European anchovy (*Engraulis encrasicolus*) in Subdivision IX.a South (Gulf of Cádiz)

ENVIROMENTALLY DRIVEN RECRUITMENT

Anchovy (*Engraulis encrasicolus*) is the most important fishery in Gulf of Cadiz, one that exhibits a particular population dynamic behaviour. Together with natural mortality, fishing pressure exerts strong population control that prevents adults from surviving beyond the first year. Due to this lack of adults, the population relies primarily on recruits to persist between years, however, recruit survival is also highly affected by the environment and thus variable between years (Ruiz *et al*. 2007).
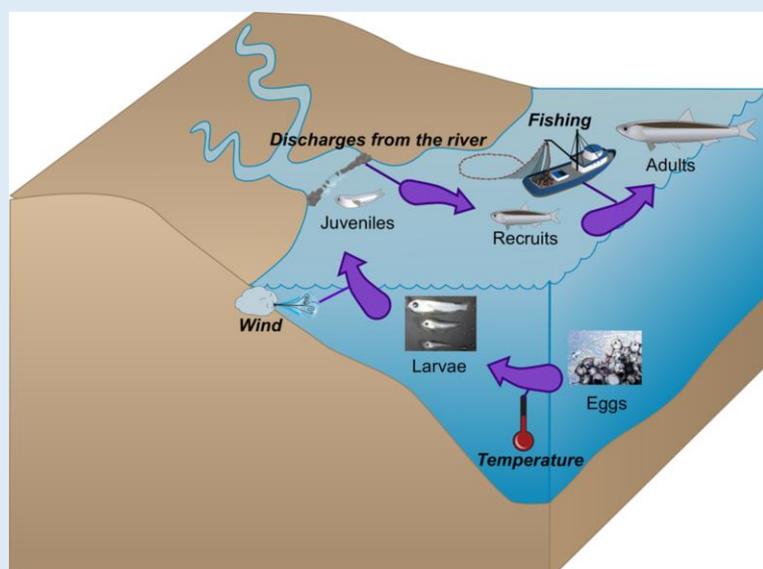

Figure 1: *Diagram of anchovy life cycle in the Gulf of Cádiz including environmental forcing on different life stages from Rincón et al. (2016).*

Sea surface temperature (SST), intense easterly winds, and discharges from the Guadalquivir River have been identified as the main factors influencing anchovy population dynamics during early life stages (Prieto *et al.* 2009, Ruiz *et al.* 2006; see Figure 1). Temperature changes determine spawning timing (García & Palomera 1996, Motos *et al.* 1996), while the wind regime influences recruitment variability in this stock (Rincón *et al*. 2016). Strong easterlies at the time of spawning can disperse eggs and larvae, impacting negatively on survival (Ruiz *et al*. 2006). The level of river discharges has also been related to stock oscillations; the 1995 stock collapse coincided with a severe drought that forced discharges to drop below 100 hm^3/month that year (Figure 2). The increase in water flow in 1996 and 1997 was followed by an increase of the stock in 1997 (Figure 2). Currently, due to agricultural demands, discharges have been stabilized around 100 hm^3/month, thus minimising the variability on recruitment in recent years (Rincón *et al*. 2016).
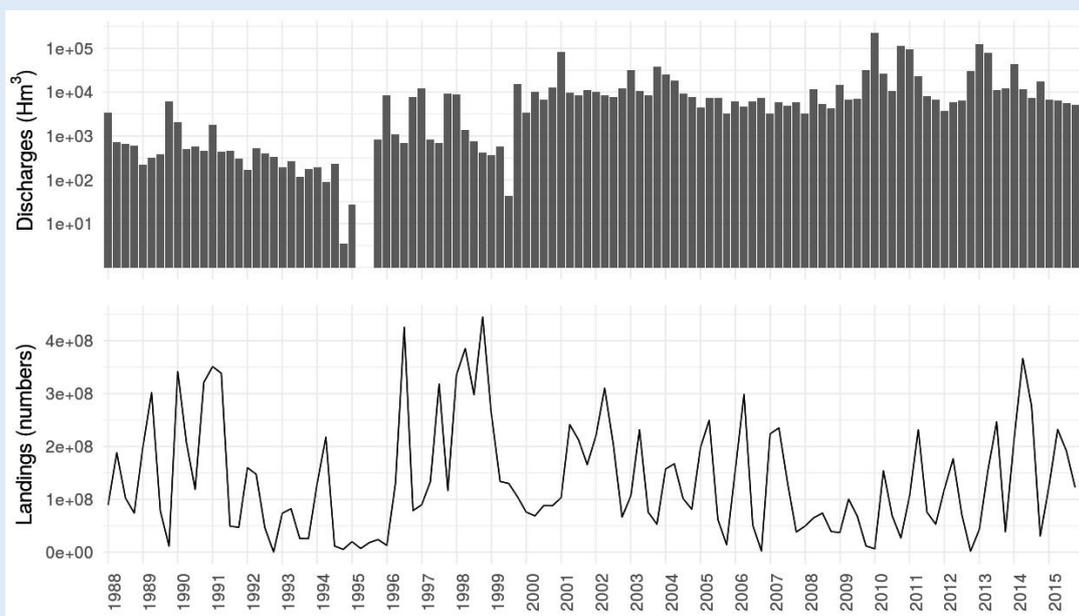
Figure 2: *Discharges from the Guadalquivir River and anchovy landings quarterly time series.*

ECOSYSTEM APPROACH

Recently, much effort is being devoted to understanding the role of the Guadalquivir estuary as a nursery ground, as this may have important implications on the stock dynamics. Since 1997, a long-term monitoring program is being carried out on a monthly basis in the estuary (e.g. González-Ortegón *et al*. 2015). In addition, an exhaustive study of the state and functioning of the estuary was conducted in 2010 (CSIC 2010), which informed and influenced governmental agencies positions regarding crucial long-term management decisions.

Over the last few years models that incorporate environmental information have been developed by means of Bayesian simulation techniques (Ruiz *et al.* 2009, 2017, Rincón *et al.* 2016, 2017), as well as mass-balanced models describing the role of anchovy in the marine food web (Torres *et al.* 2013). Studies arising from the Guadalquivir monitoring program have described long term changes in anchovy early life stages and other nekton components in relation to salinity and turbidity conditions (Drake *et al.* 2007, González-Ortegón *et al.* 2010, 2012). An ecosystem approach perspective is presented in Llope (2017). Ruiz *et al.* (2015) review the role of the estuary, its anthropogenic transformation, and the ecosystem services provided by the Guadalquivir River to the Gulf of Cadiz.

REFERENCES

References can be found at https://drive.google.com/open?id=0B0LQHqr-qs_6ZHdHQ1U4Sm94NEk