What happened to the South Coast El Niño 1997-98, squid catches?

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Introduction

FROM ALL ACCOUNTS, the intense 1997-98 c impacted most regions in the world shown to be historically sensitive to these events following text-book rules. South Africa appears to be the exception.

The original forecast gave a 77% chance of catastrophic drought for the past summer in Southern Africa *(Farmers Weekly*, April 17 1998). The impact, turned out, was mixed.

Three-quarters of South Africa experienced drought while the eastern part had 40% more rain that normal!

The South Coast lies between the western winter rainfall region of the country and the eastern summer rainfall region. The question is, what influence did El Niño have on this twix zone, and, in particular, the South Coast based squid fishery?

South coast climate and oceanography

On the South African South Coast, regional climate change is most noticeable during summer. Intuitively, fishermen know this very well and will often comment on anomalies in the summer easterly wind pattern.

Under "normal" conditions, easterly winds dominante in September-October, subside during December, then again dominate through to April. During, the other months May-September, the wind pattern is almost exclusively dominated by westerlies.

Easterly winds are associated with small-scale upwelling along the South Coast and cause sea surface temperatures (SSTS) to drop to as low as 10°C.

Climate and ocean variability on the Southern Africa South and East Coasts is monitored by the Physical Chemical Oceanography Group of the Sea Fisheries Research Institute. The group uses a network of monitoring sites (Fig 1) set up in 1992.

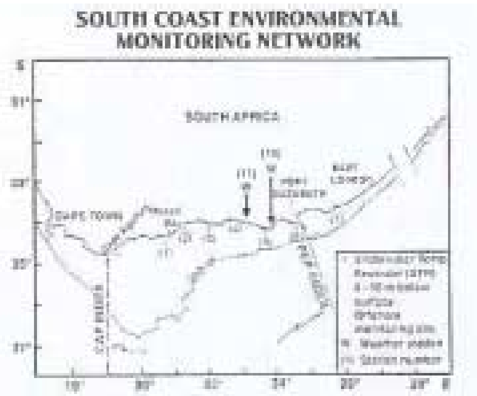

Fig 1: Climate and ocean change on the South Coast is monitored using a network of stations, referred to as the South Coast Environmental Monitoring Network. Data presently collected includes sea surface temperatures (SSTs), bottom temperature, winds and atmospheric sea-level pressure gradients.

Several indices are used to monitor local climate change, among which are the Cape Agulhas Pressure (CAP) Index (Agenbag 1996), the Port Elizabeth Pressure (PEP) Index, and the Durban Pressure (DUP) Index. At present, the CAP Index is the preferred data set to monitor climate change because, relative to the others, it shows the greatest contrasts in variability.
The CAP Index measures the difference in Sea Level Air Pressure (SLP) between Cape Agulhas and a point due south at 40'S; 20'E (Fig 2: Time series Jan 1975 to May 1998). The daily measurements are smoothed by taking the average over each month to enhance trends.

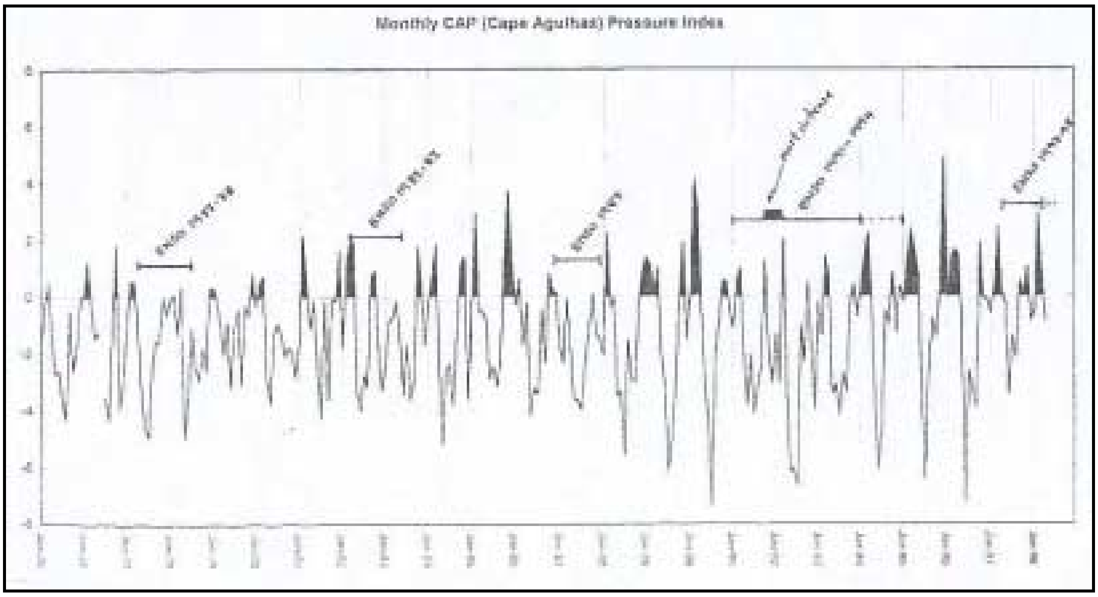

Fig 2: South Coast climate is monitored using three Seal-level Atmospheric Pressure gradients. Monthly averaged data for one of these, Cape Agulhas Pressure (CAP) Index, is shown for January 1975 to April 1998. Positive values indicate easterly winds dominate, negative values indicate westerly winds dominate. The shaded positive peaks highlight the summer bimodal switching phenomena. El Niño events are superimposed.

Negative monthly values imply that westerly winds were dominant, ie SLP gradient between the two points of measure slopes down towards the south. Positive values imply easterly winds were dominant, ie SLP gradient slopes down towards the African continent.
In general, there seems to be good correlation between the positive CAP Index and SSTs along the South Coast. The observed summer wind patterns described earlier are seen in the associated two positive CAP Index peaks, referred to here as the "bimodal peak" (BMP) phenomena (double-shaded peaks in Fig 2), or the "bimodal switching" phenomena. When specifics are required the peaks are referred to as BMP I and BMP 2 respectively.

Data trends and retrospective experience
Fig 2 shows that the "bimodal switching" phenomena has a range of variations with the magnitudes and duration (width) of both BMP I and 2 deviating considerably from mean values. Clearly, the summer wind patterns on the South Coast undergo considerable variance. The impact of El Niño Southern Oscillation (ENSO) events is seen when superimposed on the CAP Index.(Fig 2).
It would appear that the impact depends on the timing and duration of the ENSO event. For example, the 1977-78 ENSO coincided with a complete suppression of both BMPs that summer. The 1982-83 ENSO coincided with an attenuation of the first BMP in the corresponding summer, and a complete suppression of the second BMP.

Timing of the 1987 ENSO was such that it influenced the second BMP of early 1987 and the irst BMP in October 1987.

The persistent 1991-94 ENSO initially impacted on the South Coast climate by attenuation of both BMPs in the summers of 1990-91 and 1991-92, and thereafter the first BMP in the summers of 1992-93, 1993-94 and 1994-95.

The impact of the long 1991-94 ENSO on the local ocean is seen in Fig 3 which depicts the monthly temperature anomaly for Tstistikamma (see Fig 1: stn 4, start time for series Jan 1992). This is a key long-term monitoring site of the South Coast Environmental Monitoring Network (SCEMN).

The lower intensity of easterly winds during the initial stages of this ENSO are evident in the warmer than normal SSTs (positive anomalies) over the summers of 1991-92 and 1992-93. The weakening- of this event in the Pacific Ocean region corresponded with an increase in the intensity of easterly wind on the South Coast and lowers SSTS.

The SFRI El Niño forecast in July 1997

Retrospective experience has shown a relationship between ENSO events, the BMPs observed in the CAP Index, and SSTs measured on the South Coast. It is important to note that ENSO indices are near-real time monitored and reported. Local SSTs and the CAP Index, on the other hand, are not monitored in real-time, and have a time lag of about three months before the data is available for analysis.

In April 1997, after retrieval of SST data on the South Coast, anomalous high water temperatures were noted for the past summer (Fig 3). At that time, there was no indication of the 1997-98 ENSO event, and it was speculated that either an early ENSO signal had been observed, or that the Southern African regional climate was undergoing one of its own "non-ENSOrelated" perturbations.

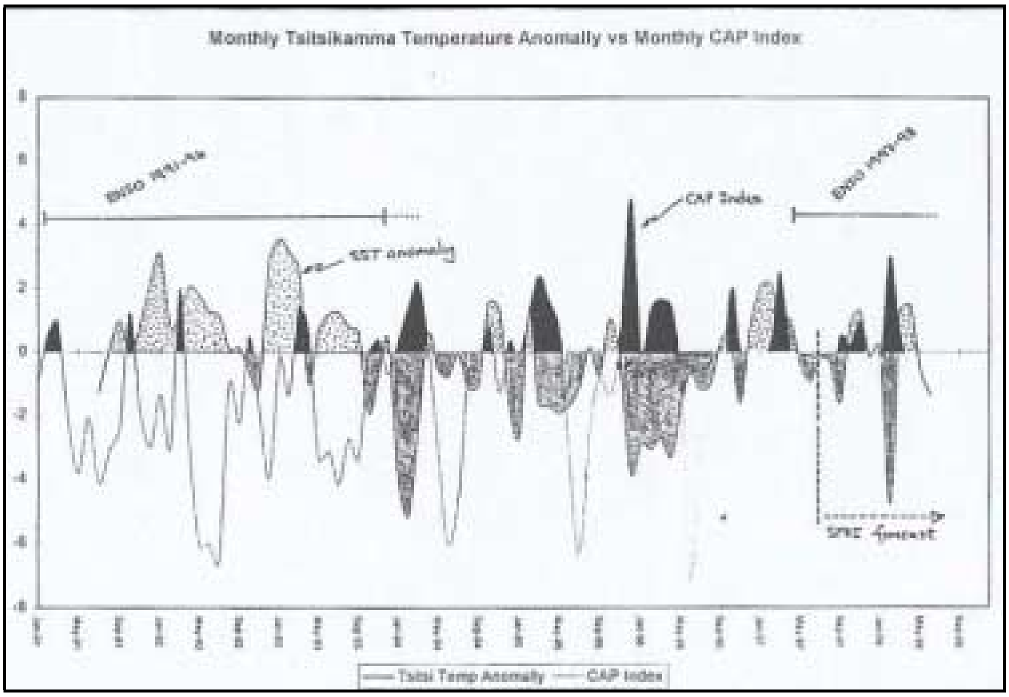

Fig 3: Local coastal ocean SST variability and response to ENSO events. The CAP Index summer bimodal peaks (BMPs) are shaded black, warm SST anomalies are dot shaded, cold water anomalies light grey shaded for clarity.

Later in the year, data provided by the Climatic Prediction Centre in Washington DC, indicated that the Pacific region was going into one of the strongest ENSOs experienced this century. Based on the fact that SST warming had already started on the South African South Coast six months earlier, and moreover, that there is at times an association between El Niño and low summer squid catches (Fig 7), the South Africa squid fishery was prepared for a poor 1997-98 summer fishing season.

A primary reason cited for this El Niño -catch relationship was that squid eggs developed in laboratory trials had shown increased levels of abnormal development when exposed to water warmer than their optimal temperature range of 12'-15'C (Fig 4) (Oosthuisen 1998). Abnormal development increases considerably above 18'C, with, for example, 50% of all eggs developing abnormalities at 21'C.

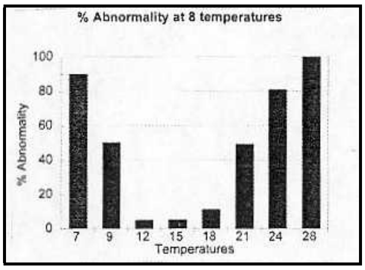

Fig 4: Laboratory trial undertaken at the university of Port Elizabeth have shown that abnormal development occurs in squid eggs when exposed to water temperatures above 15°C and below 12°C.

It is thought that spawning squid will avoid coastal regions where such high water temperatures exist. Rather, they will spawn in adjacent deeper, cooler water on the mid-shelf region, and therefore be unavailable to the jigs of the shallow water squid fishery.

Temperature measurements collected at the Kromme Bay offshore mooring (Fig 1, stn 9), which is situated on a spawning ground in a depth of 27 m, shows a relationship between SST and bottom temperatures (Fig 5).

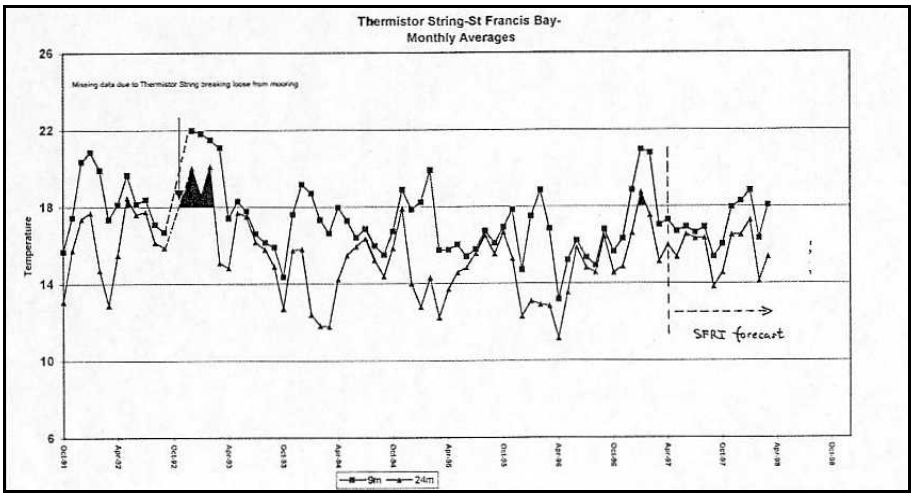

Fig 5: SST and bottom temperature measurements collected at the Kromme Bay offshore mooring (stn 9). Under normal easterly wind patterns, a strong, semi-permanent thermocline is set up in coastal waters. During summers of low easterly intensity (ie El Niño), the thermocline becomes weak, resulting in higher bottom temperatures.

Under "normal" summer conditions, ie easterly winds are dominant, a strong thermocline is established through upwelling, causing average bottom water temperatures to drop below 14°C, ideal for squid eggs. Retrospective observations had shown that under El Niño conditions, however, (ie summer of 1992-93), the summer thermocline tends to be weak with bottom temperatures exceeding the monthly average of 18°C. This was also the case in the summer of 1996-97, although to a lesser extent.
The squid fishery is relatively young, having started about 1985, and has not yet experienced an intensive El Niño such as the 1982-83 event. The forecast for the 1997-98 summer squid catch anticipated a marked change in adult spawning behaviour (and hence poor catches) due to expected unusually warm bottom temperatures on the inshore spawning grounds.
The last warm bottom temperatures, seen in Fig 5, occurred in the summer of 1992-93 during the weaker 1991-94 ENSO. During this summer, average bottom temperatures were about 3.5°C above average, but did not appear to have the same impact on squid catches as the 1987 El Niño.
Records for bottom temperature do not go back as far as the 1982-83 El Niño, so the extent of impact that an event of this intensity has on bottom temperatures is unknown. It was assumed, however, that the average bottom temperatures for the similarly intense 1997-98 El Niño would be higher than the 3.5'C experienced during a weaker event.
At the time of the South Coast forecast, similar warnings were given to the agricultural sector *(Farmer's Weekly* April 17 1998), in particular maize farmers who in former ENSO events had suffered severe drought conditions. The Climatic Prediction Centre's indication that the 1997-98 v was going to be one of the most intense this century, prompted the government to appoint an ad-hoc committee to oversee and respond to the anticipated crises.

What happened and why didn't 1997-98 impact on the South Coast?
Analysis now shows that the 1997-98 El Niño did not have any major impact on the South Coast climate and oceanography. As seen in Fig 3, appreciable BMPs (I and 2) materialised during the 1997-98 summer, albeit the former smaller in magnitude than, the latter.
The first peak had little impact on the SSTs which showed a warming trend by about 1°C (monthly average) over October and November 1997. It may be argued that this SST warming was ENSO-related. However, given similar experiences in the past (ie September 1994, Fig 3) which clearly were not ENSO-related, it is doubtful that this is the case.
The second BMP had a direct and intense impact causing average SSTs to drop almost 5°C below the monthly average over February and March 1998.
The "switching on" of the easterly wind-upwelling process was rapid and occurred over three to four hours (Fig 6) with SSTs dropping from 22°C to less than 10°C.
This shocked the ecosystem to such an extent that there were numerous reports from fishermen of fish kills along the Knysna-Tsitsikamma Coast. (There appears to be no scientific reports on this). Maximum average bottom temperatures this last summer were 16.7'C. Summer squid catches, shown in Fig 7, were average. El Niño 1997/98 therefore did not have any measurable major impact on the South African South Coast.
The relevant question then, is why did the 1997-98 El Niño not have an impact on the Southern African climate, both inland and off the coast?

To date only one explanation has been offered. Jury (1998) states that a warm SST anomaly observed in the tropical South Atlantic was responsible for disrupting El Niño-induced upper westerly winds over the Atlantic. The warm SST anomaly apparently caused upper easterly winds to oppose the El Niño-induced westerlies. This, he states, "shielded" Southeastern Africa from the adverse effects of the strong Pacific El Niño.

However, investigations continue into the causes and effects of the 1997-98 ENSO.

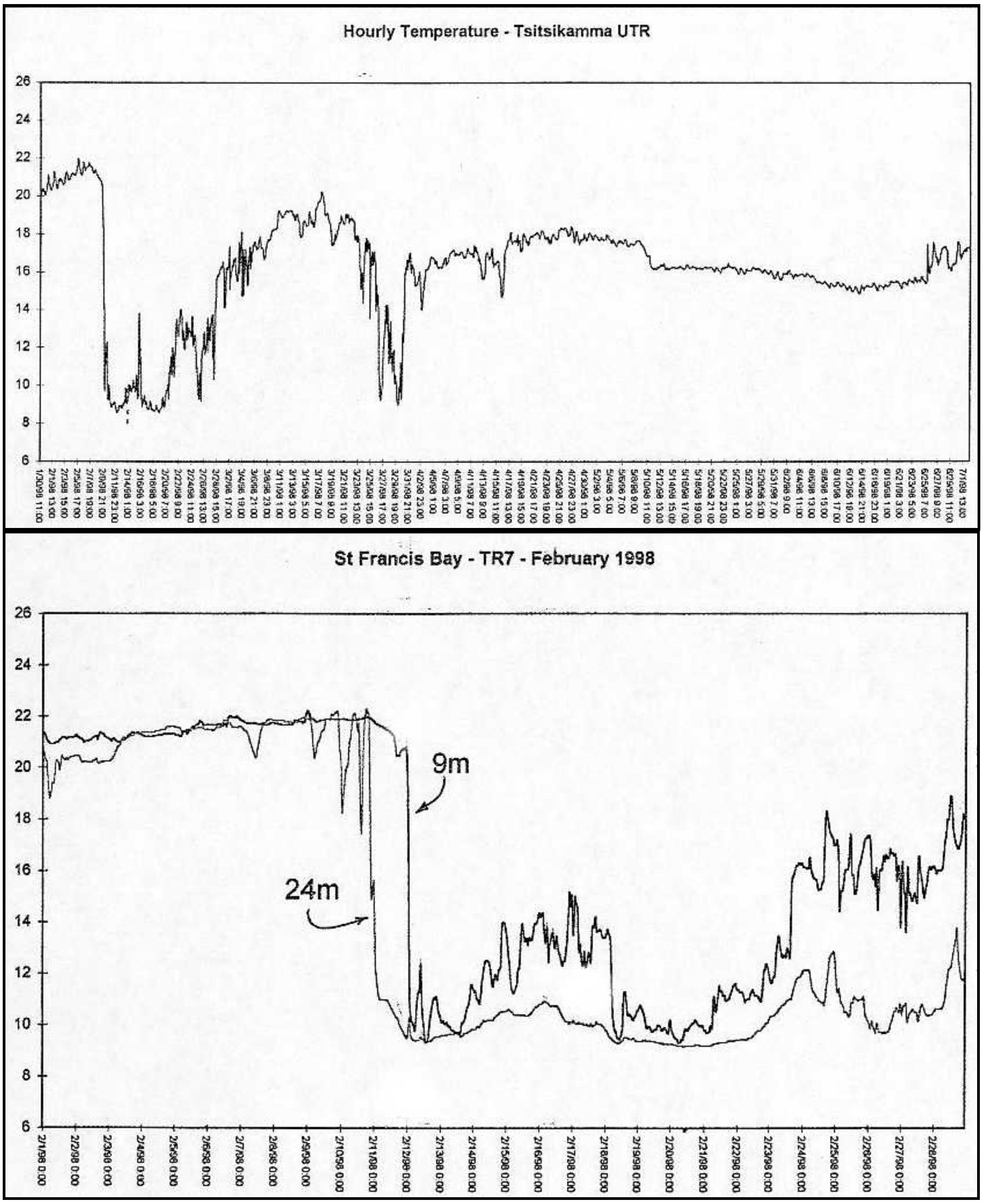

Fig 6: The significant second BMP in February and March abruptly “switched on” the easterly wind-upwelling process. This is clearly seen in (upper) the hourly temperature record for the Tsitsikamma underwater temperature recorder (UTR), 10 m depth, and (lower) at the Kromme Bay mooring (stn 9), 24 m depth. Notice the temperatures were restored to typical SST values by end March.

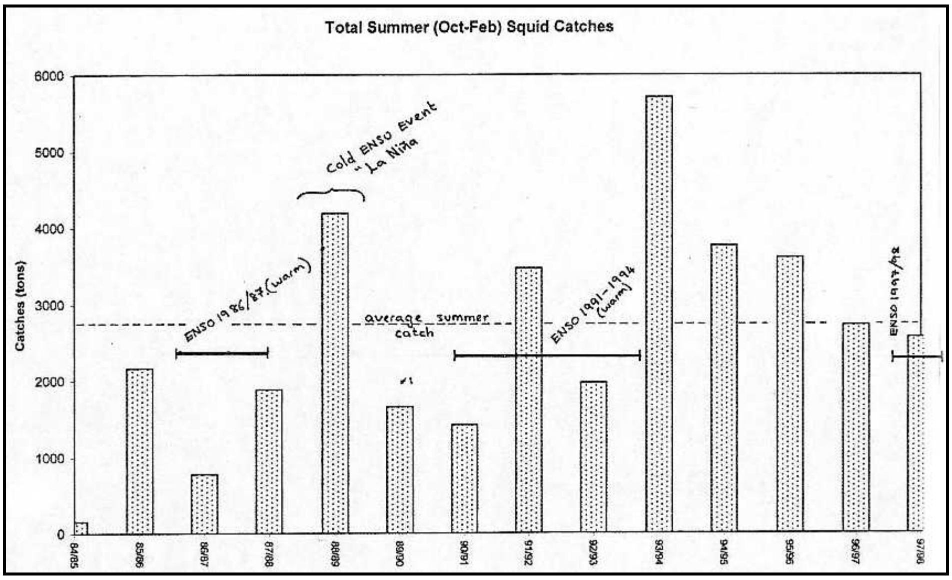

Fig 7: Total summer (October to February) squid catches. Superimposed are Pacific El Niño events and the average catch. When environmental work started on the squid fishery in 1991, it appeared that El Niño events negatively impacted catches due to warm bottom waters. This concept remains, but some exceptions are emerging as the time series expands, ie, the summer of 1991 – 92 and recently 1997-98. Clearly, the simplistic approach of superimposing Pacific ENSO event times on catches will not always give a reliable catch forecast.

Literature cited

Agenbag, J. J. 1996. Pacific ENSO events reflected in meteorological and oceanographic perturbations in the southern Benguela system. *S. A. J. Sci.*, 92: 243-247.

Farmer's Weekly, 1998, April 17, El Nifio: fact or phantom?

Jury, M. R. 1998. Global significance of climatic variability in the tropical South Atlantic: modulation of the ENSO circulation. Presented at the International Symposium on Environmental Variability in the- Southeast Atlantic, Swakopmund, Nambia, March 30 to April 4 1098.

0osthuisen, A. 1998. The effects of temperature on embryonic development and hatching success of squid *(Loligo vulgaris reynaudii)* eggs. MSc thesis, University of Port Elizabeth, 98pp

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