Integrating Fishing Accounting into the Italian System of National Accounts

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Abstract

This paper shows how the economic performance of the Italian fishing industry was affected by the depreciation of fish stock. Because of data limitation, the Net Price Method was preferred. Twenty-four measures (scenarios) of resource depreciation have been computed for the period 1975-1995, by using different fishing effort measures, two Yield-Effort Models (Fox and Schaefer) and two different opportunity cost scenarios (4% and 8%). The results show that the Italian fishery Net Value Added overestimated the growth rate of fishing sector, especially in periods during which an increases in the economic performance were reported.

Introduction

Overfishing was recognized as an international problem as far back as the early 1900s (FAO, 1996; Grainger and Garcia, 1996). With the expansion of global fishing activities in the 1950s, the exploitation of global fish stocks has followed a predictable pattern; progressing across the oceans as each region reaches its maximum productivity and then begins to decline. According to FAO, the Mediterranean Sea is considered to be one of the oldest and most intensively exploited marine systems, affected by overfishing since the first years of 1900 (FAO, 1996). According to the European Union (European Environmental Agency 2003; CEC 2001), 75% of the most important commercial fish stocks are overfished. Considering all the stocks, including fish with no significant economic importance, the ratio ranges from 20% (Aegean and Ionian Seas) to 44 % (Adriatic). There are many regional initiatives that try to promote and coordinate responsible fisheries in the Mediterranean and Italian seas. (FAO Adriamed, FAO General Fisheries Commission for the Mediterranean).

The structure of Italian fisheries is characterized by the presence of both industrial and artisanal fisheries: 77% of the vessels belong to the 0-10 gross register tons (GRT) class, while only 7% is over 50 GRT (Istituto Ricerche Economiche per la Pesca e l'Acquacoltura, IREPA 2002). Fishing techniques compete in exploiting multi-species stocks simultaneously. Moreover, fishing areas are disseminated along the 8,000 Km of coast, with more than 800 sites where production is landed. The concentration of landings is therefore very low for almost all species. For this reason no Italian region can be considered as dependent on fisheries (IREPA, 2002). The fishing sector account for about 0.14% of the Italian NNP.

Previous studies do not explicitly refer to the magnitude of overfishing in Italy. Nevertheless, this general framework suggests that possibly the Italian fishery sector failed in distinguishing between income and capital, creating the base for future productive capacity problems (Schumacher, 1973). Fish stocks are a component of a country's economic assets. They belong to natural capital, which constitutes the fundamental asset upon which environmental services, social and economic activities depend (Bresso, 1993). Recognizing the services to economic activities that can be derived from the various assets is the first step for an efficient and sustainable long-run management of the economy.

However, the current United Nations System of National Accounts (UN, 1993) does not consider such indicators. It follows that the increase in production measured in Net National Product (NNP) is usually called economic growth. This growth is viewed as the indicator for economic success (Hueting, 1991). Moreover, NNP is currently derived by subtracting from GNP the depreciation of man-made capital only. Economic growth, defined in this manner, obtains the highest priority in international and national agendas, even if, at the same time the growth of national income is accompanied by the erosion of the basis of future economic and ecological sustainability and productive capacity (Fodella, 1989). Depreciation is a fundamental economic concept, which tries to capture the declining income-generating potential of an asset over time, and indicates the level of investment necessary for an economy to maintain its productive capacity. Implicitly, assets other than the reproducible man-made capital are not really considered as capital. Therefore, it is evident that the crucial economic problem is generated by this asymmetry[1] between the treatment set to the man-made capital and that one set to the other resources (Drechsler, 1976). Deducting depreciation of natural capital in national income can provide a better indicator of economic performance (Repetto, 1989; Ahmad and El Serafy, 1989; Costanza, 1991; Daly, 1991; Da Motta *et al.*, 1991; Liu, 1998; Figueroa and Calfucura, 2003).

This study is an attempt to integrate fish stock depreciation into the Italian National Accounts, by subtracting the value of overfishing from the Fishery Net Value Added.

1. Methodology

National income accounting theory (Weiztman, 2003), based on the optimal control theory, suggests that an appropriate measure of adjusted net national product for the depreciation of fish stocks is given by the following (Hartwick, 1990; Perman 2003) (the algebraic derivation of the following equation is in APPENDIX 1),

$$ANNP_t = NNP_t - (U_E / U_C - G_E)[E_t - F(S_t)] \qquad (1.)$$

This defines a depreciation-adjusted measure of fishery Net Value Added (ANVA).[2]

In (1) ANNP is our "Adjusted Net National Product" given by NNP, corrected by the natural resources depletion. The last two terms are the necessary corrections to calculate an ANNP measure that incorporates the depreciation of natural capital, which is not included in the usual measures of the SNA. (U_E / U_C) is the ratio of marginal utility for fishing and consumption (= price or marginal benefit) and (G_E) is the marginal fishing cost. Thus, the term $(U_E / U_C - G_E)$ corresponds to the marginal unit rent of the fishery in the model that is multiplied by the net fish catch to obtain the optimal adjusted NNP.

It is interesting to notice that, when the fish capture is equal to the natural growth $[F(S_t) = E_t]$ (sustainable yield exploitation of fishery), then ANNP = NNP and no adjustment to NNP is required.

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[1] This concept is equivalent to "input asymmetry" as defined by Drechsler (1976).

[2] In the sequel Adjusted Net Value Added will be referred to as ANVA.

As a result, only over-fishing depreciates NNP. In other words, this model leaves no doubt that the gap between the NNP and the ANNP level measures to what extent the economy depends on the use of natural resources that exceeds the sustainable exploitation level. If the NNP level increases substantially, while the ANNP level increases less, i.e. if the gap between the two measures increases over time, it follows that the basis for economic growth is unsustainable. Growth is then mainly driven by an increase in natural resource use. On the other hand, if the gap between the NNP level and the ANNP level decreases over time, this indicates a diminishing over-dependence on natural resources of the economy.

The main practical problems in implementing the accounting rule, evident in equation (1), are:

- to obtain estimates of the resource rent, although the marginal cost of fish catch is not available (the second term of the RHS of (1): $(U_E / U_C - G_E)$)
- to adequately compute the depletion of fish stock (the third term on the RHS of (1): $[E_t - F(S_t)]$).

1.1. Resource rent

The first problem referred to the previous section is solved by simple substitution. Since marginal cost is not available, literature suggests the use of harvesting average cost, instead. (Da Motta, 1991; Ilarina, 2001; Lange, 2003; Perman, 2003). Thus, resource rent per unit is easily found by dividing the net profit of fishery industry by the annual catch (expressed in biophysical units). Formally, the following formulas must be applied, in order to calculate the fishery net profit and the rent[3]:

$$NP_t = (TR_t + NS_t) - (\underbrace{IC_t + CE_t + CFC_t}_{\text{Average costs}} + OP_t)] \qquad (2.)$$

$$RR_t = NP_t / Y_t \qquad (3.)$$

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[3] This formula is adapted to the Italian case from Lange, 2003; UN/ FAO, 2003

where:

- RR_t is the resource rent per unit (expressed in terms of unit of fish caught) at time *t*;
- NP_t is the fishery net profit at time *t*,
- NS_t represents the net subsidies; they are computed by subtracting the taxes on production from the total subsidies received at time *t*;
- TR_t are total revenues of the fishery at time *t*;
- IC_t is the intermediate consumption in period *t*,
- CE_t is the compensation of employees at time *t*;
- CFC_t is the consumption of fixed capital (the standard man-made capital depreciation) at time *t*;
- OP_t is the normal profit calculated as r x K_t ; where r is the opportunity cost of capital). It is a percentage on fixed capital;
- Y_t is the total amount of the catch at time *t* (expressed in biophysical unit of measure).

Generally, using average cost instead of marginal cost to compute rent would lead to an overestimation of the resource rent (Perman, 2003). Indeed, note that the marginal cost of fishing $G_E > TC_t$, then

$$U_E / U_C - G_E < TR_t - TC_t$$

1.2. Fish depletion and its monetary value

Depletion (D) in the case of renewable resource is always the difference between actual harvest and sustainable harvest. In our case,

$$D_t = Y_t - SY_t \tag{4.}$$

Where:

- *Y* is the actual catch;
- *SY* represents the harvest that does not exceed the natural regeneration rate of fish stock.

There are two main methods in the literature that suggest how to calculate the monetary value of depletion:

- The Net price method (Repetto *et al.*, 1989);
- The Net present value method (Lange, 2003).

The Net Price method applies for each year the following formula in order to calculate the monetary value of annual depletion (VD_t):

$$VD_t = RR_t\,(D_t) \qquad (5.)$$

The other valuation approach to compute the rent is the Net Present Value, which values fish stock as the net present value of a stream of income it is expected to generate in the future. Some assumptions about future prices, technology, costs of production, future fish stock and future exploitation path are required in order to employ this method.

Given that for the Italian case study necessary information for some variables was absent and in order to avoid the introduction of uncertainty elements in the models, we preferred the Net Price Mehod.[4]

Moreover, the Net Price method applies the Hotelling Rule and is unambiguously suggested by the capital-theoretic model previously analyzed (Tiezzi and Borghesi, 1999; Perman 2003, UN-FAO, 2003). However, many applications of the net price method explicitly ignored the positive changes in the resource value as increase in the stock (Perman, 2003). Doing so, they do not follow the theorists). It is evident that they found meaningless that the *net increase* of a resource can augment the NNP. In the presence of sustainable use (or, in general, no depletion) the NNP is simply not adjusted, which implies $NNP_t = ANNP_t$.

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[4] Usually, studies that adopt Net Price Value Method assume constant prices, technology and costs of production. Hence, the value of the depreciation is given by: $VD_t = \sum_{t=1}^{Ts} [(RR_t)(D_t)/(1+r)^t]$ Where T_s is the lifetime of fish stock and r is the interest rate.
For a non-renewable resource, it is generally assumed that the lifetime is finite and that extraction continues at a constant rate equal to that of the current period. For a renewable resource, there are several possibilities for future levels of stock and the rent generated, which result from different management regimes. Yet, prediction of future stock levels is very difficult to determine also because of the fluctuation of fish population across time. Thus, many studies on fisheries accounting usually make a further assumption about constant stock level and rent across time. In this case, the net present value for each year is simply given by: $VD_t = (RR_t)(D_t)\,/\,r$ (Lange, 2003, UN-FAO, 2003). Also in this case, lack of the information and so many assumptions leads us to focus preferably on Net Price Method.

In this study, we report both these approaches: when the annual harvesting is less than the sustainable yield, the positive difference is added to the NNP in one case (as theory suggests; so $NNP_t < ANNP_t$), and simply ignored in the other (and $NNP_t = ANNP_t$). For simplicity we call *net depreciation* the first case and *pure depreciation*, the second one.

Generally, corrections that lead to an increase of the NNP would be probably more justifiable if resource net growth is the outcome of an investment plan in finding new discoveries, planting new trees, or (in our case) in limiting fishing effort allowing fish population to growth.

VD_t in (5) links the rent to the depletion and translates into statistical accounting language the value of change in natural capital, the term $(U_E / U_C - G_E)\ [E_t - F(S_t)]$ in the RHS of (1). In practice (1) becomes:

$$ANNP = NNP - VD_t \tag{6.}$$

When a study does not consider a wide set of natural resource stocks, as is the case here, it is much more reasonable to compute other macroeconomic depreciation-adjusted indicators. We refer to Ilarina (2000) and National statistical coordination board (NSCB, 1998) of Philippines' Government, where an attempt was made to compute a fishery depreciation-adjusted Net Value Added[5].

The formulas that must be applied are the following:

$$ANVA_t^i = GVA_t^i - CFC_t^i - VD_t^i \quad \text{or} \tag{7.}$$

$$ANVA_t^i = NVA_t^i - VD_t^i \tag{8.}$$

where:

- $ANVA_t^i$ is the Adjusted Net Value Added for sector *i* in period *t;*
- GVA_t^i is the gross value added of the *i-th* sector at time *t*;
- CFC_t^i is the consumption of fixed capital occurred at time *t* in the *i-th* sector;

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[5] It is evident that there is a correspondence between NNP and the NVA. Both are measure of the economic activity netted out for the depreciation of man-made capital

- NVA_t^i is the net value added of the *i-th* sector at time *t*;
- VD_t^i is the value of depletion in the *i-th* sector at time *t*.

Therefore, in spite of data constraints, our study was able to find a measure of sustainability of fish production following this methodology.

1.3. Econometric models

As previously established in equation (4) the estimation of SY is crucial for the measurement of the decline in natural capital stock in the case of renewable resources. Data availability on catch and effort for Italian fishing lead to consider a Yield-Effort (Y-E) model in order to estimate SY. The Y-E function has the potential to be estimated. Formally, this function is algebraically derived from biological growth function models. Biological growth functions relate natural growth rates with stock instead, but provide a rigorous base on which Y-E curves are built. Many different specifications of biological models exist in the literature. More sophisticated models account for the age structure of the fish population and can be estimated if sufficiently detailed data are available. However, this is not the case in this study. Data constraint leads us to adopt the most known and applied single-species models: logistic-Schaefer (Gordon, 1954; Schaefer, 1954) and exponential-Fox biological growth curves (Fox, 1970). Both are related to the intrinsic growth rate of the stock (*r*), the biomass (*s*) and the environmental carrying capacity (*K*), which is the maximum stock level or virgin biomass.

However, the distinct difference between the logistic-Schaefer and exponential-Fox curve is that the growth function is symmetrical or parabolic in the logistic growth model, implying the possibility of stock extinction in an extreme case; while in the exponential growth model it is asymmetrical, based on the Gompertz curve. This basic difference could lead to divergent results in terms of SY. For this essential reason, both models are used. This allows us to compare different results and to implement a sensitivity analysis in computing depreciation.

Y-E Schaefer and Fox econometric models can be written as:

$$CPUE_t = \frac{Y_t}{E_t} = \alpha + \beta E_t + \varepsilon_t \quad \text{(Schaefer Econometric Model)} \qquad (9.)$$

$$\ln CPUE_t = \alpha + \beta E_t + \varepsilon_t \qquad \text{(Fox Econometric model).} \tag{10.}$$

Where Y_t and E_t are the observable random variables, corresponding respectively to the fish catch and a measure of the fishing effort at time t; and ε_t is the random component. The parameters α and β can be easily estimated by simple Ordinary Least Square Method. Once the parameters are estimated, it is possible to compute the MSY and SY, according to the following formulas:

$$E_{MSY} = -\frac{1}{\beta} \tag{11.}$$

$$MSY = -\frac{\exp(\alpha - 1)}{\beta} \tag{12.}$$

MSY can add some information about the sustainability of fishing activities.

The annual Sustainable Yield (SY) can be easily computed by plugging into (9) and (10) the estimated coefficients α and β:

$$SY_t = \alpha E_t + \beta E_t^2 \qquad \text{(Schaefer SY)} \tag{13.}$$

$$SY_t = E_t \exp(\alpha + \beta E_t) \qquad \text{(Fox)} \tag{14.}$$

2. Data sources

Two types of data were collected and elaborated to cover a 20 year-time series on Italian fishery: 1975-1995. These comprise biophysical data (mainly used to estimate the annual SY and the correspondent depletion) and economic data (used to derive the resource rent and the depreciation), collected from different sources.

2.1. Biophysical Data

Data on total fish capture (included inland catch) have been sourced from the FAO Fisheries Information Global System (FIGIS). Data on fishing effort (number of vessels and gross register tons) have been extracted from the same source for the period 1977-1995. Thus, they were integrated using comparable Economic Research Institute on Fishery and Aquaculture (IREPA) data on fishery statistics for 1975 and 1976.

Number of vessels and gross registered tons were the only data found about fishing effort able to cover a significant period of time (20 years). They represent two measures of the so-called nominal effort reflecting the simple total of effort units exerted on a stock in a given time period. Methodologically, a better measure should be the so-called effective efforts. It reflects the amount of fishing gear of a specific type used on the fishing grounds over a given unit of time (e.g. hours trawled per day, number of hooks set per day or number of hauls of a beach seine per day) and when two or more kinds of gear are used, they must be adjusted to some standard type (FAO, 1997). However, many studies in fishery economics use nominal measures when better information is not available, as it was the case here (Anderson, 2002).

2.2. Economic data

As shown resource rent is given by applying the following formulas:

$$NP_t = (TR_t + NS_t) - (\underbrace{IC_t + CE_t + CFC_t}_{\text{Average costs}} + OP_t)] \qquad (15.)$$

$$RR_t = NP_t / Y_t \qquad (16.)$$

All figures are provided from national accounts except for *r*, the opportunity cost of capital.[6] Therefore economic data were collected from the Italian Statistical Institute (ISTAT) from the online general data warehouse (at the following web address: www.istat.it) or from the online data warehouse National Accounts-specific (at http://con.istat.it). Some or the data were received directly from National Accounting Office in Rome (ISTAT, *Ufficio di Contabilità Nazionale*, Italy).

These measures were *translated* into Italian statistical accounting measures according to the following:

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[6] Better estimates could be provides by the annual survey and studies on fishing companies conducted by IREPA for further studies, because this database was established in 1992.

- The term *(TR_t +NS_t)* was given by the fishery production at factor cost[7], in constant 1995 Euro (production, henceforth);
- The term IC_t was given by intermediate consumption in constant 1995 Euro obtained by Agricultural Tables, ISTAT data warehouse (www.istat.it);
- CE_t is total amount of wages and salary paid by the fishery industry sector to the employees[8]. This data were from the ISTAT data warehouse on National Accounts (http://con.istat.it). This Data were corrected for inflation by using the input deflator at 1995 prices. The initial data from 1975 to 1979 were missing. They were fitted by using a backward method with a third-order polynomial regression (trend-line) on a time series 1980-2003 (LimDep 7).
- CFC_t is the depreciation of fixed assets in constant 1995 Euro. It is found in the Italian National Accounts for fishery (www.istat.it). The data from 1975 to 1979 were missing. They were fitted by means of a backward regression analysis using a second-order polynomial functional form on a time series 1980-2001 (LimDep 7).
- OP_t [9]is calculated as the rate of return on the fixed capital invested in fishing. Two rates were applied in order to perform a sensitivity analysis: 4% and 8%.

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[7] Production at factor cost is not a concept used explicitly in the SNA but it can easily be derived by subtracting the value of any taxes, less subsidies, on production (EUROSTAT, Coded). The estimation for Italian Fishery was obtained by ISTAT online data warehouse (www.istat.it or http://con.istat.it).

[8] Wages and salaries include the values of any social contributions, income taxes, etc. payable by the employee (EUROSTAT, Coded and ISTAT)

[9] In practice, the opportunity cost is difficult to measure and is therefore often defined as either the average return on capital in an economy or the average cost of borrowing capital, adjusted for risk (Lange, 2003). There were no data concerning fishery industry that might indicate an appropriate cost of capital for that sector along the period considered. These two percentages was chosen on the basis of other studies and to permit a sensitivity analysis. In our case they were applied on the net capital stock: a measure corrected for the depreciation of current fixed assets. The initial data about net capital stock were missing. They were fitted using a backward method with a second-order polynomial regression (trend line) on a time series 1980-2001.

3. Results

3.1. Trends in fish catch, fishing effort and CPUE in the Italian Fishery industry (1975-1995)

As previously mentioned, there is no unique definition for fishing effort (see section 1.2). Following the Fishery Economics literature (Anderson, 2001; Coppola *et al.*, 2002), and given data limitations, four different measures of fishing effort have been considered:

- Number of vessels (NV);
- Gross register tonnes (GRT);
- A *composite* variable obtained by multiplying NV by GRT (NVGRT[10]) and
- a measure of the average tonnage (computed by dividing the GRT by NV, GRT/NV).

The following table shows the trend of catch, the four different magnitudes of fishing efforts (E) and consequently the four different CPUE over the period considered (1975-1995).

Fish landings reached the maximum in the middle of the 80's with more than 480,000 metric tons (tons, from now on; MT in the graphs) of fish caught. This may have been the result of the high level of fishing effort measured in NV and GRT in the period 1975-1983. During that period, the percentage of increase in NV was 12% and GRT grew by 23%. In spite of the increase in the average tonnage of the Italian fishery expressed by GRT/NV, the declining trend in fish capture after 1984-85 seemed to be more affected by the NV and the GRT. This may be true both when they are considered individually and when multiplying them to obtain our composite variable NVGRT. These results could be reasonable if we consider the peculiarity of Italian fishery that is composed by 77% of small scale fishery (IREPA, 2002). This figure appears to be confirmed by the CPUE trend.

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[10] IREPA used this kind of composite variable in some researches. In a study presented to the XIVth Annual European Association of Fishery Economists (EAFE) Conference in 2002, the fishing effort used to estimate biological models is obtained by multiplying together number of vessels, days at sea, power of engine (expressed in KW), number of employees (Coppola, et al., 2002).

Table 1 Fish catch, level of fishing effort and CPUE (1975-1995)

Year	Total fish catch in metric tonnes	Different measures of fishing effort				Different Measures of CPUE			
		NV	GRT	GRT/NV	NV*GRT in million	NV	GRT	GRT/NV	NV*GRT in million
1975	399,103	20,883	262,776	12.58	5,487	19.11	1.5188	31717	7.27E-05
1976	414,847	21,227	269,575	12.7	5,722	19.54	1.53889	32666	7.25E-05
1977	363,244	21,435	271,138	12.65	5,811	16.95	1.3397	28717	6.25E-05
1978	387,029	21,797	277,094	12.71	6,039	17.76	1.39674	30445	6.41E-05
1979	412,114	22,388	295,981	13.22	6,626	18.41	1.39237	31172	6.22E-05
1980	430,266	22,604	302,598	13.39	6,839	19.03	1.4219	32141	6.29E-05
1981	430,152	22,492	305,855	13.6	6,879	19.12	1.40639	31633	6.25E-05
1982	449,271	22,981	316,788	13.78	7,280	19.55	1.41821	32592	6.17E-05
1983	454,107	23,385	323,512	13.83	7,565	19.42	1.40368	32825	6.00E-05
1984	484,031	19,155	260,512	13.6	4,990	25.27	1.858	35590	9.70E-05
1985	482,302	19,614	266,297	13.58	5,223	24.59	1.81114	35524	9.23E-05
1986	457,232	19,751	265,533	13.44	5,244	23.15	1.72194	34010	8.72E-05
1987	443,850	19,831	273,680	13.8	5,427	22.38	1.62178	32162	8.18E-05
1988	439,234	19,756	273,664	13.85	5,406	22.23	1.60501	31709	8.12E-05
1989	415,884	18,433	263,166	14.28	4,850	22.56	1.58031	29130	8.57E-05
1990	373,712	18,492	274,735	14.86	5,080	20.21	1.36026	25154	7.36E-05
1991	407,574	17,536	272,300	15.53	4,775	23.24	1.49678	26248	8.54E-05
1992	396,467	17,561	268,072	15.27	4,707	22.58	1.47896	25972	8.42E-05
1993	397,541	15,612	245,617	15.73	3,834	25.46	1.61854	25269	1.04E-04
1994	399,339	15,798	245,638	15.55	3,880	25.28	1.62572	25683	1.03E-04
1995	397,297	16,000	250,000	15.63	4,000	24.83	1.58919	25427	9.93E-05

With the decreasing effort (expressed in 16% of NV and 23% GRT) during the last part of the 80's and early 90's, catch declined stabilizing around 390,000 tons; a level close to the minimum of 363,000 tons registered in 1977. In the same period CPUE (when effort is NV and GRT and NVGRT) weakly increased, indicating an increased productivity of Italian Fishery in the 90's.

The decline in fish catch and in effort may be a first rough signal of overexploitation of some fishing grounds. The CPUE trend in the latter part of the period considered could indicate that some political measure aimed at decreasing the effort was taken.

3.2. Econometric analysis

As already shown in order to calculate the depletion of fish it is necessary to estimate the parameters of the Schaefer and Fox linear regression models reported below:

$$CPUE_t = \frac{Y_t}{E_t} = \alpha + \beta E_t + \varepsilon_t \ , \tag{17.}$$

$$\ln CPUE_t = \alpha + \beta E_t + \varepsilon_t \tag{18.}$$

Four different measures of effort (NV, GRT, NVGRT, GRT/ NV) and two biological models (Schaefer and Fox) lead to 4 x 2 regressions as shown in the following table.

Table 2 Linear regressions model

Schaefer Models	Fox Models
$\frac{Y_t}{NV_t} = \alpha + \beta NV_t + \varepsilon_t$	$\ln\left(\frac{Y_t}{NV_t}\right) = \alpha + \beta NV_t + \varepsilon_t$
$\frac{Y_t}{GRT_t} = \alpha + \beta GRT_t + \varepsilon_t$	$\ln\left(\frac{Y_t}{GRT_t}\right) = \alpha + \beta GRT_t + \varepsilon_t$
$\frac{Y_t}{[GRT / NV]_t} = \alpha + \beta [GRT / NV]_t + \varepsilon_t$	$\ln\left(\frac{Y_t}{[GRT / NV]_t}\right) = \alpha + \beta [GRT / NV]_t + \varepsilon_t$
$\frac{Y_t}{[(NV)(GRT)]_t} = \alpha + \beta [(NV)(GRT)]_t + \varepsilon_t$	$\ln\left(\frac{Y_t}{[(NV)(GRT)]_t}\right) = \alpha + \beta [(NV)(GRT)]_t + \varepsilon_t$

Where Y_t is the annual fish capture; E_t in the general models (29) and (30) is substituted by the four measures of effort chosen (NV, GRT, GRT/ NV, NVGRT).

All the models were overall significant and as expected the slope coefficient was negative for each regression. The models in which GRT was used as a measure of effort do not fit the data very well. The R-squared was low both for the Schaefer and the Fox Models (R-squared equal to 0.33 and 0.34 respectively). The biological dynamics of fish is explained better by the other model specifications for which all the coefficients were highly significant at 1% level, as it is shown by the low *p-values*. Durbin-Watson statistic revealed presence of autocorrelation in all the models.

The six models that were found to be significant overall and with high coefficient of determination were corrected for autocorrelation using the autoregressive model (AR1). As we have just 21 observations, the iterative Prais and Winsten algorithm was used. That is, the first observation was not discarded and the full generalized least squared transformation was used (LimDep 7, Prais, and Winsten, 1954).

Table 3 Parameters estimations corrected for autocorrelation with AR(1) Models

Dependent	Constant	Explanatory	ρ	Durbin-Watson
		Schaefer Models		
Y/NV	4.53E+01	-1.22E-03	7.88E-01	2.000
	0.000	*0.000*	*0.000*	
Y/(GRT/NV)	5.88E+04	-2.07E+03	0.748	2.000
	0.000	*1.34E-02*	*0.000*	
Y/NVGRT	1.56E-04	-1.41E-14	0.751	1.980
	0.000	*0.000*	*0.000*	
		Fox Models		
N[Y/NV]	4.11E+00	-5.36E-05	7.56E-01	2.04E+00
	0.000	*0.000*	*0.000*	
LN[Y/(GRT/NV)]	1.13E+01	-7.22E-02	0.737502	2.05298
	0.000	*8.30E-03*	*0.000*	
LN[Y/NVGRT]	-8.49E+00	1.78E+00	0.735736	2.03925
	0.000	*0.000*	*0.000*	

The numbers in *italics* are the *p-values*.

Table 3 shows the constants and coefficients corrected for autocorrelation following the previously described procedure. The estimated value of ρ was high (i.e. close to 1) and highly significant for all the models. In the case in which the explanatory variable is NV or NVGRT, the estimated coefficients have increased (in absolute terms) when compared to the results of the estimation which did not correct for autocorrelation. As a result, the models so obtained are viable and plausible.

Considering these results, it was decided to compute the sustainable annual catch, the MSY and the biophysical value of fish depletion by using the estimations obtained with these six models. With this method we yield a range of values that can be compared to describe the magnitudes of the overfishing instead of having just one measure of the depletion.

3.3. Maximum Sustainable Yield, Sustainable Catch and a estimation of biophysical fish depletion

The parameters estimated in the previous econometric analysis were plugged into the Sustainable Yield curves (see section 1.3) written below.

$$SY_t = \alpha E_t + \beta E_t^2 \qquad \text{(Schaefer)} \qquad (19.)$$

$$SY_t = E_t \exp(\alpha + \beta E_t) \qquad \text{(Fox)} \qquad (20.)$$

The procedure pursued allows us to compute six different values of MSY, SY and the consequent depletion. The equations of the six Sustainable Yield-effort curves are reported for convenience in the following table (Table 4).

Table 4 Sustainable Yield-Effort equations

Schaefer Models	Fox Models
$SY_t = 45.337 NV_t - 1.22\text{E-}03 NV_t^2$	$SY_t = NV_t \left[\exp(4.111 - 5.36\text{E-}05 NV_t)\right]$
$SY_t = 58848[GRT/NV]_t - 2066.643[GRT/NV]_t^2$	$SY_t = \left[GRT/NV\right]_t \left\{\exp(11.3 - 7.\text{E-}02\left[GRT/NV\right]_t\right\}$
$SY_t = 1.56\text{E-}04[(NV)(GRT)]_t - 1.41\text{E-}14[(NV)(GRT)]_t^2$	$SY_t = [(NV)(GRT)]_t \left\{\exp(-8.5 - 2\text{E-}10[(NV)(GRT)]_t\right\}$
Note: *SYt* is the sustainable catch	

Table 5 shows the estimated MSY and the correspondent effort level. According to our results, the estimated MSY for Italy lies between 416,300 and 429,800 tons of fish caught. Moreover, the effort that supports the MSY is around 18,600 in terms of NV or 14 tons per vessels.

Table 5 Estimation of the Maximum Sustainable Yield and relative Effort

	Schaefer Models		Fox Models	
Effort Variable	**E_MSY**	**Y_MSY [tons]**	**E_MSY**	**Y_MSY[tons]**
NV	18,596.05	421,547.67	18,648.61	418,391.32
[GRT/NV]	14.24	418,932.93	13.85	416,300.70
[NVGRT]	5.52E+09	429,801.40	5.62E+09	423,185.60

Briefly comparing these outcomes with fish capture over time, it is evident that the MSY was achieved and exceeded during the 80's.

The following Figures show the annual SY and the correspondent depletion (computed as catch less sustainable yield, see 1.2).

These results summarized Table 6 confirmed the above analysis. For both Schaefer and Fox models and for all the types of effort chosen, the depletion of the resource (overfishing) started at the beginning of the 80's. It increased during the first year of the 80's and reached the maximum around 1984. From 1984 it started to decrease gradually until it vanished around 1989. The annual average depletion lies between 29,000 tons and 34,000 tons. This magnitude represents 7-8% of the average annual catch. Considering just the years in which depletion occurred more intensely (1983-1985), the percentage increases at 13-14%. In one case it achieved 18% (running the Schaefer model with E = NVGRT). These quantities showed the considerable size of depletion that took place in Italy during the 80’s.

Table 6 Ratio between depletion and actual catch over time (%)

Year	Schaefer			Fox		
	E = NV	**E = GRT/NV**	**E = NVGRT**	**E = NV**	**E = GRT/NV**	**E = NVGRT**
1975	-4.03%	-3.55%	-7.69%	-4.14%	-3.84%	-6.01%
1976	0.42%	0.19%	-3.46%	0.03%	0.02%	-1.99%
1977	-13.35%	-13.90%	-17.98%	-14.02%	-14.15%	-16.43%
1978	-5.69%	-7.00%	-10.05%	-6.73%	-7.18%	-9.05%
1979	1.96%	-1.14%	-0.06%	0.26%	-0.91%	-1.21%
1980	6.58%	2.98%	5.87%	4.66%	3.30%	3.67%
1981	6.30%	2.80%	6.19%	4.54%	3.24%	3.76%
1982	11.39%	6.85%	14.13%	9.03%	7.34%	9.20%
1983	13.33%	7.82%	18.43%	10.38%	8.33%	11.27%
1984	12.99%	13.62%	12.01%	13.59%	14.01%	13.16%
1985	12.86%	13.33%	11.14%	13.36%	13.70%	12.48%
1986	8.16%	8.66%	6.23%	8.65%	8.99%	7.66%
1987	5.44%	5.70%	3.19%	5.92%	6.21%	4.71%
1988	4.40%	4.69%	2.19%	4.91%	5.22%	3.72%
1989	-1.35%	-0.73%	-1.85%	-0.60%	-0.05%	-0.72%
1990	-12.80%	-11.89%	-14.29%	-11.95%	-11.12%	-12.69%
1991	-3.09%	-1.94%	-3.55%	-2.46%	-1.45%	-2.54%
1992	-6.00%	-5.12%	-6.08%	-5.34%	-4.49%	-5.18%
1993	-3.31%	-4.22%	1.93%	-3.69%	-3.84%	0.19%
1994	-3.17%	-4.02%	1.83%	-3.41%	-3.53%	0.27%
1995	-4.04%	-4.44%	-0.01%	-4.14%	-4.00%	-1.16%

In general, the results showed comparable trends between the Schaefer and Fox in the case in which NV and GRT/ NV were used. They also provided evidence of presence of overfishing around 1976. While in the case of NVGRT no overexploitation occurred before the 80’s, but it took place at the end of the period considered (1973-1974).

It was found that the total amount of positive depletion (summed over all the years) was greater than the total amount of negative depletion (what we define as *material accumulation of capital expressed in biophysical units*) no matter which model was considered. In other words, along the period considered, *net* fish depletion occurred.

On the contrary, we can analyze only the years in which *pure* or positive overfishing accrued. Negative depletion does not equate to *material accumulation of capital*[11]. We already mentioned this resource accounting procedure in the methodological section. Many practical attempts to adjust NNP for the depreciation of exhaustible resources do not take into account new discoveries as positive changes (Perman, 2003). In the same way, the Philippines' Government study on marine fishery accounting, corrects Fishery Net Value Added only when *pure* or positive depreciation occurs (Ilarina, 2000). Most authors do not spend much effort in justifying this choice. We think that new discoveries (in the case of nonrenewable resource) and negative depletion (in the case of renewable resource) could be included as positive changes (and then in adjusted national accounts) only if they are a product of some planned *investment effort*.

Table 7 Descriptive statistics for *pure* depletion (tons)

	Schaefer Model		Fox Model	
Effort measure	**Total Net Depletion**	**Total Pure Depletion (>0)**	**Total Net Depletion**	**Total Pure Depletion (>0)**
NV	164,337	382,597	129,478	346,062
GRT/NV	85,126	307,699	115,503	324,468
NVGRT	128,821	378,059	104,642	322,486

Note: Total Net Depletion in the first column regards the summation over all years taking into account all the values. Total depletion (>0) in the second column regards positive values only. Both measures are expressed in tons.

The Table 7 reports the total amount of *net* and *pure* depletion. The difference between these two figures is remarkable. The *pure* depletion is always more than two times greater than the *net* depletion. As is shown in the table, the more optimistic scenario[12] indicated 85,126 tons (in the case of the netted measure) and 307,699 tons (in the other case). While the precautionary scenario suggested 164,337 tons against 382,597 tons. Both scenarios were obtained using Schaefer (E = GRT/ NV and E = NV). It was confirmed that the Schaefer model outputs were more variable than the ones in the Fox model.

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[11] Statistically, it means diminishing the number of observation, keeping the cases in which the depletion values are greater than zero.

[12] We called optimistic scenario the scenario that gave us the lowest level of *net* and *pure* depletion. On the contrary, the pessimistic or precautionary scenario is given by the highest level of *net* and *pure* depletion.

3.4. Fishery resource rent and the depreciation of fishery across time (1975-1995)

With the addition of two different rates of return on capital (*r*) we obtained a 24-column matrix (2 biological models x 3 different fishing effort measures x 2 different opportunity cost of capital x 2 different approaches in terms of *net*[13] and *pure* depreciation). For convenience the models were numbered and named in the next tables and figures by the respective number as follows:

- 1. Schaefer Model with E given by NV and $r = 4\%$;
- 2. Schaefer Model with E = GRT/ NV and $r = 4\%$;
- 3. Schaefer Model with E = NVGRT and $r = 4\%$;
- 4. Fox Model with E given by NV and $r = 4\%$;
- 5. Fox Model with E given by GRT/ NV and $r = 4\%$;
- 6. Fox Model with E = NVGRT and $r = 4\%$;
- 7. Schaefer Model with E = NV and $r = 8\%$;
- 8. Schaefer Model with E = GRT/ NV and $r = 8\%$;
- 9. Schaefer Model with E = NVGRT and $r = 8\%$;
- 10. Fox Model with E = NV and $r = 8\%$;
- 11. Fox Model with E = GRT/ NV and $r = 8\%$;
- 12. Fox Model with E = NVGRT and $r = 8\%$.

The following two tables (Table 8 and Table 9) present the results for the resource rent and the corresponding *net* depreciation obtained applying different opportunity cost of capital (4% and 8%) on twelve models.

As expected, the rent calculated assuming 4% as rate of return on fixed capital was lower than when 8% was applied in absolute terms. However, a decreasing trend in the first period (-56% from 1975 to 1982) and a subsequently increase of the same amount in percentage (+54% from 1983-1995) is evident.

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[13] Here the terms *net* and *pure* will be used with the same meaning that they had in the case of depletion. *Net* depreciation will take into account positive as well as negative values. *Pure* depreciation will account just for positive values.

Table 8 Resource rent and net depreciation of fish when *r*= 4% (in constant 1995 Euro)

		Net Depreciation (*r* = 4%)					
	Resource rent	Schaefer Models			Fox Models		
		E = NV	E = GRT/NV	E = NVGRT	E = NV	E = GRT/NV	E = NVGRT
		1	2	3	4	5	6
1975	992.71	- 15,951,877	- 14,069,470	- 30,463,643	- 16,394,162	- 15,227,164	- 23,794,023
1976	927.87	1,611,876	745,225	- 13,314,433	96,995	65,982	- 7,668,749
1977	717.31	- 34,774,545	- 36,206,251	- 46,851,575	- 36,523,560	- 36,864,074	- 42,818,032
1978	608.19	- 13,397,327	- 16,479,563	- 23,649,783	- 15,831,033	- 16,896,317	- 21,295,475
1979	456.82	3,697,803	- 2,138,016	- 111,880	497,991	- 1,708,214	- 2,284,567
1980	479.03	13,556,332	6,145,230	12,097,370	9,606,755	6,804,848	7,554,126
1981	435.19	11,796,629	5,249,997	11,591,484	8,492,640	6,058,844	7,042,256
1982	431.96	22,099,965	13,287,856	27,417,906	17,522,356	14,243,944	17,863,375
1983	573.55	34,709,323	20,367,364	47,996,415	27,031,058	21,684,320	29,364,421
1984	690.29	43,394,194	45,515,966	40,124,622	45,414,652	46,801,530	43,959,932
1985	670.47	41,581,210	43,092,422	36,009,264	43,213,686	44,308,293	40,366,313
1986	663.08	24,740,060	26,258,877	18,876,100	26,220,805	27,263,537	23,219,940
1987	636.21	15,371,459	16,103,378	9,007,226	16,709,706	17,528,707	13,303,229
1988	620.03	11,983,178	12,777,854	5,952,493	13,362,914	14,219,493	10,139,200
1989	644.49	- 3,629,093	- 1,962,762	- 4,949,501	- 1,597,587	- 145,102	- 1,927,651
1990	678.52	- 32,448,585	- 30,145,542	- 36,244,143	- 30,305,816	- 28,189,913	- 32,173,169
1991	724.92	- 9,136,640	- 5,739,511	- 10,499,416	- 7,279,779	- 4,288,971	- 7,507,871
1992	662.82	- 15,758,685	- 13,444,973	- 15,984,674	- 14,041,827	- 11,805,918	- 13,613,594
1993	675.08	- 8,878,361	- 11,323,145	5,168,324	- 9,898,424	- 10,298,784	506,449
1994	677.62	- 8,582,130	- 10,870,358	4,944,836	- 9,240,358	- 9,544,313	719,750
1995	882.31	- 14,147,992	- 15,580,128	- 52,155	- 14,516,423	- 14,005,456	- 4,058,059

Following the same analysis as we did for the depletion, before we presented the *Total Net Depreciation* obtained by summing negative and positive values of depreciation over time. As we already shown (section 1.2), it represented the absolute value of depletion occurred in the period considered taking into account the negative values as accumulation of capital. The difference between the models is relevant:

- the optimistic scenario indicates about 31,6 million in constant 1995 Euro (given by Schaefer model with E = GRT/NV, no. 2 in the table);
- the pessimistic or precautionary scenario suggests about 67,8 million in constant 1995 Euro (given by Schaefer Model with E = NV, no. 1).

Table 9 Resource rent and net depreciation of fish when *r* =8% (in constant 1995 Euro)

		Net Depreciation (*r* = 8%)					
	Resource rent	Schaefer Models			Fox Models		
		E = NV	E = GRT/NV	E = NVGRT	E = NV	E = GRT/NV	E = NVGRT
		7	8	9	10	11	12
1975	709.77	- 11,405,380	- 10,059,484	- 21,781,099	- 11,721,607	- 10,887,219	- 17,012,409
1976	649.80	1,128,820	521,892	- 9,324,291	67,927	46,208	- 5,370,537
1977	393.44	- 19,073,659	- 19,858,942	- 25,697,848	- 20,032,984	- 20,219,755	- 23,485,470
1978	298.67	- 6,579,229	- 8,092,869	- 11,614,058	- 7,774,385	- 8,297,531	- 10,457,892
1979	161.28	1,305,503	- 754,823	- 39,499	175,815	- 603,082	- 806,562
1980	193.45	5,474,534	2,481,665	4,885,352	3,879,553	2,748,042	3,050,627
1981	142.09	3,851,567	1,714,110	3,784,588	2,772,823	1,978,196	2,299,277
1982	146.46	7,493,220	4,505,384	9,296,323	5,941,135	4,829,556	6,056,761
1983	289.27	17,505,691	10,272,305	24,207,052	13,633,148	10,936,514	14,809,983
1984	422.98	26,590,491	27,890,641	24,587,008	27,828,559	28,678,391	26,937,156
1985	402.21	24,944,283	25,850,849	21,601,711	25,923,594	26,580,241	24,215,475
1986	378.48	14,121,556	14,988,492	10,774,424	14,966,761	15,561,949	13,253,875
1987	341.35	8,247,491	8,640,199	4,832,789	8,965,521	9,404,953	7,137,791
1988	316.95	6,125,642	6,531,870	3,042,836	6,830,945	7,268,817	5,183,025
1989	320.22	- 1,803,163	- 975,224	- 2,459,224	- 793,782	- 72,096	- 957,779
1990	314.57	- 15,043,461	- 13,975,749	- 16,803,116	- 14,050,053	- 13,069,101	- 14,915,775
1991	389.98	- 4,915,242	- 3,087,687	- 5,648,374	- 3,916,305	- 2,307,339	- 4,039,012
1992	317.83	- 7,556,383	- 6,446,944	- 7,664,746	- 6,733,139	- 5,661,008	- 6,527,799
1993	333.77	- 4,389,632	- 5,598,380	2,555,319	- 4,893,971	- 5,091,917	250,398
1994	340.53	- 4,312,938	- 5,462,884	2,485,021	- 4,643,730	- 4,796,482	361,709
1995	548.54	- 8,795,959	- 9,686,334	- 32,425	- 9,025,017	- 8,707,344	- 2,522,939

Altogether, these findings showed a significant difference between the models when depletion is translated in monetary value. The range between what we called optimistic and precautionary measures becomes big. However, it is evident that the different modelling illustrates the same general trend. The depreciation occurred during the 80's and achieved its maximum in 1984-1985. During these years the average depreciation was within the range 36-46 million Euro (at 1995 constant prices) representing 3% of the total fishery industry production in the same period.

Table 10 Descriptive statistics on *net* depreciation (in constant 1995 Euro)

Model	Total Net Depreciation when r=4%	Total Net Depreciation when r=8%
1	67,836,795	32,913,753
2	31,584,449	19,398,085
3	37,064,839	10,987,741
4	52,540,591	27,400,807
5	50,005,272	28,319,994
6	36,897,803	17,459,903

Figure 1 ***Net*** **depreciation over time when *r* = 4% (in constant 1995 Euro, millions)**

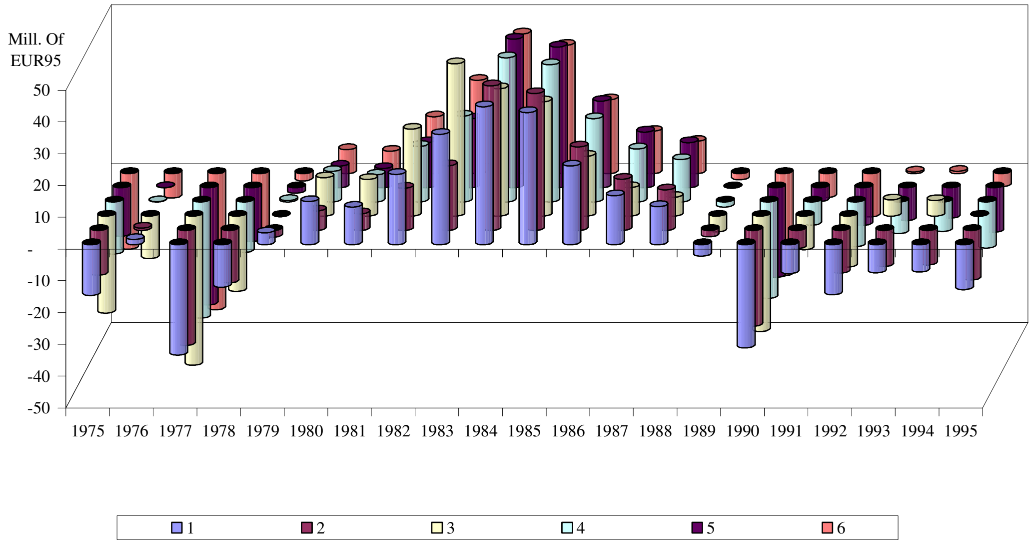
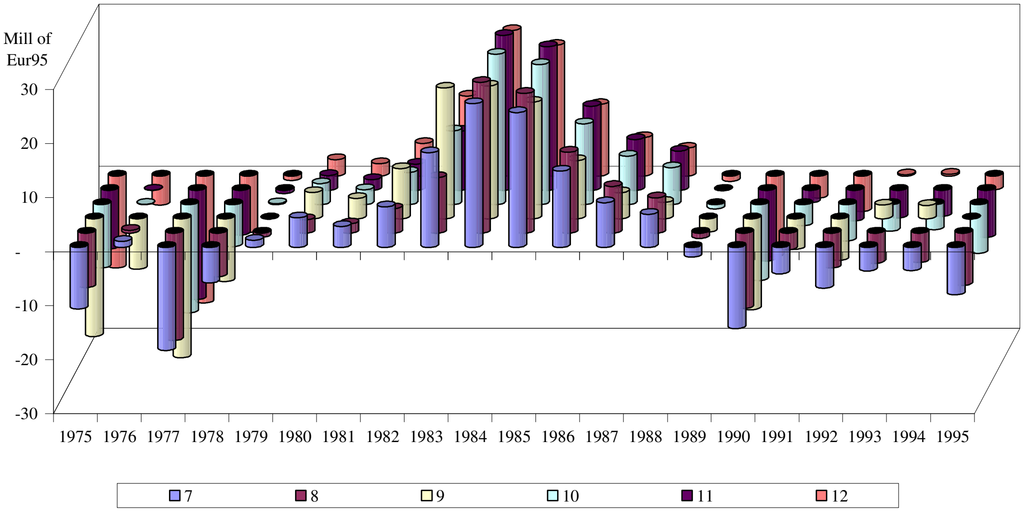


Figure 2 ***Net*** **Depreciation when *r* = 8% (in constant 1995 Euro, millions)**



The absolute values of depreciation are lower when the rate equal to 8% is applied as opportunity cost. The general discussion about the trend remains unchanged. The highest amount of depreciation (and the highest mean) are still given by the Schaefer model when E = NV (no. 7) which coincides with previous results. However, this time the sum is about 32,9 millions of Euro and the mean is about 1,6 millions of Euro (at constant price, 1995).

Instead, the lowest value in terms of absolute amount of depreciation over time was obtained by running Schaefer with E = NVGRT (no.9) and it was found to be around 11 millions of Euro.

We also report for convenience the amount of the so-called *pure* depreciation. This means that we do not consider the possibility of negative depreciation as accumulation of capital (investment).

Obviously, this approach does not change the maximum annual values of depletion and its relatively bigger incidence in 1984-1985. What is interesting here is to show the total and average amount of *pure* depreciation that will affect the next calculation on the adjusted macroeconomic measures. Another interesting feature is the greater stability (lower *between variability*) of the ranges:

- Total *pure* depreciation computed applying $r = 4\%$ ranged between 173 millions of Euro and 203 millions; the mean was between 15,7 millions of Euro (at constant 1995 prices) and 18,5. In other words, the range was given by running Schaefer no. 2 and Schaefer no. 1.
- Total *pure* depreciation calculated with 8% as rate on return of capital lied between 86,3 and 95,5 millions in constant 1995 Euro; the mean was between 7,8 and 9 millions Euro (at constant 1995 prices).

Table 11 Descriptive statistics on *pure* depreciation (in constant 1995 Euro)

Model	Total *Pure* Depreciation when r=4%	Total *Pure* Depreciation when r=8%
1	203,258,787	95,505,555
2	173,097,020	86,950,257
3	199,004,782	91,871,162
4	189,456,862	92,273,085
5	181,670,429	90,723,798
6	176,785,406	86,302,492

3.5. The Italian accounts adjusted for the depreciation of fishery

Natural resource accounting is used to adjust for the conventional macroeconomic indicators of a whole economic system. In their seminal work on

Indonesia, Repetto *et al.* (1989) showed clearly that, taking into account deforestation, soil erosion and depreciation of oil reserves in the country's national accounts, Indonesia's rate of growth in NNP during the 1980s would be half the estimated growth rate of its GNP.

This work has only considered fishery in a developed country (Italy) in which the agricultural sector is usually relatively small with respect to the rest of economic activities[14]. Thus, it is not reasonable to make the same attempt to adjust the entire country's national accounts. Furthermore, Italian Fishery industry accounts for just about an average of 0.14% of Italian NNP (1995). What could be interesting to show is the trend in the depreciation within fishery industry, correcting its *net* value added.

Following the same concept in Ilarina (2000) and NSCB (1998), the Adjusted Net Value Added (ANVA) for fishing industry, can be obtained by subtracting the depreciation of fixed and natural assets from the conventional (*gross*) value added (GVA, see section 1.1). In order to derive this *net* measure, data on fishery *gross* value added[15] across time was obtained by ISTAT (www.istat.it) and corrected for the consumption of fixed asset.

The results are presented in the following tables. As we have three specifications for effort (NV, GRT/NV and NVGRT), two different models (Schaefer and Fox), two opportunity costs (4 and 8%) and two different concepts of depreciation (*net* and *pure*), the tables present a total of 24 different measures of ANVA across time. At the bottom of each table the average annual growth rate (net value added, NVA, included) and the percentage change occurred in the whole period considered (1975-1995) for each measures are presented. This percentage change can help to understand the effect of depreciation on fishing activities.

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[14] The relatively small value in terms of agriculture (and fishery) in terms of percentage of national value added does not means that this sector plays an important role in the economy.

[15] It was logical to select the so-called value added at factor cost at current prices (base = 1995). According to Eurostat (Coded), "value added at factor cost is the gross income from operating activities after adjusting for operating subsidies and indirect taxes. (…)Value added at factor costs is calculated *gross* as value adjustments (such as depreciation) are not subtracted".

Table 12 Fishery Net Value Added Adjusted for *net* depreciation (*r* = 4%)

	Fishery Sector Net Value Added	Adjusted Net Value Added (r = 4%)					
		Schaefer Models			Fox Models		
		E = NV 1	E=GRT/NV 2	E =NVGRT 3	E = NV 4	E=GRT/NV 5	E =NVGRT 6
1975	706.52	722.48	720.59	736.99	722.92	721.75	730.32
1976	729.61	728.00	728.86	742.92	729.51	729.54	737.28
1977	648.15	682.93	684.36	695.00	684.68	685.02	690.97
1978	470.36	483.76	486.84	494.01	486.19	487.26	491.66
1979	440.90	437.20	443.03	441.01	440.40	442.60	443.18
1980	463.43	449.88	457.29	451.33	453.83	456.63	455.88
1981	466.40	454.61	461.15	454.81	457.91	460.34	459.36
1982	493.75	471.65	480.46	466.33	476.23	479.50	475.88
1983	579.70	544.99	559.33	531.70	552.67	558.01	550.33
1984	669.26	625.86	623.74	629.13	623.84	622.45	625.30
1985	662.21	620.63	619.12	626.20	619.00	617.90	621.85
1986	638.64	613.90	612.38	619.76	612.42	611.38	615.42
1987	618.06	602.69	601.96	609.06	601.35	600.54	604.76
1988	611.64	599.66	598.86	605.69	598.28	597.42	601.50
1989	617.58	621.21	619.54	622.53	619.18	617.72	619.51
1990	611.02	643.47	641.17	647.26	641.33	639.21	643.19
1991	661.22	670.36	666.96	671.72	668.50	665.51	668.73
1992	629.30	645.06	642.75	645.29	643.34	641.11	642.92
1993	645.42	654.29	656.74	640.25	655.31	655.71	644.91
1994	645.47	654.05	656.34	640.52	654.71	655.01	644.75
1995	740.86	755.01	756.44	740.91	755.37	754.86	744.92
% Average annual growth	**0.73%**	**0.70%**	**0.70%**	**0.52%**	**0.69%**	**0.68%**	**0.57%**
% Growth	**4.9%**	**4.5%**	**5.0%**	**0.5%**	**4.5%**	**4.6%**	**2.0%**

The annual growth rate of NVA is 0.73% while in the entire period considered it has increased by 4.9%. The effect on the fishery economic growth varies substantially among different models. Usually when the specification of the fishing effort is given by the composite variable (NVGRT) the effects are much more considerable. For example, looking at Table 12 and Table 13, the annual rate of growth in ANVA is 0.52% and 0.57% respectively; while the total change occurred in the whole period is 0.5% and 1.7% respectively. Some corrected measures do not appear to have great consequences in terms of (diminishing) rate of growth. This is the case of Schaefer Model when E = NV and E = GRT/ NV (first and second column in both tables). The effects are much more evident when we consider the *net* depreciation instead of the *pure* depreciation (see Table 14 and Table 23).

Table 13 Fishery Net Value Added Adjusted for *net* depreciation (*r* = 8%)

	Fishery Sector Net Value Added	Adjusted Net Value Added (r = 4%)					
		Schaefer Models			Fox Models		
		E = NV 1	E=GRT/NV 2	E =NVGRT 3	E = NV 4	E=GRT/NV 5	E =NVGRT 6
1975	706.52	717.93	716.58	728.31	718.25	717.41	723.54
1976	729.61	728.48	729.09	738.93	729.54	729.56	734.98
1977	648.15	667.23	668.01	673.85	668.19	668.37	671.64
1978	470.36	476.94	478.45	481.97	478.14	478.66	480.82
1979	440.90	439.59	441.65	440.93	440.72	441.50	441.70
1980	463.43	457.96	460.95	458.55	459.55	460.68	460.38
1981	466.40	462.55	464.69	462.62	463.63	464.42	464.10
1982	493.75	486.26	489.24	484.45	487.81	488.92	487.69
1983	579.70	562.19	569.42	555.49	566.06	568.76	564.89
1984	669.26	642.67	641.37	644.67	641.43	640.58	642.32
1985	662.21	637.27	636.36	640.61	636.29	635.63	638.00
1986	638.64	624.52	623.65	627.87	623.67	623.08	625.39
1987	618.06	609.82	609.42	613.23	609.10	608.66	610.93
1988	611.64	605.51	605.11	608.60	604.81	604.37	606.46
1989	617.58	619.38	618.55	620.04	618.37	617.65	618.54
1990	611.02	626.06	625.00	627.82	625.07	624.09	625.94
1991	661.22	666.14	664.31	666.87	665.14	663.53	665.26
1992	629.30	636.86	635.75	636.97	636.04	634.96	635.83
1993	645.42	649.81	651.01	642.86	650.31	650.51	645.17
1994	645.47	649.78	650.93	642.98	650.11	650.26	645.11
1995	740.86	749.65	750.54	740.89	749.88	749.56	743.38
% Average annual growth	**0.73%**	**0.69%**	**0.70%**	**0.57%**	**0.69%**	**0.69%**	**0.61%**
% Growth	**4.9%**	**4.4%**	**4.7%**	**1.7%**	**4.4%**	**4.5%**	**2.7%**

From these tables, one can conclude that the effect of overexploitation is not really so important in economic terms, as what it was expected. However, this argument is valid solely because we consider only one resource stock and, much more important here, the whole period 1975-1995. Indeed, depletion ceased at the end of the 1980's. Thus, for the latter year considered, the ANVA and NVA are obviously equal[16].

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[16] ANVA and NVA are equal in the case of pure depreciation. On the contrary, ANVA > NVA when net depreciation is accounted. This is because with this approach it is assumed that fishing under the regeneration level means accumulation of capital (investment) that are added to the conventional NVA.

Table 14 Fishery Net Value Added Adjusted for *pure* depreciation (*r*= 4%)

	Fishery Sector Net Value Added	**Adjusted Net Value Added (r = 4%)**					
		Schaefer Models			**Fox Models**		
		E = NV 1	**E=GRT/NV 2**	**E =NVGRT 3**	**E = NV 4**	**E=GRT/NV 5**	**E =NVGRT 6**
1975	706.52	706.52	706.52	706.52	706.52	706.52	706.52
1976	729.61	728.00	728.86	729.61	729.51	729.54	729.61
1977	648.15	648.15	648.15	648.15	648.15	648.15	648.15
1978	470.36	470.36	470.36	470.36	470.36	470.36	470.36
1979	440.90	437.20	440.90	440.90	440.40	440.90	440.90
1980	463.43	449.88	457.29	451.33	453.83	456.63	455.88
1981	466.40	454.61	461.15	454.81	457.91	460.34	459.36
1982	493.75	471.65	480.46	466.33	476.23	479.50	475.88
1983	579.70	544.99	559.33	531.70	552.67	558.01	550.33
1984	669.26	625.86	623.74	629.13	623.84	622.45	625.30
1985	662.21	620.63	619.12	626.20	619.00	617.90	621.85
1986	638.64	613.90	612.38	619.76	612.42	611.38	615.42
1987	618.06	602.69	601.96	609.06	601.35	600.54	604.76
1988	611.64	599.66	598.86	605.69	598.28	597.42	601.50
1989	617.58	617.58	617.58	617.58	617.58	617.58	617.58
1990	611.02	611.02	611.02	611.02	611.02	611.02	611.02
1991	661.22	661.22	661.22	661.22	661.22	661.22	661.22
1992	629.30	629.30	629.30	629.30	629.30	629.30	629.30
1993	645.42	645.42	645.42	640.25	645.42	645.42	644.91
1994	645.47	645.47	645.47	640.52	645.47	645.47	644.75
1995	740.86	740.86	740.86	740.86	740.86	740.86	740.86
% Average annual growth	0.73%	0.70%	0.69%	0.72%	0.70%	0.69%	0.70%
% Growth	**4.9%**	**4.9%**	**4.9%**	**4.9%**	**4.9%**	**4.9%**	**4.9%**

This situation is well depicted in the following Figures. The trend of the NVA is illustrated by the *bold* blue line and all the set of adjusted measures (ANVAs) are reported and named by the respective number. These figures illustrate that the situation was much more different during the years in which depletion occurred. During the 1980's the gap between conventional NVA and ANVA was evident, and the ANVA was less than NVA no matter which specification was chosen.

Table 15 Net Value Added Adjusted for *pure* depreciation (*r* = 8%)

		Pure ANVA (r = 8%)					
		Schaefer Models			**Fox Models**		
	Fishery Sector Net Value Added	**E = NV** **7**	**E=GRT/NV** **8**	**E =NVGRT** **9**	**E = NV** **10**	**E=GRT/NV** **11**	**E=NVGRT** **12**
1975	706.52	706.52	706.52	706.52	706.52	706.52	706.52
1976	729.61	728.48	729.09	729.61	729.54	729.56	729.61
1977	648.15	648.15	648.15	648.15	648.15	648.15	648.15
1978	470.36	470.36	470.36	470.36	470.36	470.36	470.36
1979	440.90	439.59	440.90	440.90	440.72	440.90	440.90
1980	463.43	457.96	460.95	458.55	459.55	460.68	460.38
1981	466.40	462.55	464.69	462.62	463.63	464.42	464.10
1982	493.75	486.26	489.24	484.45	487.81	488.92	487.69
1983	579.70	562.19	569.42	555.49	566.06	568.76	564.89
1984	669.26	642.67	641.37	644.67	641.43	640.58	642.32
1985	662.21	637.27	636.36	640.61	636.29	635.63	638.00
1986	638.64	624.52	623.65	627.87	623.67	623.08	625.39
1987	618.06	609.82	609.42	613.23	609.10	608.66	610.93
1988	611.64	605.51	605.11	608.60	604.81	604.37	606.46
1989	617.58	617.58	617.58	617.58	617.58	617.58	617.58
1990	611.02	611.02	611.02	611.02	611.02	611.02	611.02
1991	661.22	661.22	661.22	661.22	661.22	661.22	661.22
1992	629.30	629.30	629.30	629.30	629.30	629.30	629.30
1993	645.42	645.42	645.42	642.86	645.42	645.42	645.17
1994	645.47	645.47	645.47	642.98	645.47	645.47	645.11
1995	740.86	740.86	740.86	740.86	740.86	740.86	740.86
% Average annual growth	**0.73%**	**0.71%**	**0.70%**	**0.71%**	**0.70%**	**0.70%**	**0.70%**
% Growth	**4.9%**	**4.9%**	**4.9%**	**4.9%**	**4.9%**	**4.9%**	**4.9%**

Figure 3 Net Value Added vs. measures adjusted for *net* depreciation (Million Euro, in constant 1995 price; r = 4%)

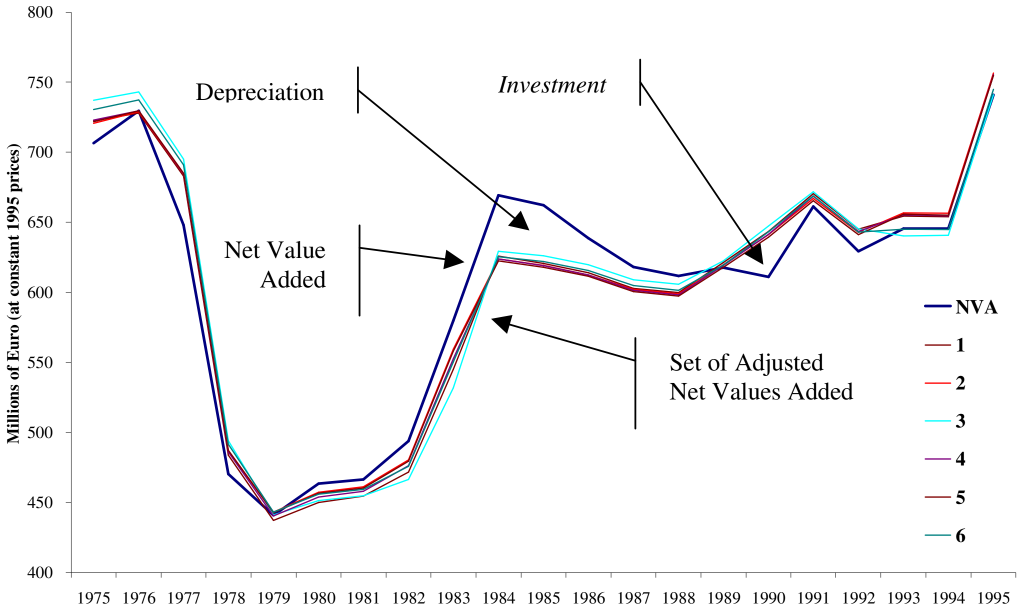


Figure 4 Fishery Net Value Added vs. measures adjusted for *net* depreciation (Million Euro, in constant 1995 price; r= 8 %)

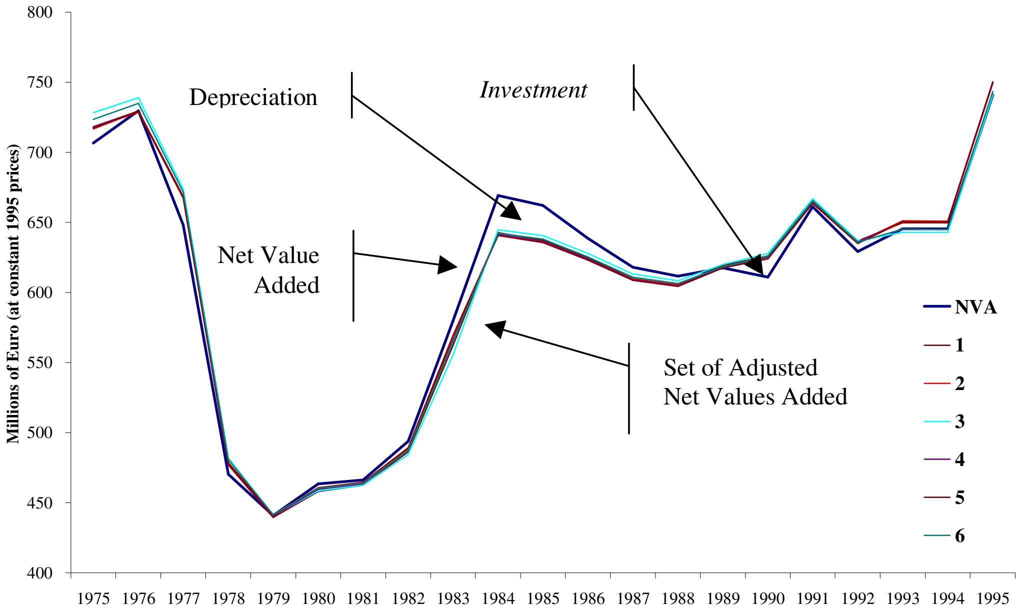


Figure 5 Net Value Added vs. measures adjusted for *pure* depreciation (Million Euro, in constant 1995 price; r = 4%)

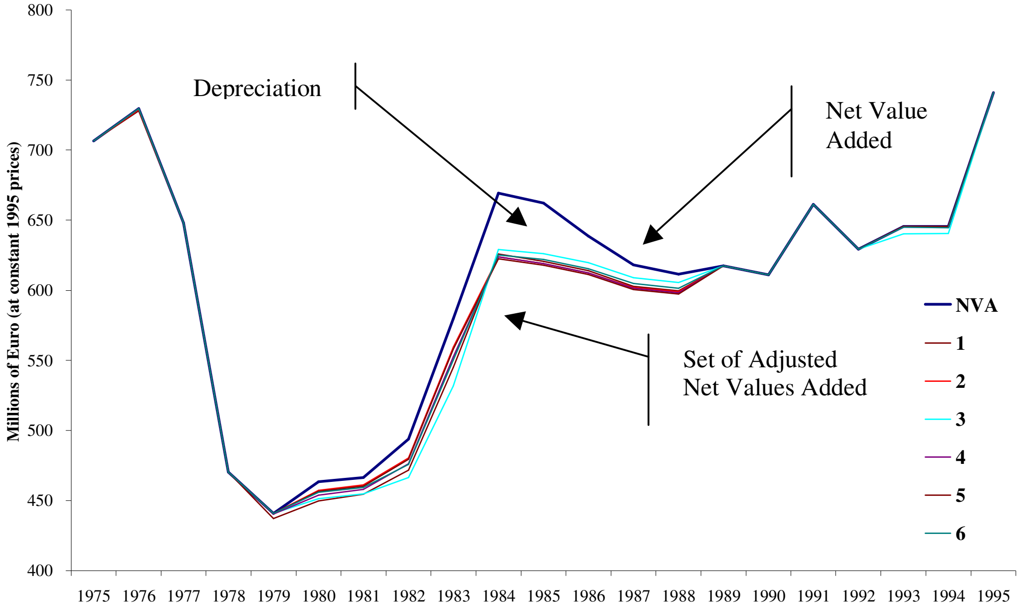
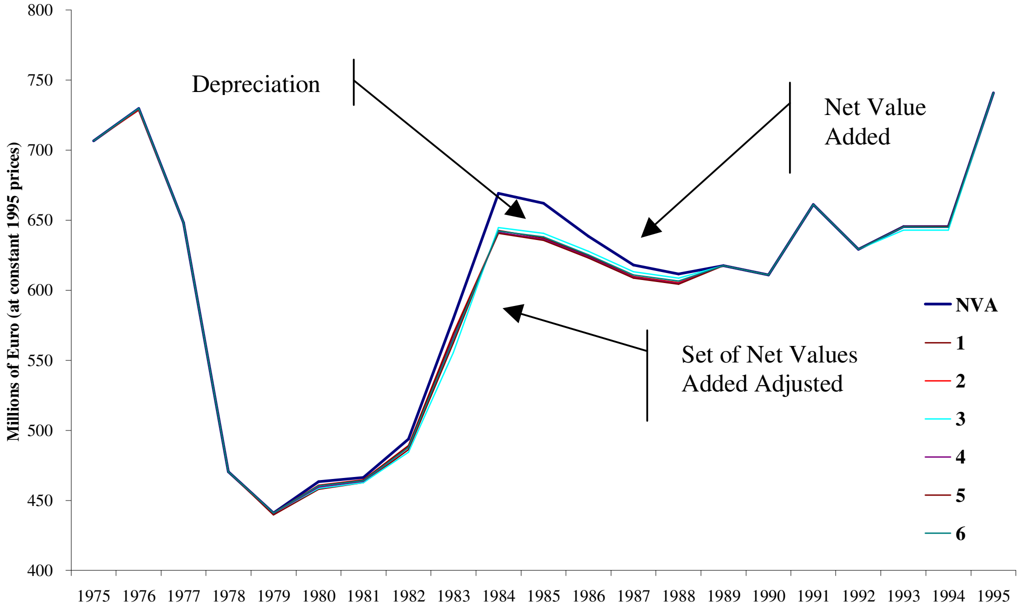


Figure 6 Net Value Added vs. measures adjusted for *pure* depreciation (Million Euro, in constant 1995 price; r = 8%)



In one word, the fishery was *dissaving* (Perrings and Vincent, 2003) to maintain the high level of growth, converting its fundamental (environmental) asset. For analogy, this condition corresponds to what Repetto *et al.* found for Indonesia (1989). Particularly interesting is the situation shown in Table 16. This compares the annual average growth rate and the total percentage change in the period of 1977 to 1985, in which increasing economic performance and overfishing were simultaneously present. Conventionally measured net value added overstated fishery net income and its growth after accounting for consumption of natural capital. In fact, while the conventional fishery NVA increased at an average annual rate of 1.22%, the different measures of ANVA rose by 0.25% - 0.75%. Furthermore, when ANVA is measured by using an opportunity cost of 4%, the fishery net income decreases in every case ([-0.19%-(-0.35)%]). Moreover, while the NVA growth rate estimated that the economy grew by 2.2% between 1977 and 1985, the ANVA estimates suggested that in reality the fishing economy experienced a decrease. The extent of this decline in economic performance obviously varies in dependence of the opportunity cost chosen and the definition of the depreciation adopted. As it is well-depicted by the Figures above, the gap between the conventional measures and our estimations is always present, no matter which period is chosen between 1975 and 1985.

This *dissaving* trend stops at the beginning of the 1990's. Unfortunately, this is not really always confirmed. Two models indicate a slight returning depletion around 1993-1995 (Fox model no. 9 and no.12). Furthermore, it could be the case that the magnitudes and persistence over time of overfishing has been underestimated for a series of reasons related to the intrinsic limitations of biological models and lack of longer data series.

Table 16 Comparison between NVA and ANVA growth rate (1977 – 1985)

	Fishery Sector Net Value Added	ANVA (r = 4%)					
		1	2	3	4	5	6
Annual average growth rate (1977-1985)	1.22%	-0.19%	-0.30%	-0.27%	-0.29%	-0.34%	-0.35%
Growth rate (1977-1985)	2.2%	-9.12%	-9.53%	-9.90%	-9.59%	-9.80%	-10.00%
		pure ANVA (r = 4%)					
Annual average growth rate (1977-1985)	1.22%	0.35%	0.28%	0.48%	0.29%	0.25%	0.35%
Growth rate (1977-1985)	2.2%	-4.2%	-4.5%	-3.4%	-4.5%	-4.7%	-4.1%
		ANVA (r = 8%)					
		7	**8**	**9**	**10**	**11**	**12**
Annual average growth rate (1977-1985)	1.22%	0.38%	0.33%	0.34%	0.33%	0.31%	0.30%
Growth rate (1977-1985)	2.2%	-4.5%	-4.7%	-4.9%	-4.8%	-4.9%	-5.0%
		pure ANVA (r = 8%)					
Annual average growth rate (1977-1985)	1.22%	0.68%	0.65%	0.75%	0.65%	0.63%	0.68%
Growth rate (1977-1985)	2.2%	-1.7%	-1.8%	-1.2%	-1.8%	-1.9%	-1.6%

4. Discussion and conclusion

Overexploitation of fish stock can be estimated from a wide range of detailed scientific and biological data on stock levels, regeneration and other changes. However this kind of information is usually difficult to obtain or to compute; as it was the case in this study. Moreover, marine biologists suggest that overfishing is difficult to quantify with one value only and that the outcomes so obtained can be misleading. They add that even more accurate biological models do not take into account all the variables that affect natural marine environments and the natural fluctuations of fish community (Pauly *et al.*, 2002). Excessively high pressure on fish populations by fishing activities can be deduced from several types of indicators. Altogether, they are able to express the symptoms of overfishing, although they do provide a diagnosis of the pathology. Some of the indicators of current unsustainable fishing activities are: changes in the relative share of juvenile over-time, catch per unit of effort, changes in percentage composition of species over time, decline of marine trophic levels and, why not, historical documents and anecdotes about how plenty the fishing grounds were (Pauly *et al.*, 2002, Pauly 1995, Kurlansky, 1998).

All these arguments argue against the conventional fishery management strategies based on Surplus Models, MSY or single species only, indicating that they have failed to manage fishery in an optimal way. It is argued, that the maximum sustainable yield has been exceeded in many cases without being detected by the modelling (Pauly *et al.*, 2002).

The major defect of the MSY concept is that MSY, as it is usually determined, does not always fully reflect the natural processes mentioned above, the effects of exploitation of non-target species, or inter-species interactions. Nor does it reflect changes in fishing methods or fishing efficiency resulting from technological improvements.

These criticisms are directed to the fishery managers, but also invites fishery economists to take into account the limitations of modelling in detecting overexploitation and improving the effort in collecting ancillary data (for example, on size and age composition of catches and populations).

However, given the data available for this work, it was necessary to use this type of modelling. Although not perfect it assigns overfishing a measure, visualizing and signalling it with the use of macroeconomic indicators. Other more accurate analysis will be available for Italy in the future, because of new economic and biological databases implemented at the beginning of the 90's from IREPA (IREPA, 2002).

However, even if MSY is still considered to be a target worth achieving it does not represent an efficient economic equilibrium point. Our study was about resource depletion, i.e. the extraction of fishery resources beyond the rate of natural growth, measured as a positive difference between catch and sustainable yield during the 1980's. The corresponding national accounts adjustment is within the national accounting literature rather than fishery economics. In other words, it was not the point here to focus on the so-called bio-economic modelling that explains the inefficiency of the effort levels of open access fisheries. Nevertheless, what is interesting to recall is that the effort levels supporting the MSY computed in this study were still too high. At MSY level, marginal fishing costs are not equal to marginal benefits. This suggests that the sustainable and efficient catch could be lower than our measured SY. Conventional fishery industry (supported by governmental subsidies; Myers, 1999) ignores biological and economic limits and leads to biologically excessive exploitation and economically inferior results.

Moreover, the lack of reliable historical series on fishing activities could not reflect the magnitudes of overfishing over time. By using longer time-series, different SY could be estimated. This is another feature of the so-called "shifting baselines syndrome"[17] (Pauly, 1995). All these arguments together appear to suggest that our assessments could be more easily underestimated than overestimated.

Our results suggest that overfishing occurred during the 1980's no matter which specifications of the model we adopt. In particular, the estimated average annual *pure* depletion lies between 29,000 and 34,000 tons. The magnitude of the observed overfishing, though, is low compared to other marine ecosystems of the world. For instance, some fishing grounds of the Northern Sea are estimated to be fully exploited (in which 90-100% of the stocks are beyond the safe biological limits, European Environmental Agency, 2003). One of the reasons of this *less unsustainable* performance can be traced back to the structure of the Italian fishing industry. The Italian fishery sector presents a predominance of small vessels (77% are smaller than 10 GRT, IREPA 2002). Small-scale artisanal fisheries can be relatively more sustainable than industrial fisheries.

However, the declining fish stock across time affected the fishery value added growth rate. The depreciation varies with respect to the model used and the opportunity cost chosen according to the sensitivity analysis conducted. The results show a gap between the conventional net value added and the depreciated-adjusted measure during the period in which overfishing occurred. For instance, the conventional fishery NVA grew by an annual average rate of 1.22%, while ANVA increased at a relatively small rate ([0.25% - 0.75%]) in 1977-1985.

The Net Price method was used instead of the Net Present Value, although it only holds under strong assumptions about optimality, endogenous prices and costs (Perrings

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[17] "Shifting baseline syndrome refers to the incremental lowering of standards with respect to nature. Pauly probably introduced the term in 1995 to describe the continual decrease in size of fish stocks that are believed to be *natural*. These diminished stocks are used by managers as the baseline to set limits to the total allowable catch. Thus, each new generation redefines what is *natural* in terms of personal experience while unaware of earlier declines. The next generation makes the same mistake. Step by step we lower our standards of Nature" Definition found in http://www.prairiestarfish.com/definition_shiftbase.htm .

and Vincent, 2003). In our case, the former was preferable over the latter because the absence of information about future prices, technology, costs of production, future fish stock and future exploitation would require the adoption of many other assumptions and elements of uncertainty in the models.

Our results are comparable with similar studies. Repetto (1989) for example found that while Indonesian GDP increased at an average annual rate of 7.1% from 1971 to 1984, the depreciated-adjusted indicator rose by only 4.0% per year. However, they considered three different non-renewable resources. The estimations of the loss of natural capital and environmental services of corrected NDP for Chile's mining industry showed that around 12.0% of the mining-NDP measure of the traditional national account system corresponds to environmental costs of economic growth (Figueora and Calfucura, 2003). In another similar study about forestry in China, estimations indicated that there was a loss in forest resources, especially in timber forests. The loss was also reflected in the forest-adjusted-NNP with depreciation of forest capital. The depreciation accounts for about 1% of the original GNP (Liu, 1998). Moreover, forestry was treated as non-renewable resource. No calculation of sustainable harvesting was implemented.

Fisheries accounting studies are usually based on built wealth indices by adding up the values of fishing closing stock at the end of each period considered with the values of other assets (Lange, 2003; FAO, 2003). They present how stock changes in fishery can affect the wealth of a nation. Obviously, there are many similarities between this study and those conducted in that manner. However, the main purpose is different. In that case they dealt with the asset accounts, while, our study addresses income accounts.

To our knowledge, only the Philippine Government project on Environmental and Natural Resource Accounts (National statistical coordination board NSCB, 1998) integrated fishery depreciation into the National Accounts following the methodology presented in this paper. Actually, that study used just a Fox Model and did not perform sensitivity analysis by using different opportunity costs. However, in spite of data limitations regarding fish catch and effort, the study came up with a depreciated-adjusted measure of fishery income. Some of the results are similar to ours. In the period in which overfishing occurred, Philippines' fishery adjusted net value added showed an increasing growth rate, but at a slower rate compared to the conventional net value added. The trends are the same in both our and their study: a high level of annual average growth rate measured with conventional net value added is accompanied by a decline in natural capital stock. In other words, fishery was *dissaving* and its higher growth rate was in part explained by the consumption of its capital.

References

Ahmad, Y. J. , S. El Serafy , E. Lutz (editors), 1989. Environmental Accounting for Sustainable Development, World Bank, Washington, DC.

Anderson, L.G., 2002. *Fisheries Economics*: Collected Essays, Volumes I and II. Ashgate Publishers, Aldershot, England.

Bresso, M., 1993. *Per un'economia ecologica*. Nis, Roma.

Coppola, G., M. Gambino , V. Placenti, 2002. *The Relationship Between Fleet Capacity, Landings and the Components Parts of Fishing Effort: The Italian Case Study.* XIVth Annual European Association of Fisheries Economists Conference, University of Algarve, 25–27 March 2002.

Costanza, R., 1991. Ecological Economics. Columbia University Press, NewYork.

Dasgupta, P., B. Kriström, K. G. Mäler, 1997. *The Environment and Net National Product.* In P. Dasgupta, K. G. Mäler (editors), The Environment and Emerging Development Issues. Volume 1, Clarendon Press, Oxford.

Daly, H. E., 1991, *Towards An Environmental Macroeconomics.* Land Economics 67(2), May: 255-59.

Da Motta, R.S., May, P.H., Young, C.E.F., 1991. *Environmental accounts estimates for Brazil.* Institute for Applied Economics Research, Rio de Janeiro.

Drechsler, L., 1976. *Problems of Recording Environmental Phenomena in National Accounting Aggregates.* The Review of Income and Wealth, 22: 39-252.

CEC, 2001, *Green Paper on the Future of the Common Fisheries Policy.* COM(2001)135. Commission of the European Communities, Brussels.

European Union Directorate-General Fisheries, 1998, *The Common Fisheries Policy*, Brussels.

European Environmental Agency, *Fishery Indicators*, 2003.
http://themes.eea.eu.int/Sectors_and_activities/fishery

Figueroa, E., B. E. Calfucura T., *Green Income in Mining* Paper presented at "Encuentro de la Sociedad de Economia de Chile", 25-26 September 2003 in Punta de Tralca, http://www.econmeetings.cl/pdf/sesion25.pdf

Fodella, G., 1989. *Risorse Umane e Materiali: Uso Creativo, Scarsità potenziale, Ottica di Lungo Periodo*, Guerini e Associati. Milan.

Food and Agriculture Organization of the United Nations (FAO), 1997. *TheState of World Fisheries and Aquaculture 1996,* FAO, Rome.

Food and Agriculture Organization of the United Nations (FAO), 1997. *Fisheries management*. FAO Technical Guidelines for Responsible Fisheries, 4.

Food and Agriculture Organization of the United Nations (FAO), ADRIAMED, Scientific Cooperation to Support Responsible Fisheries in the Adriatic Sea, http://www.faoadriamed.org/

Food and Agriculture Organization of the United Nations (FAO), FIGIS: www.fao.org/figis/servlet/static?dom=root&xml=tseries/index.xml.

Food and Agriculture Organization of the United Nations (FAO), General Fisheries Commission for the Mediterranean, http://www.fao.org/fi/body/rfb/GFCM/gfcm_home.htm

Food and Agriculture Organizations of the United Nations (FAO), 2003. *Integrated Environmental and Economic Accounting for Fisheries*, Handbook of National Accounting, Final draft circulated for information prior to official editing.

Fox W. W., 1970. *An exponential Surplus-Yield for Optimising Exploited Fish Populations*. Trans American Fishery Society. 99:80-88.

Grainger, R., S. Garcia, 1996. *Chronicles of Marine Fishery Landings (1950-1994): Trend Analysis and Fisheries Potential*.FAO Fisheries Technical Paper 359, FAO, Rome.

Gordon, H. S., 1954. *The Economic Theory of Common Property Resources: The Fishery.* In L. G. Anderson, Fisheries Economics: Collected Essays, Volumes I and II, Ashgate Publishers, Aldershot, England, 2002.

Hartwick, J., 1990. *Natural Resources, National Accounting and Economic Depreciation.* Journal of Public Economics, 43: 291-304.

Hueting, R. 1991. *Correcting National Income for environmental losses: a practical solution for a theoretical dilemma*, pp. 194–213, in R. Costanza, Ecological Economics, Columbia University Press, NewYork.

Ilarina, V. R., 2000. *The Philippine Fishery Resource Account*. International Workshop on Environmental and Economic Accounting, 18-22 September 2000, Manila, Philippines.

IREPA,2002. *Osservatorio Nazionale per la Pesca e l'Acquacoltura 2001/2002*, Istituto Ricerche Economiche per la Pesca e l'Acquacoltura IREPA (Economic Research Institute for Fishery and Aquaculture), Rome, http://www.irepa.org/irepa/pubb.html

ISTAT, Italian Statistical Institute, all tables from http://con.istat.it or www.istat.it

Kurlansky, M., 1998. *Cod: A Biography of the Fish That Changed the World.* New. York: Penguin Books.

Lange,G–M., 2003. *Fisheries accounting in Namibia.* In Perrings C., J. Vincent, Natural Resource Accounting and Economic Development – Theory and Practice, 2003, EE, Glos.

Liu, X., 1998, *Adjusted forest accounts for China*, Ecological Economics, 27: 283-298

Myers, N., 1999. *Lifting the veil on perverse subsidies*. Nature, 392: 327-328.

National statistical coordination board (NSCB), 1998. *Philippine Asset Accounts: Forest, Land Soil, Fishery, Mineral and Water Resources*. Report written for the Integrated Environmental Management for Sustainable Development (IEMSD) programme (http://www.nscb.gov.ph/peenra/Publications/Asset/AssetAccounts.pdf).

Pauly, D., V. Christensen, S. Guenette, T. J. Pitcher, U. R. Sumaila, C. J. Walters, R. Watson, D. Zeller, 2002, *Towards Sustainability in world fisheries*. Nature, 418:689-694.

Pauly, D, 1995, *Anecdotes and the shifting baseline syndrome of fisheries*. Trends in Ecology and Evolution 10:430.

Perman, R., Y. Ma, J. Mc Gilvray, M. Common, 2003, *Natural Resource and Environmental Economics*, Pearson, Essex.

Perrings J. F. Vincent, 2003, *Natural Resource Accounting and Economic Development*, Edward Elgar, Cheltenham, UK-Northampton, MA, USA.

Prais, S. J., C. B. Winsten, 1954. *Trend Estimators and Serial Correlation*. Cowles Commission Discussion Paper No. 373. Chicago.

Repetto, R, W. Mc Grath, M. Wells, C. Beerand, F. Rossini, 1989, *Wasting Assets: Natural Resources in the National Income Accounts*. World Resources Institute, WashingtonD.C.

Schaefer, M. B., 1954, *Some Aspects of the Dynamics of Population Important to the Management of the Commercial Marine Fisheries*. In L. G. Anderson, Fisheries Economics: Collected Essays, Volumes I and II, Ashgate Publishers, Aldershot, 2002.

United Nations, 1993. Integrated Environmental and Economic Accounting, Handbook of National Accounting, Studies in Methods, Series F, New York, p. 61.

Weitzman M., 2003. *Income, Wealth And The Maximum Principle*, Cambridge Mass, Harvard University Press.

APPENDIX 1

A simple model to account for fishery depreciation

We apply a Weitzman/ Hartwick/ Solow model on the optimal adjustments to national accounts in the case of depletion of fish resource. The model supposes a very simple closed economy. The economic problem is to maximize the discounted utility (which depends on consumption and fish catch) as follows[18]:

$$Max\int_{0}^{\infty} e^{-\rho t}U(C_t, E_t)dt \quad \text{subject to:}$$

a) $\dot{K} = Q(K_t, E_t) - C_t - G(E_t, S_t)$ and

b) $\dot{S} = F(S_t) - E_t$ (21.)

Where:

- U is the utility function;
- C_t is the aggregate consumption;
- E_t is the fish catch;
- ρ is the discount rate;
- K_t is the stock of man-made capital;
- $G(E_t, S_t)$ is the cost function for fishing;
- where S_t is the fish stock;
- $F(S_t)$ is the natural growth function;

and the dot notation $(\cdot)$ signifies changes in these stocks.

Note that the harvest cost depends on the size of the fish catch and on the size of fish stock.

The current-value Hamiltonian for this problem is

$$H_t = U(C_t, E_t) + P_t\,[F(S_t) - E_t] + w_t\,[Q(K_t, E_t) - C_t - G(E_t, S_t)] \qquad (22.)$$

The necessary conditions include

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[18] In this study we use the dot notation for derivatives with respect to time. In order to reduce clutter we omit the *t* subscript when referring to derivatives such as marginal utilities, writing, for example, U_C rather than U_{Ct} for $\partial U_t / \partial C_t$

$$\partial H_t / \partial C_t = U_C - w_t = 0 \tag{23.}$$

$$\partial H_t / \partial E_t = U_E - P_t - w_t G_E = 0 \tag{24.}$$

By dividing (24) by (23) we obtain the following equation:

$$U_E / U_C = (P_t / w_t) + G_E \tag{25.}$$

which implies that the consumption price of fish (ratio between marginal utilities) is equal to marginal rent plus marginal cost.

By linearising the utility function, using

$$U(C_t, E_t) = U_C C_t + U_E E_t, \tag{26.}$$

and dividing equation (22) by U_C we can write the maximised value of Hamiltonian as

$$H_t^* / U_C = C_t + (U_E / U_C) E_t + \dot{K}_t + (P_t / w_t) \dot{S}_t \tag{27.}$$

where all the variables included in (27) are the optimal values for the maximisation problem (21).

Now, by substituting in (27), $\dot{Z} = F(S_t) - E_t$ and $\dot{K}_t = I_t$, we obtain the following equation:

$$H_t^* / U_C = [C_t + (U_E / U_C) E_t] + I_t + (P_t / w_t)[F(S_t) - E_t] \tag{28.}$$

which by equation (7) and using C_t^* for aggregate consumption is

$$H_t^* / U_C = C_t^* + I_t - (P_t / w_t)[E_t - F(S_t)] \tag{29.}$$

Therefore, remembering that the traditional measure of the NNP of a closed economy is consumption plus net investment in manmade capital ($NNP_t = C_t^* + I_t$), the optimal deduction from NNP to allow for depreciation of fisheries is given by:

$$ANNP_t = NNP_t - (P_t / w_t)[E_t - F(S_t)] \qquad (30.)$$

We can write equation (30) as follows by substituting (25) in (30):

$$ANNP_t = NNP_t - (U_E / U_C - G_E)[E_t - F(S_t)] \qquad (31.)$$