ENVIRONMENTAL FORCING ON ANCHOVY (*ENGRAULIS ENCRASICOLUS*) CATCHES IN THE SOUTHERN IBERIAN PENINSULA

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Abstract

Fluctuations of clupeoids catches are frequently associated to the process of survival during early stages of the life cycle. Connections between meteorological and oceanographic factors on one side and survival of anchovy early life stages on the other are explored in the southern Iberian shelf. The wind regime in the area is dominated by easterlies and westerlies, the former originates oligotrophy and advects early life stages towards open sea waters. Rain fertilizes the shelf. The combined forcing of rain and easterlies on the primary production and current system of the shelf probably originates part of the variance in the inter-annual fluctuations of anchovy landing observed in the last decades.

Keywords : Strait Of Gibraltar, Spawning, Fisheries, Ichthyoplankton, Circulation.

The Gulf of Cádiz has a wide shelf (∼50 Km) in a geographical context, the southern Iberian Peninsula, where this is usually narrow. Oceanographic processes at this shelf are affected by the proximity to Gibraltar and the influence this strait exerts on both the meteorology and the oceanography of the region. The strait influence on the former is neat in any analysis of the wind regime in the area. This is clearly dominated by easterlies and westerlies with strength usually increasing nearby Gibraltar. Westerlies are more frequent and, because of the coastline orientation and the Ekman pumping, they fertilize the shelf. In addition, the two major rivers of the southern Iberian Peninsula (Guadalquivir and Guadiana) discharge at the Gulf of Cádiz. Although heavily regulated with reservoirs, the fresh water of these rivers also fertilizes the inner shelf [1].

River and westerlies fertilization notably increase the primary production of the shelf, which is higher than at offshore waters of the basin. This increment is not accompanied by colder waters, as frequently occurs in tropical and subtropical latitudes, where nutrients inversely correlate to temperature [2]. The positive correlation between nutrients and temperature is associated to land-ocean interaction at saltmarshes in the region. At summer, the water inundating the marshes is heated during tidal flooding and this energy is brought back to the sea with the ebb tide [3]. This buoyancy input in the east side of the shelf (marshes at the Guadalquivir River and the Bay of Cadiz) originates the westward counter current usually present during summer in this shelf [4, 5].

The counter current and the south eastward circulation at the slope build a cyclonic cell, which is relevant for anchovy reproduction. Anchovy spawns at the slope side of the shelf, where the flow is towards the southeast. In the absence of the counter current at the inner shelf, eggs should keep flowing towards the strait of Gibraltar and from there inside the Mediterranean where oligotrophy hinders larvae survival. The counter current forces the streamlines towards the northwest and recirculates the suspended eggs towards the inner shelf, where high larvae concentration can be found one month later. This cyclonic circulation is only present during summer in connection with shelf overheating, which starts in June. June is also the peak for anchovy spawning in the Gulf of Cádiz [6]; therefore, suggesting a reproductive strategy that spawns not only where but also when currents are suitable for the survival of early life stages.

Consequently, the Gulf of Cádiz shelf offers during summer a combination of thermal, trophic and current features suitable for the success of anchovy early life stages. Nevertheless, this combination is substantially altered under easterly winds. Ekman pumping generates downwelling and oligotrophy in the shelf during easterlies. Although less frequent than westerlies, easterlies usually blow very intense when they occur. Easterlies are warm and dry during early summer, and generate a massive transport of latent heat from the surface ocean towards the atmosphere. The cooling of water they generate is enough to stop the spawning process [6]. In addition, easterlies intensity is enough to force the counter current to flow beyond the cyclonic cell and across cape Santa María. Under persistent easterlies, the westward progression of the counter current across cape Santa Maria can continue its westward progression to go beyond cape San Vicente [5] while advecting eggs and larvae from the shelf to deep sea waters of the north Atlantic. Westward advection of eggs and larvae has been observed during two synoptic surveys performed only several days apart under westerly and easterly wind regimes, respectively [7].

Therefore, the optimal combination of thermal, trophic and current features is significantly altered during easterlies bursts. Together with interannual changes in precipitation, yearly variations in easterly intensity during anchovy spawning can be at the origin of the variance in the landing of this fishery. This is the case for the fishery crisis at mid nineties, which is associated to a period of strong easterlies and low precipitation. Although one co-occurrence of negative oceanographic conditions and low landing at mid nineties does not constitute a definitive proof for a causal connection, the fact that this connection is also supported by a mechanistic understanding of the underlying process provides further evidence in support of the significant role played by oceanography for anchovy fisheries in the southern Iberian Peninsula.

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