

The study aims at understanding the mechanisms leading to changes in the trophic flow structure of the Bahía de Independencia ecosystem (Southern Peru) over the cycle of a strong El Niño (1997/1998). Observed changes comprised a strong proliferation of scallop and octopod biomass, a significant decrease in macrophyte, crab and polychaete biomass and several minor changes in other system compartments. Based on survey-, landing- and catch per unit of effort data (CPUE) of IMARPE (Instituto del Mar del Peru), trophic steady state models were constructed for the years 1996 (normal upwelling) and 1998 (El Niño conditions) (see Taylor et al., this conference) and used along with monthly series of relative biomass (as estimated from CPUE) for several groups over the period 1996-2003 to simulate the observed ecosystem changes over the ENSO cycle. We also used monthly temperature time series to simulate scallop recruitment using a previously constructed empirical model. The results of a series of simulations suggest: 1) the main cause for the scallop outburst and for the reduction in crab and macrophyte biomass is a temperature dependent population response (increase in scallop recruitment, mortality in crabs and macrophytes) during the El Niño warming period. The scallop proliferation is substantiated by the fact that the model responded to the temperature mediated scallop recruitment variation with (the observed) eighty fold increase in adult scallop biomass during 1998, followed by a substantial rise in (the also observed) octopod biomass. 2) Other observed changes can well be explained by trophic interactions as suggested by our ECOSIM simulations, when the model was forced to respond to time series of scallop, crab, phytoplankton and macrophyte biomass. The model predicted the following observed changes quite well: an El Niño caused decrease in the groups of benthic detritivores, miscellaneous filter feeders, polychaetes, small carnivores, herbivorous gastropods, and an increase in sea stars, octopods and littoral fish. 3) The time of onset and intensity of the scallop pulse fishery heavily influence the development and magnitude of the scallop stock and the bulk of the total catch during the El Niño, but does not greatly impact the general flow structure of the bay.

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HCS033 - Abrupt environmental shift links with changes in fish spawning in the southern Benguela

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Cape anchovy (*Engraulis encrasicolus*) is an economically-important small pelagic fish in the southern Benguela, which, together with sardine (*Sardinops sagax*), is the target of a medium-sized purse-seine fishery that has shown average annual catches of just under 400 000 tonnes over the past six decades. Interannual changes in abundance and distribution patterns of South African anchovy have been assessed bi-annually via acoustic surveys conducted since 1984. Data collected during summer surveys indicate that anchovy spawners have shown an eastward shift in their distribution (fig. 1), from being located primarily over the western Agulhas Bank (to the west of Cape Agulhas) to being located primarily over the central and eastern Agulhas Bank (to the east of Cape Agulhas). This shift in distribution occurred abruptly in 1996 and has persisted since then, with around two-thirds (on average) of the anchovy spawner population found to the east of Cape Agulhas during subsequent surveys. This eastward shift in spawning appears to have resulted in improved anchovy recruitment success.

In this communication, we present a brief review of the biological facts that best illustrate the change in the spatial dynamics of anchovy spawning, and changes in the spatial distribution of other pelagic species during the same period are also briefly described. Environmental variability over the Agulhas Bank since the early 1980's is then documented using sea surface temperature data in different regions of the bank. These data show that the inner-shelf of the Agulhas Bank east of Cape Agulhas suddenly became colder than the mid-shelf region in 1996 (Fig. 1). A signal, coherent with the 1996 shift recorded in SST is also found in atmospheric surface pressure data. Increased wind-induced coastal upwelling east of Cape Agulhas is thought to be the main driver of the enhanced cooling of the coastal region. The synchrony between the environmental and biological signals, and evidence of favourable feeding conditions for adults on the eastern side of the bank compared to the western side of the bank, have led to the development of the following hypothesis: the anchovy eastward shift was environmentally-mediated through a coupled ocean-atmosphere process, and arose from a change in environmental forcing that altered the relative favorability for spawning of regions to the west and east of Cape Agulhas.

Our results highlight how a relatively minor change in the environment can lead to a drastic spatial reorganization of the life history of one component of an ecosystem. The opening in 1996 of an environmentally-driven window of opportunity for spawning on the eastern Agulhas Bank, and its

persistence since 1996, allowed that region to become the dominant anchovy spawning ground, and that dominance has persisted since then. In the context of Global Climate Change, this example can be used to infer the response to changes in the environment of similar species in other upwelling ecosystems.

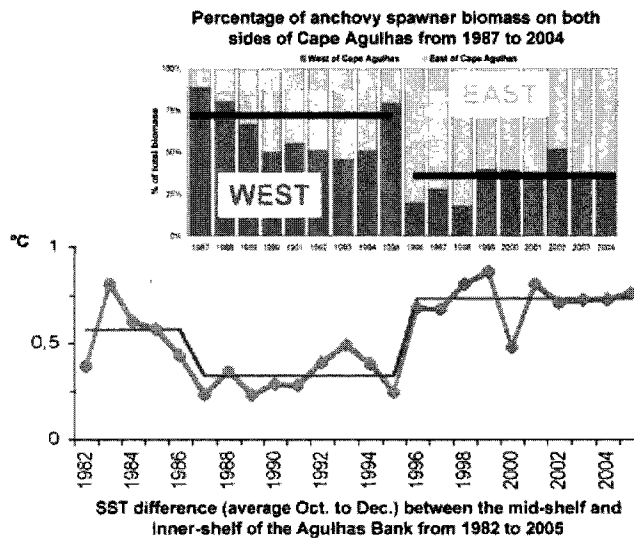


Figure 1: Environmental variability over the Agulhas Bank (bottom) and percentage of anchovy spawner biomass located on both side of Cape Agulhas (top). The abrupt shift of the spawner biomass to the east of cape Agulhas in 1996 corresponds to a sudden increase of the SST gradient between the mid-shelf and inner-shelf regions of the bank. Data on anchovy egg distribution dating back from the early eighties provide also evidence of enhanced anchovy spawning on the eastern Agulhas Bank in 1983.

HCS080 - The relationship of anchovy and sardine to water masses in the Peruvian Humboldt Current Ecosystem from 1983-2005

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Although the large fluctuations in abundance of anchovy (*Engraulis ringens*) and sardine (*Sardinops sagax*) off Peru have been well documented (e.g. Alheit and Niquen, 2004; Bertrand *et al.* 2004; Gutierrez *et al.*, in press) little is known about the functional processes underlying these dynamics in relation to ENSO events and/or decadal regimes. It has been hypothesized that colder upwelling waters provide favourable habitat (hydrologic and feeding conditions) for anchovy while sardine appear to be favoured by warmer oceanic waters habitat. In this work we use water masses as a proxy of habitat conditions. Data from 44 acoustic surveys conducted off the Peruvian coast from 1983-2003 by the Peruvian Marine Institute (IMARPE) provide an unique opportunity for testing the hypothesis of a relation between the range of distribution of these water masses and the abundance of these species. If such a relationship can be established it may suggest that the expansion and contraction of sardine and anchovy populations tracks expansion and contraction of the range of colder upwelling and warmer oceanic waters in Peruvian coastal waters. To monitor changes in water masses composition we constructed an algorithm for determining water masses based on temperature and salinity ranges but also on season and latitude ranges. Classification and Regression Trees (CART) using recursive partitioning, modelling sardine and anchovy presence-absence as a function of year, water mass and latitude showed that anchovy were primarily found in cold and mixed waters, while sardine were more ubiquitous relative to water masses. This result was supported by Generalized Additive Model (GAM) analysis of anchovy and sardine abundance versus temperature and salinity as well as spatiotemporal variables. The predominance of cooler, upwelling associated water masses since 1999, can help to explain the absence of sardine and the more pervasive nature of anchovy in the Humboldt Current System. The extension-contraction of the range of distribution of these species according to the availability of each water masses is discussed.

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