Updated Status of the Chilean Jack Mackerel Stock
(presented in 5th Conference SPRFMO, Guayaquil 2008)

by

Cristian Canales&Rodolfo Serra
IFOP - Chile

1. Background

This report contains an update of the assessment and condition of the Chilean jack mackerel stock distributed inside and outside the EEZ off Chile.

2. Methodological aspects.

2.1. Statistical catch-at-age model

Chilean jack mackerel stock was assessed using a statistical catch-at-age model based on a Bayesian estimate approach (Fournier and Archibald, 1982: Deriso et al., 1985; Hilborn, 1990b; McAllister and Ianelli, 1997, Maunder et al., 2000; Hilborn et al., 2003; Ianelli and Lamberson, 2003, Serra y Canales, 2007). This methodological approach is considered the state of the art in modern stock assessment. The advantage it offers is its flexibility to include different types of information, test hypotheses and to assess the implications of different uncertainties.

According to Hoyle and Maunders (2005) the term “statistical” indicates that the model implicitly recognizes that data collected from fisheries do not represent with precision the population; there is uncertainty in our knowledge about the dynamics of the system and about how the observed data relate to the real population. The model uses annual time steps to describe the population dynamics. The parameters of the model are estimated by comparing the predicted catches, age compositions and abundance indexes to information collected from the fishery. After these parameters have been estimated, the model is used to estimate quantities that are useful for managing the stock.

In the stock assessment model, the catch-at-age information is modeled using multinomial probability distribution and lognormal distributions are employed in modeling the relative abundance indexes (cpue, acoustic biomass, spawning biomass from the eggs production method). In a manner consistent with changes in availability by age groups along the coast, for the Chilean fleet operating in the northern area a “dome shape” selection pattern is applied. In the center south fishery ─including the former URSS catch─ a logistic model is used.

The parameters are resolved minimizing the negative sum of the log probabilities identified to model the information error and the “a priori” log distributions considered for some parameters. This is equal to maximizing the “a posteriori” distribution from a Bayesian perspective. In this sense, and in order to have risk measurements for the relevant variables, uncertainty analysis is done by integrating the a posteriori distribution using the MCMC (Markov Chain MonteCarlo) re-sampling technique.

2.2. Information

The assessment considers the data collected from the fishery since 1975 until 2007. Fishing inside and outside the EEZ by national and international vessels is considered; with regard to the latter the catch of the former URSS fleet between 1979 and 1992, the People's Republic of China, Vanuatu, Holland and Faroe Island are also included (Table 1). The relevant information considered in the analysis include the age composition of the catches by zone or fleet, landings, and series of indicators such as the biomass obtained through hydro-acoustic surveys and spawning biomass using the Daily Egg Production Method (DEPM).

Figure 1 contains the catch statistics of jack mackerel for the different fishing areas and fleets considered in the stock assessment. Information on Chilean catches is based on statistics provided by the Instituto de Fomento Pesquero (IFOP) for 1975 - 2001 and official data provided by the National Fisheries Service for the years 2002 to 2006. Data for the former URRS fleet is based on catch statistics for the period 1978 – 1992. Data for the fleet of the People's Republic of China was obtained from information provided at bilateral meetings with Chile and from the other countries during meetings of the SWG from the SP-RFMO.

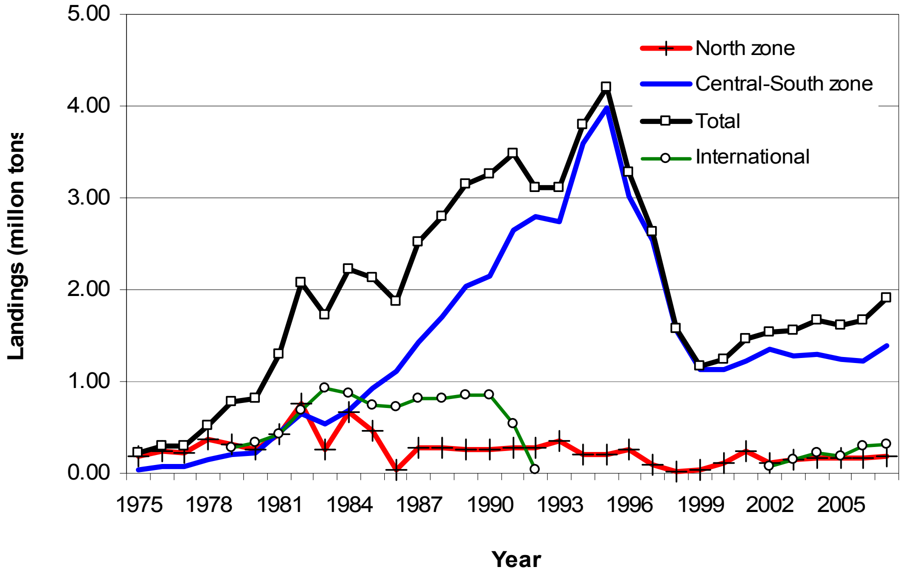


Figure 2. Chilean Jack mackerel landings by area, 1975 – 2007.

Table 1. International landings (tons) employed in the stock assessment

Year	China	Holland	Vanuatu	Faroe I.	Total
2001					
2002	76,261				76,261
2003	96,000		53,959		149,959
2004	130,000		94,685		224,685
2005	130,000	5,381	53,711		189,092
2006	130,000	67,532	91,879		289,411
2007	130,000	67,532	91,879	29,221	318,632

The jack mackerel stock assessment for the period 1975 -2007 took following information into account:

- Catch-at-age matrix by zone. The catch-at-age matrix considers the information generated through a permanent sampling of fish size and otoliths at landings. The size composition of the Soviet fleet catch (obtained by INPESCA from VNIRO) is also included. Due to the lack of otolith from the Soviet fleet this size composition was afterwards converted to age using an age-length key from the Chilean fishery off the center-south fishing area. This is supported by the similarity of the size composition of catches by both fleets, seasonal inshore and offshore migration of the jack mackerel.

- Mean weight at age matrix, which are estimated considering the mean length at age and the length-weight relationship.

- Biomass from acoustic surveys 1997-2007 and its corresponding age compositions.

- CPUE index in the Central-South Zone 1996-2003. The CPUE index since 2004 was not considerate in the assessment because it was strongly affected by regulations.

- Spawning biomass for the years 1999-2001 and 2003-2006 estimated from eggs surveys and the daily eggs production method (DEPM).

- Sexual maturity ogive, which considers that specimens of age 3 and less are immature while mature specimens are those of age 6 and more. Specimens of ages 4, 5 and 6 are considered to have a 4%, 50% and 96% of sexual maturity, respectively.

- The natural rate of mortality is assumed constant between the ages and years with a value M=0.23 per year.

3. Model fit

Figures 2, 3 and 4 show the fit for relevant information, underlining its ability to suitably reproduce the dynamics of age structures in Chile’s north and center-south areas. The model fit for the acoustic biomass index reproduces a strong decrease of the population. The model fit for the spawning biomass indices (DEPM) is less satisfactory, because the assessment can not reproduce the strong drop in the spawning biomass calculated by DEPM which is also not consistent with the enhancement observed in catch age composition in that period.

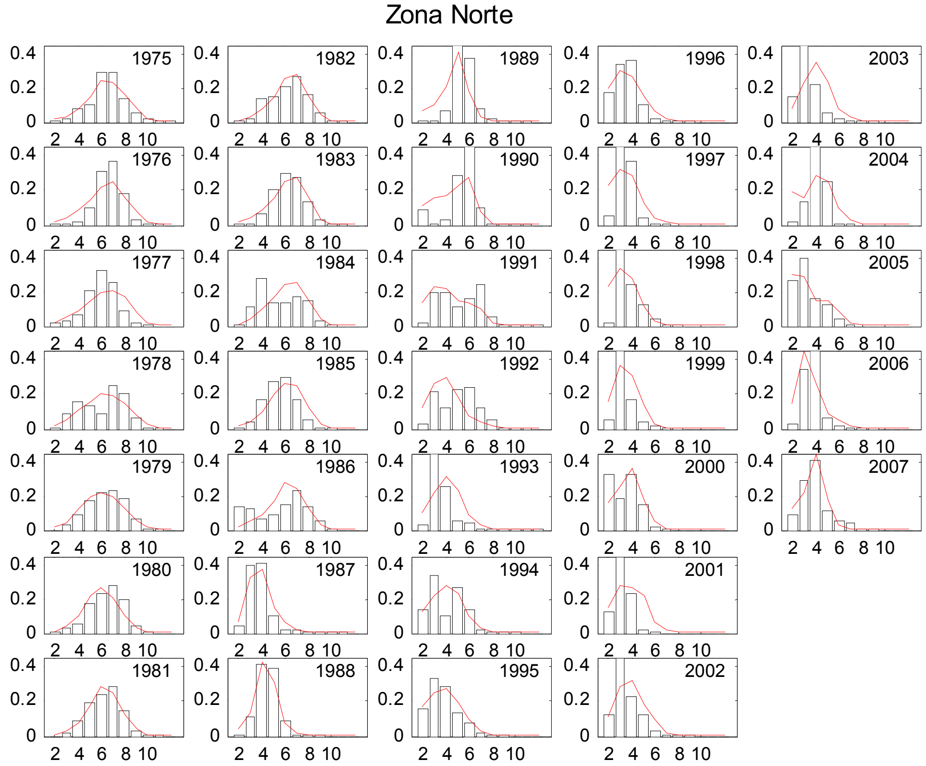


Figure 2. Model fit to the age information of the jack mackerel catches in the North Zone of Chile. (Source:IFOP)

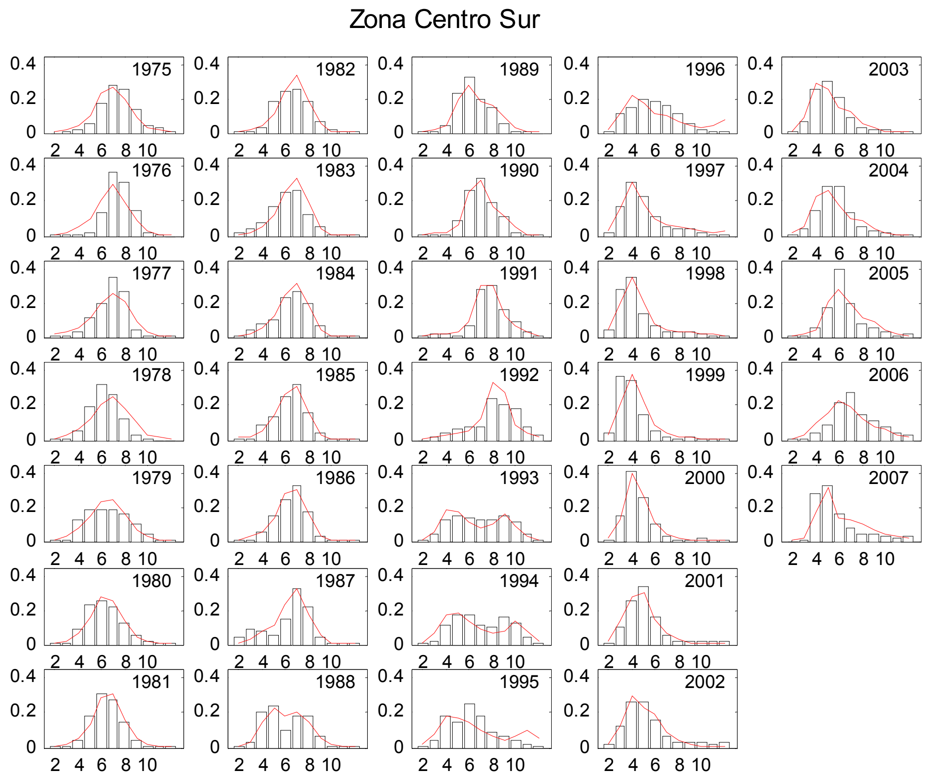


Figure 3. Model fit to the age information of the jack mackerel catches in the Central-South zone of Chile (Source:IFOP)

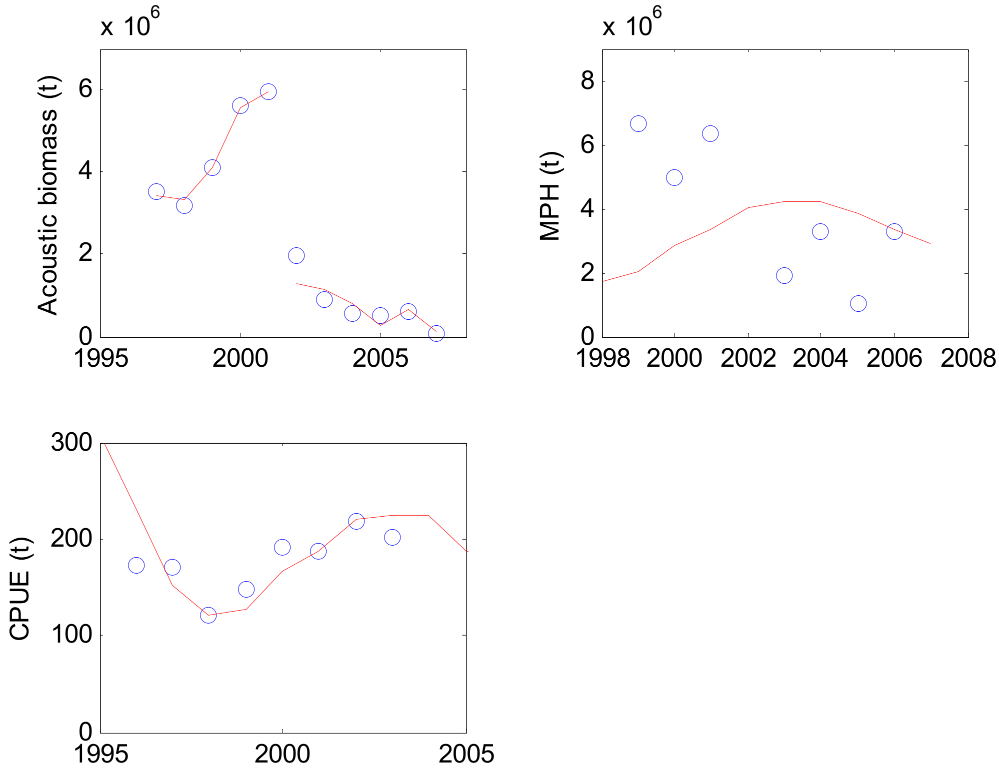
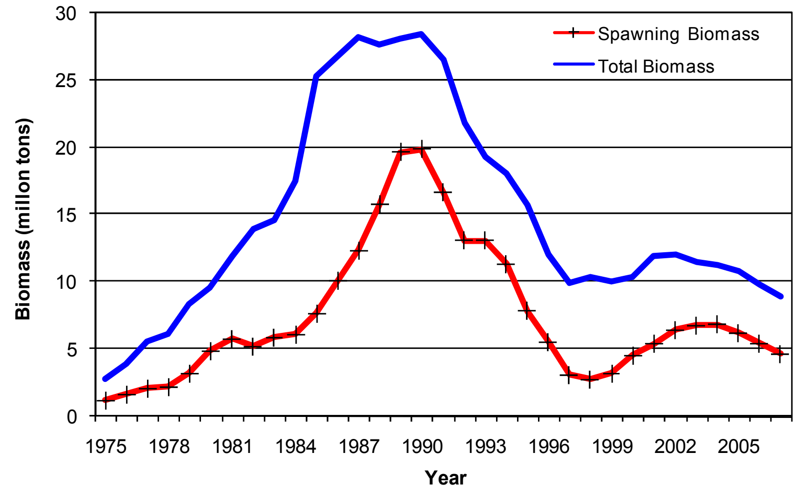


Figure 3. Model fit to the relative biomass index of the jack mackerel catches in the Central-South zone of Chile (Source:IFOP)

4. Results.

The jack mackerel biomass grew from 1975 to 1985 as a consequence of positive surplus production generated by a sustained growth in recruitment and somatic growth. Increased abundance of jack mackerel in this region is also mentioned by Serra (1991) and Elizarov et al. (1993). Jack mackerel recruitment reached its peak in 1985 and 1986, declining from 1987 onwards. Parallel to this, between 1985 and 1991, landings grew importantly (about 88%), maintaining a positive trend until it reached a maximum level of 4.2 million tons in 1995. (Figure 4).

It is important to state that recruitment show a decreasing trend since 1998. The likelihood that the year classes that entered the fishery at age 2 in 2003 and 2004 are weak is high. This conclusion is supported by the weakening of younger ages (ages 2-4) in the age composition of the catch and in the biomass assessed by the hydroacoustic survey.



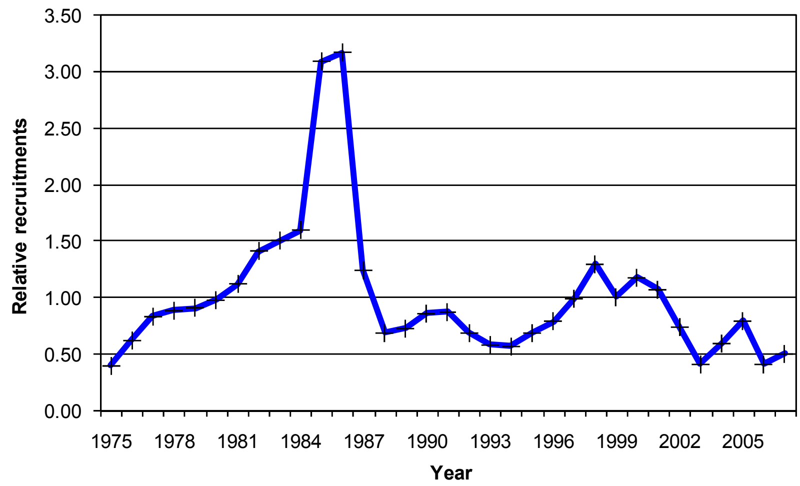


Figure 4. Level and tendency of total biomass, spawning biomass and recruitment of the Chilean Jack Mackerel (Source:IFOP)

As a result of decreased level of recruitment since 1987 and the increase in catches during the same period, overfishing occurred. This is demonstrated by catches that exceed the surplus production of the stock and by excessive exploitation rates toward 1997 (Figure 5). These factors accentuate the abundance decrease. In this period, the spawning biomass ratio (SBR) dropped strongly to levels of 15%, which is significantly less than the biological target (40%SBR), which also indicates the overexploitation that occur during this period. Since 2003, the fishing mortality increased again indicating the intensification of the exploitation process which together with weak year classes that entered the fishery and new declining trend in spawning biomass has raised an increasing concern about the stock condition. In this period the catch has been larger than the biological surplus production of the stock.

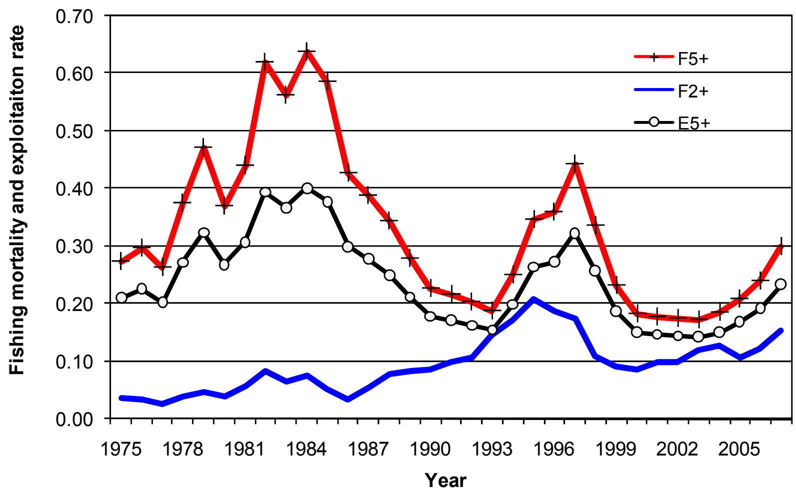


Figure 5. Fishing mortality and exploitation rate of the Chilean Jack Mackerel (Source:IFOP)

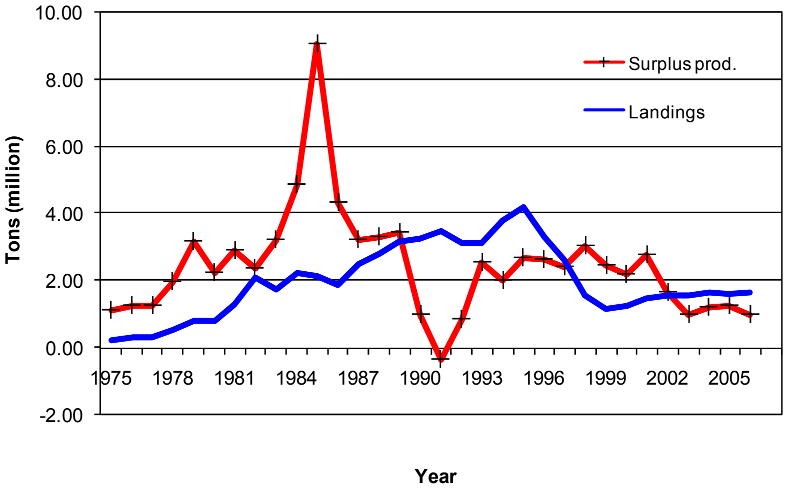


Figure 6. Landings and surplus production of the Chilean Jack Mackerel. (Source:IFOP)

Serra et al. (2005) find a significant effect between sea surface temperature (SST) with recruitment. Low SST produces low recruitments and the opposite with high SST. The SST of years 2001 and 2002 were low and correspond to the years in which the recruitments that enter to the fisheries in 2003 and 2004 were produced. This result reinforces the conclusion that it is highly likely that during these years, recruitments was weak compared with the years 1996-2001. The latter with the regulations applied in that time, among which the establishment of catch quotas stands out, produced the partial recovery of the spawning stock until 2003.

The jack mackerel abundance starts to decreased in coastal waters (inside the EEZ) and made that the fishing fleet intensifies its fishing activity beyond the EEZ. Two hypotheses were raised to explain this change: one that says that the jack mackerel changes its distribution. The second hypothesis says that this decrease is due to the contraction in the stock distribution because of its decreased abundance and was included in the stock assessment model.

5. Stock status.

The declining trends in the spawning biomass, recruitment, together with the increasing trend of the exploitation indexes indicates a scenario of increasing risk for the stock and the fishery. An added factor of concern is the increasing trend in the catch and the growth of the size of the distant flag fleets off Chile and beyond the EEZ, especially in the recent year.

The spawning biomass ratio (SBR) (Maunder and Watters, 2003) or spawning potential ratio is the ratio of the spawning biomass that exists which the one that would have been witout exploitation. It shows a declining trend below the 40% which is an adequate management target for a pelagic fish like jack mackerel (Figure 7) and demonstrate the present condition of the stock.

This conclusions suggest a rather pessimistic perspective of the stock and consequently on the fishery.

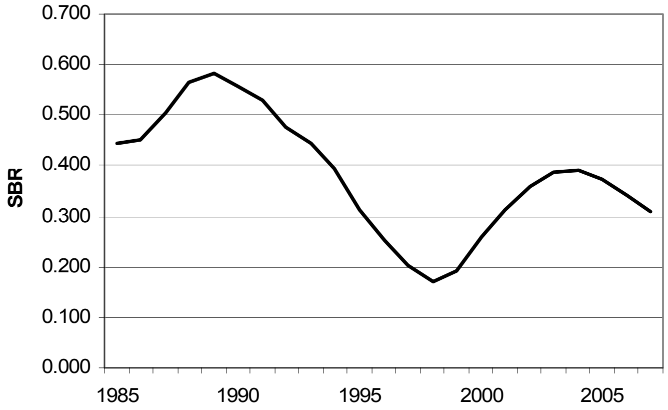


Figure 7. Trajectory of the jack mackerel spawning biomass ratio (Source:IFOP)

6. References

Deriso, R.B., Quinn II, T.J., Neal, P.R., 1985. Catch-age analysis with auxiliary information. Can. J. Fish. Aquat. Sci. 42:815-824.

Elizarov, A.A., A.S. Grechina, B.N. Kotenev & A.N. Kuzetov. 1993. Peruvian jack mackerel, Trachurus symmetricus murphyi, in the open waters of the South Pacific. Journal of Ichthyology, 33(3): 86-104.

Fournier, D. & C.P. Archibald. 1982. A general theory for analyzing catch at age data. Can. J. Fish. Aquat. Sci., 39: 1195-1207.;

Hilborn R, Maunder M, Parma A, Ernst B, Payne J, Starr P., 2003. Coleraine: A Generalized Age-Structured Stock Assessment Model: User's Manual Version 2.0. Technical Report. School of Aquatic and Fishery Science, Fisheries Research Institute, Washington University [Rep. Fish. Res. Inst. Wash. Univ.], [np].;

Hilborn, R. 1990. Determination of fish movement patterns from tag recoveries using maximum likelihood estimators. Canadian Journal of Fisheries and Aquatic Sciences 47:635-643.

Hoyle S.D and M.Maunders., 2005. Status of yellowfin tuna in the eastern Pacific Ocean in 2004 and outlook for 2005. Inter-Amer. Trop. Tuna Comm., Stock Assessment Report, 4: 1-100.

Ianelli J, Lamberson RH., 2003. Introduction to special issue: Modeling in fisheries science, past, present and future. Natural Resource Modeling 16, 337-340.

Maunder MN, Watters GM., 2003 A-Scala: An age-structured statistical catch-at-length analysis for assessing tuna stocks in the Eastern pacific ocean. Bulletin. Inter-American Tropical Tuna Commission 22, 435-437.

Maunder MN, Starr PJ, Hilborn R., 2000. A Bayesian analysis to estimate loss in squid catch due to the implementation of a sea lion population management plan. Marine Mammal Science 16, 413-426.

McAllister, M. & J. Ianelli. 1997. Bayesian stock assessment using catch-age data and the sampling-importance resampling algorithm. Can. J. Fisheries Aquat. Sci., 54: 284-300.

Serra, J.R. 1991. Important life history aspects of the Chilean jack mackerel, *Trachurus symmetricus murphyi*. Investigación Pesqueras (Chile), 36: 67-83.

Serra, J.R y C. Canales, 2007. Evaluación y Captura Total Permisible de Jurel (*Trachurus symmetricus murphyi*) Sub Regional, 2008. Pre-Informe Final, Instituto de Fomento Pesquero, Valparaíso, Chile, 85 pp.