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Proceedings of the INCO-DC International Workshop on Markets, Global Fisheries and Local Development

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Preface

This proceedings contains most of the papers presented at an European Commission (EC)-sponsored international workshop held on March 22 and 23, 1999 at the Chr. Michelsen Institute (CMI), Bergen, Norway. The editors made it a point to include all the papers presented and made available to them by the participants at the workshop, after undertaking the usual editorial work.

The interesting discussions at this workshop mark the beginning of an important and policy relevant dialogue of topical issues in the interface between globalisation, markets and local development. It is the intention of the participants to continue this dialogue in a constructive manner well into the future. Interested readers may contact the authors, details of whom are given at the back of the report.

We take this opportunity to thank the European Commission for funding the workshop through an Accompanying Measure under the INCO-DC Programme. Thanks also to the Chr. Michelsen Institute who hosted the event, and for the organisation of the workshop. Finally, we wish to thank all the participants for their enthusiasm, and for engaging a very lively and intense debate at the conference.

The Editors

ACP-EU Fisheries Research Report Series

The ACP-EU Fisheries Research Reports is a series of publications that aim to share information about the development of the ACP-EU Fisheries Research Initiative and findings generated in order to maximise the impact of its activities. It includes proceedings of workshops and meetings, statements on policy and research activities under the Initiative.

Abstract

This report presents the papers discussed at an EC/INCO-DC-sponsored international workshop 'Markets, Global Fisheries and Local Development' held on March 22 and 23, 1999 at the Chr. Michelsen Institute (CMI), Bergen, Norway. The main objective of the workshop was to initiate a debate on how markets impact on global fisheries, and how these in turn impact on the ability of developing fishing nations to improve the welfare of their citizens. The motivation for the workshop stems from the observation that over time two things have happened to the world's fishing sector. First, through improvement in fishing technology and the activities of distant water fishing fleets, fish exploitation and harvest have become global. Second, with significant technological improvements in the handling, processing and transportation of fish products, the markets for fish products have also became global such that fish caught off Mauritania, for instance, may end up in the plates of people living thousands of kilometres away. These two developments raise immediate questions that need to be explored systematically, which is exactly what this seminar sought to initiate. Hence, the meeting explored three inter-related issues: the effects of globalisation of fish exploitation and marketing on the sustainability of world fisheries, the consequential effects on the development of fishing nations, and third, the potential incorporation of economic data into existing database and analytical tools (FishBase and Ecopath/Ecosim) that will enable us to explore these questions globally.

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Table of Abbreviations

ACP-EU	Development co-operation between African, Caribbean and Pacific (ACP) countries and the European Union (EU) and its member states in the framework of the Lome Convention.
CPF	Common Fisheries Policy of the European Union
CRODT	Centre de Recherches Océanographiques de Dakar-Thiaroye, Senegal
DWF	Distant Water Fleet
EC	European Commission
EEZ	Exclusive Economic Zone
FAO	Food and Agricultural Organization of the United Nations
FIAS	Fisheries Information and Analysis System
HACCP	Hazard Analysis and Critical Control Points
ICES	International Council for the Exploration of the Sea
ICLARM	International Center for Living Aquatic Resources Management
INCO-DC	International Cooperation in Science and Technology with Developing Countries
IPIMAR	Instituto de Investição das Pescas e do Mar, Lisbon, Portugal
ISSCAP	International Standard Statistical Classification of Aquatic Animals and Plants
ITQ	Individual Transferable Quota
JRC	Joint Research Centre of the EC
MSC	Marine Stewardship Council
NGO	Non-governmental organisation
TAC	Total Allowable Catch
UK	United Kingdom
UNCLOS	United Nations Conference on the Law of the Sea

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Introductions

Executive summary

A two-day international workshop was convened with the support of the EC (INCO-DC Programme) and the Chr. Michelsen Institute, Bergen, Norway, to discuss how the globalisation of fish markets may affect the development prospects of developing fishing nations. This report includes eleven articles presented at the workshop. The papers address a wide range of issues related to the topic of the workshop.

The report starts with two papers (Asche and Bernard; Asche and Hannesson) that investigate whether there is indeed a global market for fish and fish products. These papers come to the conclusion that it is indeed possible to speak of a global market for fish such as whitefish. During the last decades there has been a substantial increase in the trade of seafood, as the world's markets have become more integrated. A good part of this increased trade is due to increased exports from developing to industrialised countries. The next set of papers provides case studies of the impact of markets on fisheries in Africa and Latin America. Bøe explores the co-existence of variable prices with stable consumer prices in the market for 'kapenta' in Zambia. She concludes that the different price variability observed is due to different market characteristics in the consumer and producer markets. Deme analyses the impact of artisanal fishery effort redeployment towards species destined for foreign markets and the consequences on fishery resource sustainability and home market supply. He concludes that the orientation of the artisanal fishery towards foreign markets coupled with the free access to the fishery has caused an increase in the artisanal fishing effort already judged to be excessive for some species, particularly the demersal species. Charting the impact that the globalisation process has had upon the exploitation and sustainability of fish stocks in Latin American waters, Thorpe and Bennett argue that while globalisation may indeed boost environmental awareness and lead to more sustainable harvests through the decreased influence of local political interests, this has yet to happen in Latin America.

The next two papers are concerned with data needs for the analysis of the impact of global markets on fisheries management. Sumaila and Bawumia outline how to develop a detailed economic database for Fishbase, a biological database on finfish developed through a global collaboration (see www.fishbase.org). They also present a method, based on demand composition analysis, for tracking the flow of fish landings around the world. Lopes Garcês provides an inventory of socio-economic information needs to help the decision making process of regional agencies in the fisheries sector.

Finally, a set of four papers explore the application of ecosystem models in global fisheries analysis. Chuenpagdee and Vasconcellos present a simple and straightforward approach, known as the damage schedule, as a tool that allows an ecosystem to be evaluated using ecological, economic, and socio-cultural importance as criteria. The authors present an exploratory study to test the applicability of the damage schedule approach to evaluate the importance of the Eastern Bering Sea ecosystem. Coelho and Stobberup present a proposed project that seeks to extend work from the FIAS project in Northwest Africa. They intend to include socio-economic indicators in relation to the ecosystem in their study. The next paper by Vasconcellos and Chuenpagdee provides an overview of the ecosystem impacts of fisheries

(capture and aquaculture), which could guide the development of a framework for assessing the effects of globalisation of exploitation and marketing on the sustainability of fisheries. The last article given by Vasconcellos and Sumaila, introduces some of the concepts of mass-balance assessment and ecosystem modelling with the Ecopath/Ecosim software, and provides an illustrative example of the use of this approach in the analysis of the ecological and economic impacts of fisheries in the Eastern Bering Sea.

Foreword

Globalisation is not a new phenomenon but its current phase is characterised by unprecedented scale and pace, primarily due to revolutionary changes in communications and information technology. For such reasons, the agenda of development, both institutional and intellectual, will, for the next many years, be largely established on the axis of a debate about globalisation. This will include fisheries where we have seen not only that fish exploitation and harvest has become global due to technological improvements and the activities of distant water fishing fleets, but also, increasingly, that markets for fish products have become truly global, again due to major technological advances in the handling, processing and transportation of fish products.

Globalisation, however, is not a single set of processes, nor does it lead in a single direction. The phenomenon from which the globalisation metaphor derives is based on different and distinct happenings in countless separate places. It produces multiple outcomes, different responses, new institutional arrangements, a complex variety of coping strategies, winners and losers, solidarity in some places, their absence or destruction in others. What is required, therefore, is intensive and serious scholarship to increase our understanding of the complex and subtle ways in which the global, the regional and the local interact, influence one another and establish both synergies and conflict in a world which is still heterogeneous but rapidly changing. For such research, local and place-specific appreciation of reality must be a foundation stone of scholarship, combined with the understandings and techniques that link those micro appreciations to the larger contexts. It is also important to recognise that globalisation should not be understood as wholly an economic concept. Rather, the essence of globalisation must be searched for in the sphere of relationships.

Something is global because it is generated and maintained through relationships that connect, combine and direct the use of resources located in various parts of the world. Through such processes, global trends emerge, including eating habits, styles in dress, sports and music. Thus the marketing of fish products is closely connected to such global trends (e.g. the increasing popularity of Japanese sushi, the growing consumption, in new markets, of smoked salmon).

At the Chr. Michelsen Institute, we strive to encourage more research on such and similar issues. It is, therefore, a great pleasure for me to introduce this collection of papers, which deal with various aspects of global fisheries analysis, based on an EU-sponsored international workshop held at the Institute on March 22-23, 1999.

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Fisheries and internationalisation of markets[a]

Frank Asche[b] and Pascal Bernard[c]

Abstract

During the last decades there has been a substantial increase in the trade with seafood, as the world's markets have become more integrated. A large part of this increased trade is increased exports from developing countries to industrialised countries. In this paper some stylised facts about the trade is given, and a discussion of the causes and effects of trade is provided using a simple economic model. As trade value has increased much faster than traded volume, trade has at least in aggregate been beneficial to all trading countries. However, some groups within each country will, at least, in the beginning lose due to the trade.

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1. Introduction

Fish has been a major traded commodity for more than a thousand years. As such, trade with fish has influenced living conditions and policy issues for just as long. An important characteristic of goods that are traded is that they must be transportable and conservable for at least the transportation time.[1] The traded fish has therefore, for most of this time, been dried or dried and salted, since this is the best traditional preservation methods, and also because it reduces the weight of the fish substantially.

However, even though there has been a substantial trade with fish for a long time, in most places local fishers have been the most important providers of fish. In particular, local fishers have been without competition in the most valuable market — the market for fresh fish. Hence, even for the same species there has mostly existed separate local and regional markets, where prices have been determined by local supply and demand. Abundance of fish and low prices in one market has not meant anything for the price in other markets.

During the last decades this picture has changed substantially. Increased fishing efficiency has led to increased supply. Total seafood production is currently well above 100 million tonnes. Furthermore, changes in the institutional framework, and particularly the introduction of the 200 miles Exclusive Economic Zone (EEZ), has given coastal nations control over most fish stocks.[2] However, most important for the increased trade are improvements in conservation and transportation methods. This has created one integrated world market where there used to be many independent regional and local ones. This has led to new opportunities and challenges for fishers and the seafood industry all over the world as one has gained access to new markets, but also faces competition from new sources.

In this paper we will look into how the trade with fish has developed and the economic mechanisms behind this. We will be particularly concerned with the relationship between industrialised and developing countries. In Section 2, an overview of the most important developments for the growing trade with seafood is given. In Section 3, we present some statistics both to get a snapshot of the trade and its development since the mid-1980s. In Section 4, we present some theoretical models for what has been going on. This enables an analysis of costs and benefits of trade, and a discussion of expected future developments. In Section 5, discussion and concluding remarks are provided.

2. Background

From the turn of the century, technological improvements have substantially increased harvesting capacity. This has led to increased landings, but also to the possibility that harvesting might lead to extinction of or serious damage to fish stocks. The need to protect fish stocks led to the creation of EEZs, where coastal nations got an exclusive right to manage the resource within their EEZ. The most important step here was the creation of the 200 miles EEZ in 1977, after the Law of the Sea conferences. Both the increased landings and the EEZs have been important for the increase in trade with seafood products. Many fish stocks exist in waters close to rather remote regions, and as harvests increase, these regions, because of their size became increasingly became increasing unable to absorb their landings in profitable way. As such, distant markets are almost as important for increasing fishing effort as improved technology. However, distant resources need not create trade. Distant water fleets might well supply their home markets. However, the introduction of the 200 miles EEZ did, to a large extent, prevent this as most fish stocks are found within the EEZs. As most coastal nations exclude foreign fishers from their EEZ,

[1] See e.g. Kurlansky (1997) for a very entertaining account of the cod trade, which during the middle ages was the major traded seafood commodity.

[2] Munro (1996) gives a brief account of the developmen of fisheries regulations and the Law of the Sea.

this increases the likelihood for trade. In addition to the creation of the EEZ and the increased catches, trade has also been eased by the removal of trade barriers following international treaties like the GATT and the creation of the WTO.

During the last century, both conservation and transportation methods have been revolutionised. Conservation methods improved remarkably in the 19th century. A Frenchman, Nicolas Appert, invented canning in 1809, and although it took some time before this innovation was commercially utilised, a substantial canning industry for fish was established in many places by the end of the century. However, while canning increased trade with fish, it did not affect local fish markets to any extent, as canned fish rather was a new product, and not sufficiently similar to fresh fish to be a close substitute. As such, canning was mostly an improvement for large seasonal and remote fisheries, as it improved the quality and/or reduced the cost of storing fish so that one could reach new markets.

Freezing was the next revolution when it comes to conservation, and brings the conserved product closer to fresh fish. However, the difference is still large enough to question whether frozen products are substitutes to fresh fish. Moreover, while frozen fish certainly has opened up new market segments, it is also a more expensive technology of conservation, since one must operate a freezer to continue to conserve the product. Freezing as a conservation technology was also important for increasing supply, since it increased the quality of the product that distant water fishing fleets could supply.

New means of transportation have both increased speed and reduced cost. This might be the most important source for the increased growth with seafood. Transportation is now so inexpensive for conserved products that, distance means virtually nothing if one has access to a harbour. For instance, to move a kilo frozen Norwegian salmon cost less then 20 cents to any major harbour in the world, and it is not very much cheaper to move it to another part of the country. The most expensive part of the transportation might be the first stretch, as a transporter does not like to go in one direction without cargo. It is therefore a problem for Maine salmon farmers that there are no big cities in Maine, and a substantial part of their transportation cost is accordingly to get the fish into the major transport system in the US (Boston). In fact, because of the relative remoteness of Maine, it tends to be cheaper to transport Canadian salmon to Boston than to transport it from Maine, even though the Canadian salmon travels a longer distance. Air freight of fish has also been increasingly common, as transportation costs even for this kind of transportation has come down to a level which makes this a feasible alternative, at least for more valuable fish.

The reduction in transportation costs has removed most of the barriers that earlier prevented trade with seafood, and therefore created one integrated market where there used to be several regional ones. This has led to new challenges and opportunities for fishers and the seafood industry all over the world, as one has gained access to new markets, but also new challenges as one faces competition from new sources.

3. Stylised facts

Total world catch of fish and other seafood including aquaculture production is shown in Table 1. The catch, or production, is still increasing, but this is mostly due to aquaculture. Most fisheries are now fully utilised, so it is not likely that landings will increase very much in the future. We might still see some increase in seafood production, as aquaculture production is likely to grow. From Table 1, one can also see that the quantity of fish that is used for reduction (which is 99% of the other category) is rather constant, between 25 and 30 million tonnes, so that the increase in catches is mostly used for human consumption. It is also evident from Table 1 that a major share of the total supply of fish is traded. In 1996, almost 37% of total catches were traded. 1994 turns out to be the year when the traded share was highest at more than 40%. This has increased from 33% (*or 29%? I see 29% in the table*) in 1984.

In Table 2 we show the development in the use of the catches by the product form. It is clear that the share that is sold fresh has increased substantially over the period, from 19.2% in 1984 to 32.3% in 1996. Fresh is the only product form that has substantially increased its share of the catch. The share of the catches that is sold as frozen and cured has remained rather constant, while the share of canned fish and reduction has declined. This is to a large extent what we will expect both because of aquaculture's increasing share of total production and because of better transportation and conservation methods, since fresh fish tends to be the most valuable product form.

Table 1. World catch of fish and trade (1 000 tonnes)

Year	Total	Human consumption	Other	Trades	Trade as % of total catch
1984	83851	57949	25902	24233	28.9*
1985	86335	59750	26585	27282	31.6*
1986	92754	63722	29032	29218	31.5*
1987	94298	66252	28046	30647	32.5
1988	98890	69327	29563	31862	32.22
1989	100115	70333	29782	34530	34.49
1990	97432	69840	27592	32698	33.56
1991	97402	69110	28292	33253	34.14
1992	98785	70889	27896	33458	33.87
1993	101418	73388	28030	37727	37.2
1994	113458	79992	33466	46087	40.62
1995	117278	86494	30784	44507	37.95
1996	121010	90616	30394	44253	36.57

* interpolated based on the 1996 numbers, since there is a jump compared to earlier statistics from 1986 to 1987. In the earlier statistics trade as share of total catch was a few percentage points higher. For instance, in 1994 the old statistics reported that trade was 43.84% of total catch.

Source: FAO Fisheries Statistics: Commodities

In Table 3 and 4, we show the development in total real export value and export and import value from industrialised and developing countries. The first thing that is evident is that trade has increased substantially also in value. In real terms, the value of trade increased by 119% from 1984 to 1996 when measured as imports and 115% when measured as exports. As the increase in traded quantity is only 26%, value increase much faster then quantity. This is what we would expect since an increased share of the catches is consumed as fresh, the most valuable product form, as indicated in Table 2. Moreover, as a crude estimate of the global demand elasticity for fish and seafood this might also indicate that demand is very elastic, indicating that there is still a substantial scope to increase trade value.

The share of imports to the industrialised countries is fairly constant at about 85% of all imports. As such one can say that most seafood exports end up in the industrialised countries. When we look at the exports, it is clear that an increasing share of the worlds traded fish comes from developing countries. In 1984, 44% of all exports came from developing countries, while in 1996 this had increased to about 50%.

Table 2. Shares (in %) of total catch by use.

	Human consumption				Other	
Year	Fresh	Frozen	Cured	Canned	Reduction	Miscellaneous
1984	19.2	24.7	11.6	13.6	29.3	1.6
1985	19.8	24.3	11.8	13.3	29.4	1.4
1986	21.1	24.2	11	12.4	29.6	1.7
1987	24.1	23.7	10.7	12.3	27.6	1.6
1988	24.7	23.6	10.2	12.1	27.8	1.6
1989	23.8	23.7	10.4	12.4	28.2	1.6
1990	23	24.8	11	13.1	26.7	1.5
1991	22	24.6	11.1	13.3	27.4	1.6
1992	25.7	24.3	10	12.3	26	1.8
1993	25.3	24.8	9.9	12.2	26.1	1.7
1994	25.8	23.6	9.8	11.2	27.9	1.6
1995	29.5	23.3	10	10.9	24.7	1.5
1996	32.3	22.8	9.6	10.3	23.5	1.6

Source: FAO Fisheries Statistics: Commodities

4. Trade models

We will here describe the situation for fishers that face export competition and fishers that are potential exporters using simple economic models in a graphic presentation. We assume that the products we are looking at are identical independently of whether they are consumed locally, exported or imported. As such, we treat all price differences between different markets as caused by transportation costs. While this is not a very realistic assumption, it still gives the key insights that are of interest here. More realistic assumptions will mainly give a more complicated presentation without providing any substantially different insights. For the species where one has investigated the degree of integration, whitefish and salmon, one clearly concludes that there is a world market.[3] We will therefore always assume that the potential competitor or the potential new market is the world market. As most local markets will be relatively small compared to the world markets, we assume that the agents in these markets take the world market price as given.[4] Initially, we also assume that the fisheries in question are well managed, so that the part of the supply schedule that are potentially backward bending is irrelevant.

Table 3. World imports of seafood.

	1 000 000 USD (1990=1)			Shares	
Year	**Total**	**Industrialised**	**Developing**	**Industrialised**	**Developing**
1984	21603	18497	3106	0.86	0.14
1985	22585	19548	3037	0.87	0.13
1986	28917	25235	3681	0.87	0.13
1987	35043	30728	4315	0.88	0.12
1988	38963	33758	5205	0.87	0.13
1989	37765	32421	5344	0.86	0.14
1990	39562	34380	5182	0.87	0.13
1991	41854	35913	5940	0.86	0.14
1992	42267	36034	6232	0.85	0.15
1993	40359	34326	6034	0.85	0.15
1994	45411	38547	6863	0.85	0.15
1995	48055	40366	7689	0.84*	0.16*
1996	47363	40258	7105	0.85*	0.15*

Source: FAO Fisheries Statistics: Commodities (*FAO Fishstat plus data base)

[3] See Gordon and Hannesson (1996), Asche and Sebulonsen (1998) and Asche, Bremnes and Wessells (1999).

[4] This is basically the same as assuming that the local agents do not have market power on the world if they coordinate their actions.

Table 4. World seafood exports.

	1 000 000 USD (1990=1)			Shares	
Year	**Total**	**Industrialised**	**Developing**	**Industrialised**	**Developing**
1984	20367	11392	8975	0.56	0.44
1985	20944	11757	9187	0.56	0.44
1986	27338	15001	12337	0.55	0.45
1987	32115	17602	14514	0.55	0.45
1988	35154	19043	16111	0.54	0.46
1989	33759	18056	15703	0.53	0.47
1990	35731	20132	15599	0.56	0.44
1991	37335	20325	17010	0.54	0.46
1992	37446	20165	17281	0.54	0.46
1993	37536	19158	18379	0.51	0.49
1994	41401	20437	20964	0.49	0.51
1995	44135	22067	22068	0.50	0.50
1996	43693	22283	21410	0.51	0.49

Source: FAO Fisheries Statistics: Commodities (*FAO Fishstat plus data base)

Let us then first start with a country that is a potential importer of fish, i.e. an industrialised country (see figure 1). Here, the demand schedule D gives local demand. It is downward sloping since consumers will buy more fish (or any other commodity) the lower the price. The supply schedule S1 gives local supply and is upward sloping, since it will be profitable *cet. par.* for producers to increase production only if the price increases.[5] If this is a truly local market, there is no demand or supply from other sources. The transaction price and quantity is then determined by the intersection of the two schedules and gives the market price P_1 and the quantity Q_1.

[5] The supply schedule needs not be upward sloping if there is increasing returns to scale. However, it is highly unlikely at the production levels where most fisheries operate.

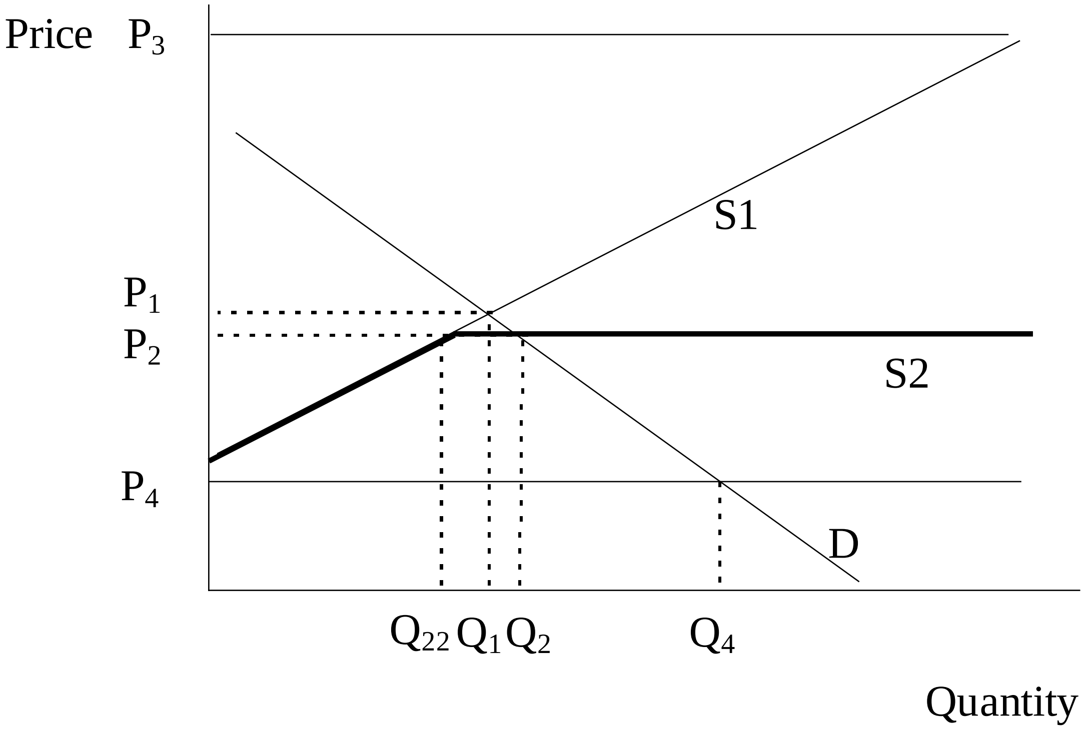


Figure 1. Demand and supply for potential importer of fish.

That there is no supply from the world market, implies that transportation costs makes the price that the world market can supply this local market so high that no one is interested in importing fish when the local supply is available. A possible world market supply for this scenario is illustrated in the figure by the supply schedule at the price P_3.

Assume than that there is a reduction in transportation costs so that the world market price including transportation costs is reduced to P_2. Up to this price level, the relevant supply schedule is still S1, or the supply by local fishers. However, at this price one can buy as much fish as one wants at the world market price, so local fishers will therefore not be able to sell any fish at a higher price. The supply schedule therefore has a kink at this price, as shown by the supply schedule S2 in the figure. In the scenario drawn in Figure 1, at the price P_2, total quantity sold will be Q_2. The quantity supplied by local fishers is Q_{22}, and the imported quantity is Q_2-Q_{22}. Since the quantity Q_{22} is less than Q_1, the imports leads both to a reduction in the quantity supplied by local fishers and a reduction in the price they receive for their catch. Hence, also their income will fall. If the world market price decreases to lower levels, the kink will be at lower price levels, and imports' share of the consumption will increase. The final supply schedule that is drawn in Figure 1 is for the world market price of P_4. At this price all fish in this market will be imported, and the quantity sold is Q_4.

Let us then look closer at a country that is a potential exporter of fish, i.e. in most cases a developing country (see figure 2). Here, the supply schedule S gives the supply by local fishers, and the demand schedule D1 gives local demand. If this is a truly local market, there is no demand or supply from other sources. The transaction price and quantity is then again determined by the intersection of the two schedules and gives the market price P_1 and the quantity Q_1. That there is no demand from the world market, implies that transportation costs makes the price at which local fishers find it profitable to supply the world market so low that no one is interested in exporting fish. The world market demand for this scenario is shown in the figure by the demand schedule at the price P_3.

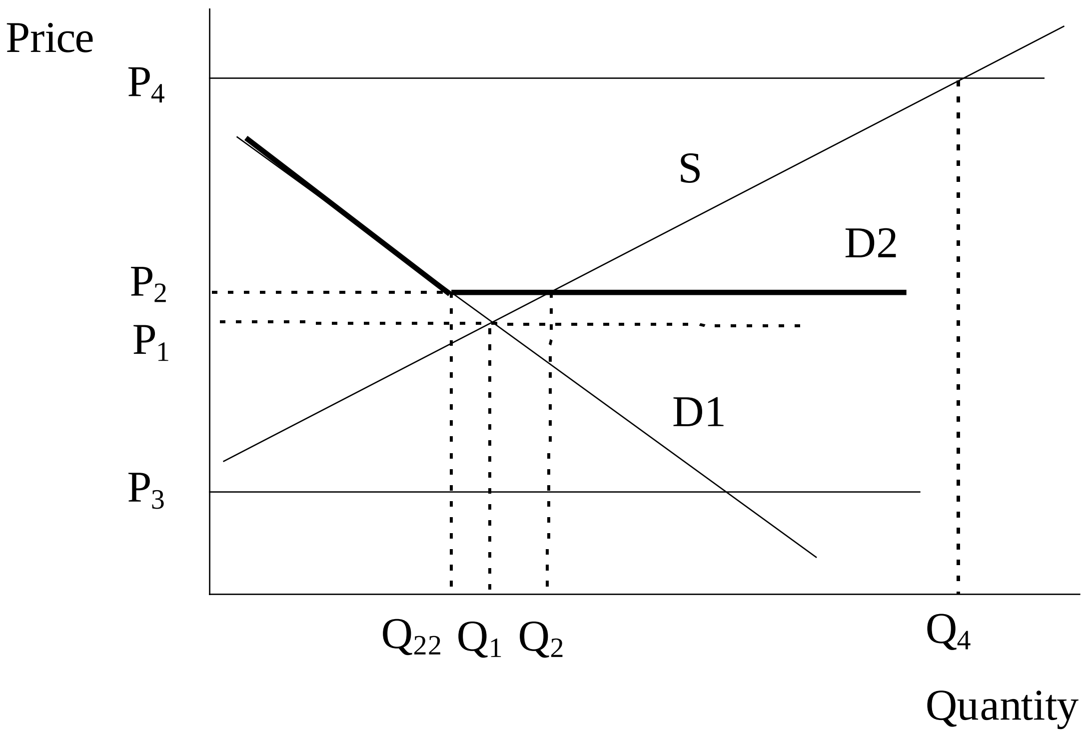


Figure 2. Demand and supply for potential exporter of fish

Assume then that there is a reduction in transportation costs so that the world market price for local fishers is increased to P_2. Down to this price, the relevant demand schedule is still D1, or the local demand. However, at this price one can sell as much fish as one wants at the world market price, so local fishers will therefore not be willing to sell at the local market for a lower price. The demand schedule therefore has a kink at this price, as the demand schedule D2 has in the figure. In the scenario drawn in Figure 2, at the price P_2, total quantity sold will be Q_2. The quantity sold locally is Q_{22}, and the exported quantity is Q_2-Q_{22}. Since the quantity Q_{22} is less than Q_1, exports leads to an increase in their landings, to a reduction in the quantity supplied to the local market and an increase in the price that fishers receive for their catch. Fishers's income will therefore also increase. If the world market price increases to higher levels, the kink will be at higher price levels, and a larger share of the catch will be exported. The final demand schedule that is drawn in Figure 1 is for the world market price of P_4. At this price all fish from these producers will be exported, and the quantity sold is Q_4.

The scenarios in Figures 1 and 2 are basically mirrors of each other. When one starts with a truly regional market, this is not linked to the world market either because the price that local fishers receive is too high compared to what they can get at the world market or because the price that local consumers are willing to pay is too low for the world market. As the wedge that transportation costs drive between local and global markets becomes smaller, the local market might become a part of the global market. When this happens, it is also possible that all locally produced fish will be exported or that all consumption is imports.

Moreover, when imports start flowing in to a formerly local market, local fishers will see that the quantity they sell will decrease, as will the price they receive. Hence, their income will fall, and one will see that employment in the fishing sector of the importing country falls. However, consumers will gain, as they can consume a higher quantity at lower prices. In the exporting market, fishers will see their prices increasing, and will respond by increasing landings. As such, fish revenues will increase. However, the price of fish at the local market will increase relative to other goods, and the consumers will find that their real income has decreased.

Most introductory texts in international economics will show that on the balance, trade increases social welfare, since the gainers are always able, at least in principle, to compensate the losers from trade so that their utility is not diminished.[6] As such, the main story is that in countries where fish imports increase due to trade, the society is better of, but the number of people employed in the fishery is reduced. In exporting countries the society is again better of, as the fishers increase their income, but everybody else is worse off since their real income is reduced. Hence, despite trade being welfare increasing for the society as a whole, some groups will lose. Unfortunately, this is an unavoidable part of economic progress. Moreover, since markets are likely to continue to integrate, one will expect trade with fish and seafood to continue to increase.

The assumption of well-managed fisheries deserves further comments, since this is obviously not true in many cases. In countries where the fisheries are not industrialised to any extent, this does not create any substantial problems for the results from the model. However, for countries where the fishing technology used is powerful enough to fish the stock down bellow the level that gives Maximum Sustainable Yield (MSY), this might create some problems. This is because the supply schedule will then be backward bending, and further price increases will lead to a lower level of landings. This situation is illustrated in Figures 3 and 4.

In Figure 3, we show the situation for a potential importer of fish. The supply schedule for local fishers is S1, while the supply schedule when local fishers compete with imported fish is S2. We see that the price is reduced when imports are coming in, and that landings from local fishers are also reduced. As such, the conclusions here are not affected by the introduction of the backward bending supply schedule. Note that if the original local price is higher, this will not affect this conclusion. Hence, an importer of fish will always benefit by increased trade. However, it should be noted that in industrialised countries, who are the main importers of fish, a substantial part of this potential gain is wasted by subsidisation of their fishers.[7]

[6] See e.g. Krugman and Obstfelder (1994). With well managed fisheries this is also shown more rigorously by Hannesson (1978).

[7] For an overview of the enormous subsidies provided to the world's fisheries, see Milazzo (1998). Hatcher and Robinson (1999) is also of interest in this context.

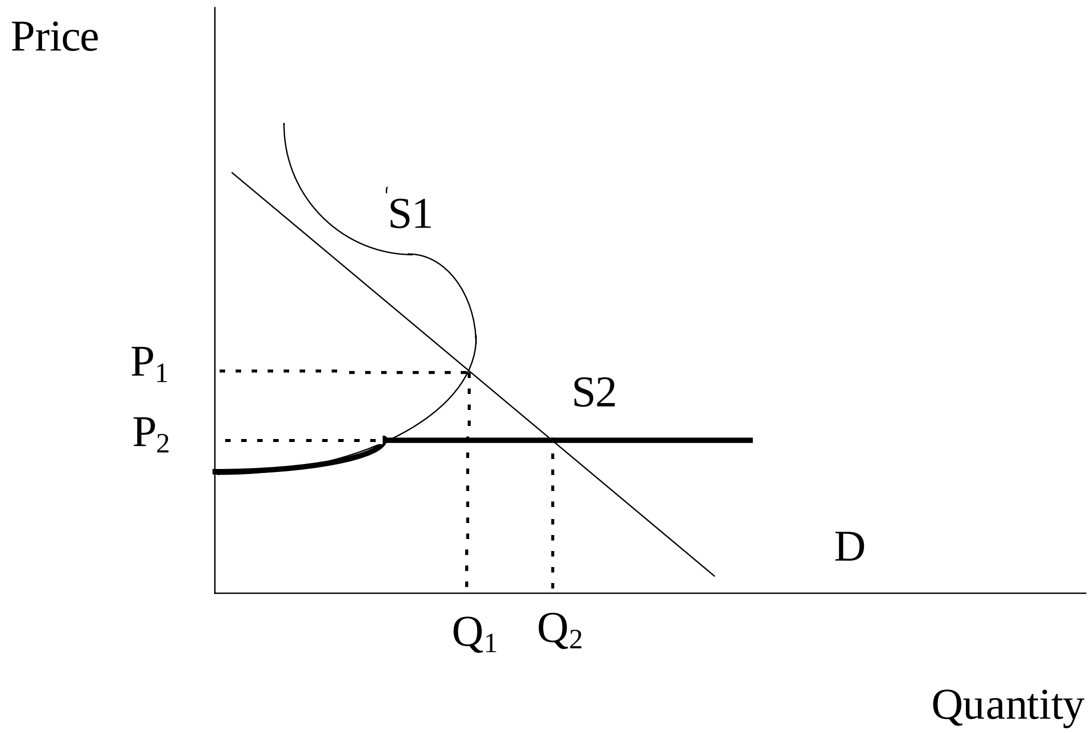


Figure 3. Demand and supply for potential importer of fish, indicating the competition of supply by local fisher and importer

In Figure 4, we show the same scenario for a potential exporter of fish. Here, the picture is somewhat different. The supply schedule S, is backward bending, and local demand is given by the demand schedule D1. When there is no trade, the transaction price and quantity is determined by the intersection of the two schedules and gives the market price P_1 and the quantity Q_1. Let us then introduce a world demand at the price P_2, so that the new demand schedule is D2. At this higher price, the landed quantity is still Q_1 because of the backward bending supply schedule. This is just a result of the way that the curves are drawn, although one such point will always exist. At price levels above P_1 but below P_2, the supply will be higher. If the price is increased further above P_2, landings will fall further. For instance, at the much higher price P_4, landings are reduced to Q_4. In this case, it is not obvious that trade will increase fishers's income except for in the short run when one is fishing down the stock. It is therefore possible that trade in this case will reduce social welfare since total income can be reduced and less fish is available at higher prices. Hence, good management of a fishery is even more important when the fishery is exposed to trade.

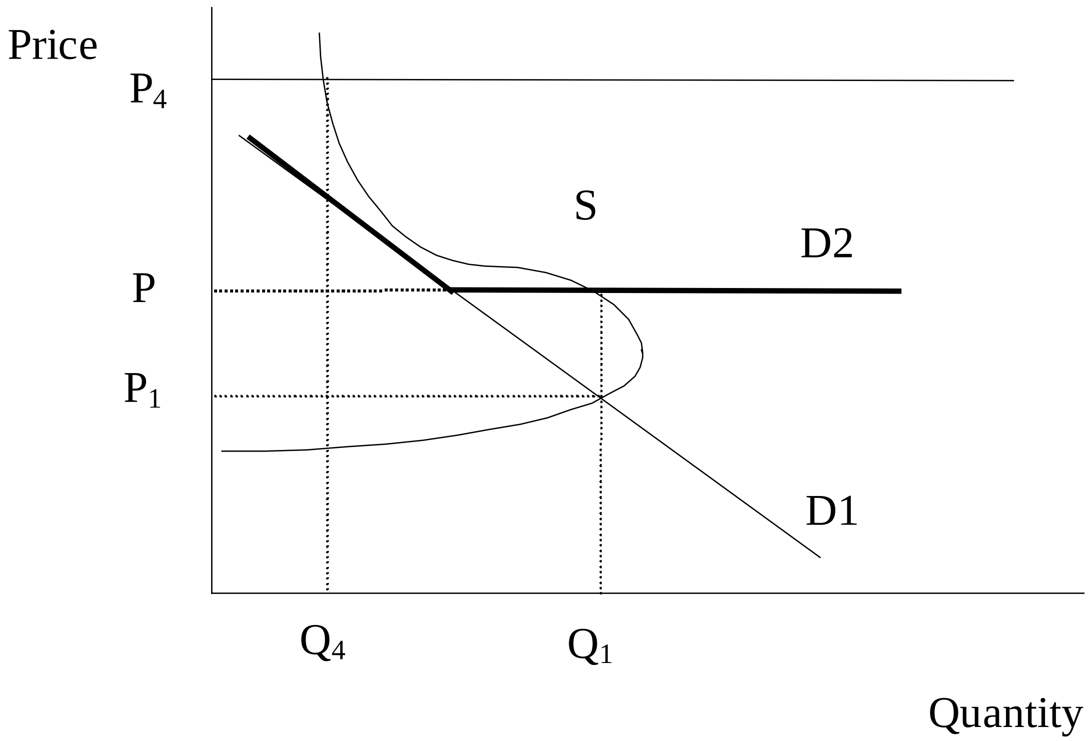


Figure 4. Demand and supply for potential exporter of fish, indicating the competition of supply by local fisher and importer

5. Where are we today?

Given this theoretical outline, it is of interest to ask, where are we today? We know that some of the world's fisheries are overfished, some are fully utilised and some are not yet fully utilised. To relate this to the theory presented in the preceding section, we will here try to sketch the supply schedule for the world, for developing countries and for industrialised countries. The sketches are fairly rudimentary, as we use no statistical tools and we do not try to control for other relevant factors. However, we still think that this exercise is useful in providing the general picture.

In Figure 5, we show the development of the global price of fish, together with total seafood production, production in developing countries and in industrialised countries. To make the series comparable, we normalise all numbers to 100 in 1984. The first thing to note is that the (*real???)* price has been increasing over the period, although not by very much. Furthermore, landings from developing countries increase substantially while landings in industrialised countries are fairly stable. This still gives a clear increase in total availability in seafood.

In Figure 6, we cross-plot price and quantities. The first section shows price together with total world supply of fish. We see that there seems to be a positive relationship between price and quantity, which indicates that we are on the increasing part of the supply schedule. In the third section, we show the relationship between price and landings in developing countries. Also here, the relationship seems to be positive, indicating that we are on the increasing part of the supply schedule. In the second section of the figure we show the relationship in industrialised countries. Here, there does not seem to be a very clear relationship. This might indicate that these countries are on the bend of the supply schedule. This should not be too surprising given FAO's assessments of the state of the world's fisheries resources and the fact that developing countries increase their share of the catch. Hence, also these figures indicate that trade is likely to increase, and that total revenues will increase. In aggregate, increased trade might therefore be beneficial. However, one caveat is in place. If most of the imports continue to flow into industrialised countries, this will improve the situation for the fish stocks here. For the developing countries who provide the exports, the situations is opposite in that increased exports will lead to increased pressure on the stocks. To avoid the very bad situation that exists for fish stocks in the industrialised countries in developing ones, the importance of good management can not be over-emphasised.

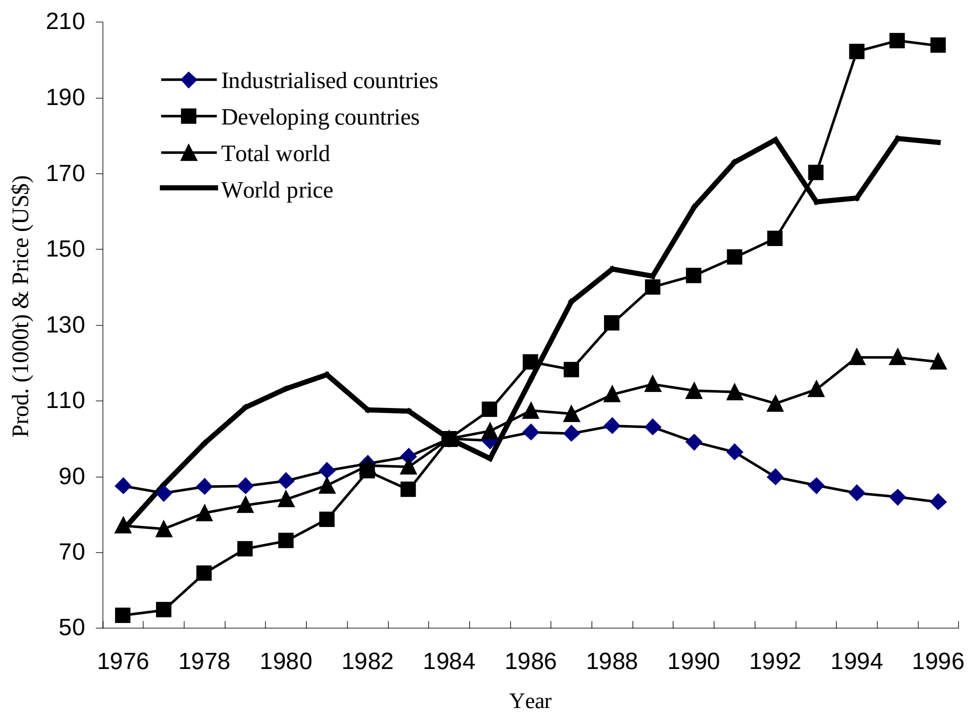
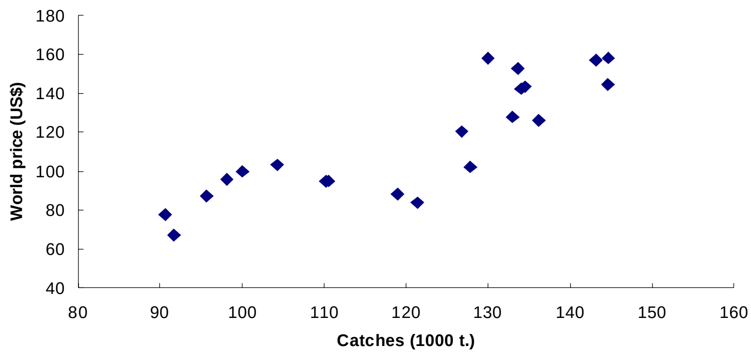
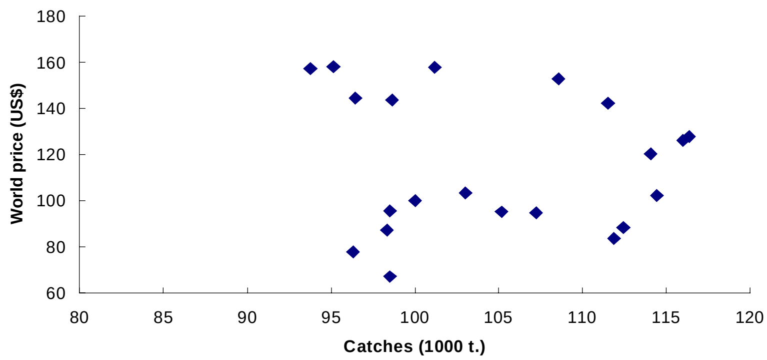


Figure 5. Seafood production (1000t.) and price (US$) (base 100 = 1984).

(a)



(b)



(c)

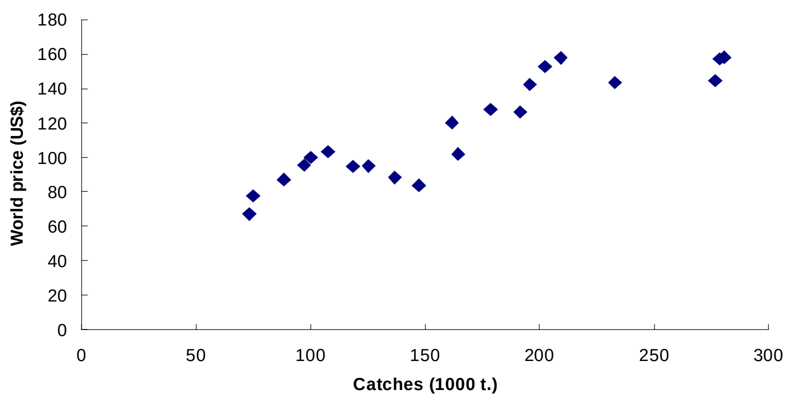


Figure 6. Relationship between seafood production and world price (base 100 =1984); (a) world total; (b) industrialised countries; (c) developing countries.

6. Concluding remarks

Trade with fish and seafood has increased substantially since the mid 1980s. This is mainly due to faster and cheaper methods for transportation and conservation, although increased catches, the introduction of the 200 mile EEZs, and lower barriers to trade also contributed to this development. To a large extent the trade is either between industrialised countries or from developing countries to industrialised countries. In 1994, about 85% of all imports went to industrialised countries, while more than 50% of the exports came from developing countries.

Simple economic analysis indicate that if the fisheries are well managed, all parties will gain by trade, although there are groups both within importing and exporting countries that will lose. In particular, fishers in the importing countries will lose. However, not very many fisheries in the world can be considered well managed. In poorly managed fisheries, the importer will still gain by trade, although we must say that this potential gain is certainly wasted in many industrialised countries today by the huge amounts of subsidise they give to their fishers. Exporters that do manage their fisheries poorly can either gain or lose from engaging in trade. What will be the outcome is an empirical issue. However, as trade value is increasing much faster than quantity, for the world as a whole, there is no doubt that the exporters gain by the trade. Moreover, as world demand seems to be highly elastic, and as transportation and conservation methods are likely to continue to become better and cheaper, trade is likely to increase further in the future.

References

Asche, F. and T. Sebulonsen, 1998. Salmon prices in France and the UK. *Aquaculture, Economics and Management*, 2:21-30.

Asche, F., H. Bremnes and C.R. Wessells, 1999. Product Aggregation, Market Integration and Relationships Between Prices: An Application to World Salmon Markets, Forthcoming in the *American Journal of Agricultural Economics.*

FAO Fisheries Statistics, various issues. Rome, Food and Agricultural Organization of the United Nations.

Gordon, D.V., and R. Hannesson, 1996. On Prices of Fresh and Frozen Cod. *Marine Resource Economics,* 11:223-238.

Hannesson, R., 1978. A Note on the Welfare-Economic Consequences of Extended Fishing Limits. *Journal of Environmental Economics and Management*, 5:187-197.

Hatcher, A. and K. Robinson, 1999. Overcapacity, Overcapitalisation and Subsisies in European Fisheries. Portsmouth, University of Portsmouth.

Krugman, P.R. and M. Obstfeld, 1994. International Economics: Theory and Policy, New York, Harper Collins.

Kurlansky, M., 1997. Cod: A Biography of the Fish that Changed the World. New York, Penguin.

Milazzo, M. 1998. Subsisies in World Fisheries. The World Bank, Washington, *World Bank Technical Paper*, 406.

Munro, G.R., 1996. Approaches to the Economcs of the Management of High Seas Fishery Resources. In D.V. Gordon and G.R. Munro, Fisheries and Uncertainty: A Precautionary Approach to Resource Management. Calgary, University of Calgary Press.

A global market for whitefish?[a]

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Abstract

This paper reports from an investigation of the co-integration of fish prices across products and markets. Most groundfish prices are found to be co-integrated across products such as frozen fillets of cod, saithe and haddock, fresh cod and salted cod. Prices of the same or similar products are also found to be co-integrated not just across European borders but across the Atlantic. It appears possible, therefore, to speak of a global market for whitefish. Fish prices were not found to be co-integrated with the price of meat products, and meat prices have in fact followed a distinctly different pattern from fish prices since 1980.

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1. Introduction

In some stores in Bergen it is possible to buy frozen fillets of Alaska pollock. The fish is caught on the other side of the globe, possibly by Norwegian-owned trawlers. The fillets are frozen at sea and transported to Germany where they are cut up into smaller pieces suitable for the ordinary household and repackaged. The packages carry a text in both Russian and Norwegian.

This story illustrates the global integration of the world fish markets rather well. Norway is not a country deficient in fish supply, and Russia catches Alaska pollock on her own. Possibly the raw fillets come from Russia but that would only make the story better. The punchline is that the fish we buy can come from anywhere, from whoever is able to catch fish at a competitive cost, and the final product may have gone through several intermediate destinations along the way, depending on where it is most cost-effective to process the fish.

To the extent this trade flow over long distances and across national boundaries is typical, we would expect the prices of similar products to be similar in all countries. Otherwise, the producers would channel their products to the country that pays the highest price, which would tend to equalise prices across countries. Similarly, if the prices of similar products are too far out of line in any particular country we would expect consumers to shy away from the most expensive ones and buy the less expensive ones instead, which would tend to align the prices for these products. As such, we can exploit knowledge about price movements to test whether markets for different products, both geographically and in product space, are integrated.

In this paper we report from our investigations of co-integration of groundfish prices in Europe and the United States. The study is more fully documented in Asche and Hannesson (1997). In this study we examined the co-integration of fish prices in two dimensions, (i) co-integration of prices of the same product across national boundaries, and (ii) co-integration of prices of different but seemingly related types of products within each national market. Prices were defined as unit values of imports. We also looked at the integration of fish prices and meat prices; as fish and meat are to some extent substitutes, their prices might be expected to follow a similar pattern.

2. Integration of fish prices across national boundaries

2.1 Testing for market integration

A number of market definitions in economics are based on the relationship between prices. For instance, the Nobel laureate Stigler (1969, p. 85) defines a geographical market as “the area within which the price of a good tends to uniformity, allowances being made for transportation costs”. A similar definition in product space is provided by Stigler and Sherwin (1985), where quality differences play the part of transportation costs. The basic thought here is that if two goods belong to the same market, economic forces (arbitrage opportunities or substitution possibilities) will prevent prices from diverging for long periods of time, as noted in the example in the introduction. On the other hand, if two goods are not in the same market, there is no reason to expect any relationship in the development of the prices over time. Of course, for two markets to be completely related (or integrated), the Law of One Price (LOP) must hold, after accounting for factors such as transportation costs and quality differences. However, as goods need not be perfect substitutes to compete in the same market segment, weaker relationships between prices have also received attention.

The statistical relationship that is investigated when testing for market integration is:

(1) $$p_t^1 - \alpha - \beta p_t^2 = u_t,$$

where p_t^1 and p_t^2 represent the logarithms of the prices in two different markets, or of two different goods. The residual error term u_t represents deviations from price parity. If $\beta \neq 0$, there exist a causal relationship between the two prices, and one can conclude that the goods in question compete in the same market. If $\beta = 1$, the LOP hypothesis holds, while if also $\alpha = 0$, prices are identical except for short-run deviations represented by the residual. The basic relationship in (1) is sometimes extended with lags of the prices, and/or by including the price of more than one good on the right-hand side.

Most price series have the statistical property that they are non-stationary. This prevents us from using traditional statistical tools when analysing such data series. However, co-integration analysis has been developed as a tool for data series with this characteristic (Engle and Granger, 1987; Johansen, 1988). For co-integration analyses to be used, the data series must be generated by the same type of stochastic process, or more technically, they must be integrated of the same order. This is verified for our data set. One can show that in the context of market analysis, the information obtained with co-integration analysis is the same as the information one can obtain with traditional statistical tools when the data series are assumed to be non-stationary (Asche, Gordon and Hannesson, 1998).

2.2 Integration across national boundaries in Europe

Not surprisingly, fish prices seem to be more closely integrated across national boundaries in Europe than between Europe and the United States. Let us look, first, at the co-integration of prices in Europe. Table 1 shows the products and countries for which the analysis was carried out. The choice of countries investigated for each particular product reflects differences in consumption, as the imports of some products to some countries are too small in some months to provide meaningful price series. Redfish fillets are, for example, not a popular item in the United Kingdom, and haddock fillets are similarly rare in the import statistics for Germany. The Latin countries are the main importers of salted cod, and frozen hake fillets are important in Spain.

The price series are displayed in Figures 1 - 9 (all figures are annexed at the end of the paper). All prices are expressed in a common currency (ECU/Euro = US$ 0.86). The price series for each product clearly follow a very similar pattern, and the standard tests for co-integration (Engle and Granger, 1987; Johansen, 1988) indicate co-integration across national borders for all products.

It is particularly interesting to note that the prices of fresh cod are co-integrated across national boundaries, even if the price levels are quite different, with Denmark at the bottom and Belgium on top. These differences are due to the fact that most of the fresh cod imports to Denmark are for further processing while the imports to Belgium are for final consumption. The price of fish of the same type used for processing is typically lower than that for fish meant for final consumption. But it should be noted that the two prices move roughly in unison, such that the difference between them is preserved over time.

Table 1. Products and countries analysed for a cross-border co-integration of prices in Europe.

Product	Countries
Frozen cod fillets	United Kingdom, France, Germany
Frozen haddock fillets	United Kingdom, France
Frozen redfish fillets	France, Germany
Frozen saithe fillets	United Kingdom, France, Germany
Frozen fillets of Alaska pollock	United Kingdom, France, Germany
Frozen hake fillets	United Kingdom, France, Germany, Spain
Fresh cod	United Kingdom, France, Germany, Belgium, Denmark
Dried salted cod	France, Italy, Portugal
Salted cod, not dried	France, Portugal, Spain

2.3 Market integration across the Atlantic

Since product prices appear to be co-integrated across the borders of Europe, we take France as a representative of Europe and compare prices in France to prices in the United States, to get an idea of how well prices are integrated across the Atlantic. Table 2 shows the products being compared.

Table 2. Products for which prices were compared between France and the US.

French products	US products
Frozen cod fillets	Frozen cod fillets, frozen cod blocks
Frozen haddock fillets	Frozen haddock fillets, frozen haddock blocks
Fresh cod	Fresh cod, fresh cod fillets

The longest of these price series are shown in Figures 10 - 12. The prices of frozen cod and haddock fillets follow a similar pattern when expressed in a common currency. Note that the United States distinguishes between two kinds of fillets; fillets proper, which are used for final consumption, and blocks, which are an intermediate input for further processing. When expressed in domestic currency, prices deviate much more over time, as can be seen by comparing Figures 13 and 14. Figure 13 shows the real prices of frozen cod fillets in the United Kingdom and frozen cod blocks in the United States, while Figure 14 shows prices in domestic currency in the United States and Europe expressed in a common currency. It is, of course, not surprising that prices expressed in a common currency follow one another more closely than prices expressed in a domestic currency. Presumably the forces holding prices aligned stem from producers shifting their product between either side of the Atlantic according to the profitability of each market expressed in a currency of their choice. The formal tests show that the prices of all the product pairs in Table 2 are co-integrated, with one exception, the price of frozen cod fillets in the United States is not co-integrated with the price of fillets in France.

3. Integration of prices of different products in different national markets

Again we take France as being representative of Europe and look at co-integration of prices of different products in France. The result is summarised in Table 3.

The time series are shown in Figures 15 - 16. It is of particular interest to note that fresh salmon is something of an exception here; the price of fresh salmon is not co-integrated with frozen fillets, but it is co-integrated with fresh cod. This allows us to conclude that fresh cod is a closer substitute to fresh salmon than frozen fillets.

Figures 17 - 19 show the time series of prices for some groundfish products imported to the United States. Fillets and blocks of cod and haddock consistently fetch a higher price than similar products of whiting, Alaska pollock and pollock. Table 4 summarises the cointegration analysis of the prices of these and some other products for the United States. There is obviously a rather close relationship between fresh cod and frozen fillets of the various types of groundfish. Surimi stands out as something of an exception; the price of surimi is co-integrated with the low priced fillets and blocks; Alaska pollock, pollock and whiting. Surimi is produced from Alaska pollock, and one would expect that the producers who can switch between the production of fillets and surimi would do so if the price of surimi gets too far out of line with the price of fillets and blocks. The prices of fillets and blocks of whiting and pollock seem more closely related to fillets and blocks of Alaska pollock than other types of groundfish, as already mentioned, which explains why the price of surimi is co-integrated with the price of these products. What is less expected, however, is that the price of surimi is co-integrated with the price of frozen haddock fillets but not with the rest of high priced products.

Table 3. Pairwise co-integration analysis of prices of products imported to France. The sign * indicates significant Johansen test at the 1% level, and ** at the 5% level.

Product type	Fresh cod	Frozen haddock fillets	Frozen redfish fillets	Frozen saithe fillets	Fresh salmon
Frozen cod fillets	*	*	*	*	
Fresh cod	—	*	*	*	*
Frozen haddock fillets	—	—	**	*	
Frozen redfish fillets	—	—	—	*	
Frozen saithe fillets	—	—	—	—	

4. Fish and Meat

How closely is the price of fish correlated with the price of meat? For some people, and on some occasions, fish and meat are substitutes. If the price of fish gets too far out of line with the price of meat, one would expect consumers to buy more fish and less meat, or vice versa, thus pulling the prices together again. Is this relationship strong enough to force the prices of fish and meat to follow a similar pattern?

To answer this question, a cointegration analysis was carried out for fish and meat prices in France and the United States. The fish products being considered were frozen cod fillets while the meat prices used were wholesale prices of beef, poultry and pork. The time series of prices are shown in Figures 20 - 21, with all prices being expressed as relative to 1980.

It may be noted that fish prices were considerably higher at the end of 1996 than in 1980, having peaked in 1991, while there has been little upward trend in meat prices. The development of real prices of fish and meat has thus been quite different.

As shown in Figure 13, the real domestic price of frozen fillets in the United Kingdom and the United States shows two distinct peaks, one in 1987 and the other in 1991. In the United Kingdom the prices peaked already in 1987, while in the United States and the rest of Europe the 1991 peak is higher. Real and domestic prices of frozen fillets in Europe are further illustrated in Figures 22 - 24. The trend in the real prices of meat products has clearly been downwards.

The different trends in fish and meat prices indicate that they cannot possibly be co-integrated. It turns out that the French meat prices and the prices of broiler and pork in the United States are stationary while fish prices are not, so co-integration is ruled out. An analysis of the prices of beef and frozen cod fillets in the United States did not show co-integration of these prices. Hence the substitutability between meat and fish apparently is not strong enough to force the prices of these products to follow a similar pattern.

Table 4. Pairwise co-integration analysis of prices of fresh cod and frozen fillets and blocks of various types of groundfish imported to the United States. The sign * indicates significant Johansen test at the 1% level, and ** at the 5% level.

Product type	Froz. cod fillets	Froz. cod block	Had-dock fillets	Had-dock block	Alaska poll. block	Whi-ting block	Ocean perch fillets	Poll. fillets	Alaska poll. fillets	Surimi
Fresh cod	*	*	**		**	*	*	*	**	
Frozen cod fillets	—	**	**		**	**	**	*		
Frozen cod block	—	—	*		*	*		*	*	
Had-dock fillets	—	—	—	*	*	*		*	**	
Had-dock block	—	—	—	—	*	*		*	*	
Alaska poll. block	—	—	—	—	—	*	*	*	*	*
Whi-ting block	—	—	—	—	—	—	*	*	**	**
Ocean perch fillets	—	—	—	—	—	—	—	*	*	**
Pol-lock fillets	—	—	—	—	—	—	—	—	*	*
Alaska poll. fillets	—	—	—	—	—	—	—	—		**

5. Conclusion

The co-integration analysis leads us to believe that there is indeed a world market for whitefish. We found that the prices of whitefish products are closely interrelated across different products derived from the same species (cod), across similar products derived from different species (frozen fillets), and across national markets, not only in Europe but also between Europe and the United States. Even if the European Union and the United States are responsible for no more than roughly one half of all imports of fresh, chilled and frozen fish, their share of the global whitefish market is undoubtedly much higher, as the category fresh, chilled and frozen fish contains many sundry types of fish, with whitefish being a dominant category in American and European imports. The jump towards the conclusion that there exists a global whitefish market is therefore not a heroic one.

As can be seen from the figures displaying the price series they show two distinctive peaks, one in 1987 and the other in 1991. If the series are deflated these peaks become even more marked, with the one occurring in 1987 being higher in some countries than the latter one. We have been unable to find a good explanation for these peaks. Variations in landings of cod and other whitefish species are only a part of the answer and do not explain the first peak at all. The latter peak coincided with a severe decline in catches of cod in the Barents Sea, but the price declined from 1991 onwards despite the disappearance of the Northern cod off Newfoundland. A hypothesis that comes to mind is that the price of substitutes may drive this development. We therefore investigated whether the price of fish products is co-integrated with the price of meat and found that this is not the case, neither in Europe, represented by France, nor in the United States. The prices of meat in France and the United States follow a pattern distinctly different from the price of fish. The price of fish has increased substantially relative to the price of meat since 1980, and even if it has fallen recently it is still higher than it was in 1980, relative to the price of meat.

References

Asche, F. and R. Hannesson, 1997. On the Global Integration of the Markets for Whitefish. Bergen, Centre for Fisheries Economics, The Norwegian School of Economics and Business Administration, SNF Report 98/97.

Asche, F., K.G. Salvanes and F. Steen, 1997. Market Delineation and Demand Structure. *American Journal of Agricultural Economics,* 79:139-150.

Asche, F., D.V. Gordon, and R. Hannesson, 1998. Price Founded Tests for Market Integration: Fish Markets in France. Paper presented at the Salt Lake City meeting of the American Agricultural Economics Association.

Bose, S. and A. McIlgrom, 1996. Substitutability among Species in the Japanese Tuna Market: A Cointegration Analysis. *Marine Resource Economics,* 11:143-156.

Engle, R. F., and C.W.J. Granger, 1987. Co-integration and Error Correction: Representation, Estimation and Testing. *Econometrica,* 55:251-276.

Gordon, D.V. and R. Hannesson, 1996. On Prices of Fresh and Frozen Cod. *Marine Resource Economics,* 11:223-238.

Gordon, D.V., K.G. Salvanes and F. Atkins, 1993. A Fish is a Fish is a Fish: Testing for Market Linkage on the Paris Fish Market. *Marine Resource Economics,* 8:331-343.

Hannesson, R., 1994a. On the Cointegretion of Groundfish Prices in the European Community. Bergen, Norwegian School of Economics and Business Administration, SNF Working Paper No. 80/94.

Hannesson, R., 1994b. Prices of Frozen Groundfish Fillets in the U.S.: A Cointegretion Analysis. Bergen, Norwegian School of Economics and Business Administration, SNF Working Paper No. 80/94.

Johansen, S., 1988. Statistical Analysis of Cointegration Vectors. *Journal of Economic Dynamics and Control*, 12:231-254.

Salvanes, K.G. and D.J. DeVoretz, 1997. Household Demand for Fish and Meat Products: Separability and Demographic Effects. *Marine Resource Economics*, 12:37-55.

Steen, F., 1994. Testing for Market Boundaries and Oligopolistic Behavior: An Application to the European Market for Salmon. Bergen, Norwegian School of Economics and Business Administration, Ph.D. Dissertation.

Stigler, G.J., 1969. “The Theory of Price,” London, Macmillan.

Stigler, G.J. and R.A. Sherwin, 1985. The Extent of a Market. *Journal of Law and Economics*, 28:555-585.

Vassdal, T., 1996. Verdensmarkedet for Kvitfisk: En Statistisk Analyse (The World Market for Whitefish: A Statistical Analysis). Tromsø, Norwegian College of Fishery Science, University of Tromsø.

The co-existence of variable producer prices and stable consumer prices in closed market situations[a]

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Abstract

The current paper addresses the different price variability within consumer and producer markets for Kapenta in Zambia. The price in the consumer markets is set in January, in the rainy season when supply is low relative to demand, and stays relatively unchanged until the following January when a new price is set. On the producer side, producers within the same geographical production area agree on the price to charge at the start of each production period. The price they agree upon usually reflects the total amount of Kapenta being marketed in Zambia at a time, but this is usually set somewhat above the local market clearing price. In spite of the price agreement, individual producers often reduce their price unilaterally in order to clear their stocks. The analysis shows how the different price variability is due to different market characteristics in the consumer and producer markets.

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1. Introduction

Kapenta is a small pelagic fish living in many fresh-water lakes in Sub Saharan Africa. On Lake Kariba in Zambia, Kapenta is caught during the night by semi-industrial vessels operated by a restricted number of Kapenta operators. The fish is mainly sun-dried and sold to wholesale traders calling at the production camps. The wholesalers transport the dried fish to the wholesale markets in the cities and resell it to retail traders, who then sell it to the consumers at the consumer markets.

The trade in Kapenta from Lake Kariba is characterised by producer prices being variable during the production year dependent upon the quantity of Kapenta caught. At the start of each production period the Kapenta operators agree on the monthly price to charge.[8] The price reflects the total amount of Kapenta being marketed in Zambia at a given time. At the same time, however, the price is usually set above the local "camp-calling" market clearing price at the lakeshore. In spite of the price agreement, individual producers often reduce their price unilaterally to sell their monthly catch.

The consumer price, on the other hand, stays remarkably stable throughout the year. The price of Kapenta sold at the consumer markets in the big cities of Zambia is set in January, in the rainy season when supply is low relative to demand. The price stays relatively unchanged until next January when a new price is set. The consumer price is fairly inflexible, especially in the downward direction and there is no tendency for the price to go down in response to increased supplies.

The different variability in producer and consumer prices is a puzzle given the fact that the majority of the Kapenta produced in Lake Kariba is sold within the country. When times are good the producers lower their prices to sell a larger quantity. Since most of the fish is intended for resale within the national market characterised by a consumer price that does not reflect the increased supply, some unsold quantity of Kapenta must be generated somewhere along the trading chain. Wholesale traders appear to be subject to variable prices both when buying and selling, dependent upon supply and demand conditions at the producer and wholesale markets. The storage of Kapenta appear thus to be done by the retailers who charge the inflexible consumer price.

The existence of a stable consumer price could be the outcome of explicit collusion on the part of the retail traders. The individualistic organisation of the Zambian markets, however, would seem to suggest the absence of institutional mechanisms ensuring explicit collusion through enforceable contracts. Given that there are no central co-ordinating mechanism in place, the fixed price must be upheld by individual sellers who somehow prevent the price from being pushed down to the competitive level. Given that they do so in the full awareness that by keeping the high price level they might end up with an unsold amount of Kapenta at certain periods of the year, we have to reject the usual assumption that traders treat the going price level parametrically, responding passively to whatever price level the market comes up with.

Our basic hypothesis is that the market setting in both the consumer and the producer markets for Kapenta are best understood as the outcome of individual choices based on strategic considerations. Each producer/trader decides on the price level to demand in exchange for his/her fish, but in doing so he/she contemplates the likely actions of the other market sellers and the way those actions are going to affect the demand for his/her own goods. The different outcomes are due to different market characteristics in the producer and consumer market.

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[8] Kapenta production is closed down around full moon when the fish is not attracted to the lamps on the fishing rigs.

2. Market structure

In a country like Zambia retail trade is a typical marginal adaptation strategies taken up by poor people in order to make ends meet. Trade is performed by the amount of money available when other responsibilities are met. In the following, therefore, we will assume each retail trader to have a given amount of trading money and furthermore that each trader chooses to buy the maximal amount of fish he/she can buy for this amount of money. The retail traders know that they can be lucky and sell all the fish at the going market price. If that happens, they will earn a good profit. Given the high fixed price, however, there is a positive probability that some of the fish is left unsold. In that case the retailer accumulates an involuntary stock. The loss encountered in this case depends upon the amount of unsold fish and the value attached to the unsold fish. Given that it is eaten by the trader and his/her family and/or exchanged for other consumer goods through barter trade, unsold fish have some economic value. If, on the other hand, it cannot be used but has to be thrown away, it’s value is zero.

In Zambia, as elsewhere in Sub-Saharan Africa, the retail markets tend to be highly segregated with retail traders sticking to their respective markets or even subparts of specific markets. Retail traders operating in a specific market do not normally sell their products at markets outside their domain. While being at the market, the retail traders interact with each other on a daily basis and exchange information and services. One important service is to look after each other’s stalls whenever someone has to depart from the market for shorter or longer time. Due to the segregated market structure, the exchange of services and information and the fact that retail trade is a marginal adaptation performed by poor people in approximately the same economic situation, we will in the following assume that the traders operate in a closed seller’s market and to have information about the amount of trading money operated by every other trader in the market. In addition the traders are assumed to operate within a settled trading regime. The assumption of a settled trading regime is meant to capture the idea that the traders are aware of the demand conditions prevailing in the market in which they traditionally operate.

The assumptions of a closed market, settled trading regime and common knowledge about the trading money available, imply a situation where a given stock of traders with a given amount of money face a given supply and demand situation. The assumption of a given supply and demand situation does not preclude changes in the quantity of Kapenta produced or demanded due to seasonality. The main point, however, is that everybody is assumed to know the supply and demand conditions at any particular time.

At the producer side the operators sell the Kapenta to relatively regular wholesale traders calling at the production camps. When coming to the area the traders spread out between the different producers. Sale is done at a first comes first serves basis, and in order to secure high quality fish, traders choose to call at different producers. As long as the price stays the same, quality is the main issue. The traders profit, however, depend not only on quality but also on price. The traders, therefore, negotiate with the producer in order to try to get a price reduction. Another price-cutting strategy is to sit and wait at the production camps without buying. Sun-dried Kapenta start losing its appearance after three weeks. The longer it goes before the fish is sold, therefore, the more eager the producers will be to get rid of it. By playing delay tactics the traders thus put pressure on the producers to cut the price. During the period of waiting the traders visit other production camps to acquire price information. If it is learnt that one (or more) of the other producers has reduced his price, traders flock to his camp to by, leaving the rest with a smaller demand.

In practise, therefore, in spite of the price agreement, the producers often reduce their price unilaterally to sell their monthly catch. Each and every producer knows that this may happen, and tries to keep track of the price charged by the other producers by sending someone to the competitors to buy a bag of Kapenta at the going price rate. Some producers admit that even though they would have preferred a high, stable price, they have themselves reduced the price unilaterally in the past. And as long as they have no guarantee that the high price will be kept by all the other producers, they might also undercut the price in the future. In order to establish such a price guarantee the largest Kapenta operator in the Sinazongwe area of Lake Kariba proposed that all the producers in the area should enter into a binding commitment not to undercut the agreed price. This has not materialised, however, due to resistance from some of the smaller producers.

Due to poor infrastructure in the lakeshore area, both when it comes to roads and telecommunications, the traders travelling to one region of Lake Kariba will have to buy the Kapenta from one of the operators in this region as going elsewhere is too costly. Furthermore, while staying in the area the traders will only get information about the producer prices in this region. As a result the producers compete primarily with their colleagues in their local production area. When competing the producers know the total amount of Kapenta caught in their region as they exchange production data as a way to control theft from their production rigs. In the same manner as for the retail traders, therefore, the producers can be assumed to operate in a closed marked where they know the relevant supply and demand conditions.

In spite of the apparent similarities, when it comes to market structure, the price behaviour in the consumer and producer market differ. We will, in the following, abstract from changes due to seasonality and concentrate on determining the central factors explaining the existence of a stable non-clearing consumer price in the retail market, and an unstable non-clearing producer price in the producer market in situations characterised by strategic interaction between the traders/producers.

3. Price competition in capacity constrained oligopolies

In the following each retail trader, $i,\ i = 1,...,n$, is assumed to buy the maximal amount of Kapenta he/she can afford given his/her amount of trading money, m_i. The fish is bought at the going wholesale price, p_w. The amount marketed, but not necessarily sold, by each retail trader is thus equal to $k_i = m_i/p_w$. The total amount of Kapenta marketed by the *n* retail traders is then given by $\sum_{i=1}^{n} k_i = \frac{1}{p_w}\sum_{i=1}^{n} m_i$. Since the amount of Kapenta marketed by each trader, k_i, is determined by the trader's amount of trading money and the wholesale price, the quantity traded by anyone trader is limited and cannot be instantly changed. This shows that each individual retail trader operates under a capacity constraint.

On the production side, the operators have to acquire fishing licences in order to operate. Each licence allows an operator to operate 4 rigs in a specific region of the lake. The licences are issued by the Zambian authorities and have to be renewed yearly. For the Sinazongwe area of the lake no new licences are issued for the time being. Total fishing capacity in the region is thus constant. Changes in individual fishing capacity depend on renting or buying existing companies – if available. In practise, therefore, the individual Kapenta operator operates under a capacity constraint. In the following we will assume dried Kapenta to be supplied by *n* firms with exogenously given sales capacities $k_1, k_2, ..., k_n$, $\sum_{j=1}^{n} k_n = k$, and identical constant unit costs, *c*.

The demand facing each retail trader and/or producer at any given day is assumed to be determined by the configurations of overall supply and demand. In specifying the individual demand, each individual's demand depends upon the price he/she charges relative to the price charged by other traders. This is essentially a neutrality assumption as it rules out characteristics like group membership, kinship relations and other, as determinants of the amount sold. We are thus restricting the scope of our model to impersonal markets characterised by unattached seller-buyer relationships.

The neutrality assumption also implies that the amount sold on any particular day does not depend on personal salesmanship. For the producers the neutrality assumption is based on the wholesale traders' statement that their choice of producer to call at depends primarily upon the distribution of traders in the area (as long as all the producers charge the same price). The traders choose to call at the producers with the lowest number of traders relative to capacity. For the retail traders the rationale for the neutrality assumption is the observation that the most outstanding sellers are rewarded not by a higher price but by being secured sufficient customers buying all their fish. These traders thus accept the common price level applicable to the general traders but enjoy the luxury of selling all their goods at any time. Consequently the price formation process can be conceived as one where the price game is played only among the general run of traders, excluding any outstanding ones. Among the actual players of the game, therefore, the neutrality assumption is not too unrealistic.

The fact that there is a finite number of retail traders and/or operators each operating under a capacity constraint and facing a market demand that is assumed to be continuous and decreasing show that traders and producers alike participate in price competition in a capacity constrained oligopoly.

The first analysis of this phenomenon was by Egdeworth (1897) for a market with capacity constraints, which are binding at the competitive equilibrium. He noticed that in such a situation there was a range over which the price might be expected to fluctuate. This range will depend upon the capacity *k*.

Consider the following model where market demand is assumed given by $D(p) = a - bp$. Capacity constrained firms having identical capacity, $k_i = k$, are assumed to produce according to the cost

function $C(q) = \begin{cases} cq \text{ if } q \le k & \text{with } c < \frac{a}{b} \\ \infty \text{ otherwise} \end{cases}$.

In such a game the different firms may charge different prices. It is assumed that the customers buy first from the cheapest supplier and that income effects are absent. Whenever the lowest price supplier cannot satisfy the market, some customers are left for the remaining firms. How much these firms will sell depends on the form of their contingent demand curve. Here we will assume that if the *n* firms are ranked in increasing order, then i) firm *i* obtain no customers unless all firms charging a lower price, $j < i$, sell at capacity, and ii) firm 1 serves the *k* consumers with the highest reservation prices, firm 2, the *k* with the next highest, and so on until the demand is satisfied. A firm setting the *r*th lowest price thus face a contingent demand of $D(p_r) = \max(0, a - bp_r - (r-1)k)$. When the *n* firms are of identical size we have that if a subgroup $h \le n$ firms charge the same price they each receive 1/*h* of contingent demand. Sales are equal to $\min(k, D(p))$ for each firm.

The type of equilibrium achieved in this market depends on the relative values of *n* and *k*. For some values an equilibrium exists only in mixed strategies. Dasgupta and Maskin (1986 a,b) showed that in a model of a market in which capacity constrained firms set prices there is always a Nash equilibrium in mixed strategies. A mixed strategy equilibrium in a many-person game consists of a set of probability distributions over the respective strategy spaces with the property that for each player any strategy chosen by a positive probability must be optimal against the other players' probability mixture.

In order to solve for the upper and lower bound of the range containing equilibrium in mixed strategies, let the prices at the bottom and top of the range be $\underline{p}$ and $\overline{p}$ respectively. Suppose that the prices of the other firms are indefinitely close to the bottom of the range and that the last firm has the choice of picking the price at the bottom or raise it's price to *p*. It will be indifferent if profits are equal,

1) $$(\underline{p} - c)k = (\overline{p} - c)(a - b\overline{p} - (n-1)k)$$

Solving for the optimal top price from the right hand side of equation 1) we get

2) $$\overline{p} = \frac{1}{2b}\left(a + cb - (n-1)k\right)$$

Inserting the expression for the top price from 2) into 1) give the bottom price equal to

3) $$\underline{p} = c + \frac{1}{4bk}\left(a - bc - (n-1)k\right)^2$$

Equation 3) reveals that as $k \to \infty$ the second term on the right hand side goes towards zero and the bottom price goes towards the firms' marginal cost, *c*. No firm would ever charge a price below marginal cost as such a price would result in negative profit. In a situation with large capacities, therefore, all the firms charge $p^* = c$.[9] When they all charge a price equal to marginal cost, any firm contemplating raising the price above *c* will get no customers, $D(p) = a - bp - (n-1)k \le 0$. A firm will thus never find it profitable to raise it's price above marginal cost given that $k \ge \frac{a - bc}{n-1}$.

For *k* very small on the other hand, each firm can sell at capacity at the price equating supply and demand, $a - bp = nk$ or $p = (a - nk)/b$. Since each firm sell at capacity, no firm has any incentive to lower the price . For small capacities therefore, each firm will charge the same price p*=(a– k)/b. Substituting the capacity constrained price, *p**, for $\overline{p}$ in 2) we see that a firm will never undercut the common high price given that k ≤ (a-bc) / (n+1).

Instability in price competition is thus bounded from below by extreme excess capacity. If all the firms are able to fulfil the market demand at a price equal to unit cost, the capacity limits are irrelevant and we are back in the standard Bertrand model with the unique equilibrium price equal to marginal cost. The price instability is also bounded from above by shortage of capacity. When there is under-capacity in the industry, there is no incentive for competition as each firm is producing at capacity and cannot benefit from undercutting it's rival's price level. In such a situation everything is as if all the firms put outputs equal to their capacities at the market and an auctioneer equated supply and demand. The equilibrium price is then charged by all the producers.

In situations with neither extreme excess capacity nor under-capacity, no pure strategy equilibrium exist. The existence of an equilibrium in mixed strategies means that if the oligopoly lasts for more than one period, the model predicts variations in prices between periods as the firms' random devices generate different realisations.

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[9] In the retail market the unit cost is given by the wholesale price p_w, that is $p^* = p_w$.

Turning back to the Kapenta market situations we have that on the producer side no single producer is able to serve the total market demand at unit cost. On the other hand, the fact that individual producers reduce their price at irregular intervals in order to sell their total produce, show that there are no under-capacity in the industry. The producer side of the Kapenta market appears thus to fit the model of capacity constrained price competition when capacity is in the medium range. The model then predicts price variations between periods, a prediction that is confirmed by the observed price behaviour in the producer market.

In the retail market the situation is different. The fact that retail trade is a marginal adaptation taken up by poor people and performed with the money left over when other responsibilities are met, indicate that each trader's capacity is very small. The high and stable price could thus be the result of under-capacity in the industry making it possible for each trader to sell their total capacity at the high market clearing price. This is not very likely, however. Firstly, because the majority of Kapenta produced in Zambia is sold within the country. Under-capacity in the retail market should then be reflected in the producer market. This is not the case.[10] Secondly, retail trade requires a small starting capital and no official permission or licence. There are thus no entry barriers into retail trade. In a situation with no entry barriers high profits would attract new traders and the entry of new traders would soon eliminate the under-capacity. Economic theory thus predicts that the retail market will consist of a large number of traders, each seller supplying only a small part of the total volume of fish traded. This prediction is confirmed by observation. The Bertand-Edgeworth equilibrium in situations with many firms where each firm is small relative to total demand, is analysed by Allen and Hellwig (1986). They found that as the number of firms increases, the corresponding equilibria converge in distribution to a perfectly competitive price. This being the case, one would expect the price at the retail market to be the competitive price and not the high and stable non-clearing price observed. The high and stable retail price must thus be due to other factors.

4. Repeated interaction

The high, stable price charged by all the retail traders could be achieved by explicit co-operation sustained by a binding contract requiring the traders never to undercut each other. Such a solution, however, require institutional mechanisms able to enforce the contract. The individualistic organisation of the Zambian fish market indicates lack of such enforceable institutional mechanism. Explicit co-operation, therefore, do not appear to explain the high and relative stable price demanded at the consumer markets in Zambia.

In markets where interaction is made every day, weak and/or month, strategic behaviour assumes the properties of a repeated non-cooperative game. In such repeated games implicit self-enforcing co-operation is possible even when there is no mechanism for explicit co-operation at any stage. This way of analysing the market situation is in line with the work of Osmani (1991), where the author investigated the existence of non-clearing wage rates and involuntary unemployment within South Asian rural labour markets.

If all the retail traders at the consumer market demand the market clearing price p^c, characterised by $D(p^c) = \sum_i k_i$, where $D(p^c)$ is total market demand at price p^c, they will sell all their fish. The traders

[10] The price variability could be due to market power in the wholesale market. This appears not to be the case as the wholesale market is characterised by relatively low operating costs and free entry and exit.

will in other words have a unit probability of selling their total quantity marketed. For any other price vector, $\overline{p}$, each trader, *i*, face a probability, ϕ_i, $0 \leq \phi_i \leq 1$, of selling one unit of fish (usually a cup of standard size) which depends upon the configurations of supply and demand at this price vector. Consider first the simplest case of uniform capacity, $k_i = k$, and a common price *p* restricted to the meaningful case of $p \geq p^c$. Due to the neutrality assumption every seller will enjoy the same individual demand towards one unit of fish given by the ratio between total demand and supply of fish at *p*. The first property of ϕ is given by:

4) $$\phi(p,k) = \frac{D(p,k)}{\sum k}, \text{ for } i = 1,...,n \text{ and all } p \geq p^c,$$

when p^c is such that $D(p^c) = \sum k$. When all traders charge the same price they will all face a contingent demand given by $D(p) = \frac{1}{n}(a - bp)$. The higher the common price rate, therefore, the lower the demand towards one unit of fish from any trader.

5) $$\phi_p = \frac{\partial \phi_i(p,k)}{\partial p} < 0: \text{ for all } i\text{, for all } p \geq p^c$$

Furthermore, the larger the capacity the lower the probability that any trader will sell one unit of fish,

6) $$\phi_k = \frac{\partial \phi(p,k)}{\partial k} < 0: \text{for all i, for all } p \geq p^c$$

Since the retail trader's capacity is determined by her/his amount of trading money, and the wholesale price, k = m/p_w, we have that the larger the amount of trading money and the lower the wholesale price, the lower the probability ϕ,

6a) $$\phi_m = \frac{\partial \phi(p,k)}{\partial m} < 0,$$ 6b) $$\phi_{p_w} = \frac{\partial \phi(p,k)}{\partial p_w} > 0,$$

In the case of non-uniform capacity and non-uniform price demands given by the vector $\overline{p}$ the price demands can be arranged in ascending order and each trader be designated the rank of his/her price. The *i*'th trader refers thus to the person whose price demand occupies the *i*'th position from the bottom. If every trader now were to demand the same price, p_e, for a unit of Kapenta, total demand would be equal to $e = l(p_e)$. In such a situation, anyone who charges $p' < p_e$ is assured to sell all his/her fish given the assumption that the consumers try to minimise their expenditure outlays and given that the quantity supplied by the trader at price p' do not exceed demand at this price, $k_i \leq D(p')$. As long as the trader charging the lower price is relatively small, the traders selling for exactly p_e will have a positive demand for their fish. This conditional demand, however, is smaller than their supply if the total quantity of fish marketed at price, p_e, exceeds the demand at this price as given by *e*. Should the trader charging price p' be very large on the other hand, $k_i \geq D(p')$, the traders demanding price, p_e, face a zero conditional demand.

Given the facts that i) total market supply is exogenously determined by the traders' amount of trading money, and ii) total demand is a function of the price and not of the amount of fish at the market, we have that the larger the amount k_i relative to total demand, the larger trader *i*'s share of the total quantity traded. Generally therefore, the larger the amount, k_i, sold at a low price relative to the total amount of fish marketed, $\sum_i k_i$, the smaller the demand left over for the other traders, and the smaller their probability of selling one unit of fish at price p_e. In a situation with a non-uniform price, therefore, the probability of selling one unit of fish facing the individual trader is a function of the price vector $\overline{p} = p_1, p_2, ..., p_n$, and the size vector, $\overline{k} = \frac{k_1}{\sum k_i}, \frac{k_2}{\sum k_i}, ..., \frac{k_n}{\sum k_i}$, showing the distribution of fish between the traders operating at the same market; $\phi_i(\overline{p}, \overline{k})$.

For a non-uniform (ranked) price vector $\overline{p}$, where p_e and p' are elements of $\overline{p}$ which satisfy the equations $l(p_e) = e$, $l(p') = e'$, the probability of selling one unit of fish, ϕ, facing anyone retail trader has the following properties. Given that the traders charging price, p_e, have a positive demand for their fish,

7) $$\phi_i(\overline{p}, \overline{k}) > 0 \quad \text{for all } i \text{ such that } p_i \leq p_e$$

traders charging less than p_e will be sure to sell their total quantity,

8) $$\phi_i(\overline{p}, \overline{k}) = 1 \quad \text{for all } i \text{ such that } p_i < p_e$$

Consider now trader *i* who is contemplating a demand, p_i, for his/her fish. On the basis of the perceived price vector, $\overline{p}$, which consist of her own price demand as well as the expected price demand of the other traders, he/she estimates the number of units he/she will be able to sell at price p_i. Trader *i*'s expected price per unit of fish is thus given by,

9) $$P_i(\overline{p}) = (\phi_i(\overline{p}) \cdot p_i + (1 - \phi_i(\overline{p}))d_i)$$

where d_i refer to the value attached to one unit of unsold fish. We assume each trader to maximise his/her expected profit, $\pi_i(P_i) = (P_i - p_w)k_i$. His or her strategy is thus to choose a price level, given the level demanded by the other retail traders, that is such that it maximises his/her own expected profit.

For the individual trader, as long as the expected profit obtained by demanding a price p_i in excess of the market clearing price p^c exceeds the profit corresponding to p^c, it is in every traders personal interest to demand such a price. This will be the case given that

10) $$((\phi_i \cdot p_i + [1 - \phi_i]d_i) - p_w)k_i \geq (p^c - p_w)k_i$$

which is identical to

11) $$\phi_i \geq \frac{p^c - d_i}{p_i - d_i}$$

Since d_i is the value trader *i* attach to one unit of unsold fish, $(p^c - d_i)$ and $(p_i - d_i)$ show the gain obtained if the unit is sold at price p^c and p_i, respectively. However, since every trader is assured to sell all their fish when charging the competitive price, p^c, the value attached to a unit unsold fish must in such a situation be equal to the competitive price. This being the case, condition 11) state that as long as there is a positive probability of selling one unit fish at a price $p_i > p^c$, it will be in trader *i*'s interest to charge such a price.

The repetitive nature of market activities indicates a mechanism capable of inducing all the retail traders to charge a price in excess of the competitive price. In the one-period capacity constrained price games referred to in the previous section, everyone acted according to their short term self-interest. Even though they collectively could have profited from co-operating, such co-operation was deterred by everyone's temptation to gain even more by undercutting the collusive price. In static, one period games the problem of co-ordination stems from the fact that if one player decides to be selfish and undercut the agreed price, he or she cannot be punished in the absence of enforceable contracts. In a repeated game, on the other hand, it may be possible to punish deviant behaviour by pursuing a strategy that imposes a bigger future loss than present gain on the renegade. The possibility of such punitive action may encourage each trader to stick to the agreed price with the confidence that no trader will dare to undercut. The consequence of this is a self-enforcing co-operative outcome.

There are many strategies for achieving a co-operative outcome in repeated non-cooperative games. One simple and often used strategy is the trigger strategy. By employing a trigger strategy, which induces implicit self-enforcing co-operation among the retail traders, it may be possible to achieve a high, stable consumer price. The equilibrium price achieved through such implicit co-operation could in principle consist of a non-uniform price vector. Empirically, however, the uniform price scenario is the relevant one as all the traders at the same market charge the same price[11]. When all traders charge the same price, they all face the same probability of selling one unit of fish at this price, regardless of their total quantity marketed. Furthermore, since retail trade is a marginal adaptation performed by poor people, their individual trading capacity is very limited and approximately equal. Each trader can thus be assumed to supply the same fraction of total supply. Within the retail market, therefore, the size vector reduces to a single element common to all the retail traders. When each trader has equal capacity and face the same probability of selling one unit of fish, their expected profit from charging the price, p^*, will be identical, $\pi_i = \pi$.

Due to the characteristics of the retail market, we will in the following restrict ourselves to a situation characterised by a uniform price, $p_i = p^*$, and show the circumstances required for such a price to be sustained by a trigger strategy.

Any price $p^* > p^c$, is collectively superior to p^c as long as $\phi(p^*) > 0$. The following trigger strategy is then assumed: Demand price p^* the first day regardless of what the other traders do. Continue to demand price p^* everyday as long as everybody else has demanded price p^* every day in the past. If anybody is ever observed demanding a lower price, demand the market clearing price p^c the next day and ever after.

The trigger strategy includes a carrot and a stick. It puts up a carrot saying that if all behave well and restrain from undercutting the price, I will do so as well. If others are ever observed misbehaving, however, I will use the stick and push the price down to the lowest level forever. If everybody decides to abide to the trigger strategy and charge p^* the first day, no trader will ever have the reason to deviate from p^*. This being the case, the market equilibrium known as the trigger strategy equilibrium, will be established at this price. The trigger strategy equilibrium satisfies the conditions of a Nash equilibrium; given that everybody else chooses to co-operate, I can do no better than to co-operate myself.

Under what conditions can a trigger strategy be expected to work? The first condition that must be fulfilled is that the threat of a punitive action must be credible. Each trader must be convinced that the others can actually force the price level down to a harmfully low level should he/she decide to deviate. This is the case when the Nash-equilibrium price-level in the single period market game is the competitive price level, as it is in the retail trader game characterised by a large number of traders each selling small share of the total amount traded. In this case, if every retail trader except trader *i* demand the competitive price, then *i* can do no better than to demand this price her/himself. The threat embodied in the trigger strategy is a genuine one.

[11] The price, however, may vary from market to market within the country. Typically the price of Kapenta is higher in the Copperbelt than in the capital Lusaka.

The second condition is that, given a credible treat, each retail trader must find it worthwhile not to court the punitive action. This they will do as long as her/his immediate gain from undercutting the price is less than future losses. Assuming $\delta \in [0,1]$ to be the retail trader's common discount factor[12], the second condition is fulfilled given that the discounted value of all profit resulting from the trigger strategy price rate, $p*$, is higher than the profit resulting from deviating from the trigger strategy.

The discounted value of the profit stream resulting from the trigger strategy price rate,

$p*$, is given by,

12) $$S(p*) = \pi(P(p*)) + \delta\pi(P(p*)) + \delta^2\pi(P(p*)) + \cdots = \frac{1}{1-\delta}\pi(P(p*))$$

By deviating from trigger strategy anyone day the consequences will be twofold. Given that everyone else demand $p*$, the trader undercutting the price can be sure to sell all his/her fish. By choosing a price *p'* such that $P(p*) < p' < p*$, the trader undercutting the price will increase her earnings at day *t*. The closer the trader gets to the price $p*$ without actually reaching it, the higher her pay-off at day *t*. Each trader can thus do better for a day by bidding $p' = p* - \varepsilon$, where ε positive number arbitrary close to zero. However, while gaining something extra at day *t*, the trader knows that from day $t+1$ onwards she will get only the price p^c. The discounted value resulting from defecting is thus given by,

13) $$\frac{1-\delta^t}{1-\delta}\pi(P(p*)) + \delta^t\pi(p') + \frac{\delta^{t+1}}{1-\delta}\pi(p^c)$$

Given that the value of 13) is smaller than or equal to the value of 12) for all retail traders at time *t*, it will not be worthwhile for any trader to deviate from the price *p**. The discounted value of defecting is smaller than the discounted value of adhering to the price *p** as long as the discount factor, δ, is sufficiently large,

14) $$\delta \geq \frac{\pi(p') - \pi(P(p*))}{\pi(p') - \pi(p^c)}$$

As long as the discount factor fulfil condition 14) the trigger strategy $p*$ is viable and can sustain an equilibrium consumer price level above the competitive level. The high and stable consumer price observed may thus be due to implicit co-operation arising from a repeated game situation in the consumer market.

[12] The discount factor reveals how the traders value future incomes. When the discount factor is δ, an income of *X* \$ tomorrow is worth δX \$ today.

5. Barriers to implicit co-operation

Implicit co-operation or tacit collusion is enforced through a purely non-cooperative mechanism. In the theory on oligopolistic behaviour it is generally assumed that high market concentration facilitates collusion (Tirole, 1992). In a homogeneous goods industry with *n* firms facing the same constant marginal costs, the per period and per firm profit in a fully collusive outcome in which all firms charge the monopoly price and share the market equally, are equal to π^m/n. The per firm profit per period is thus a decreasing function of the number of firms, *n*. More firms reduce the profit per co-operating firm and thereby the cost of being punished for undercutting. In contrast, the short run gain from slightly undercutting the monopoly price, which is given by $\pi^m\left(1-\frac{1}{n}\right)-\varepsilon$, increases with *n*. Fewer firms thus increase the cost - and reduce the short run gain - from defecting, thereby facilitating collusion.

Within Kapenta trade, the retail market is characterised by a far higher number of sellers than the producer market. This being the case, one could expect an even higher tendency to collude in the producer than in the retail market. The unilateral price cuts observed within the producer market, however, reveal that this is not the case. The absence of collusive agreements in the producer market must therefore be due to some barriers preventing a stable collusive outcome.

Collusive agreements are feasible only if cheating can be detected and punished severely enough. Factors hindering detection or punishment may thus act as barriers to collusion. If there exist detection lags retaliation is delayed. The future becomes more distant and dynamic interaction less relevant. This makes it less costly to cut the price unilaterally and tacit collusion will be harder to sustain. Furthermore, the existence of some large sales will make it harder to sustain collusive arrangement. The arrival of big orders from a large buyer tend to break down collusion as the short run private gain from undercutting is large relative to the long term losses due to future retaliations. Cost asymmetries between the producers may also hamper collusion as the cost differentials may make it difficult for producers to agree on the price on which to co-ordinate. Finally, a small discount factor among the producers may hinder collusion as this would make the producers put far more weight on the present than on the future.

Equation 14) in the section on repeated interaction shows that as long as the discount factor is sufficiently high, all firms will find it optimal to abide by the tacit collusive agreement and never cheat. The weaker the condition in the discount factor, therefore, the higher the probability that any collusive arrangement will be stable. The above mentioned factors, with the exception of cost asymmetries, all facilitate or impede collusion by influencing the condition on the discount factor. A small number of firms increases the collusive gain, $\pi(P(p^*))$, and reduces the short run gain of undercutting, $\pi(p')$, thereby facilitating collusion. Detection lags, on the other hand, can be seen as reducing the cost of defecting by reducing the collusive gain, $\pi(P(p^*))$, thereby hampering collusion. The existence of some large sale hamper collusion by directly increasing the short run gain from defection, $\pi(p')$. On the other side of the coin we have that the smaller the discount factor, δ, for given short run and collusive gains, the smaller the probability of a stable collusive arrangement.

In addition to the above mentioned collusion barriers, Davidson and Denecker (1984) found that horizontal mergers among firms in a capacity constrained oligopolistic industry may strengthen the condition on the discount factor and thereby act as a collusion barrier. In a situation with *n* firms of identical size, if $h < n$ firms merge into a large one, this merger strengthens the condition on the discount factor in situations characterised by intermediate industry capacity, $\frac{a-bc}{n+h} \leq k \leq \frac{a-bc}{n-h}$. This result stems from the fact that mergers increase the profits earned by outside firms at the treat point (that is, the equilibrium at which the repeated game reverts to if cheating is defected: *Turid, this sentence does not seem right to me*). A higher profit in the one period game is equal to a higher value of $\pi(p^c)$ in 13).

The increase in the profit earned at the treat point in the after merger situation reduce the losses due to retaliation. The outsiders, therefore, are more likely to cheat on the arrangement. Furthermore, as larger mergers benefit cheaters more than smaller ones, the larger the merger the lower the probability of a stable collusive arrangement[13].

Relating these collusion barriers to the situation facing the Kapenta operators we find that the operators do not appear to face detection lags. The producers compete primarily with other operators within a limited geographical area and are able to keep track of the daily prices charged by others by sending someone to their competitors to buy a bag of Kapenta at the going price. The lack of collusion does not appear to be due to large orders. The individual trader normally buys from 10 to 100 twenty kilo bags of Kapenta. According to the operators there is no single trader large enough to influence the price. When it comes to production costs they are approximately similar among all producers. All the operators use the same types of production rigs and the same number of workers per rig. As to the discount factor, the Kapenta operators are far richer than the retail traders. This being the case, one would expect the retail traders to have a smaller discount factor than the operators since consumption today is of a more immediate concern for the poor than the rich. The lack of price collusion among the producers appears, therefore, not to be due to detection lags, the existence of large sales, cost asymmetries or a small discount factor.

The barriers to collusion stemming from mergers, on the other hand, may explain the lack of collusive arrangements observed among the Kapenta producers on Lake Kariba in Zambia. In the Sinazonge area, Kapenta is caught by a limited number of operators with different catching capacity. The smallest producers operate only one fishing rig. There are also two relatively small firms running four rigs each. The majority of the companies run about 10-12 rigs each. In addition there is one company running 24 rigs and the largest one having a total of 56 rigs. Since they all use identical technology and have similar cost structure, the largest firm(s) can be seen as consisting of a number of smaller, merged firms. The largest company is actually partly established by merger of a number of identical smaller ones under one leadership. The size variability within the group of Kapenta operators thus indicate that the lack of collusion may be due to “merger-reduced” treat of retaliation.

The interpretation is supported by the fact that the largest Kapenta operator in the Sinazongwe area proposed that all the producers should enter into a binding commitment not to undercut each other, but was rejected by some of the smaller ones. According to the Davidson and Denecker model, a merger always benefits the outsiders more than the colluders. The outsiders, therefore, would lose more than the colluders on establishing an all compassing co-operative arrangement. Furthermore, the fact that the small ones did not oppose the establishment of a co-operative arrangement as such, but only their own participation within it, also fits the model predictions. According to the model, the larger the merger the larger the outsiders’ benefit. If such a coalition includes a sufficiently large portion of the industry it may even choose to ignore cheating by outsiders. A superior situation from the outsiders point of view as they then would be sure to sell their total capacity at a price slightly below the price charged by the merged firm.

6. Conclusion

The co-existence of variable producer prices and constant consumer prices of Kapenta within Zambian producer and retail markets, is explainable as the outcome of strategic price behaviour among actors operating in closed markets with different market characteristics. The consumer market being composed

[13] If the collusion incorporates a sufficiently large portion of the industry, it may choose to ignore cheating by outsiders. In such a situation the industry will obtain a stable price situation, but this is not due to collusion but to the fact that the merged firm carries the costs incurred by keeping the high stable price.

of a large number of retail traders each selling a small amount of the total quantity traded, allow for a collusive outcome due to implicit co-operation in a indefinitely repeated game. The lack of collusion observed in the producer market, on the other hand, is seen as the result of a collusive barrier stemming from the size variability among the Kapenta producers. In a market situation where there is neither excess capacity, nor under-capacity, merger of a portion of the firms into a large coalition, may act as a collusion barrier.

References

Allen, B. and M. Hellwig, 1986. Bertrand-Edgeworth Oligipoly in Large Markets. *Review of Economic Studies*, LIII:175-204

Dasgupta, P. and E. Maskin, 1986. The Existence of Equilibrium in Discontinuous Economic Games, I: Theory. *Review of Economic Studies*, LIII:001-026.

Davidson, C. and R. Deneckere, 1984. Horizontal Mergers and Collusive Behaviour. *International Journal of Industrial Organisation*, 2:117-132.

Gibbons, R., 1992. A Primer in Game Theory. Harvester Wheatsheaf.

Osmani, S.R. 1991. Wage Determination in Rural Labour Markets. The theory of implicit co-operation, *Journal of Development Economics*, 34:3-23.

Tirole, J., 1992. The Theory of Industrial Organisation. The MIT Press.

International markets and sustainability of marine resources: The case of the Senegalese small-scale fisheries[a]

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Abstract

One of the major objectives of the Senegalese authorities, by providing assistance to small-scale fishers, is to improve the nutritional standard of the Senegalese population through a sufficient supply of fish in the home market at a fair price. However, the small-scale fishery is presently an industry well integrated into the economic activity of the country and contributes more than 60 percent of the supply of the processing plants for exports. The orientation of the artisanal fishery towards the foreign markets coupled with the free access to the fishery has caused an increase in the artisanal fishing effort already judged to be excessive for some species, the demersal species in particular. This article tries to analyse the impact of artisanal fishery effort redeployment towards species destined to foreign markets and the consequences on fishery resources sustainability and home market supply.

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1. Economical importance of the fishery sector

Senegalese fisheries benefit from some exceptional natural factors like a sea rich in fish, a climate characterised by sub-tropical upwelling conditions and a coastal zone extending over 700 km. Maritime fishing employs about 600 000 people, thus contributing to bring down unemployment (MPTM, 1998). The fishing sector is a big part of the government's policy for food self-sufficiency in Senegal, as it covers almost 75% of people's needs in animal protein at a relatively cheap price.

In the face of problems in the agricultural sector due to unfavourable rainfall conditions, the authorities have quickly taken an interest in the fishery sector to help redress the country's balance of trade, which had been in deficit for many years. The fishery sector, the Senegal's main source of export, with 107 000 tonnes of fish products sold abroad, provided the country with 159 billion CFA francs (1US$ = 761 CFA francs) of export receipts in 1996.

With its total turnover of about 200 billion CFA francs in 1996, the fishery sector has generated an estimated 62 billion CFA francs of added value with 60% of this coming from direct fish catching and the rest representing added value from processing. In all, this represents 11% of primary Gross Domestic Product (GDP) and 2.3% of the total GDP (MPTM, 1998).

Besides the economic, commercial and technical compensations, the fishery sector provides the state with receipts through the various accords signed. Concerning the latest fishing accord between Senegal and the European Union (1997-2001), the direct financial compensation is about 48 billion CFA francs. To this are added taxes paid at the time of granting fishing licences to boats and licence cards to wholesalers; the fines imposed on those in violation of the fishing regulations, and finally, parafiscal taxes.

1.1. Artisanal fishery and home market

The Senegalese government, realising the importance of fishery as a major source of animal protein, income, and employment, instituted several development projects. The most important are the motorization of pirogues and the introduction of the purse seine gear in the small-scale fishery. These two major projects benefit from financial support programs. Outboard motors, fishing gears, and spare parts are sold to fishers duty and tax free, and gasoline includes a subsidy element, which is about 51 percent of the total price.

One of the major objectives of the state authorities, in providing assistance to small-scale fishers, is to improve the nutritional content of the diet of the Senegalese population at reasonable prices. However, the small-scale fishery is presently an industry well integrated into the economic activity of the country and contributes more than 60 percent of the supply of the processing plants for exports. These financial support programs have, without doubt, contributed to the development of small-scale fishery just as they have also generated adverse effects in the industry.

1.2. The traditional fishing sector and the export market

The fish catches in the industrial fishing sector are visibly insufficient to meet the demands in fish export. Thus, in their concern to ensure regular supplies of fish products some fishing industries call on a certain number of traditional fishers; they even provide these fishers with fishing equipment for their activities. These fishers go fishing and take back their products to be sold exclusively to the fishing units in which the fishers work; the products are sold at a mutually agreed price in advance. The repayment is a systematic deduction on delivering the fish products. Generally, 50 to 100 CFA francs are taken for each kilogram of fish delivered. Thus a contact of almost total integration is made between fishers and fishing units.

Taken as a whole, nearly 60% of supplies to fish exporting factories come from the traditional fishing units. Industrial exporters have greatly influenced the orientation of traditional fishing. Through the impetus of these industries, new types of traditional fishing have appeared; these have been developed only for export purposes. These new fishing types help to develop, among others, the cephalopod and the rock lobster fisheries.

With the substantial profits expected on the international markets following the devaluation of the CFA franc, we are now witnessing important fishing effort being transferred from species for local markets (small pelagic) to species caught for export purposes. Although the phenomenon is not new, it has intensified recently. Thus, through the fishing period of noble species like cephalopods - which have a high market value - most of the traditional types of fishing are turned toward the exploitation of these species. For instance, in recent years, from June to September, almost all traditional fishers on the Senegalese "Petite Côte" used to seek for priority species such as cuttlefish and *Octopus* for factories. Many pelagic fishing units -surrounding gillnets - have turned themselves to demersal fishing to catch the *Octopus*. From October to May, many boats involved in angling have used sole nets for fishing. Thus, cheap fish have become scarcer for the people as the pressure on fishing is now oriented towards exportable species, and as, traditional fishing is excessively developing for export purpose (sole, crayfish, cuttlefish, *Octopus*, shrimps). This sustained fishing effort has led to a state close to the overexploitation of demersal coastal resources. The most affected species represented 70% of the demersal coastal fish export in 1996.

2. The case of the *Octopus* fishery

Unlike the species sold in the local market where the fishers have only a little idea about the prices of the different fishes, which are generally fixed through mutual agreement without any confrontation between sellers and buyers, the producer prices of *Octopus* are an object of intense negotiations between fishing trade unions, wholesalers and industrials. This new balance of forces between the different actors operating in the fishery sector is due to the emergence of powerful fishers' trade unions in the early 90's. in the face of the rise in price of producing factors (nets, boats, engines) and exploitation expenses following devaluation of the CFA currency, these fishing unions have managed to strike a deal for the octopus purchase price which is profitable and much closer to the price of the international market. This remarkable increase in the producer price has stimulated the effort of traditional fishing by the redeployment of their fishing effort towards octopus and has also favoured the introduction of new cephalopod fishing units.

In fact, the wholesale trade of the *Octopus* signals a quick capitalisation process in the fishing industry. Thanks to the income they get from *Octopus* fishery, many fishers and wholesalers have been able to get new fishing units. Others have used the opportunity instead, to repair and make operational their boats, which had broken down for many years. Thus, many fishers have passed from the status of simple sailor to that of a master. The induced effects of this capitalisation process has caused increased fishing effort of traditional fishing which has already been excessive as far as *Octopus* fishing is concerned (Deme *et al*., 1998).

This sustained increase in the pressure on resources beyond the limits of overexploitation has caused the reduction in the number of middle-sized *Octopus* and the stagnation or downturn of yields in both traditional and industrial fisheries despite the high increase in fishing effort. In the face of signals indicating a state of over-fishing and the dangers to destroy the *Octopus* population, the Department of Oceanography and Marine Fishing (DOPM), in association with the research staff and the fishing unions instituted a twenty one day period of biological rest for the Octopus in 1996 (from July 1st to July 20th) and another forty-five days period of rest in 1997 (from June 1st to July 15th) by prohibiting the capture, stocking and marketing of the *Octopus* in Senegal during these two periods.

3. The case of *Cymbium* fishery (*Yeet*)

Fishing the *yeet* species with fixed nets has mostly been used in the Senegalese "Petite Côte" (Mbour, Joal). Fishers' women process the *yeet*. Until recently, the production of *yeet* has been a secondary activity and was used as a complement in the transformation of *guedj* (dried fish). In fact, the *yeet* was used only in Senegal where it was only an extra ingredient (Deme, 1996). Used after being dried and cut up into small pieces, the *yeet* is used as a seasoning condiment to "give flavour" to almost all Senegalese dishes. Until recently, *yeet* had only a limited market as the outlets of the products were exclusively confined to local needs. In these conditions, in Joal, as soon as there were abundant landings, prices would fall. And there were even periods in which fishers did not fish because of the low market prices of *yeet*.

Nowadays the *yeet* has become an export product to Asian countries. Fewer quantities of the species are now going to artisanal transformation. Only the by-catch of the industrial fleet and the landings from artisanal gears, which are not adopted for export, are used for artisanal transformation. For that matter most of the women involved in the artisanal processing of *yeet* are now limited to the collection of the product for industrial exporters.

The *yeet* is exported in many ways: fresh, frozen or cut up into pieces of varying sizes before being baked. The high profits from the exportation of the yeet have caused a visible increase in the fishing pressure on this resource. Thus, within 10 years the catches have grown from 20,000 tonnes to 5,000 tonnes. In the face of such over-fishing and over-capitalisation means of the means of production, the authorities have instituted a biological rest for the species all through the month of March 1999, this period corresponding to the highest production of *yeet*.

4. Conclusion

Octopus and *yeet* fisheries in Senegal show that the existence of a large market demanding huge quantities of products (creditworthy international demand, attractive prices) can cause both a biological and economic overexploitation of fish resources (Clark, 1990). These fishing activities cannot generate a sustainable economic surplus unless they are rationally planned for fear of dissipating the economic and social benefits expected. This is the reason for the different biological reference points instituted in Senegal to protect these resources. The objective of a sustainable exploitation being a precondition to any regulation, biological reference points should be closely supervised to contribute towards that purpose. However, because of various reasons. This is not adopted punctually, it appears the measure is applied in a reactive than preventive manner.

References

Clark, C.W., 1990. Mathematical Bioeconomics. The optimal management of Renewable Resources. New York, John Wiley & Sons, 399 p.

Deme, M. *et al*., 1998. Présentation des pêcheries nationales: Cas du Sénégal. Document de travail du Projet INCO-DC «Gestion durable des ressources marines renouvelables», Juillet 1998, 41 pages.

Deme, M., 1996. Etude financière des activités de transformation artisanale et semi-industrielle du poisson au Sénégal. Dakar, Groupe ABC, 20 pages.

MPTM, 1998. Plan Directeur des Pêches Maritimes: Analyse descriptive, politiques et stratégies. Vol. I, Version provisoire. Dakar, Ministère des Pêches et du Transport Maritime, 100 p.

Latin American fisheries, globalisation and the sustainability debate: a relocation boundaries?[a]

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Abstract

This chapter describes how Latin America was integrated into the global fisheries production system in the post-1945 period, highlighting the roles played by both foreign and domestic fleets in the process. Using globalisation and state-denial theories, it charts the impact that the globalisation process has had upon the exploitation and sustainability of fish stocks in Latin American waters. It argues that while globalisation may indeed boost environmental awareness and lead to more sustainable harvests through the decreased influence of local political interests, this has yet to happen in Latin America.

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1. Introduction

Globalisation has been variously blamed for an increase in poverty, environmental degradation, and a breakdown in democracy and governance (Holland, 1987; Schlesinger, 1997). Some, however, disagree with this view and see globalisation as a positive process that could, by strengthening international trade links, fortify local governance by reducing the power of previous dominant interests (Phillips, 1998).

Fisheries have not been unaffected by the globalisation process. The expansion of the activity of Distant Water Fleets (DWF) in the post World War II period and an increasingly global market for fish has put increasing pressure on global fish stocks as the race for fish continues. This paper argues that fisheries development in Latin America has passed through three distinct phases: first, the globalisation of fish production as DWF plundered stocks around the world; second, the globalisation of trade as neo-liberal economic reforms and the establishment of Exclusive Economic Zones (EEZs) gave coastal states the power and ability to fish and market their own catch; and finally the globalisation of regulatory control as the impact of the first two phases has forced a new look at the sustainability of fisheries in Latin America. It asks whether, in fact, the current globalisation process may, rather unexpectedly, help to reinforce national fishery management efforts. Improved regulatory control, externally-aided (or ordained) and domestically implemented, can only be beneficial from a stock sustainability perspective.

The paper is divided into 4 sections. Section 2 describes the globalisation of production (1945-1970s), section 3 the globalisation of trade phase (1970s-1990s), and section 4 the globalisation of regulatory control (1990s-present). We offer a tentative conclusion in section 5.

2. The globalisation of production (1945-1973)

While distant water fishing is not merely a 20th century phenomena, the post World War II (WWII) period saw an unprecedented rise in this form of fishing. One of the regions that saw the greatest increase in foreign fleet activity was Latin America, which in the 1950s remained relatively underexploited from a fisheries perspective. Although there was some domestic concern in Mexico at the level of stock exploitation, and indeed a number of regulations to control foreign fleet activity, these often went unheeded and it was not unusual to see foreign vessels operating in Mexican coastal waters. A growing awareness that they had an extremely valuable resource on their doorstep led Chile, Peru and Ecuador to lay claim to a 200-mile territorial sea through the Santiago Declaration (1952). Although this declaration was not universally recognised, state intervention and interest in the exploitation of natural resources was growing in the region. In 1971 the Chilean copper industry was nationalised, Mexico embarked on the 'Mexicanisation' of its industries in 1970-1976 and the military government of Brazil expanded state involvement during the same period. In Peru the anchovy fleet was nationalised in 1973 following a stock collapse brought on by a particularly strong El Niño event. Argentina, however, took a slightly different approach, introducing Total Allowable Catches (TACs) and imposing license fees on the increasing number of Soviet boats fishing for hake in the South Atlantic.

The tide was turning. As coastal states became more aware of the resources potentially under their control, African and Asian fishing nations followed in Latin America's footsteps[14]. The Third United Nations Conference on the Law of the Sea (UNCLOS III) held in 1974 saw the legitimisation of EEZs. Now, following UNCLOS III, a significant proportion of the world's fishery resources came under the jurisdiction of developing country coastal states. It also signaled the end of the global production phase, firmly placing the responsibility for fisheries management in the hands of coastal states.

[14] The history of Latin American maritime legislation is dealt with by Orrego Vicuna (1984)

3. The globalisation of trade (1973-1990s)

With EEZs now underpinned by the legal framework of UNCLOS III, many Latin American nations moved to expand their fisheries sector. Political and economic policy provided the foundation and support for such a move inasmuch as it protected the national fleet through a variety of measures. Although the state was in all cases pro-active in establishing the EEZs, this was often seen as the 'be all and end all'. Little attention, as explained below, was subsequently paid to regulation of catch or effort within these zones: a situation compounded by expanding neo-liberal influence in the region (Ibarra *et. al*., 1998).

(i) The growth of domestic fleets

A measure of the increased fisheries trade emerging in Latin America is the growth of both the national fleet and production (Table 1). Fleet expansion can be divided into two periods: pre- and post-NEM[15]. In some instances (Mexico, Uruguay and Ecuador) growth was greatest in the pre-NEM period due to the level of production assistance provided by the state. For others (Colombia, Argentina and Chile), the neo-liberal agenda provided the main impetus for growth by removing market restrictions.

The neo-liberal agenda which had gradually grown to dominate development thinking and policy in the region first took root in Chile in 1973. The Pinochet government firstly privatised the northern anchovy fleet, foreign fishing activities gradually being squeezed out of southern waters. A combination of privatisation of the fleet and opening up new fishing grounds led to a 58% increase in the number of purse seiners working off the Northern coast, while the number working the Southern coasts rose 75% between 1974 and 1981 (Thorpe *et al*., 2000).

The Peruvian and Mexican cases point towards the strong intervention of the state prior to NEM adoption. Following nationalisation, Peru's military reformist government continued to subsidise and protect its national fleet, recognising that it was a major income earner for the national economy. Mexico, on the other hand, channeled significant financial and technical support into the artisanal and cooperative fleets. It also used considerable sums of money to create an industrial tuna fleet. Table 1 demonstrates how fleet growth slowed dramatically after 1988 as economic reforms saw state financial support drastically cut. In both Peru and Mexico, however, state involvement was oriented towards boosting production and 'mining' its fisheries resource, not fostering sustainable management of the stocks.

Argentina and Colombia, unable to take full advantage of their own waters after declaring an EEZ, extracted resource rent by contracting other nations to fish their waters. In the case of Argentina, it also encouraged the promotion of joint ventures, a situation that still pertains today, Argentina having a major fisheries agreement with the EU. This policy allowed Argentina to increase catch and production locally, whilst simultaneously increasing its linkages to the global market. Likewise, Colombia, with little national fisheries activity to speak of, made full use of its Pacific and Caribbean coast and contracted-in mainly US vessels to fish those waters. After the adoption of neo-liberal policies (1991), local investment by a large US tuna company saw a sharp increase in Colombian fleet capacity.

This fleet growth has allowed Latin American fishing states to make the most of their renewable resources. Through state protection, support and/or the growth of markets, production has increased locally within Latin America, whilst trade has become increasingly more globalised.

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[15] 'The New Economic Model' (NEM) is a series of policy measures (trade reform, privatisation, financial and market deregulation) designed to enable indebted countries to 'grow out of debt'. The impact of such models on national fisheries policy in the region is discussed in Thorpe *et al*. (2000) and Ibarra *et al*. (1998)

Table 1. Growth of Latin American Industrial Fishing Fleets (Vessels over 100 GRT), 1970-1995.

						Mean growth (% .year^{-1})	
Group‡	**Country**	**1970 GRT**	**NEM Date‡‡**	**GRT at NEM Date**	**1995 GRT**	**Pre-NEM**	**Post-NEM**
1	Costa Rica	0.0	1986	5.2	3.1	N/A	-5.59
1	Mexico	8.1	1988	288.5	299.6	21.96	0.54
1	El Salvador	4.9	1989	3.5	3.6	-1.76	0.47
1	Venezuela	26.5	1989	88.1	95.5	6.53	1.35
1	Guatemala	0.8	1991	2.9	2.5	6.32	-3.64
1	Nicaragua	*	1991	12.1	12.4	N/A	0.61
1	Ecuador	15.7	1992	49.1	52.7	5.32	2.40
1	Honduras**	0.8	1992	14.4	14.8	14.04	0.90
1	Brazil	8.0	1994	19.2	17.8	3.72	-7.29
2	Argentina	9.5	1991	128.7	212.6	13.21	13.37
2	Uruguay	1.8	1991	14.4	20.6	10.41	9.36
3	Chile	16.0	1975	15.4	168.2	-0.76	12.70
3	Colombia	0.1	1991	4.3	14.1	19.61	34.57
4	Peru	61.6	1990	128.6	157	3.75	3.75
	Panama**	12.1	1995	346.4	-	14.36	-
	TOTAL	**165.0**	**-**	**-**	**1,400.9**	**-**	**-**

GRT in 000 GRT.
* signifies less than 100 GRT.
** The Panamanian and Honduran figures should be viewed with some caution due to the registration of vessels under‘flags of convenience’.
‡ See text for details.
‡‡ For current purposes, an economy is deemed to be following the New Economic Model (NEM) policies once it has implemented a trade liberalization program *and* stabilized inflation (IADB, 1996, p.77ff).

Source: Thorpe *et al*. (2000), extracted from FAO (1998) and personal communications *(ii) Latin American fish trade*

The reduction industry has been the major contributor to Peruvian, Chilean and, to a limited extent Ecuadorian fish production and exports (see Fig. 1)

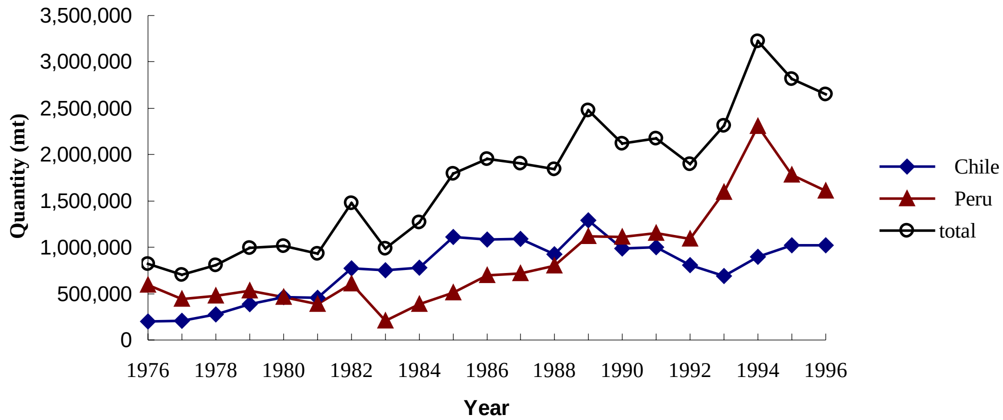

Fig. 1 Fish meal exports in tonnes (Source: FAO Fisheries data)

While Peru exploited its historic processing capacity to boost production, Chile took advantage of the gradual southwards movement of a number of pelagic stocks and a growing harvesting capacity to increase processing production.

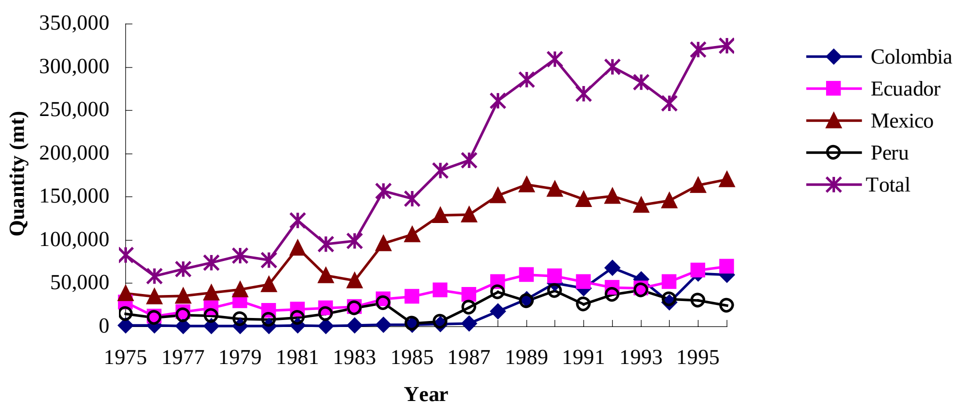

Fig. 2 Tuna catches in tonnes (Source: FAO fisheries data)

Fishmeal continues to be an important input to aquaculture and South East Asia, where a large indigenous aquaculture sector has long been a traditional market for Latin American exports. Yet, the fishmeal industry, reliant as it is upon pelagic stocks, is highly susceptible to stock collapse, a factor made clear in 1998 when a new El Niño event pushed global production down by 40% on the previous year, leaving meal production at its lowest level since 1977 and oil production at its lowest since 1973 (IFOMA web-site).

In response to growing global demand for tuna, production in the continent has soared (see Fig. 2). Mexico is the biggest producer following its heavy investment in the tuna fleet in the late seventies, Ecuador and Colombia (since 1987) also making significant inroads into the global market. While some of this catch is directed to domestic consumption, much of the catch is destined for export.

In response to the crisis in white fish stocks in northern waters, a number of Latin American nations have been able to take advantage of hake stocks in their waters (see Fig. 3). Unregulated growth, periodic overfishing and moves to restrict catches have characterised the Chilean hake fishery although, in volume terms, the industry is rather less important than the pelagic fishery. Peru has also exploited this highly valuable species, while hake has been particularly important to Uruguay and Argentina where it remains the main stay of both the domestic freezer fleet and the large EU fleet operating in those waters.

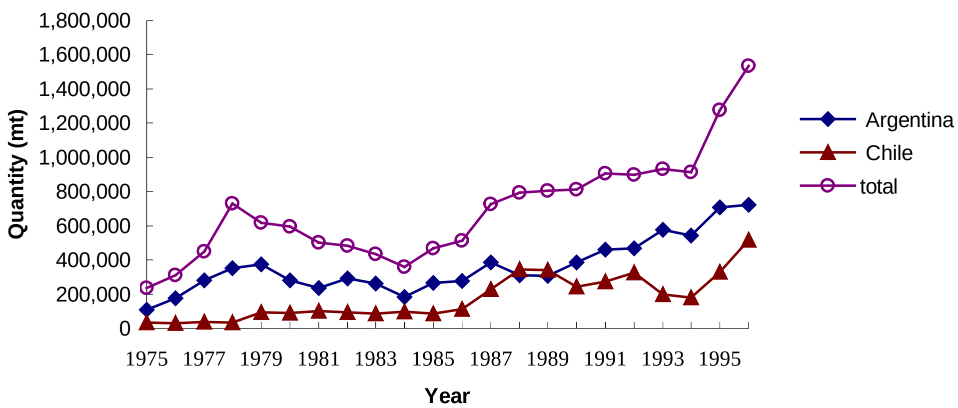

Fig. 3 Hake Catches in tonnes (Source: FAO Fisheries Data)

(iii) The current status of Latin American fish stocks

The expansion of trade in fish has not been without its problems. Growing world demand for fish and an increase of effort and capacity in Latin America has led to the likelihood of persistent and serious stock collapses throughout the region (see Table 2).

The various hake stocks relied upon by Chile, Argentina and Uruguay are already in the fully to over exploited category and yellowfin tuna stocks in Mexican and Venezuelan waters are also fully exploited. The story is similar regarding the pelagic species, these being either moderately to fully fished (jack mackerel, pilchard and Pacific anchovy), fully to over exploited (Peruvian anchovy, South American pilchard and Araucanian herring) or over-exploited (Brazilian Sardinella). Overfishing and stock collapse are endemic problems in pelagic fisheries in the region, as the peaks and troughs in Figure 1 gives such indication of.

As Table 2 clearly demonstrates, the real consequences of the increased expansion of fisheries trade in the continent is that Chub Mackerel stocks off the western sea-board of Chile, Peru and Ecuador were the only stock to remain in the moderately exploited category according to the most recent FAO data. The biggest current fears concern the Chilean Jack Mackerel fishery which was abruptly closed by the government early in 1999 when it was discovered that the stock was made up of 93% juveniles (Fish Information Service, Sea-World, Various 1999). The extraordinarily high catches of this stock recorded since 1994 have led Chilean scientists to doubt that the ban will be sufficient to prevent the complete collapse of the stock.

(iv) The pitfalls of excessive export dependence

Concerns about the state of fish stocks were brought to the fore by the collapse of the East Asian economies in 1997. One of the principal implications of this collapse was the impact it was predicted to have upon primary commodity trade flows, fish included. The Asian crisis has affected Latin America in three ways, through: market contraction (as a result of reduced buying power in South East Asia); loss of market share (as currency depreciation makes South East Asian commodities more competitive) and reduced income from license fees (as South East Asian companies contract their distant water fishing operations).

Fishmeal has been the biggest victim of contracting markets. Although Peru survived the crisis reasonably well (China, untouched by the crisis, is the biggest importer of Peruvian fishmeal), Chile did not. Both Taiwan and Thailand, the biggest importers of Chilean fishmeal reduced their purchases, leaving Chile with a US$ 81.4 shortfall in fishmeal revenues in 1998 compared to the previous year. Market displacement is harder to quantify, yet international squid and tuna prices were forced downwards as South East Asian producers redirected their now cheaper products to traditional Latin American markets in the US. The Falkland Islands (Malvinas) have been hardest hit by the reduction in license fees, as it is heavily reliant upon the sale of licenses for its rich squid fishery. Korean vessels, one of the Falkland Islands' biggest customers, only purchased 61 licenses in 1998 (compared to 116 licenses in 1997), aggregate fishing income dropping around 12% over the same period.

Table 2. Principal Latin American Marine Fisheries‡: Catches (000 tonnes) and Present Status of Exploitation‡‡

Species	Participating Countries	1995 Catches	1980-1995 Catches Peak	Low	Status
Peruvian Anchovy	Peru	6,558	9,800	22	(R), F-O
	Chile	2,086	2,086	8	
Chilean Jack Mackerel	Chile	4,404	4,404	1,060	M-F
	Peru	377	377	37	
	Ecuador	174	174		
South American Pilchard (Spanish Sardine)	Peru	1,266	3,398	1,182	(D), F-O
	Chile	162	2886	162	
	Ecuador	-	694	-	
Argentine (Hubbsi) Hake	Argentina	574	574	183	F-O
	Uruguay	58	97	55	
Californian Pilchard	Mexico	370	509	94	M-F
Patagonian Grenadier	Chile	207	227	18	F-O
Shortfin Squid	Argentina	199	199	9	F-O
Round Sardinella	Venezuela	153	153	28	U
Araucanian Herring	Chile	127	1,687	18	F-O
Chub Mackerel	Chile	110	192	2	M
	Ecuador	64	570	26	
	Peru	44	87	17	
Yellowfin Tuna	Mexico	108	119	24	F
	Venezuela	65	67	-	
Pacific Anchovy	Panama	107	241	39	M-F
S. Blue Whiting	Argentina	104	104	-	M-F
S. Pacific Hake	Chile	75	75	26	F-O
Patagonian Hake	Chile	25	69	18	F-O
Braz. Sardinella	Brazil	57	250	32	O

‡ Criteria for inclusion: landings exceeded 50,000 tonnes in at least one country between 1980 and 1995. Pelagic species are in italics.

‡‡ As defined by FAO (1997), where: U = unknown; M = moderately exploited; F = fully exploited, O = overexploited; D = depleted; R = recovering.

Sources: Thorpe *et al*. (2000), originally from FAO (1997,1997a)

4. Regulatory globalisation (1990s-present)

The largely ineffective early attempts at stock management, most notably in Chile, only served to underline the need for more coherent and far-reaching fisheries policies. New fisheries laws enacted by the region's four principal marine fishing nations during the nineties was the result of this perceived need for more effective fisheries management. This, we contend, was the beginning of the third globalisation phase.

(i) Domestic regulatory measures

The laws enacted (Appendix 1), while virtually excluding DWFs from Latin American waters, take somewhat different regulatory stances. TACs based on catch records are applied to 30 species in Argentina, although highly public disputes have prevented the government from introducing a TAC on its main hubbsi hake fishery. Mexico has now abolished the preferential access status for cooperatives and currently only has TACs for turtles. Chile has taken the biggest steps towards a market driven TAC approach, introducing Individual Transferable Quotas (ITQs) for a number of its less important (in terms of aggregate catch) species. ITQs for industrial species have so far not been introduced due to successful lobbying by the industrial sector. Political pressure by the industrial sector has also prevented ITQs being adopted in the Peruvian pelagic fisheries.

Although there is doubt that domestic forces alone might be strong enough to overcome the political power of the industrial sectors in these countries, there is a possibility that international pressure might force the hand of states on regulatory matters.

(ii) Global regulatory measures

There is already evidence that the globalisation of regulatory control is having some impact in three areas: standard setting, compliance agreements and industry self-regulation. The Health and Safety Standards (Hazard Analysis and Critical Control Point - HACCP) is a process-based quality control principle applied to fish storage/processing/marketing, which is having an increasingly important impact on marine resource trade, forcing Latin American countries to conform in order to ensure that their products are not subject to US or EU export barriers. However, at present, this standard does not take into account sustainability of the underlying fishery and so is unlikely to affect harvesting levels. The World Trade Organisation (WTO) also has a series of standards which apply to international trade in fish products: anti-dumping agreements, the removal of technical barriers thus ensuring greater harmonisation of trade, agreements on sanitation and phytosanitary measures and the removal of subsidies. However, they are just that, trade standards, and so are unlikely to affect the extent to which a fish stock is mined. Finally trade embargoes, such as the US embargo on non-dolphin friendly tuna are further examples of standard settings. While, this particular instance is a good example of how the global community may direct domestic regulatory control towards sustainability criteria, such actions run the risk of running foul of the WTO rules.

Effecting compliance globally is problematic, and as Steinberg (1999) points out, there are currently, no satisfactory global control mechanisms. Other attempts, ranging from UNCLOS III, which brought in the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks in December 1982, to the 1995 FAO Code of Conduct for Responsible Fisheries in 1995 remain largely ineffectual to date.

Because ensuring compliance on a global scale is difficult, industry self-regulation has emerged in the past couple of years in the hope that market driven incentives will perform better. The Marine Stewardship Council (MSC) as a partnership between the World Wildlife Fund and Unilever, was set up in 1996 to promote sustainable fishing through the use of eco-labelling. Local fleets that operate in a sustainable manner will be certified and those processors and distributors who buy from those fleets will be able to place the MSC logo on their product. Thus, the market may be able to enforce more sustainable fishing through exploiting consumer preferences for such fishing, for whilst ensuring such pressures are placed beyond the reach of WTO trade rules (Steinberg, 1999).

5. Some tentative conclusions

Through a process of state support and legislative measures, many Latin American countries successfully managed to increase their share of the global trade in fisheries products while, at the same time increasing national participation in that activity. Latin America's high degree of linkage to global capital markets has, on a number of inglorious occasions, led to dramatic financial collapses; its commodities markets are open to the same degree of speculation, nervousness and global fickleness. The 1997 collapse of many South East Asian markets revealed the extent to which global linkages have arrived. Latin America came out of the crisis reasonably well, and perhaps with a profound sense of relief that for once, all eyes were on the Asian Tigers' financial woes rather than their own.

However, globalisation has spread beyond its original trading boundaries and is now present in other realms. Growing environmental concern has 'globalised' the sustainability debate. What is more, as trade becomes ever more international, environmental regulations governing the manufacture or production of a particular good will become vital characteristics that influence the decision to purchase. The global marketplace of vocal consumers is now moving to demand, and get, changes to the world supply of marine products, changes that can have dramatic impacts upon countries highly reliant on that one export market. The founding of the Marine Stewardship Council, and its moves are, perhaps, undeniable signals of the state of the world's fish markets to come. So, through the increased empowerment of local governance, backed-up by consumer demand, globalisation may, after all, prove itself as a positive influence on world fisheries.

References

FAO, 1997. Yearbook of Fisheries Statistics: Catches and Landings. Rome, FAO.

FAO, Marine Resources Service, Fishery Resource Division, 1997a. Review of the state of world fishery resources: marine fisheries. Rome, *FAO Fish.Circ.*, 920:173 p .

FAO, Fishery Information, Data and Statistics Unit, 1998. Fishery fleet statistics, 1970, 1975, 1980, 1985, 1989-95. Rome, *FAO Bulletin of Fishery Statistics*, 35:501 p.

FAO, Fishery Information, Data and Statistics Unit, 1999. Capture production 1997. Rome, *FAO Yearbook of Fishery Statistics. Capture production,* 84:703 p.

Fish Information Services, Sea-World, http://www.sea-world.com

Holland, S. 1987. The Global Economy. London, Weidenfeld and Nicholson.

IADB, 1996. Economic and Social Progress Report 1996. Washington DC, IADB.

Ibarra, A.A., C. Reid and A. Thorpe, 1998. Neo-liberalism and the Latin `Blue Revolution': Fisheries Development in Chile, Mexico and Peru. CEMARE Research Paper, University of Portsmouth, 139.

IFOMA web-site, http://www.ifoma.com/trade.html

Argentina s/b 'Ley 24.922: Regimen Federal de la Pesca (1997)', 1997. Buenos Aires, MAG.

Chile s/b 'Ley de Pesca y Acuicultura', Decreto Superom No.430 (1991), 1997. Santiago, Editoría Jurídica Manuel-Montt.

México s/b 'Ley de Pesca' (1991), 1991. México D.F., Diario Oficial de la Federación.

Perú s/b 'Ley General de la Pesca - Decreto Ley 25977 (1994)', 1994. Lima, Ministerio de Pesquería.

Orrego Vicuña, F. (ed.), 1984. The Exclusive Economic Zone: A Latin American Perspective. Boulder, Colorado, Westview.

Phillips, N., 1998. Globalisation and the "Paradox of State power": Perspectives from Latin America. University of Warwick, CSGR Working Paper No.16/98.

Schlesinger, A. Jr., 1997. Has Democracy a Future? *Foreign Affairs Journal*, September/October, 76(5):2-12.

Steinberg, P.E., 1999. Fish or Foul? Investigating the Politics of the Marine Stewardship Council. Paper presented at the Marine Environmental Politics in the 21st Century Conference, MacArthur Program on Multilateral Governance, Institute of International Studies, UC Berkeley, 30 April-2 May.

Thorpe, A. and A.A. Ibarra, 2000. The New Economic Model and Fisheries Development in latin America. *World Development*, 28(9):1689-1702 .

Appendix 1: Management Systems Introduced by Current Fisheries Laws of Principal Latin American Fishing Nations

	Chile (1991)	**Argentina (1997)**	**Mexico (1991)**	**Peru (1994)**
Access to Fisheries Resources	**i**. Open access fisheries - unlimited but non-transferable permits for industrial vessels, denoting area and species[1]. **ii**. Fully exploited fisheries - access to new entrants can be suspended (up to one year, but renewable), although transfer of authority is permissible. Up to 50% of TACs auctioned in 5% shares as extraordinary 10-year permits (divisible, transferable) [2]. **iii**. Recuperating fisheries[3] - no new authorisations, all current authorisations cancelled. TACs auctioned in 10% shares as extraordinary 10 year permits. Shares 'depreciate' by 10% per annum, allowing 10% to be auctioned each year. **iv**. Incipient Fisheries - no new authorisations. Authorised firms granted extraordinary 10 year permits[4]. Auction procedure as for recuperating fisheries. **v**. Not necessary for artisanal firms, except for 'benthonic' stocks.	**i**. Permits grant temporary or full access to fish in Argentine EEZ or high seas. **ii**. Permits of 10 years (individual boat) or 30 years (processing company boats), depending on vessel age, origin and crew composition. Only transferable to boats with equivalent hold capacity. **iii**. Partly transferable quotas assigned at National Fisheries Council's discretion, on the basis of crew composition, average landings over previous 8 years, and investment and compliance record. **iv**. Transfer of quotas between refrigerated and freezer vessels prohibited.	**i**. 5-20 year concessions, extendable upon termination[5]. Permits granted for a maximum of four years. **ii**. Transferable concessions to fishing vessels/firms awarded competitively. **iii**. No control over artisanal fishers landing fish for domestic consumption.	**i**. All concessions are suspended in over-exploited fisheries. **ii**. Requests to increase or substitute vessels within fully-exploited fisheries judged upon a 'replacement hold capacity' basis. **iii**. Under-exploited fisheries licensed by renewable annual permits. **iv**. Not required in artisanal fisheries.
Reasons for Rescinding Access	**i**. Failure to operate concession, pay fees or comply with regulations. **ii**. Catches exceed ITQs by more than 10%.	**i**. Depends upon 'gravity of offence'.	**i**. Failure to operate concession, pay fees or comply with regulations. **ii**. Operation harms the eco-system.	**i**. Failure to operate concession, pay fees or comply with regulations.

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	Chile (1991)	Argentina (1997)	Mexico (1991)	Peru (1994)
Sanctions other than rescinding access	**i**. Confiscation of catch. **ii**. Fines equivalent to 0.5 tax units multiplied by tonnage increase if vessel size increased. **ii**. Next period's quota reduced by double the excess if extraordinary permit holders overfish. **iii**. Fines up to 4 times `sanction value' of overfished species, plus additional fines for captain (30-300 tax units) and owner (3-150 units).	**i**. Fine of between 10,000 and 1 million pesos, doubled for subsequent infringements in following five years. **ii**. Temporary suspension of between 15 days and a year. **iii**. Vessel decommissioned.	**i**. Confiscation of catch. **ii**. Fines of 20-20,000 times the minimum wage, depending on the offence[6].	**i**. Confiscation of catch. **ii**. Fines of 0.5- 5,000 tax units, depending on the offence[7].
Foreign Flagged Vessels	**i**. No provisions.	**i**. Where Congress signs an international fishing treaty.	**i**. Permitted in underexploited fisheries.	Permitted: **i**. when vessels are chartered by Peruvian companies; **ii**. in underexploited fisheries or those for highly migratory species; Requiring: **i**. Peruvian technical observance and a 30% Peruvian crew; **ii**. annual permit renewal.

1. Fees for authorisation permits calculated according to vessel size: <100 GRT (excluding artisanal vessels) ~ 0.5 tax units × GRT; 100>1,200 GRT ~ 1.0 tax units × GRT; 1,200> GRT ~ 1.5 tax units × GRT. As of late-June 1998, 1 tax-unit equalled 25,106 pesos (approximately US$450 at prevailing exchange rates).
2. The remaining 50% covers (i) by-catch, and (ii) the catch of authorised permit holders.
3. The red shrimp and southern hake fisheries have been declared as 'under recuperation' and ITQs auctioned off. The procedure is summarised in Peña (1997:271).
4. Firms are entitled to quotas equivalent to average catches in the three years following announcement of incipient status, expressed as a percentage of total the TAC.
5. Permits are granted when investment is deemed insufficient to justify feasibility studies.
6. The minimum daily wage currently stands at 30.20 pesos (approximately US$3.30 at late-June 1998 exchange rates).
7. A tax-unit is currently equivalent to 2,600 soles (approximately $880 at late-June 1998 exchange rates).

Source: Thorpe *et al*. (1999), originally published in *Ley de Pesca y Acuicultura, D.S. No.430* (Chile), *Regimen Federal de la Pesca, Ley 24.922* (Argentina) *Ley General de la Pesca - Decreto-Ley 25977* (Peru), *Ley de Pesca* (Mexico) and all associated regulations.

Data needs for global fisheries analysis

Economic data for FishBase[a]

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Abstract

This paper attempts to do two things. First, it outlines how to develop a detailed economic database for Fishbase, which is a CD-ROM database on finfish developed at ICLARM. Second, it presents a method, based on demand composition analysis, for tracking the flow of fish landings around the world. Our general aim is to complement the huge biological data already contained in Fishbase on more than 17 500 fish species. By including economic data and providing a system to track the flow of imports and exports around the world, Fishbase will become an even more powerful tool for the study and analysis of the world's fisheries. The reader should note that in discussing economic data, we will refer to prices throughout this paper, but in principle, what we say about prices can also be applied to costs.

a) Paper presented at the INCO-DC International Workshop on 'Markets, Global Fisheries and Local Development', Bergen, Norway, 22-23 March 1999

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1. Economic data

Essentialy all fish species recognised by science (25,000) classified according to the International Standard Statistical Classification of Aquatic Animals and Plants (ISSCAP) are included in FishBase (see www.fishbase.org). Our effort aims, at this point, to include into FishBase prices for each of the 78 major species groups under the ISSCAP classification and thus to enable economic analysis of the catch and related data included in FishBase. Of course, the ultimate goal is to develop unit prices for each single species traded on the market. In future it should be possible to incorporate unit values for non-marketed marine resources (see Angelsen and Sumaila, 1998 and the references therein).

It is reported that in 1983 - 85, nine fishing nations accounted for 60% of total world catch. While the top eighteen fish producing nations landed almost 80% of total world catch. Japan and the former Soviet Union landed a third of world catch during this period (Pontecorvo, 1988). This high concentration of fish catches in a few countries has not abated with time. FAO (1996) reports that in 1994, ten countries accounted for nearly 70% of total world fish catches, while twenty countries accounted for about 80%. In our attempt to put together global unit prices, it is natural to take as point of departure these top twenty countries, which according to FAO (1996) are China (accounting for nearly 18.9%), Peru (10.6%), Chile (7.1%) Japan (6.8%), USA (5.4%), India (4.1%), Indonesia (3.7%), Russia (3.5%), Thailand (3.1%), Republic of Korea (2.5%), Norway (2.4%), Philippines (2.1%), Denmark (1.7%), Democratic People's Republic of Korea (1.6%), Iceland (1.5%), Spain (1.3%), Mexico (1.2%), other Asia (1.1%), Malaysia (1.1%) and Viet Nam (1.1%).

1.1. Steps in calculating global unit prices

1. Collect price data for ISSCAP fish group landings in the most important fishing nations in each region of the world. Special efforts should be made to obtain data for the catches of the twenty leading fishing nations listed above.

2. The country data collected are grouped according to the regions of the world they belong to, as defined in FAO (1996): (i) South Pacific (ii) East Asia (iii) Europe (iv) Latin America and the Caribbean, (v) North America, (vi) Near East and North Africa, (vii) South and Southeast Asia and (viii) Sub-Saharan Africa.

3. Build aggregate regional prices based on the country data collected under (1) above. To do this, country data are aggregated using a weighting system that depends on the relative size of their catches.

4. Aggregate global prices are built from the regional prices computed in (3) above. The framework for calculating aggregate prices, both regional and global, is described below.

1.2. Aggregating country-level data to obtain regional and global prices

The point of departure here is the country-based data collected. The countries for which data are available are classified into the regions of the world to which they belong. For each region we note the catch of each of the countries we have relative to the total regional catch. To formalize the method, let the catch of country $i=1,2..I$ of a given group of fish, g, in region r be denoted by $x_{i,g,r}$ then the total regional catch of g is given by,

1) $$x_{g,r} = \sum_{i=1}^{I} x_{i,g,r}$$

The above implies that the relative catch of fish group *g* by country *i*, is given by

2) $$\frac{x_{i,g,r}}{x_{g,r}} \quad \text{where} \quad \frac{1}{x_{g,r}} \sum_{i=1}^{I} x_{i,g,r} = 1$$

Hence, the aggregate regional price of group *g* fish is given by

3) $$p_{g,r} = \frac{1}{x_{g,r}} \sum_{i=1}^{I} p_{i,g} x_{i,g,r}$$

where $p_{i,g}$ is country *i's* average price for fish group *g*.

Similarly, the global aggregate price for fish group *g* is given by,

4) $$p_{g,g} = \frac{1}{x_{g,g}} \sum_{i=1}^{I} p_{g,r} x_{g,r}$$

where $p_{g,g}$ is the aggregate global price for fish group *g*; $x_{g,g}$ is the global catch of group *g* fish; and $p_{g,r}$ and $x_{g,r}$ are as defined earlier.

1.3. Present value calculations

A spreadsheet is provided as part of this database containing different discount factors. The purpose for including this table is to allow data collected at different points in time to be discounted to present value. As it is well known, there is an on-going debate on what the appropriate rate of discount should be, especially among environmental economists (see for example, Nordhaus, 1997 and the references therein). The answer to this question is still not clear, mainstream economists turn to argue that the discount rate should not be tempered with in our effort to stem the drive to over-exploit natural resources (Pearce *et al.*, , 1990). On the other hand there are, for instance, climatic change economists who argue for selective discounting, where a discount rate of 0% is applied to projects or components thereof that will lead to long term negative effects on the climate (Nordhaus, 1997). Our table is designed to cater for all concerns, I therefore present discount factors for rates ranging from 0 to 20%, and leave the choice of which discount rate to apply in a specific situation to the particular analyst undertaking a study.

2. Tracking the flow of fish landings

The ecosystem consists of an interdependent number of elements, including the fish and its environment. Single species and therefore single country analysis of fish flows is not sufficient to provide a clear picture of what is happening to the ecosystem at the global level. Single country analysis ignores the observed interdependencies of different countries and therefore different ecosystems in the flow of fish landings. This provides a strong rationale for the mass-balanced approach that we advocate in the tracking of fish catches and consumption, at the country, regional and global levels.

It is important to note that an imbalance between demand and supply of a particular species of fish at the country, regional or global level would be reflected in the market for this species by way of a change in price. For example, an excess demand for cod in country A is likely to result in an increase in its price. This would provide the signal for increased cod fishing at the local level, further depleting available stocks. This is likely to result in the increased fishing of other species. Furthermore, this excess demand is likely to be met by importing from another country or region. It is very possible therefore that changes in the demand or supply can lead to changes in the ecosystem far beyond the location of the change in demand or supply. It is therefore important that fish flows be tracked not only at the country level, but also at the regional and global levels in order to have an idea of what is happening to the local, regional and global ecosystem. How can we do this?

The framework developed here is based on a simple demand and supply analysis in which we can track the flow of fish landings by summing up net supplies (net exports) or net demands (net imports) of different species of fish for different countries. Net demand or supply for each country is measured by fish landings (output) minus domestic consumption for each country.

The following tables provide an example of the type of data to be collected using this approach. Basic tables (a) organize landings, domestic demand and net exports by species, countries and regions. Sums by species across regions and countries are then obtained in a second table (b).

Table 1. Demand Composition Analysis.

(a) Landings, Domestic demands and net export by Region, Country and Species

Region	**Country**	**Species**	**Landings**	**Domestic Demand**	**Net Exports**
i = 1 to n	j = 1 to n	k = 1 to n	x	y	z

(b) Landings, domestic demand and net exports by species summed across regions and countries.

Species	**Landings**	**Domestic Demand**	**Net Exports**
k = 1 to n	$\sum_i \sum_j x$	$\sum_i \sum_j y$	$\sum_i \sum_j z$

The framework presented is a rather simple and straightforward tracking of excess demands but the information such an analysis can provide can be rather powerful in getting a clearer picture of what is happening to particular species of fish at the country regional and global levels. In doing so we can draw on our existing knowledge of the interrelationships between various elements of the ecosystem to predict what is likely to happen if there is over or under fishing of a particular species at the local regional or global level. In fact such a mass-balanced approach could lead to interesting conclusions. One can envisage circumstances in which what might appear to be over fishing at a local level might in fact be encouraged if the global picture is taken into account and vice-versa.

References

Angelsen, A. and U.R. Sumaila, 1997. Hard methods for soft policies: Environmental and social cost-cost benefit analysis. pp. 20-42 In F. A. Wilson (ed.). Towards sustainable project development. Edward Elgar, Cheltenham, UK.

Nordhaus, W.D., 1997 Discounting in economics and climate change. *Climatic Change,* 37:315-328.

Pearce, D.W., E.B. Barbier, and A. Markandya, 1990. Sustainable Development: Economics and Environment in the Third World. Aldershot, Edward Elgar.

Pontecorvo, G., 1988. The State of Worldwide Fishery Statistics: A Modest Proposal. *Marine Resource Economics*, 5:79-81.

Scott, A., 1960. The need for economic statistics of the fisheries. *FAO Fisheries Papers,* No. 16.

The Socio-economic data needs on regional and local level to support a correct diagnostic for fisheries management[a]

Pedro M. M. Lopes Garcês[b]

Abstract

The objective of this paper is to provide an inventory of socio-economic information needs to help the decision making process of regional agencies in the fisheries sector. This communication originates from several studies that we have been carrying about fisheries on a regional and local basis, with especial emphasis on employment, and the Algarve region of Portugal. A result of this effort is that a structural solution to the problems of the fisheries sector would have to have at its an information system for the sector at a regional level.

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1. Introduction

The motivation for this paper arose from one of the themes of the Workshop, namely, the information required to help incorporate socio-economic data into new forms of modelling such as the ECOPATH system. The problem of fisheries management is subject to multiple objectives and it is very complex, as it requires integration of economic, biological and social considerations. We usually attempt to integrate those interactions but frequently we forget that the management of fisheries cannot be an isolated policy, it has to be integrated also with all other sector policies. Also we cannot forget that we have to manage European fisheries at the EU level, but the success of those policies depend on the capacity of each regional administration in each country to make a correct diagnostic that supports good decisions. We have to decentralise the administration on fisheries, and to introduce more spatial considerations into it. Fisheries development cannot be more important that sustainable development, whenever we talk about development we necessarily have to introduce the space variable.

Considering the above, we need a regional administration that has the knowledge of the economy of the region, especially, of the fisheries sector and the interactions with other sectors. This paper is developed with the considerations in mind.

2. Decision process in the Fishery Sector in Portugal

The decision process in the fishery sector in Portugal is extremely centralised. The central government body responsible, the General Directorate for Fisheries and Aquaculture (DGPA) has three divisions – the North, Central and South divisions. Each of these divisions have little decision-making powers, their main responsibility is policy execution. This means that the main policies are defined in Lisbon and executed by the different regional administrations. Although, the study of the level of centralisation/decentralisation of fisheries policy in Portugal is not the aim of this paper, this research is orientated towards socio-economic information needs of the regional administration with competencies in policy definition. A decision process, even when centralised requires a diagnostic phase, which needs gathering biological and socio-economic information.

Our main concern is socio-economic information. We all know how the diagnostic phase is important/relevant for the decision process. However, we rarely question the quality of the information on which the decisions are based. Inadequacy of information often renders economic models ineffective, leading to a misunderstanding of the real mechanisms of socio-economic systems and to inconsistent decisions. One of the findings in the regional information systems literature is that, qualitative and quantitative information decrease in quality as we desegregate information at the spatial level.

Besides the above, the lack of sufficiently desegregated information or lack of its quality at a regional and local level, affects negatively the diagnostic and therefore the decisions reached. This becomes a more serious problem when the decisions are centralised. Moreover, it is the qualitative information which is most affected as it is transmitted to the top management along the hierarchy. Taking decisions without assessing the local and regional specificity can only aggravate the actual conflict of interests amongst the various agents within the sector. It is relevant to emphasise the need of considering a decentralised administration, which leads to a more efficient decision. The figure below shows the role of biological and socio-economic information in the diagnostic formulation process.

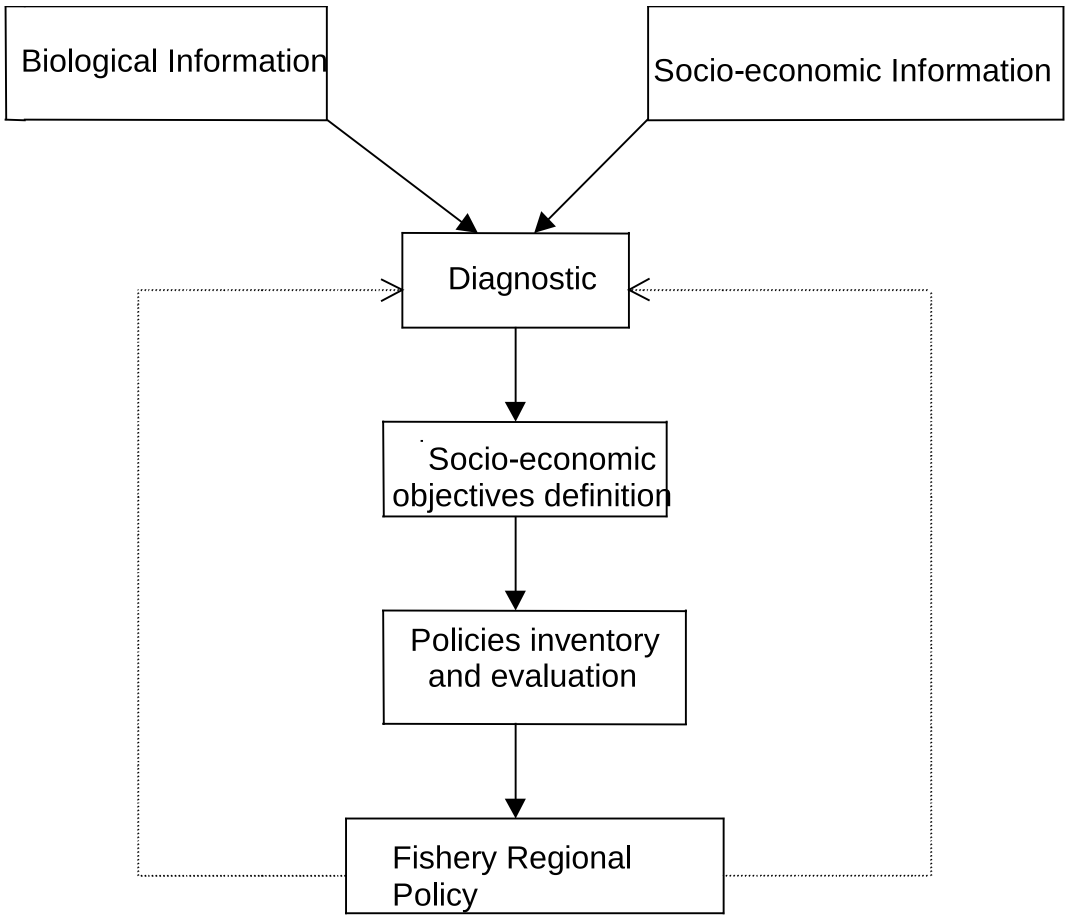

Figure 1. Decision process in fishery process in Portugal.

During the last decade, socio-economic policies have been seen as a way of minimising the social impact of fishery effort reduction measures (as dictated by biological concerns). Under the Common Fisheries Policy (CFP) within the European Union (EU), employment and other social policies have been considered as a secondary objective compared to fishing effort reduction, in order to achieve specific goals like total allowable catches (TACs). The EU Common Fishery Policy has been conditioned, on one hand, by the need for political commitments regarding the access and share of resources, and on the other, by the prevalence of the biological concerns over socio-economic problems. Therefore, there have been some conflicts between the different objectives which are more evident at regional and local levels. Unemployment and other social problems when high, are seen as a burden - frequently these become issues after the event (*ex-post*) rather than taken into account *ex-ante*.

The administration's main concern is normally the accuracy of biological information. We find there is no such concern regarding socio-economic information relating to employment and related variables. When we are assessing the implementation of fishery effort reduction measures, we often do not have in mind its direct or indirect impact on employment. Even when this concern is present and we attempt to evaluate the impact of the measures referred above on employment, frequently we find there is neither detailed nor accurate information. The fishery globalisation phenomenon, which was one of the issues of the workshop, makes the regional policies even more necessary in the sector.

3. Local and Regional Economic Data

The level of desegregation of data is a major factor affecting the degree of accuracy with which fishery dependent areas can be identified and defined from statistical sources. The desegregation and accuracy of the data has also great influence on the diagnostic made by the administration, and an incorrect diagnostic about fishery dependent areas is sometimes the cause of serious social and economic problems.

The knowledge of the local area is very important, but we have to take into consideration the interactions between fishery dependent areas within a region. Sometimes, the landings outside the Council have great importance, local multiplier effects of fishing can be quite small, but a wider (regional) geographical coverage would result in larger values. That will be the case of the Algarve region, which has got ports that depend on each other. For instance, the port of Olhão (where the canning industry is concentrated) depends on the landings of other ports like Portimão, and vice-versa.

3.1. Socio-economic Information Available at a Regional Level

The first type of economic information that we usually want to have at a regional level is data from regional accounts. It's useful to know for each sector the basic macroeconomic variables. Every country has their national accounts and we normally can obtain the values of the principal macroeconomic variables for the fishery sector and for the transformation of fish products. The problem is that not all of the countries have regional accounts, especially with sufficient desegregation of the sectors.

In Portugal we have regional accounts, but we do not have the desegregation that we need. However, we can access unpublished data that enables us to know for example the final production, the intermediate consumption of the branches (03 and 19), respectively, the fish products branch and the transformation-of-fish branch.

We have more difficulties to determine variables like consumption, gross fixed capital formation or exports and imports, at the regional level but we can always make some estimates of those variables by using unpublished data. By consulting published and unpublished statistics in the sources listed at the end of this article, we obtain the following data at the regional level:

- Fishing fleet distribution by region;
- Characterisation of the fishing fleet by main ports (number /GRT/ Engine power);
- Fishing fleet classification by area of operation (coastal/ long distance/ local);
- Fleet classification by methods used (trawl fleet/ seine fleet/ polyvalent fleet);

- Aquaculture production by region and by species;
- Marine and fresh water farms by type and region;
- Total area of the aquaculture farms;
- Market measures - granted financing by region;
- Landings of fresh and chilled fishery products by region, in quantity and in value;
- Landings of fresh fish species by the principal ports;
- Production of the salting, drying and canning industry; and
- Number of fisherman by ports.

3.2. Problems with data accuracy

Official sources of fisheries employment data in Portugal contain many errors; we list here the major problems:

- Many fishers and fish processing workers (mainly women) work or are employed on a seasonal basis;
- The fish processing companies (especially the canning industry) have a low number of permanent employees and a percentage of casual employment to cope with fluctuating supplies of raw material (specially sardine, chub mackerel, and other small pelagic species). Many of the fish processing workers work only a few months in a year and then (some of them) become dependent on social security payments, while working on non-qualified occupations in agriculture and services (for example, cleaning staff in private houses and hotels), mainly activities associated with tourism;
- Fishers that worked on vessels which where withdrawn from service continue to contribute to the increase in fishing effort. Although they are retired they buy their own small boat, and register themselves as sport fishers, catching and selling fish illegally.

The above listed problems must be evaluated through personal interviews conducted with fishers, fish processing workers, and the owners of the canning industry. There is some evidence resulting from one of such studies conducted which shows that there exist large discrepancies between fishery statistics of the National Statistics Institute (INE) and the number obtained in the study with regard to the number of fishers operating in each port in the Algarve region. There are cases of ports where the figures showed by INE are approximately 30% above our figures. Besides the fact that INE and our study cover different periods, namely, 1997 and 1998, respectively, we think the difference is far too large to be justified by only a year difference. We can think of only one reason for this discrepancy, that is, the INE updating process involves a questionnaire to the port authorities who may not fill in the above according to the fishers's registrations they have.

3.3. Other socio-economic information required for decision process

Beyond available information on employment referred to above, it is necessary to complement it with information on the following:

- aquaculture;
- fresh fish commercialisation;
- canning industry; and

- other related services.

As to the characterisation of the fishery sector employment, it would be extremely important to gather information about:

- fishing worker's age group;
- educational attainment of fishers;
- their employment status;
- employment in fishery by occupation;
- marital status of workers;
- fishers' spouse's activity status; and
- members of the fisherman's household.

To better understand and identify the social and demographic profiles of those working in the fishery, data on occupational activity by group, age-groups, educational attainment and the like are available in the Population Census carried out by INE. However, these data are updated only in every ten years, the last census was in 1991.

4. A suggestion for Implementing an Information System for the fishery sector at a regional level

During the study, we identified one of the main causes for the lack of accuracy of the information to be because the following administrative authorities exist as separate entities: DGPA (General Directorate for Fisheries and Aquaculture), Docapesca, SA and Port Authorities. They deal with different phases of the fishery administrative process. The co-ordination between them is remarkably low. While DGPA deals with vessel licensing, port authorities deal, amongst other things, with the registration process of each fisherman. In this way, each fisherman can be associated to a particular vessel. On the other hand, Docapesca, SA collects and keeps information about the vessel's registration number; landings by species in quantity and value. Thus, we have three entities dealing with relevant information on fishery, but we find lack of communication among them.

This system works as a barrier for obtaining precise, complete and "on time" information. We overcame this problem in our study by collecting data from each entity, and cross-examined the data. This was a "one off" solution which enabled us to obtain the number of fishers working per vessel in each activity. However, we have been able only to merge data from DGPA and Port Authorities, leaving the other entity out as the information obtained about landings lacked vessel's registration numbers, which was not provided due to its confidential character.

A permanent solution to the above would require implementing an information system on a regional scale. Consequently it is crucial to propose the implementation of an information system at a regional scale, which after testing could be extended to other regions. We believe DGPA is the entity with enough competence and capacity for leading the process. The hardware needed is already available in the Port Authorities and in DGPA. What are needed now are human skills, which could be attained by investing in vocational training.

We describe below simple steps for implementing the system, so that its execution becomes easier:

1. The first phase requires combining efforts by DGPA and Port Authorities which will lead to the availability of a single database on fishers' registration, which would make it easy to obtain updated information on the following: (a) vessel registration name and number; (b) fishing vessel's characteristics; (c) fishing methods and their features; (d) vessel owner's name; and (e) number of fishers associated to a given vessel.

2. The above two entities should be associated to Docapesca, SA. Although this entity provides DGPA with information regarding landings, it is still quite necessary to get its improved involvement as it provides other types of information. At this stage the information obtained from Docapesca, SA concerning, first selling point, landing dates and quantities, and value of species traded, should be merged with information gathered in phase 1 above.

3. The Port Authorities should provide a questionnaire to the fishers, who would answer it whilst requiring their registration or its renewal. The answers to these questionnaires will provide useful information, which will allow the social characterisation of fishers' households. One of the most relevant items in the questionnaire concerns gathering information on household members wanting to become fishers.

4. This last phase will require private sector involvement, in order to gather information about employment from all fishery linked activities such as shipyards, the canning industry, fresh fish commercialisation, etc.

Some ideas on employment and research questions for debating

If we want to manage fisheries resources in a sustainable manner, whilst minimising the social impact, we must implement some measures on the local and regional bases:

- creating new jobs through the implementation of local endowment strategies;
- enhancing the value of fisheries activity in tourism development;
- development "quality mark" schemes for fish of high intrinsic quality from particular regions, with the help of marketing campaigns;
- occupational training in non-fisheries activities, like activities associated with tourism (maritime tourist transport, marinas);
- investments in aquaculture in the production of species of high market value;
- increase the study of regional income and employment multipliers as in a standard input-output analysis;
- study the measure of value for smaller vessels, which have a disproportionate value in terms of dependency of small communities with few employment opportunities;
- measure the effect of fishing and tourism linkages, the effect of fisheries activities as a tourist attraction, where fisheries may act as a focal point for tourism activity.

5. Conclusion

We conclude this presentation by referring to some ideas that we think became clearer in the workshop. First, globalisation implies that the regional administrations in each country should enhance its efforts, principally if the production is orientated towards exportation. Second, we have to raise in many countries the preoccupation about the accuracy of socio-economic information, as it is the base of a diagnostic process. Third, a regional information system could be a solution to obtain better and "on time" socio-economic information. Fourth, accuracy is fundamental, as ecosystem modelling tools are being widely used and extended to incorporate socio-economic data.

References

Amstrong, H., and J. Taylor, 1993. Regional Economics and Policy. Philip Allan Publishers Ltd.

COWI, Megapesca Lda and FDL, 1997. Employment Impact Assessment in the Fishing Industries of the UK, Portugal and Denmark. Project Nº94/62.

Nijkamp, P. and P. Rietveld, 1984. Spatially Oriented Information Systems. *In* Nijkamp P. and P. Rietveld (eds.). Information Systems for Integrated Planning. Elsevier Science Publishers, Contributions to Economic Analysis, 149.

Jentoft, S., 1997. Five Truisms of Fisheries Management. Institute of Planning and Community studies, faculty of Social Science- University of Tromso, Norway. Paper presented at the International Meeting on Fisheries: "Multiple Objectives and Fisheries Management: Strategies for the Future", Nov.3-4, Vilamoura, Portugal.

Application of the Damage Schedule Approach on the Ecopath Ecosystem Modelling[a]

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Abstract

While ecosystem modelling such as Ecopath and Ecosim could be used to evaluate ecosystem impacts of fisheries, they are based primarily on biological and ecological information. In the management of fisheries, however, one needs to consider not only ecological impacts of fishing, but also its effects on economic and social-cultural values. These values, in particular the latter, are, unfortunately, difficult to measure, using traditional evaluation methods, such as benefit-cost analysis or contingent valuation. A simple and straightforward approach, the damage schedule, is therefore presented as a tool that allows an ecosystem to be evaluated using all three components, i.e. ecological, economic, and social-cultural importance, as criteria. The damage schedule approach is a ranking system based largely on judgments of both technical experts and 'layexperts' (such as resource users). An exploratory study was conducted to test the application of the damage schedule approach to evaluate the importance of the Eastern Bering Sea ecosystem. Results based on responses from a small group of selected experts are reported in this paper.

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1. Introduction

Ecosystem modelling with Ecopath/Ecosim (Christensen and Pauly, 1992; Walters *et al*., 1997) has increasingly been applied in the study of marine ecosystems around the world and in the analysis of fisheries strategies for multi-species resources. The models contribute greatly to the understanding of the dynamics of ecosystem, which is one of the biggest challenges in applying ecosystem-based management framework to resource management. The approach is based on a relatively simple method to assess the biomass and fluxes within an ecosystem, and to turn these estimates into a fully parameterised simulation model (see Vasconcellos and Sumaila, this vol.). While results of Ecopath mass balance model could suggest different characteristics of an ecosystem from one period to the next, we still have yet to determine the overall importance of these systems, in terms of ecological, economics and social considerations. This knowledge is crucial for fishery management purposes, as it could provide a framework for policy development. Ecopath, as an ecosystem-based model, offers a good guideline serving the ecological objectives of fishery management. Nonetheless, other factors, such as economic, social and cultural importance, have to be considered in designing fisheries policies, particularly if they are to be broadly accepted. This, unfortunately, is a difficult task, as we are dealing with sensitive issues that concern a diverse group of resource users and other stakeholders, often with conflicting interests. Even as we acquire new knowledge and understanding of an ecosystem we are dealing with, we might not be able to design regulations that are welcome by all parties. In sum, we are confronted with different kinds of trade-offs, such as economic benefits to a group of users versus social and cultural importance to other groups. We also need to consider that some of these groups rely heavily on fisheries as their major sources of income and employment, and that their resource dependency makes them vulnerable to resource depletion, technological innovation and decisions made by governments (Bailey and Pomeroy, 1996). Policies imposed by the government on these communities are most likely not welcome, contributing thus to a poor outcome.

Given the complications both in the design of management policies and their implementations, an innovative approach is needed to combine scientific knowledge of the ecological importance with public considerations about the ecosystem. One possibility is through an application of the 'damage schedule' approach, which is initiated by Knetsch (1994) and further developed by Chuenpagdee (1998). The damage schedule approach is a tool that assists policy makers in designing a resource management program that is consistent with community judgments of the relative importance of the resources. The schedules are constructed based on the importance scales reflecting the values of the resources as indicated by both technical experts and resource users. Different policy responses, such as protected areas and other restrictions, can be assigned to manage the resources according to their importance. An application of the damage schedule approach to evaluate the importance of an ecosystem allows scientific communities and general public to actively contribute in the decision-making process for the management of the fisheries and the related ecosystem.

This paper describes an experimental study of the application of the damage schedule approach to evaluate the importance of the Eastern Bering Sea ecosystem. First, based on Ecopath and Ecosim models, six hypothetical management scenarios were applied to the Eastern Bering Sea, which resulted in six ecosystems with different major components. The method of paired comparisons was used to present these six ecosystems in pairs to respondents, whose task was to choose, in each pair, the ecosystem that they considered more important, using biological, economic, social and cultural considerations as criteria. Importance scales were then developed based on these responses to indicate the importance of these ecosystems under stated criteria. We report the results of this preliminary study, as well as suggest policy implications and future research.

2. The damage schedule approach

The damage schedule approach is a non-monetary valuation tool that aids policy makers in their decisions about management of resources when public interests are of prime concern. The approach allows scientific knowledge, traditional knowledge as well as people's preferences and values to be incorporated in the same framework. The damage schedule is simply a ranking of relative importance of resources obtained using a method of paired comparisons. Rather than asking people to provide a direct ranking of the importance of resources, several resource scenarios are presented in pairs and people are asked to choose within each pair, the scenario that is more important (or more preferable). Responses from these paired comparisons are analysed and importance scales are obtained. A damage schedule is then constructed by mapping different policy responses in accord with the level of importance of the resources indicated on the importance scales.

The damage schedule approach is an alternative to existing valuation methods that rely either on a comprehensive knowledge about resources, such as the changes in productivity, or monetary estimates of the resources, such as the contingent valuation. With the damage schedule approach, a knowledge-based valuation of resource is obtained from the judgments of both technical experts and layexperts (i.e. resource users and other interest groups). The approach is advantageous as it offers decision-makers a basic framework to develop management policies, such as resource allocation, compensation schemes, etc., which are in accord with both experts and public values. In addition, as the schedules are flexible, quick and inexpensive to develop, new information, knowledge and changes in values could easily be incorporated.

The first application of the damage schedule approach was to study the importance of resources in two coastal areas of Thailand (Chuenpagdee, 1998). About 200 people in each study area were asked to provide judgments about the relative importance of several coastal resources, by considering the severity of different losses or damages to the resources in one instance and the adverse impacts of different activities or incidents causing such losses in another instance. The results showed that there was no significant difference in the rankings of the relative importance of resources among the 200 people who responded to the survey in each area, despite the fact that they were from different interest groups, such as technical experts, fishers, shrimp farmers and land developers. This consistence in the rankings allowed the damage schedule to be developed based on total respondents and could be complementarily used with other tools to guide management policies for the two coastal areas of Thailand.

Ecosystems could be evaluated using a similar approach used in developing the damage schedules. This relies also on the basis that while we might not have all the information needed to fully understand the ecosystems, and the effects of each activity or each management policy on such systems, we might be able to provide a well-grounded judgment about the relative importance of these systems. Because evaluation of ecosystem could be done using several criteria, such as ecological, economic and social-cultural importance, different outcomes could be obtained. Moreover, some of these considerations could be done on an objective basis using available scientific information, while some could only be done subjectively. This is when the damage schedule approach is most applicable. As in Chuenpagdee (1998), this study employed the method of paired comparisons to present the items in consideration (in this case, management scenarios) to a group of respondents. Respondents were asked to choose the scenario within each pair that they considered more important (or more preferable) using a specified criterion. Paired comparison responses were analysed and scale value representing each scenario was obtained for each criterion used. Correlation of the rankings of these scale values was tested to determine the significant difference of the respondents' judgments when using different criteria. Based on this analysis, we learned whether the scenarios were ranked differently when evaluated using different criteria. This knowledge could then help us decide on the scenarios that we should propose for the management of the ecosystem, and at the same time, suggest other scenarios that may be potentially useful.

3. Case study of the Eastern Bering Sea ecosystem

Mass-balance models of the Eastern Bering Sea ecosystem were constructed by Trites *et al.* (1998) to describe the system in two distinct time periods: during the 1950s, before large scale commercial fisheries; and during the 1980s, after the decline of many marine mammals populations. For a complete description of the model see Vasconcellos and Sumaila (this volume). In this study, we applied Ecosim to simulate different fishing scenarios for the Eastern Bering Sea after the 1980s. Simulation results were then evaluated and ranked according to ecological, economic and social criteria using the Damage Schedule approach.

Six hypothetical management scenarios were developed, all of which involved a ten-fold increase in fishing effort of a certain species, or combination of species, to the Eastern Bering Sea (table 1). The ten-fold increase in the fishing effort, although may seem implausible and may not represent actual situations in the fisheries, was chosen to allow the changes in the biomass of effected species to be large enough for consideration. For each scenario, we recorded the changes in biomass of the three components in the ecosystem, i.e. pollock, deepwater fish, such as black cod, and sea birds. These three groups were selected to represent a low-value species with high production, an economically importance species with low production, and a species with no market value.

Once the scenarios were formulated, we developed a questionnaire, containing a series of pairs of scenarios for comparisons. All 15 pairs from the total possible paired comparisons of six scenarios were used. Only one pair of scenarios was presented on each half-sheet paper. Random positioning of the scenarios in each pair and random ordering of pairs in each booklet was performed. An example of a paired comparison is as follows:

Considering overall importance of the Eastern Bering Sea ecosystem, please indicate which management scenario you would prefer, ***A*** *or* ***B****? (Please choose one.)*

10-fold increase in F for
Pollock
⇓

30% decrease in **Pollock** biomass
+
5% decrease in **Deepwater fish** biomass
+
30% increase in **Sea birds** biomass

A

20% increase in **Pollock** biomass
+
20% increase in **Deepwater fish** biomass
+
30% increase in **Sea birds** biomass

B

10-fold increase in F for
Large Flat Fish
⇓

Table 1 Six hypothetical management scenarios for the Eastern Bering Sea (all values in percentage)

Scenario	10-fold increase in fishing effort of	Resulting biomass Pollock	Deepwater fish	Sea birds
1	Pollock	-30	-5	+30
2	Large flat fish	+20	+20	+30
3	Small flat fish	0	+5	+30
4	Demersal	+10	+30	-30
5	Pollock + Large flat fish	+5	+10	50
6	Demersal + large flat fish	+20	+40	+50

Note: '+' = increase and '-' = decrease

For example, Scenario 1 reads as follows*:*

"A ten-fold increase in the level fishing effort for adult pollocks, resulting in a 30 percent decrease in pollock biomass, a 5 percent decrease in deepwater fish biomass and a 30 percent increase in sea birds biomass."

Each respondent was given four questionnaire booklets that differed only in the instruction on the front page. In the first set of questionnaires, respondents were asked to consider the overall importance of the ecosystem resulting from different management scenarios. In the other three sets, they were asked to use ecological, economic and social importance as criteria, respectively. Additional information on price of some species groups was provided in the economic booklet, and number of vessels operated in the area was given in the socio-cultural booklet. Respondents were instructed to complete the questionnaire in the order stated above.

Ideally, the respondents must include both a reasonable number of technical experts and of various groups of resource users. Unfortunately, it was not possible to do that in this study due to time and budgetary constraints. The survey was thus conducted in March 1999 only with 10 respondents, all of whom were fishery scientists and researchers, in Vancouver and in Washington State, who were familiar with the Eastern Bering Sea and its ecosystem.

5. Results and discussion

The analysis of paired comparison questions was performed using Dunn-Rankin's variance stable rank sum method (Dunn-Rankin, 1983), which is an adaptation of Thurstone's Case V method (Thurstone, 1927). First, the scenarios were scored, using the scoring system of 1 and 0. For example, when Scenario A was chosen to be more important or more preferable to Scenario B, Scenario A would get a score of '1', while Scenario B would get a score of '0'. These scores were then summed across all respondents and normalised to the scale of 0 to 100. These normalised scores represented the relative importance of each management scenario. The same analysis was conducted for each part of the questionnaire to determine the difference in the scale values and the ranking of the importance when different criteria are considered, using Kendall's tau rank correlation coefficient (Kendall and Gibbons, 1990).

Table 2 shows the resulting scale values obtained from all ten respondents based on four different criteria. Rankings are assigned based on these values (e.g. rank '1' for highest value, rank '2' for the second highest value, etc.). In general, the correlation of the ranking of the importance of six management scenarios using ecological and social importance as criteria was significant at 0.01 alpha level. As well, there was a significant correlation (alpha = 0.05) between these two sets of ranking and the ranking obtained using overall importance. On the contrary, there is no significant correlation of the ranking of importance obtained using economic importance as criteria with those obtained from the other two criteria and with that from overall consideration.

Table 2 Scale values of importance of management scenarios

	Overall		Ecological		Social		Economic	
Scenario	**Scale value**	**Rank**	**Scale value**	**Rank**	**Scale value**	**Rank**	**Scale value**	**Rank**
1	34	4	34	5	28	5	10	6
2	62	3	58	3	58	3	70	2
3	32	5	40	4	30	4	16	5
4	24	6	20	6	20	6	62	3
5	66	2	74	1	78	2	48	4
6	82	1	74	1	86	1	94	1

These results can also be illustrated to show the relative importance of the six management scenarios, as in figure 1. While scenario 6 (increase level fishing effort for demersal fish and large flat fish) was considered the most preferable management option based on all criteria, the order of importance of other scenarios differed when using economic importance as criteria. For example, increase in level of fishing effort for demersal fish (Scenario 4), while ranked last using other criteria, was more preferable to increasing the level of fishing effort for a combination of pollock and large flat fish (scenario 5), for small flat fish (scenario 3) and for pollock (scenario 1).

It was also noted that the spread of the importance scale values using economic criteria was larger than when using other criteria. In general, the spread of the scale values suggests the similarity of the scenarios for comparison, such that when the two scenarios are similar, the difference in the scale value is small. In this study, however, the difference in the spreading of the scale values occurred under different criteria, even when the same scenarios were compared. For instance, when using ecological importance as criteria, the difference between scale values of the most important scenario (Scenario 6) and the least important one (Scenario 4) was 54. This difference increased to 66 under social-cultural importance criteria. Yet, the largest difference of 84 was observed, as mentioned previously, when economic importance was used as criteria (table 2).

The notable difference in the spread of the scale values under different criteria suggests that it may be more difficult to evaluate the ecosystem using ecological importance as criteria, than when using social-cultural and economic importance. This point is further emphasised considering that our understanding of the ecological interactions of various components in the ecosystems is still limited. The fact that all ten respondents were technical experts could have made the matter worse, as experts tend to be overly careful about the judgments they provide. As stated in Ludwig *et al*. (1993), scientific judgments could be influenced by their training, as well as could be subject to political pressure.

On the other hand, when using social-cultural criteria, people (experts or lay) may feel more comfortable at making these judgments simply because the issues become less technical and everyone could consider themselves experts. It could also be expected that, with a basic understanding of economic concepts that apply to daily life activities, respondents were able to provide a clearer distinction among these different ecosystem scenarios when using economic importance as criteria.

An analysis of the inconsistency of the paired comparison responses supports the above discussion. Inconsistency in the responses can be detected when circular triads are observed. A circular triad is a situation, for example, when in the paired comparisons of three objects, A, B, and C, the response is A > B > C > A ('>' means prefers to).

In this study, when using the overall consideration and the ecological importance, respondents were less consistent (higher number of circular triads) in their responses than when using economic and social importance as criteria. Circular triads may occur because of simple mistakes or when the choices are too similar making them difficult to compare. As previously discussed, the inconsistencies observed when using ecological considerations were likely due to the latter cause. Nevertheless, these inconsistencies had insignificant effects on the ranking of the ecosystems, as was the case in Chuenpagdee (1998).

A further observation of the choices made under different considerations offers some explanation about the disparity in the ranking of importance and suggests the validity of the approach. Increasing fishing pressure on demersal fish (Scenario 4) could result in, among others, a 10 per cent increase in the biomass of pollock and another 30 per cent increase in the biomass of deepwater fish. This scenario was considered more economically preferable than an increase in fishing level for small fish flat (Scenario 3), which could result in no increase in pollock biomass and only 5 per cent increase in deepwater fish biomass.

Using simple economic analysis based on market prices, the overall benefit from Scenario 4 was greater than that from Scenario 3. However, when using ecological, social and overall consideration as criteria, the opposite was found. It was possible then that respondents used the biomass of sea birds was a key criterion used in their judgments of the ecosystem importance. While Scenario 4 could result in a 30 per cent decrease in sea birds biomass, Scenario 3 actually could cause an increase of 30 per cent. Although there is no market value for sea birds, the results suggested that sea birds might play an important role in maintaining the balance of the ecosystem, as well as in providing aesthetic and social-cultural values.

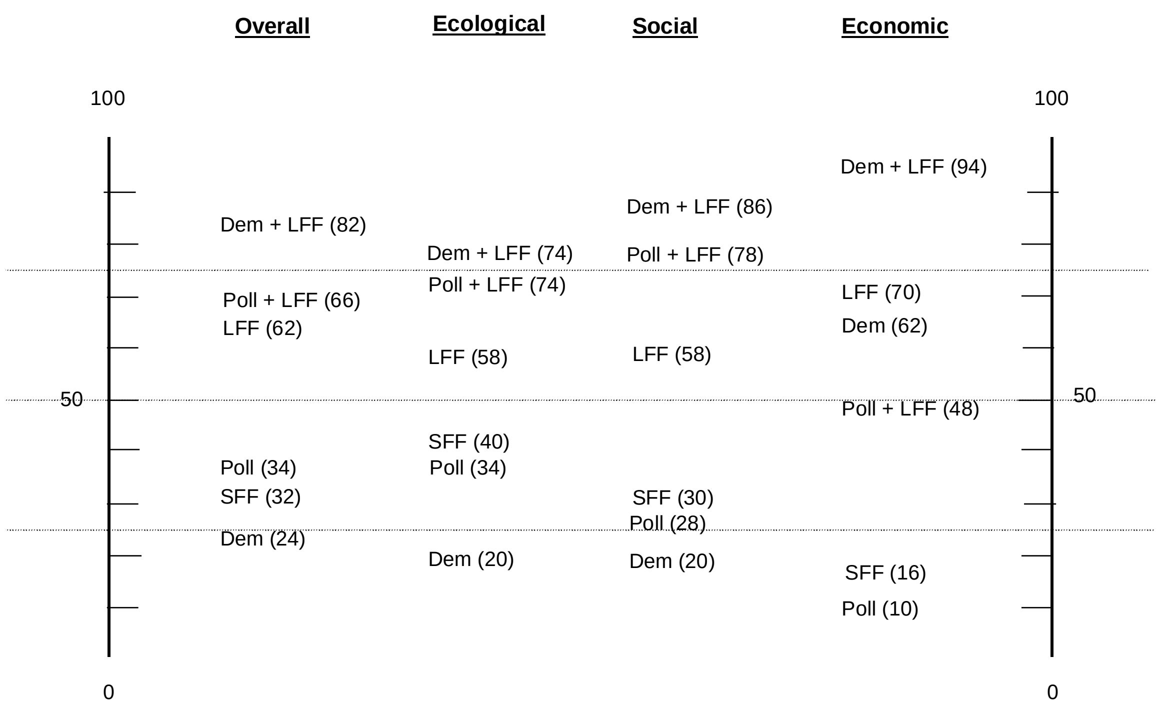

Figure 1. Importance scales of management scenarios for the Eastern Bering Sea under different criteria (abbreviations are as follows: Dem= Other demersal fish; Poll=pollock; LFF=Large flatfish; SFF=Small flatfish.

6. Policy implications and future research

In designing management policies for an ecosystem, several considerations, such as ecological, economic and social-cultural importance, should be taken into account. The difficulty lies, however, in deciding what criteria should be given a higher consideration. This paper suggests the damage schedule approach as a possible tool that could indicate these priorities. By asking people to rank various ecosystems using different criteria, a fixed schedule could be developed to reflect the importance of these ecosystems. The results show that people were able to provide these importance judgments, although the rankings of the importance did not differ significantly under some criteria, but differed significantly with other criteria. The knowledge about the similarity and disparity of the importance of ecosystem under these criteria is an input that could help decision-makers in policy design. When the rankings of the ecosystems are consistent under different criteria, policies can be made in accord with the importance of the ecosystems as indicated by the schedules. In cases where these rankings are different, knowing where people differ in their judgments would allow managers to formulate new management polices that could be more acceptable to the concerned communities and the public at large. In sum, the approach presented in this study could be used complementarily with other ecosystem-modelling tool, such as Ecopath and its family, to provide a basis framework for ecosystem management. As the evaluation of an ecosystem using the damage schedule approach can be done quickly and inexpensive, it could incorporate new knowledge and suggest alternative management scenarios to be used in Ecosim dynamic simulation model.

As this study was limited to a small, homogenous group of respondents, the results were presented purely to demonstrate the applicability of the approach. Undoubtedly, in practice, the survey should include a diverse group of respondents, including resource users and other stakeholders. Formulation of the scenarios must be carefully done to represent both actual and hypothetical situations and questionnaires should be pre-tested several times to check for both information and content biases. Some varieties of the questionnaire format could be tried. For example, instead of asking respondents to first rank the ecosystems based on the overall importance, this criterion could be used last, and different order could be used for the other three criteria. Efforts should also be made to understand the socio-political structure of the communities relying on the ecosystem. Once the importance scales are developed, a workshop should be conducted to provide a forum for further consultation and discussion with the community and other concerned public in the management of resources in the ecosystem.

References

Bailey, C. and C. Pomeroy, 1996. Resource dependency and development options in coastal Southeast Asia. *Society and Natural Resources*, 9:191-199.

Christensen, V. and D. Pauly, 1992. ECOPATH II - a software for balancing steady-state models and calculating network characteristics. *Ecol. Modelling*, 61:169-185.

Chuenpagdee, R., 1998. Damage schedules for Thai coastal areas: an alternative approach to assessing environmental values. EEPSEA Research Report Series. August 1998. Economy and Environment Program for Southeast Asia, 76 p.

Dunn-Rankin, P., 1983. Scaling Methods. New Jersey, Lawrence Erlbaum Associates, 429 p.

Kendall, M. and J.D. Gibbons, 1990. Rank Correlation Methods. Fifth edition. London, Edward Arnold, 260 p.

Knetsch, J. L., 1994. Environmental valuation: some problems of wrong questions and misleading answers. *Environmental Values*, 3:351-68.

Ludwig, D., R. Hilborn and C. Walters, 1993. Uncertainty, resource exploitation, and conservation: lessons from history. *Science*, 260:17, 36.

Thurstone, L.L., 1927. The method of paired comparisons for social values. *The Journal of Abnormal and Social Psychology*, 21:384-400.

Trites, A.W., P. Livingston, M.C. Vasconcellos, S. Mackinson, A.M. Springer and D. Pauly, 1998. Ecosystem change and the decline of marine mammals in the Eastern Bering Sea: testing the ecosystem shift and commercial whaling hypotheses. Vancouver, University of British Columbia, *Fisheries Centre Research Report*, 7(1):106 p.

Vasconcellos, M.C. and U.R. Sumaila, 2000. Regional ecological-economic analysis of fisheries: The case of the Eastern Bering Sea Ecosystem. Brussels, *ACP-EU Fish.Res.Rep.*, (7):103-112

Walters, C., V. Christensen and D. Pauly, 1997. Structuring dynamic models of exploited ecosystems from trophic mass-balance models of marine ecosystems. *Reviews in Fish Biology and Fisheries*, 7(2):139-172.

Towards the Sustainable Exploitation of Fisheries Resources in Cape Verde[a]

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Abstract

The FIAS project for Northwest Africa specifies objectives that deal with: (1) improving the access to existing fisheries data; (2) application of the ecosystem approach in the analysis of fisheries data; (3) reinforcing the national capacity for fisheries management and promote regional collaboration for the implementation of coherent strategies on sustainable management and development. These efforts should be seen in light of the many problems facing the fisheries sector world-wide, such as unsustainable fishing, poor management practices, over-investment in fishing capacity, and the failure to take a regional approach when dealing with trans-national stocks.

Cape Verde is strongly dependent on its fisheries and will gain from a study of the coastal ecosystem, which can answer many questions regarding a further development of the fisheries. A major objective of this study is to reach a better understanding of the coastal ecosystem dynamics, including characteristics such as trophic structure, community structure, production, and fishing pressure including spatial and temporal effects. A major feat will be to collate and standardise all existing information on biological and oceanographic conditions in the waters of Cape Verde. The data available spans a period of at least 40 years, with the most recent research cruise undertaken by IPIMAR in 1997, which will allow comparison of ecosystem characteristics for different time periods. Cape Verde and Portugal will undertake this work in close collaboration, through the relevant institutions, in the context of FIAS and Bilateral Agreements on co-operative marine research.

We intend to take the study one step beyond the FIAS context by including the analysis of socio-economic indicators in relation to the ecosystem. This approach includes a whole range of factors including physical, biological, economic, and social factors, which are known to affect the success of fisheries management, in the attempt of defining an optimal system of governance.

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1. Introduction

The current state of many important fisheries resources world-wide can be characterised as seriously depleted or in danger of depletion due to poor management practices and fishing pressure**.** This has increased to such a point that the current exploitation pattern is not considered sustainable (Pauly *et.al.*, 1998; Anon., 1997; Pauly & Christensen, 1995) and a continued economic productivity of the ocean depends on the maintenance of their ecological integrity (Pauly *et.al.*, *in press*). Unsustainable fishing practices coupled with excessive levels of investment in fishing capacity have resulted in serious degradation and low yields in northern fish stocks, creating new pressures on resources located in developing countries. These pressures are largely trans-national, highlighting the importance of regional aspects to resource management (e.g. Koranteng *et.al*., 1996; Bas, 1993). Also, it has become generally accepted that fisheries management should adopt a multispecies approach, as single stock assessment has serious limitations by not taking into account species interaction and other ecosystem characteristics (e.g. Jarre-Teichmann and Christensen, 1998; Pauly and Christensen, 1993).

The Fisheries Information and Analysis concept (FIAS: McGlade and Nauen, 1994) addresses the above issues explicitly in order to improve the management of resources and achieve a sustainable development of fisheries in Northwest Africa. FIAS is a regional project involving six African countries, Cape Verde, Gambia, Guinea, Guinea-Bissau, Mauritania, and Senegal, which are associated through the "Commission Sous-Régional des Pêches" (CSRP). The project is financed by the European Union under the ACP-EU Fisheries Research Initiative (Magagula, 1997), and includes collaboration with FAO and five European research organisations; ENSAR[16], IEO[17], IPIMAR[18], JRC[19], IRD (ex-ORSTOM)[20].

The FIAS project for Northwest Africa involves a number of specific objectives that can be divided into three categories:

1. Improve the access, management, and analysis of relevant fisheries data in the region, forming the basis for a better resource management. This involves the repatriation of historical data which has not yet been made accessible to the region, the standardisation of data formats, the creation of compatible databases, and the use of common analytical methods and tools in the processing of information. These steps are necessary in order to undertake retrospective analysis of fisheries data in a regional context. Training is an essential component in this process.

2. Place the analysis of fisheries information in their ecosystem context. This objective is in line with "Concerted Action on Placing Fisheries in their Ecosystem Context: Cooperation, Comparisons and Human Impact", EU-INCO/DC, and will involve the study of trophic structure and the effects of the environment in the following pre-defined areas which may be subject to change depending on results:
    - upwelling ecosystem (Gambia, Mauritania, Senegal);
    - coastal and estuarine ecosystem subject to strong run-off effects (Guinea, Guinea-Bissau);
    - insular ecosystem (Cape Verde).

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[18] Instituto Português de Investigação das Pescas e do Mar, Portugal

[19] Joint Research Centre, Institute for Space Applications, Italy

[20] Institut de Recherche pour le Développement, France

This will also include the development and compilation of geographical information (GIS) for each area.

3. Reinforce the national capacity for fisheries management and promote regional collaboration for the implementation of coherent management strategies. The establishment of easily accessible information bases on the national and regional level is an important component in this process.

1.1.Cape Verde, the Insular Ecosystem

The present study refers specifically to the archipelago of Cape Verde, which is located 600 km off the coast of Senegal, consisting of ten islands, of which nine are inhabited. The total area of the archipelago is 4.033 km^2 and the total coastline is estimated at 2.000 km. The islands, S.Antão, S.Vicente, S.Luzia, S.Nicolau, Sal and Boa Vista form the northern group called “Barlavento” (windward), while Maio, S.Tiago, Fogo and Brava form the southern group “Sotavento” (windway).

The islands are of volcanic origin, rising from a depth of at least 4.000m, and the continental shelf, generally narrow and irregular, is limited to a total area of 5.394 km^2. The eastern islands Sal, Boavista, and Maio, form one system with a more extensive continental shelf compared to the other islands. The shelf plus slope, extending down to 500m, constitutes an area of 7.650 km^2.

Although the continental shelf area is of limited area, the EEZ of Cape Verde covers an area of 734.265 km^2, much of which is not currently being exploited by the national fisheries.

1.2. Climate and oceanography.

The climate of Cape Verde is characterised by warm, relatively even temperatures, ranging from an average of 22°C during the cold season to 27°C during the warm season, and very low and variable values of precipitation (approx. average: 200 mm/year). Winds are predominantly north-easterly winds, except for the period from December to March, the colder, dry season, where the winds are predominantly easterly. Drought has brought severe problems to Cape Verde on several occasions during the last century. As a result of these climatic conditions, only an estimated 10% of the total area is suitable for agriculture (Hanek *et.al*., 1984).

The archipelago is situated in the southern part of the Canary Current System. Although, the waters arriving at Cape Verde are generally cold (≤ 23° C), they transport nutrients from the upwelling areas in northern Africa creating favourable conditions for production around the islands most affected by this north-eastern current (Almada, 1993). During the period July to November, changes occur in the intensity and position of the St. Helena and Azores anticyclones, resulting in a predominantly south-western current along the southern islands, thus causing warmer waters to reach these southern islands. These warmer waters (24° - 27°C) create the necessary conditions for pelagic fish such as tuna (Almada, 1993).

1.3. Relevant economic and social aspects

In order to feed the population of approximately 390 000, Cape Verde is forced to import around half of its total consumption from other countries (Anon., 1989). Most of the local food production are marine products and fisheries therefore play an extremely important role in Cape Verde, contributing with 40% of the animal protein supply amounting to a yearly per capita fish consumption of 18 kg. Exports are insignificant due to the lack of mineral resources and are dominated by marine products, mainly lobster and tuna. Although catches of lobster are relatively small (approx. 20 t/year), this is an important resource due to its high economical value.

An estimated 17 000 people are employed in the fisheries sector, either directly or indirectly, which is around 5% of the population. This percentage can vary greatly among villages, reaching up to 50 % of the village population being employed directly by the fisheries sector in some cases (Hanek, 1985).

Emigration has been important due to the lack of resources and the limited prospects in the country, leading to the formation of important Cape Verdean communities in countries such as Portugal and the United States. These Cape Verdeans, who are believed to reach to some 500 000 people living abroad, play a crucial role in the Cape Verde economy (i) by sending money to their families and (ii) through their direct investments in Cape Verde.

Cape Verde depends also on foreign aid and loans for their development and has received assistance from other countries, international organisations, and NGOs. The historical ties between Cape Verde and Portugal have also led to collaboration through Bilateral Agreements, involving IPIMAR and INDP[21] as executing partners in marine and fisheries research, cruises, training, and technology (Table 1). In a wider context, this is part of collaboration with PALOP[22] and CPLP[23] countries, covering a wide range of fields such as political, economic, cultural, educational, and scientific. Both countries, Cape Verde and Portugal, are participants in the ACP-EU Fisheries Research Initiative (Magagula, 1997) and FIAS, as part of a major network involved in fisheries development, research, and management.

1.4. Fishery catches and composition.

The fishery catches consist primarily of tunas (≅ 50%), bigeye scad, mackerels, and several demersal species (Figure 1). Catches have been relatively stable, during recent years, with a total of 7 000 to 9 000 t per year (FAO, 1998; Medina and Tavares, 1992). Considering the rising number of fishing vessels, there appears to be a trend for lower catches per effort (Medina & Tavares, 1992), which is in contradiction with the estimated values for maximal sustainable exploitation. Although there is no consensus, all studies indicate that total catches are considered to be far below (10% - 50%) the potential for maximum sustainable exploitation (Medina & Tavares, 1992).

Various licensing agreements have been made with other countries which have resulted in a substantial fishery by foreign vessels operating offshore in the Cape Verdean EEZ.

1.5. Available information

An expanded statistical collection system was implemented in 1984, which improved the estimates of catch, effort, prices, fishing vessels, and fishers (Hanek *et.al.*, 1984). Considerable work has also been undertaken in elucidating the social structure of fishing communities including fishers numbers and age, status as employers or employees, incomes, and family dependants (Hanek, 1985; Horemans, 1985; dos Santos *et.al.*, 1985). Fisheries development in Cape Verde was the central theme of a meeting held in 1985, emphasising the role of trade, bait fish production, fish technology, infrastructure, industrial fishing, credit incentives, research and training (Anon., 1985).

[21] Instituto Nacional de Desenvolvimento das Pescas, Cape Verde

[22] Países Africanos de Língua Oficial Portuguesa

[23] Comunidade dos Povos de Língua Portuguesa

Table 1: Research cruises undertaken by IPIMAR in Africa (Coelho, 1998).

Country	Year	Objectives
R. Guinea Bissau	1988	Experimental fishing, biological sampling, oceanography
R. Guinea Bissau	1989	Experimental fishing, biological sampling, oceanography, fish processing, fishing gears
R. Guinea Bissau	1990	Experimental fishing, biological sampling, oceanography
R. Guinea Bissau	1991	Experimental fishing, biological sampling, oceanography
R. Guinea Bissau	1995	Experimental fishing, biological sampling, oceanography
R.P. Angola	1995	Experimental fishing, oceanography
R. Cape Verde	1997	Experimental fishing, oceanography
R. Mozambique	1999	Experimental fishing, oceanography

Furthermore, research vessels from various countries have assisted in the study of the waters in the Cape Verde archipelago generating a large amount of data on oceanographic conditions and the abundance of organisms important to the fisheries (Table 2). No attempt has yet been made to collate, standardise, and synthesise this information, which would be invaluable in the understanding of the dynamics of the Cape Verde ecosystem.

Considering the highly migratory and oceanic nature of most tuna species, it is essential to take into account the wider spatial distribution of these stocks. Much effort has gone into the study and assessment of tuna species in the Atlantic Ocean through ICCAT[24], with the participation of Cape Verde, making these information accessible to the present study of the Cape Verde ecosystem.

[24] International Commission for Conservation of Atlantic Tuna

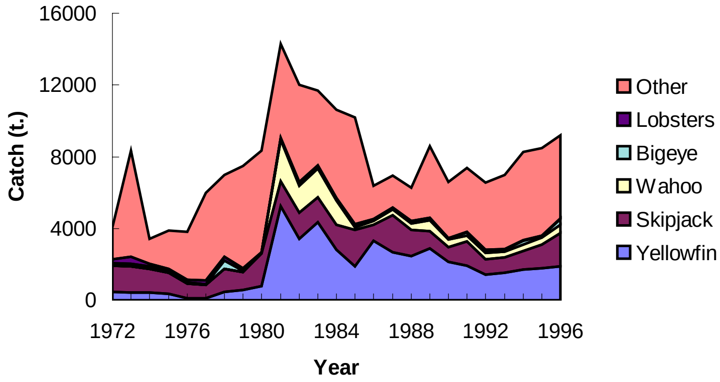

Figure 1: Composition of catches in Cape Verde. The group 'Other' includes coastal pelagics such as mackerels and demersal fish. (CECAF data, 1998)

3. Study objectives proposed

Cape Verde is heavily dependent on its fisheries and will gain from a study that attempts to improve on the understanding of the coastal ecosystem. As part of the FIAS project and Bilateral Agreements on fisheries research, IPIMAR intends to undertake this work in close collaboration with colleagues from Cape Verde, following the objectives already stated above. This approach will also help to maximise the return from considerable investments, which have gone into research cruises and statistical sampling schemes.

A major objective of this study is to reach a better understanding of the coastal ecosystem dynamics, including characteristics such as trophic structure, community structure, production, and fishing pressure including spatial and temporal effects. A major feat will be to collate and standardise all existing information on biological and oceanographic conditions in the waters of Cape Verde. The data available spans a period of at least 40 years, which will allow comparison of ecosystem characteristics for different time periods.

The study will concentrate on the coastal area of Cape Verde as it is relatively well defined. However, the study will attempt to estimate the highly variable distribution of tuna in order to link the oceanic system to the coastal system. The following questions are of particular relevance regarding the fisheries in Cape Verde:

- what is the sustainable level of exploitation of the relevant species?
- what is the potential for increasing mackerel catches?
- how is the current level of exploitation affecting the lobster and demersal stocks?
- what is the potential for increasing the live bait fishery?
- should the coastal system be divided into several subsystems in order to account for differences between eastern and western islands?
- how do physical factors such as temperature, salinity, oxygen, and currents affect the coastal ecosystem?
- should Cape Verde proceed with its efforts in developing an industrial offshore fleet and what catches may be expected to be taken by such fleet?

Table 2: Research cruises undertaken in the waters of Cape Verde, with the Portuguese participation highlighted. (Anon., 1999; Almada, 1993; Vieira, 1985).

Vessel	Year	Study Objectives
Gérard Trèca	(1952)	Experimental fishing, oceanography
Baldaque da Silva	(1957, 1958, 1959)	Experimental fishing, oceanography
Walther Herwig	(1964, 1970)	Experimental fishing
Ernst Haeckel	(1976)	Experimental fishing, acoustic survey
Dr. Fridtjof Nansen	(1981)	Experimental fishing, acoustic survey
Pedro Badejo	(1981, 1982)	Tuna tagging campaigns
El Gran Rey	(1982)	Experimental fishing (mackerel)
Santissima Anunciata	(1982)	Experimental fishing (coral)
Playa de Tamaris	(1982)	Experimental fishing (longline)
Patrão Lagoa	(1982)	Experimental fishing (gillnet)
Capricorne	(1973, 1983, 1984)	Oceanography
Fengur	(1984)	Experimental fishing
Capricórnio	(1997)	Experimental fishing, acoustic survey

Having undertaken the above, which is within the FIAS context, we intend to go further with the study and include socio-economic factors in the analysis in order to suggest suitable management and development measures. Three basic data types, which are fish prices, fishing costs and discount rates are available in order to undertake at least a basic bio-economic analysis of the fisheries. A more advanced approach may be applied by incorporating into the analysis the stakeholders and their motivations and behaviour in relation to fishing (Sumaila, 1998). Other relevant socio-economic indicators should be taken into account such as:

- employment and income;
- capital investments;
- fiscal revenue;
- trade balance;
- fisheries incentives.

This approach includes a whole range of factors including biological, economical, and social factors, which are known to affect the success of fisheries management, in defining an optimal system of governance (Nauen *et al*., 1996).

4. Modelling and analysis

An approach based on trophic modelling has been developed, Ecopath (Christensen and Pauly, 1992), which has gained wide acceptance as a powerful tool for the analysis of management scenarios. Its acceptance is also related to the fact that Ecopath models are easy to construct and require limited information as opposed to more data-driven approaches such as the North Sea MSVPA (Christensen and Mahon, 1997). Ecopath incorporates the possibility for simulation over time under different scenarios and allows for spatial considerations (Ecosim/Ecospace) (Walters, 1998; Walters *et.al.*, 1997).

However, Ecopath is only one of several tools available and as all models have their weak points (Statbase, FiSat, Adapt, Aspic), they should be used with a critical spirit and in complement to each other. Several indices are available for a critical study on community and trophic structure (Pauly *et.al.*, *in press*; Rice, *in press*). A major challenge will be to find ways of linking the effects of physical factors to the biological models (e.g. Bertignac, 1998), as it is well known that they can be the driving forces in many ecological processes.

References

Almada, E.O., 1993. Dinâmica e estado térmico das águas do arquipélago de Cabo Verde. *Boletim Técnico-Científico INDP*, nº. 0:7-13.

Anon., 1985. “Reflexões sobre a Pesca em Cabo Verde; 1º Encontro Nacional sobre as Pescas”, Praia (Cape Verde), 5-12 February 1985. Praia, Publicado pela Secretaria de Estado das Pescas. 500 p.

Anon., 1989. Visita Oficial de sua Ex.ª o Secretário de Estado das Pescas de Cabo Verde. Praia, Secretaria de Estado das Pescas.

Anon., 1997. ACP-EU Fisheries Research Initiative. Proceedings of the Third Dialogue Meeting, Caribbean and Pacific and the European Union. Belize City, Belize, 5-10 December 1996. Brussels, *ACP-EU Fish.Res.Rep*., (3):180 p.

Anon., 1999. Campanha de oceanografia e avaliação de pequenos pelágicos na ZEE de Cabo Verde. Junho/Julho 1997 - NI “Capricórnio”. Lisboa, IPIMAR.

Bas, C., 1993. Long-term variability in the food chains, biomass yields, and oceanography of the Canary Current Ecosystem. pp. 94-103 *In* Sherman, K.A., L.M. Alexander and B.D. Gold (eds.). “Large Marine Ecosystems: Stress, Mitigation, and Sustainability”. AAAS Press.

Bertignac, M., P. Lehodey and J. Hampton, 1998. A spatial population dynamics simulation model of tropical tunas using a habitat index based on environmental parameters. *Fish.Oceanogr*., 7(3/4):326-334.

Bravo de Laguna, J., 1984. Recursos pesqueiros, pescas e investigação na República de Cabo Verde. *Relatório técnico PNUD/FAO*-CVI/82/003/Rel/tec/2:75 p.

Christensen, V. and R. Mahon, 1997. Researchable issues relevant for management of large marine ecosystems, with special reference to the Caribbean. pp. 79-100 *In* Anon. ACP-EU Fisheries Research Initiative. Proceedings of the Third Dialogue Meeting, Caribbean and Pacific and the European Union. Belize City, Belize, 5-10 December 1996. Brussels, *ACP-EU Fish.Res.Rep*., (3).

Christensen, V. and D. Pauly, 1992. Una guia al Ecopath II sistema de software (Version 2.1). Manila, *ICLARM Software*, 6:72 p.

Coelho, M.L., 1998. (Ms.). Papel do IPIMAR na Cooperação com os Países Africanos de expressão oficial Portuguesa. II Forum de Agricultura Tropical e Alimentação. Aveiro e Oeiras, 7 e 9 de Dezembro de 1998.

Dos Santos, J.A., A. Barros, G. Mascarenhas, O. Sanches and G. Heidrich, 1985. Organização das comunidades de pescadores artesanais. pp. 335-358 *In* "Reflexões sobre a Pesca em Cabo Verde; 1º Encontro Nacional sobre as Pescas", Praia (Cape Verde), 5-12 February 1985. Praia, Secretaria de Estado das Pescas.

FAO, 1998. FAO Fishery Statistics. Rome, FAO Yearbook of Fisheries Statistics.

Hanek, G., 1985. Pesca Artesanal: Situação geral. pp. 55-68 *In* "Reflexões sobre a Pesca em Cabo Verde; 1º Encontro Nacional sobre as Pescas", Praia (Cape Verde), 5-12 February 1985. Praia, Secretaria de Estado das Pescas.

Hanek, G., B. Horemans and J. Lozac'hmeur, 1984. Cap Vert: Pêche Artisanale. Projet pour le renforcement du Secrétariat d'Etat des Pêches du Cap-Vert, FAO/UNDP, CVI/82/003/Rapp/Tech/5:113 p.

Horemans, B., 1985. Pesca Artesanal: Unidades económicas de pesca (UEO); Estrutura, Tipos e Valor. pp. 69-77 *In* "Reflexões sobre a Pesca em Cabo Verde; 1º Encontro Nacional sobre as Pescas", Praia (Cape Verde), 5-12 February 1985. Praia, Secretaria de Estado das Pescas.

Jarre-Teichmann, A. and V. Christensen, 1998. Comparative modelling of trophic flows in four large upwelling ecosystems. pp. 423-443 *In* Durand, M.H., P. Cury, R. Mendelssohn, R., C. Roy, A. Bakun, and D. Pauly (eds). Global versus Local Changes in Upwelling Systems. Éditions de l'ORSTOM, Collection Colloques et Séminaires, Paris.

Koranteng, K., J.M. McGlade and B. Samb, 1996. Review of the Canary Current and Guinea Current large marine ecosystems. pp. 61-84 *In* Anon. ACP-EU Fisheries Research Initiative. Proceedings of the Second Dialogue Meeting, Western and Central Africa, the Comoros and the European Union. Dakar, Senegal, 22-26 April 1996. Brussels, *ACP-EU Fish.Res.Rep.*, (2).

Magagula, F., 1997. Fourth dialogue sets stage for implementation of Research Intiative. *EC Fish.Coop.Bull.*, 10(3):16-17.

McGlade, J.M. and C.E. Nauen, 1994. A Fisheries Information and Analysis System for West Africa. *EC Fish.Coop.Bull.*, 7(4):6-7.

Medina, A. and M. Tavares, 1992. Estatísticas das pescas em Cabo Verde; Retrospectivas e perspectivas. Cabo Verde, Cardume INIP, nº 1:17-20.

Nauen, C.E., N.S. Bangoura and A. Sall, 1996. Governance of aquatic systems in West and Central Africa: Lessons of the past, prospects for the future. pp. 147-165 *In* Anon. ACP-EU Fisheries Research Initiative. Proceedings of the Second Dialogue Meeting, Western and Central Africa, the Comoros and the European Union. Dakar, Senegal, 22-26 April 1996. Brussels, *ACP-EU Fish.Res.Rep.*, (2).

Pauly, D. and V. Christensen, 1993. Stratified models of Large Marine Ecosystems: A general approach and an application to the South China Sea. pp. 148-174 *In* Sherman, K.A., L.M. Alexander and B.D. Gold (eds.). Large Marine Ecosystems: Stress, Mitigation, and Sustainability. AAAS Press.

Pauly, D. and V. Christensen, 1995. Primary production required to sustain global fisheries. *Nature* (16 March 1995), 374:255-257.

Pauly, D., V. Christensen and M.L. Coelho (eds.), 1999. Ocean Food Webs and Economic Productivity. Proceedings of the EXPO 98 Conference, Lisbon, Portugal, 1-3 July 1998. *ACP-EU Fish.Res.Rep.*, (5):87 p.

Pauly, D., V. Christensen, J. Dalsgaard, R. Froese and F. Torres Jr., 1998. Fishing down marine food webs. *Science* (Feb. 6, 1998), 279:860-863.

Pauly, D., V. Christensen and C. Walters, (*in press*). Ecopath as a tool for evaluating ecosystem impacts of fisheries. *In* "Ecosystem Effects of Fishing", ICES/SCOR Symposium, 15-19 March 1999, Montpellier, France.

Rice, J., (*in press*). Use of community structure indices to measure impacts. *In* “Ecosystem Effects of Fishing”, ICES/SCOR Symposium, 15-19 March 1999, Montpellier, France.

Sumaila, U.R., 1998. Bioeconomics and the Ecopath/EcoSim framework. pp. 19-20 *In* Use of Ecopath with Ecosim to evaluate strategies for sustainable exploitation of multi-species resources. Proceedings of a workshop held on 25-27 March 1998, at the Fisheries Centre, UBC, Canada. Vancouver, *Fisheries Centre Research Reports*, 6(2).

Vieira, M.H., 1985. A Investigação dos Recursos Halieuticos: situação actual e perspectivas. pp. 139-182 *In* “Reflexões sobre a Pesca em Cabo Verde; 1º Encontro Nacional sobre as Pescas”, Praia (Cape Verde), 5-12 February 1985. Praia, Secretaria de Estado das Pescas.

Walters, C., V. Christensen and D. Pauly, 1997. Structuring dynamic models of exploited ecosystems from trophic mass-balance assessments. *Reviews in Fish Biology and Fisheries*, 7:139-172.

Walters, C., 1998. EcoSim and Ecospace: basic considerations. pp. 11-14 *In* Use of Ecopath with Ecosim to evaluate strategies for sustainable exploitation of multispecies resources. Proceedings of a workshop held on 25-27 March 1998, at the Fisheries Centre, UBC, Canada. Vancouver, *Fisheries Centre Research Reports*, 6(2).

Putting marine fisheries in an ecosystem context[a]

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Abstract

The globalisation of exploitation and marketing of fisheries has helped to perpetuate the general belief on the ever-continuing growth of fisheries production at the expense of the depletion of important stocks and ecosystems. Recent reviews of the status of world fisheries revealed alarming signs of human dominance and impact on marine ecosystems, including the depletion of many important stocks, the simplification of marine ecosystems and local surprising changes in the species compositions following heavy commercial fisheries. The demise of important natural stocks has been accompanied by a steady increase of world aquaculture production. Aquaculture may pose different threats to capture fisheries, by impacting the ecosystems that support wild stocks and by competing in the market for fish products, besides relying on marine resources to satisfy the nutritional requirements of cultured fish. The objective of this paper is to provide an overview of the ecosystem impacts of fisheries (capture and aquaculture) which could guide the development of a framework for assessing the effects of globalization of exploitation and marketing on the sustainability of fisheries.

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1. Introduction

To explore the effect of globalisation of exploitation and marketing on the sustainability of the world fisheries, we address one aspect of sustainability that has been particularly overlooked by markets, and by the economic model of development. That is, the natural carrying capacity of ecosystems or the ecological sustainability of fisheries activities. As noted by Rees (1996) the economist's case against carrying capacity is based in part on the principles of market-induced technological advances and inter-regional trade. While the first can increase the efficiency of resource use and substitute human-made capital for natural capital, the second can relieve local constrains on growth. This optimist view of the future accepts the ever-continuing growth of human-made components of capital at the expense of a depletion of natural capital (Folke *et al*., 1994). Ecological-economics proposes an alternative and more realist vision of the future, one that accepts a continuous qualitative development of the economy as long as its physical dimensions are kept below the natural carrying capacity of its supporting ecosystems (Folke *et al*., 1994). The objective of this paper is to provide an overview of the ecosystem impacts of fisheries (capture and aquaculture) which could guide the development of a framework for assessing the effects of globalization of exploitation and marketing on the sustainability of fisheries.

The paper is divided into three main parts. First we discuss both the direct and indirect ecosystem effects of fishing and aquaculture. This is followed by an overview of fisheries production statistics, both from captured and culture fisheries. We also present a case of salmon and shrimp production, to suggest some important trends that may lead to further impacts on the ecosystem. In the third section, we address the impacts of globalization of markets and exploitation on fisheries. Finally, we propose an integrated framework that could be used for the management of fisheries, as part of the whole ecosystem, rather than on its own.

2. Ecosystem effects of fishing

Many ecosystem impacts follow the activities of fisheries and aquaculture. Marine capture fisheries can have direct and indirect impacts on marine ecosystems (Botsford *et al*., 1997; Goni, 1998). Direct impacts include overfishing of particular stocks, bycatch and discards of non-target species, decrease in genetic diversity of stocks, and physical disturbance and habitat destruction by fishing gears (see Sumaila *et al*., 1999). Indirect impacts are mostly mediated through the food web where the effect of intense fishing "cascade" to other components of the system.

Overfishing is the most documented and important cause of fisheries impact. Recent analysis of the state of world fishery resources showed that 69% of the stocks for which assessments were available to FAO are considered either fully exploited, overfished, depleted or slowing recovering from depletion (Garcia and Newton, 1994). Many current fishing methods are highly indiscriminate and result in the incidental catch of non-target species. Alverson *et al*. (1994) estimated that the quantities caught and discarded by the world marine fisheries amount to 27 million tonnes, i.e. about 25% of the fish caught is discarded. Among the discarded organisms incidentally caught are turtles, marine mammals and birds.

Fisheries have the potential to affect the genetic diversity of populations by selectively removing older and larger individuals (Goni, 1998), and/or by depleting small reproductive stocks of metapopulations, such as salmon and herring (Policansky and Magnuson, 1998). Ultimately, the decrease in genetic diversity by fishing can cause the loss of resilience of fish populations to both human and natural impacts. Fisheries are also responsible for physically damaging important marine habitats. The physical impact of fishing gears is more pronounced in fisheries with towed gears (otter trawls, beam trawls, dredges). The effects of trawling on the sea bed vary from destruction of suitable habitats for the settlement of juveniles and adult phases of diverse marine organisms, changes in abundance and species composition of benthic communities, and concomitant changes in the fish species composition associated with the physical alterations of bottom structures (Goni, 1998). Other destructive fishing gears, such as cyanide and dynamite fishing, are widely employed in diverse regions of the Pacific and Atlantic, especially in coral reefs (Goni, 1998).

The scale of fish production can considerably alter the structure of food webs. Fisheries alone use about 8% of the total global primary production of the oceans, and up to one third of the primary production of the most intensively exploited marine regions of the world (Pauly and Christensen, 1996). Fisheries have therefore the potential for outcompeting all other natural predators at the top of the food chain, and indirectly cause major changes in the structure of marine communities. In fact, heavy commercial harvesting is responsible for a progressive simplification of marine ecosystems towards small, short-lived, low-trophic-level, planktivorous fish species that are capable of supporting higher fishing pressures (Pitcher and Pauly, 1998). Fishing-down-the-food-web is a phenomenon observed in many regions of the world where higher trophic-level, slow-growing fishes were severely depleted (Pauly *et al*., 1998).

Examples of major changes in marine ecosystems with intense fishing are present in almost every region of the world (Goni, 1998), although in many cases it has proven difficult to separate the natural and anthropogenic causes of the changes (Steele, 1998). Heavy commercial harvesting, often associated with the operation of distant water fleets, has been responsible for drastic changes in species composition of marine communities. Among the best documented examples are the cases of switches in dominance between sardines and anchovies in coastal upwelling systems where small pelagic species were targeted as protein source for fishmeal (Lluch-Belda *et al.*, 1989; Bakun, 1996). In the Bering Sea, human exploitation of whales and other top predators is thought to be responsible for cascading effects on other components of the ecosystem, such as declines in sea lions and seals, and the increase and dominance of ground fish, specially pollock and large flatfishes (Trites *et al*., 1998). On Georges Bank, large scale disturbances caused by intense fishing and habitat destruction are also associated with apparent replacement of gadid and flounder species by species of low commercial value, including dogfish sharks and skates (Fogarty and Murawski, 1998).

Aquaculture is responsible for about 20% of the total fisheries production worldwide. The impacts of fish and shellfish farming has been mostly related to pollution and contamination of coastal waters, introduction of exotic species, spreading of diseases to wild populations, and the destruction of coastal habitats, specially mangrove forests. Mangroves are disappearing rapidly to make way for commercial fishing farms in many regions of the world. For instance, in the Philippines the mangrove area declined from 450,000 to 145,000 hectares between 1920 and 1988, and in Thailand a decrease of ca. 40% of the mangrove forests occurred since 1979 mostly as a result of the introduction of fish farming (Le Sann, 1998). The long-term effect of this destruction may be a drastic reduction in productivity of wild fish and shellfish stocks which rely on mangroves and other estuarine habitats as nursery grounds. Therefore, aquaculture can cause environmental changes that may affect other fisheries. On the other hand, aquaculture relies on optimal environmental conditions to succeed, and may be impacted by several activities in the coastal zone, such as harbour development and shipping, coastal pollution, and tourism, which can adversely affect water quality and have a direct conflict over land usage (ICES, 1995). Aquaculture and fisheries are also intrinsically linked by the dependence on marine resources to satisfy the nutritional requirements of cultured fish. Aquaculture and fisheries can also compete for space and in the market for fish products.

3. Fisheries catches vs aquaculture production

Total world fishery production has steadily increased from close to 100 million tonnes in 1990 to about 121 million tonnes in 1996. Of this total, 75% are used for human consumption, the other 25%, for other purposes, mainly reduction in terms of oil and fish meals (FAO, 1998c). Although marine capture fisheries consistently dominate the total global production of fish, world aquaculture production has steadily increased during the last few years (table 1) and has contributed to an increment of fish available for human consumption (FAO, 1997; FAO, 1998b). In terms of values of production, capture fisheries contribute about 67% of total world value (about 85 billion US$), while the value of aquaculture production is about 42 billion US$ (or 33% of world) in 1996. It should be noted that although 60% of aquaculture production comes from inland water, their values are equivalent to those from marine waters (about 21 Billions US $ each) (table 1). From 1990 to 1996, a small increase in production is observed in captured fisheries (10% in marine and 15% in inland waters). On the contrary, aquaculture production has doubled in both marine and inland areas.

Table 1. World fisheries production, 1990-1996.

***Quantity* (t. 10^3)**

	Capture fisheries		**Capture**	**Aquaculture**		**Culture**	**Grand**
Year	**Marine capture**	**Inland capture**	**total**	**Marine culture**	**Inland culture**	**total**	**Total**
1990	79,292.2	6,588.0	85,880.2	4,956.4	8,172.4	13,128.7	99,008.9
1991	78,706.0	6,382.4	85,088.4	5,345.3	8,421.8	13,767.1	98,855.5
1992	79,955.5	6,253.3	86,208.8	6,128.8	9,390.7	15,519.6	101,728.4
1993	80,618.1	6,660.7	87,278.8	7,334.5	10,592.5	17,926.9	105,205.7
1994	85,774.7	6,908.2	92,682.9	8,666.0	12,108.7	20,774.7	113,457.6
1995	85,621.7	7,379.4	93,001.1	10,416.2	13,860.1	24,276.4	117,277.5
1996	87,072.6	7,552.8	94,625.4	10,777.9	15,606.6	26,384.6	121,009.9

Values (US $$10^6$)

	Capture	**Aquaculture**		**Culture**	**Grand**
Year	**Total**	**Marine**	**Inland**	**Total**	**Total**
1990	74,245.0	11,518.3	13,346.2	24,864.5	99,109.5
1991	75,722.0	13,113.1	13,188.5	26,301.7	102,023.7
1992	78,938.0	14,651.4	14,351.4	29,002.7	107,940.7
1993	74,172.0	16,310.7	15,472.9	31,783.6	105,955.6
1994	78,960.0	18,833.3	17,156.7	35,990.1	114,950.1
1995	83,082.0	20,512.8	18,547.6	39,060.4	122,142.4
1996	84,744.0	20,796.3	20,749.7	41,546.0	126,290.0

The distribution of catches varies by continent to continent, for instance, 45% of total catch comes from Asia, and another 22% comes from South America. The contribution from Europe is about 13%, while that from North America is less than 10%. In terms of species, almost 25% of the catches are from the group of herrings, sardines, and anchovies. The next two groups, with respect to production volume, are cods, hakes and haddocks, and jacks, mullets, and sauries. Shrimps and prawns comprise of about 3% of the total marine catches. The contribution of salmon is slightly less at about 1%.

In terms of aquaculture, major freshwater fish species groups are carps, barbels and other cyprinids (about 75% of the total fish and shellfish freshwater aquaculture production, contributing to about 60% of total value). Based on data from 1996 (FAO, 1998a), oyster production leads the world fish and shellfish aquaculture (about 35% of world production), followed by clams (17%), mussels and scallops (about 11% each) (table 2). The other two groups, salmons, trouts and smelts, and shrimps and prawns, contribute about 10% each to the marine aquaculture production. If we look at the value of production, however, these two groups are the top contributors at 30% and 18% of the total value of marine aquaculture production, respectively.

Table 2 Major species groups from marine fishery catches, 1996. Quantity in $t.10^3$ and value in $US\$10^6$.

Species	Quantity	%Total	Value	%Total
Salmon	1,072.5	9.95	3,821.6	18.38
Shrimp	914.7	8.49	6,213.5	29.88
Oyster	3,067.3	28.46	3,364.6	16.18
Mussels	1,179.0	10.94	523.1	2.52
Scallops	1,275.9	11.84	1,680.9	8.08
Clams	1,777.5	16.49	2,378.9	11.44
Total marine	**10,777.9**	**86.17**	**20,796.3**	**86.47**

Table 3 shows the top major producers of fisheries products, based on 1996 (including Canada, which ranks 21st). This list includes the top six principal producers of aquaculture products, namely China (over 65%), India, Japan, Indonesia, Thailand and USA. Taking both captured and culture fisheries combined, China leads world production at 27%. Although only about 2% of Chinese fisheries production are exported, it is still ranked as one of the world leading exporters, in terms of export value, after Thailand, Norway, and USA. Because of its major inland aquaculture fisheries, the value of imports from China is about 2% of the world total, half of which is in the form of fish meal. A major exporter of fish meals is Chile who produces about 6% of the total world fisheries production.

3.1. The case of shrimp and salmon production

We select two species groups, shrimps and salmon, to illustrate the relationship between capture fisheries and aquaculture and the impacts that each group might have on the ecosystem. Table 4 shows the production of shrimps and salmon, both from capture and culture fisheries from 1990 to 1996. In general, production from both groups increased from 1990 to 1996. However, while the difference in the increase in shrimp capture and culture production is small (25% vs 38%), that of salmon is much larger because of the 82% increase of the cultured production. The large increase in the production of cultured salmon makes up for the decrease in captured fisheries and thus maintain its total production proportion with shrimp at about one-third.

When looking at the proportion of capture and culture production of each group in each year, we found that the ratio for shrimp is steady at 70% capture. On the contrary, salmon production from culture has increasingly gained relative importance from about 40% of the total production in 1990 to about 50% in 1996.

Values of captured shrimps and salmons show a contrasting scenario. While values of captured shrimps increased 40% from 1990 to 1996, those of wild salmon decreased. In terms of values of cultured production, a large increase of more than 40% is observed in both groups during the last few years. Price per kg of cultured shrimp increases slightly from US$ 6.31 in 1990 to US$ 6.79 in 1996, however, price per kg of cultured salmon decreases from US$ 4.52 in 1990 to US$ 3.56 in 1996 (table 4).

Table 3 Nominal catches of fish, curstaceans, and molluscs, by principal producers, 1996

	Capture		**Culture**		**Total**		**Export**		
Country	**t.10^3**	**% world**	**t.10^3**	**% world**	**t.10^3**	**% world**	**t.10^3**	**%**	**% total export**
China	14,222.3	15.03	17,714.6	67.14	31,936.8	26.39	740.2	2.32	1.67
Peru	9,515.0	10.06	6.9	0.03	9,521.9	7.87		0.00	0.00
Chile	6,692.6	7.07	217.9	0.83	6,910.5	5.71	1,475.1	21.35	3.33
Japan	5,964.0	6.30	829.3	3.14	6,793.4	5.61	262.6	3.87	0.59
USA	5,000.8	5.28	393.3	1.49	5,394.1	4.46	1,119.7	20.76	2.53
Russian Fed	4,675.7	4.94	52.9	0.20	4,728.6	3.91	1,271.3	26.89	2.87
Indonesia	3,729.8	3.94	672.1	2.55	4,401.9	3.64	527.2	11.98	1.19
India	3,491.9	3.69	1,768.4	6.70	5,260.4	4.35	294.9	5.61	0.67
Thailand	3,138.2	3.32	509.6	1.93	3,647.9	3.01	971.3	26.63	2.20
Norway	2,638.4	2.78	324.5	1.23	2,963.0	2.45	1,670.5	56.38	3.77
Canada	900.8	0.95	70.4	0.27	971.2	0.80	478.3	49.25	1.08
World	**94,625.4**		**26,384,583**		**121,009.9**		**44,252.0**		

This is because the majority of cultured shrimp is giant tiger prawn (*Penaeus monodon*) which is priced very high in the market. Price per kg of wild salmon, while slightly less than that of cultured salmon, follows a similar decreasing trend.

At what prices do we pay for the increases in cultured production of these two example commodities? Norway leads the world in culture production of Atlantic salmon (*Salmon salar*), and Thailand leads the world in the aquaculture of shrimps, mainly giant tiger prawns. One of the implications of aquaculture industry is the use of fish meals for feeding. Data on fish meal production and imports of fish meals from Thailand suggests the high demand in this product, while world product of fish meals is declining during 1994 to 1996 (FAO, 1998c). Thailand produces about 6%, yet, it imports about 4% of fish meals annually. The story in Norway is less obvious, as it produces about 3% of total production of fish meals, imports about 3% and exports 2%[25].

Table 4 Shrimp and salmon production, captured and cultured, 1990-1996

Shrimp production [t.10^3]				**% total**		**Value [US\$.10^6]**		**price/kg**	
Year	**Capture**	**Culture**	**Total**	**Capture**	**Culture**	**Capture**	**Culture**	**Capture**	**Culture**
1990	1,968.7	662.6	2,631.2	74.82	25.18	7,187.0	4,180.5	3.65	6.31
1991	2,024.7	823.4	2,848.2	71.09	28.91	6,642.0	5,111.8	3.28	6.21
1992	2,087.9	881.8	2,969.8	70.31	29.69	7,830.0	5,543.1	3.75	6.29
1993	2,087.2	837.1	2,924.4	71.37	28.63	8,139.0	5,367.9	3.90	6.41
1994	2,246.3	881.3	3,127.6	71.82	28.18	8,984.0	5,948.4	4.00	6.75
1995	2,280.4	936.3	3,216.7	70.89	29.11	9,006.0	6,199.5	3.95	6.62
1996	2,470.0	914.7	3,384.7	72.98	27.02	10,008.0	6,213.5	4.05	6.79
Salmon production [t.10^3]									
1990	911.2	911.2	588.6	60.75	39.25	3,125.0	2,663.1	3.43	4.52
1991	1,048.5	1,048.5	650.0	61.73	38.27	3,343.0	2,758.6	3.19	4.24
1992	822.7	822.7	644.0	56.09	43.91	2,856.0	2,841.1	3.47	4.41
1993	978.3	978.3	721.3	57.56	42.44	3,315.0	3,093.5	3.39	4.29
1994	993.3	993.3	809.7	55.09	44.91	3,227.0	3,345.0	3.25	4.13
1995	1,149.8	1,149.8	938.7	55.05	44.95	3,531.0	3,656.7	3.07	3.90
1996	1,029.7	1,029.7	1,072.5	48.98	51.02	3,090.0	3,821.6	3.00	3.56

[25] For further discussion on cultured salmon, see Asche, F., 1997. Trade disputes and productivity gains: the curse of farmed salmon productivity? *Marine Resource Economics*, 12:67-73.

Also well-studied is the environmental impacts of shrimp farming in Thailand, in particular when farming involved clear-cutting of mangrove forests, the case of shrimp culture development in its early year. Mangrove forests in Thailand are being destroyed at an average rate of 6,225 ha per year, from 1961 to 1993, with the highest destruction rate of almost 13,000 ha per year in 1986 when intensive shrimp farming boomed (Sathirathai, 1998). Mangrove forests have been mostly converted to other uses as they are often considered to be of low economic values. Sathirathai (1998) shows, however, that when considering indirect benefits (such as shoreline stabilization, nutrient retention, etc.), the net present value of converting mangrove forests into commercial shrimp farms is in fact negative. This is supported by the report by Costanza *et al.* (1997) of the value of ecosystem services of mangrove forests at US$ 9,990 per ha and year.

4. Towards an ecosystem framework for the management of fisheries

The globalization of markets and exploitation has influenced fisheries in different ways. With respect to the ecological impacts of fishing activities we emphasize here three general effects. First, the increasing world demand for fish products and the technological advances for catching and processing fish have led to the development of industrial fisheries for export of fish products in many developing countries. The results were very often disastrous. Industrial fisheries were usually accompanied by overcapacity, overcapitalization, overfishing and social conflicts, especially with traditional, small-scale, artisanal fisheries.

Second, the growth of Distant Water Fleet (DWF) activities during the last decades caused the expansion of fisheries in every oceanic region of the world, from the Arctic to the Antarctic. Historically, however, most of the fishing activity has been concentrated in the Central Eastern, Northwest and Southeast Atlantic, and in the Northeast Pacific (WWF, 1998). The top six main fisheries resources pursued by DWFs are, in order of importance, tunas, horse mackerels, small pelagics (sardines, herrings and anchovies), cods, hake and Walleye pollock (WWF, 1998). Overall, Distant Water Fleets have contributed to the problem of fisheries overcapacity globally, aggravated overfishing and the ecological impacts of fisheries locally, and intensified conflicts over ownership of fisheries resources in the Exclusive Economic Zones of coastal countries.

Third, the worldwide spread of intensive agricultural systems has increased the demand for protein as feed for pig, poultry, fish and shellfish farming. Currently, about one third of the global fish production (that made of anchovies, sardines, and other small pelagic fishes) is converted into fishmeal for intensive farming. Developing countries (mostly Peru and Chile) supply half the world’s fishmeal, which is used mostly by intensive agricultural systems of developed countries (Le Sann, 1998). The production of fishmeal is a very wasteful process, requiring on average five tons of fish to produce one ton of fishmeal. Significant losses also occur in the intensive farming systems, where a large proportion of pellets end up being dispersed into surrounding environment aggravating pollution problems. The established pattern of international trade has therefore created a major flow of resources from south to north, where a large share of fisheries resources of developing countries is used to meet the demand for fishmeal in developed countries (Le Sann, 1998).

Although globalization has introduced another dimension into the management of fisheries, its major effect has been to aggravate the already existing regional problems of fisheries due to mismanagement by coastal countries, e.g. overfishing, habitat destruction, ecosystem impacts and social crisis. Therefore, in order to analyze the impact of globalization on the sustainability of fisheries it is fundamental to place fisheries in a regional, ecosystem context, where fisheries and other human activities interact over the use of coastal resources.

Capture fisheries and aquaculture are the two human activities responsible for fish production. The relationships between these two activities are represented in the conceptual model (Fig. 1). Both activities depend on marine and coastal ecosystems to provide the support for fish production by means of feeding, nursery, clear water and waste assimilation. Fisheries can conflict with other human activities in the coastal zone, such as urban and industrial development, tourism and other recreational activities, either by direct use of the ecosystems that support fish production (e.g. clear cutting of mangroves for coastal development) or by shared interests in fish stocks (e.g. recreational fishing). Capture fisheries rely mostly on energy transferred through the food web to higher order consumers. In this process there are substantial losses of energy into unavailable or less available forms (e.g. heat) due to respiration. Contrary to marine capture fisheries, intensive aquaculture is totally dependent on energetic subsidies from adjacent systems including agricultural ecosystems which provide feeding supplements, mangrove areas that provide post-larvae (in the case of shrimp farming) and space for the construction of tanks, fossil fuels and clear water from diverse sources. Fisheries and aquaculture are intrinsically linked by the inflow of marine catches compressed into pellets fed to the cultivated shrimps or fishes. Pellets fed to intensively monocultured fish generates concentrated forms of waste which are continuously dispersed into the surrounding ecosystems at a higher rate than they are assimilated.

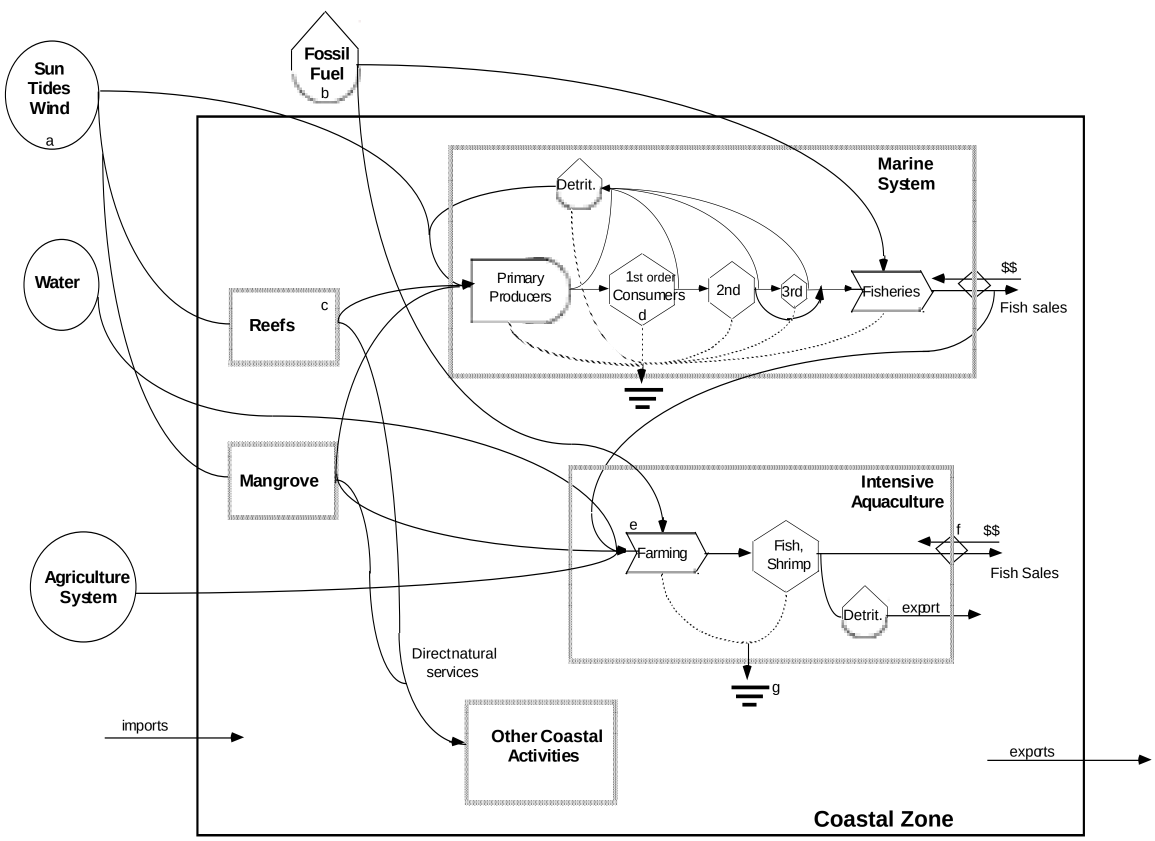

Figure 1. Conceptual model of coastal fisheries (capture and intensive fish farming). a. circular symbols represent sources of energy and materials; b. storage; c. system; d. consumer; e. work gate where two or more flows interact to produce a higher quality energy; f. transaction, money flows in opposite direction to the flow of energy to pay for labor, transportation, fossil fuels, etc.; g. heat sink required according to the second law of thermodynamics for all processes that transform energy (source Odum, 1997).

Exchanges within the economic system occurs through the harvesting and marketing of fish products, and economic subsidies, which pays for the costs of labor, fossil fuels and appliances. Market prices do not reflect however the appropriate energy from the different systems, and the actual impacts and costs of deteriorated coastal and marine ecosystems caused by fisheries and aquaculture. Moreover, ecological functions and services provided by coastal ecosystems are generally not accounted for in the economic analysis of the fisheries and coastal development. Existing valuation methods, while trying to capture both market and non-market values of resources, fail to recognize that some of the goods and services provided these environmental goods should not be valued in monetary terms.

The model points at important questions to be addressed for the full appreciation of the sustainability of fisheries. First, how do capture fisheries impact the structure and productivity of marine ecosystems? Second, how do habitat losses caused by coastal activities (including fisheries and aquaculture) impact the productivity of marine fisheries? And third, how should we balance the use of coastal resources to reduce conflicts and optimize the economic and social values of fisheries? These questions present real challenges to scientists and managers alike. They prompt us to move towards an integrated ecosystem-based management framework for fisheries and for coastal areas, that incorporates other considerations such as economic, social and cultural importance of coastal communities and their values. As it has been recently acknowledged, traditional knowledge of resource users may provide useful insights for the design of management policies, while involving communities at an early stage of the planning process could contribute to the success in implementation of such policies.

References

Alverson, D. L.; Freeberg, M. H.; Murawski, S. A. and J. G. Pope. 1994. A global assessment of fisheries bycatch and discards. *FAO Fisheries Technical Paper*, 339:233 p.

Bakun, A., 1996. Patterns in the Ocean. Ocean processes and marine population dynamics. California Sea Grant, 323 p.

Botsford, L.W., J.C. Castilla and C.H. Peterson, 1997. The management of fisheries and marine ecosystems. *Science*, 277:509-514.

Costanza, R., R. d'Arge, R. De Groot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R.V. O'Neill, J. Paruelo, R.G. Raskin, P. Sutton and M. van den Belt, 1997. The value of the world's ecosystem services and natural capital. *Nature*, 387:253-259.

FAO, 1997. The State of World Fisheries and Aquaculture 1996. Rome, Food and Agriculture Organization of the United Nations.

FAO, 1998a. Aquaculture production statistics, 1987-1996. Food and Agriculture Organization of the United Nations, Fishery Information, Data and Statistics Unit. *FAO Fisheries Circular*, 815(Rev. 10):197 p.

FAO, 1998b. FAO Yearbook - Fisheries Statistics - Capture production, 1996. Rome, Food and Agriculture Organization of the United Nations, FAO Fisheries Series No. 50, Vol. 82.

FAO, 1998c. FAO Yearbook - Fisheries Statistics - Commodities, 1996. Rome, Food and Agriculture Organization of the United Nations, FAO Fisheries Series No. 51, Vol. 83.

Fogarty, M.J. and S.A. Murawski, 1998. Large-scale disturbance and the structure of marine systems: fisheries impacts on Georges Bank. *Ecological Application*, 8(1):6-23.

Folke, C., M. Hammer, R. Costanza and A. Jansson, 1994. Investing in natural capital - why, what and how? pp. 1-20 *In* Jansson, A. *et al*. (eds.). Investing in Natural Capital.

Garcia, S.M. and C. Newton, 1997. Curent situation, trends and prospects in world capture fisheries. pp. 3-20 *In* Pikitch, E.K., D.D. Huppert and M.P. Sissenwine (eds.). Global Trends: Fisheries Management. American Fisheries Society Symposium, 20.

Goñi, R., 1998. Ecosystem effects of marine fisheries: an overview. *Ocean and Coastal Management*, 40:37-64.

ICES, 1995. Report ICES Workshop on Principles and Practical Measures for the Interactions of Mariculture and Fisheries in Coastal Area Planning and Management. July 19 to 22, 1995.

Le Sann, A., 1998. A livelihood from fishing: globalization and sustainable fisheries policies. London, Intermediate Technology, 123 p.

Lluch-Belda, D., R.J. Crawford, T. Kawasaki, A.D. MacCall, R.H. Parrish, R.A. Schwartzlose and P.E. Smith, 1989. World-wide fluctuations of sardine and anchovy stocks: the regime problem. *S.Afr.J.mar.Sci*., 8:195-205.

Odum, E.P., 1997. Ecology. A Bridge between science and society. Massachusets, Sinauer, 330 p.

Pauly, D. and V. Christensen, 1995. Primary production required to sustain global fisheries. *Nature*, 374:255-257.

Pauly, D., V. Christensen, J. Dalsgaard, R. Froese and F. Torres Jr., 1998. Fishing down marine food webs. *Science*, 279:860-863.

Pitcher, T. and D. Pauly, 1998. Rebuilding ecosystems, not sustainability, is the proper goal of fisheries management. pp. 311-329 *In* Pitcher, T., D. Pauly and P. Hart (eds.). Reinventing Fisheries Management. London, Chapman & Hall.

Policanski, D. and J. Magnuson, 1998. Genetics, metapopulations, and ecosystem management of fisheries. *Ecological Applications*, 8(1):119-124.

Rees, W.E., 1996. Revisiting carrying capacity: Area based indicators of sustainability. *Population and Environment*, 17(3):95-215.

Sathirathai, S., 1998. Economic valuation of mangroves and the roles of local communities in the conservation of natural resources: case study of Surat Thani, South of Thailand. *EEPSEA Research Report Series*, June 1998, 51 p.

Steele, J., 1998. Regime shifts in marine ecosystems. *Ecological Application*, 8(1):33-37.

Sumaila, U.R., S. Guénette and R. Chuenpagdee, 1999. Addressing the ecosystem effects of fishing using marine protected areas. Paper presented at the Ecosystem Effects of Fishing Symposium in Montpellier, France, March, 1999. Sumitted to *ICES Journal of Marine Science*.

Trites, A.W., P. Livingston, M. Vasconcellos, S. Mackinson, A.M. Springer and D, Pauly, 1998. Ecosystem considerations and the limitations of ecosystem models in fisheries management: Insights from the Bering Sea. Proceedings of the Symposium on the Ecosystem Effects of Fisheries, Anchorage, 1998.

WWF, 1998. The footprint of distant water fleets on world fisheries. WWF, Endangered Seas Campaing, 172 p.

Regional ecological-economic analysis of fisheries: The case of the Eastern Bering Sea Ecosystem[a]

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Abstract

Fisheries management has been urged to consider the ecosystem impacts of fishing activities. Although the need for ecosystem management has been widely recognized, scientific advice is still hampered by the lack of an adequate understanding of the complex dynamics of ecosystems, and the lack of consensus on which framework should be used to account for the ecosystem effects of fisheries. In this paper we introduce some of the concepts of mass-balance assessment and ecosystem modelling with the Ecopath/Ecosim software, and provide an illustrative example of the use of the approach in the analysis of the ecological and economic impacts of fisheries in the Eastern Bering Sea.

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1. Introduction

Recently many scientists and others alike have been stressing the need for fisheries management to take into account the ecosystem impacts of fishing activities. Scientific advisory work is now compelled to consider, as much as possible, more diverse aspects or consequences of fishing activities to marine populations and ecosystems, ideally linked by a common framework (Mangel *et al*., 1996). Although the need for ecosystem management has been widely recognized, scientific advice is still hampered by the lack of adequate understanding of the complex dynamics of ecosystems, and the lack of consensus on which framework should be used to account for the ecosystem effects of fisheries. During the last decades, attension has been given to the development of tools that account for the trophic interactions in the food web, mainly represented by the multispecies virtual population analysis (MSVPA, Sparre, 1991), and mass-balance models such as Ecopath (Polovina, 1984; Christensen and Pauly, 1992). The widespread application of the first is being hampered in part by the need for extensive time series of catch-at-age data, difficult parameterization, the high degree of expertise required from the modeller, and the overall lack of transparency in the estimation procedure (Walters et al., 1997). Ecopath offers, on the other hand, a simpler approach for the analysis of trophic interactions in fished ecosystems, and has been widely applied to aquatic ecosystems (more than 80 Ecopath models have been published world-wide describing upwelling systems, shelves, lakes, rivers, open oceans and terrestrial farming systems; see the Ecopath homepage at http:\\www.ecopath.org).

The Ecopath approach has some advantages over other existing trophic modeling approaches. A key advantage of this approach is that it includes all trophic levels in the analysis (from primary producers to top predators) as opposed to focusing only on the commercially important fish species. In addition, its emphasis on ecological relationships makes it intuitively simple. It incorporates and standardizes large amounts of scattered information, ranging from data routinely collected by fisheries scientists and marine biologists to those based on traditional ecological knowledge. Moreover, further developments of the mass-balance model, which originally focused on describing systems at steady-state conditions, has resulted in a dynamic ecosystem model called Ecosim which is capable of answering “what-if” questions about policy and ecosystem changes that would cause shifts in the balance of trophic interactions (Walters *et al*., 1997). In addition, recent work has sort to extend the framework to permit economic analysis of ecosystem use (Sumaila, 1998).

1.1. Mass-Balance Assessments with Ecopath

Ecopath is built on an approach presented by Polovina (1984) for the estimation of the biomass and food consumption of the various elements of an aquatic system. The approach provides a static picture of the ecosystem trophic structure by answering the question (Walters *et al.*, 1997): what must trophic flows and biomasses be to support the current ecosystem trophic structure and be consistent with growth and mortality patterns?

The model relies on the truism of the following equation for each group, *i*, in the system:

Production by (i) = All predation on (i) - Fisheries catches - Other mortality - Losses to adjacent systems

This applies to any time period (e.g. year or season). This can also be formulated as

$$P_i - B_i \,.\, M_i - P_i \,.(1 - EE_i) - EX_i = 0 \quad (1)$$

where P_i is the production of (i), B_i is the biomass of (i), M_i is the predation mortality of (i), EE_i is the ecotrophic efficiency, i.e., the fraction of the production of (i) that is consumed within the system or harvested, $(1\text{-}EE_i)$ is the other mortality, and EX_i is the export of (i) through fisheries catches or losses to adjacent systems. Equation 1 can be re-expressed as

$$B_i.(\frac{P}{B})_i.EE_i - \sum_{j=1}^{n} B_j.(\frac{Q}{B})_j.DC_{ji} - (Y+EX)_i = 0 \quad (2)$$

where in a system of i=1,...,n functional groups; P/B_i is the production/biomass ratio of (i) (equal to the total mortality rate Z_i under the assumption of equilibrium); EE_i is the ecotrophic efficiency; Y_i is the yield of (i), in weight, with $Y_i = F_i.B_i$, where F_i is the fishing mortality; EX_i is other exports of (i) from the system; B_j is the biomass of the consumers or predators; $(Q/B)_j$ is food consumption per unit of biomass for consumer j, and DC_{ji} is the fraction of i in the diet of j.

The implication of this relationships is that the system or model is mass-balanced, i.e. biomass is "conserved" or accounted for in the ecosystem. This principle of mass conservation provides a rigorous framework - formalized through a system of linear equations - through which the biomass and trophic fluxes among different consumer groups within an ecosystem can be estimated (Christensen and Pauly, 1995). Ecopath balances the system using one production equation (2) for each group in the system. Parameters Y_i, EX_i and DC_{ij} must always be entered, while entry is optional for the four parameters B_i, Q/B_i, P/B_i, and EE_i. The algorithm used to estimate missing parameters is described in detail in Christensen and Pauly (1996).

1.2. Ecosim - Dynamic model from mass-balance assessments

By re-expressing the system of linear equations (2) to differential equations, Ecosim provides a dynamic model suitable for simulation of the effects of fishing mortality (F) varying in time on the biomass of each group in the system. The model provides dynamic biomass predictions of each (i) as affected directly by fishing and predation on (i), changes in food available to (i), and indirectly by fishing or predation on other groups with which (i) interacts (Walters *et al*., 1997). Three modifications to equation 2 are required in order to change Ecopath from being static to being dynamic. First, the left hand side of the equations must be replaced with a rate of change of biomass function. Second, for primary producers, a functional relationship to predict changes in P/B_i with biomass B_I needs to be specified. Third, the static pool-to-pool consumption rates has to be replaced with functional relationships that predict how consumption will change with changes in the biomasses of B_i and B_j (Walters *et al*., 1997). After these modification, equation (2) becomes

$$\frac{dB_i}{dt} = f(B_i) - M.B_i - F_i.B_i - \sum_{j=1}^{n} c_{ij}(B_i.B_j) \quad (3)$$

where f (B_i) is a function used to predict production with changes in biomass; f (B_i) is a function of B_i if (i) is a primary producer or $f(B_i) = g_i \sum_{j=1}^{n} c_{ij}(B_i.B_j)$ if (i) is a consumer, and $c_{ij}(B_i.B_j)$ is the function used to predict consumption rates from B_i and B_j. Altering the form of this consumption function allows the representation of different hypotheses about "top-down" versus "bottom-up" control of trophic interactions (Walters *et al*., 1997). Under "bottom-up" control prey-availability governs the productivity of predators, while under "top-down" control the increase in the biomass of predators leads to cascade effects in the food web by depressing the abundance of preys and releasing the predation on lower trophic level organisms. Ecosim also provides equilibrium biomass predictions by adjusting the biomasses of the different groups (i) over a range of fishing mortality rates directed to one or more groups in the system.

1.3. Working Definitions

An important first step in the analysis of the ecosystem effects of fishing, and for the screening of ecosystem management policies using the Ecopath/Ecosim frameworks, is defining what ecosystem is under study. Ecopath allows for modelling ecosystems of any kind. Christensen and Pauly (1996) suggested however that the system should be defined such that the interactions within the system add up to a larger flow than the interactions with adjacent systems. For marine resource management purposes, Large Marine Ecosystems (LMEs) have been proposed as appropriate ecosystem units (Sherman, 1993).

LMEs are relatively large regions of the ocean, in the order of 200,000 Km^2, characterized by distinct bathymetry, hydrography, productivity, and trophicaly dependent populations (Sherman, 1993). Several factors make LMEs particularly appropriate as units for the analysis of the sustainability of fisheries (Sherman, 1993): about 95% of the annual yield of marine fisheries is caught within the limits of 49 identified LMEs, which are located within or extending beyond the limits of Exclusive Economic Zones; they have spatial scale consistent with the scale of critical processes controlling the structure and functioning of marine ecosystems; and as regional ecosystems, they are amenable to comparative studies with other similar ecosystems (e.g. Eastern Boundary Current Systems, Bakun, 1996).

Steady-state models, like Ecopath, require an arbitrary definition of the period to which their state and rate estimates may apply. Usually, the period considered will be a typical season or a typical year, but the states and rates used for constructing the model may reflect averages of longer periods (Christensen and Pauly, 1996). The model must then reflect a period (years or decades) when no major changes in the structure of the community has occurred. Systems characterized by decadal shifts in species compositions (such as most Eastern Boundary Current systems, and the Bering Sea) will require models that represent their distinct states.

Next, the components of the system under study must be defined. A component (pool, functional group) in the system may be a species, or a group of ecologically or taxonomically related species, or size/age classes of the same species (Christensen and Pauly, 1996). Although species may be the most appropriate component definition, in many cases grouping of species is necessary due to the lack of information, and/or due to practical reasons when the system is highly diverse. In effect, the choice of the optimal group definition, and the number of groups in the system will depend on data availability and on the scope of the study. For instance, species that show strong cannibalism or ontogenic changes in diet are better represented in split pools describing different size classes. Very often, grouping of these ontogenic phases into a single pool produces unrealistic results during ecosystem simulations (Walters *et al.*, 1997).

2. Ecological and Economic analysis of exploited ecosystems: the Eastern Bering Sea

In this section we present an illustrative example of the use of Ecopath/Ecosim in the analysis of the ecological and economic impacts of fisheries. The eastern Bering Sea is used as the Large Marine Ecosystem for the simulation of fisheries scenarios.

The Bering Sea has supported considerable indigenous and commercial demand for fish, crustaceans and marine mammals over the past century (NRC, 1996). Today, the Eastern Bering Sea supports one of the largest fisheries in world, that for walleye pollock, which is used mainly for surimi production. After pollock, groundfish constitutes the most important commercial fisheries in the region, especially yellowfin sole, Pacific halibut, Pacific cod, sablefish, and Pacific Ocean perch (Bakkala, 1993). Some species in the Bering Sea underwent large changes between the 1950s and 1980s, among the most documented are the declines of Steller sea lions and northern fur seals, and the increase in dominance of bottom fish, mainly pollock and flatfishes. A frequently proposed explanation for these changes is that a change in the physical environment acted in concert with intense human exploitation of top predators (including marine mammals) and shifted the structure of the system to one dominated by pollock (Trites *et al*., 1998).

Trites *et al*. (1998) employed ECOPATH to describe quantitatively the Eastern Bering Sea ecosystem during the 1950s, before large-scale commercial fisheries, and during the 1980s, after many marine mammal populations had declined. The model represents the hundreds of species of the Eastern Bering Sea in 24 functional groups (Figure 1). These mass-balance assessments are here used to characterize the ecological and economic losses suffered in the Bering Sea between these two time periods. We then use equilibrium simulations to analyze how species biomass would respond to changes in fishing pressure applied in the 1980s ecosystem.

2.1. Ecosystem changes

Table 1 summarizes the main changes in the biomass and catches of the different functional groups in the Bering Sea between the 1950s and 1980s, as estimated by Ecopath. The most dramatic changes noted are (i) the decline in the biomass of most marine mammals, pelagic fishes (mostly herring), deep-water fish (e.g. sablefish, rockfish), other demersal fishes (e.g. Pacific cod), and crabs, and (ii) the increase in the biomass of adult and juvenile pollock, and of small and large flatfishes. Changes in the biomass of these groups altered mainly the structure of the higher trophic levels of the system, i.e. trophic levels 3 and 4. The relative importance of species occupying trophic level 3 shifted from pelagic species in the 1950s to pollock in the 1980s. Changes at trophic level 4 were mainly due to the increase in the dominance of large flatfishes, and the decreased importance of seals and Sperm whales. The major results of these changes were the simplification of the top of the food web and the shift in species dominance at the mid-trophic level.

Various ecosystem indices obtain from Ecopath runs can be used to describe the changes in the structure and functioning of the Bering Sea between the two time periods. Table 2 describes some indicators of fisheries impact, complexity in community structure, community energetics and homeostasis (for a detailed description of ecosystem indexes see Christensen and Pauly, 1992; Christensen, 1995).

The total catch from the system was 0.33 $t.Km^{-2}$ in the 1950s and 2.62$t.Km^{-2}$ in the 1980s. The almost 10-fold increase in harvest reflects the massive fishery for pollock, which developed during the 1980s. The shift from primarily harvesting whales and other apex predators to catch mainly pollock is also reflected in the mean trophic level of the catches, which decreases from 3.44 to 3.29. The result is that although catches are much higher during the 1980s, the “carrying capacity appropriated by fisheries” (measured by the total Primary Production Required to Sustain Catches, PPR) in this period is much smaller than during the 1950s, when most of the catches were from higher trophic level groups.

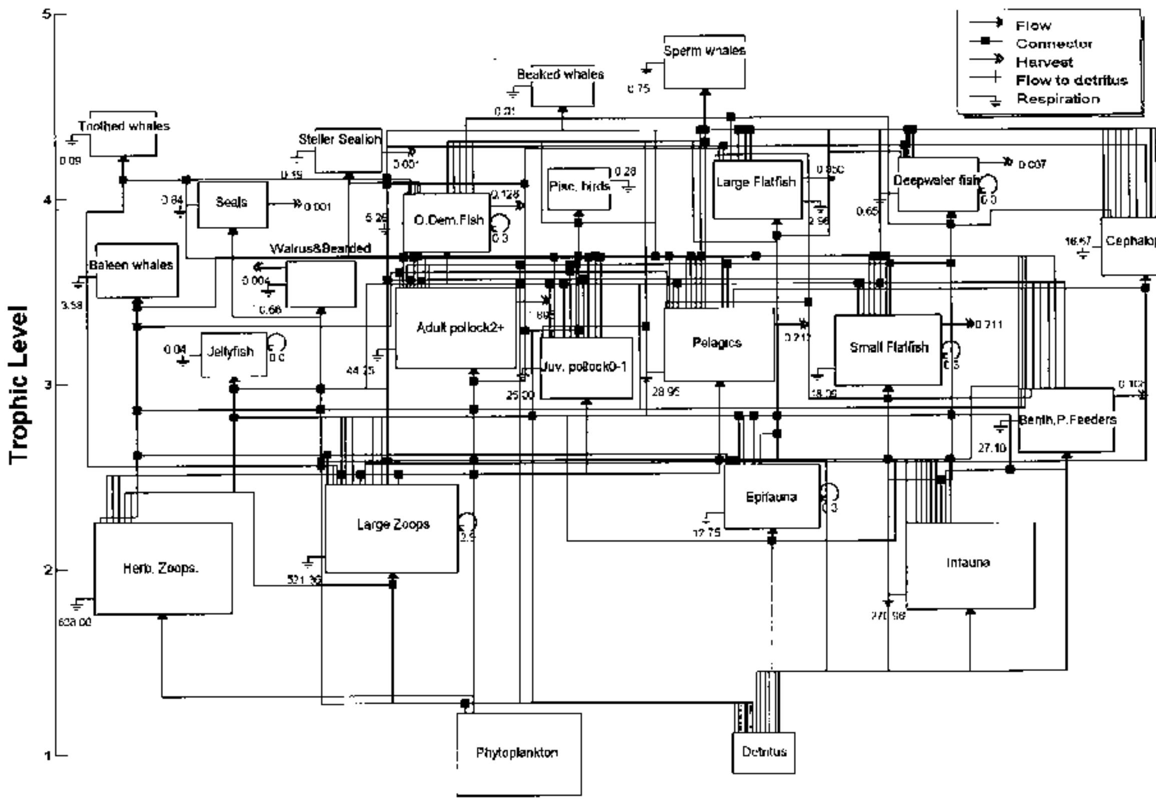

Figure 1. Flowchart of the trophic relationships in the Eastern Bering Sea during the 1980s (Trites *et al*., 1998). The size of boxes is proportional to the abundance of each group.

The smaller “footprint” of fisheries during the 1980s does not reflect, however, the changes in community structure and energetics associated with the shift in the eastern Bering Sea. Four indexes are used to compare the ecosystems between the two time periods.

The *total system throughput* measures the “size” of the system in terms of its flows.

The *ratio of primary production to respiration* (P/R) reflects the maturity and development of an ecosystem, where values close to 1 suggest that the amount of energy fixed in the ecosystem is balanced by the cost of maintenance.

System omnivory measures the distribution of feeding interactions between trophic levels, and can be used to characterize the complexity or the extent to which a system displays web like features.

Finally, the *recycling index* measures the fraction of the total flows that is recycled within the system. These indices indicate that the 1980s ecosystem is at a more disturbed state than in the 1950s, which is reflected by the smaller size, the lesser complexity in the food web, and the reduced ability to recycle nutrients within the system.

Table 1. Comparison of changes in biomass and catches from the 1950s and 1980s models (Trites *et al*., 1998).

Functional Group	Biomass ($t.Km^{-2}$)		Catches ($t.Km^{-2}.year^{-1}$)	
	1950s	***1980s***	***1950s***	***1980s***
Baleen whales	0.696	0.394	0.084	—
Toothed whales	0.009	0.009	—	—
Sperm whales	0.439	0.208	0.021	—
Beaked whales	0.001	0.001	—	—
Walrus & bearded	0.054	0.074	0.006	0.004
Seals	0.106	0.066	0.005	0.001
Steller sea lions	0.029	0.019	0.001	0.001
Pisc. Birds	0.006	0.006	—	—
Adult pollock	5.500	27.451	0.014	1.895
Juvenile pollock	0.942	6.000	—	—
Other demersal fish	8.957	3.904	0.001	0.128
Large flatfish	1.169	1.900	0.002	0.050
Small flatfish	8.530	9.161	0.105	0.211
Pelagics	28.869	13.644	0.083	0.212
Deepwater fish	1.011	0.407	0.001	0.007
Jellyfish	0.048	0.048	—	—
Cephalopods	3.500	3.500	—	—
Benth. Par. Feeders	29.000	5.800	0.010	0.108
Infauna	75.000	46.500	—	—
Epifauna	8.000	5.858	—	—
Large Zoops.	44.000	44.000	—	—
Herb. Zoops.	55.000	55.000	—	—
Phytoplankton	32.000	32.000	—	—
Detritus	—	—	—	—

Table 2. Comparative statistics for the eastern Bering Sea models.

Period	Catch $t.Km^{-2}.year^{-1}$	Mean T.L.	PPR %	Throughput $t.Km^{-2}.year^{-1}$	P/R	System Omnivory	Recycling %
1950s	0.33	3.44	47.0	6,535	0.94	0.183	13.2
1980s	2.62	3.29	6.1	5,692	0.78	0.157	11.1

3. Economic Analysis

In order to investigate the gains and losses due to changing fishing patterns between the 1950s and the 1980s, we combined 1952 and 1994 North American prices reported in FAO (1954/55 and 1996), with the catches reported in table 1 above to perform a simple economic analysis. It should be noted that only the species whose prices were reported in FAO publications are valued. In order words, this valuation is only for the marketed species. Questions we seek answers to include: what are the landed values that would have accrued had the 1950s catches been valued using 1952 and 1994 prices? Similarly, what are the landed values that would have accrued had the 1980s catches been valued using 1952 and 1994 prices, respectively?

Table 3 presents the answers to our two questions. We see from column two that using 1952 prices on the 1950s and 80s catches shows that the landed value from fishing a kilometer square of the Bering Sea ecosystem increased in real terms by about 3 times. When 1994 prices are applied instead, the landed value of the 1980s catches turn out to be 5 times greater that the 1950s landed values. The larger increase over time when 1994 prices were applied is an indication that the lower trophic level species that constituted most of the catches in 1980s, enjoyed a much higher increase in real prices than the catch composition (of relatively higher trophic level species) in the 1950s. Thus, leading to what has been described as the “masking” of the real economic effects of changing fishing patterns from high to low trophic level species (Sumaila and Pauly, 1999)

Table 3: Landed values from 1950s and 1980s catches using 1952 and 1994 prices

	Prices	
Catches	***1952***	***1994***
1950s	256	882
1980s	881	4461

3.1. Equilibrium fishing scenarios

Equilibrium simulations with Ecosim were used to predict the changes in biomass of the different groups in the system with the increase in fishing mortality for large flatfish in the 1980s model (Figure 2). Increasing fishing pressure for large flatfish caused the decrease in biomass and a domed shaped yield curve with maximum at $F \sim 0.15\ year^{-1}$ (Fig. 2a). With the decrease of large flatfish biomass the model predicts an increase of Stellar sea lions, seabirds, and deepwater fish due to a competitive release of their food (i.e. pollock, small flatfish and other demersal fish). Deepwater fish also benefits from a decrease in the biomass of seals caused by cascading effects in the food web.

As a simulation tool Ecosim can, therefore, be used to explore the future effects of fishing strategies, both in terms of ecosystem changes and economic indicators. Yet, improvements in the framework are still needed, specially in treating spatial and oceanographic/climatic information (Trites *et al*., 1998), and in the incorporation of economic costs of fishing strategies. Research efforts in these directions are planned for the near future.

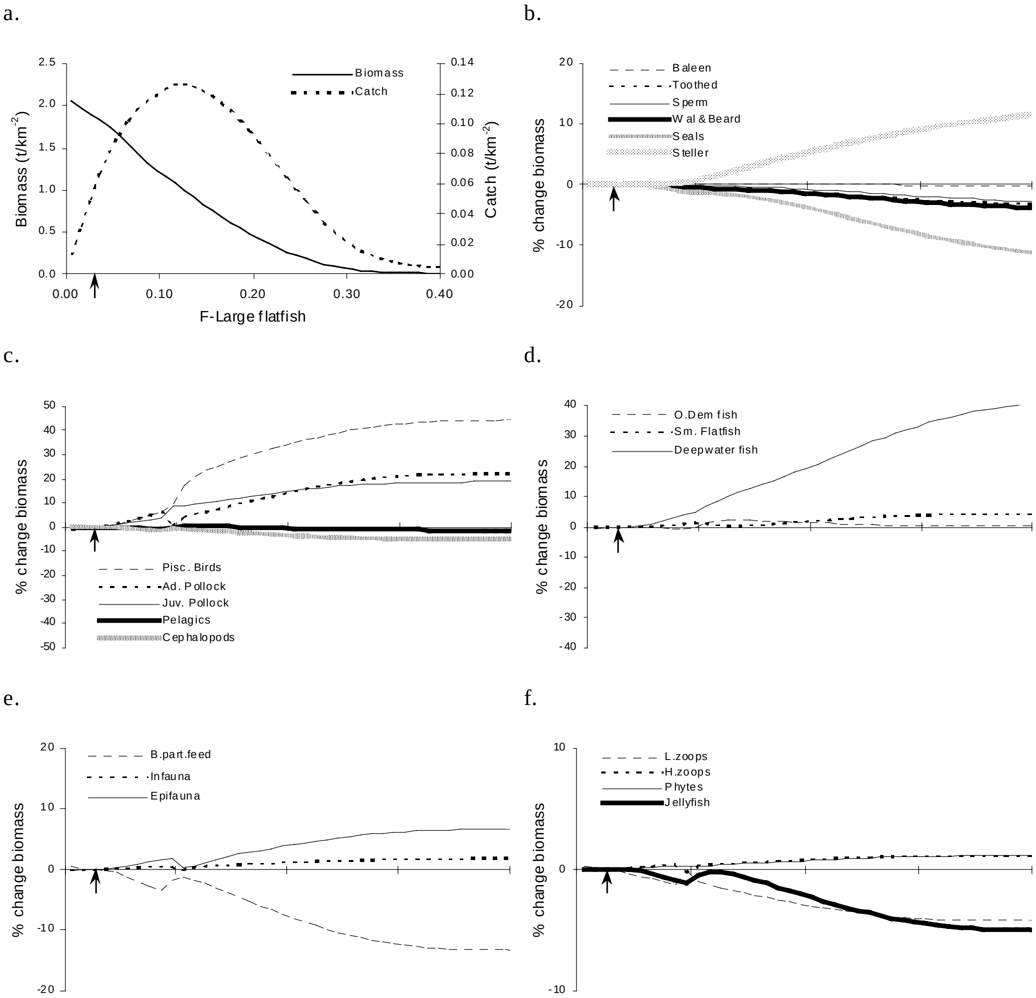

Figure 2. Equilibrium simulations for large flatfishes in the 1980s model (Trites et al., 1998). The *x-axis* represent fishing mortality for large flatfishes (year-1). The *y-axis* represent the predicted change in absolute catches and biomass of large flatfishes (panel a), and percent change in biomass of other ecosystem components (panels *b* to *f*).

4. Concluding remarks

This paper has presented an outline of the Ecopath/Ecosim framework and used it to demonstrate how the framework can be employed to undertake simple but powerful analysis of the ecological and economic impacts of fishing on ecosytems. The analysis is couched on the Eastern Bering Sea Ecosystem. Main results from the study show that, from the ecological perspective, the Eastern Bering Sea was a more mature ecosystem during the 1950s, when it sustained much larger biomasses of top-predators such as marine mammals. From the economic point of view, our analysis shows that because of the relatively higher increase of the real price of the 80s catch composition compared to those of the 50s, it is difficult to see the underlying ecosystem shifts revealed by this paper when one looks at only the overall economic return from the catches taken from the ecosystem.

References

Bakkala, R.G., 1993. Structure and historical changes in the groundfish complex of the Eastern Bering Sea. NMFS, *NOAA Technical Report*, 114:91 p.

Bakun, A., 1996. Patterns in the Ocean. Ocean processes and marine population dynamics. California Sea Grant, 323 p.

Christensen, V., 1995. Ecosystem maturity - towards quantification. *Ecol.Model*., 77:3-32.

Christensen, V. and D. Pauly, 1992. ECOPATH II - a software for balancing steady-state models and calculating network characteristics. *Ecol.Model*., 61:169-185.

Christensen, V. and D. Pauly, 1995. Fish production, catches and the carrying capacity of the world oceans. *NAGA, the ICLARM Q*., 18(3):34-40.

Christensen, V. and D. Pauly. 1996. Ecopath for Windows - A user guide. Manila, Philippines, ICLARM, 71 p.

FAO, 1954/55. Yearbook of Fisheries Statistics. Production and craft. Rome, FAO, vol. 5, d-1 to d-30 p.

FAO, 1996. Yearbook of Fisheries Statistics. Commodities. Rome, FAO, 79:357 p.

Mangel, M. *et al*., 1996. Principles for the conservation of wild living resources. *Ecological Applications*, 6(2):338-262.

National Research Council (NRC), 1996. The Bering Sea ecosystem. Washington, D. C., National Academy Press, 207 p.

Polovina, J.J., 1984. Model of a coral reef ecosystem I. The ECOPATH model and its application to French Frigate Shoals. *Coral Reefs*, 3:1-11.

Sherman, K., 1993. Large Marine Ecosystems as global units for marine resources management - An ecological perspective. Pp. 3-15 *In* Sherman, K., L.M. Alexander and B. Gold (eds.). Large Marine Ecosystems. Stress, mitigation and sustainability. AAAS Press, 376 p.

Sparre, P., 1991. Introduction to multispecies virtual population analysis. *ICES Mar. Sci.Symp*., 193:12-21.

Sumaila, U.R., 1998. Bioeconomics and the Ecopath/EcoSim framework. pp. 19-20 *In* Use of Ecopath with Ecosim to evaluate strategies for sustainable exploitation of multispecies resources. Proceedings of a workshop held on 25-27 March 1998, at the Fisheries Centre, UBC, Canada. Vancouver, *Fisheries Centre Research Reports*, 6(2).

Sumaila, U.R. and D. Pauly, 1999. Pricing down marine food webs. Unpublished manuscript.

Trites, A.W., P. Livingston, M.C. Vasconcellos, S. Mackinson, A.M. Springer and D. Pauly, 1998. Ecosystem change and the decline of marine mammals in the Eastern Bering Sea: testing the ecosystem shift and commercial whaling hypotheses. Vancouver, *Fisheries Centre Research Report*, 7(1):106 p.

Walters, C., V. Christensen and D. Pauly, 1997. Structuring dynamic models of exploited ecosystems from trophic mass-balance models of marine ecosystems. *Reviews in Fish Biology and Fisheries*, 7(2):139-172.

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Sumaila, U.R., R. Chuenpagdee & M. Vasconcellos (eds.), 2000. Proceedings of the INCO-DC International Workshop on Markets, Global Fisheries and Local Development, Bergen, Norway, 22-23 March 1999. *ACP-EU Fish.Res.Rep.*, (7):115 p. – ISBN 92-894-0786-7, Catalogue # KI-NA-19-433-EN-C EUR-OP, Luxembourg

Titles of Related Interest

Anon, 1995. ACP-EU Fisheries Research Initiative. Proceedings of the First Dialogue Meeting, Eastern and Southern Africa, Indian Ocean and the European Union. Swakopmund, Namibia, 5-8 July, 1995. Brussels, *ACP-EU Fish.Res.Rep.*, (1):144 p.

Anon, 1996. ACP-EU Fisheries Research Initiative. Proceedings of the Second Dialogue Meeting, West and Central Africa and the European Union. Dakar, Senegal, 22-26 April 1996. Brussels, *ACP-EU Fish.Res.Rep.*, (2):166 p.

Anon, 1997. ACP-EU Fisheries Research Initiative. Proceedings of the Third Dialogue Meeting, Caribbean and Pacific and the European Union. Belize, Belize City, 5-10 December 1996. Brussels, *ACP-EU Fish.Res.Rep.*, (3):180 p.

Anon, 1997. ACP-EU Fisheries Research Initiative. Proceedings of the Fourth Dialogue Meeting, all ACP Regions and the European Union. Brussels, Belgium, 9-11 July 1997. Brussels, *ACP-EU Fish.Res.Rep.*, (4):51 p.

European Commission, 1999. EC Co-operation on oceans and seas. A review of policies, programmes, financial instruments and projects. Brussels, European Commission, Directorate General for Development, 80 p.

Pauly, D., V. Christensen & L. Coelho (eds.), 1999. Ocean food webs and economic productivity. Proceedings of the EXPO 98 Conference, Lisbon, Portugal, 1-3 July 1998. Brussels, *ACP-EU Fish.Res.Rep.*, (5):87 p.

The ACP-EU Fisheries Research Initiative

The ACP-EU Fisheries Research Initiative was requested by the ACP-EU Joint Assembly, composed of Members of the European Parliament and Representatives of African, Caribbean and Pacific (ACP) Countries, in a Resolution on Fisheries in the Context of ACP-EEC Cooperation, adopted in October 1993. A series of dialogue sessions was conducted between ACP and European aquatic resources researchers, managers and senior representatives of European cooperation, using a draft baseline paper for the Initiative produced by intra-European consultation.

The Initiative aims at promoting sustainable economic and social benefits to resource users and other stakeholders, while preventing or reducing environmental degradation. It has set an agenda for voluntary collaborative research based on mutual responsibility and benefits. It promotes commitment to addressing the most crucial problems of rehabilitating complex resource systems and their ecological and economic productivity with the objective of informing and supporting more directly economic and political decision making, through pro-active and high quality research.

Suitable instruments to fund such research are, among others, the European Development Fund (EDF), International Science Cooperation (INCO-Dev) as part of the EU 5th Science Framework Programme, European Member States bilateral research and cooperation programmes and ACP institutions' own resources.

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