Rouault et al. (2010) report a statistically significant negative trend of up to 0.5 °C per decade in the southern Benguela from January to August, and a cooling trend of lesser magnitude along the South Coast. This trend is clearly shown in Figure 4.67 in Griffiths and Mead (2011), who present data from Rouault et al. (2010). The latter authors state that the cooling trend 'is a result of the unique dynamic upwelling system being influenced by shifts in wind and rainfall patterns, a well known effect of climate change'.

## Conclusion

The major kelp in the southern Benguela region, *E. maxima*, has spread c. 70 km eastwards since January 2006, and evidence suggests that it had not changed its distribution over the past 70 years. It is quite possible that this is on account of a general cooling of inshore sea temperatures in the region, which may continue to decrease. As *E. maxima* is an ecosystem engineer that is responsible for the majority of primary production where such kelp beds occur on the west coast of South Africa (Newell et al. 1982), and is directly utilised on a large scale as a marine resource (Anderson et al. 2007), further spread of this species could have major ecological and sociological consequences.

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