Use of a fishery independant index to predict recruitment and catches of the spiny lobster

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Abstract

This paper presents a review of recruitment and catch predictions based on an index of abundance of juveniles and pre-recruits (fishery independent index) in the Cuban lobster fisheries. This methodology can provide information based on fisheries data that can improve the management of the fishery.

Introduction

The Caribbean spiny lobster (*Panulirus argus*) supports economically important fisheries throughout its distribution from Bermuda and North Carolina in the United States, to Rio de Janeiro in Brazil. The Cuban archipelago supports the most valuable fishery for *P. argus* in the Caribbean that accounts for 30 to 35 per cent of the sold commercial catches in the region. The Cuban fishery involves 250 boats and 1 300 fishermen who operate 300 000 fishing gears during a nine-month fishing season. The fishing methods for *P. argus* are unique: 70 per cent of fishing gear is artificial shelters (*pesqueros*) made from the trunks of a coastal tree or from fibrocement sheets and palm trunks.

Spiny lobsters are distributed widely in shallow waters with seagrass beds. Measurements of the juvenile, pre-adult, and adult spiny lobster abundance can be easily undertaken by collecting them from the artificial shelters. The juvenile abundance indices for lobsters in artificial shelters have been used successfully in the forecast of recruitment and catches of the lobster in Cuba and in Australia. The juvenile index is a measure of abundance independent from the fisheries data. Although the recruitment can be measured with the catch and effort data (González 1991; Medley and Ninnes 1997), the measurement in Caribbean spiny lobster fishery is complex because the lobsters are caught by a range of fishing gears which make it difficult to obtain a single measure of effort.

The objective of this paper is to summarize the data on artificial shelters collected over more than a decade and use it as an alternative tool to predict recruitment and catches of the juveniles and pre-recruit Caribbean spiny lobster in Cuba.

Materials and Methods

This study was done in the Gulf of Batabanó which lies in the southwestern part of the Cuban archipelago (Fig. 1).

Fig. 1. Map of the Cuban western archipelago showing the locations of monitoring sites in the Gulf of Batabanó (Bocas de Alonso and Coloma).

Study of the abundance of juveniles (16 to 50 mm Carapace Length - CL) began in 1980 at selected sites at Bocas de Alonso, located southeast of the Isla de la Juventud. The study of mature and pre-recruit lobsters (50 to 77 mm CL) was carried out in the fishing grounds of the west Coloma region.

Artificial shelters of concrete blocks were used to sample juveniles (Fig. 2). The shelters consisted of two layers of eight blocks placed on top of one another forming a square of 16 blocks measuring 118 x 30 cm. A total of 60 artificial shelters were positioned in the nursery area, separated by 25 to 30 m, covering an area of 0.25 km^2. Lobsters were caught by SCUBA divers (using hand bully nets or lobster nets). They were classified and then returned to the same shelter from which they were caught. Monthly sampling of juveniles was conducted over 180 months during the period 1982 to 1996. The annual index of abundance of juveniles was calculated as the mean numbers per block per month (January to December) and per station.

Sampling of mature and pre-recruit lobsters was carried out using artificial shelters (*pesqueros*), also known as Cuban casitas in Mexico (Fig. 2). The index of abundance of pre-recruits in the fishery was calculated as the average number of undersized lobsters per *pesquero* noted by the researchers every month. Further details of the concrete blocks and *pesqueros* used as shelters and the sampling methods have been described by Cruz and Phillips (2000) and Cruz (2002).

Four models for the predictions of the lobster catch were used: 1) full year model (January-December); 2) natural year model (June-February); 3) *recalo* model (October-February); and 4) *levante* model (June-September). The catches were calculated using the following equations:

1) Full year model:

$$\text{Catch} = 5203 + 64.83\ Ij_{(t-1)}$$

2) Natural year model:

$$\text{Catch} = 5003 + 73411\ Ij_{(t-1)}$$

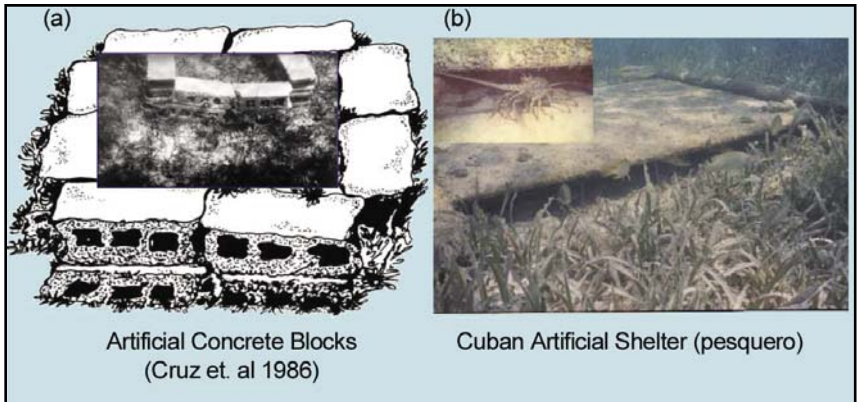

Fig. 2. (a) Schematic representation of the artificial concrete blocks; and (b) Cuban artificial shelter (*pesquero*) used for sampling juvenile and pre-recruit lobsters.

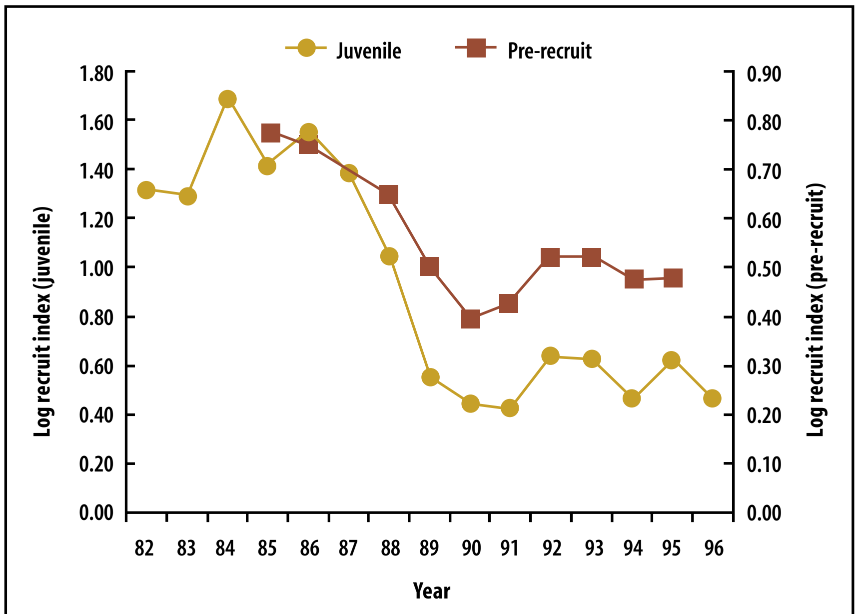

Fig. 3. Annual log juvenile index (1982-1996) at Bocas Alonso and log pre-recruit index (1984-1995) at the Coloma region, Gulf of Batabanó, Cuba.

3) *Recalo* model:

$$\text{Catch} = 3.9701(Ij_{(t-1)}\text{^}0.1111)(ft\text{^}0.6767)$$

4) *Levante* model:

$$\text{Catch} = 3987 + 40.89 Ij_{(t-1)} - 0.49\ \text{Catch}_{(recalo)(t-1)}$$

where, $Ij_{(t-1)}$ = index juvenile previous year (t-1); $\text{Catch}_{(recalo)(t-1)}$ = recalo catch in the previous season (t-1); ft = number of fishing days, during the months of October to February, in the year t.

Results and Discussion

Between 1982 and 1994, 21 047 lobsters were caught, ranging in size from 12 to 77 mm (CL) in the nursery area of Bocas de Alonso. Altogether 69 979 adult lobsters were measured between 1985 and 1990, of which 35 542 were male and 34 437 were female, in the fishing ground of Coloma.

Indices of the abundance of juveniles and pre-recruits varied considerably from year to year (Fig. 3). In each area, recruitment indices declined over time from 1982 to 1996. The catches of juveniles in the concrete blocks reached their highest levels between 1982 and 1988 and their lowest levels between 1989 and 1996. The difference was highly significant (t =9.1985, p <0.001). These two periods

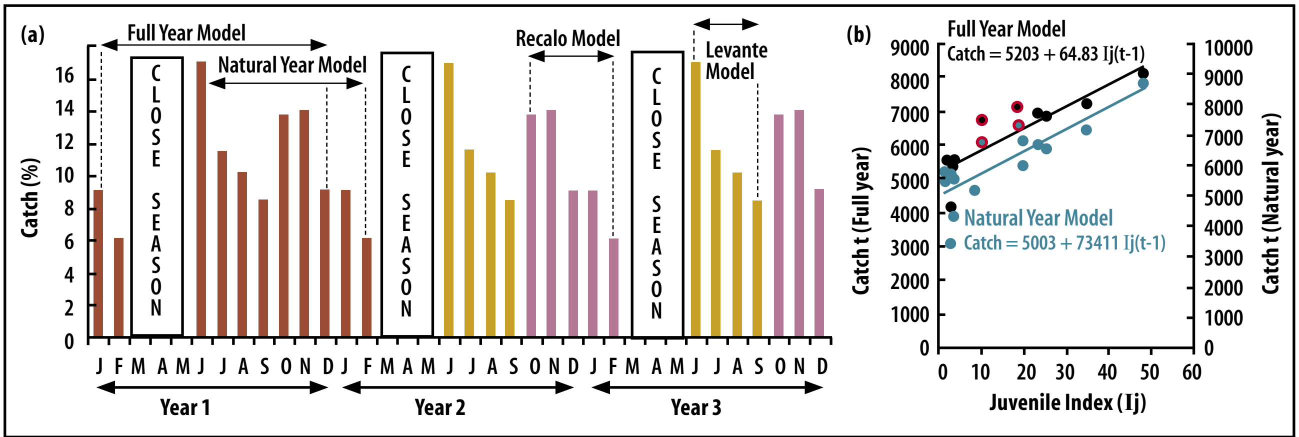

Fig. 4. Summary of seasonal models for predictions of the lobster catch in the Gulf of Batabanó, Cuba: (a) schematic representation of the period used for the prediction of the lobster catch; (b) relationship between annual juvenile index and the catch of Panulirus argus one year later using the full year and natural model.

also differed significantly in terms of catch rates of pre-recruits (t = 3.2152, p <0.001). The index of abundance of juveniles was significantly correlated with that of pre-recruits (sub-legal) lobsters in the following year at location of Coloma (n = 9; R^2 = 0.8573, p <0.01). This result confirms that the juvenile and pre-recruit abundance indices are associated with the recruitment levels of lobsters to the fishery at those stations. The lower juvenile numbers during 1988 to1990 were reflected in the lower numbers of the pre-recruits to the fishery.

The seasonal pattern of average catches (%) from 1978 to 1996, the methods and the equations of each model for predicting the lobster catch in the Gulf of Batabanó are summarized in Fig. 4. The full year prediction model (January-December) of recruitment in the fishery is based on the high correlation between the commercial catch in any year and the juveniles abundance index, before the lobsters are recruited to the fishery. A highly significant relationship was observed between the juvenile abundance index of a particular year and the lobster catch (t) in the following year in the Gulf of Batabanó (n =14; R^2 = 0.77, p <0.001) (Cruz et al. 1995; Cruz et al. 2001). This model predicted lobster catch for the period 1983 to1996 from the annual index of juvenile abundance one year earlier (1982 to 1995).

The natural year (June-February) prediction model (Fig. 4) of recruitment in the fishery is based on the highly significant relationship between the juvenile abundance index and the lobster catch for the following natural year (n =14; R^2 = 0.67, p <0.001). Methods have also been developed that predict the catch from the *puerulus* settlement indices (Phillips 1986) and/or juvenile abundance (Caputi et al. 1991, 1995; Phillips et al. 2000) of the western rock lobster, *Panulirus cygnus*.

In Cuba, separate predictions of the lobster catch are made for the two parts of the fishery (Fig. 4): the season of the massive migrations or *recalo* (October-February) and the *levante* season (in June), just after the beginning of the fishing season, because the lobsters enter the artificial shelters in the fishing area during the closed season in March to May). By examining these two phases of the fishery separately, Cruz et al. (2001) have shown that the catch during massive lobster migrations is dependent on the intensity of recruitment and the number of fishing days. In the *levante* season (June-September), it depends on the juvenile index and the catches during the previous *recalo*).

The poor prediction of the lobster catches in 1984 and 1989 (pointed with red ring, in the full year and natural year model as seen in Fig. 4) resulted from the very few data points of the juvenile index in 1983 and 1988, respectively. This discrepancy may be the result of fluctuations in annual catches induced by environmental conditions that affect the catch of legal-sized lobsters or the levels of recruitments (Cruz and Adriano 2001).

The independent recruitment index model provides a good basis for assessing the lobster stock. In particular, it permits new management options to be developed to plan for fluctuations in recruitment. The current results suggest that the stock is largely self-recruiting and the spawning stock requires careful management.

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