Example of capacity assessment of a Mediterranean fishery and relevant bio-economic indicators

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Abstract

This paper, beginning with a definition of fishing capacity, reports on a case study which aims to assess trawl fishing capacity in the Central and North Adriatic (GFCM geographical sub-area 17), a preliminary description of which is also given. Over the last four years, the fleet analysed has been affected by a constant decrease in all technical parameters, partly due to the capacity management policies adopted by the European Commission through the Multi-Annual Guidance Plans (MAGPs). Moreover, during the period under consideration, the trawl fleet has also undergone some significant variations following the application of national regulations on fishing days. In order to obtain a concise measurement of the capacity employed, fishing effort has been calculated; this was obtained by multiplying the capacity indicator (gross tonnage) by that of activity (average fishing days).

Indicators of capacity, activity and effort, used to measure the impact of the fishery sector on natural resources, have been completed by CPUE analysis so as to assess the impact of capacity management policies on the state of resources. The CPUE analysis was carried out for four target species of the trawl fleet in the area being studied. The biomass indices of these species were compared to the catch per unit effort. The joint use of economic (CPUE) and biological (biomass indices) indicators produced interesting conclusions and therefore should be positively considered as an effective means of analysing the effects of fishing effort management policies.

Finally, to describe further elements of complexity in the management of capacity and effort in the Adriatic Sea (such as the presence of shared stocks), distribution maps for the five species analysed have also been included.

1. Introduction

This paper, beginning with a definition of fishing capacity, reports on a case study which aims to assess the capacity of one Mediterranean fishery.

Partly to put the case study into context, this paper begins with the definitions of capacity both from a technical and an economic point of view, some clarification of the most commonly used measurement methods are also provided as taken from literature and used in the framework of management.

The case study was carried out on trawl fishing in the Central and North Adriatic (GFCM geographical sub-area, GSA, 17), a preliminary description of which is given. As well as the
assessment of the capacity of the fishery in question, an analysis will be carried out of the legal and management measures which aim to control fishing capacity and effort. In the light of these measures the trends in fishing capacity from 1997 to 2001 will be studied.

Furthermore it will be interesting to evaluate whether fishing capacity and effort management have had a noticeable biological impact on the resources. In order to do this, the trends of some biological parameters will be studied in the light of the trends of capacity indicators.

Analysis of other biological data will be performed to define problematic aspects of fishing capacity management in the Central and North Adriatic.

2. The concept of fishing capacity and its measurement

Among the most important topics concerning fisheries that are under discussion at national and international level, the excess of fishing capacity, the over exploitation of resources and the relative management issues can certainly be included. Nonetheless, the definition of fishing capacity and its measurement are obscure and not unequivocal concepts. According to the point of view (economic, biological or technical), several definitions and ways of measuring capacity have been proposed some of which are conflicting. These definitions and measurements have often been adopted in order to correspond to the aims of those involved in fisheries management.

Capacity is often expressed in terms of variables which are simple and easy to monitor; such as number of vessels, physical characteristics, fishing time, fishing gear and methods used. However capacity is defined more accurately in terms of catch (output) or in economic terms (capital costs).

In its most common application, fishing capacity is often identified with capital stock. Specifically fishing capacity is defined as “the maximum available capital stock in a fishery that is fully utilized at the maximum technical efficiency in a given time period given resource and market conditions” (Kirkley and Squires, 1998).

FAO suggests using a definition of fishing capacity in terms of output, the proposed definition is: “fishing capacity is the maximum amount of fish over a period of time that can be produced by a fishing fleet if fully utilised, given the biomass and age structure of the fish stock and the present state of the technology” (FAO, 1998, p 10).

Capacity measured at the level of single enterprises, vessels, vessel classes, ports or regions can be aggregated to obtain a measurement of total capacity. This measurement of total capacity can thus be compared to the target capacity or reference point.

The concept of capacity utilisation (CU) represents the available part of capacity which is utilized. CU is usually defined as the relationship between effective output and one of the measures of capacity. In the approach adopted by FAO, full CU represents full capacity and CU cannot exceed 1. Capacity utilization lower than 1 indicates that the fishing enterprises have the
potential for higher production without having to incur any further expense for new capital or equipment.

Capacity and capacity utilisation are strictly short-term concepts, defined or measured on the basis of a stock of fixed capital and of the state of technology. In the long term, capital can be modified on the basis of changes in economic conditions, or there could be technological changes and therefore capacity and capacity utilisation can also alter.

An excess of capacity (overcapacity) occurs when an enterprise or industry has the potential to produce more than is actually produced. To express this in greater detail, an excess of all inputs is present – including work, capital, and other fixed factors – in order to produce a given set of output. Therefore overcapacity is present when the output of capacity (or the maximum possible output) is greater than the desired target capacity levels.

FAO (1998) proposed a general description of target capacity: “target fishing capacity is the maximum amount of fish over a period of time that can be produced by a fishing fleet if fully utilized, while satisfying fishery management objectives designed to ensure sustainable fisheries”.

Estimation of overcapacity allows fishery managers to define a series of significant adjustments of the fleets with the purpose of rebalancing the fleet’s capacity with the availability of resources.

2.1 The measurement of fishing capacity by the European Union

Fishing capacity in the EU has historically been measured in terms of two vessel characteristics, gross tonnage and engine power. These two characteristics have been measured, monitored and registered as fishing capacity indicators by most member states, as defined in EC Regulation n. 2930/86 and have been considered the most relevant parameters to express the fishing capacity of fleets with active gear.

The number of kilowatts of an engine (total of continued maximum power) is a relatively clear measurement, although different measuring procedures among member states has caused some complication. There have been problems concerning de-rating practices, the exclusion of auxiliary engines as well as different measurement in terms of official kilowatts (kW) and maximum effective kW (Lindebo, 2000).

Calculation of gross tonnage has, however, proved to be less linear. Historically tonnage has been measured as Gross Registered Tonnage (GRT), defined by the Oslo Convention of 1947. Progressively the EU has introduced a standard, common measurement of tonnage, a volumetric quantification known as Gross Tonnage (GT) defined by the International Convention on Tonnage Measurement of Ships, 1969. However the registration of fleet tonnage for many member states still includes a combination of measurements due to the slow and complicated conversion process, this has limited the transparency of the results of fishing capacity reduction initiatives. The re-measurement process should be concluded by the end of 2003.
The EU has used the concept of fishing capacity to define a further term known as fishing effort. Both terms have been used in parallel since 1992 to achieve the desired fleet reduction. Lassen (1996) states that fishing effort can be considered to be composed of two separate elements: an element of capacity (characteristics of the vessel and the gear) and an element of activity (utilisation of the capacity, fishing time etc). In other words:

Fishing effort = capacity (vessels) * capacity (gear) * activity

The EU has adopted a measurement of fishing effort per fleet segment, in terms of aggregate tonnage, engine power and fishing activity (EC Regulation n. 2091/98):

\[
\text{Fishing effort (tonnage)} = \sum_{i=1}^{n} a_i J_i
\]

\[
\text{Fishing effort (engine power)} = \sum_{i=1}^{n} a_i P_i
\]

Where \( n \) is the number of vessels in the segment, \( a_i \) is the number of days at sea in the period of observation, \( J_i \) and \( P_i \) are respectively the average tonnage per vessel and the average engine power in each segment and during the period of observation.

It is easy to see that, as in all cases, estimation of fishing effort is difficult and the objectives can therefore be manipulated.

3. Description of the area and the fleet which are the focus of the case study

The morphological characteristics of the Adriatic allow for a straightforward differentiation of the three basins: the deep southern one, the central one and the northern one (Figure 1). The morphology and the physiographical nature of the northern basin are such that it is significantly different from the two basins further south.

The most relevant aspects are:

- The lower average depth.
- The absence of marked irregularities on the sea bottom, which slopes progressively towards south-east.
- The presence of several of the largest rivers of the area along its coast, which convey the flow-off from the Po valley and from the slopes of the Alps and Apennines which surround the area.
On a geological scale, these elements have had a direct influence on the morphological modelling of the seabed as it is now and, in the short term, are very important for the determination of the structure of the density of the water contained in the basin, as well as of the chemical and physical properties of the water and the various processes which occur there.

The shallowness of the water, the considerable quantity of nutrients which these areas receive, above all from the freshwater run-off from the rivers, together with the distinctive processes of sedimentation, accumulation and decomposition of the organic silt on the sea bed are the fundamental components for the development of an extremely rich and diverse trophic chain.

Marine waters are significantly influenced by variations in temperature that occur during the changes in the seasons, and the temperature range is appreciable due to the very fact that the water is shallow. The water mass warms up and cools down more quickly than in basins which
contain a larger mass. In particular, summer temperatures accelerate the bio-geo-chemical cycle of the mineral elements, making them more available to the trophic chain and more quickly.

The Central and North Adriatic is therefore an environment characterised by many elements which define its peculiarity and above all interact to determine the biological richness and the availability of fishery resources. In particular, the moderate slope and soft sea bottom which covers a large area going away from the coast and is for the most part sandy, muddy and alluvial, have made the Adriatic particularly suitable for trawl fishery, both bottom and beam trawling for demersal species, mid-water pair trawl for small pelagic fish and dredgers for clams. The fishery activities requiring this environment therefore flourish, from the coastal fishing valleys to the open sea.

In general, among the various techniques present in the fishery sector, trawl fishery is the most widespread since it guarantees technical and economic yields which are higher on average than those obtained using other methods. The trawl net is not a highly selective gear, targeting medium to high value demersal fish stocks, in accordance with the times and procedures permitted in the fishing area and within the limits of prevailing regulations.

The study area covers 764 km of coast on the Adriatic Sea and for administrative purposes is divided into 11 ports of registration (maritime districts).

In 2001 in the regions of the Central and North Adriatic, 502 vessels operating with trawl nets were registered in the Archive of Fishing Licences in the segment 4H2 (coastal, trawl), with a gross tonnage of 17659 GRT and an engine power of 109960 kW. The category MAGP 4H2 does not cover all vessels using trawl nets, as part of them are classified for MAGP purposes as 4H6 (coastal, polyvalent) and 4H7 (Mediterranean, bottom and mid water trawl). This study, however, looks exclusively at segment 4H2 where fishing capacity is concerned, whereas effort and CPUE data refer to the entire trawl fleet in GFCM GSA 17.

4. EC capacity adjustment policy

Control of the fleet’s fishing capacity comes under the jurisdiction of the EC regulations and is governed by the Multi-Annual Guidance Plans (MAGPs). These plans aim to bring fishing effort into line with the volume of resources available. They allow the development of each member state’s fishing fleet to be planned, establishing objectives concerning the reduction of tonnage and engine power, which have to be achieved within the set time limits.

Subsequently, according the criteria fixed by the Council, the member states set up four- or five-year adjustment plans for their fleets. To make the measures more suitable for each type of fishery, the fleets have been divided into groups or “segments” which correspond to the main fishery activities carried out. It is then a question of calculating the reduction in effort necessary in each segment for each national fleet, using a specific means of calculation.

The MAGP applicable to the period considered in this paper is MAGP IV which was in force from 1997 – 2001. The aims established by the EC for the fourth MAGP with reference to the
segment concerning trawl fishery, scheduled a reduction in capacity, expressed both in terms of
tonnage and in terms of engine power.

The fishing capacity of the trawl fleet can be contained by blocking the concession of new
licences and also by binding the construction of new vessels to the withdrawal of the old vessel
(demolition, sale to non EU countries, passage to another destination) on the condition that the
old vessel is 120% of that to be built.

5. National regulations regarding fishing capacity and effort

In order to achieve the objective identified by the EC of limiting the effort exerted by the fleet on
the fishery resources, the national administration uses another tool which is to reduce the number
of days at sea. The interruption of fishing activity constitutes a protective measure for the
resources, in particular during the recruitment period and it is applicable to vessels with licences
for bottom and with pelagic trawling.

The prohibition of access to the fishing zone for a consecutive period is employed at different
times according to the management areas concerned. From 1997 to 2001 the periods of
interruption to fishing activity in the Central and North Adriatic took place in several ways in the
different years (Table 1) and were further conditioned by unexpected events which had a strong
impact on the normal, regular fishing activity.

Table 1. Periods and typology of the interruptions to fishing activity in the Central and North Adriatic in the years

<table>
<thead>
<tr>
<th>Year</th>
<th>Periods and typology of the interruptions in the Central and North Adriatic</th>
<th>Duration in days</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>31 July - 13 Sept. (Obligatory)</td>
<td>45</td>
</tr>
<tr>
<td>1998</td>
<td>20 July - 2 Sept. (Obligatory)</td>
<td>45</td>
</tr>
<tr>
<td>1999</td>
<td>14 May - 3 June (Voluntary - war)</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>4 June - 15 July (Obligatory)</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>16 July - 31 Aug. (Facultative)</td>
<td>46</td>
</tr>
<tr>
<td>2000</td>
<td>- 19 July (Facultative)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>20 July - 1 Sept. (Obligatory)</td>
<td>44</td>
</tr>
<tr>
<td>2001</td>
<td>1 -30 August (Obligatory)</td>
<td>30</td>
</tr>
</tbody>
</table>

Knowledge of national regulations concerning technical interruption of activity will be useful for
a correct interpretation of some of the indicators referred to hereafter. Furthermore, although
fishing effort is a separate concept from fishing capacity, as we have already seen, “the
management of fishing capacity closely relates to many issues and concepts of conventional
fisheries management and conservation. In general terms, issues raised are often quite similar to
those relating, for example, to the management of fishing effort.” (FAO, 1998).
6. Assessment of fishing capacity and effort for the bottom trawl fleet in the Central and North Adriatic.

6.1 Capacity

In Italy, as in most EU countries, fishing capacity is identified by the quantity of capital and is often associated with the variables gross tonnage (GRT) and engine power (expressed in kW). These and other variables are analysed in this paper in order to provide a complete picture of the trend in capacity of the bottom trawl fleet in the Central and North Adriatic relative to the period 1997 – 2001 and to be in a position to evaluate the impact this fleet’s activity had on the fishery resources.

The analysis is carried out considering the total values of each single variable per vessel, as this allows for a better description of the evolution of the structure of the fishing fleet considered. Data concerning the dimensions of the fleet are taken from the Archive of Fishing Licences, while data on activity and production are from the IREPA database produced in the context of the programme “Economic observatory on the productive structures of Italian marine fisheries”.

In the course of the last four years, the fleet under analysis has been affected by a constant decrease in all technical parameters (Table 2). The downward trend is most consistent where gross tonnage is concerned, compared to the indications in the multi-annual guidance plan this parameter has suffered a more marked reduction than those found for the other technical characteristics of the vessels.

Table 2. The bottom trawl fleet* in the Central and North Adriatic (Source: Archive of Fishing Licences).

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of vessels</td>
<td>661</td>
<td>642</td>
<td>584</td>
<td>548</td>
<td>502</td>
</tr>
<tr>
<td>Gross tonnage (1000 GRT)</td>
<td>25</td>
<td>24</td>
<td>22</td>
<td>20</td>
<td>18</td>
</tr>
<tr>
<td>Engine power (1000 Kw)</td>
<td>137</td>
<td>135</td>
<td>124</td>
<td>120</td>
<td>110</td>
</tr>
</tbody>
</table>

* the vessels which, according to MAGP classification, are in segment 4H2 have been considered.

Total tonnage (Figure 1) decreased by 30% from 1997 to 2001, going from 25 thousand tons to 18 thousand. In terms of average tonnage per vessel, there was a reduction of 8%; in 1997 a trawl vessel had an average tonnage of 38 t whereas in 2001 this value was 35 t.
Engine power shows similar behaviour to tonnage, but at lower rates. Engine power decreased constantly in the period analysed for a total of about 27 thousand kW. Contrary to tonnage, average engine power per vessel increased slightly, going from 208 kW in 1997 to 219 kW in 2001.

The differing behaviour of the two variables can be explained with reference to the objectives of the multi-annual guidance plan to reduce effort and the regulations which followed this. The aims of reducing tonnage and engine power were pursued by blocking the issue of licences and by limiting the construction of new vessels by imposing the withdrawal of old vessels to a total of 120% of those being built. The latter measure clearly brought about a reduction of the average tonnage of bottom trawlers, however the reduction did not have such strong repercussions on engine power.

Tonnage and engine power are the variables which are most directly influenced by the measures set out to achieve a reduction in capacity; however, at the same time they are remote from the definition of capacity given in paragraph 2. Fishing capacity as proposed by FAO is a measure of output and refers to the full utilisation of the fleet. Kirkley and Squires’ definition, expressed in terms of capital stock, refers to a fully utilised fishing fleet. Capacity expressed in terms of tonnage or engine power certainly cannot be considered fully utilised, on the other hand it is not easy to find capital stock that corresponds to this requisite. Capacity management policy cannot be limited to a consideration of capacity as such, but should also associate a measurement of its real utilisation. Even if consideration of “full utilisation” is not limited exclusively to the temporal aspect, this latter is certainly an indispensible element in defining the degree of real utilisation of the capacity. In the case study in question, the activity of the trawl fleet has been analysed in terms of average fishing days per vessel. During the period considered, the activity of the trawl fleet underwent some significant variations. These variations were due to both the effect of the regulation of its activity and also to the occurrence of some exceptional events, such as the beginning of the Balkan conflict and the phenomenon of mucilage. In particular, following a relatively stable period from 1997 to 1998, the conflict of 1999 caused a reduction of total fishing days of over 18% (Figure 2).
In the following two years a substantial recovery was observed. In 2000 the increase was partially slowed down by the presence of mucilage, but in spite of this the number of fishing days was able to return to the levels seen before the period of war. In 2001 there was further growth with a rise of over 2% compared to the previous year. This increase was mainly due to a reduction in the number of days of the closed fishing period, which went from 45 days the previous year to just 30 days.

The analysis of the indicator of activity allows for a clearer picture of the capacity which is actually employed by the vessels of the fleet under examination. For example, this allows us to reveal how in 2000, compared to 1999, in spite of a considerable reduction in tonnage, the fishing effort of each single vessel remained virtually the same as the previous year. Moreover, if the capacity in terms of gross tonnage decreased by 17.5%, its level of use in terms of days of activity grew by almost 19%. Concise measurement of the capacity employed can be obtained by multiplying the capacity indicator (gross tonnage) by that of activity (average fishing days). This measurement is also used to estimate the fishing effort exerted on the resources. In any case, it is necessary to consider that the calculation of the number of fishing days is affected by the fact that the fleet has numerous small vessels, thus the duration of each fishing day is highly variable. Small fishing vessels operate for 8-10 hours a day, while for medium and large vessels the fishing day is between 22 and 24 hours. This indicates that there is a significant margin of the fleet’s fishing capacity which is not utilised. Another aspect which is linked to the partial utilisation of the fishing capacity is the engine power available which is actually used for towing the nets. Generally this is less than 50% of the power available.

### 6.2 Fishing effort

As with capacity, effort does not have an unequivocal definition, consequently there is no single measurement method, however in empirical studies present in literature, several measurements of effort have been proposed. For example, Gulland (1983) measured fishing effort in terms of
vessel length, tonnage and engine power, whereas Beverton and Holt (1957) only in terms of gross tonnage.

A decidedly economic method was applied by Placenti et al., (1992) who employed the composite index “vessel tonnage*vessel engine power*fishing hours” in a bioeconomic model applied to Italy. This formula can be considered a synthesis of the two measures predominantly adopted by the EU “vessel tonnage*fishing hours” and “engine power*fishing hours”.

Sabatella (2000) concluded that to measure capacity in fisheries (a measure of capital) it was necessary to develop investment time series.

In this case study, it was deemed preferable to use a simpler formula, obtained from the product of vessel tonnage and fishing days. Figure 3 demonstrates an initial decline of this parameter until 1999, followed by a slight increasing trend until 2001.

![Figure 3. Total effort, trawler fleet (GSA 17) 2001. Source: IREPA Observatory.](image)

The most marked reduction (-24%) occurred in 1999 and was chiefly due to the reduction of fishing days for the risks connected to the Balkan conflict. The following year effort began to increase slowly. This trend, as has already been stated, was the result of a significant reduction in tonnage, almost entirely compensated by an increase in days of activity.

**7. Catch per unit of effort**

Capacity, activity and effort indicators are used to measure the impact of the fishery sector on natural resources. These indicators are necessary, although certainly not sufficient, to assess the state of the resources in a given geographical area. The information obtained from these indicators needs to be completed by that which derives from the total of the catches, that is, from the output of the productive process. In this sense, one of the most widely used indicators is the catch per unit of effort (CPUE). CPUE is extensively used by biologists to determine variations in biomass and by economists as a measure of the efficiency of the fleet (van Hoof et al., 2001).

Consider a simple model for the fishery sector, where catches are defined as:

\[ C = EqB \]  

where \( C \) are the catches expressed in kg, \( E \) represents fishing effort as previously defined (gross tonnage*fishing days), \( q \) is the catchability coefficient and \( B \) is the biomass level.
CPUE is therefore defined as the relationship between total catches and total fishing effort in a given period of time:

\[ U = \frac{C}{E} \] 

where \( U \) represents the CPUE.

From (1) and (2) it follows that CPUE can be connected to biomass:

\[ U = qB \] 

As stated previously, CPUE can be used to measure variations in biomass level. Consider the variations of the indicator:

\[ \frac{C_t}{E_t} = \alpha \left( \frac{C_{t-1}}{E_{t-1}} \right) \] 

where \( t-1 \) and \( t \) represent the two consecutive time periods. \( \alpha \) is a coefficient linked to biomass development:

\[ q_t B_t = \alpha (q_{t-1} B_{t-1}) \]

If the catchability coefficient is assumed to be constant, CPUE variations can be considered a good proxy of the variations which arise in the stock. Figure 4 shows the trend of this indicator in relation to the trawl fishery system in the Central and North Adriatic. Until 1999, the indicator is subject to slight oscillations.

In 1998, CPUE was equal to 7.6 kg per GRT unit daily and this level was also maintained in 1999. More significant variations were registered in the last two years. In 2000 a considerable increase, over 10%, highlights a rise in biomass probably due to the prolonged closed period in the previous year which allowed the fishery stocks to build up. Finally, in 2001, with a reduction of 14.5%, CPUE reached its lowest level for the entire period being studied (7.2 kg). This figure,
which indicates a significant decrease in total stock, is probably the consequence of the constant increase in the days the Adriatic fleet spent at sea in the period 1999 – 2001.

8. Indices of biomass and CPUE for some target species of trawl fishery

The biomass index is a biological indicator which measures the abundance of a species, it is calculated on the basis of scientific assessment surveys at sea and expresses an index of the quantity in kg per species per square kilometre. Among the most important species for Adriatic trawl fisheries, the following have been considered:

- European hake (*Merluccius merluccius*)
- Norway lobster (*Nephrops norvegicus*)
- red mullet (*Mullus barbatus*)
- horned octopus (*Eledone cirrhosa*)
- musky octopus (*Eledone moschata*)

The biomass indices for these species were compared to the catch per unit effort, for the two *Eledone* species only one CPUE measurement is available because this indicator is calculated on commercial catches and it is not commercially possible to distinguish between horned and musky octopus. The biomass indices and the catch per unit effort have been reported for the years from 1999 – 2001 in Table 3.

Table 3. Biomass indices and CPUE.

<table>
<thead>
<tr>
<th>Species</th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>European hake</strong></td>
<td>32,25</td>
<td>19,36</td>
<td>17,62</td>
</tr>
<tr>
<td><em>Merluccius merluccius</em></td>
<td>0,84</td>
<td>0,52</td>
<td>0,46</td>
</tr>
<tr>
<td><strong>Norway lobster</strong></td>
<td>2,66</td>
<td>1,18</td>
<td>1,25</td>
</tr>
<tr>
<td><em>Nephrops norvegicus</em></td>
<td>0,47</td>
<td>0,35</td>
<td>0,38</td>
</tr>
<tr>
<td><strong>Red mullet</strong></td>
<td>51,20</td>
<td>10,70</td>
<td>13,47</td>
</tr>
<tr>
<td><em>Mullus barbatus</em></td>
<td>0,61</td>
<td>0,67</td>
<td>0,55</td>
</tr>
<tr>
<td><strong>Musky octopus</strong></td>
<td>18,84</td>
<td>7,47</td>
<td>18,64</td>
</tr>
<tr>
<td><em>Eledone moschata</em></td>
<td>1,43</td>
<td>5,34</td>
<td>8,26</td>
</tr>
<tr>
<td><strong>Horned octopus</strong></td>
<td>0,33</td>
<td>0,34</td>
<td>0,66</td>
</tr>
<tr>
<td><em>Eledone cirrhosa</em></td>
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</tbody>
</table>

In the case of the hake, the tendencies of the biomass index and CPUE in the three-year period considered, follow the same downward trend (Figure 5). The catch per unit of effort passed from 0.84 kg per unit of effort in 1999 to 0.46 kg in 2001. For both indicators, the decrease was most marked between 1999 and 2000.
Figure 5. Bio-economic indicators, base year 1999 (*Merluccius merluccius*). Source: IREPA Observatory and MEDITS.

Passing on to an analysis of the bio-economic indicators of Norway lobster (Figure 6), a decline in both biomass index and CPUE can be noted between 1999 and 2000, with cautious recovery in 2001. Between 1999 and 2000 catch per unit of effort reduced by 24% while the biomass index decreased by 56%. The increase in catch per unit effort in 2001 compared to the previous year can be put down to the albeit slight recovery of the state of the resources, as the increase in biomass proves.

Figure 6. Bio-economic indicators, base year 1999 (*Nephrops norvegicus*). Source: IREPA Observatory and MEDITS.

The red mullet is the only species for which the trends of CPUE and biomass indices are not in agreement (Figure 7). Between 1999 and 2000 CPUE increased from 0.61 to 0.67 kg, while the biomass index decreased from 51.2 kg per square kilometre to 10.7 kg. Between 2000 and 2001 this trend reversed: the biomass index increased (taking it to 13.47 kg) while the CPUE decreased (taking it to 0.55 kg). This trend is, however, justifiable if the meaning of the two bio-economic indicators is analysed better.
The CPUE indicator refers to commercial catches achieved in a year’s fishing, in relation to the effort exerted in the same year. The biomass index, in the other hand, refers to resource abundance at the moment in which the appraisal survey is carried out at sea. These biological surveys are carried out in late spring, which is the reproduction period of the red mullet. The life cycle of the species in question can explain the difference; the red mullet grows quickly and in the months of September and October the largest quantities of mullet are landed which were born from the June reproduction. To summarise, the two trends are in contrast because the biomass index is calculated at the moment of reproduction and therefore only counts the individuals which have “survived” a year’s exploitation, while the CPUE indicator refers to an entire year of activity and is influenced by the recruitment of the young mullets. This example suggests that, for species with a short life cycle, it would be better to compare the two indicators over a shorter time period (month or three-month periods).

Lastly, analysis of horned octopus (E. cirrhosa) and of musky octopus (E. moschata) was performed. The catch per unit effort index was calculated considering the sum of both species.
because commercial catch statistics do not report them as two species. Two separate biomass indices are, however, available. As can be observed in Figure 8, the tendencies of the indicators using 1999 as the base year show the CPUE trend is the same for both species, whereas the biomass index for *E. cirrhosa* shows a different trend for the years considered. This situation can be explained if we consider that the prevailing species in the study area is *E. moschata* of which a far higher quantity is caught, it is therefore justifiable that the biomass index of *E. moschata* is correlated with the indicator constructed on the basis of fishery activity and production.

As a conclusion to this analysis, it can be stated that biological and economic statistics allow for joint analysis and the integrated use of biological and economic indicators, as well as being possible, is highly recommendable as a tool for the analysis of the effects of fishing effort management policies.

9. Distribution maps

Management of fishing capacity and/or fishing effort should consider spatial distribution of species in order to have an effective result on resources. Reduction of capacity in one port could have no effect whatsoever on a particular species, if that species is distributed in different areas to those of the fleet from the port in question. For small fishing vessels the fishing area is very limited.

In order to describe this element of complexity in the issue of management of fishing capacity and fishing effort in the Adriatic Sea, hereafter follow the distribution map of *Mullus barbatus* (Figure 9), *Merluccius merluccius* (Figure 10), *Nephrops norvegicus* (Figure 11), *Eledone cirrhosa* (Figure 12) and *Eledone moschata* (Figure 13).

The maps emphasize how the areas of distribution differ greatly according to the species. However, also considering the same species, distribution also changes according to the length class. An example can be seen in Figures 14, 15, and 16 which show the distribution maps for *M. merluccius* for three different length classes (less than 12 cm total length, from 12 cm to 20 cm, and greater than 20 cm, respectively).

The distribution maps highlight another important aspect of fisheries in the Adriatic Sea: the presence of shared stocks. In this context, the application of all encompassing management plans is unavoidable for effective fisheries management; unilateral efforts to control fishing capacity could otherwise be futile.

The example described in this paper considers only the fishing capacity and fishing effort of Italian vessels operating with bottom trawl nets, the same resources are also targeted by the fishing vessels of countries on the other side of the Adriatic, in particular from Croatia, as well as fishery using other types of gear.

To obtain reliable indications, it is essential to be aware of the variations in abundance of the resources and the variations in total fishing effort applied to all the species by all the fishing units that operate in the area.
Figure 9. Distribution map of *Mullus barbatus*.
Figure 10. Distribution map of *Merluccius merluccius*.
Figure 11. Distribution map of *Nephrops norvegicus*. 

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Figure 12. Distribution map of *Eledone cirrhosa*. 

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Figure 13. Distribution map of *Eledone moschata*.
Figure 14. Distribution map for *M. merluccius* (less than 12 cm total length).
Figure 15. Distribution map for *M. merluccius* (from 12 cm to 20 cm total length).
Figure 16. Distribution map for *M. merluccius* (total length greater than 20 cm).
10. Conclusions

The recent EC action plan for the conservation and sustainable exploitation of fishery resources in the Mediterranean states that management of fishing effort is necessary to achieve the objectives of the Common Fishery Policy. Fishing effort management must build upon experience already gained at local or national level, with the enforcement of simple rules such as the maximum allowable annual fishing days, the short week, a fishing ban during national holidays and the fixing of a maximum allowable daily time out of port or, in the case of longer than daily fishing trips, limitations of weekly fishing hours.

Among other tools, it is important to mention the introduction of collective property rights as in the case of clam management. This tool has proved to be particularly efficient both in biological and in economic terms.

Control of fishing capacity has been a task of the EU through the Multi Annual Guidance Programmes (MAGP). From an analysis of the official data relative to the area and fishery system studied from MAGP IV, for the period 1997 – 2001, it emerges that facing a 24% reduction in the number of vessels, gross tonnage fell by 28% and engine power went down by just 19%. This type of control, therefore, produced a fleet of vessels with lower tonnage but with more powerful engines.

The case study presented in this paper highlights, as in the case of the Mediterranean, that reduction of capacity must be accompanied by measures to control fishing activity. For example, it has been possible to reveal how in the year 2000, in spite of the large reduction in tonnage, the fishing effort of single vessels remained almost unchanged compared to the previous year. Indeed, if capacity in terms of average tonnage decreased by 17.5%, the level of utilisation in terms of days' activity grew by almost 19%.

Indicators of capacity, activity and effort are used to measure the impact of fishing on natural resources. However capacity and effort indicators are not sufficient to evaluate the state of the resources. From 1997 to 2001 the CPUE of the trawl fleet in the North and Central Adriatic decreased by 9.6% due to both a reduction in effort and a reduction in biomass available for fishing. The drop of CPUE represents a clear signal of deterioration of the state of the resources.

The management of fishing capacity should be conducted at local level in order to consider different distribution patterns and species size distributions. Moreover, the fishing of shared stocks should be subject to an EC and/or international regulatory framework, including effort limitation and technical measures.

11. References cited


12. References consulted


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