

Spawning, daily egg production, and spawning stock biomass estimation for common sardine (*Strangomera bentincki*) and anchovy (*Engraulis ringens*) off central southern Chile in 2002

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Abstract

In this paper, the first daily egg production method (DEPM) parameters were estimated for anchovy and common sardine stocks distributed in the central-south area off Chile (33–40°S). The study area was stratified according to the topography, shape and orientation of the coastal line, and the survey was carried out on the continental shelf during the main spawning peak (August–September, 2002). The bulk of the spawning of both species was successfully covered, which was characterized by a coastal distribution within the first 20 nautical miles, and following the inner zone associated with the 100 m bottom depth. The coastal distribution of the spawning can be related to the oceanographic conditions occurring during the transition from winter to spring (southern Hemisphere), which are characterized by the alternation between northerly and southerly winds. Probably, these factors are interacting to produce enrichment, concentration and retention of egg in coastal zones in the study area. The daily egg production rate (P_0) was estimated for two geographic strata, and was different in each region. Also, the length frequency and adult reproductive parameters were different between geographic strata, specially the daily spawning fraction. For anchovy, the P_0 was lower in comparison with available estimates for the same species in Peru and in the north area off Chile. Also, the relative fecundity of anchovy was lower, probably because anchovy in the study area have bigger eggs as compared with the anchovy in Northern Chile. The DEPM parameters estimated for common sardine in the investigated area were similar to the range of existing values for the *Engraulis* genus in other upwelling areas. The stratified spawning stock biomass estimate was 133,031 t (CV = 44%) for anchovy and 706,792 t (CV = 68%) for common sardine. Probably, daily egg production and adult reproductive parameters of both species are highly variables and further research is suggested for improvements future DEPM application for the species.

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Keywords: Daily egg production; Spawning; Reproductive parameters; Small pelagic fish; DEPM; Central-south Chile

1. Introduction

Two small pelagic fish, locally known as common sardine (*Strangomera bentincki*) and anchovy (*Engraulis ringens*), are important fish resources for both industrial and small-scale purse-seine fleet in the central-south area off Chile (34–40°S), with Talcahuano as the main port for landings (Cubillos et al., 1998, 2002). *S. bentincki* is an endemic species distributed

from northern Coquimbo (29°S) to Puerto Montt (42°S), while *E. ringens* is distributed from northern Peru to southern Chile (Arrizaga, 1981; Serra, 1983). In the central-south area off Chile, these small pelagic species are caught together by fishermen because anchovy and common sardine are co-occurring species and aggregated in mixed schools (Gerlotto et al., 2004). In addition, the biological characteristics are similar in terms of the spatial distribution, growth rate, reproduction time, spawning area, and recruitment time (Cubillos et al., 2001, 2002).

The spawning season of the species tends to occur in winter (southern Hemisphere) and extends from July to September, with a peak between August and September (Cubillos et al.,

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1999). Three to four months after the spawning, the surviving juveniles are recruiting into the population from November to January at a modal length between 5 and 6 cm total length (Cubillos et al., 2001, 2002). The fishery is heavily dependent on the annual pulse of recruitment, which is due to the higher abundance, availability and accessibility of recruits in bays and gulfs from January to March (Cubillos et al., 1998).

Stock assessments of common sardine and anchovy have been done through cohort analysis on a monthly basis due to their short-life cycle and the seasonal behavior of the fishery (Cubillos et al., 2002). Since 2000, hydroacoustic surveys have been carried out to assess the annual pulse of recruitment in January every year (Castillo et al., 2001, 2002, 2003a,b, 2004), and only one hydroacoustic survey was carried out in August 2001 to estimate total and spawning stock biomasses (Castillo et al., 2002). In the former, the acoustic survey estimated a total biomass of 564 thousand t for anchovy and 261,000 t for common sardine, from which 41 and 60% represented the mature biomass of anchovy and common sardine respectively (Castillo et al., 2002).

However, the spawning stock biomass of both species can be assessed by applying the daily egg production method (DEPM, Lasker, 1985; Hunter and Lo, 1993). In fact, both species have a coastal and well defined spawning area (Castro et al., 1997), and they are species with asynchronous oocyte development (undetermined fecundity) (Arancibia et al., 1994; Cubillos et al., 1999). Biomass estimation by DEPM has several advantages over hydroacoustic assessment because DEPM provides information about the reproductive condition of females, distribution of the spawning, reproductive habitat, egg production and mortality during the peak of spawning. These parameters are important for stock assessment and fisheries management if DEPM estimates can be keeping on sufficiently long-time periods, and particularly when DEPM parameters can be compared across species and genus (Alheit, 1993; Somarakis et al., 2004).

In 2002, a DEPM was applied for spawning stock biomass estimation of common sardine and anchovy off central southern Chile. This is the first application of DEPM for the southern stocks of anchovy and common sardine in the Humboldt Current System, providing important and new information in terms of the spatial distribution of the spawning, the daily egg production, egg mortality, as well as the reproductive adult parameters. In this paper, results are compared with the daily egg production and the adult reproductive parameters available for other clupeoids stocks in upwelling areas particularly on Northern anchovy (*E. mordax*) off California, *E. ringens* off Peru and northern Chile, and *E. encrasicolus* off South Africa.

2. Materials and methods

2.1. Study area and survey description

The study area was located off central southern Chile (33–40°S) covering 27,837 km², which represents the main spawning area for both species. According to Cubillos et al. (1999, 2001), spawning extends from July to September, peaking between August and September for both anchovy and common

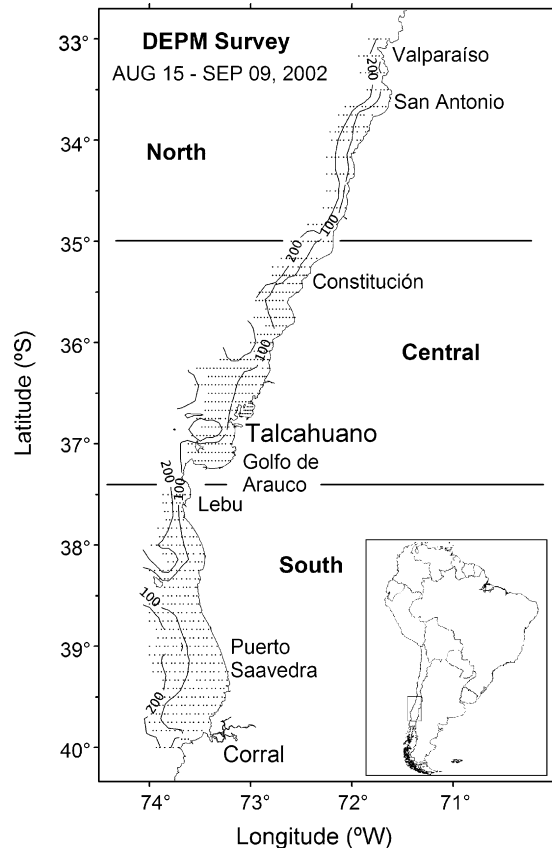


Fig. 1. Study area showing the location of the plankton stations and depth contour.

sardine. In this way, a single survey is enough to characterize the spawning process of the two species. The study area was divided in three strata: (a) northern zone, from Valparaíso to northern Constitución (33–35°S), (b) central zone, from Constitución to Gulf of Arauco (35–37° 10'S), and (c) south zone, from Lebu to south of Corral (37° 28'–40°S) (Fig. 1). Plankton stations were distributed regularly on the continental shelf (200 m depth) with stations spaced by two nautical miles apart along E–W transects, and transects separated by five nautical miles. The northern zone was considered an exploratory area in which transects were spaced by 10 nautical miles apart, because egg abundance practically has been not observed in this zone previously (Castro et al., 1997; Castillo et al., 2002). During 15 August–9 September 2002, two ships were used to collect ichthyoplanktonic data by means of vertical hauls of Paironet nets (25 cm diameter, 0.150 mm mesh size, Smith et al., 1985) from 70 m or near the seabed in depth less than 70 m. The research vessel “KAY KAY” of the “Universidad de Concepción” operated in the central zone, while the fishing vessel “FOX” operated in northern and southern zones.

In addition, 10 small purse-seine boats (18 m length) were used to obtain adult samples of anchovy and common sardine during the study period. Five boats were allocated to the central zone and five to the southern zone. A total of 106 fishing sets were conducted from which 17 were without fish, and the majority of the sets occurred in the daytime, mainly between 6:30 and 18:00 h. The sets covered a wide geographic area between Con-

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