Deep-Sea Research II ∎ (∎∎∎∎) ∎∎∎–∎∎∎

Contents lists available at ScienceDirect

Deep-Sea Research II

journal homepage: www.elsevier.com/locate/dsr2

Multi-decadal variability and trends in the El Niño-Southern Oscillation and tropical Pacific fisheries implications

D.E. Harrison [a,*], Andrew M. Chiodi [a,b]

[a] NOAA Pacific Marine Environmental Laboratory, 7600 Sand Point Way NE, Seattle, WA 98115, USA
[b] Joint Institute for the Study of the Ocean and Atmosphere, University of Washington, Seattle, WA 98195, USA

ARTICLE INFO

Keywords:
ENSO
Decadal
Multi-decadal
Variability
Trend
Statistical significance

ABSTRACT

Extremes of the El Niño-Southern Oscillation (ENSO) are known to have various socio-economic impacts, including effects on several Pacific fisheries. The 137-year-long record of Darwin sea-level pressure offers a uniquely long-term perspective on ENSO and provides important insight into various aspects of interannual to century-scale variability that affects these fisheries. One particular issue of interest is whether there is a centennial-scale (or longer) trend that can be expected to alter the future distributions of these fisheries. Since most tropical Pacific fishery records are no longer than a few decades, another issue is the extent to which trends over these recent decades are a good basis for detecting the presence of long-term (e.g., centennial-scale) deterministic changes, and perhaps thereby projecting future conditions. We find that the full 137-yr trend cannot be distinguished from zero with 95% confidence, and also that the ENSO variance in recent decades is very similar to that of the early decades of the record, suggesting that ENSO has not fundamentally changed over the period of large increase in atmospheric CO_2. However, the strong multi-decadal variability in ENSO is reflected in decades with quite different levels of ENSO effects on the ecosystem. Many multi-decadal subsets of the full record have statistically significant trends, using standard analysis techniques. These multi-decadal trends are not; however, representative of the record-length trend, nor are they a useful basis for projecting conditions in subsequent decades. Trend statistical significance is not a robust foundation for speculation about the future. We illustrate how the difficulties involved in determining whether a trend is statistically significant or not mean that, even after careful consideration, an unexpectedly large number of trends may reach standard statistical significance levels over the time spans for which many newer records are available, but still not continue into future decades or be indicative of deterministic changes to the system. Analysis of the Southern Oscillation Index, another common ENSO index, but one that has been directly measured for fewer years than has Darwin, yields similar results.

1. Introduction

The warm (El Niño) and cool (La Niña) phases of the El Niño-Southern Oscillation (ENSO) are now well known to cause extremes in temperature and precipitation in affected areas around the globe (see Ropelewski and Halpert, 1987, 1989; Halpert and Ropelewski, 1992, for seminal studies on this topic, and Chiodi and Harrison, 2013, for an updated U.S. perspective). They can also cause large-scale changes in the distribution of several pelagic fish populations (Fiedler, 2002; Lehodey et al., 2006). These changes include an at least temporary collapse of the Peruvian anchovy population during some strong El Niño years (Barber and Chavez, 1983, 1986; see also Bertrand et al., 2004), links to various aspects of northeast Pacific ecosystem variability (McGowan et al., 1998), as well as dramatic changes in the distributions of Pacific tuna, especially the tropical skipjack (*Katsuwonus pelamis*) species (Kimura et al., 1997; Lehodey et al., 1997, 2006; Lu et al., 2001). Different upper-ocean changes associated with ENSO have been used to rationalize the ENSO effects on these fisheries. Among the more conspicuous are the observed basin-scale changes in the distributions of warm water, thermocline and mixed layer depth, and chlorophyll concentration along the equatorial Pacific. Zonal displacements of typical conditions extend over thousands of kilometers along the equator during ENSO extremes, and chlorophyll and sea surface temperature (SST) often track each other closely (see Fig. 1 and Park et al., 2011). Very large changes in large-scale tropical Pacific chlorophyll concentration and distribution also exist between warm and cold extremes (see Lehodey et al., 1997; Murtugudde et al., 1999; Fig. 2). In the tropical Pacific, these interannual ENSO changes have

* Corresponding author. Tel.: +1 206 526 6225.
E-mail address: D.E.Harrison@noaa.gov (D.E. Harrison).

0967-0645/$ - see front matter © 2014 Published by Elsevier Ltd.
http://dx.doi.org/10.1016/j.dsr2.2013.12.020

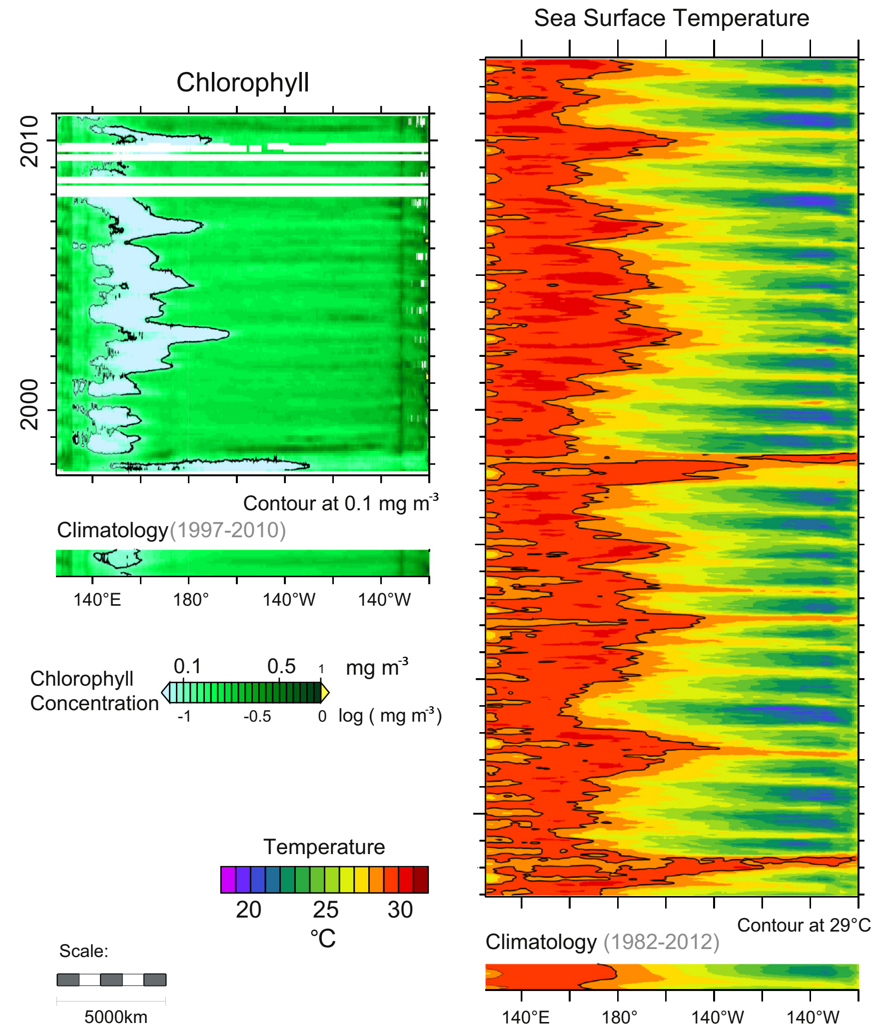

Fig. 1. Time-longitude sections of equatorial Pacific (2°S–2°N average) chlorophyll concentration (left) and sea surface temperature (right).

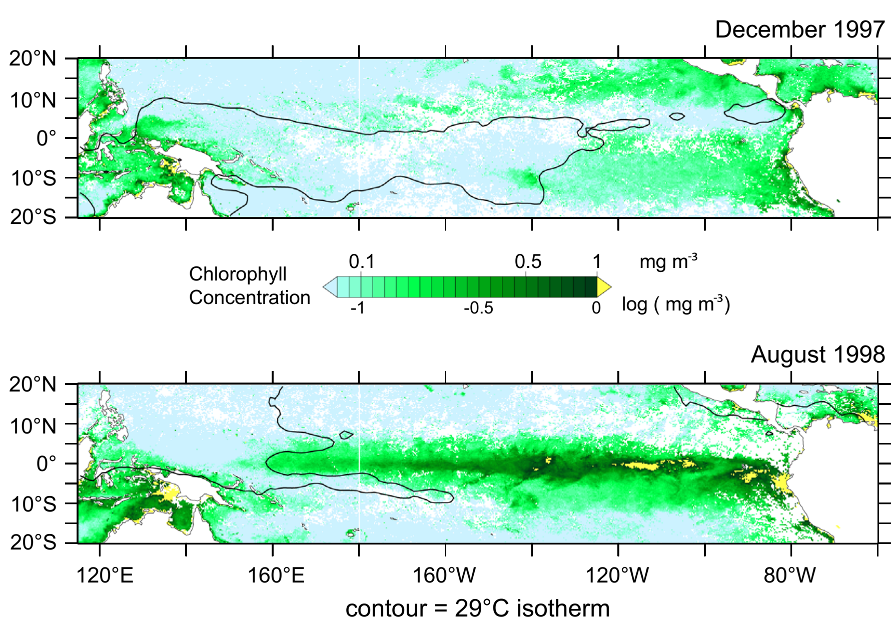

Fig. 2. Snapshots of monthly average chlorophyll conditions during the 1997–1998 transition from a strong El Niño (upper panel) to La Niña (lower panel) state. The 29 °C contour is overdrawn for reference.

Please cite this article as: Harrison, D.E., Chiodi, A.M., Multi-decadal variability and trends in the El Niño-Southern Oscillation and tropical Pacific fisheries implications. Deep-Sea Res. II (2014), http://dx.doi.org/10.1016/j.dsr2.2013.12.020