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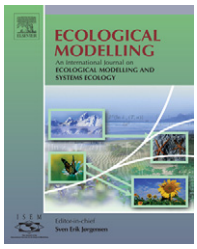

A catch forecast model for the Peruvian scallop (*Argopecten purpuratus*) based on estimators of spawning stock and settlement rate

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ABSTRACT

The Peruvian Bay scallop (*Argopecten purpuratus*) fishery in Independencia bay (Southern Peru) is being subjected to great inter-annual variability in catch and effort. This is mainly due to the ENSO (El Niño-Southern oscillation)-caused changes in the population dynamics of the stock, which greatly proliferated during the El Niño events 1983 and 1998. As a consequence "gold rush" conditions arose and resource users profited from a multi-million dollar export business. After the El Niño booms, the system normalized and catches dropped to normal levels. This boom and bust situation has made a rational management of the resource difficult, and annual catches are considered unpredictable, just like the stochastic environment. This paper attempts to provide a catch forecast model to enable the scallop fishery to better prepare for and adapt to the ever-changing conditions of the scallop stock. The model proposes that annual catches are mainly the result of the recruitment success of the incoming new cohort, which is a function of adult spawning stock size and the number of settlers to the sea bottom. The latter is considered a function of the larval mortality rate and the temperature-dependent development time to the settlement stage, while the former is proportional to the catches taken over the spawning period (November–April). Using monthly catch and temperature data for the period 1983–2005, we constructed a regression model to predict the catch for the year after the recruitment period (July–June) as a function of (a) the catch during the spawning period (as a proxy for spawning stock biomass) and (b) the settlement factor that was derived from the mean water temperature over the spawning period, an assumed instantaneous larval mortality rate, and the relationship between temperature and larval period to settlement. The resulting multiple regression ($R^2 = 0.930$) proves that both factors can explain a large part of the inherent variability of the data. The model reveals that annual catches greatly depend on the spawning stock size when temperatures are low, while this factor decreases in importance with increasing temperatures, at which the settlement factor is much more influential instead. These findings are relevant for the stock management: at low temperatures, the maintenance of a large enough spawning stock over the spawning period (November–April) is decisive for the yield of the post-recruitment fishing period thereafter, while at increasing spawning temperatures, spawning stock size is of decreasing importance for determining the yield.

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1. Introduction

The Peruvian Bay scallop (*Argopecten purpuratus*) is the main target of the multispecies diving fishery of Peru. It is being caught in shallow waters (5–30 m) along the entire coastline, but substantial stocks and fisheries are concentrated around two areas only: Sechura bay in the north and Independencia bay in the south (Fig. 1). In Independencia bay, the largest and most productive natural scallop banks are found.

During the El Niño warming event in 1983–1984 the scallop population of Independencia bay exhibited an unprecedented proliferation, causing annual landings to rise from some hundred tonnes of normal (cold upwelling) years to about 25,000 t during the 3 years following the warming event (Wolff, 1985, 1987; Mendo et al., 1988; Arntz and Fahrbach, 1991) (Fig. 1). A scallop export line was established and the scallop fishery became a multimillion dollar business, providing not only work for more than a thousand of divers, but also for a great number of middlemen, factory workers and exporters. This scallop boom thus greatly improved the sustenance basis for thousands of associated families of the nearby town of Pisco.

This "gold rush" period for scallop fishery ended with a normalization of the ecosystem, an almost depletion of the natural scallop stock and the need for scallop divers to shift again to other resources besides the scallops (such as mussels, crabs, clams, octopods among others) and to become used again to low catches and income levels. Another El Niño event of about the same strength impacted the region again in 1997–1998 and the positive effect on the scallop population of the bay was very similar as during the preceding event 15 years ago. Unfortunately, total scallop harvest was much lower during these years due to a mismanagement (growth over fishing) of the resource (Wolff and Mendo, 2000).

Numerous studies have been conducted on the population dynamics of the scallop during normal years and during the El Niño impact (Wolff and Wolff, 1983; Wolff, 1985; Mendo et al., 1988; Mendo and Jurado, 1993; Wolff and Mendo, 2000) showing that population parameters greatly change over an El Niño-cycle, with recruitment and growth rates increasing with water temperature. These studies revealed that Argopecten purpuratus is a relatively short-lived species, whose population sizes greatly depend on the recruitment success of the same year.

Catches are as yet considered unpredictable due to the great environmental stochasticity of the ecosystem and the many abiotic and biotic factors that may affect stock size. As a consequence, the diving fishermen have become used to act like opportunistic predators, searching for and moving towards those areas where scallop abundance happens to be profitable. If this is not the case, other invertebrates are targeted. During the two Niño events mentioned, the diving fleet of Independencia bay increased from less than 100 boats in normal years to over 1000, operating in the zone.

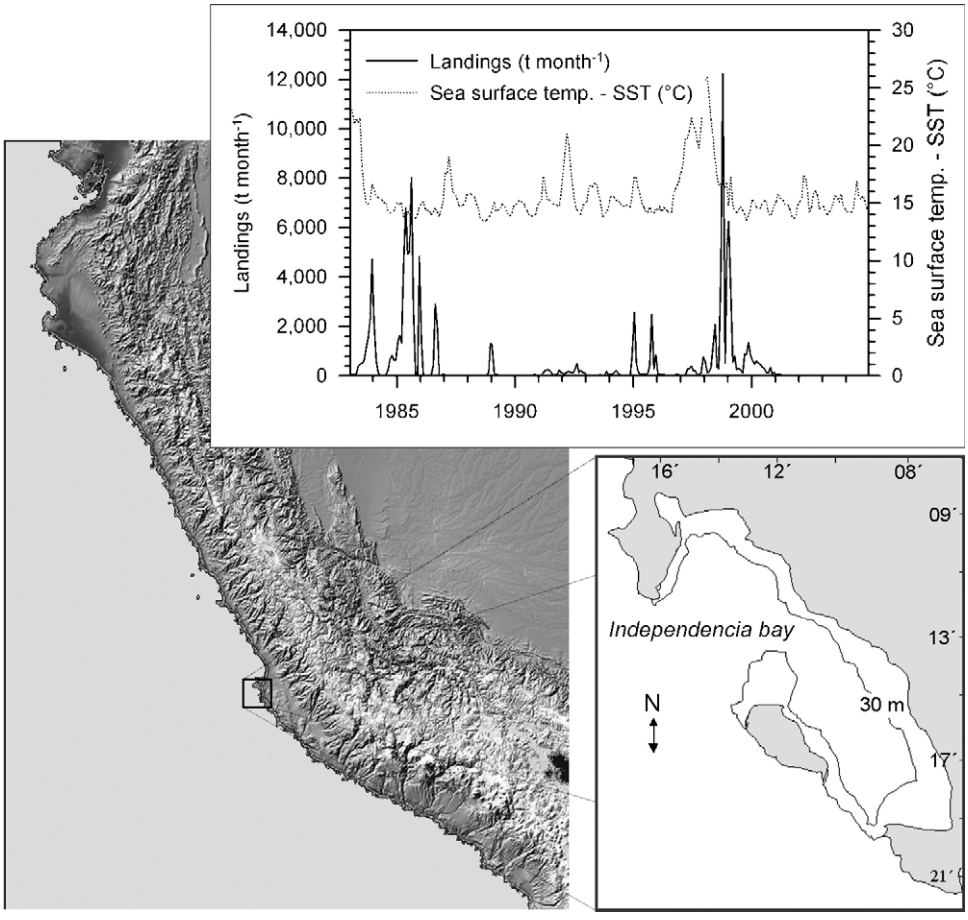

Fig. 1 – Independencia bay (right); scallop landings and SST (°C) (1983–2004) (left).

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