Influence of latitude variations in spawning habitat characteristics on the early life history traits of the anchoveta, *Engraulis ringens*, off northern and central Chile

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Introduction

The Peruvian anchoveta, *Engraulis ringens*, is distributed along the Humboldt Current from 4˚S through to 42˚S, a latitudinal range over which strong variations in environmental conditions occur. The effect of latitudinal changes in oceanographic conditions on early life history traits of the anchoveta, a species that constitutes one of the most important pelagic fisheries of the world, has, however, been traditionally ignored. Most of the studies throughout the species range have been carried out to determine egg and larval distributions, for adult stock assessment or as recruitment studies, primarily on the largest stocks.

Three major stocks are recognized along the Humboldt Current System; the largest stock off northern Peru, a medium-sized one off southern Peru–northern Chile, and a smaller stock off central Chile. In an attempt to determine how the early life stages of this species cope with the variations in environmental conditions along its latitudinal range, a series of studies were initiated in 1995 in the southern stock area (Castro *et al.* 2000, Castro and Hernandez 2000, Hernandez and Castro 2000). These studies have now been extended to the area of the medium-sized stock. In this study we report a) preliminary results on variations in some early life history characteristics of populations located at different latitudes along northern and central Chile, and b) we document latitudinal variations in environmental characteristics during the spawning season that correlate with the early life history traits under study. The early life history characteristics analyzed are: i) egg size, ii) larval hatch size, iii) yolk volume at hatch, and finally iv) larval growth rates. The approach has been to combine information and samples collected in the field with new results of egg and larval rearing experiments carried out under laboratory-controlled conditions.

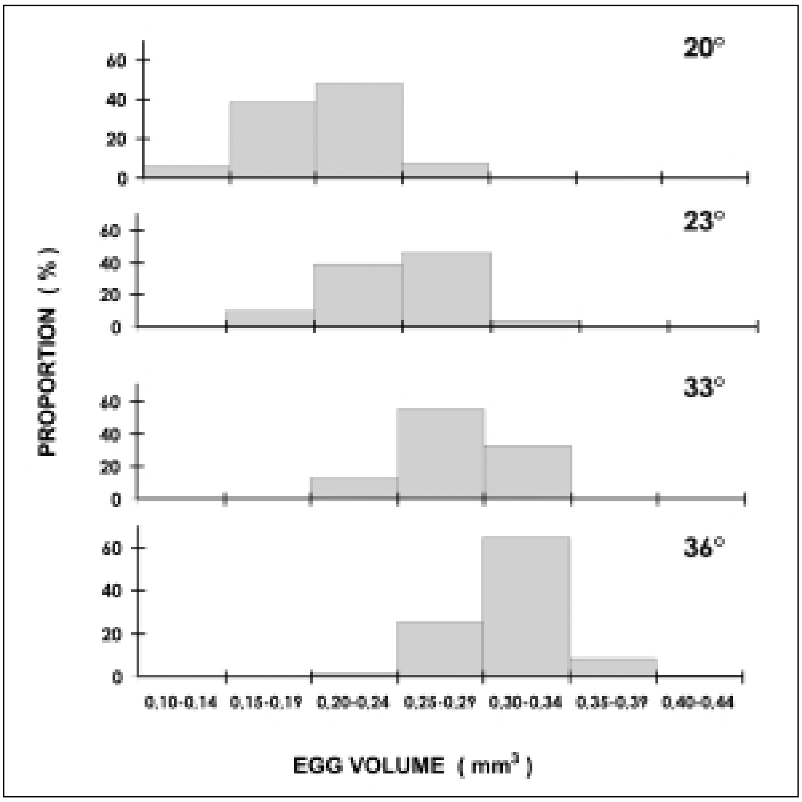

Fig. 1

Results

The analyses of egg size data based on ichthyoplankton samples collected during the peak spawning season (July – September) in 1996 show that the mean anchoveta egg volume increase with latitude (Fig. 1). At the southern location considered in this study (Talcahuano, 36˚S), the mean egg volume was 55% larger than that of eggs from the northern location (Iquique, 20˚S).

From rearing experiments carried out on stage-III eggs collected from the wild during the peak spawning season at two localities (Antofagasta and Talcahuano) in the year 2000, we determined that larval size at hatching increased only slightly with latitude. Larvae at the southern location (Talcahuano, 2.81mm notochord length) were only 5% longer than those hatched from eggs collected at the northern experimental location (Antofagasta, 2.66mm notochord length), with both eggs and larvae reared at the same temperature (15˚C). Interestingly, the yolk volume of recently hatched larvae showed the greatest

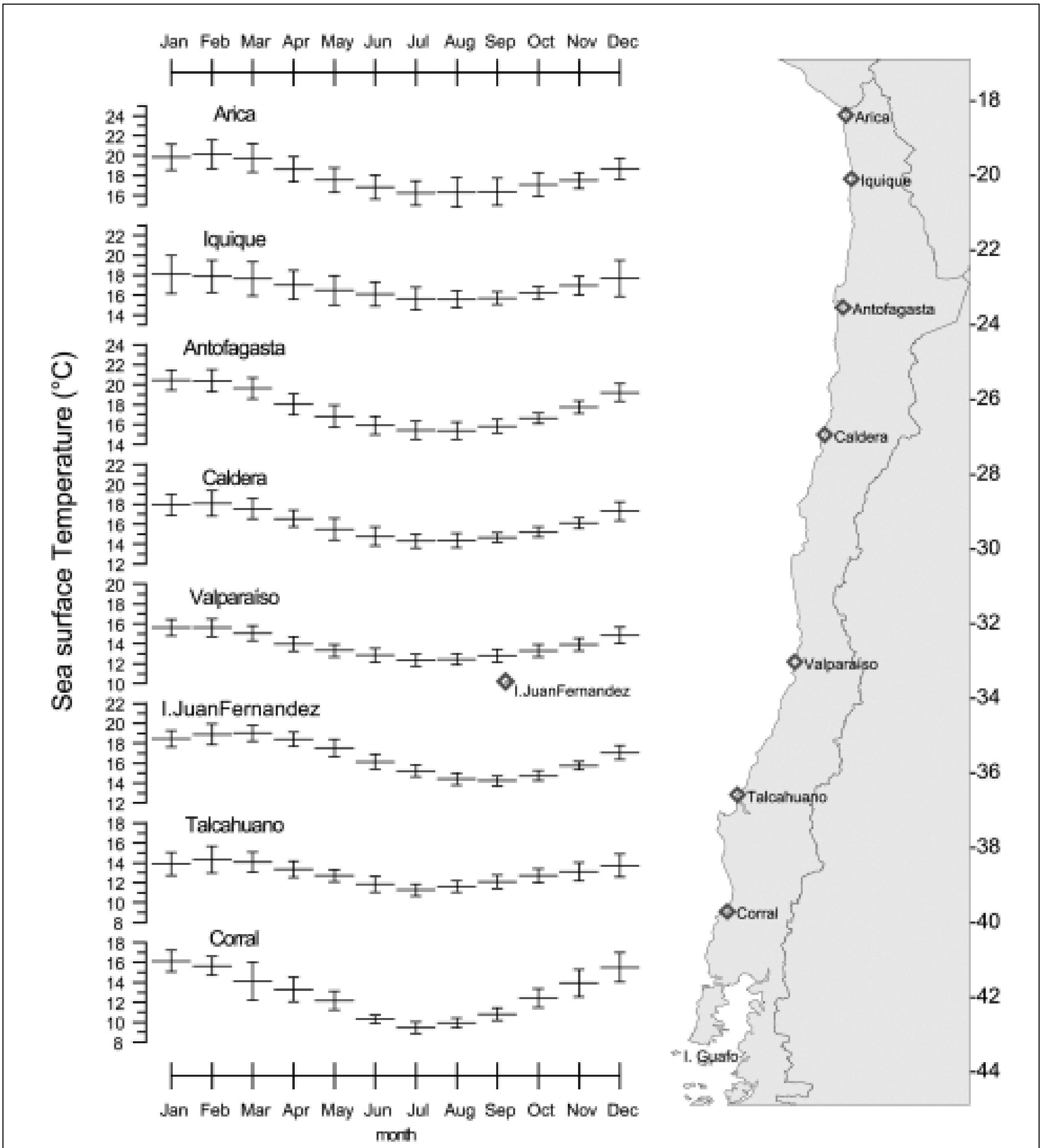

Fig. 2

variation between localities, with the volume of southern larvae (Talcahuano, 0.12mm^3) being on average twice that of recently hatched larvae from the northern location (Antofagasta, 0.05mm^3). As the number of recently hatched larvae measured is small (< 50 larvae) these results, although very remarkable, should be still be considered preliminary.

The growth rates determined for larvae reared in the laboratory under the same temperature and feeding conditions in Antofagasta and Talcahuano tended to increase with temperature. Growth rates were on average between 20 and 30% higher for larvae from the northern population (Antofagasta) at all temperatures considered (10, 12, 15 and 18˚C). Interestingly, at the lowest temperature utilized (10˚C), survival was very low in larvae from Antofagasta, in contrast to the situation that occurred in larvae from the Talcahuano population where survival was lowest at the highest temperature (18˚C).

Discussion

Our results show that egg size, larval length at hatch, and yolk sac volume of recently hatched larvae increase with latitude, and that instantaneous larval growth rates decrease with latitude. Concurrently, from our time series of environmental characteristics during the peak spawning season in winter we determined that the sea surface temperature decreases with latitude (*i.e.* about 4˚C difference between Antofagasta and Talcahuano, Fig. 2), wind induced turbulence increases with latitude, and offshore surface Ekman transport decreases with latitude (Fig. 3). A brief analysis of these results suggests they are in agreement with the expectations based on known temperature effects on physiological rates (Houde 1989) and on ecological factors related to the requirement for the retention of early life stages in nearshore environments (Bakun 1996). At lower latitudes the sea surface temperature is higher and the offshore surface Ekman transport is stronger, suggesting that larvae growing in such conditions should grow rapidly. Alternatively, anchovy larvae at higher latitudes are retained nearshore in winter (as the Ekman transport is negative) but are exposed to lower temperatures and to very strong turbulence that may not facilitate the first feeding of recently hatched larvae and subsequent rapid larval development.

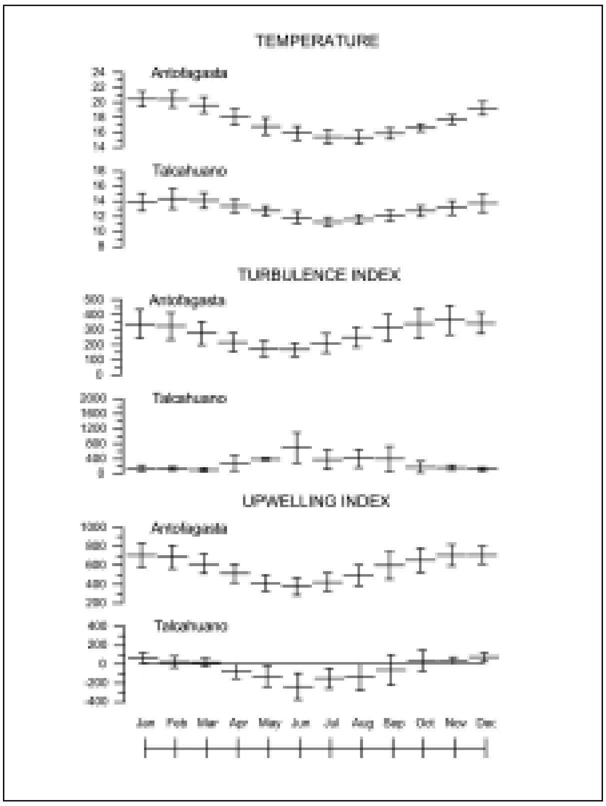

Fig. 3

Another important implication of this study results from the comparison of larval growth rates between populations located in northern and central Chile. Both populations showed plasticity in their larval growth rates; however, their tolerance to extreme lower and upper temperatures differed. This suggests that their capacity for growth is different (Conover 1990, Conover and Present 1990) and, therefore, that some selection might be taking place between these populations located at different latitudes.

Acknowledgements

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Figure Legends

Figure 1. *Engraulis ringens* egg volume distribution at different latitudes along the Chilean coast from field samples collected during the peak anchoveta spawning season.

Figure 2. Time series from 1970-1999 of sea surface temperature (˚C) measured at the tidal gauge stations along the Chilean coast.

Figure 3. Time series from 1970-1999 of sea surface temperature (˚C), turbulence index m^3/s^3) and upwelling index ($m^3/s/1000$) at Antofagasta (23˚S) and Talcahuano (36˚S).