The small pelagic fisheries on the Western coast of the Adriatic Sea: monitoring and assessment

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Abstract

This paper provides a comprehensive review of small pelagic fisheries in the Western Adriatic Sea from the beginning of 1975 to early 2000. Statistical and biological data on anchovies (*Engraulis encrasicolus*) and sardines (*Sardina pilchardus*) are illustrated. Stock assessment was performed using the De Lury model, the Virtual Population Analysis and Length- frequency Classes distribution Analysis.

1. Introduction

According to the recommendation made during the first meeting of the Adriamed Working Group on small pelagic fishery resources, held in Split 12-13 October 2000, a brief description of the current situation concerning statistical and biological data collection on small pelagic resources in Italy is given. Some information about recent assessment accomplished by means of population dynamic models is also described. More extensive information can be found in the references included.
This report concerns anchovy (*Engraulis encrasicolus* L.) and sardine (*Sardina pilchardus* Walb.), the most important small pelagic species in Italy.

2. Data collection system

Statistical and biological data collection began in 1975, it continues to the present day and will continue in the future. In 1982 and 1983 statistical and biological data collection was interrupted. When the project was restarted in January 1984, the statistical data of 1982 and 1983 were retrieved.

2.1 Catch and fishing effort data

In 1975 IRPEM established a data collection network in the following Adriatic ports: Trieste, Chioggia, Porto Garibaldi, Cesenatico, Cattolica, Ancona. In 1984 the network was extended

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to S. Benedetto del Tronto and Vieste (see Figure 1). For these two ports previous data were retrieved.
The importance of the above-mentioned ports changed during this long period. For example small pelagic fisheries in Cattolica decreased in the eighties and stopped in July 1993. Only in the last three years have one or two "volante"[1] fishing units been operating in Cattolica. In the meantime the fleet of the port of Rimini increased by some fishing units while the port of Ancona has seen the biggest increase in fishing units involved in small pelagic fisheries.
To complete the network, data from the so-called minor ports (Grado, Marano Lagunare, Caorle, Goro, Rimini, Fano, Giulianova) were collected. Data from ex-Yugoslavia were retrieved from bibliographic sources (mainly from Morsko Ribarstvo) and from scientific research sources.

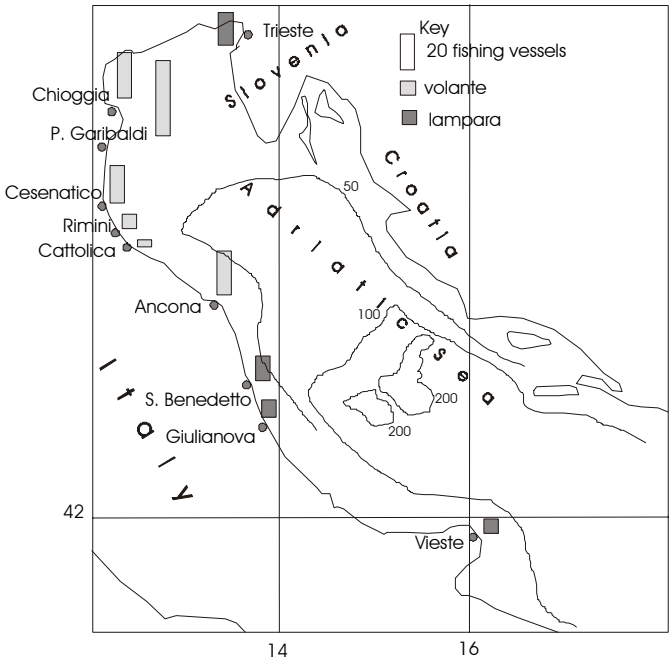

Figure 1. Map of ports and of small pelagic fishing fleets.

In the main ports, for each fishing unit, data on daily catch by species and daily effort (fishing days) were collected. Data from minor ports were generally collected by species/month (sometimes by species/year).
At the beginning of the nineties IRPEM started data collection (catch, fishing effort) in the South Adriatic. Unfortunately data collection in this area, characterised by fishing vessels which are not grouped into co-operatives, was very expensive. Due to insufficient budget, data collection in the southern area of the Adriatic ended few years later. Data of the former Yugoslavia were collected by species/month.
Data collection in the main ports was not homogeneous for all ports and all years, because of the long period covered. Data missing from the years 1982 and 1983 (during this period data collection was interrupted) and any other data which were missing were retrieved. Porto Garibaldi has the best time series, it is the leading port for catch and effort data.

[1] Mid-water pair trawl

Figure 2 and Figure 3 show the catches of the western Adriatic coast and of the eastern Adriatic coast.

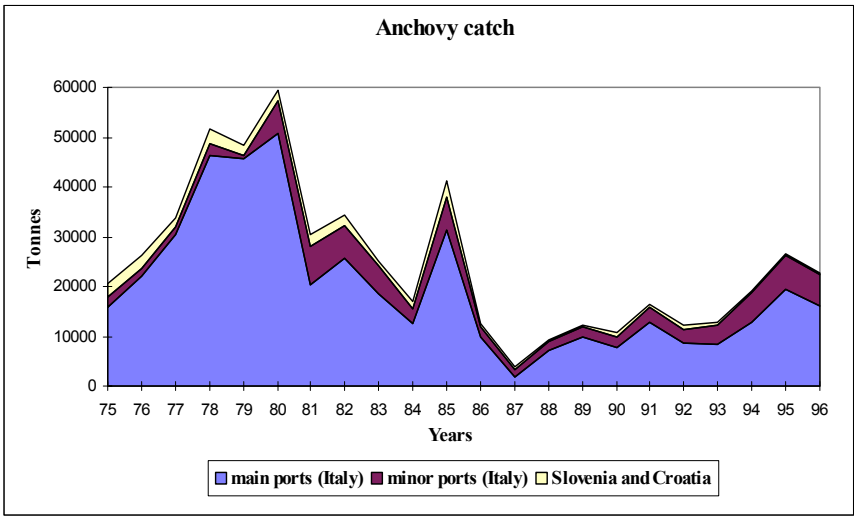

Figure 2. Anchovy: Adriatic landing (1975-1996).

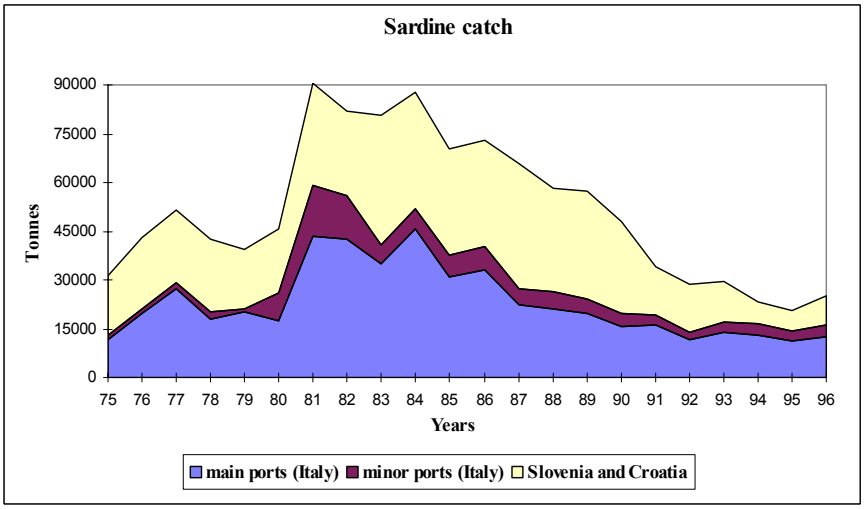

Figure 3. Sardine: Adriatic landing (1975-1996).

It should be noted that characteristically the Slovenian and Croatian fishing fleet focused on anchovy fishing.

2.2 Fishing fleet data

Structural data (HP, GRT, Overall length) of fishing vessels involved in small pelagic fishery have been collected together with the fishing gear used. Data are updated in real time, because of migration between lampara[2] and volante and between volante and trawl depending

[2] Surrounding net with light

on the fishing season and on catch abundance. In the Adriatic two kinds of fishing gears are used: the mid-water pair trawls (volante) and a surrounding net with light (lampara) (Cingolani *et al*., 1996$_a$).
The volante is a pelagic net towed by a pair of fishing vessels. Fishing with volante is carried out throughout the year. The fishing trip starts early in the morning and ends in the late afternoon.
The lampara is a fishing technique carried out at night with fish attracted by a light source (named lampara). When the fish are grouped near a light source the fishermen close the surrounding net previously thrown into the sea. The lampara is a seasonal fishing technique, as calm sea is needed the fishing season starts in April and ends in November. During the winter months most of the lampara stop fishing although some of them continue to fish using the volante gear. The most common fishing gear in the Adriatic is the volante; it is used in the area from Trieste to Ancona. The lampara is used south of Ancona (see Figure 1).
In Summer the Southern Adriatic fleet moves to the Central Adriatic because there is greater small pelagic biomass north of the Gargano Peninsula. Since 1992, during the warm season about 20-30 lampara from Sicily move to the Adriatic. They come in late Spring and stay until early Autumn. The reasons for this migration are the scarcity of small pelagics in their own fishing areas and a better market price in the Adriatic.

2.3 Length-frequency distribution data

Since 1975 biological samples have been collected from the main ports (data collection in S. Benedetto del Tronto and Vieste started in 1984). The biological sample is a commercial box (the weight is about 7 kg) of anchovy, sardine or fishmeal. Fishmeal is a mixture of dirty anchovy, dirty sardines, and other dirty or discarded small pelagics (*e.g.* sprats, *Sprattus sprattus*). Dirty fish originates from very high small pelagic catches (like in the late seventies and in early eighties) or when the fish caught are small. In such cases the fish are crushed inside the net. Fishmeal is used for animal feed, it was very common in the landed catches between 1975 and 1985. After the anchovy catch collapse of 1987, fishmeal disappeared from the landings.
From 1975 to 1981 a biological sample for each species (anchovy, sardine) or mixed species (fishmeal) was collected twice a week in each port (Trieste, Chioggia, Porto Garibaldi, Cesenatico, Cattolica, Ancona). Since 1984 two ports (S. Benedetto del Tronto and Vieste), have been added to the network and the frequency of biological sampling has become fortnightly.
Each biological sample is weighed and the total length to the nearest unit below the chosen frequency class (half-centimetre in our case) of each fish is measured in order to obtain the length frequency distribution. During the period 1975-1987 the length frequency classes used were of one centimetre.
In 1994, in order to optimise the sampling strategy, the IRPEM population dynamics staff carried out a preliminary study (with the collaboration of MRAG, Marine Resources Assessment Group at Imperial College, London) followed by a research project funded by the EU with the aim of optimal allocation of effort in sampling for age and length from commercial fisheries (Cingolani *et al.*, 1998$_c$). According to the results obtained, in January 1995 a new, more efficient and less expensive biological sampling strategy was implemented.

The new biological sampling frequency is different from port to port, because it is related to the amount of landed catches (by species) in each sampling port.
The sampling ports changed during the long period covered by the project, due to cessation in fishing (*e.g.* Cattolica) or as consequence of an improvement in sampling. The present biological sampling ports are Chioggia, Porto Garibaldi, Ancona and S. Benedetto del Tronto.

2.4 The biological sub-samples

A sub-sample of anchovy and a sub-sample of sardine, for each port and for each month, is taken during the length frequency measurement. The sub-sample consists of the otoliths of ten anchovies or ten sardines for each length class. With the adoption of length classes of half-centimetre (January 1988), five anchovies or five sardines are taken for each length class.
The fish of the sub-sample are individually weighed and from each fish the two otoliths are extracted, cleaned and stored in a small tube. A progressive number is assigned to each fish. Furthermore from each sardine of the sub-sample six scales are taken, cleaned and stored in a small envelope.
A sub-sample of anchovy and a sub-sample of sardine were taken from the fishmeal box. Up to 1994, the sub-samples were collected by species/port/month. After the sampling improvement (see para 2.3) the sub-samples were collected from each biological sample/species/port. As consequence more than one sub-sample/species/port/month is taken. With this adjustment the age determination is more accurate. This refinement of sub-sample collection took place in 1995.

2.5 Age determination

The otoliths are structures which consist of calcium carbonate and proteins. They are located inside the internal ear of the fish. During the growth of the fish, areas with different transparency are formed inside the otoliths, corresponding to the different growth rate of the warm season in comparison with the cold season. Those areas (named rings) assume the same elongated shape of the otoliths. Counting the areas with different transparency it is possible to determine the age of the fish. The scales of sardines also have rings with different transparency, but age determination using scales is uncertain.
Age determination by means of otoliths is carried out simultaneously by two researchers using a stereo-microscope with reflected light, bathing the otoliths in distilled water. If they do not agree on the reading, the datum is discarded.
June 1st has always been assumed to be the birthday of anchovies (the spawning period occurs between April and October/November). While January 1st that of sardines, because the spawning period occurs in Winter. As age reading is very time consuming, only the monthly sub-samples of anchovy for the years 1977, 1978, 1986, 1987, 1989, 1990, 1995, 1997, 1998 were read. Otoliths were obtained from the following ports: Chioggia, Porto Garibaldi, Cesenatico, Cattolica, Ancona, S. Benedetto del Tronto and Vieste.

Scales were used for age determination of sardines. Scales of the period 1984-1988 were read. Unfortunately the age-length keys obtained were unreliable and age determination by scales was abandoned.
A technique for age determination of sardines by means of otoliths has been adjusted. Otoliths of the years 1984, 1988, 1994, 1998 were read.
Otoliths of about 90,000 anchovies and otoliths of about 80,000 sardines are available in the biological databank of IRPEM. Spatial distribution (Northern and Central Adriatic mainly, but also Southern Adriatic for some years) of the available data and the long period covered (more than 25 years), give the opportunity for further study, *e.g.* joining these data with environmental data.

2.6 Observer data

To improve the knowledge of small pelagic fishery, since 1993 an observer was put on board fishing vessels. When on board the observer takes random samples of catches, the co-ordinates of each haul are recorded on a geographical map and in general all useful information to describe fishing fleet behaviour is annotated. Data collected are very precious to understand the state of fisheries, in particular during catch crises.
Figure 4 shows the map of the observer programme between July 1998 and December 1999.

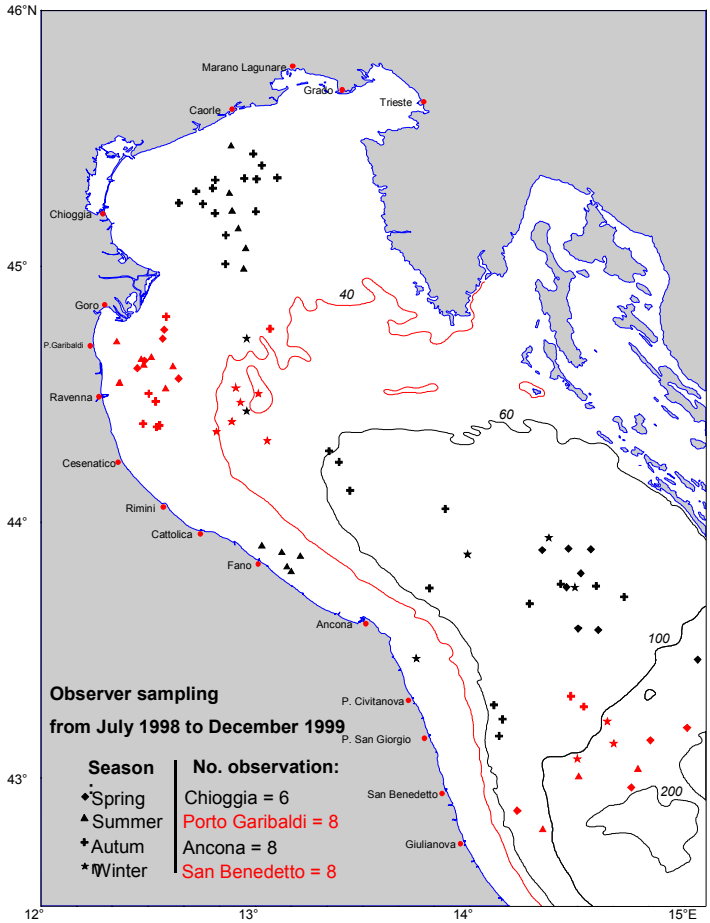

Figure 4. Map of observer sampling from July 1998 to December 1999.

2.7 Logbook data

Data collection using logbooks was not very successful because many skippers were not collaborative. Nevertheless some skippers of the Ancona fishing fleet agreed to collaborate and a high number of logbooks was filled in. Figure 5 shows the map of the wide fishing area covered by the small pelagic fishing fleet of Ancona.

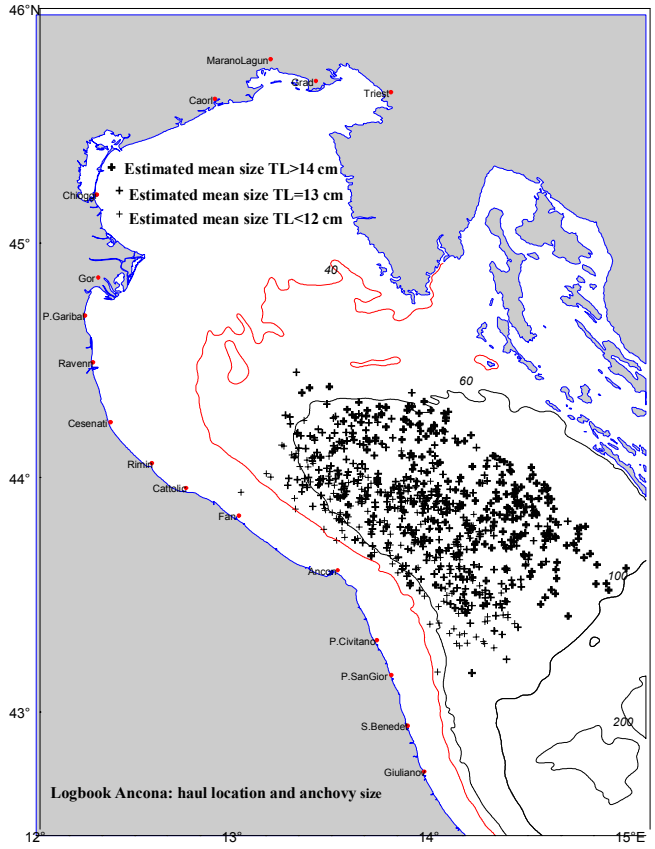

Figure 5. Port of Ancona: map of haul points, estimated anchovy mean size in the catch are also given.

3. Stock assessment

3.1 Methodology

Stock assessment by means of population dynamics is generally carried out using more than one mathematical model. In this way it is possible to compare independent estimations to each other, thus verifying the reliability of the results.
For anchovies and for sardines three assessment models were used: i) the DeLury model (Ricker 1975, MRAG, 1992), ii) the Virtual Population Analysis (VPA) (Hilborn and Walters, 1992), iii) the cohort analysis based on length-frequency classes distribution (LCA) (Gallucci *et al.*, 1996). The DeLury model is based on catch and effort data. The model needs annual catch data, CPUE (catch per unit of effort) and data of annual recruitment index. The version used is CEDA (Catch Effort Data Analysis), developed in 1992 by MRAG (Marine Resources Assessment Group) at Imperial College of London. It has been used for anchovies and for sardines.

Due to the unreliable age-length keys obtained by scales reading, it was not possible to use the VPA model for sardines. The LCA model has been used for sardines. The software package named VIT developed by the Instituto de Ciencias del Mar of Barcelona (Lleonart and Salat, 1992) was used. The LCA is based on the distribution of annual catches by length classes. The VPA is based on the distribution of population by age classes. It has been used for anchovies. The VPA is the model adopted by International Council for the Exploration of the Sea (ICES). The software package developed by MAFF (Ministry of Agriculture, Fisheries and Food) Fisheries Laboratory of Lowestoft, United Kingdom, (Darby and Flatman, 1994) was used.
Due the availability of age-length keys coming from otolith readings, a few months ago a new assessment for sardines (up to 1999) was carried out using the VPA model. As the exercise was carried out in the framework of a project funded by EU, the results will be made public after the approval of the final report by EU. Currently, a new assessment for anchovies (up to 1999) is in progress.

3.2 Stock assessment of anchovy with the DeLury model

Stock assessment of anchovy with DeLury model has been carried out using the CPUE series of Porto Garibaldi (Cingolani *et al.,* 1993; Cingolani *et al.,* $1998_{a,b}$). Value of natural mortality M=0.6 yr^{-1} was used. Figure 6 shows the anchovy biomass at mid-year and the corresponding catches. The peak of biomass is 370,000 t (1978) followed by a decrease up to the minimum values in 1987 (35,000 t) and 1988 (45,000 t).

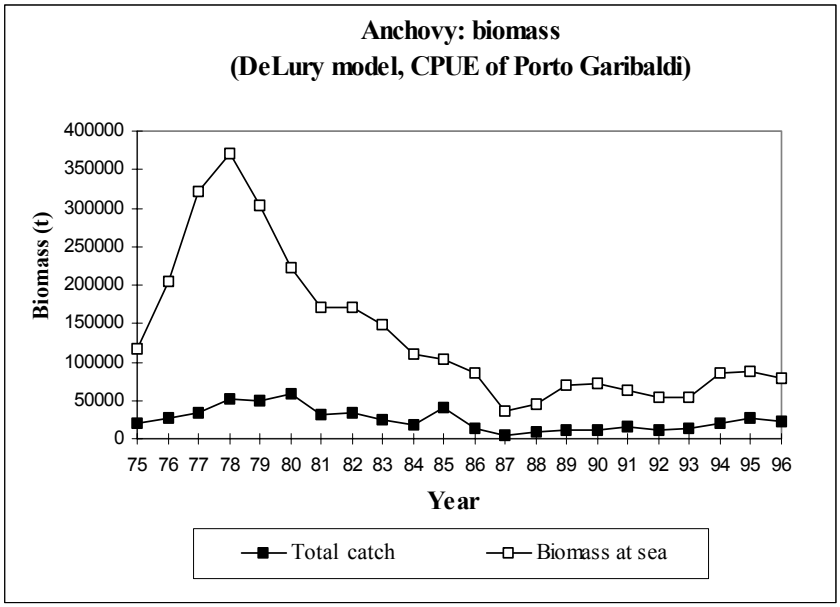

Figure 6. Anchovy biomass (DeLury model), total catch refers to Northern and Central Adriatic.

The minimum estimates of the biomass coincided with the so-called "anchovy collapse" of 1987. After 1987 the biomass increased reaching the maximum value in 1995 (88,000 t).

3.3 Stock assessment of anchovy with VPA model

VPA estimates of anchovy biomass were obtained using the natural mortality M=0.5 yr^{-1} (Cingolani *et al.,* 1993; Cingolani *et al.,* $1998_{a,b,c}$). Fish aged 4 and over were combined into a "plus group" 4+.
Figure 7 shows the biomass of anchovy and the corresponding catches. Peak biomass occurs in 1978 at around 350,000 t. The minimum value is in 1987 at around 25,000 t. After the crisis of 1987 the VPA estimates a peak of biomass in 1995 (135,000 t).

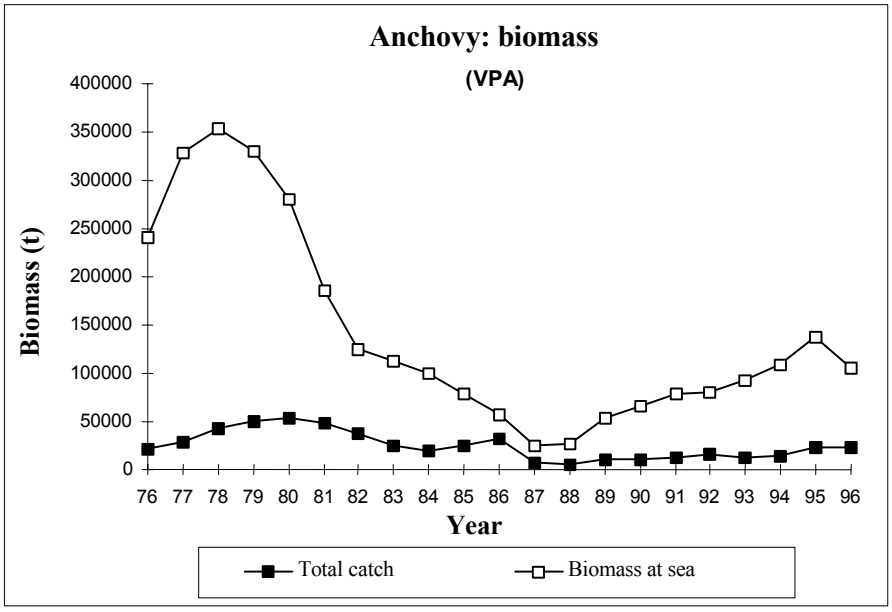

Figure 7. Anchovy biomass (VPA model), total catch refers to Northern and Central Adriatic.

The results obtained with the two models (DeLury and VPA) are substantially coherent. The partial recovery of the stock, after the crisis of 1987 is more evident in the estimates obtained with VPA.

3.4 Assessment of sardine with the DeLury model

The value of natural mortality M was set to 0.5 yr^{-1}. As for anchovy the CPUE series of Porto Garibaldi and the recruitment index calculated with Porto Garibaldi data were used.
As the results obtained were not good, a different version of the DeLury model was used (Cingolani *et al.,* 1993; Cingolani *et al.,* $1998_{a,b,c}$; Santojanni *et al.,* 1999). This version requests the catchability coefficent (q). Two values of catchability were used in order to compare the results. The estimates of sardine biomass are shown in Figure 8.
The lower estimates were observed in the seventies (70,000 and 90,000 t depending on which q is considered). The peak of biomass was in 1981 and 1982 at around 260,000 and 390,000 t. In the period 1992-1996 the biomass was around 100,000 – 160,000 t depending on which q is considered.

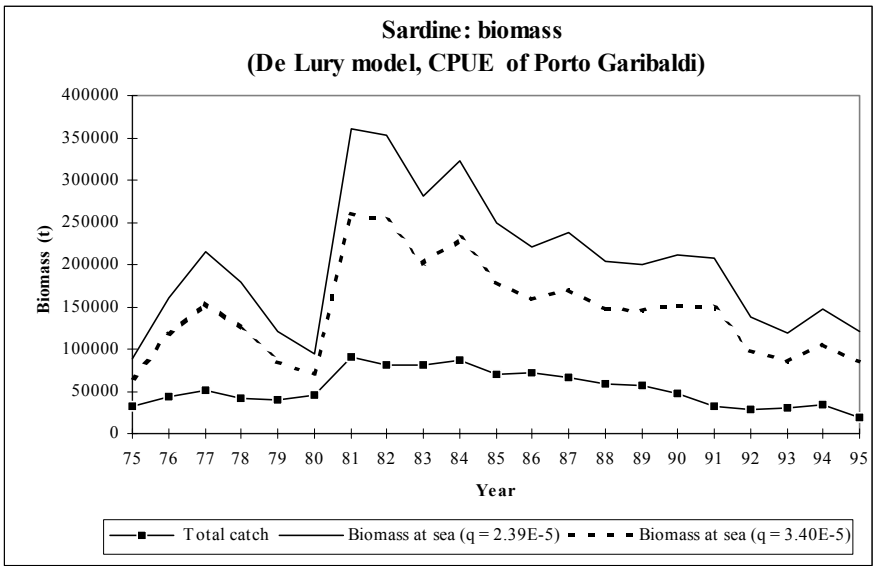

Figure 8. Sardine biomass, total catch refers to Northern and Central Adriatic.

3.8 Assessment of sardines with LCA model

Two catch distributions by length frequency were used. The first distribution was calculated as average of the period 1988-1996, the second one was calculated as average of the whole period (1975-1996). The annual mean values of biomass (see Figure 9) were obtained by using two Bertalanffy curves: the curve reported by Sinovcic (1984) and a curve – case d – reported by CGPM/GFCM (1980). The estimates of sardine biomass obtained using LCA were coherent with the results of the DeLury model (Cingolani *et al.,* 1998$_{a,b,c}$; Santojanni *et al.,* 1999).

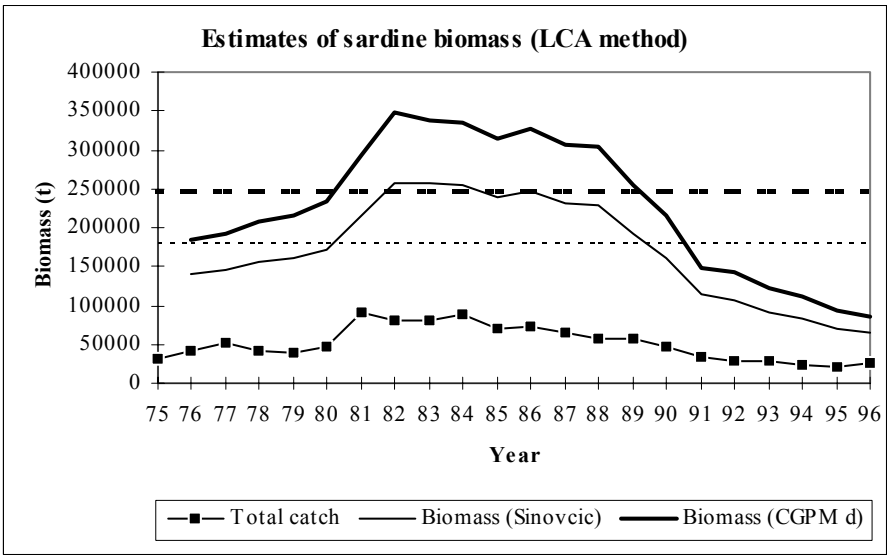

Figure 9. Sardine biomass (LCA method), total catch refers to Northern and Central Adriatic.

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