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Global value, full value and societal costs; capturing the true cost of destroying marine ecosystems

Abstract. *World fisheries are characterized by ecological, economic and social costs which are not taken into account by current market mechanisms. However, the sustainability of ecosystems and fishing activities depends on their being taken into account in order to arrive at the most appropriate management decisions. The European research programme ECOST (Ecosystem, Society, Consilience Precautionary principle: Development of an assessment method of the societal cost for best fishing practices and efficient public policies) develops an integrative approach to the various costs generated by fishing activities. In doing so it seeks to develop a decision-making tool which can contribute to the success of the Plan of Implementation proposed at the Johannesburg summit.*
Keywords*. ECOST – Ecosystem – Consilience -- Societal costs – Fishery -- Ocean*

Résumé. *Les pêcheries mondiales sont caractérisées par des coûts écologiques, économiques et sociaux qui ne sont pas pris en compte par les mécanismes de marchés actuels. Or la pérennité des écosystèmes et des activés de pêche dépend de leur prise en compte afin de prendre les décisions d'aménagement les plus appropriées. Le programme de recherche européen en coopération ECOST (Ecosystèmes, Société, Consilience et Principe de précaution : développement d'une méthode d'évaluation des coûts sociétaux pour parvenir à des pratiques de pêche et*

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des politiques publiques durables) développe une approche intégrative des différents coûts engendrés par les activités de pêche ainsi que les politiques publiques. Il tend de la sorte à développer un outil d'aide à la décision pouvant contribuer à la réussite du plan d'implémentation du sommet de Johannesbourg.
***Mots clés**. ECOST -- Ecosystème – Consilience -- Coûts sociétaux – Pêche -- Océan*

Introduction

When one decides to build a dam or any other structure, one carries out an economic feasibility study together with an analysis of environmental impact. When one decides to carry out a fishing project there is a tendency to only analyse its financial and economic feasibility. Why is there no environmental evaluation of the effects which will be induced by the project? The fishing project will contribute to the improvement of production, generating additional added value, employment upstream and/or downstream, etc. It is seen as an *a priori* "good". On the contrary, the dam is viewed at the same time as potentially injurious to human, animal or vegetable populations as the rise in water levels leads to the displacement or worse, extinction of a species. Without resorting to the same provocative manner as Ost (1997), who asks whether trees have the right to vote, it nevertheless seems appropriate to question the legitimacy of ecosystem protection if fishing projects continue to be undertaken with no accompanying environmental impact study. What would the ecosystem think of the construction of a new unloading dock, a new processing plant, the introduction of more powerful ships, the use of more "efficient" fishing gears? Without an environmental impact study, it seems that the voice of the ecosystem cannot be heard.

Is this the same as saying that the protection and the conservation of resources are forgotten aspects of fishing policies and projects? Apparently not, since each fisheries policy/project is presented as showing that the health of the ecosystem is what it holds dear to its heart. So why then not formulate conservation policies and conceive development projects which are articulated around the conservation of the resources and their ecosystem? Unfortunately, conservation concerns generally rank lower in the management process - where the development or the maintenance of the industry has priority.

How is it that, in spite of the application of the principles of sustainable development, the promotion of responsible fishing, and the adoption of the precautionary approach, fishing today often rides roughshod over ecosystem needs. The answer undoubtedly lies in the logics of fisheries management which are applied. Sall (2007, in this issue) showed that fishing policies in West Africa still operate according to a developmental paradigm that considers industrial fisheries as modern and sees artisanal fisheries as an archaic production form that will disappear over time. Public decision makers are thus obliged to modernize and develop their fisheries. However, given the inexorable decline of fisheries resources in the majority of the world's oceans and rivers (1), the question of reconciling the development (or maintenance) of a fisheries sector with the well-being of the underlying ecosystems becomes central.

Therefore, the first question to be addressed – particularly in the light of the Johannesburg Plan of Implementation - is the following: Is it possible to develop tools that aid decision-making (evaluating the environmental effects of fishing projects, the introduction of new vessels, for example) within the fisheries sector in a way that will allow ecosystems to be restored by 2015? Secondly, if so, how should this be done so as to maximize the chances of success?

The structure of the paper that follows addresses these questions. First, we detail how the market mechanism presently fails to incorporate the ecosystem effectively within the development of fishing policies. This leads us to suggest that current notions of value need to be extended so as to embrace the concept of societal cost. We then apply these ideas by coupling the concept of societal cost to the ecosystem model Ecopath. This forms the basis for the ECOST model approach which seeks to model aspects of the link between ecology, economy and sociology. A brief conclusion completes the article.

Traditional management approaches and external costs

The techniques of bio-economic modeling of fisheries, developed largely from the 1950s onwards, draw primarily upon standard economic theory. Yet while the use of such models permitted significant theoretical advances in the practice of fishery management, their actual application failed to fulfill the hopes of economists (Meuriot, 1987). Maximization of individual profit and the fishery rent under technical and resource scarcity constraints, and the adjustment of supply and demand through the mechanism of prices, had seemed to offer insight into effective fisheries management. The development of the concepts of resource and market equilibrium ("Maximum Sustainable Yield" and "Maximum Economic Yield") were applied to the management of commercial species and, in the majority of cases, helped to explain stock decline. Notwithstanding the availability of increasingly strong and sophisticated computing capacities, the models developed remained attached to the analysis of mono-specific stocks. It was about herring of the North Sea, the cod of Newfoundland, the sardine of Morocco, the tuna of the Gulf of Guinea, etc. By ignoring interactions between the species (2), and of the species with the marine environment, the bio-economic models fostered:

- the reduction of the reality to a simple problem of revenue maximization (fishing management becomes a technical exercise – requiring the adjustment of fishing effort to the availability of the resource);
- the illusion of the simplicity of the functioning of the marine environment (the system is presumed to be in/moving towards equilibrium - and so fails to take into account resource variability over time and space and the diversity of living resources within an eco-system);
- the partitioning of reality (insofar as the biologist deals only with biological aspects such as stock recruitment, the economist deals with the economic agenda, while the manager assumes responsibility for the introduction of given policies);
- the mistaking of the object of fishing management (insofar as the focus became managing the species of commercial value - without considering the place of these species within an ecosystem).

The reductionism of contemporary management models therefore leads to an impasse. This impasse can be seen in the following diagram which presents, in a simplified manner, how fisheries are generally perceived by traditional managers, economists and biologists. Relations between the entities are unilateral. The government impacts on the fleet and their activities through management measures such as prohibiting certain types of gear, introducing quotas and setting total allowable catch quotas (TACs). It also acts in the market by means of regulations relating to food safety, food quality and/or price control. The ecosystem is reduced to a residual – to be impacted upon – as fish stocks fluctuate in line with the policies introduced.

FIGURE 1 about here

Such a perception of reality ensured that only costs of production, processing and marketing are considered (referred to henceforth as “production” costs). These costs are of a private nature and are the only ones incurred by producers - even if the productive activity generates a series of indirect effects, both on the marine environment and on civil society in general. Economists generally refer to these indirect effects as “externalities” (3). In the case of fisheries there are a number of such externalities which, while not integrated into the production sphere as private costs, are crucial for the well-being of the fishery.

In the economic and social sphere:

- The costs of fishing management (primarily research, design and application of management measures, control and monitoring) – which Arnason (1999) found reached 30% of the value of landings in the USA, and 25% of the value in Newfoundland.
- The public subsidy of fishing activity (this can take the form of financial support for the construction and modernization of boats, exemption from taxes and customs duties, state payments for access rights to the Exclusive Economic Zone (EEZ) of third countries, etc.) (OECD, 2000 and 2003);
- The opportunity costs related to the extraction of marine resources through fishing, rather than their exploitation in other ways (eco-tourism ventures, for example);

In the natural sphere:

- By-catch (Wiium [1999], for example, suggests that 14 kg and 7 kg of fish respectively are discarded as by-catch for each kilo of shrimps or octopi landed, by-catch being equivalent to as much as 26% of world landings).

- The destruction of natural services (oceanic function as a carbon and pollution "sink", the stability of the marine environment etc) which ensure marine patrimony.
- The destruction of particular properties and functions of the ecosystem (for example, Pauly, Christensen and Coelho [1999] and Curry, Shannon and Shin (2001) note how the over-fishing of certain levels of the trophic chain generates disturbances which are reflected through the whole ecosystem)
- Irreversibility of the damage caused (the resilience of the environment and ecosystems is very variable, and more sensitive systems may be irrevocably damaged – to the detriment of both current and future generations).

The market price is supposed, in standard economic theory, to act as indicator of scarcity (value) and as a behavioral signal. In the fisheries case, price can account for the increasing scarcity of the resource – but it will not be capable of securing the ecosystem against over-fishing of species. It does not therefore function as an effective mechanism regarding the incidence/impact of fishing - both at the societal and natural level - since it ignores or belittles the external costs of fishing activity. The limits of traditional fishing management approaches are therefore reached.

From the notion of value to the concept of social cost

An asymmetry develops between the use of marine resources as consumption products and as generators of environmental services due to the shortcomings of the market pricing system. Such a situation presents a very real challenge to the public authorities as inertia would almost certainly lead to resource overexploitation - and so it is consequently imperative to take affirmative action so as to compensate for the shortcomings of the market pricing system. In some instances, the creation of a market of negotiable quotas - starting from a given global quantitative constraint – can help reveal a market price which better reflects the marginal opportunity cost of the fishing activity. Yet the opportunity cost disclosed does not necessarily reflect the full value of the ecosystem, it merely provides additional information on one possible productive use of the eco-system. There is thus a gap between what the opportunity cost (marginal) of fishing suggests – and which managers use to optimize the allocation of resources - and external costs, as noted above. To remedy this we need to include prices reflecting all external societal and natural effects, but this requires knowledge of all the various use values which can be encountered in the marine environment. The diagram below tries to give an indication of these;

FIGURE 2 here

The marine environment delivers several broad services; the extraction of commercial and subsistence resources, the provision of factors of production, and ecosystem services. If the first two functionalities are measurable using indicators of price, the third is not so easily reducible to a monetary variable. Yet these services are of primary importance for the functioning of the marine environment and, in particular, the production of marine resources. Fortunately, it seems that there is a possibility of integrating those external costs (which contribute to the degradation of the ecosystem and its services) into an evaluation of the "true" cost of fishing policies through recourse to the notion of social – or societal -- cost. The concept of social cost, first enunciated by Pigou (1920) and subsequently developed by Coase (1960), was formulated to allow for the "internalisation" of externalities. They suggested that compensation was in order in those instances when the activities of economic agents caused a nuisance (externality) to the well-being of others. Although the concept of social cost as formulated by Coase and his successors only measured nuisance in human terms, we contend that the approach is equally applicable when considering disturbances caused to ecological systems.

However, taking into account the external effects associated with a fishing activity requires a change in our understanding of the operational dynamics of fisheries. The following diagram illustrates the complexity of incorporating such effects within the marine environment. Now a social request is added to the production demand of the fishery to reflect not just intergenerational concerns, but also current non-market values of the ecosystem (this includes the range of use values given in the right hand boxes of Figure 2). The ecosystem is thus a new actor in the fishery landscape. Formerly reduced to the various stocks exploited by the fishery, the ecosystem is now placed centrally within the landscape and viewed as having functions and properties which it is advisable to preserve (see Figure 3 below).

FIGURE 3 here

Thus, the analysis in terms of rights to pursue a certain strategy is simply one option within a portfolio of competing rights which, in the fisheries context, might include:

- the right to catch fish, and to reject/discard those which are not wanted (the by-catch);
- the right to continue fishing, despite evidence suggesting that stocks are being degraded/are in ill-health;
- the right to one to contribute to the loss of functionality of the ecosystem by destroying some of its properties, functions or elements.

The question then is the following: how is it possible to limit - even suppress - the rights of the ship-owners to degrade stocks and the ecosystem? The contemplation of a framework which integrates societal costs with a dynamic ecological model which reflects the relationships between the various trophic levels while contextualizing the economic drivers of fishing activity may then offer some prospects for capturing the non-market effects associated with the activity and, in this way, come to offer a better view of a complex reality.

Towards an economic and social extension of the ECOPATH-ECOSYM model

The Ecopath model, as delineated in this issue by Christensen, Aiken and Villanueva (2007), is a functional representation of the ecosystem which can be used as a starting point for developing a framework to evaluate the social cost of fishing activities and, more particularly, to inform development projects and management plans.

The basic idea is to apply the iterative process which characterises Ecopath as a method of measuring - in an incremental way - what occurs in the ecosystem when a fisherman uses a particular fishing gear (such as a trawl). The following figure shows the ecological costs that result from the first iteration.

FIGURE 4 fait

The costs related to the activities of management, the public subsidy of fishing activity etc. are costs which can be expressed in monetary form. They are thus easily added to the private costs. On the other hand, the reduction in the functionality of the ecosystem due to the use of trawl nets is more difficult to express in monetary terms. While it may be possible to allot a monetary value, this value is still likely to only capture those ecosystem goods and services which have a commercial value, and other non-market outcomes such as ecosystem degradation will continue to remain unpriced (and so undervalued).

It is of course possible to compare what the ecosystem in good health (situation before fishing) produces and relate this to the ex-post scenario of fishing and over-fishing to obtain the difference in expected incomes. However, a reduction in trophic levels (or a shortening of the food chain) can lead to an increase in biological productivity (Palomares and Pauly 2004), or even to the subsequent extraction of species such as shellfish or cephalopods with greater commercial value. Even here though, in simply conceiving of the ecosystem as a natural entity intended to produce fish for human consumption, we are guilty of disregarding its remit in the regulation of climate, the absorption of CO_2, etc. Thus, ecological costs related to the degradation of the ecosystem through over-fishing must ultimately be quantified if the resulting model is to be a robust one.

The renewal/continuation of fishing activities will be reflected (as shown by figure 5) by both an increase in private costs due to the increased scarcity of the targeted species (while this is compensated to some degree by rising sales prices, declining marginal elasticities of the demand will not fully offset the revenue loss), but also by ecosystem change.

FIGURE 5 here fait

The immediate consequence of such a situation, which is becoming increasingly commonplace across the world today, is that the cessation of fishing for a particular species – or at a particular level of the trophic chain – sees fishing effort redirected towards other species lower down the trophic chain. In other words, fishers target increasingly smaller and smaller species.

Modelling the complexity of ecological, economical and sociological interactions: model choice and the concept of societal cost

As mentioned earlier, in a market economy, the majority of goods and services are assigned by price. Price acts as a signal to producers and consumers and allows them to adjust their production and consumption decisions accordingly. It is an indicator of relative scarcity under conditions of current (and anticipated) supply and demand. However, the resources and services offered by oceans, and nature in general (fauna and wild flora, water, air, ecosystems, etc), are outside the market. They don't have a price. And, without a price indicating the importance of the sacrifices made in order to obtain or conserve them, economic agents have the tendency to presume that their price is zero. There are, as a consequence, innumerable instances where natural assets have been sacrificed because their intrinsic values have been ignored in economic calculations.

Yet if economists attempt to put a price on natural assets, philosophers urge them to exercise caution in seeking to quantify human perceptions regarding nature. If A. Sen (1987) has restored an ethical dimension to economics, Collet (2001 and 2002), R. Larrère (1994) and C. Larrère (1997) have pointed out the necessity to go a step further and analyse our relationship with nature – first by discarding dualistic approaches to human kind and nature (the intrinsic value of nature approach), and second by redefining the interactive relationship between humans and nature using the notion of ecocentrism. Under this more novel approach, the choices we make regarding how to utilize natural systems have fundamental implications for their maintenance, and ultimately therefore for the sustainability of the services they provide. That is why ethics is a key issue in marine natural resource management (see Collet's [2007] paper in this issue).

The choice of the model is fundamental to the management of natural resources. Until now, the main models used have been neo-classical models (initially developed by Gordon-Schaefer, later extended by Clark, Munro, Bjørndal, see Anderson (1986) for a general review). They are usually used to measure the economic effects of fishing activities through reference to the stock level and fishing capacities. The advantage of such models resides in their simplicity and transparency, it being possible to reproduce them once a certain amount of basic data has been collected, and they have been widely applied in Europe and throughout the world. While they have, in effect, "proved" themselves through such widespread use, such use has also highlighted their limitations - particularly as regards their (in)ability to give a complete picture of the full impact of fishing activities. Accounts of fishing's effect on the natural environment are either omitted completely, or considered solely in terms of the target species under consideration. The effects on the underlying ecosystem are never taken into account, consideration of their economic and social impact is limited to the creation of jobs, value added, and effect on public revenues – while the costs borne by civil society in management and/or restoring damaged ecosystems are invariably ignored (Failler and des Clers, 2002). The primary purpose of such models therefore is to consider the private profit involved, without taking into account the costs borne by society and the ecosystems themselves.

Since the beginning of the 1990s, new types of ecosystem models have emerged which provide a more comprehensive understanding of the structure, function, and regulation of major ecosystems (see Mann, 1988; Pahl-Wostl, 1993; and Gaedke, 1995, for example). Mass-balance biomass models (such as Ecopath and the inverse methods model) are being used globally to systematically describe ecosystems and to explore their properties (see Vézina and Platt, 1988; Christensen and Pauly, 1992 and

1993; and Pauly and Christensen, 1996). Mass-balance descriptions of trophic interactions between all the functional groups of the ecosystem recognise the complexity of the habitat and provide valuable information on the health of the marine environment.

Integrated economic-biological-ecological models have also been developed since the beginning of the 1990s. Integration is possible because of the predominant use of mathematics in biology, economics and ecology. Mathematical models are used to analyse and study relationships in each of the disciplines, and this commonality provides a conducive environment for integration. Linkages between the different disciplines generally precedes in one of two ways. One method is to extend the originally formulated model towards the other spheres and integrate the "foreign components" into a modified model which retains a degree of disciplinary bias. Ecologists, for instance, have developed what we might term "ecology-cum-economic" models that rely on the use of system dynamics to investigate how the ecological system behaves under a specified set of policy instruments. Economists, on the other hand, have produced "economic-cum-ecology" models to help determine optimal policy responses within a given system. However, while they have been diligent in modeling robust and dynamic economic systems, they have been as guilty as the ecologists in downplaying the dynamics of the "other" system. A second method is to construct a new model through interdisciplinary work, each discipline bringing its own tools and ideas into a common core framework. The consilience principle can also act as a bridge, helping to link facts and fact-based theories across disciplines so as to create a common groundwork (Wilson, 1998). Nevertheless, and despite the impressive recent advances in computer technology, truly integrative models have only been developed within the climate change community. Natural and marine resources management models are largely still designed according to neo-classical norms (4).

The ECOST model

The ECOST project attempts to move the discussion further forward, developing a methodology that can assist policy or decision makers in assessing fishery practice and thus inform fisheries management. Not only does it embrace the integrated assessment models developed over the last twenty years, it seeks to extend such models into the societal or social domain. It does this by constructing a new model through interdisciplinary endeavour, using the consilience principle as an analytic cement to fuse social, economic and ecological systems into an integrated assessment model that can address the interrelationships between the three systems while maintaining detailed disciplinary descriptions of each of the systems. Figure 6 below shows that the economic system consists of production, processing, and distribution. Production has an impact on the biomass of the species and thus affects the ecological system. While economic activity creates products, it also generates and distributes income among factors of production (incomes which are subsequently distributed among people). The distribution of personal income can have profound implications for the social system. Equally, fishing effort varies across fishing metiers and the selection (non-selection) of these will have differential impacts on the ecological system, employment and functional income in the sector, besides further affecting other parts of the economic and social systems.

FIGURE 6 here

The economic activity of fishing occurs because the social system demands the consumption of fish. The social system benefits from consumption of fish (social benefit of consumption) while incurring a number of operational costs - production, processing, distribution and service costs (economic cost of operation). The functional income distribution resulting from the fishing activity may disturb the social system, thereby imposing costs (social cost of disturbance). If the economic system intends to correct the disturbance, the correction introduces a cost (economic cost of correction), although socially the correction is beneficial (social benefit of improvement).

Equally, economic activity may lead to a degradation of the ecological system (ecological cost of degradation), as resource stocks are identified (economic benefit of exploration). If action is taken to reverse the degradation, costs will be incurred (economic cost of restoration), although the ecological system will benefit from ecosystem restoration (ecological benefit of restoration). In the absence of policies to reverse degradation, degradation (or depletion) may trigger greater fishing effort that reduces the social value of the marine environment, imposing further costs (economic and social cost of depletion). The ecological system can also benefit through resource protection or management (ecological benefit of protection or management). Figure 7 below summarises all these interactions.

FIGURE 7 here

Societal costs and benefits

While all economic costs can be measured in monetary terms, ecological cost is assessed through comparing current catches with historical levels of stock biomass, social costs are usually identified through indices such as the poverty index, consumption ratio, nutritional intake and gender (in)equity. Therefore in the ECOST model we seek to convert social and ecological costs into monetary terms using economic costs and benefits analysis. The equations below present the various variables and structural relationships that support the ECOST model.

Society = social system + economic system + ecological system

Societal benefit = social benefit + economic benefit + ecological benefit

Societal cost = social cost + economic cost + ecological cost

Then:

Net social benefits = social benefits - social costs

Net economic benefits = economic benefits - economic costs

Net ecological benefit = ecological benefits - ecological costs

Social benefits = social benefit (consumption) + social benefits (improvement of poverty, inequality, gender)

= value of consumption + economic costs (correction)

Social costs = social cost (disturbance) + social cost (depletion)

= economic cost (correction) + willingness-to-pay

Economic benefits = surplus

Economic costs = economic cost (operation) + economic cost (correction) + economic cost (depletion)

Ecological benefits = ecological benefit (protection) + ecological benefit (restoration)

= social cost (depletion) + economic cost (restoration)

= willingness-to-pay + economic cost (depletion)

Ecological costs = ecological cost (degradation)

= economic cost (depletion) + [net economic benefit with action – net economic benefit with rest] + [net social benefit with action – net social benefit with rest]

Household, employment and income

We break down the fishing sector into four constituent parts:

-Small-scale fisheries

-Industrial fisheries - workers

-Industrial fisheries - capitalists

-Government (representing the population outside the fisheries sector).

and fisher employment can be classified into 13 groups according to the nature of the productive operation:

(1) Production

-Small-scale fishers (m/f)

-Industrial fisheries - workers (m/f)

-Industrial fisheries - capitalists (m/f)

-Foreign fleets - government

(2) Processing

-Industrial fisheries - workers (m/f)

-Industrial fisheries - capitalists (m/f)

(3) Distribution

-Small-scale dealer (m/f)

-Retailers (m/f)

-Local wholesaler (m/f)

-Exporter

(4) Business services

-Small-scale worker (m/f)

-Industrial worker (m/f)

-Industrial capitalist (m/f)

Once population and employment are integrated into our model, we allocate incomes to each employment group (and also to each population group).

(1) Small-scale fisheries group average income:

N – population size

L – labour force employed

Y – total income

AY – average income

ss – small-scale

sf – small-scale fisher

sd – small-scale dealer

sw – small-scale worker

Then, total income: $Y_{ss} = AY_{sf} \cdot L_{sf} + AY_{sd} \cdot L_{sd} + AY_{sw} \cdot L_{sw}$

And, average income per labourer: $Y_{ss}^{L} = \frac{Y_{ss}}{L_{ss}}$

While average income per capita is: $Y_{ss}^{N} = \frac{Y_{ss}}{N_{ss}}$

(2) Group average income for industrial fishers (workers)

ine –industrial fisheries employee

ifw – industrial fishing worker

ipw – industrial processing worker

rt – retailer

is – industrial service worker

m - metier

Total income: $$Y_{ine} = AY_{ifw} \cdot L_{ifw} + AY_{ipw} \cdot L_{ipw} + AY_{rt} \cdot L_{rt} + AY_{is} \cdot L_{is}$$

Average income per fisherman across metier: $$AY_{ifw} = \sum_{m} AY_{ifw}^{m} \cdot L_{ifw}^{m}$$

Average income per labour unit: $$AY_{ine}^{L} = \frac{Y_{ine}}{L_{ine}}$$

Average income per capita: $$AY_{ine}^{N} = \frac{Y_{ine}}{N_{ine}}$$

(3) Group average income for industrial fishers (capitalist)

ik – industrial skipper

ipc – industrial capitalist (processing)

lw – local wholesaler

ex – exporter

isc – industrial service worker (capitalist)

Total income: $$Y_{inc} = AY_{ik} \cdot L_{ik} + AY_{ipc} \cdot L_{ipc} + AY_{lw} \cdot L_{lw} + AY_{ex} \cdot L_{ex} + AY_{isc} \cdot L_{isc}$$

Average income per skipper: $$AY_{ik} = \sum_{m} AY_{ik}^{m} \cdot L_{ik}^{m}$$

Average income per crew member: $AY_{inc}^{L} = \frac{Y_{inc}}{L_{inc}}$

Average income per capitalist: $AY_{inc}^{N} = \frac{Y_{inc}}{N_{inc}}$

(4) Government income from foreign fleets

P^{G} – price of access rights

Q^{G} - quantity of effort

Total government revenue from foreign fleets: $Y^{G} = P^{G} \cdot Q^{G}$

Per capita government revenue from foreign fleets: $AY^{N} = \frac{Y^{G}}{N}$

Social indicators

A number of social indicators – such as level of poverty, degree of inequality, gender inequity and the extent of food (in)security – can be derived with respect to these sectoral and employment groupings. In the case of poverty, we may use either Sen's "comprehensive" index or the FGT index (see 1 and 2 below); for inequality, we may use the Gini coefficient (see also 1 below); for gender inequity, we are currently exploring the benefits of using the ratio of total income [women] to total income [men and women] (see 3 below). In the case of food security, we are presently experimenting with the use of average fish consumption rates (see 4 below). These four individual measures can also be blended into a composite measure with given weights (see 5 below). The subsequent step will then require the development of a methodology that equates these social indices with the economic-ecology part of the ECOST model.

(1) Sen's 'comprehensive' measure of poverty (Sen, 1976)

Sen's poverty index is a comprehensive measure of poverty in the sense that it incorporates the numbers in poverty (poverty headcount), the extent to which the income of these poor individuals falls below the poverty line (poverty gap), and the degree of societal inequality. Let:

S – Sen poverty index

H – the poverty headcount ratio

I – the poverty gap (in percentage terms)

G – Gini coefficient of inequality

Then $S = H \cdot [I + (1 - I) \cdot G]$

S will always be between 0 and 1 (The closer to 1 is the index, the worse is the social situation).

(2) The FGT measure of poverty (Foster, Greer and Thorbecke, 1984).

The FGT poverty measure is also called the P-alpha poverty index, and is another comprehensive index. If α = 0, the P-alpha index reduces to the poverty headcount. If α = 1, it measures both the poverty headcount and the poverty gap. If α = 2, it reflects the poverty headcount, poverty gap and societal inequality.

Denote:

P_α – P-alpha poverty index

$\underline{AY}$ – poverty line

i – ith group

n – number of groups

$\alpha = 0, 1, or\ 2$

Then,

$$P_\alpha = \frac{\sum_i \left[\frac{(\underline{AY} - AY_i)}{\underline{AY}} \right]^\alpha}{n}$$

for all $AY_i < \underline{AY}$

(3) Gender development index

Many factors have been used to reflect women's lower social status, lower earnings level and reduced participation rates. The ECOST model presently seeks to capture gender inequity by comparing the total female income with total income (male and female) as this can represent the effects of both earnings and employment discrimination. Let then:

W – gender development index

Yw – total income of women in each group

Ym – total income of men in each group

i – ith group

So we have $$W_i = \frac{Y_i^w}{Y_i^m + Y_i^w}$$

The gender development index will be always between 0 and 1. In most cases it is likely to be below 0.5, although in cases where female employment is higher than male employment (which is often the case in the distribution part of the fish chain) it can exceed 0.5.

(4) Food security index

Fish consumption is an important indicator for food security, as it reflects the average nutritional intake of each individual in the society. As the current highest level of fish consumption in developed countries is below 50 KG per capita, we take 50 KG as a benchmark – and calculate the ratio of local per capita fish consumption to 50 KG. The ratio will lie between 0 and 1 (the closer the index is to 1 the better is the local food security situation).

F – fish consumption index

FC – average fish consumption of each fishery group in KG

i – *i*th group

50 – 50 KG consumption of fish

C – constant

$\overline{P}$ – average price of fish

$$F_i = \frac{FC_i}{50}$$

$$FC_i = C \cdot \overline{P}^{\alpha_1} \cdot AY_i^{\alpha_2}$$

(5) A composite measure of social wellbeing

The above indices (1-4) reflect - or measure - the status of a social system from differing perspectives. The advantage of a composite measure is that it can blend all these individual indices into a unified index that reflects societal change. However, blending should be exercised with caution.

Let then:

SI – composite social index

β – weight, and: $\beta_1 + \beta_2 + \beta_3 = 1$

We have $$SI_i = S_i^{\beta_1} \cdot F_i^{\beta_2} \cdot W_i^{\beta_3}$$

The composite social index will always be between 0 and 1 inclusive. However, values approaching 1 are not necessarily better (and, equally, values approaching 0 are not necessarily worse) but simply serve to indicate the aggregate nature of change. Examination of the individual social indices is necessary in order to evaluate the desirability of the societal changes that have occurred.

Conclusion

Ecological assets are common pool resources (public goods), although the consequent externalities associated with their use are not usually well accounted for in market mechanisms. In response, introducing the concept of societal cost into the policy debate demands the capture (and hence allows the internalisation) of these externalities. However, the notion of societal cost is not widely addressed in the scientific literature. While Nadav (2000) and Garcia-Alte, Olle, Antoñanzas and Colom (2002) have employed the concept to discuss sociological change at the societal level, we contend that it should take a broader meaning. Not only should it embrace; (i) "total economic value" - the measurement of the monetary and non-monetary values of the services rendered by the environment (actual use value), of services that it may potentially be able to render in the future (optional value) and the value of the existence of the former (existence value) (Pearce, 1996); but also (ii) the "marginal cost of replacement" - the cost of replacing the services currently provided by a piece of nature (Arrow, K, G. Daily, P. Dasgupta, S. Levin, K.-G.Mäler, E. Maskin, D. Starrett, T. Sterner, T. Tietenberg , 1999); and (iii) the functional value of a species in an ecosystem - and the function of one particular ecosystem within the wider ecosystem (Christensen and Pauly, 1993). Thus, the societal cost can be interpreted as a shared concept uniting ecology, economics and sociology.

The concept (societal cost), we contend, can be beneficially employed in helping to analyse - and then address - some of the common issues that fisheries in West Africa, South-East Asia and the Greater Antilles are facing, namely:

- The (surplus) capacity of the fishing fleets operating in national and international waters (Chavance, Bâ et al. 2004);
- The loss of biodiversity and biomasses (Christensensen, 2004) that has occurred over the last 50 years;
- Increased poverty – either at the local level [in fishing communities] or at the national level [proxied by an increase in external indebtedness] (Failler and Kane, 2003; Kaimowitz, Thiele and Pacheco, 1999; Kessler and Van Dorp, 1998; Muradian and Martinez-Alier, 2001);
- * The introduction of fishing management practices designed to resolve the problem of over fishing – but which, in doing so, raise the cost of fishing activities, erect barriers to entry into the fishery, and create a dependence on subsidies (Tietenberg, 2003).

The dimension of the fishery problem can no longer be confined to a local level. As Kurien (2003) pointed out:

"the macro trend of globalisation and the counteracting micro trend of localisation in many 'tropical-majority' world countries give rise to the need for new approaches to governance at both levels". p. 10.

ECOST – the project and its end-product (the ECOST model) – is intended to help address this. Central to the project is the logic of the Johannesburg Plan of Implementation (JPoI): to restore as much as possible marine ecosystems by 2015, a logic that is also in accord with the philosophy of the Code of Conduct for Responsible Fisheries (Doulman, 2007). To meet this challenge, the project mobilises, on top of the sixteen renowned scientific organisations entrusted with carrying out the applied research, seven regional and international UN development and management organisations. It also maintains close links to key NGOs in order to facilitate interaction with social actors and the dissemination of findings and policy prescriptions to the various levels of decision-making (local, national, regional and international). In this way, the concept of societal costs – which this paper presents preliminary sketches thereof – trekked through fishing activities and fishery policies, will contribute to the more effective management of the oceans.

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Notes

(1) In the West African case, see the results of the Project of co-operation "Fishery Information and Analysis System" at: http://www.ird.sn/activites/sih/symposium /

(2) See Curry, Shannon and Shin (2001) for a complete presentation of the functioning of ecosystems and relationships between species.

(3) Externalities occur when the action of one agent impacts on the wellbeing of other agents (and such agents are not compensated for this impact via the market). Externalities can be positive (effect of a vaccination campaign for example), or negative (pollution for example) (Boncoeur et Olivier, 1996).

(4) One exception to this is the attempt made by the European Project PECHDEV.

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