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Use of Size-based Indicators for evaluating long-term trends in Indian oil sardine (*Sardinella longiceps*) fishery

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Introduction

Size-based indicators (SBIs) are being currently used to evaluate the response of fish populations to exploitation, and may also lead to the development of an ecosystem based fisheries management (EBFM) approach. At a population level, the selective removal of larger or smaller fish will be reflected in changes in mean length (L_{mean}) or mean weight (W_{mean}), maximum length (L_{max}) and minimum length (L_{min}) of the population. For example, decrease in the mean size of a population may either point to overexploitation or to enhanced recruitment. Besides, influence of environmental factors will also play a vital role in determining the success of recruitment, growth rate and condition factor (K_n) of the population. Thus SBIs are a cost effective tool to evaluate the effects of fishing on a population of fish, and have been used for several temperate water species such as cod and plaice.

Database creation

The Indian oil sardine (*Sardinella longiceps*) is the mainstay of Indian marine fisheries forming as much as 30% of the total production in some years. However, the fisheries is subject to very high fluctuation from a peak exceeding 3,00,000 tonnes to as low as 3000 t in some years (as much as 100 times difference). Because of the high magnitude of the fisheries, it plays an important role in the local economy wherever it is caught, and consequently, historical statistics of its landings are available from government records. Therefore, oil sardine catch statistics for the southwest coast of India (Kerala, Karnataka and Goa) was collated as a time-series for the period 1926 to 2005 (80 years). More importantly, through the BIOBASE database held by CMFRI and from records and publications of the erstwhile Madras Presidency, length frequency data pertaining to oil sardine was assembled for the period 1934 to 2005 (70 years) with some data gaps (Jul 1944 to Feb 1956). The L/F in BIOBASE mostly pertains to data collected from Mangalore, Kozhikode and Kochi, and that in Madras Presidency records to Mangalore and Kozhikode. The L_{mean}, L_{max} and L_{min} were calculated on monthly and annual basis and plotted for delineating trends. The trends in SBIs were related to the catch trends using regression techniques.

Catch trends

The catch trends (Fig.1) shows that until 1956 the catches were below 100,000 t and it is only after this that catches were on an uptrend, and for the first time in 1968 production touched 3,00,000 t. Production reached a low of 3000 t in 1994 similar to the nineteen thirties and forties. The 6-point moving average line also shows that the abundance of oil sardine was remarkably low until the nineteen fifties and only from the sixties an upward trend in the production was noticed, notwithstanding its remarkable failure during the early nineties.

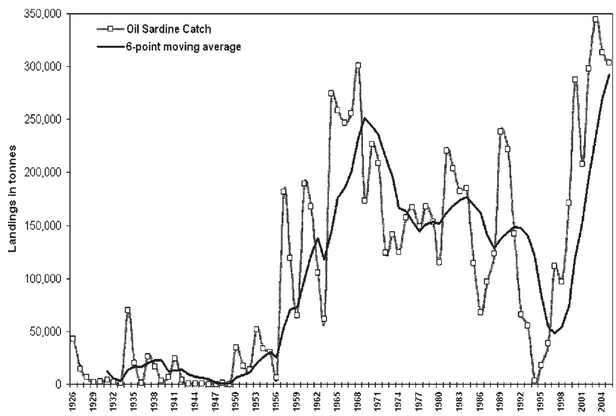

Fig.1. Time-series data (1926-2005) of *Sardinella longiceps* landings from southwest coast of India (Kerala, Karnataka and Goa)

Change in SBIs

The lengthy time-series of L_{mean}, L_{max} and L_{min} shows fluctuation without a definite pattern (Fig.2).

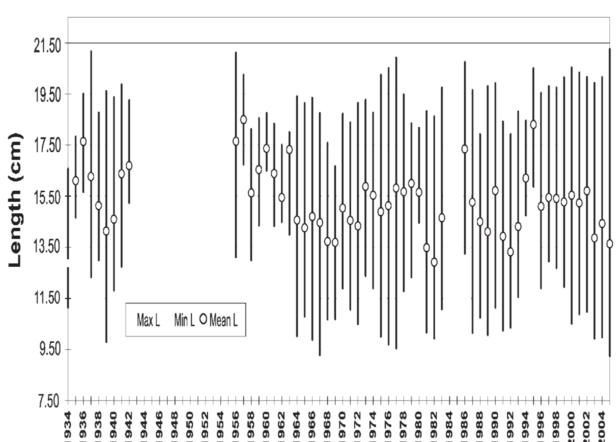

Fig.2. Annual time-series of maximum, minimum and mean lengths of oil sardine.

In general, annual mean lengths are lower when catches were higher. When the fishery was a failure, as in the late nineteen thirties and 1994, mean lengths were above 15.5 cm. In years in which the fishery exceeded 1.5 lakh tonnes, the L_{mean} was lower than 15.5 cm. The size range (min-max) was also wider in years in which the fishery was a success. The monthly mean lengths did not show any definite trend with variation in catch (Fig.3). In most of the years the recruitment to the fishery took place in September-October, as evident from the occurrence of smaller individuals (below 7.5 cm). The relationships between the SBIs (L_{mean}, L_{min} and $L_{range} = L_{max} - L_{min}$) and catch was subjected to regression analysis and the results are shown in Table 1. The mean length, maximum length and length range did not show any relationship, however, the minimum length showed moderately good negative relationship with catch. When the L_{min} was less, the catch showed an increasing trend (Fig. 4 and 5). This indicates that L_{min} is reasonably good predictor of any given years catch. Intense recruitment leads to an increase in the abundance of oil sardine. It can be clearly seen from Fig.4 that in years in which the fishery failed, such as 1994, the minimum length was comparatively high (16 cm). In years in which the fishery was a good success, the L_{min} is close to 10 cm. The L_{max} did not show any relationship with catch. However, the long-term trend shows that the L_{max} is increasing and it has presently crossed 21 cm. Theoretically this augurs well for the fishery, though high L_{max} are also seen in years in which the fishery failed like 1994, 1936 and 1939.

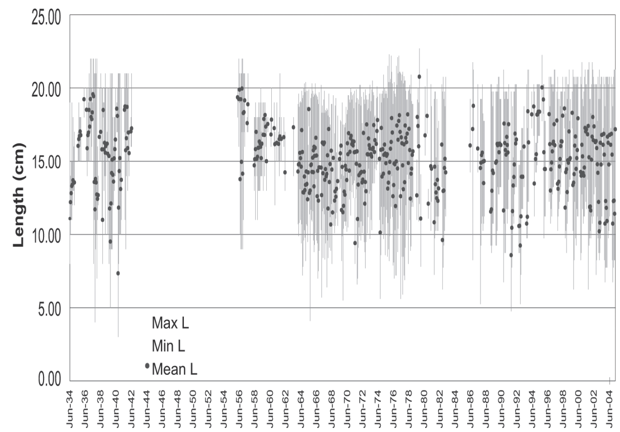

Fig.3. Monthly time-series of maximum, minimum and mean lengths of oil sardine.

Table 1 Regression coefficients and goodness of fit for relationships between SBI and catch

S. No	Relationship	Regression coefficients	Goodness of fit (R^2)	Remarks
1	L_{mean} and catch	y = -13663x + 384834	0.1738	Poor fit – no relationship
2	L_{range} and catch	y = 1E-05x + 5.6383	0.2129	Poor fit – no relationship
3	L_{min} and catch	y = -1E-05x + 13.634	0.4596	Moderately good relationship
4	L_{max} and catch	y = 6E-07x + 19.108	0.0033	Poor fit – no relationship

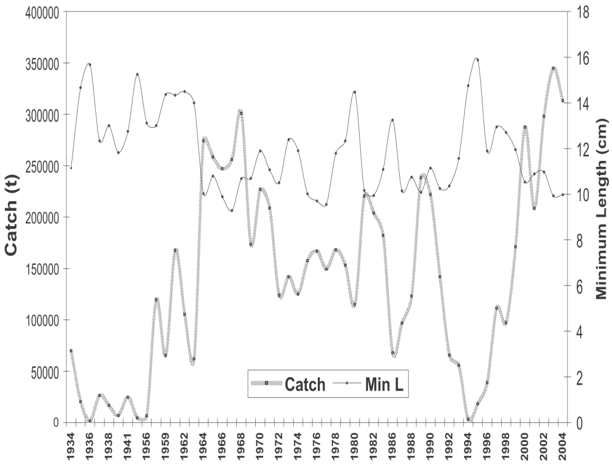

Fig.4. Striking inverse relationship between L_{min} and catch of oil sardine

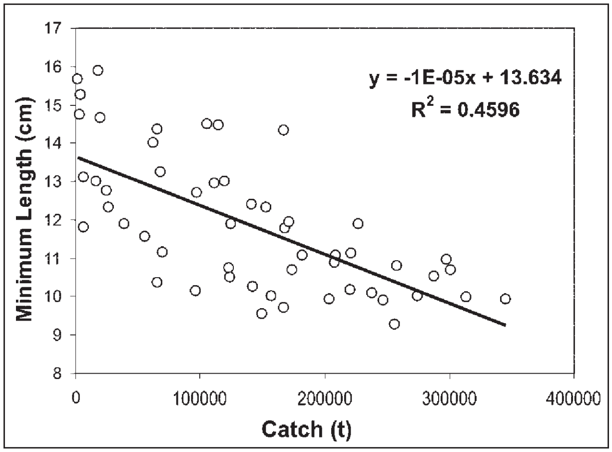

Fig.5. Scatter plot showing inverse relationship between L_{min} and catch

These results are in contrast to what has been observed for temperate water stocks, where a decrease in mean length and maximum length can signify adverse fishing effects on the population. In the case of oil sardine, L_{mean} was not a good predictor of stock health, probably because of the fast growth rate and the presence of multiple broods in the population. The L_{min} was however a reasonably good predictor of recruitment success and eventually a good fishery. The use of SBI in tropical fish stocks needs to be evaluated for more number of species before definite conclusions can be drawn. A recent study on demersal fish stocks of northwest Africa also shows that changes in size structure is not a suitable indicator for the effects of fishing in areas characterized by faster growth rates, small sizes, high species diversity and complex interrelationships, such as the tropics.

This work was carried out under an AP Cess Fund project on ‘Assessing the impact of fisheries on the biodiversity of marine fish resources of southwest coast of India’ and one of the targets of the projects was to evaluate the usefulness of SBI for assessing the impact of fishing on fish populations.