Biodiversity loss and economic value: preliminary approach to fishing activities in the Venice Lagoon

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Keywords: fishery activity, externality, biodiversity management, Venice Lagoon

JEL codes: Q2

Introduction

Coastal ecosystems are subjected to different types of antropic pressures that are revealing to be unsustainable and have irreversible effects on marine biodiversity. Among these, one of the main causes of biodiversity loss is recognized to be the fishery (NRC, 1995). Fishing activity can affect biodiversity by selecting, catching, discarding commercial and non-commercial species (Pauly *et al.*, 1998; Mustafa and Rahman, 1999; Bohnsack, 2000; Pranovi *et al.*, 2000). Acting as a source of ecological disturbance (*sensu* Pickett and White, 1985), fishing activity produces direct and indirect impacts at different levels: species, population, community and ecosystem. Those effects could result in negative feedbacks for the fishing activity itself by reducing commercial stocks and jeopardizing size and structure of populations, and for the society by affecting ecosystem functions and services.

Fisheries, therefore, have an important role in the context of management policies of the marine environment as recognised in a number of international agreement and conventions (Tasker *et al.*, 2000).

The goal of a conservation strategy should consider the different levels of fishing disturbances and protect not all biodiversity in some areas, but biodiversity thresholds in all areas (Folke *et al.*, 1996) because human pressures exist in any case we decide to manage ecosystems. Considering human activities as part of the ecosystem is a starting point for re-thinking to biodiversity conservation within fishery management, but, despite all the attention that is paid to the conservation of biodiversity, management tools are often limited and do not solve the problem at the root, often failing the ecosystem management goal (Pitcher *et al.*, 2001).

In order to meet development and sustainability an effective interdisciplinary relationship is needed between ecology and economics; this will request to rectify the tendency to ignore humans in ecology, while at the same time rectifying the parallel tendency to ignore the natural world in the social sciences (Costanza, 1996)

Natural capital and *ecological services* (Charles, 2001) are two of the variables that have to be considered in order to assess the management structure of the interventions, and to estimate the biological diversity to the private individual and its value to society as a whole. Internalizing only a few of the external costs of biodiversity loss is often enough to motivate the conservation of biodiversity (Folke *et al.*, 1996), therefore a key role of conservation is the assessment of human activity and the consequent economic valuation of these externalities.

Many of direct and indirect effects of fishing activities (such as impact on non-target species, modifications of benthic habitats, alterations of trophic webs) could be considered as externalities. In this framework we attempt a preliminary estimate of some externalities linked to the fishing activities in the Venice Lagoon, basing on an ecological approach.

The aims of the study are:

- to assign a preliminary monetary value to unmarketable species (to estimate the natural capital);
- to roughly estimate the functional value of the species involved, basing on the previous value and on an ecological index (to estimate ecosystem services);
- to apply these values for assessing the externalities of fishing effects on non-target species (discard), comparing two different kinds of fishing activities.

Materials and Methods

Fishing activities in the Venice Lagoon

The Venice Lagoon is a sensitive area subjected to different kinds of anthropogenic pressures mainly due to industrial pollution, eutrophication, and fishery exploitation. At present two different kinds of fishing activity are practiced in the lagoon: the artisanal fishery and the mechanical clam harvesting.

The artisanal fishery could be defined as a small-scale, multitarget activity, which uses traditional gears (till the first half of 1900 more than 25 fishing gears were used, at present only two gears are used) and is based on a deep link between fishermen and the exploited environment, a sort of fishermen ecological knowledge. This fishing activitiy targets a wide range of species (more than 20) including residents and migrants, depending on seasons, tide, and fishing grounds (Malavasi *et al.*, 2002), and with a low discard/commercial catch ratio (0.14:1).

The mechanical clam harvesting, is a quite recent activity, which started at the end of 80s to exploit natural banks of a new exploitable resource (Manila clam – *Tapes philippinarum*) and quickly developed spreading in most of the lagoon. Due to the absolute absence of traditions, and the high level of technology employed, the clam harvesting could be considered, although improperly, an industrial fishery.

Recent studies (Da Ponte, 2001; Pranovi *et al.*, 2003a) have demonstrated that the mechanical clam dredging (which has a high discard/commercial catch ratio 1.39:1) directly affects the bottom morphology and biogeochemical cycles, disrupting benthic habitats and deeply impacting the biological communities.

All this produced an unbalancing of the lagoon ecosystem and generated a conflict beween the two fishing activities which have no common target species but share the exploited environment.

An example of this comes from the fishmarket data: the fish production in the lagoon of Venice till the late 80s came totally from the artisanal fishery and corresponded on average to 2,100 MT per year (data from fishmarket of Chioggia, 1971-1981) with an income of about 8.5 millions €. In 1999 the mechanical clam harvesting production was 40,000 MT corresponding to 60 millions €, while artisanal product dropped to 629 MT (2.31 millions €).

Data sampling

To describe the two fishing activities data collected by means of experimental and field surveys (Da Ponte, 2001; Malavasi *et al.*, 2002) were used. Moreover time series of landing data were collected from the fishmarkets (Chioggia and Venezia) which record the lagoon production.

Estimate of the 'natural capital' - to obatin a valuation of non commercial species

From an ecological point of view, a good way to describe an ecosystem is to use the energy flows. The complex of energy flows in an ecosystem determine the food web and so the trophic pyramid. Due to its trophic relationships each species has a position in the web and this is described by its trophic level (TL).

The integer Trophic Level, as defined by Lindeman, is the number of passages that one could count in the trophic chain from the organism down to the autotrophy organisms or the non-living organic matter (Lindeman, 1942). However, the living species usually feed on more food items of different trophic levels: weighting the trophic level of the preys by their proportion in the diet one obtains the effective Trophic Level (TL), as a real number ranging from 2 (detritivores or herbivores) up to 5 or 6 (large top predators).

For each species involved in the lagoon fishing activities the TL was estimated using Trophlab, a software package purposely built by Pauly and colleagues (Pauly *et al.*, 2000). The software allows one to estimate the TLs for all organisms of the trophic chain by using diet composition for each species.

Starting from these assumptions:

- the same energy quantity is required to sustain two different species having the same TL;
- fish prices are greatly influenced by a lot of variables, but a relationship has been recognized between TL and prices of species landed as an index (Sumaila, 1998);

in a first approximation it is possible to consider two species with the same TL as equivalent in terms of energetic budget for the eco-system and therefore to assign a value to non-commercial species by using the market value of the same TL marketable species. A linear regression is done between commercial species prices and their Trophic Levels, the resulting function is used for determining a hypothetical market value for the non commercial species (TL Value).

Estimate of the ecosystem services – to estimate the function of each species

A description of the role played by each species in the ecosystem could give a broad description of the function of this species. The evaluation of the role of the species was obtained by using a mass-balance model developed with the software Ecopath with Ecosim (Christensen *et al.*, 2000). The model allows to represent both biotic and abiotic components of the ecosystem by means of the flows of matter and energy, including the fishing activities and other major features influencing the flows between the ecosystem components (Christensen and Walters, 2000). Therefore, the model allows to explore the impacts of the fishing activities, described as a part of the ecosystem, on the biological communities through both direct and indirect effects (Pauly *et al.*, 2000).

A published model describing the Venice Lagoon ecosystem in 1998 was here used (Pranovi *et al.*, 2003b), where biological data are organized to estimate the average parameters and biomasses for the exploited areas, leading to a model that represents the "average exploited habitat". The biological components of the ecosystem were aggregated in 25 functional groups, plus bottom sediment and organic matter in the water column.

As output of the model there is also the Mixed Trophic Impact (MTI), an index which synthesizes all the interactions, positive and negative, of each species upon each other (Ulanowicz and Puccia, 1990).

So MTI was used as indicator of the function of each species in the lagoon ecosystem and utilized for converting the previously obtained monetary values data (MTI x TL Value = Function Value per Unit).

Then combining the values obtained with the method above described and the field data (collected) about the quantity of discard produced by the two fishing activities in the Venice Lagoon, it was possible to gain a preliminary estimate of the externalities due to the direct effect on non-target species.

Results and Discussion

From our field sampling activity it resulted that in the mechanical clam fishery the discard (*i.e*. the total amount of non commercial catch) achieves 139.8% of commercial catch biomass, while in the artisanal activity it is 14% of commercial catch biomass. The number of non-target species involved in mechanical clam harvesting is 10 and in artisanal fishery 22.

Applying the proposed evaluation methodology to obtain the *natural capital* loss due to fishing activity it resulted that 143% is the percentage of loss relative to the commercial catch in the mechanical clam fishery, and it is 13.6% in artisanal fishery.

Calculating monetary value related to *functional values* it resulted that for mechanical clam fishery, discard is 404% of commercial catch, while, for artisanal fishery, it is 12.4%.

Depending on different vulnerability of each species to capture by mechanical clam fishery, exposure to the air, manipulation and damage, it is possible to describe three different scenarios:

- *a)* all individuals of catch species survive to the fishing activity, and no loss in ecosystem functions could be recognized;
- *b)* all individuals of each species die in relation to the fishing activity and the maximum loss of ecosystem function is recorded;
- *c)* due to different vulnerability, 50% of all individuals of each species die in relation to fishing activity.

Therefore, reporting the results for the three scenarios, it resulted that respect to an euro revenue the euros of natural capital loss because of mechanical clam fishery are: 0.00 € in scenario *a*, 1.43 € in scenario *b*, 0.72 € if we refer to scenario *c*. While the loss of ecosystem functions referred again to 1 € of commercial catch is 1.01 € in scenario *a*, 4.04 € in scenario *b*, and 2.02 € in scenario *c*. The most suitable scenario, considering the species discarded and the fishing techniques, seems to be the scenario *c* where capital loss is 0.72 and loss of ecosystem function is 2.02.

For artisanal fishery it was supposed only one scenario where all discard species die, the natural capital loss calculated results to be 0.13 € for each € commercial catch, while the functional value loss 0.12 €.

Refering to 1999 landings value, the most suitable scenario indicate a natural capital loss of 43.2 million € due to mechanical clam harvesting, and 0.3 million € due to artisanal activity; and the functionality value loss is 60.6 million € due to mechanical clam fishery, and 0.27 million € due to fishing activity.

This preliminary analysis is carried on attributing a value to all the species that are directly involved in fishing activities even if they are non-commercial species. A rough estimation in monetary units gave an idea of two fundamental steps in ecological economics: *natural capital* and *ecological services* (Charles, 2001). For describing and studing the ecosystem a model approach is here used and the value of different species depends on the energetic content of that species and on their MTI. Obviously the obtained value is a fishery related value and is only a part of the externalities that are produced by this kind of human activities. Therefore it represents a starting point for a cost-benefit analysis that includes also externalities. It has also to be assumed that this method to attribute an economic value to the “non-product” is an underestimation because it does not consider all the services provided by these species (Daily, 2000).

The problem to be addressed for the development of a strategy for fishery management and biodiversity conservation is that current institutions in society, including markets, do not respond to environmental feedbacks, as ecosystem does. The implication of this is that individual users of biological resources will not take the true cost of their actions into account (Folke *et al.*, 1996). Many valuation methods had been used for facing up this problem generating three basic types of economic valution methods: indirect market valuation (WTP, WTA), contingent valuation, and group valuation

(Nunes and van den Bergh, 2001; De Groot *et al.*, 2002). In this framework the here proposed methodology can enforce the ‘traditional’ methods to arrive at a monetary estimantion of the ecosystem services and natural capital.

At present we face with the challenge of assessing fishing effects on communities that have long been exploited, without knowing their ‘pristine’ state (Jackson *et al.*, 2001), and restoring the ecosystem at the original level besides economically unaffordable, could be impossible as the original state remain unknown.

The ecosystem approach here applied allows to quantify the costs of direct effect of fishing activities, these costs are an evaluation of the social costs of biodiversity loss directly linked with fishing activities, actually these costs are not payed and refer directly the future generations.

The value obtained with this methodology has to be considered not as a tradeable value, but as a tool in managing the resources and the fishery in the lagoon, it is not the cost for habitat restoration, but a price that cost-benefit analysis has to consider as a society cost, as an externality.

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