



THE EVOLUTION OF THE ANGOLAN SARDINELLA STOCK IN RELATION TO THE CLIMATIC EVENTS IN THE EASTERN TROPICAL ATLANTIC 1985-2014

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- Two species of Sardinella, *S. aurita* and *S. maderiensis* co-occur in Angolan waters.
- Fisheries on these species provides an important source of food, as well as major employment opportunity for the coastal population.
- Although the fishing on sardinellas is maintained at sustainable levels, the stock exhibits large seasonal and interannual fluctuations in terms of availability of fish to fisheries.
- Variability in combination of physical factors determining the sardinella habitat is believed to drive this fluctuations, but our understanding of these interactions specific to the Angolan system is poor.
- The physical forcing in the Angolan tropical ecosystem (5-13°S) is unique, as the coastal wind is perennially low while the timing of high and low productivity seasons is determined by the annual march of the coastally-trapped Kelvin waves.
- In this presentation we look at seasonal and interannual patterns in the sardinella biomass, fish length structure and seasonal migration and to relate them to the satellite-derived indices of the seasonal cycle of Kelvin waves, to the interannual events, as well as to the decadal trend observed in the vicinity of the Angolan coast

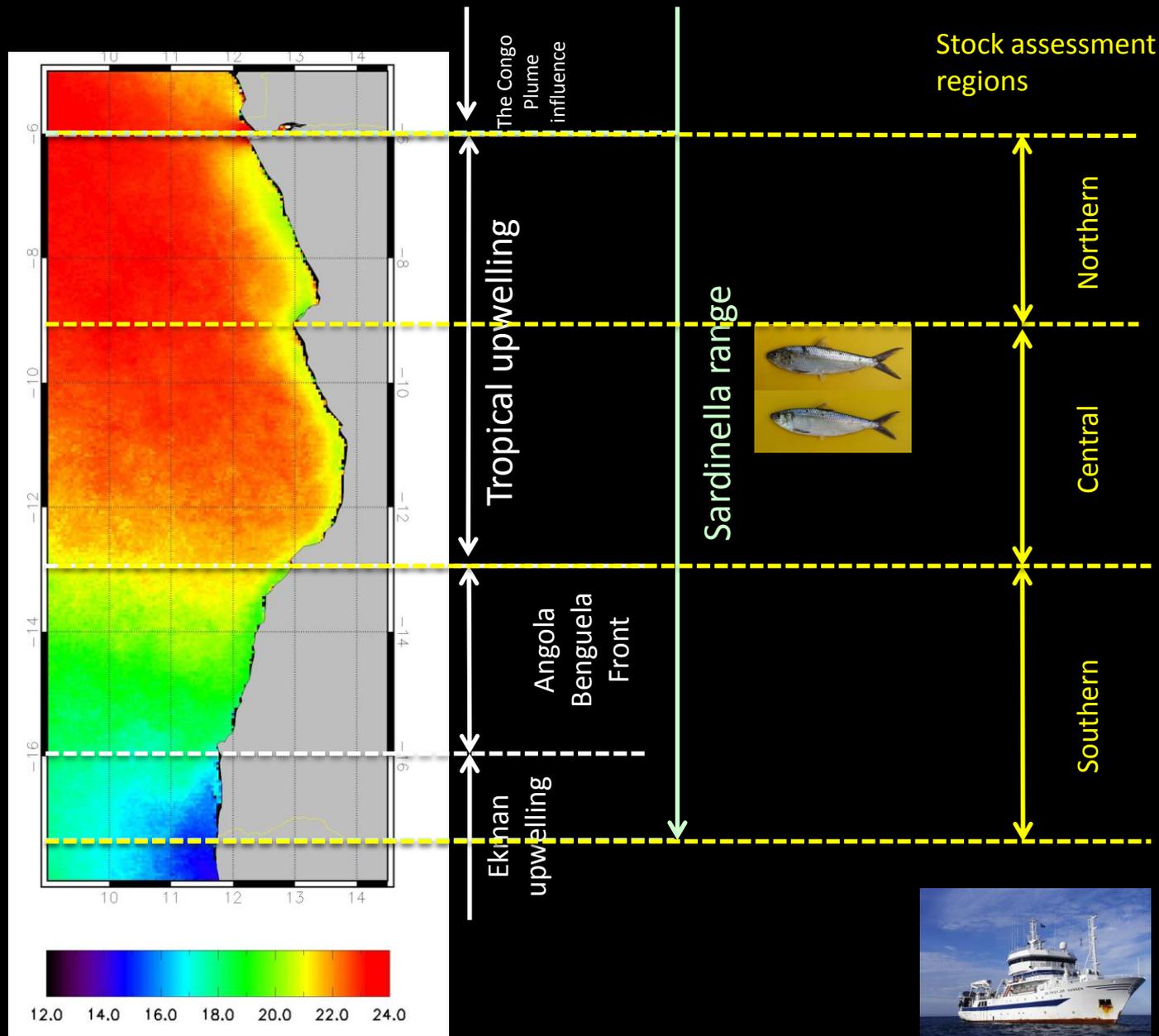


DATA

- Acoustic biomass estimates from Pelagic surveys with R/V “Dr. Fridtjof Nansen” in Angolan waters, 1985-2014
- Length frequency distributions from the same surveys
- Angolan catch statistics data 1985-2013
- SST weekly time series 1985-2013, composed from 4 km Modis AQUA and Pathfinder SST extracted at 20 km from the coast.
- Absolute sea surface height weekly time-series extracted at 75 km from the coast, derived from the 2014 AVISO dataset
- Merdinal component of the surface geostrophic current weekly data at 75 km from the coast from the same source

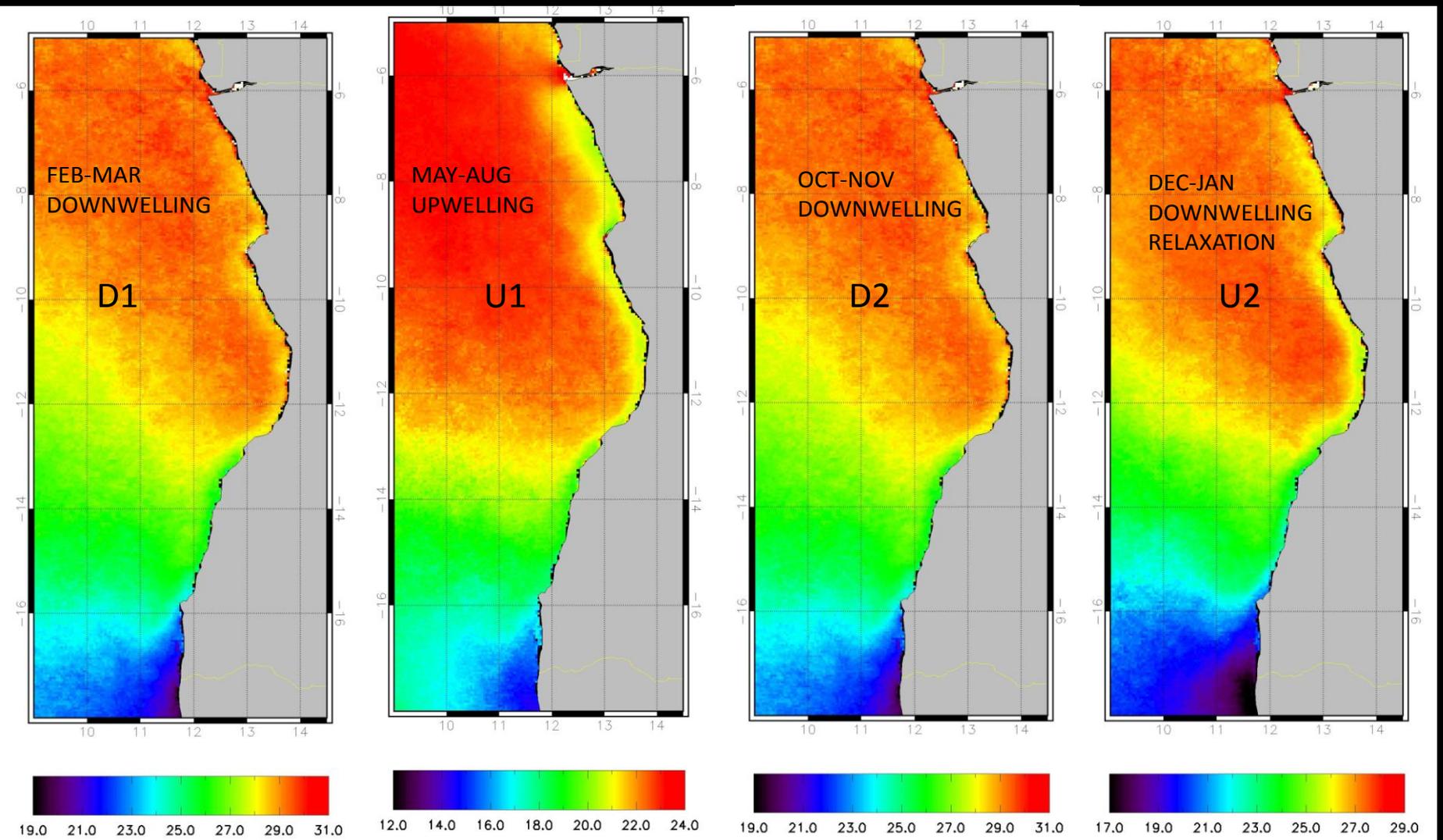


Oceanographic and stock assessment divisions of the Angolan coast





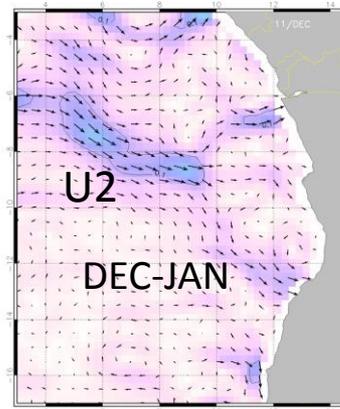
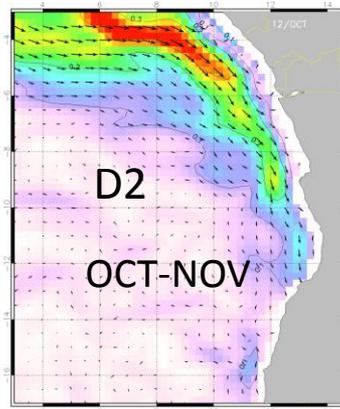
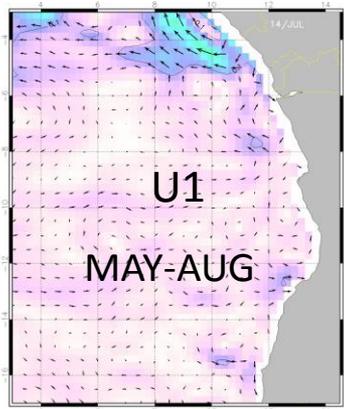
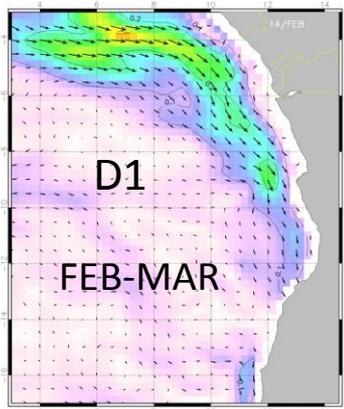
THE SEASONAL DOWELLING/UPWELLING SST REGIMES ALONG THE ANGOLAN COAST



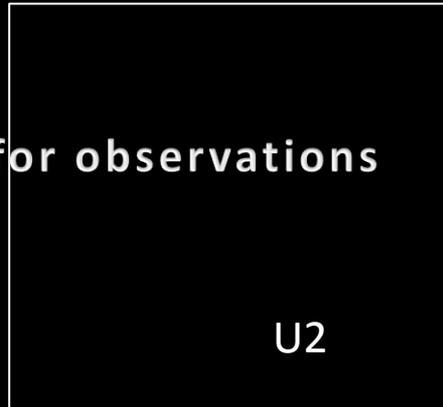
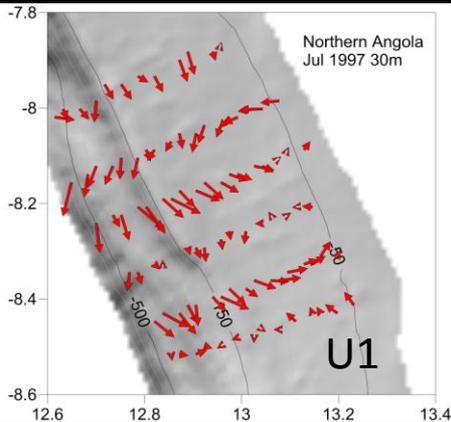
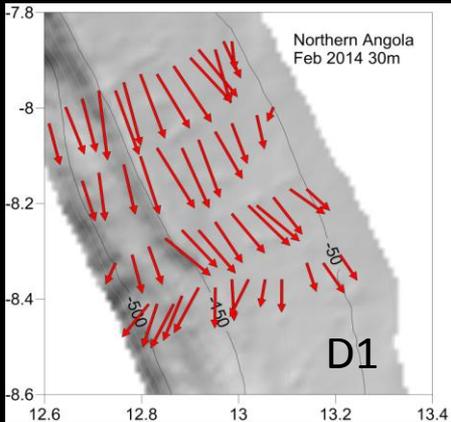


THE SEASONAL SURFACE TRANSPORT PATTERNS ALONG THE ANGOLAN COAST

Derived from altimetry



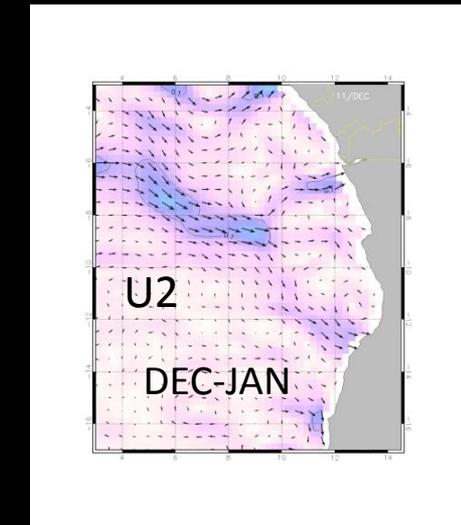
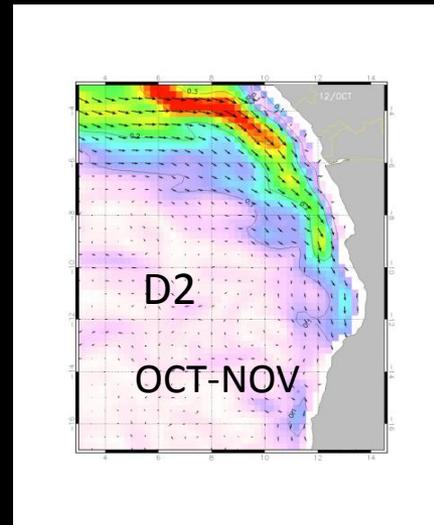
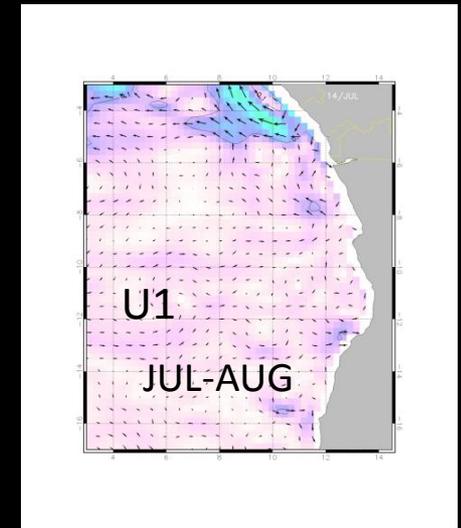
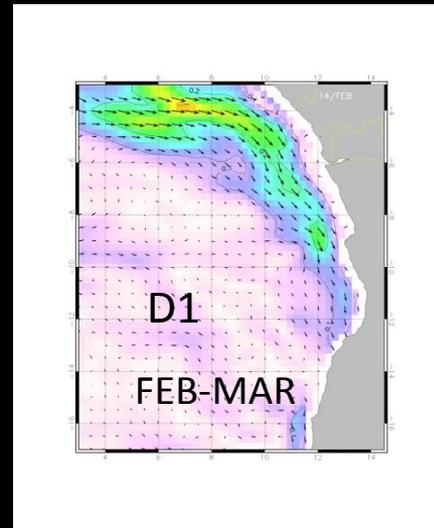
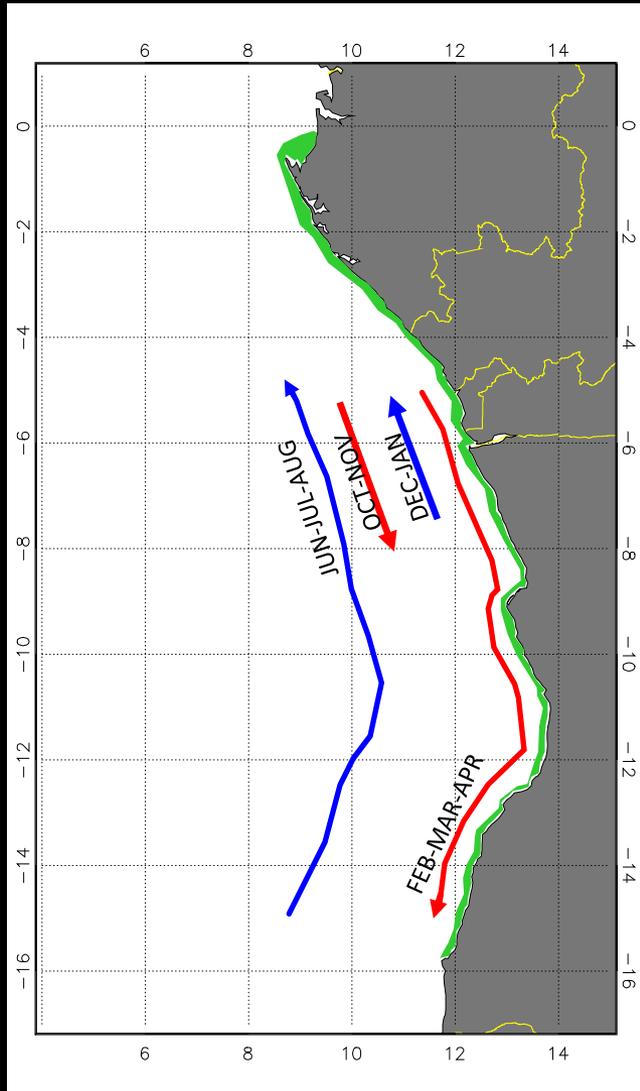
Observed



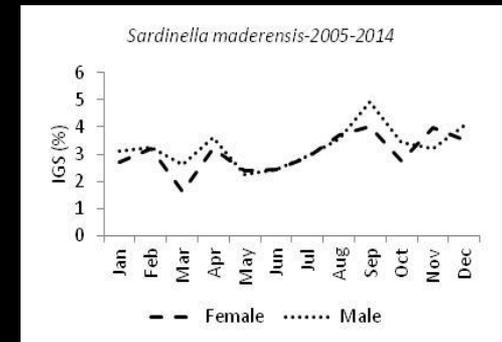
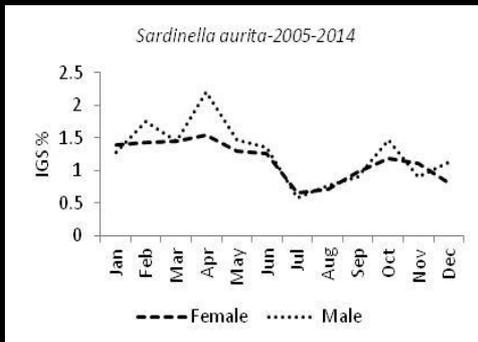
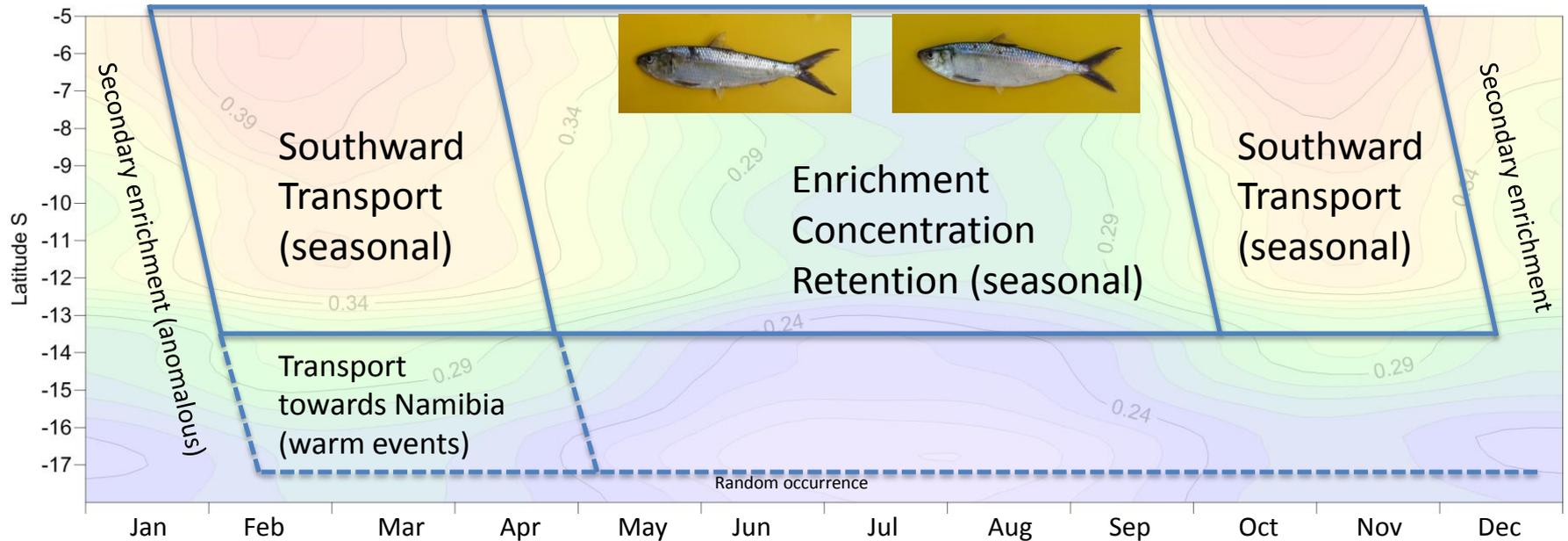


The annual migratory cycle of sardinella in the Angolan system has been known since the 1970s, inferred from fish landings data

Modern satellite observations indicate that this cycle is synchronous with the seasonal cycle of the current induced by coastally-trapped Kelvin waves in the southeastern tropical Atlantic

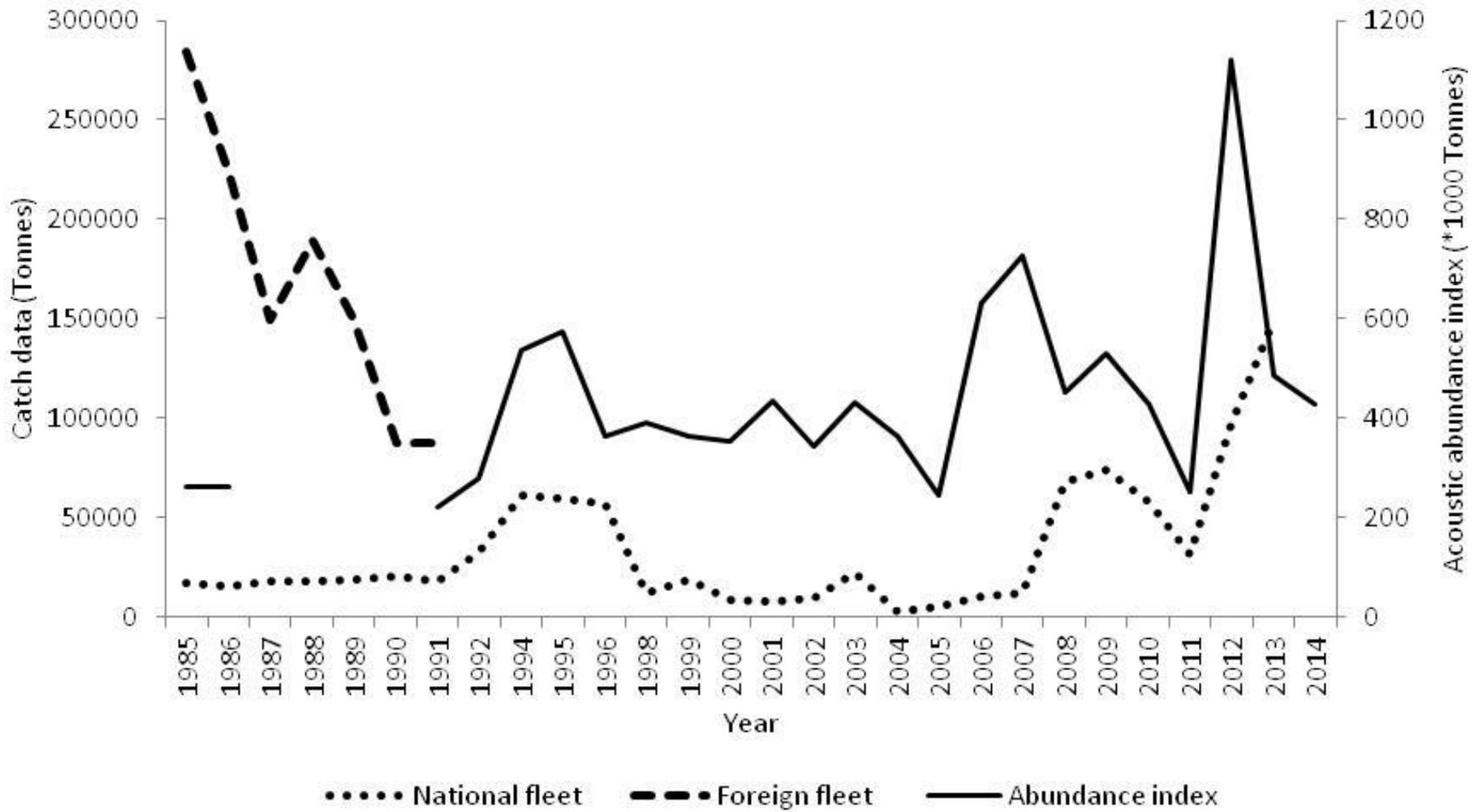


THE SEASONAL TIMING OF PHYSICAL PROCESSES AFFECTING RECRUITMENT AND MIGRATION PATTERN OF SARDINELLAS ALONG THE ANGOLAN COAST



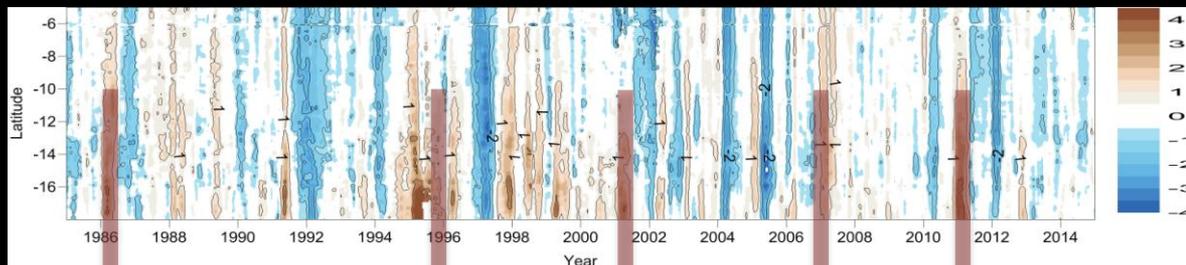


Evolution of the catches of both sardinella landed in Angola and acoustic abundance index during the period from 1985-2014

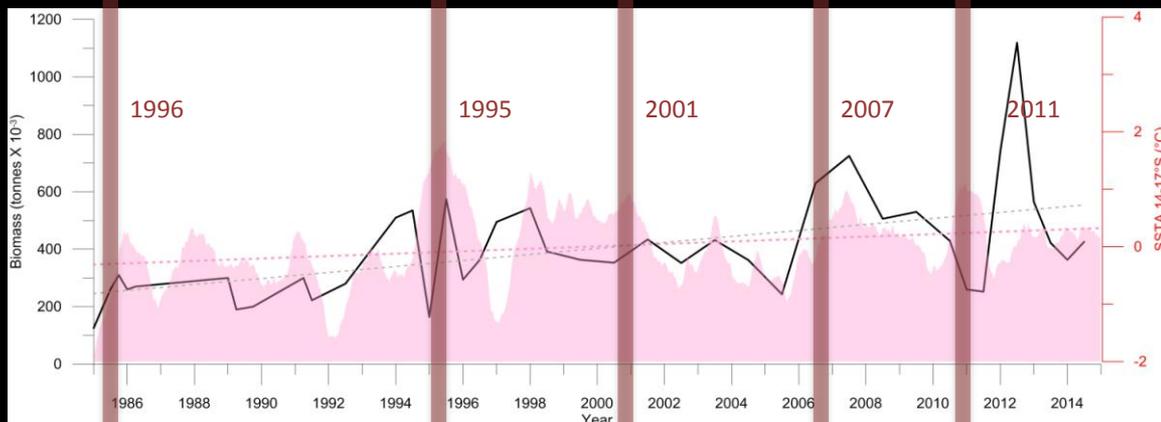


Acoustic biomass index and SST anomaly nearest to Angolan coast, 1985-2015

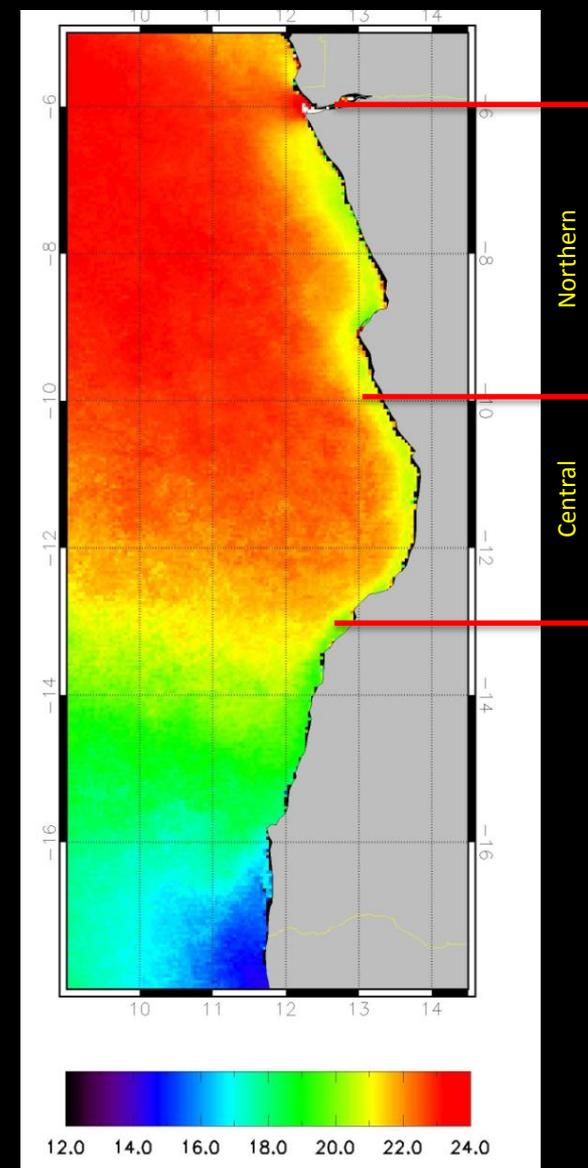
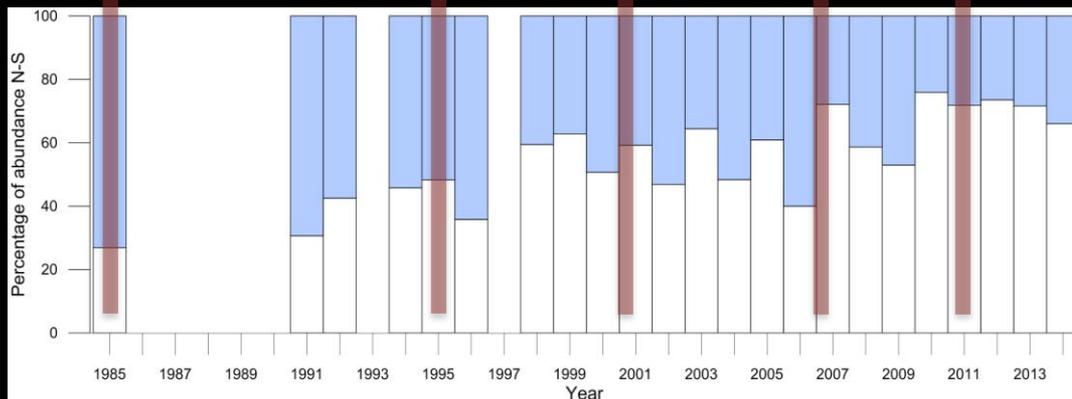
Time-latitude evolution of SST anomaly nearest to Angola coast (detrended)



Biomass index and SSTA (1 year low-pass filtered)

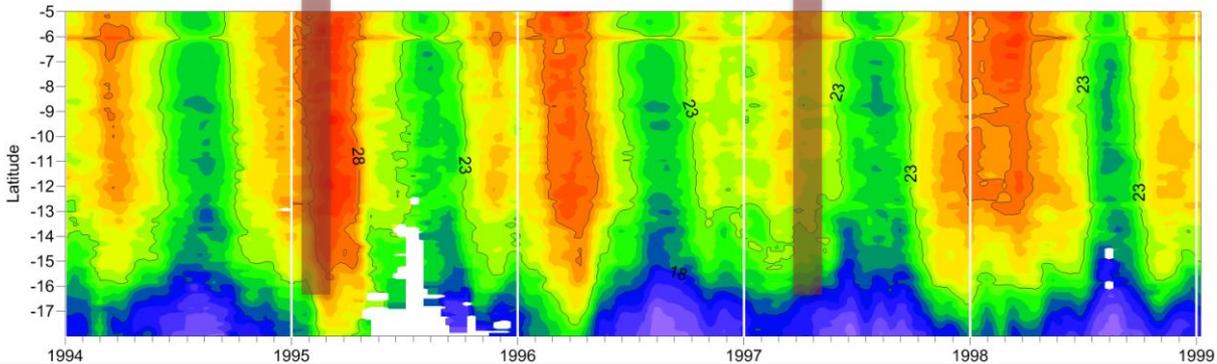
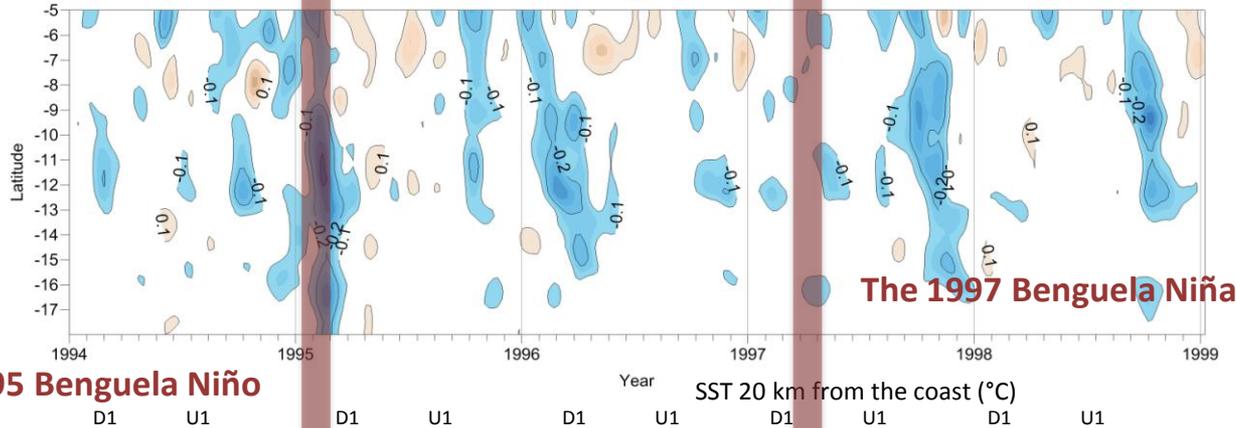
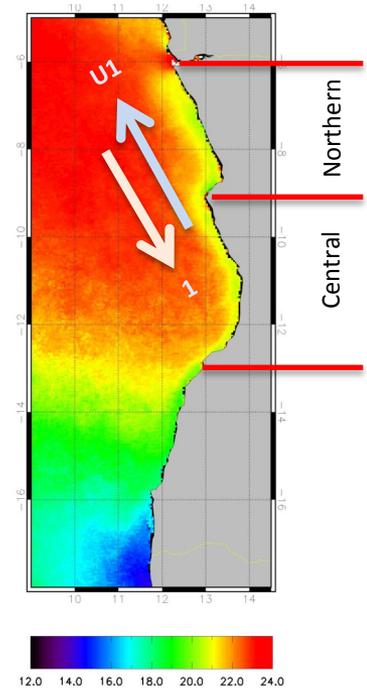
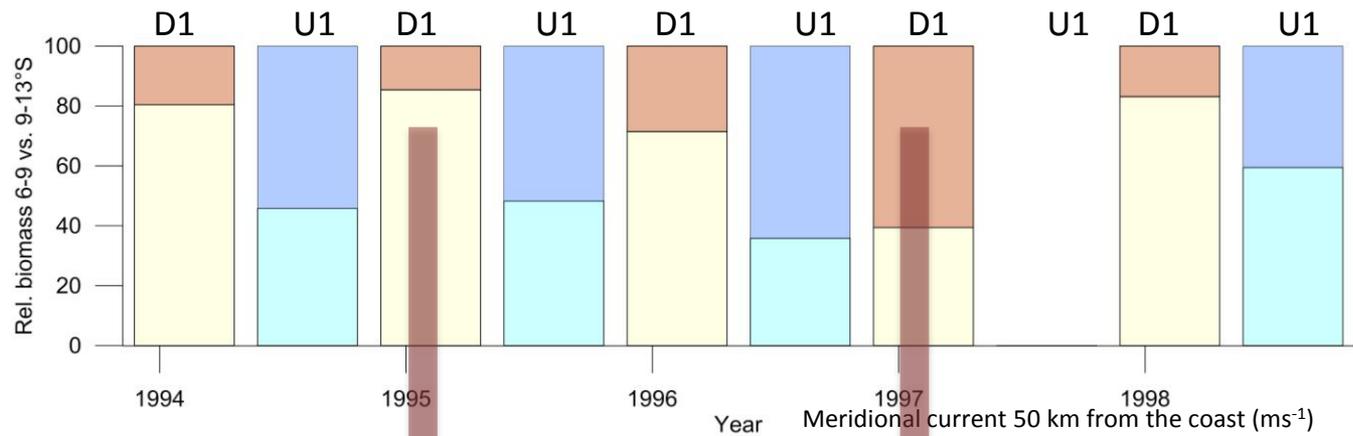


Relative biomass, North (blue) – Central (white) region

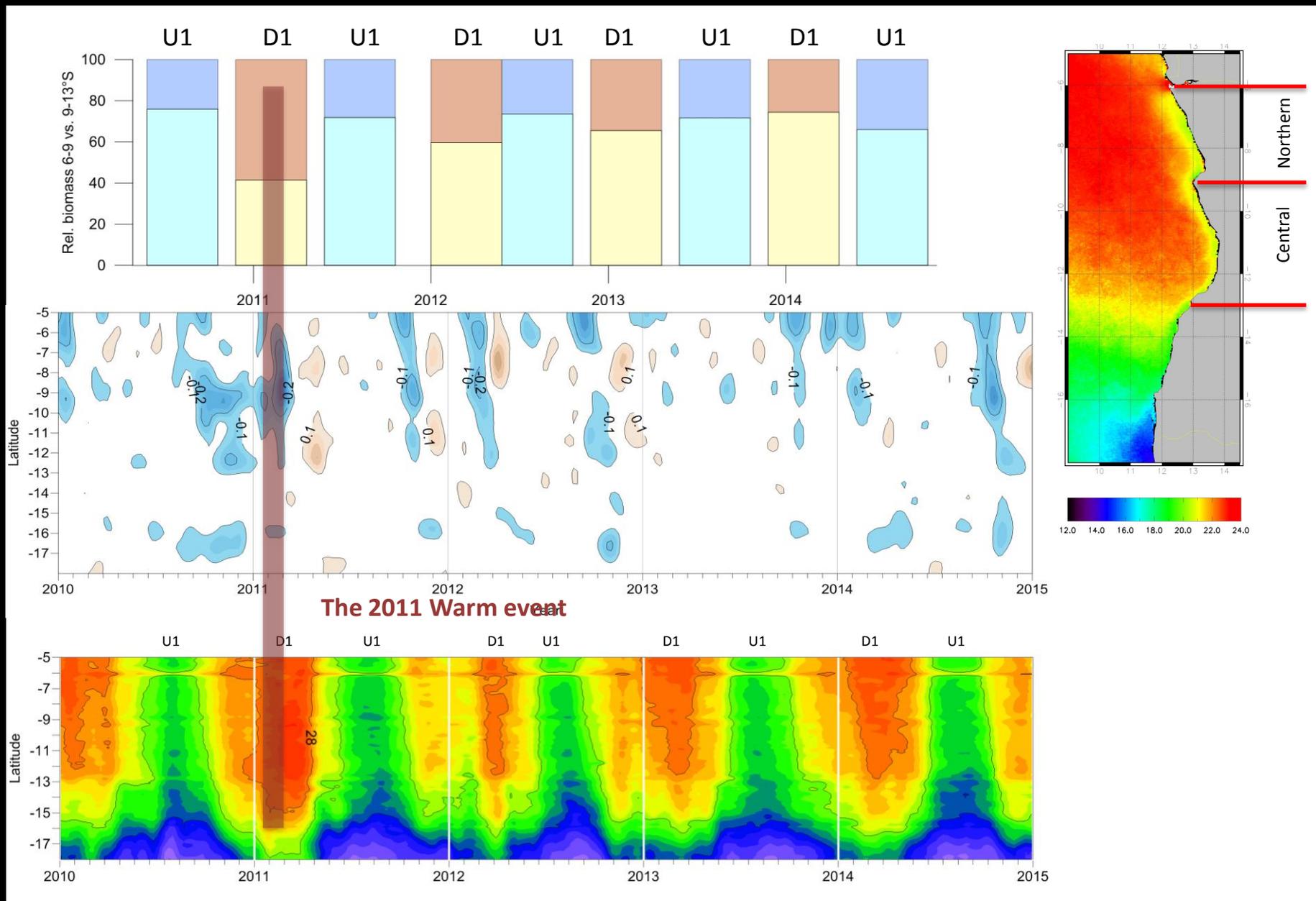




Seasonal changes in Relative biomass between the Northern and Central region during the Benguela Niño/Niña period, 1994-1999

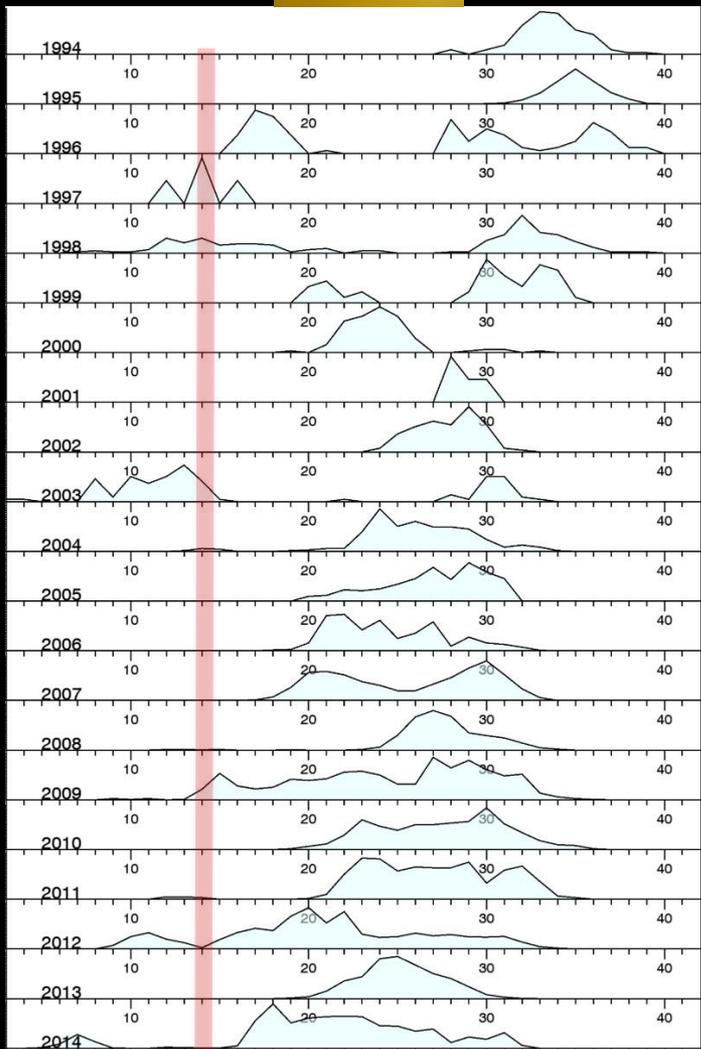


Seasonal changes in Relative biomass between the Northern and Central region during and in the wake of the 2011 Warm Event

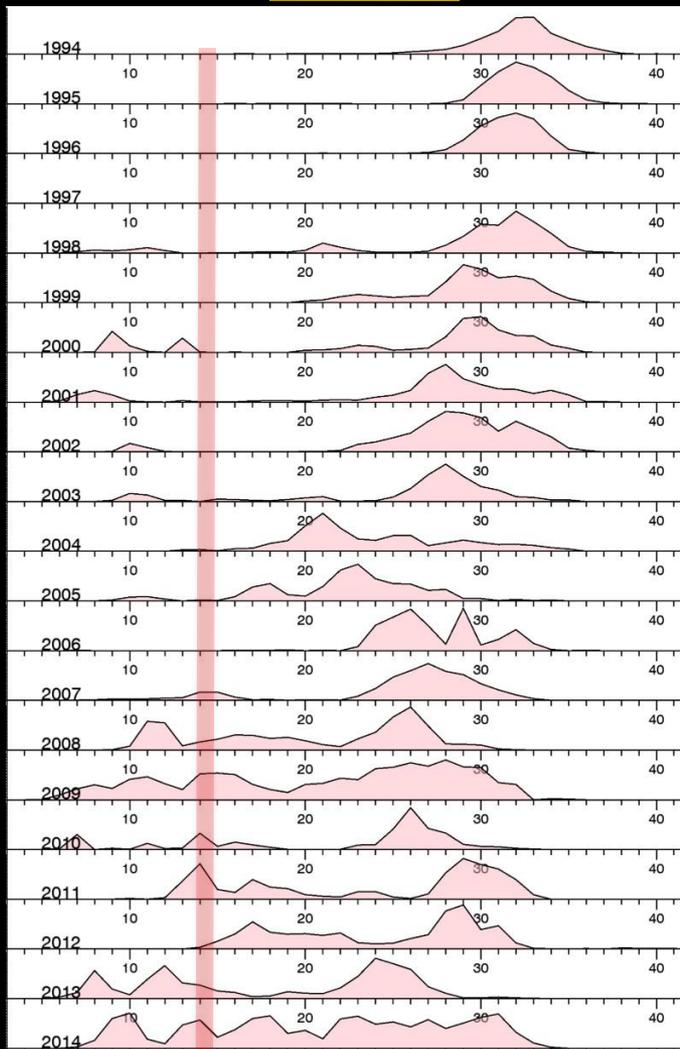




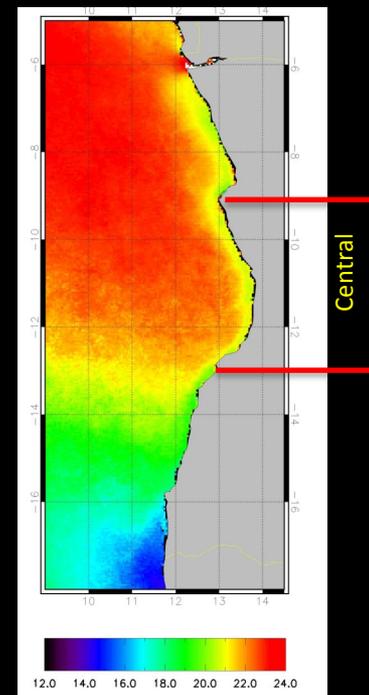
Evolution of length distributions for the two species of sardinella in Central Region during U1, 1994-2014



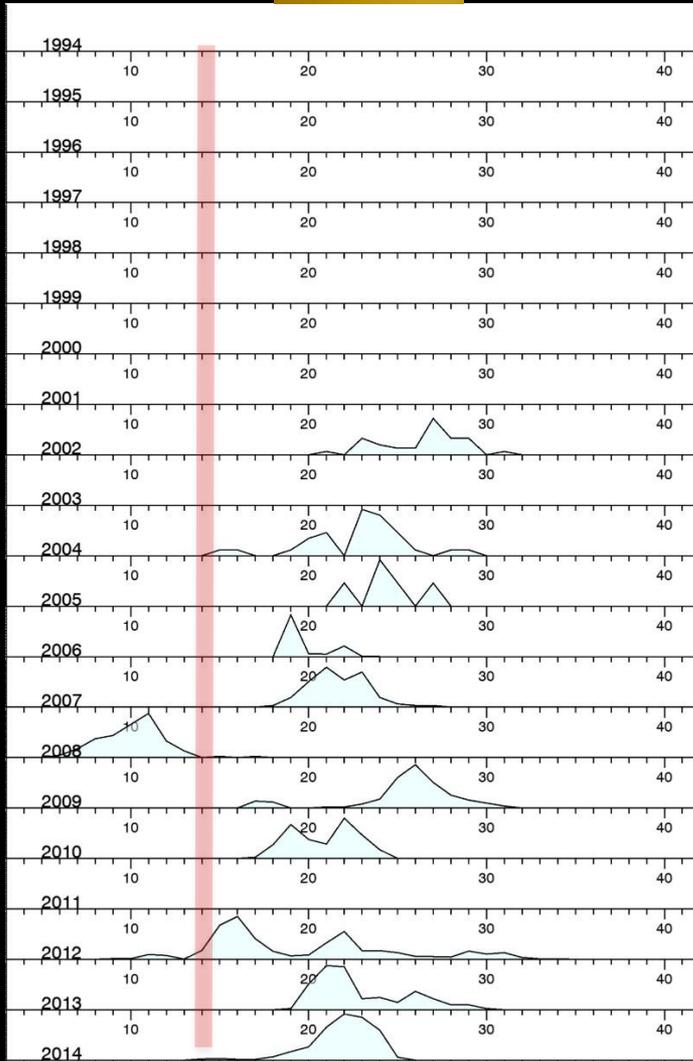
S. aurita



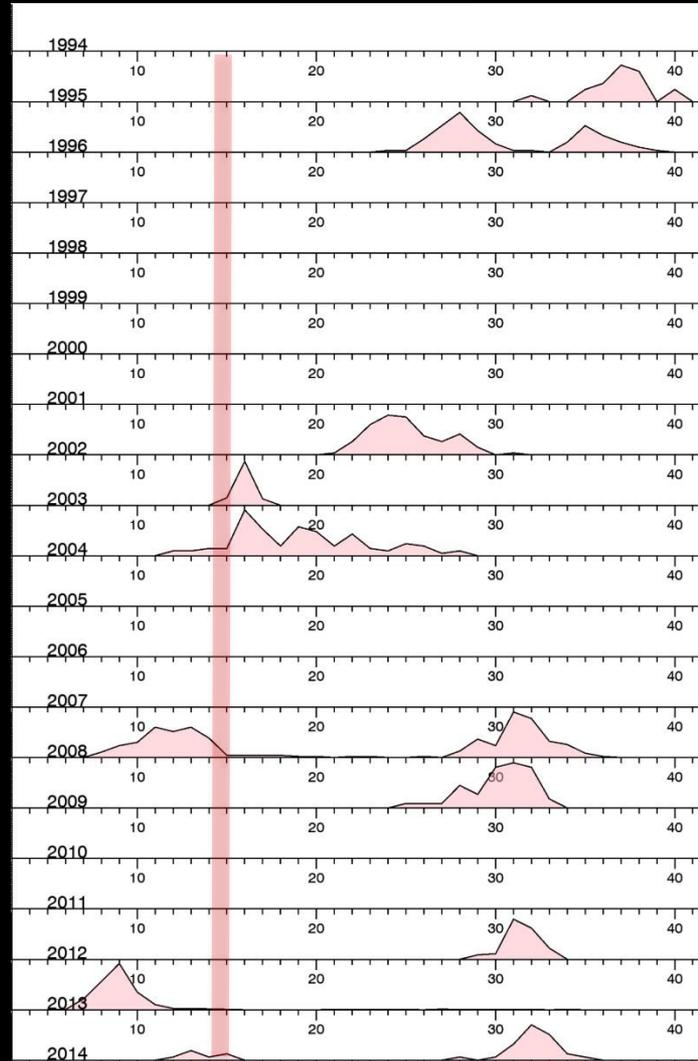
S. maderensis



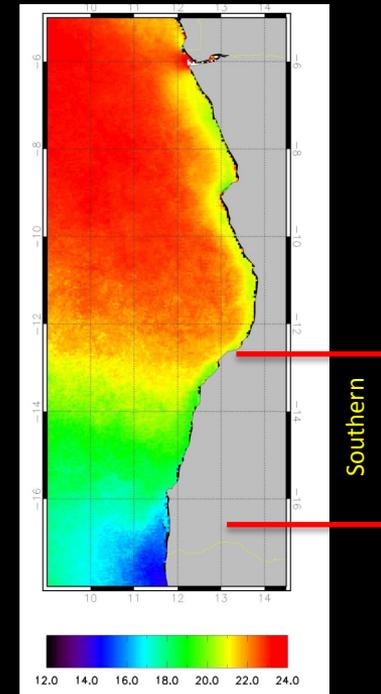
Evolution of length distributions for the two species of sardinella in Central Region during U1, 1994-2014



S. aurita

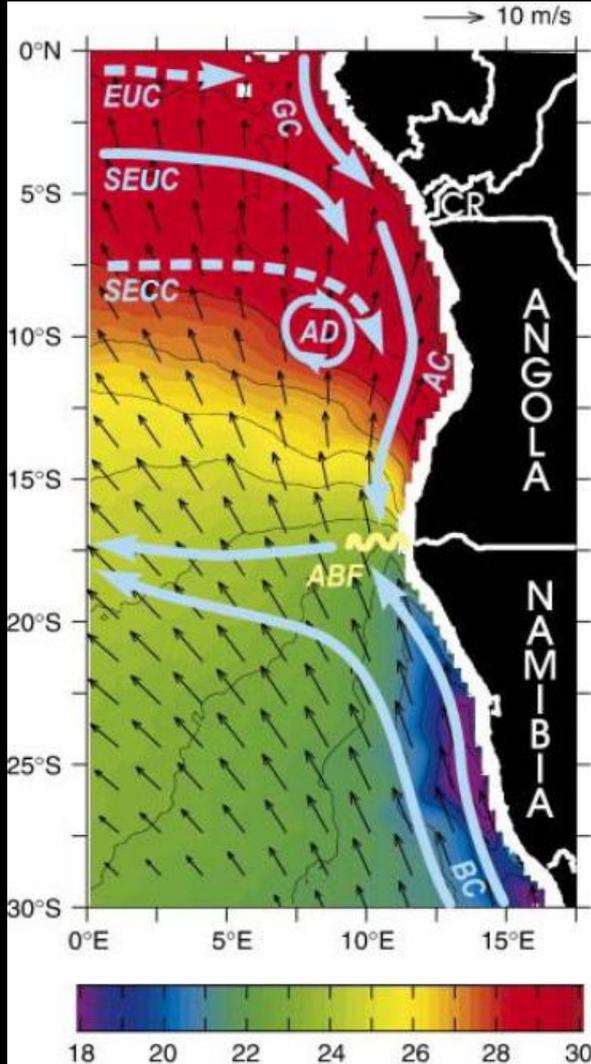


S. maderensis



Southern

Summary



(Rouault et al., 2007)

- The range of the sardinella occurrence is associated with the extent southward flowing Angola Current.
- Within the tropical sector of Angola (5-13°S), sardinella is exposed to the regular semiannual cycle of intensified southward drift followed by the season of calm upwelling.
- Within the Angola Benguela Front (13-17°S), the fish is exposed to interannual variability. Strong warm events provide a transport mechanism for fish to expand its southern range.
- During 1985-2014 the coastal ocean off Angola became warmer. This decadal-scale warming coincided with a systematic increase in the sardinella biomass
- The center of the biomass, historically located to the north of Luanda (9°S) has been shifting to the south. In the recent years over 60 percent of the biomass is located between 9 and 13 °S. In this region, The fish length structure, historically consisting large (old) fish, currently exhibits high proportion of juveniles (< 12 cm).
- Within the ABF Front (13-17°S), during upwelling season (low southward current) *S. aurita* was not observed before 2002. In the recent years observations of *S. aurita*, including juveniles < 12 cm are frequent.
- Strong seasonal migration between the central (9-13 °S) and northern (6-9 °S) regions was observed during 1994-1999. The migration seasonal patterns appear to have recently diminished (2010-2015).

