SCI. MAR., 60 (Supl. 2): 269-277 SCIENTIA MARINA 1996

THE EUROPEAN ANCHOVY AND ITS ENVIRONMENT, *I. PALOMERA and P. RUBIÉS (eds.)*

Anchovy fisheries in the Adriatic Sea*

NANDO CINGOLANI, GIANFRANCO GIANNETTI and ENRICO ARNERI

Istituto di Ricerche sulla Pesca Marittima (IRPEM - CNR), Largo Fiera della Pesca, 60125 Ancona, Italy.

SUMMARY: Anchovy (*Engraulis encrasicolus*, L.) is one the most important commercial species of the Adriatic Sea. With a surface area of 138,000 km2, about one twentieth of the Mediterranean Sea, the Adriatic Sea produced about 13,000 tonnes of anchovy in 1991, equal to 19% of the Mediterranean anchovy catches. The value of Adriatic anchovy catches has been estimated at about 15.6 MECU in 1991. Adriatic anchovy catches were very high in the late seventies (53,000 tonnes, average 1978-1980), then they decreased in the following years, until they collapsed in 1987. During this year, with a fishing effort similar to previous years, catches were only 3,700 tonnes. In successive years, stock recovered partially and anchovy catches increased to 10,000-15,000 tonnes. Anchovy is caught by Italian fishermen using two kind of fishing gears: midwater pair trawls (Italian name is *volante*) and purse seines (Italian name is *lampara*). The same fishing gears also catch sardines (*Sardina pilchardus*, Walb.). The *volante* is mainly used in the northern and central Adriatic. At present about 70 couples of fishing vessels use this gear, their average engine power is 400 HP, average size of the vessels is 50 GRT. The *lampara* vessels operating in the Adriatic Sea number about 40 and they are concentrated, mainly, in the southern part of the Adriatic Sea. The *lampara* vessels, generally, have a bigger size than *volante* vessels (average of GRT is 85), but they have lower engine power (average of HP is 300). Since 1975, IRPEM has carried out a research programme on stock assessment of *Engraulis encrasicolus* (L.) and *Sardina pilchardus* (Walb.) in the Adriatic Sea, using population dynamic models. IRPEM collects catches by species (anchovy and sardine), effort data, fishing fleet characteristics and length frequency data. Stock assessments and biomass estimations of anchovy have been carried out in the last twenty years using direct methods as echosurveys and ichthyoplankton surveys as well as indirect (catch and effort and VPA) methods. Anchovies biomass is estimated around 50,000 tonnes in the years 1990-1992. In recent years anchovy catches are about the 30% of estimated biomass. The exploitable stock size each year seems determined in the main by the size of the recruitment in the two immediately preceding years rather than by the prevailing levels of fishing effort.

Key words: Anchovy, *Engraulis encrasicolus*, fisheries, fishing fleet, catches, biomass estimation, Adriatic Sea.

RESUMEN: LAS PESQUERIAS DE ANCHOA DEL ADRIÁTICO. – La anchoa (*Engraulis encrasicolus* L.) es una de las especies comerciales más importantes del Adriático. Con una superficie de 138.000 km^2, alrededor de una vigésima parte del Mediterráneo, el Adriático produjo en 1991 unas 13.000 toneladas de anchoa, representando el 19% de las capturas mediterráneas de anchoa. El valor de dichas capturas de anchoa en el Adriático se ha estimado en unos 15,6 MECU en 1991. Las capturas adriáticas de anchoa fueron elevadas a finales de los setenta (53.000 toneladas de media en 1978-1980), decreciendo en los años siguientes hasta su colapso en 1987. En ese año, con un esfuerzo de pesca similar al de años anteriores, las capturas fueron de sólo 3.700 toneladas. En los años sucesivos, el recurso se recuperó parcialmente y las capturas de anchoa se incrementaron a 10.000-15.000 toneladas. La anchoa es capturada por los pescadores italianos por medio de dos clases de artes de pesca: redes de arrastre pelágico en pareja (cuyo nombre italiano es *volante*) y redes de cerco (cuyo nombre italiano es *lampara*). Dichos artes capturan tanbién sardinas (*Sardina pilchardus*, Walb.). El *volante* se emplea principalmente en el Adriático septentrional y central. Actualmente, unas 70 parejas de pesqueros utilizan este arte, con una potencia de motor media de 400 HP, y un tamaño medio de los barcos de 50 TRB. Los barcos de *lampara* que operan en el Adriático son unos 40, que se concentran principalmente en la parte meridional de este mar. En general, los barcos de *lampara* son de mayor tamaño que los de *volante* (85 TRB de media), pero de menor potencia de motor (300 HP de media). Desde 1975, el IRPEM ha llevado a cabo un programa de investigación para evaluar las poblaciones de *Engraulis encrasicolus* (L.) y *Sardina pilchardus* (Walb.) en el Adriático con el uso de modelos de dinámica de poblaciones. El IRPEM recolecta datos de capturas por especies (anchoa y sardina), esfuerzo, características de la flota pesquera y frecuencias de tallas. Durante los últimos veinte años se han llevado a cabo evaluaciones de poblaciones y estimas de biomasa de anchoa a través de métodos

*Received July10, 1995. Accepted May 7, 1996.

directos, tales como muestreos acústicos y de ictioplancton, además de los métodos indirectos (modelos de captura y esfuerzo y de VPA). La biomasa de anchoa se estimó en unas 50.000 toneladas en los años 1990-1992. En estos últimos años, las capturas representan alrededor del 30% de la biomasa estimada. El tamaño de la población explotable cada año parece estar principalmente determinada por el volumen de reclutamiento en los dos años precedentes más que por los niveles existentes de esfuerzo de pesca. (Traducido por los Editores).

Palabras clave: Anchoa, *Engraulis encrasicolus*, pesquerías, flota, capturas, estima de biomasa, Adriático.

INTRODUCTION

Anchovy (*Engraulis encrasicolus*, L.) is one of the most important commercial species of the Adriatic Sea. With a surface area of 138,000 km^2, about one twentieth of the Mediterranean Sea, the Adriatic Sea produced about 13,000 tonnes of anchovy in 1991, equal to 19% of the Mediterranean anchovy catches (Stamatopulos, 1993). The value of Adriatic anchovy catches has been estimated at about 15.6 MECU in 1991 (STCF, 1991). The Adriatic Sea is of paramount importance for Italian fishery: it produces around 50% of all Italian catches (all species) (Bombace and Cingolani, 1988). Fishing for anchovy (*Engraulis encrasicolus*, L.) is one of the most important fisheries in the Adriatic Sea and in Italy. The first data on anchovy catches available from ISTAT (the Italian Institute for Statistics) refer to 1958 and report about 9,000 tonnes of anchovy caught in the Adriatic Sea. This amount represented 41% of the total official landings of anchovies for Italy in that year.

In the period 1959-74 the Italian fishery for anchovies in the Adriatic showed an important development, following the introduction of pelagic trawling, and official catches marked an increase of about 300% (CGPM, 1976). Adriatic anchovy catches in the seventies reached over 50,000 tonnes/year. The fishery registered a severe drop in catches in 1987 and the recovery from this collapse has been only partial. During the seventies the behaviour of fishermen was to maximise catches. After the anchovy catches collapsed in 1987 and the subsequent increase in price, the fishermen tended to improve the quality more than the quantity of the anchovies landed.

Pelagic fisheries have developed on both side of the Adriatic but as far as anchovies are concerned

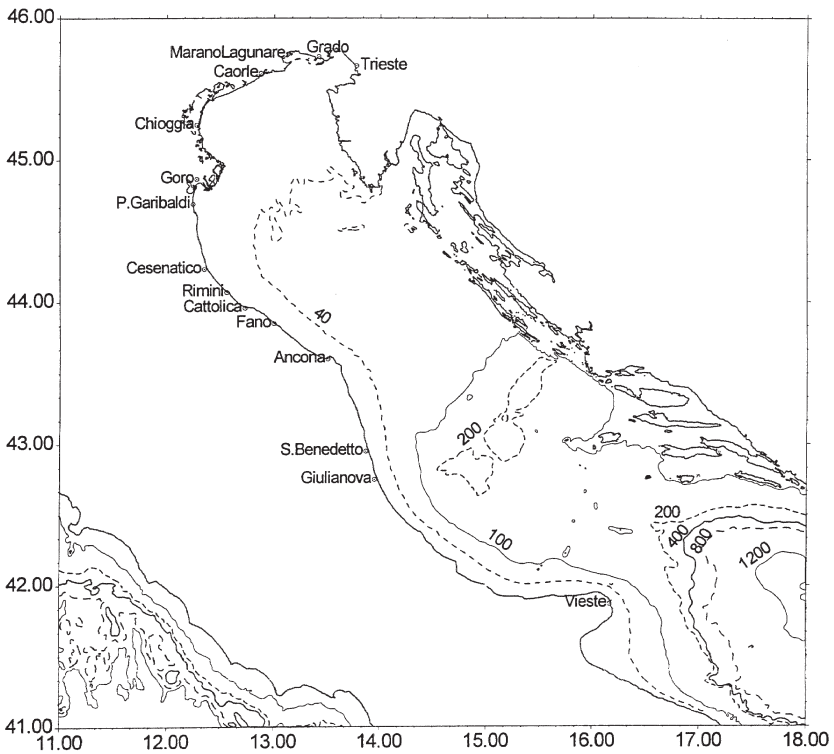

FIG. 1. – Main Italian fishing harbours for anchovy in the northern and central Adriatic Sea.

the Italian fleet has always been responsible for most (about 90%) of the catches. Pelagic fishing fleet activity on the eastern part of the Adriatic (ex Yugoslavia, Croatia, Slovenia) has always been directed mostly at sardines (Anon., 1975-92).

Adriatic pelagic fishery has been the focus of an extensive debate among scientists in the region to clarify various aspects of the biology, population dynamics and fishery management of this resource (CGPM, 1976; 1980; 1981; 1984; 1986; 1988).

The Directorate General for Fisheries of the Italian Government has been financing various research projects on fisheries biology and stock assessment of small pelagic fish in the Adriatic for the last fifteen years and in this framework IRPEM (Istituto di Ricerche sulla Pesca Marittima) has collected since 1975 data on catch quantities, size and age compositions of the catches, data on the commercial fleet composition and on its activity in terms of fishing effort. All these data refer to the fishery for small pelagic fish in the northern and central Adriatic. Therefore this report deals mainly with the fishery for anchovy in the northern and central Adriatic; anchovies catches of the southern Adriatic are about 5-10% of the catches of northern and central Adriatic.

FISHING FLEET

The Italian pelagic fishing fleet is distributed all along the Adriatic coast line (Fig. 1). Two kind of fishing gears are currently used to catch anchovies: mid-water pelagic trawl nets towed by two vessels (*volante*) and light attraction purse seines (*lampara*). The name of the gear often characterises the name of the fishing vessels, which are commonly called *volanti* and *lampare*.

Mid water pair trawling is the most common fishing method for anchovy in the northern Adriatic. It was introduced in the fifties (Ferretti, 1981) but it started to replace *lampara* purse seining after the mid sixties. By the time the IRPEM collection of catch and effort data started, i.e. 1975, *volante* was already the most utilised fishing gear for pelagic fish in the northern Adriatic down to Ancona: at present, exceptions to this rule can be considered Trieste where small *lampara* vessels still operate, and Cattolica where *lampara* vessels were in use up to 1990.

Volante vessels fish only by daytime and land their product every evening: the fishing trips last about 11-14 hours. Catches up to 15 tonnes per couple of boats per day have been recorded especially in the late seventies and early eighties, when the European Community was paying a bonus for the fish in excess unsold. At present, maximum catches are about 4 tonnes per day.

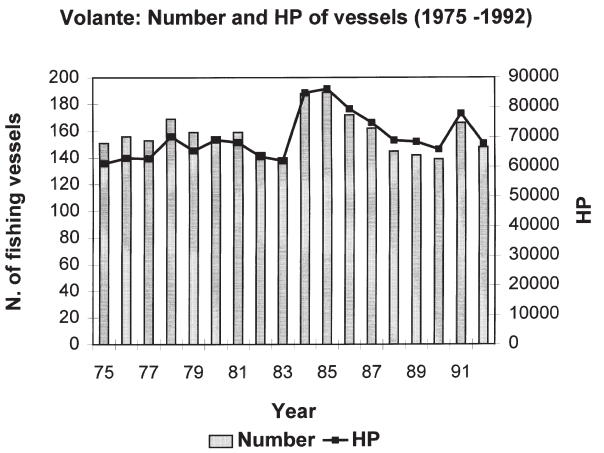

FIG. 2. – Trend in number and total engine power for mid-water pair trawlers (*volanti*) in the Adriatic from 1975 to 1992.

Average size of *volante* vessels is 50 GRT while average engine power is about 400 HP. Fig. 2 shows the trend in number and in total engine power of *volante* vessels in the Adriatic from 1975 to 1992. At present (1994) about 140 vessels (70 couples) operate in northern and central Adriatic.

Lampara vessels at present operate mainly in the central Adriatic (south of Ancona) and in the Gulf of Trieste; they fish by night in good weather conditions attracting fish with lights. Their activity is often, but not always, suspended during the colder months. Maximum catch of about 8 tonnes per day per vessel have been recorded. Anchovies caught by

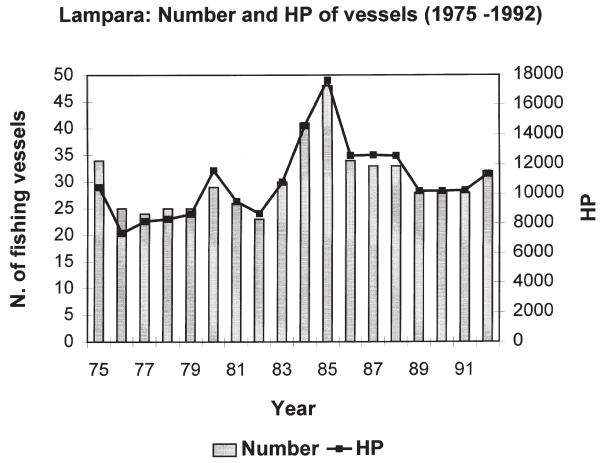

FIG. 3. – Trend in number and total engine power for purse seiners (*lampare*) in the Adriatic from 1975 to 1992.

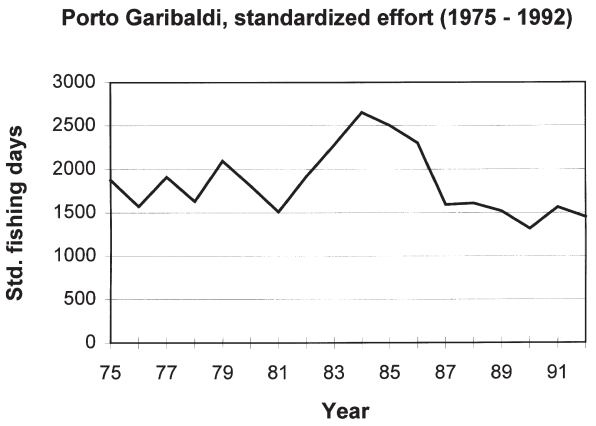

FIG. 4. – Trend of standardised fishing effort for Porto Garibaldi fleet (northern Adriatic) expressed in standard fishing days from 1975 to 1992.

lampara are in better condition and usually fetch a higher price than anchovies caught by *volante*.

At present (1994) in the Adriatic 40 *lampara* vessels with an average dimension of 85 GRT and an average engine power of 300 HP operate. There are also 17 small vessels of 6 GRT and 88 HP operating in Trieste.

The trend in number and in total engine power for *lampara* vessels from 1975 to 1992 is illustrated in figure 3.

IRPEM has collected fishing effort data including the number of days at sea for each fishing vessel (when these data were available). This fishing effort has been standardised, as reported in Levi *et al.* (1985), using the program FPOW (Abramson, 1971). The trend of standardised effort for Porto Garibaldi fleet is presented in figure 4.

FISHING HARBOURS

The geographic distribution of most Italian fishing harbours for anchovies in the Adriatic is reported in figure 1. Main harbours can be considered Trieste, Chioggia, Porto Garibaldi, Cesenatico, Rimini, Cattolica, Ancona, San Benedetto del Tronto and Vieste: in these harbours about 85% of the catch of anchovies is landed. Other important harbours are Grado, Marano Lagunare, Caorle, Goro, Fano and Giulianova. Table 1 gives an overview of anchovy landings and number of fishing vessels at the most important fishing harbours in the period 1975-92. To stress how the relative importance of different ports has changed in the last twenty years in terms of catches of anchovies Fig. 5 shows quantities of anchovies landed in some years. The general trend is a reduction in catches but in terms of number of fishing boats the trends of the various ports have been different. In Trieste the number of boats has been constantly decreasing since 1975; Cattolica shows a similar trend which has been accelerated by the general crisis of 1987, the same applies to Cesenatico. On the contrary Chioggia and Porto Garibaldi, the two most important fishing harbours in the northern Adriatic have remained fairly constant in terms of the number of fishing boats but not in terms of catches which registered a marked decrease in the last ten years.

In the central Adriatic the situation is opposite and despite the crisis in 1987 the importance of Ancona, San Benedetto and Giulianova in terms of the number of fishing vessels and catches has increased.

TABLE 1. – Fishery for anchovy in the northern and central Adriatic: historical data series of catches, fishing vessels and fishing gears for the most important ports.

Ports/Year	fish. gear	1975 n	1975 tonnes	1976 n	1976 tonnes	1977 n	1977 tonnes	1978 n	1978 tonnes	1979 n	1979 tonnes	1980 n	1980 tonnes	1981 n	1981 tonnes	1982 n	1982 tonnes	1983 n	1983 tonnes
Trieste	lampara	57	292	48	331	55	201	56	295	55	352	62	230	36	129	23	48	23	35
Chioggia	volante	37	5,013	26	2,905	23	5,089	35	12,671	39	14,115	26	12,258	30	3,932	28	6,735	28	5,422
Porto Garibaldi	volante	33	5,276	44	11,921	35	19,488	42	26,705	26	20,446	26	20,485	26	8,410	26	10,119	26	7,421
Cesenatico	volante	33	1,272	35	2,659	44	2,264	47	4,643	47	5,885	41	14,247	41	3,353	28	4,464	25	1,952
Cattolica	vol+lamp	19	1,023	10	1,124	9	780	10	1,070	7	594	12	1,005	5	1,593	5	1,314	5	799
Ancona	volante	18	2,322	17	2,392	17	1,854	11	151	13	3,385	13	1,454	12	1,629	12	1,958	12	2,171
S. Benedetto del T.	lampara	7	749	7	793	7	838	7	894	10	950	9	1,088	11	1,225	8	1,039	12	852

Ports/Year	fish. gear	1984 n	1984 tonnes	1985 n	1985 tonnes	1986 n	1986 tonnes	1987 n	1987 tonnes	1988 n	1988 tonnes	1989 n	1989 tonnes	1990 n	1990 tonnes	1991 n	1991 tonnes	1992 n	1992 tonnes
Trieste	lampara	36	371	28	449	40	84	32	39	27	106	24	68	19	122	15	74	18	108
Chioggia	volante	44	728	42	8,688	29	1,106	28	331	27	2,770	40	2,820	36	2,567	45	3,692	26	1,820
Porto Garibaldi	volante	59	4,720	46	7,603	44	1,030	45	481	46	1,439	38	1,966	35	2,064	41	2,756	42	1,914
Cesenatico	volante	28	1,800	35	1,919	29	224	25	151	18	262	18	620	19	296	19	832	21	253
Cattolica	vol+lamp	7	1,096	15	1,212	7	160	5	99	5	120	2	132	2	96	2	141	4	72
Ancona	volante	12	2,189	12	2,749	12	727	12	190	10	693	10	1,113	15	1,332	24	3,368	24	2,781
S. Benedetto del T.	lampara	21	1,420	21	3,977	15	1,575	15	509	15	681	12	856	12	1,428	12	1,700	14	1,310

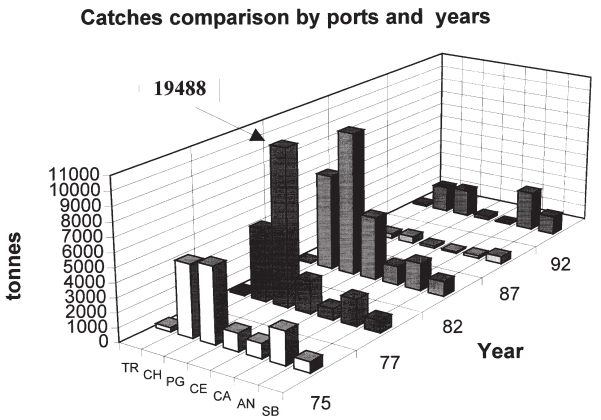

FIG. 5. – Trend in catches of anchovies landed in different fishing harbours of the northern and central Adriatic: Trieste (TR), Chioggia (CH), Porto Garibaldi (PG), Cesenatico (CE), Cattolica (CA), Ancona (AN) and San Benedetto (SB).

CATCHES

As mentioned before Italy is responsible for about 90% of the catches of anchovies in the Adriatic, to obtain a record of catches the most comprehensive as possible, official Yugoslavian and Croatian catches (Anon., 1975-92) have been summed up to IRPEM data and figure 6 shows the trend of total catches for northern and central Adriatic. It should be stressed that after the crisis of 1987 the price of anchovy has registered a substantial increase which has somehow compensated the drop in catches: trends for Italy and Marche Region (central Adriatic) of wholesale prices of anchovies (adjusted to the inflation) are illustrated in figure 7.

There is a substantial difference in the length composition of catches of anchovies between northern ports (Fig, 8), and southern ports (Fig. 9). As

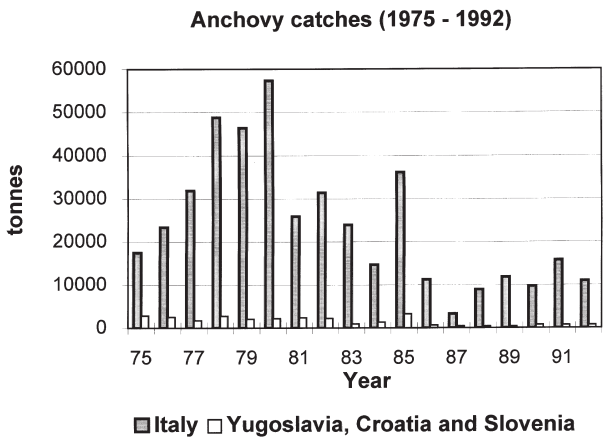

FIG. 6. – Total catches of anchovies in the northern and central Adriatic from 1975 to 1992.

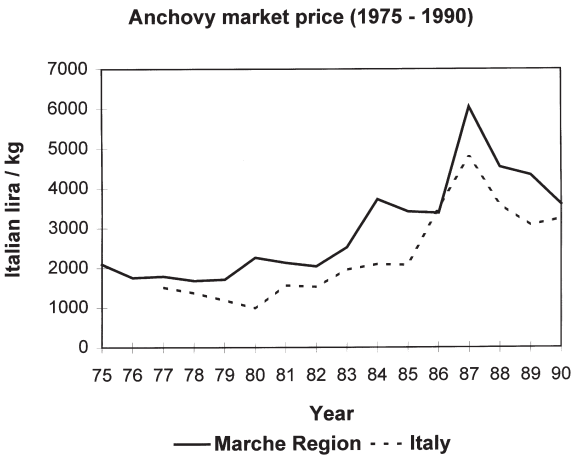

FIG. 7. – Trend of wholesale anchovy price adjusted to inflation (1990 as reference value) for Italy and Marche Region (central Adriatic).

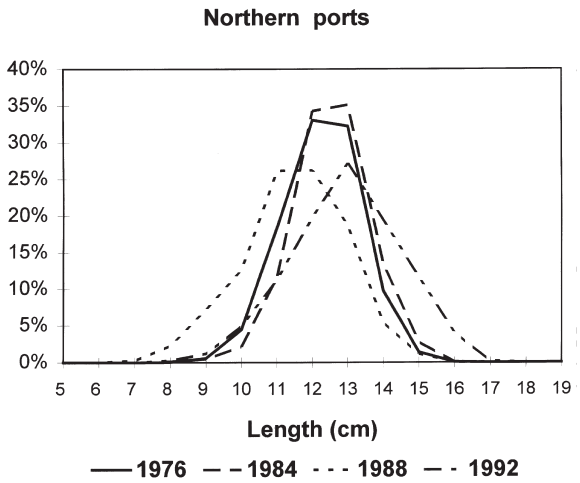

FIG. 8. – Length frequency distributions of catches of anchovy in northern ports (from Trieste to Ancona included) in four different years.

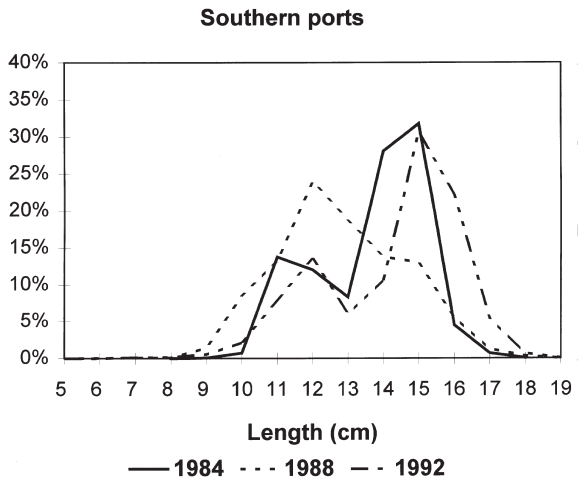

FIG. 9. – Length frequency distributions of catches of anchovy in southern ports (from San Benedetto to Vieste) in three different years.

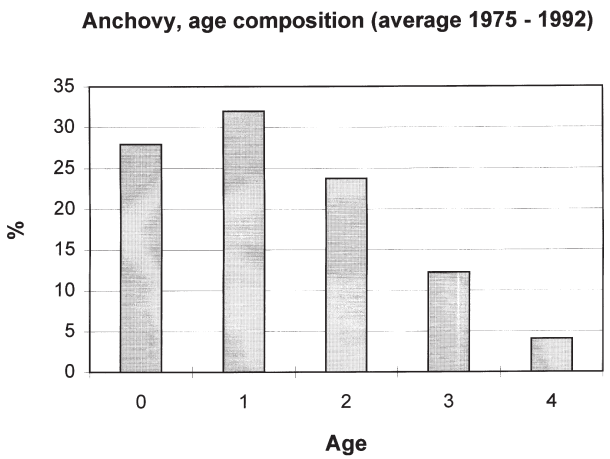

FIG. 10. – Average age composition of catches of anchovies in the Adriatic in the period 1975-1992.

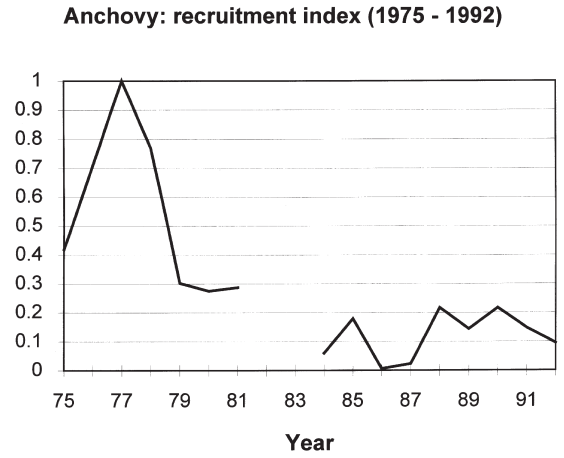

FIG. 11. – Trend of recruitment index of anchovy in the Adriatic obtained by length frequency distributions of the catches.

mentioned before two different fishing gears are used in the two areas but these differences are due mainly to the fact that different fishing grounds are exploited by the fleet: it has been observed that when *volante* and *lampara* boats fish on the same fishing ground the length composition of the catches do not differ. It is worth noting that in both figure 8 and figure 9 there is a shift towards smaller sizes in 1988: a likely consequence of the collapse of 1987.

Length frequency distributions have been converted into age distribution of catches by means of otolith reading: Figure 10 gives an average age distribution of anchovies in the catches for the period 1975-92. The high importance of first year classes (0, 1 and 2) which form about 80% in number of the total catch of anchovies in the Adriatic is evident.

RECRUITMENT TO THE FISHERY

From an analysis of length frequency distributions of commercial catches collected fortnightly in all major ports in the period 1975-1992 by IRPEM anchovies falling into length classes 9 and 10 cm have been identified as new recruits to the fishery. The average period of peak recruitment tends to occur from October to February, with lowest recruitment in the summer months.

Recruitment indices (Fig. 11) were calculated from estimates of the proportion of small (9-10 cm TL) fish in the catches and corresponding CPUE data: no length frequency data were available for 1982-83. Figure 11 shows very low levels of recruitment in 1986 and 1987, the year immediately preceding the anchovy crash and the year of the crash. Recruitment was estimated to have been much higher in the late 1970s than in the mid to late 1980s.

It is very likely that the anchovy collapse in 1987 was caused by very low recruitment. Since recruits form a relatively large proportion of the population in relatively short-lived animals as anchovies (see also Fig. 10) the exploitable stock size each year is determined in the main by the size of the recruitment in the two immediately preceding years.

MIGRATIONS AND STOCK STRUCTURE

In the Adriatic it has been asserted for a long time by fishermen that “black and big” anchovies from central and southern Adriatic were different from “silver and thin” anchovies from the northern Adriatic: in the absence of scientific evidence of migrations it has been argued for a long time whether there are two separate stocks or only one stock with extensive migrations and a preferential displacement of older individuals in the deeper waters of the central and southern Adriatic.

Anchovy spawning is widespread throughout the northern and central Adriatic, except over deep water (Sinovcic, 1978; Gamulin and Hure, 1983): Taking into account the fact that no separate spawning grounds are known and analysing seasonal variations in landings in various ports of the Adriatic, Piccinetti (1970) postulated that anchovies are capable of extensive migrations throughout the central and northern Adriatic, but he did not completely reject the hypothesis of two stocks: one migrating inside the northern Adriatic and the second one in the central and southern Adriatic.

On the basis of the movements of the commercial fishing fleet during the year, Varagnolo (1968) suggested that anchovies of the north Adriatic migrate only inside this area. This migration was also postulated by Stirn (1974) using echo survey data.

Recent studies on growth based on otolith readings (Levi *et al.*, 1994) detected differences in growth rates between northern and central Adriatic anchovies: these differences suggest the possibility of the existence of two stocks and weaken the hypothesis of extensive migration of anchovies throughout the Adriatic Sea.

The northern and central Adriatic Sea are characterised by different physical and oceanographic properties: average depth, salinity, temperature, input of nutrients and principal current patterns indicate a certain degree of separation between the two basins (Fonda Umani *et al.*, 1992). These environmental differences, together with differences in intraspecific and/or interspecific competition for the available food resources could account for the observed differences in growth rates. In order to determine whether there is genetic differentiation between the two stocks (Ihssen *et al.*, 1981) a research program funded by the European Community has been conducted in collaboration between the Marine and Fisheries Genetics Laboratory of the University of Wales and IRPEM Ancona. The final report (Carvalho *et al.*, 1994) is still under approval by the EC but data from both the allozymes electrophoresis and the morphometrics indicate a certain degree of genetic stock separation of anchovies within the Adriatic. Two stocks are proposed: one in shallow waters (less than 50 metres of depth) of the northern western Adriatic, and the other in deeper offshore waters of the central southern Adriatic. The biological basis for this stock differentiation (i.e. spatial and/or temporal separation in spawning) are still to be clarified.

BIOMASS ESTIMATES

Research on biomass estimates and stock assessment of anchovy in the Adriatic has been carried out since 1975-76 using different techniques: direct methods as echosurvey (Azzali *et al.*, 1993) and ichthyoplankton surveys (Piccinetti *et al.*, 1981, Regner *et al.*, 1986; Regner, 1990) and indirect methods as Virtual Population Analysis (VPA) and a production model based on catch and effort data: the De Lury depletion model with recruitment index (MRAG, 1992; Cingolani, 1993; Cingolani *et al.*, in press).

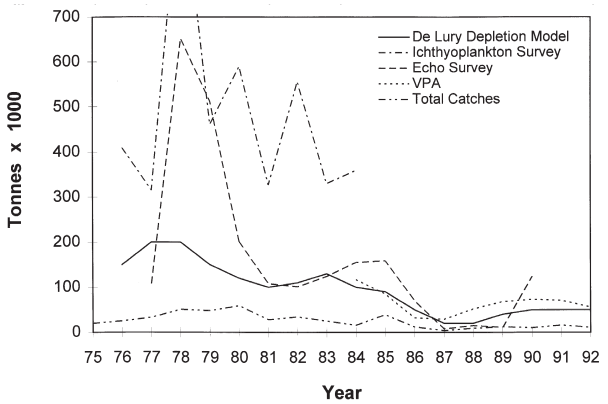

FIG. 12. – Trend in biomass estimates of anchovy obtained by different methods in the Adriatic: total catches for the corresponding years are also reported.

All the methodologies used have their own advantages and disadvantages which have been the object of extensive discussions among scientists of the region. Figure 12 summarises the anchovy biomass trends obtained using the different methodologies over the period 1976-92 in the northern and central Adriatic. Originally ichthyoplankton surveys estimates were based on the traditional egg and larvae method of Saville (1964) with an underestimation of the individual fecundity and consequently an overestimation of the anchovy biomass (Regner, 1990). Regner (1990) simulated the batch fecundity method (Lasker, 1985) using previous eggs and larvae surveys data and obtained a mean biomass value of 430,000 tonnes for years 1976-84 and a much lower (partial) estimate for 1989. Figure 12 reports the values recalculated by Regner: original estimates with the Saville method were ranging from 1 to 5 million tonnes with an average of 1.6 million tonnes for the period 1976-84.

Estimates of anchovy biomass from catch and effort data and VPA are all around 50 thousand tonnes for the most recent years, 1990-92. Peak biomass (with the DeLury depletion method) was observed between 1975 and 1979 at levels of around 200 thousand tonnes. The general trend of these figures, although slightly more conservative, do not differ too much (except for 1979 and 1980) from the acoustic estimates.

Notwithstanding the difficulty and imprecision in comparing biomass estimates obtained with different methodologies for a short lived and migratory fish like anchovy, it is important to note that both acoustic, ichthyoplanktonic and analytic methods estimate much higher anchovy biomass for the period 1976-1984 than for the period 1987-

1992 and therefore the recovery after the collapse (1987) can be considered only partial.

LEVEL OF EXPLOITATION AND CURRENT MANAGEMENT OF THE FISHERY

No specific management of the anchovy fishery is enforced in Italy: only general regulations concerning trawling apply. Since 1988 the fishing of anchovy (except for the *lampara* boats) is suspended for 40 days in summer. Moreover, in the two months after the fishing stops all boats can fish for a maximum of four days per week. This has meant a general reduction of the total fishing effort in a year. In addition, it has been forbidden to transform anchovy into fish meal since 1983.

Over the last five years, catches have represented around 30% of the estimated stock biomass. Current level of fishing mortality is estimated at around 0.2-0.3 depending on the method used (catch and effort or VPA). The effect of inter-annual variability in recruitment of the stock appears to be much more important than the effects of likely variations in fishing intensity. The anchovy crash was almost certainly due to two years of very poor recruitment. While it is true that the estimated spawning stock size in 1986 and later years have been well below levels estimated for previous years (Fig. 12), no clear evidence has been found that the low recruitments were directly caused by overfishing. Although overfishing is thought not to be the primary cause of the anchovy collapse, the subsequent levels of recruitment following the year of the crash have not yet risen to former high levels. In consequence, the current level of spawning stock biomass has also not yet recovered to former levels. In this situation it would be better to closely monitor the levels of fishing effort.

REFERENCES

Abramson, N.J. – 1971. Computer programs for fish stock assessment. *FAO Fish.Tech.Pap*., 101**:** 1-148.

Anon. – 1975-1991. Morska lovina SFRJ po podrucjima i glavnim vrstama. *Morsko Ribarstvo*, Zagreb, vols. 25-43.

Anon. – 1992. Morska lovina hrvatske po podrucjima i glavnim vrstama. *Morsko Ribarstvo*, Zagreb, vol. 44.

Azzali, M., G. Cosimi and M. Luna. – 1993. Valutazione delle biomasse, delle loro composizioni specifiche e distribuzioni spaziali, utilizzando una metodologia acustica integrata. *Rapporto per il Ministero Marina Mercantile*, 73 pp.

Bombace, G. and N. Cingolani. – 1988. Distribution de l'éffort de pêche dans les pêcheries des mers italiennes, densité (CV/n mi^2) et cpue (kg/CV) pour les différents métiers de pêche. *FAO Fish. Rep*., 394: 234-244.

Carvalho, G.R., D. Bembo, A. Carone, G. Giesbrecht, N. Cingolani, D. Levi and T.J. Pitcher. – 1994. Stock discrimination in relation to the assessment of Adriatic anchovy and sardine fisheries. *Final Project Report on European Community Funded Project EC XIV1/MED/ 91/001/A*, 172 pp.

CGPM. – 1976. Rapport de la sixième session du Groupe de Travail sur l' Evaluation des Ressources et les Statistiques des Pêches du Conseil General des Pêches pour la Méditerranée (CGPM). Rome, Italie,10- 14 novembre 1975. *FAO Rapp. Pêches*, 182: 1-69 pp.

CGPM. – 1980. Rapport de la Consultation technique pour l'évaluation des stocks dans l'Adriatique. Split, Yougoslavie, 2-6 juin 1980. *FAO Rapp. Pêches*, 239: 1-72.

CGPM. – 1981. Rapport de la deuxième Consultation technique pour l'évaluation des stocks dans l'Adriatique. Ancona , Italie, 18-22 mai 1981. *FAO Rapp. Pêches*, 253: 1-186.

CGPM. – 1984. Rapport de la troisième Consultation technique pour l'évaluation des stocks dans l'Adriatique. Fano, Italie, 6-10 juin 1983. *FAO Rapp. Pêches*, 293: 1-255.

CGPM. – 1986. Rapport de la quatrième Consultation technique pour l'évaluation des stocks dans l'Adriatique. Split, Yougoslavie, 7-11 october 1985. *FAO Rapp. Pêches*, 345: 1-204.

CGPM. – 1988. Rapport de la cinquième Consultation technique pour l'évaluation des stocks dans l'Adriatique et la mer Ionienne. Bari, Italie, 1-5 June 1987. *FAO Rapp. Peches*, 394: 1-306.

Cingolani, N. – 1993. Valutazione degli stocks pelagici di alici e sardine in Adriatico con metodi di dinamica di popolazione. *Rapporto per il Ministero delle Risorse Agricole Alimentari e Forestali*, 184 pp.

Cingolani, N., G. Kirkwood, G. Giannetti, E. Arneri and D.Levi. – (In press). Note on the stock assessment of *Engraulis encrasicolus* (L.) and *Sardina pilchardus* (Walb.) of the northern and central Adriatic sea. *GCFM FAO Third Technical Consultation on Stock Assessment in the Central Mediterranean. Tunis, 8-12 November 1994*.

Ferretti, M. – 1981. Evolution de la technologie dans la pêche au chalut pélagique en Adriatique. *FAO Rapp. Pêches*, 253: 159-161.

Fonda Umani, S., P. Franco, E. Ghirardelli and A. Malej. – 1992. Outline of oceanography and the plankton of the Adriatic Sea. *Proc. 25th Europ. Mar. Biol. Symp*.: 347-365.

Gamulin, T. and J. Hure. – 1983. The spawning and spawning areas of pelagic fishes (*Sardina pilchardus, Engraulis encrasicolus, Scomber scombrus, Sardinella aurita* and *Sprattus sprattus sprattus*) in the Adriatic Sea. *Acta Adriatica*, 24: 97-131.

Ihssen, P.E., H.E. Booke, J.M. Casselman, J.M. McGlade, N.R. Payne and F.M. Utter. –1981. Stock Identification: Materials and Methods. *Can. J. Fish. Aquat. Sci*., 38: 1838-1855.

Lasker, R., (ed.). – 1985. An egg production method for estimating spawning biomass of pelagic fish: application to the northern anchovy, *Engraulis mordax. U.S. Dep. Comm., NOAA Tech. Rep. NMFS, 36*: 1-99.

Levi, D., M.G. Andreoli, E. Arneri, G. Giannetti and P. Rizzo. – 1994. Otolith reading as a tool for stock identification. *Fish. Res.,* 20: 97-107.

Levi, D., N. Cingolani, G. Giannetti, R. Scorcelletti, E. Peloni and N. Frontini. – 1985. Stocks assessment of *Sardina pilchardus* (Walb.) and *Engraulis encrasicolus* (L.) of the Northern-Central Adriatic Sea: some preliminary results. *Quad. Ist. Ric. Pesca Marittima*, 4: 1-34.

MRAG. – 1992. Catch and effort data analysis. The CEDA package user manual. *MRAG 27 Campden Street, London W8 7EP, UK*, 90 p.

Piccinetti, C. – 1970. Considerazioni sugli spostamenti delle alici (*Engraulis encrasicolus* L.) nell'alto e medio Adriatico. *Boll. Pesca Piscic. Idrobiol*., 25: 145-157.

Piccinetti, C., S. Regner and M. Specchi. – 1981. Estimation préliminaire de la production maximale d'anchois et de sardine en Adriatique. *FAO Fish. Rep*., 253: 155-158.

Regner, S. – 1990. Stock assessment of the adriatic sardine and anchovy using egg surveys. *In*: O. Giovanardi (ed.): *Atti del Seminario Reproductive biology of small pelagics and stock assessment through ichthyoplanctonic methods. ICRAP Quad. PESCA*, 4: 17-31.

Regner, S., C. Piccinetti, and M. Specchi. – 1986. Statistical analysis of the anchovy stock estimates from data obtained by egg surveys. *FAO Fish. Rep*., 345: 169-184.

Saville, A. – 1964. Estimation of the abundance of a fish stock from egg and larval surveys. *Rapp. Reun., Cons. Int. Explor. Mer,* 155: 165-173.

Sinovcic, G. – 1978. On the ecology of the anchovy, *Engraulis encrasicolus* (L.), in the central Adriatic. *Acta Adriatica*, 19: 1-32.

Stamatopulos, C. – 1993. Trends in catches and landings. Mediterranean and Black Sea fisheries: 1972-1991. *FAO Fish. Circ.*, 855: 1-177.

STCF. – 1991. *Commission of the European Communities, 19th Report of the Scientific and Technical Committee for Fisheries. SEC* (91) 1651, 103pp.

Stirn, J. – 1974. Contribution to the knowledge of migrations and the volume of the pilchard and anchovy populations in the Northern Adriatic. *Acta Adriat.*,16: 401-422.

Varagnolo, S. – 1968. Analisi della produzione ittica dei mercati di Chioggia e di Venezia. *Arch. Oceanogr. Limnol.*, 15(Suppl): 201-235.