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**NOTE**

# Easter Island: climate change might have contributed to past cultural and societal changes

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ABSTRACT: Proxy climate data for the Pacific Ocean show that the most intense El Niño-Southern Oscillation (ENSO) activity during the last millennium coincides with the most recent period of deforestation on Easter Island. We therefore raise the question as to whether an abrupt change in ENSO variability and its associated impact on the marine resources surrounding Easter Island might have been—for a population already under strain from a number of different pressures—the final stressor causing social collapse. Studies showing how this hypothesized interaction between climate, marine resources and human history on Easter Island could be investigated are discussed.

KEY WORDS: Easter Island · Marine resources · ENSO variability · Social collapse · Deforestation



## 1. INTRODUCTION

The extent to which population change and cultural adaptation are driven by climate and other environmental changes has recently received much attention (Redman 1999, Rolett & Diamond 2004, 2005, 2007, Zhang et al. 2007). Rolett (2008) suggests that cultural adaptation has played a key role in sustainability on Pacific islands. According to Rolett (2008), shifting environmental conditions forced Polynesians inhabiting small islands to change their agricultural strategies to avoid severe deforestation. Successful adaptations included a transition from a continuous expansion of shifting cultivation field systems and the use of fire to either irrigated agriculture and/or arboriculture. However, because of its particularly fragile environment and limited possibilities of changing agricultural strategies, Easter Islanders did not manage to culturally adapt like other Polynesian societies. The consequence was total deforestation of the entire island (Rolett 2008), an ecological disaster that is believed to have lead to social collapse, warfare and striking cultural changes on the island (Diamond 2005).

Lack of cultural and societal adaptations to a changing environment will necessarily have profound societal effects (see e.g. Diamond 2005, Rolett 2008). These considerations therefore lead to the question of to what extent the cultural changes and societal collapse that are known to have occurred on Easter Island are a result of climate variation over the past millennium.

## 2. ECOCIDE

The cliff-girded coastline of Easter Island permits shallow-water fishing in only a few places (Diamond 2005). The diversity and amount of fish available for the inhabitants are therefore much more restricted compared to other Polynesian islands. Steadman et al. (1994) investigated bones in ancient garbage heaps from early Polynesian settlers on the island, and by so doing documented that fish and marine mammals, such as porpoises and seals, were important parts of the diet of the first inhabitants of Easter Island. However, a few hundred years later, at the very time the rich avian fauna on the island seem to have disap-

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peared, the amount of marine resources consumed also seems to have dropped drastically (Steadman et al. 1994, Diamond 2005). A popular interpretation of the reduction in the amount of fish and sea mammals in the diet of island inhabitants has been deforestation and the resulting lack of timber to build sea-worthy canoes, leading to overexploitation of the avian fauna when the islanders needed alternative food sources (e.g. Diamond 2005). This interpretation might very well be valid; indeed, people must clearly have played an important role in the famous ecocide on Easter Island. However, forces beyond the control of humans may also have facilitated the collapse.

### 3. CLIMATE VARIABILITY

Although debated, the paleo-environmental record for Easter Island suggests that deforestation occurred over about 400 yr from about 1250 to 1650 AD (Hunt 2007). It is therefore interesting to note that the last period of deforestation on Easter Island coincides with the most intense El Niño–Southern Oscillation (ENSO) activity during the last millennia (Cobb et al. 2003) (Fig. 1). Some studies, based on data at decadal time scales, have found no evident correlation between the El Niño–Southern Oscillation (ENSO) and climatic variables like rainfall on Easter Island (MacIntyre 2001, Genz & Hunt 2003). However, the possible negative effects of ENSO activity on the marine environment surrounding the island have not yet been properly investigated.

ENSO events are known to (directly or indirectly) cause shifts in sea surface temperature (SST), leading to lower biomass production (e.g. Le Bohec et al. 2008). If climate change reduced the availability of marine resources around Easter Island, this may suggest additional explanations for the deforestation and societal collapse. When catches declined in traditional fishing grounds, one response would have been to investigate new places to fish. However, to reach new and previously inaccessible fishing grounds, more wood would have been needed to build better and larger canoes, resulting in an acceleration of the deforestation. Furthermore, if the decline in marine resources outlasted the islanders' attempts to find better places to fish, trees may have started to seem of lesser value than before if they no longer represented a prerequisite to get fresh food. One way to manage this poor situation would have been to allow for an expanded agriculture by cutting trees and clearing land (Rolett 2008), a solution probably even more devastating for the remaining forest than the increased production of canoes earlier on. The combination of deforestation and hungry islanders might then have led to the extinction of much of the avian fauna on the island.

Although trees were no doubt still important as house building material and for use as firewood, these uses might have started to become secondary when the expanding agriculture needed more land to be cleared to feed the starving population. The above scenario may therefore help us understand the apparently low effort by the islanders to save the last trees during the final stages of deforestation of Easter Island.

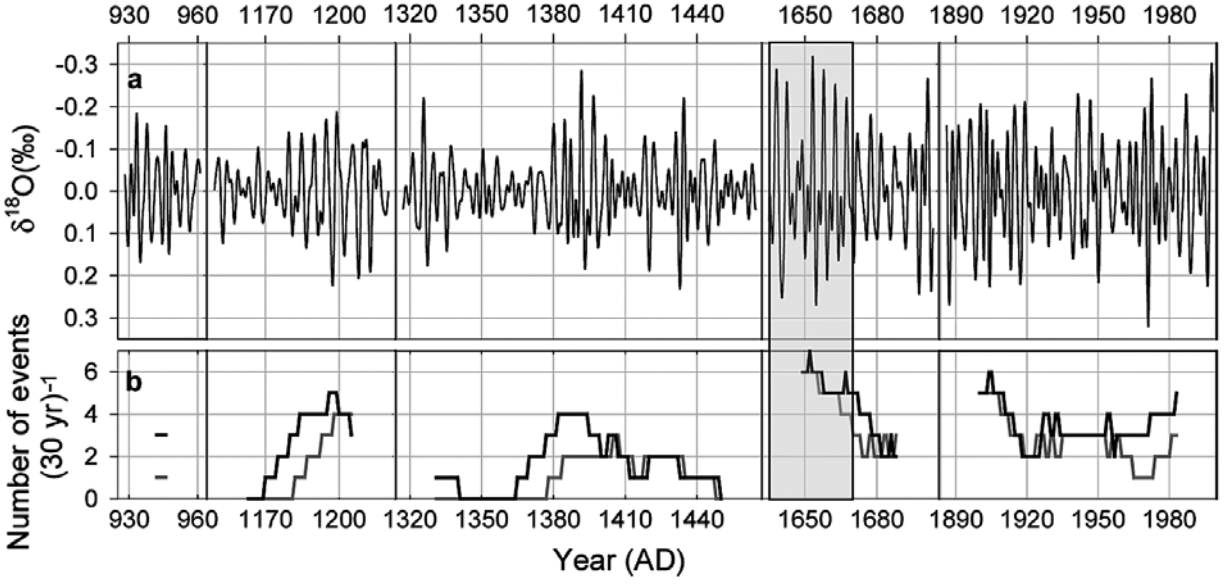


Fig. 1. Palmyra corals register the most intense ENSO activity in the tropical Pacific of the last millennium during the 17th century (from Cobb et al. 2003): (a) ENSO variability, isolated by applying a 2–7 yr bandpass filter to the deseasoned monthly coral $\delta^{18}O$ anomaly data, plotted contiguously; (b) index of ENSO activity, defined as the number of El Ninõ (black) and La Ninã (grey) events in a sliding 30 yr window. Highlighted band: hypothesised period of societal collapse on Easter Island

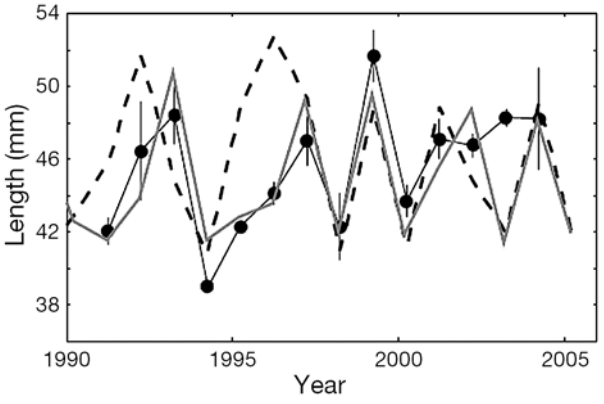


Fig. 2. Interannual changes in mean krill length in the diet of Antarctic fur seals at South Georgia in March (—●—) (error bars: 95% CI). The graph also shows model-estimated changes where recruitment of post-larval krill is driven by a functional relationship based on the sea surface temperature (SST) anomaly 2 yr (- - - - -) and 1 yr (——) previously (from Murphy et al. 2007)

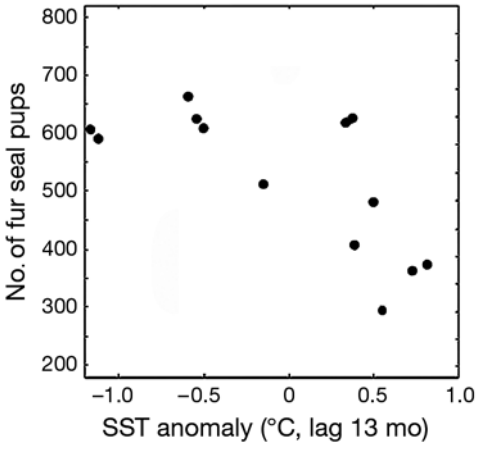


Fig. 3. Relationship between SST anomalies and the number of Antarctic fur seal pups produced at Bird Island, South Georgia (modified from Murphy et al. 2007)

The hypothesis suggesting that climate change influenced the societal collapse on Easter Island has been around for some time (e.g. Nunn 2000). However, although studies analysing lake sediment cores have shed some light on the island's ecological and environmental history, testing hypotheses involving climate change as a contributor to societal collapse has proven to be difficult; the paleo-environmental history of Easter Island is poorly known and its geographical isolation makes it difficult to infer its environmental history from other, better known islands (Mann et al. 2008). Obtaining more and better data on the climate history of Easter Island is very important if we are to understand how environmental changes might have contributed to the cultural and societal changes on the island.

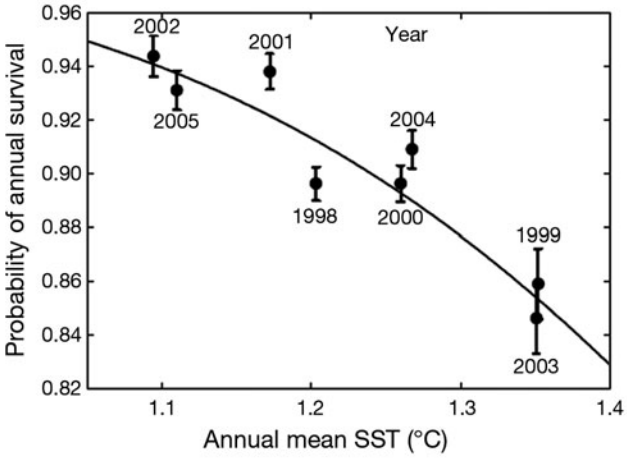


Fig. 4. Probability of annual survival of adult king penguins from Crozet Islands plotted against SST 2 yr earlier at 56° S, 46–56° E (error bars: ±SE) (from Le Bohec et al. 2008)

However, a number of studies indicate how we should proceed in our investigations to better test hypotheses concerned with the interaction between climate, marine resources and human history on Easter Island.

## 4. HOW TO PROCEED

Marine resources are affected by climate variability (e.g. Ciannelli et al. 2005), which drives ecosystem variation at all trophic levels, including top predators like seabirds and marine mammals (e.g. in the Southern hemisphere; Murphy et al. 2007, Le Bohec et al. 2008) (Figs. 2–4). Top predators are good indicators of changes in marine ecosystems (Durant et al. 2007, Piatt et al. 2007). Similar information for the geographical region around Easter Island is not yet available. However, the climatic oscillations in the tropical Pacific throughout the last millennium have been documented by Cobb et al. (2003) (Fig. 1). Studies based on coral data around Easter Island may provide a potential link between climate variability and cultural change on Easter Island.

Combining the insight presented by Cobb et al. (2003), Cianelli et al. (2005), Murphy et al. (2007), Durant et al. (2007) and Piatt et al. (2007), it seems reasonable to hypothesize that much of the marine resources surrounding Easter Island may have been profoundly affected by severe changes in climate (which in turn might have affected marine resources traditionally hunted by the islanders) during the periods of great societal and cultural changes (Fig. 5).

Climate is, of course, very likely not the only cause of the environmental and societal changes on Easter Island. However, the abrupt change in ENSO variabil-

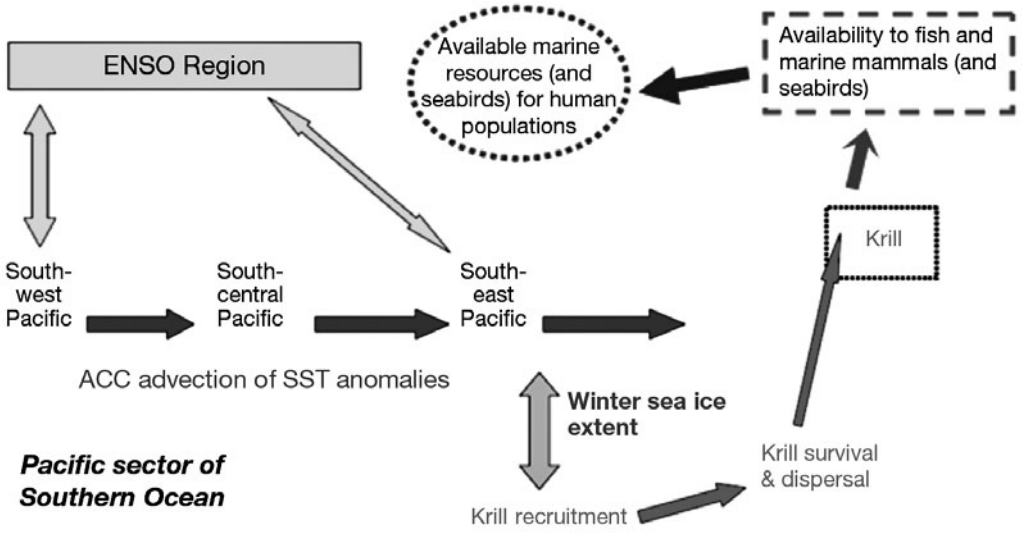


Fig. 5. Schematic illustration of physical and biological links generating variations in the availability of krill, fish, marine mammals, and sea birds as well as how these variations may affect the food resources of human populations. Anomalies in sea surface temperature (SST) initiated by the El Niño Southern Oscillation (ENSO) propagate through the Pacific in association with the Antarctic Circumpolar Current (ACC) and affect the recruitment, survival and dispersal of Antarctic krill, and in turn the breeding success of seabird and marine mammal predators that depend on krill as food. The distribution of sea ice also affects krill populations (modified from Murphy et al. 2007)

ity and its associated impact on marine resources could have been—for a population already under strain from a number of different pressures—the final stressor causing societal collapse. To pursue this further, an interdisciplinary approach involving humanities and the sciences may be particularly fruitful (cf. Snow 1959).

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