FISHERIES IMPACTS ON NORTH ATLANTIC ECOSYSTEMS: EVALUATIONS AND POLICY EXPLORATION

Edited by

Tony Pitcher, Ussif Rashid Sumaila and Daniel Pauly

2001

Fisheries Centre Research Reports 9(5), 94 pp

CONTENTS

A Research Report from
The Sea Around Us project at the Fisheries Centre, UBC

Director's Foreword

Who would have thought that every single one of the major international agencies set up with such hope in the 1950s and 1960s to manage fisheries on North Atlantic fish populations would have been found, by 2000, to have totally failed in their mandate? This series of four reports[1], presenting the output of the first two-year phase of the *Sea Around Us* project (SAU), makes a detailed and solid case for this spectacular and depressing failure.

Two questions immediately arise. Why did this happen? What can we do in the future?

A search for causes raises many further questions. Were stock assessments misleading? Did stock assessments miss the big picture by ignoring ecosystem effects? Were unreported catches large enough to cause declines invisible to conventional stock assessment? Was the ability of fish population age structure to buffer climate fluctuations ignored? Did political pressure cause quotas approved by scientists to be raised? Was industry locked into serial depletion by area, species and habitat? Was industry driven by a perverse economic investment ratchet? Was industry seduced by subsidies that turned money-losing fisheries into money-makers? It is quite likely that all of the above apply and the work reported here addresses many of these questions.

But how can a major industry have caused a disaster on such a scale? If we understand this 'meta-question' we may be able to find a solution. So we will try to address this in the next two-year phase of the *Sea Around Us* project.

The Fisheries Centre at the University of British Columbia supports research that first clarifies, and then finds ways to mitigate, the impacts of fisheries on aquatic ecosystems. Only with such insight of how whole aquatic ecosystems function can management policies aim to reconcile the extraction of living resources for food with the conservation of biodiversity, with the maintenance of ecosystem services, with amenity and with other multiple uses of aquatic ecosystems. Indeed, the present dire state of marine ecosystems and their fisheries around the globe signals a pressing need for what may be termed the 'ecosystem imperative'.

Although ecosystem agendas of this kind has recently become embodied in the legislative goals of many nations, and are an integral part of the FAO Code of Conduct for Responsible Fisheries, in practice there have been few attempts to work out how it might actually be done. In sponsoring the Sea Around Us project, the Pew Charitable Trusts[2] of Philadelphia, USA, have devoted a significant amount of funding to an ambitious pilot project focuses on the North Atlantic that aims to address this question. The research team[3] of senior scientists, postdoctoral research assistants, graduate students, consultants and support staff commenced work in late 1999.

The first two-year phase has focussed on the fisheries and ecosystems of the North Atlantic. In addition a book for the general public is being published[4]. Members of this team have been excited and challenged by the unprecedented scope of the research work. Most of the methods used to tackle the problem are new[5] (see Pauly *et al.* 2000), and many of the measures developed by the team have been translated into a revolutionary new mapping system.

These reports are the latest in a series of *Fisheries Centre Research Reports* published by the UBC Fisheries Centre. A full list is shown on our web site at www.fisheries.ubc.ca, and the series is fully abstracted in the *Aquatic Sciences and Fisheries Abstracts (ASFA)*. The research report series aims to focus on broad multidisciplinary problems in fisheries management, to provide a synoptic overview of the foundations and themes of current research, to report on research work-in-progress, and to identify the next steps and ways that research may be improved. *Fisheries Centre Research Reports* are distributed free to all project or workshop participants. Further copies are available on request for a modest cost-recovery charge. Please contact the Fisheries Centre by mail, fax or e-mail to 'office@fisheries.ubc.ca'.

Tony J. Pitcher
Professor of Fisheries
Director, UBC Fisheries Centre

---

1 Zeller, D., Watson, R. and Pauly, D. (eds) (2001) Fisheries Impacts on North Atlantic Ecosystems: Catch, Effort and National/Regional Data Sets. Fisheries Centre Research Reports 9 (3): 254 pp.
Guénette, S., Christensen, V. and Pauly, D. (eds) (2001) Fisheries Impacts on North Atlantic Ecosystems: Models and Analyses. Fisheries Centre Research Reports 9 (4).
Pitcher, T.J., Sumaila, R. and Pauly, D. (eds) (2001) Fisheries Impacts on North Atlantic Ecosystems: Evaluations and Policy Exploration. Fisheries Centre Research Reports 9 (5): 94 pp.
Pitcher, T. J., Alder, J. and Pauly, D. (eds) (2002) Fisheries Impacts on North Atlantic Ecosystems: Rapid Appraisal of the Status of North Atlantic Fisheries. Fisheries Centre Research Reports (*In prep*).

2 *Sea Around Us* is a Fisheries Centre partnership with the Pew Charitable Trusts of Philadelphia, USA. The Trusts support non-profit activities in the areas of culture, education, the environment, health and human services, public policy and religion. Based in Philadelphia, the Trusts make strategic investments to help organizations and citizens develop practical solutions to difficult problems. In 2000, with approximately $4.8 billion in assets, the Trusts committed over $235 million to 302 nonprofit organizations.

3 A list of SAU team members may be found in Annex 1 of Zeller *et al.* (2001).

4 *In a Perfect Ocean*. Island Press. (*in press*).

5 Pauly, D. and Pitcher T.J. (eds) (2000) Methods for assessing the impact of fisheries on marine ecosystems of the North Atlantic. Fisheries Centre Research Reports 8(2): 195pp.

Generational Cost Benefit Analysis for Evaluating Marine Ecosystem Restoration

Ussif Rashid Sumaila
Fisheries Centre, UBC

Abstract

Conventional Cost Benefit Analysis (CBA) tends to show that most ecosystem restoration programs are not worthwhile in economic terms. This is because discounting significantly reduces future net benefits from restoration, since benefits are discounted using the time perspective (i.e., the discounting clock) of the current generation only. I propose the use of what is termed Generational CBA, which discounts net benefits from the perspective of all generations. This CBA takes into account the fact that current restoration efforts may produce benefits to future generations, and that these benefits need to be valued using the respective discounting clocks of the generation receiving the benefits.

Introduction

This paper introduces the concept of Generational Cost Benefit Analysis (CBA) for assessing the potential net economic benefits from marine ecosystem restoration. This is a CBA framework that takes into account the full benefits of ecosystem restoration to both the current and future generations. Restoration efforts are generally about something in the 'past' that has been lost and therefore is not available in the 'present'. Further, what has been lost is usually missed very much, and thus one would want to restore it not only for the 'present' but also the 'future'. Several articles have appeared recently in the literature highlighting the current sorry state of the world's marine ecosystems and the marine life they support (e.g., Safina, 1995, Pauly et al., 1998 and Pitcher, 2000, Jackson et al., 2001), and the need to undertake restoration efforts (e.g., Pitcher and Pauly, 1998). The FAO and the National Research Council (U.S.) maintain that sustainable harvests of world capture fisheries are approaching the ceilings imposed by nature (FAO, 1999; NRC, 1999). The FAO also reports that 70 per cent of world fishery resources are either fully, or overexploited (FAO, 1999). Overexploitation in the past means that many capture fishery resources are now producing below their full potential. The Magnuson-Stevens Fisheries Conservation and Management Act of the USA recognizes that many fish stocks in the U.S. are overfished, and therefore specifically calls for the restoration of depleted fish stocks in U.S. waters (Anon., 1996).

A number of marine restoration efforts are currently in place in many parts of the world. For instance, the U.S. House of Representatives recently approved \$600 million to restore Pacific salmon. In arguing for these funds to be approved, the U.S. Congressman who sponsored the bill stated the following, "If we restore salmon populations, future generations – like their ancestors – can enjoy and prosper" (see the June 14, 2001 issue of *WorldCatch News Network*: www.worldcatch.com). This quote shows that future generations feature strongly when people argue for the restoration of marine ecosystems. The European Union and Norway have just announced a joint program for the restoration of cod stocks in the North Sea (see http://odin.dep.no/fid/engelsk/p10001957/pressem/008041-070046/index-dok000-b-n-a.html). After independence in 1990, Namibians decided to approve very low total allowable catches for their valuable hake fisheries, with the hope of restoring the once abundant hake biomass (see Sumaila and Vasconcellos, 2000). The United Nations and a number of South-east Asian countries have recently announced a restoration plan for the South China Sea. It is the view of this article that this trend will continue into the future, and hence an economic valuation technique that captures the benefits to current as well as future generations is needed.

First, I present the 'Back to the Future' approach for the restoration of marine ecosystems described in Pitcher (2000) that is relevant to this paper. Second, a description of the key elements of the Conventional Cost Benefit Analysis framework is given. Third, the article discusses the Generational CBA approach to evaluating ecosystem restoration benefits. Fourth, I make a comparison of the outcomes from the two approaches using an example based on a restoration program for a generic marine ecosystem. Finally, a discussion of possible areas for the extension of the ideas developed in this article is given.

The 'Back to the Future' approach

The 'Back to the Future' Approach provides analytical tools for policy decision making with regards to ecosystem restoration programs (see Pitcher 2000). It consists of :

1. Model construction of 'past' and 'present-day' marine ecosystems;
2. Simulation of the present-day ecosystem under a status quo regime in which the current fishing pattern is retained;
3. Simulation of the present-day ecosystem under a well-defined regime of restoration, which is meant

to return the ecosystem to 'some' state in the 'past';
4. Computing the economic gains under (ii) and (iii).

Ecological Modelling of Past and Present Ecosystems

The Ecopath and Ecosim modeling frameworks are used to implement steps (i), (ii) and (iii) while economic valuation techniques are used to implement step (iv). Ecopath is a static mass-balance model that describes the trophic relationships in an ecosystem (Christensen 1995). Ecosim is a dynamic version of Ecopath, which tracks ecosystem changes over time (Walters et al., 1997). Ecosim relies on a system of differential equations for each component i defined by

$$\frac{dB_i}{dt} = g_i \sum_{j=1}^{n} C_{j,i}(B_i, B_j) + I_i - MB_i - F_i B_i - \sum_{j=1}^{n} c_{ij}(B_i B_j) \qquad (1)$$

where B_i is the biomass of group i; dB_i/dt is the rate of change in biomass; g_i is the growth efficiency; $C_{j,i}$ is the food intake of prey j by group i; I_i is the net immigration rate; M is the natural mortality from causes other than predation; F_i is the fishing mortality and $c_{ij}(B_i.B_j)$ is the function used to predict consumption rates from B_i to predators, B_j. By making $dB_i/dt = 0$ in equation (1), the dynamic system of equations (Ecosim) is reduced to its static version (Ecopath: see Christensen, 1995).

Conventional Cost Benefit Analysis

Cost Benefit Analysis (CBA) is a conceptual framework for the evaluation of the economic desirability of a project, including ecosystem restoration efforts. The framework attempts to quantify and value the costs and benefits accruing from a project at different points in time, into a common unit – the Net Present Value (NPV). In general, the CBA technique consists of the following steps (see Angelsen and Sumaila, 1996):

1. Defining the alternatives (projects);
2. Identification of the major environmental effects;
3. Quantification in physical terms of the environmental effects;
4. Valuation of the costs and benefits;
   a. Between different income groups (intra-temporal);
   b. In time (inter-temporal): discounting;
5. Sensitivity and risk analysis;
6. Modifications of the project(s) and policy recommendations to meet stated objectives.

In terms of restoration projects, step (1) can be interpreted as defining alternative restoration goals. In other words, answering the question: How much of the 'past' marine ecosystem can and should society aim to restore?

Formally, the Conventional CBA can be expressed as:

$$NPV = \sum_{t=0}^{T} \frac{V_t - C_t}{(1+\delta)^t}, t = 0,1,2,.., T \qquad (2)$$

where V_t and C_t are the gross benefits and total costs, respectively, from the project at time t, and δ is the discount rate. Equation (2) takes inputs from steps (1) – (4) above. A project is accepted if NPV>0, otherwise it is rejected. When used to decide between alternative projects, the project with the highest positive NPV is preferred.

This article addresses the question whether the CBA approach as outlined above is appropriate for the evaluation of marine ecosystem restoration projects. This question is relevant because most restoration efforts are bound to be long term projects that would result in huge costs in the short term/near future but could lead to significant benefits in the distant future. Discounting has been identified in the environmental economics literature as a possible source of problems for the CBA technique when dealing with projects with long-term benefits but short-term costs. Some economists, notably those dealing with issues with long-term consequences such as the impacts of the actions of the current generation on climatic change, have questioned the prevailing levels of discount rates. Some have argued that rates currently in use are too high and therefore should be lowered (see Nordhaus, 1997). Others have proposed the use of different and lower rates when analyzing problems with long-range consequences such as climatic change (Hasselmann et al., 1997).

However, most economists, including Nordhaus (1997) caution against tampering with the discount rate – they argue that lowering the discount rate could serve as a double-edged sword with respect to conservation, because resource intensive projects that would otherwise not be profitable from the perspective of private investors could turn out to be profitable with a lower discount rate. The proposal presented here does not suffer this problem because it does not tamper with the discount rate to apply as seen from the perspective of the generation in existence – rather, it applies the same discount rate using different discounting clocks for each generation.

Weitzman (1998, 2001) states that a critical feature of the distant future is currently the unresolved uncertainty about what would then be the

Table 1: Groups of marine creatures, prices and fleet types used in the hypothetical example.

No.	Group name	Prices (US$/t)	Fishing Fleet
1	Toothed whales	270	Foreign Pelagic
2	Baleen whales	909	Foreign Demersal
3	Pinnipeds	114	Line + Gill
4	Seabirds	1,471	Danish Seine
5	Adult Cod	1,080	Bottom Trawl
6	Juvenile Cod	1,080	Midwater Trawl
7	Haddock	1,080	Lobster Trawl
8	Saithe	1,080	Herring Seine
9	Redfish	2,400	Capelin Seine
10	Greenland Halibut	2,950	Capelin Midwater trawl
11	Other Flatfish	2,950	Shrimp trawl
12	Other Dem. Fish	850	Dredge + Trap
13	Herring	240	Seal guns
14	Capelin	243	Harpoon
15	Other Pelagics	1,095	
16	Nephrops	1,200	
17	Northern Shrimp	3,950	
18	Molluscs	1,593	
19	Benthos	296	
20	Other Fish	530	
21	Zooplankton	-	
22	Benthic producers	296	
23	Phytoplankton	-	
24	Detritus	-	

appropriate rate of return to use for discounting. By developing this line of thought, Weitzman suggests that it may be essential to incorporate declining discount rates into any CBA methodology for evaluating long-term environmental projects. This paper provides another rationale for discounting long-term environmental benefits at lower discount rates from the perspective of the current generation. Pontecorvo (2001) categorically states that the desirability of restoration of stocks, e.g., as incorporated in the Magnuson Act (Anon. 1996), raises serious questions about the discount rates and the time horizons to be utilized in managing the resource. This paper proposes an approach that attempts to resolve this concern.

Generational Cost Benefit Analysis

The proposed Generational CBA approach is based on the argument that, due to the length of time that would normally be required for depleted marine ecosystems to be restored after cessation or substantial reduction in fishing activities, the cost of such projects would be felt immediately while the benefits of restoration will accrue much later in the time horizon of the restoration effort. This difference in when the costs and benefits of restoration projects are incurred and received, would in most cases, lead to the discounted cost of restoration being higher than the discounted benefits from restoration. The way to deal with this, I argue, is to apply different discounting clocks to calculate the flows of benefits that accrue to different generations, as expressed by equation (3) below:

$$NPV = NPV_1 + NPV_2 + NPV_3 + .. + NPV_L$$
$$= \sum_{t=1}^{t_1} \frac{V_t - C_t}{(1+\delta)^t} + \sum_{t=t_{1+1}}^{t_2} \frac{V_t - C_t}{(1+\delta)^{t-t_1}} + \sum_{t=t_2+1}^{t_3} \frac{V_t - C_t}{(1+\delta)^{t-t_2}} + .. + \sum_{t=t_{L-1}+1}^{t_L=T} \frac{V_t - C_t}{(1+\delta)^{t-t_{L-1}}} \tag{3}$$

where t=0, 1, 2, ...T (the terminal period in the analysis); $0 = t_0 < t_1 < t_2 < .. < t_L = T$ are the points in time when the generations come into existence; and L is the last generation included in the analysis. Equation (3) states that the total NPV from a restoration project is the sum of NPVs that accrue to each generation, discounted using their own clocks, which start when the generation comes into existence and stops when they cease to exist.

The rationale for this is both simple and intuitive. The benefits to the current generation from the use of ecosystem resources today would never have appeared in the Conventional CBA of the generations that were here a hundred years ago. Similarly, the generation that will be here in a hundred years time, would receive benefits from restored marine ecosystems that would mean much to them but would not appear in the current generation's Conventional CBA. Therefore, to capture the benefits to all generations from ecosystem restoration projects, it is necessary to use the CBA approach expressed in equation (3) rather than that in equation (2).

A Hypothetical Example

Consider a generic marine ecosystem, for example, that of Iceland (see Mendy and Buchary, 2001). The ecosystem contains various groups of marine creatures. Some of these creatures feed on other creatures (predator-prey relationship), while some eat their own kind (cannibalistic behavior). In addition, there are a number of fisheries operating different vessel gears in the ecosystem.

Twenty four different groups of marine creatures, and fourteen different fleet types are incorporated into our hypothetical model (see Table 1). The 'past' (1950) and 'present' (2000) states of this generic ecosystem are captured first by using Ecopath and Ecosim as described earlier. Two scenarios are developed and used to compare the benefits from restoration, namely, the status quo and restoration: Under the status quo scenario, the present-day model is run for 100 years into the future, using the present day fleet structure. In the case of the restoration scenario, simulation of the present-day model with different configurations of fleets and fleet sizes is first carried out to determine the configuration that best meets the stated restoration goal, are carried out for a

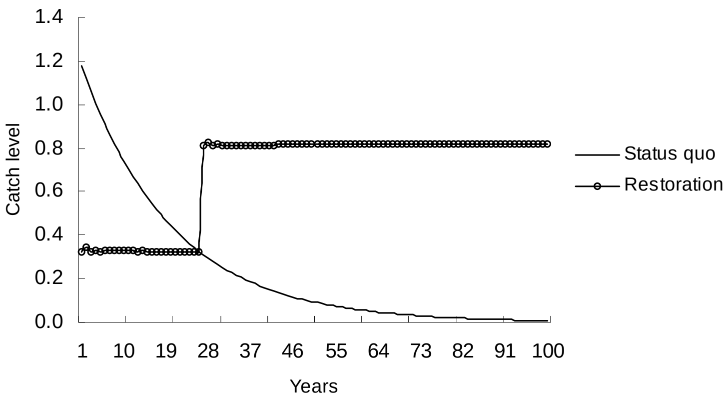


Figure 1. Profile of catches over 100 years.

period of 100 years. It turns out that the restoration program that gives the best results required the line fishers, gill netters, bottom trawlers and the capelin seiners to be retired from fishing for 25 years, and then re-introduced into the fishery after 25 years with only 50% of their year 2000 fleet capacities. All other vessel types are allowed to continue fishing with their year 2000 fishing capacities.

Economic valuation of the outcomes under the status quo and restoration regimes

The catches from the above simulations are valued by applying prices per unit of species group landed (see Table 1). From this, we subtract the cost of catching and landing the fish, which is assumed to be about 40% of the price per unit weight of a fish group. Thus, we focus only on market values in this paper. This choice of focus is deliberate, as it makes it possible to show that, in most cases, restoration efforts can be justified using market values alone, provided net benefits are counted from the perspective of the generation to which the benefits accrue. To produce the results presented below, a discount rate of 7% is applied. However, because the discount rate is very central to the argument presented in this article, we carried out sensitivity analysis on this parameter for rates of 0 to 20%. Valuation of net benefits from the two models was carried out using both the Conventional and the Generational CBA. The calculations were made under the assumption that benefits would accrue to two non-overlapping generations each of 50-year life span. We then relax the non-overlapping generation assumption by continuously introducing annually a new generation of 50-year life span for the next 50 years. The NPVs from restoration are then calculated as seen by each of these generations using their respective discounting clocks.

Results

Catch profiles

Figure 1 presents the predicted flow of catches in each 100-year simulation of the status quo and restoration models. The model predicts high initial total catches under the status quo model. But this declines steadily from year to year until it approaches zero by the end of the 100-year simulation. On the other hand, catches start low in the restoration model, and remain so for 25 years, after which the ecosystem has been restored and the retired fishing fleets are re-introduced into the fishery. The restoration effort then starts to pay off with higher steady catch levels until year 100.

Net benefit profiles

We see from Figure 2 that when the Conventional CBA approach is applied, net benefits are high initially but decline rapidly, approaching zero by year 35, under the status quo scenario. The picture differs slightly under the restoration scenario. Here, benefits start low and decline slowly until year 26 when they receive a sudden increase signaling the end of the restoration effort and the re-entry of the retired fleets into the fisheries. It should be noted that in both the status quo and restoration scenarios, benefits that accrue to the future generation, that is, after year 50, count for nothing even though their harvests are high under the restoration model (see Figure 1).

On the other hand, when the Generational CBA

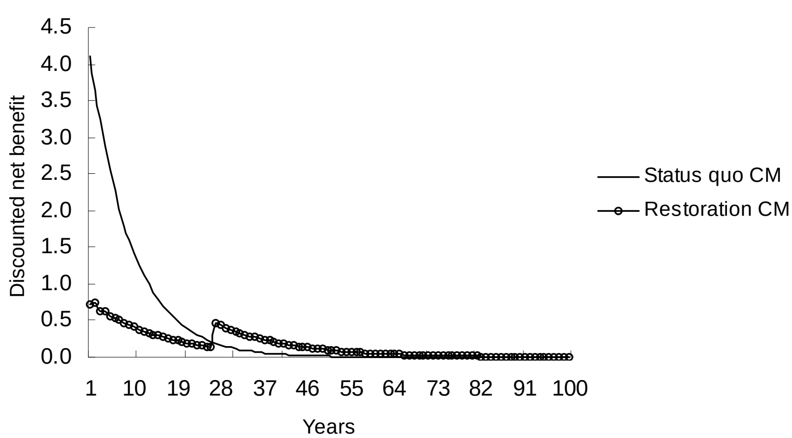


Figure 2. Net discounted benefits obtained using the Conventional CBA (CM).

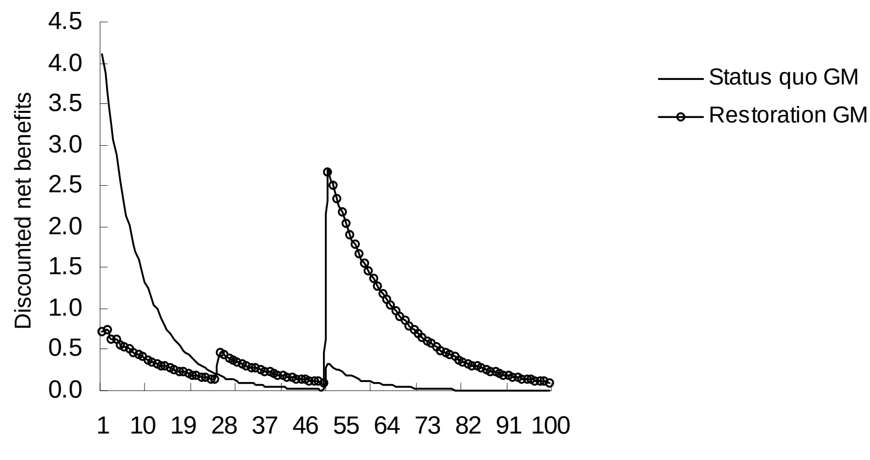


Figure 3. Net discounted benefits obtained using the Generational CBA (GM).

approach is applied, net benefits start very high under the status quo regime but decline in the same fashion as when the Conventional CBA is used until year 51 when the next generation comes into existence and start discounting their benefits from this time onwards (see Figure 3). For the restoration model, net benefits start low and decline until year 25, when benefits jump due to the re-entry of the retired fleets into the fishery. Then in year 51, we see a big increase, this is when the second generation comes into existence, and the flow of benefits is discounted using their own clock.

Figure 4 presents the total net present value obtained in the 100-year period of the simulation under the restoration and status quo models using the Conventional and Generational CBA approaches. We see from the figure that restoration would not be worthwhile if the Conventional CBA is used, while it would be economically sensible to undertake restoration when the Generational CBA is applied.

Impact of changes in discount rates

The discount rate is the single most important parameter in this analysis. Hence, we carried out sensitivity analysis by varying it from 0 to 20% (this covers a realistic range in practice). Figure 5 present the results obtained using the Conventional and Generational CBAs, resp-ectively.

We can make the following observations from this figure:

1. The Conventional and Generational Models both favor restoration when discount rates are low – in this example between 0 and 3%.
2. The Conventional Model does not support restoration for high discounts – here, rates greater than 3%.
3. The Generational Model comes out in favor of restoration for discount rates ranging between 0 to about 15%. It comes out about neutral for discount rates between 15 to 20%.

Net present value of benefits as seen by each of 50 overlapping generations

Figure 6 plots the total net present value of benefits as seen by each generation (i.e., year class) as they come into existence. To obtain the graph, the flow of benefits from restoration, as seen by each generation using their respective discounting clocks, over their assumed 50-year life span is summed and plotted.

This figure reveals that based on the benefits each generation perceives, earlier generations in this example (up to generation 12, that is, the generation to arrive 12 years from now), would come to the conclusion that restoration is not economically sensible. But later generations would definitely find restoration to be a sensible proposition. When the interests of all generations are taken into account, however, restoration becomes the preferred course of action, since the area under the 'Restoration curve' is much larger than that under the 'Status quo curve'. Figure 3 brings to the fore, in a very clear way, the important point that choosing to restore marine ecosystems is a choice to invest in the future, while choosing

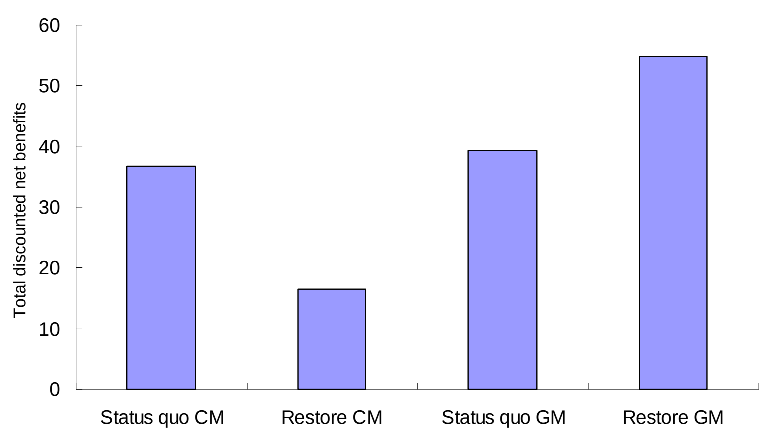


Figure 4: Total net present value of benefits over 100 years (CM = conventional CBA; GM is Generational CBA).

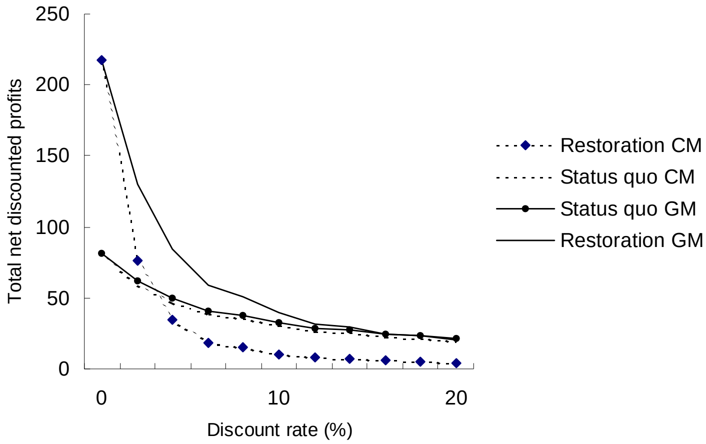


Figure 5 Effect of discount rates.

to keep doing things as usual is a decision to disinvest.

Concluding Remarks

This paper has proposed a CBA approach denoted as Generational CBA that takes into account that benefits from the restoration of marine ecosystems may flow not only to the current generation but also to future generations. It argues for the benefits to accrue to future generations to be discounted from their time perspective rather than that of the current generation.

Through the use of a generic model, it is shown that at low discount rates (0 to 3% for the example in this paper), both the Conventional and Generational models produce the outcome that restoration is a sensible economic proposition. At higher discount rates (over 3%), however, the Generational CBA still shows that restoration is desirable and beneficial to society while this is not the case with the Conventional CBA approach.

The ideas in this paper will be developed further in future work and applied to models of real marine ecosystems from around the world. I also plan to develop both analytical and game theoretic models based on the ideas of this paper. This would allow the extension of the Generational CBA approach to bio-economic models. Finally, it appears that Generational CBA has a conceptual link with the shifting baseline idea of Pauly (1995). I will explore these linkages in future work.

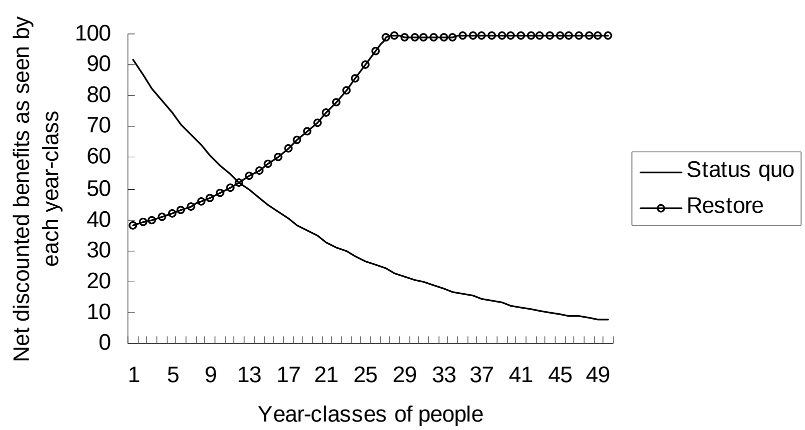


Figure 6. Net Present Value (NPV) as seen by each of 50 overlapping generations.

Acknowledgments

I am grateful to all members of the *Sea Around Us* project (SAU), which is funded by the Environment Program of the Pew Charitable Trusts, and participants at the SAU Final Report Workshop for their valuable comments and suggestions. My thanks also go to James Amegashie, Claire Armstrong, Frank Asche, John Bishir, Trond Bjorndal, Derek Clark, Jon Conrad, John Hayfron, and Robert McKelvey for their helpful comments and suggestions.

References

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

Anon. 1996. Magnuson-Stevens Fishery Conservation and Management Act US Public Law 94-265. J. Feder version (12/19/96),

Christensen, V. 1995. A model of trophic interactions in the North Sea in 1981, the Year of the Stomach. Dana 11(1), 1-19.

FAO The State of World Fisheries and Aquaculture, Rome, Italy, 1999.

Hasselmann, K., S. Hasselmann, R. Giering, V. Ocana and H.V. Sorch 1997. Sensitivity study of optimal CO2 emission paths using a simplified structural integrated assessment model (SIAM). Climatic Change 37, 335-343.

Jackson, B.J.C., M.X. Kirby, W.H. Berger, K.A. Bjorndal, L.W. Botsford, B. J. Bourque, R.H. Bradbury, R. Cooke, J. Erlandson, J.A. Estes, T. P Hughes, S. Kidwell, BC.B. Lange, H.S. Lenihan, J.M. Pandolfi, C.H. Peterson, R.S. Steneck, M.J. Tegner and R.R. Wraner. 2001. Historical overfishing and the recent collapse of coastal ecosystems. Science 293, 629-

637.
Mendy, A.N and E. Buchary 2001. Constructing the Icelandic marine ecosystem model for 1997 using a mass balance modeling approach. In S. Guenette, V. Christensen, T. Pitcher and D. Pauly (eds.) Fisheries impacts on North Atlantic Ecosystems: Models and Analysis. Fisheries Centre Research Report 9(4), in press.
National Research Council 1999. Sustaining Marine Fisheries, Washington, National Academy Press. 164pp.
Nordhaus, W.D. 1997. Discounting in economics and climate change: An editorial comment. Climatic Change 37, 351-328.
Pauly, D. 1995, Anecdotes and the shifting baseline syndrome of fisheries. Trends in Ecology and Evolution. 10(10), 430.
Pauly, D., V. Christensen, J. Dalsgaard, R. Froese and F.C. Torres Jr. 1998. Fishing down marine food webs. Science 279, 860-863.
Pitcher, T.J. 2000. Rebuilding as a new goal for fisheries management: Reconstructing the past to salvage the future: Ecological Applications, 11(2), 601-617.
Pitcher, T.J. and Pauly, D. 1998. Rebuilding ecosystems, not sustainability, as the proper goal of fishery management. Pages 311-329 in Pitcher, T.J. Hart, P.J.B. and Pauly, D. (eds) Reinventing Fisheries Management, Chapman and Hall, London. 435pp.
Pontecorvo, G. 2001. Supply side uncertainty and the management of commercial fisheries: Peruvian Anchovetta, an illustration. Marine Policy, 25, 169 – 172.
Safina, C. 1995. The world's imperiled fish. Scientific American, 273, 46-53.
Sumaila, U.R. and M. Vasconcello 2000. Simulation of ecological and economic impacts of distant water fleets on Namibian fisheries. Ecological Economics, 2000 **32**, 457-464.
Walters, C., Christensen, V. and Pauly D. 1997. Structuring dynamic models from trophic mass-balance assessment. Reviews in Fish Biology and Fisheries, 7(2), , 139 - 172.
Weitzman, M.L. 2001. Gamma discounting. American Economic Review, 91(1), 260-271.
Weitzman, M.L. 1998. Why the far-distant future should be discounted at its lowest possible rate. Journal of Environmental Economics and Management, 36, 201 – 208.

Subsidies and Their Potential Impact on The Management of the Ecosystems of the North Atlantic

Gordon R. Munro and
Ussif Rashid Sumaila
Fisheries Centre, UBC

Abstract

This paper provides both an estimate and assessment of subsidies in fisheries in the North Atlantic. The subsidies are estimated, on the basis of data taken from an OECD study and the Sea Around Us Project database, to be in the order of U.S.$ 2.0 to 2.5 billion per year. The assessment of the impact of the subsidies upon resource management and sustainability requires an examination of the underlying economics of subsidies in fisheries. There is general agreement, to which we subscribe, that fisheries subsidies do great harm by exacerbating the problems arising from the 'common pool' aspects of capture fisheries. Many economists, however, believe it that, if the "common pool" aspects of a fishery could be removed by, for example, establishing a fully-fledged property rights system, the negative impact of fisheries subsidies would prove to be trivial. This paper demonstrates that the aforementioned comfortable belief is unfounded. Fisheries subsidies can be seriously damaging, even if the 'common pool' aspects of the fishery are removed. There is also a widely held belief, among economists and government officials, that subsidies used for vessel decommissioning schemes, far from being harmful, actually have a beneficial impact upon resource management and sustainability. About twenty percent of the fisheries subsidies in the North Atlantic are directed towards these purposes. In this paper, we argue that these seemingly beneficial subsides can, in fact, be highly negative in their impact.

Introduction

The impact of subsidies upon the management of fishery resources, and the surrounding aquatic ecosystem, has been a source of rapidly increasing concern over the past decade. The Food and Agricultural Organization of the United Nations (FAO), early in the decade, maintained that a critical first step towards reversing the severe overexploitation of capture fishery resources is the removal of harmful subsidies in fisheries (FAO, 1992). The FAO continued examining the subsidy issue through the 1990's into the new millennium (see for instance, Steenblik and Munro, 1999). Along with the FAO, there has been a steadily increasing stream of studies on the impact of subsides on fisheries, that have been undertaken by national governments, e.g. the U.S.A (Congressional Research Services, 1995), by NGOs, such as the World Wildlife Fund for Nature (1997) and by other international organizations other than the FAO. Prominent studies have been undertaken for the World Bank (see Milazzo, 1998) and the Organisation for Economic Cooperation and Development (OECD). The OECD study (OECD, 2000), will be drawn upon heavily in this paper.

We commence the paper by attempting to define subsidies and provide a workable classification of subsidies. The classification adopted will be that provided by the OECD, because it is the OECD upon which we shall be most reliant for data on fisheries subsidies in the North Atlantic. Definitions and classifications will be followed by a review of the economic theory of the impact of subsidies in fisheries. With the economic theory in hand, we then attempt to provide a point estimate of the level of fisheries subsidies in the North Atlantic region as defined in the Sea Around Us Project (SAUP). In addition, we carry out an assessment of the subsidies.

Subsidies defined and classified

The OECD defines subsidies (or Government Financial Transfers – GFTs) as "the monetary value of government interventions associated with fisheries policies" (OECD, 2000, p. 129). This definition has the merit of breadth. To find a definition that is more precise, and workable, we turn to a recent article on the concept of subsidies, as applied to fisheries, by Schrank and Keithly (1999). These authors define a subsidy as "*any* government program that potentially permits the firm to increase its profits [through time], beyond what they would have been in the absence of the government program" (Schrank and Keithly, 1999, p. 156). We would only note that, to be included, are government programs, which increase firm profits indirectly, as well as those that increase firm profits directly.[1]

[1] The FAO, in a recent expert consultation pertaining to subsidies, includes in its definition the impact of the absence of correcting interventions in fisheries, on the part of resource managers (FAO, 2001). At a later point in the discussion, we shall examine the negative consequences of the "common pool" characteristics of capture fisheries. Governments can attempt to address the consequences of the aforementioned "common pool" characteristics through various management means. One approach is through the use of taxes. It can be shown easily that the fishers would collectively be better off without the taxes, than with. Consequently, if the only management option is taxes, then the government's refusal to implement taxes can be seen as constituting a positive subsidy for the fishers. However, there exist alternative management techniques that improve the profits of the fishers over the long run. A refusal on the part of government to implement such management measures could be seen as a negative subsidy to the fishers.

Schrank reiterates the aforementioned definition of subsidies in a paper prepared for a recent FAO expert consultation on subsidies (Schrank, 2001). In the paper, he goes on to make two important points. The first is that subsidies must be judged in terms of their impacts, rather than upon the intent, and objectives, of those introducing the subsidies. The second point is that, while subsidies are often condemned as being universally negative in their impacts, some subsidies may, in fact, produce socially desirable results. Some, of course, may be neutral in their effects. In any event, individual subsidies are not to be judged on an a priori basis (Schrank, 2001).

The OECD study (OECD, 2000) classifies subsidies/GFTs in terms of programs, and in terms of whether, in the authors' view, the subsidies constitute direct payments from government budgets, whether they are cost reducing transfers, or whether they constitute general services, such as research. For our purposes, we find it most useful to employ the classifications by programs. The program classifications used by the OECD are:

- Management, research, enforcement and enhancement (MRE);
- Fisheries infrastructure (FI);
- Investment and modernization of vessels and gear (IM);
- Tax exemption (TE);
- Decommissioning of vessels and license retirements (DLR);
- AOC) expenditures to obtain access to other countries EEZs;
- Income support and unemployment insurance (ISU);
- Other GFTs (OT).

Estimates of the size of such GFTs/subsidies vary widely. In 1992, the FAO reported that subsidies in world fisheries may exceed U.S. $50 billion per annum (FAO, 1992). A much more conservative estimate produced in a study, prepared for the World Bank by Matteo Milazzo (Milazzo, 1998), placed the level at between U.S. $15-20 billion per annum.[2] Even if one were to argue that the conservative estimate is more accurate, one is forced to conclude that GFTs in world fisheries are very large indeed.

We have accepted the Schrank (2001) argument that subsidies are to be judged in terms of their impacts. We can divide such impacts into two broad categories:

A. Distributional impacts

B. Impacts upon resource management and sustainability.

The subsidies will have an obvious impact upon distribution of incomes. Those receiving the subsidies are better off – temporarily, if not permanently. Those called upon to finance the subsidies, e.g., through taxes, will clearly be made worse off. The distributional impact of the subsidies will have equity consequences, which we may applaud, or condemn. Important though the distributional consequences of subsidies undoubtedly are, they shall be ignored in this paper. Rather we shall focus on the Category B impacts.

Milazzo (1998), in his detailed, and much cited, World Bank study on subsidies, discusses the many ways in which subsidies can serve to undermine fisheries conservation and management, e.g., by intensifying the over-exploitation of the resources. He also insists, however, that there exists a set of 'conservation subsidies,' which, as the name implies, have a positive impact upon fishery resource conservation and management (Milazzo, 1998, pp. 12-13). We shall examine his arguments pertaining to 'conservation subsidies' in some detail, at a later point in the paper.

With subsidies in fisheries now defined, and classified, we turn to a review of the economics of the impact of subsidies upon fisheries management and sustainability.

The basic economics of the impact of subsidies in fisheries: Part One

The FAO (1992, 1998, 2001), the United States National Research Council (NRC, 1999), the OECD (2000), and others emphasize the damaging effect that subsidies may have by exacerbating the common property, or 'common pool', problems associated with capture fishery resources. The common pool aspects of the resources will, it is argued, result in a perverse system of incentives confronting fishers, which will lead, if unchecked, to overexploitation of the fishery resources, or, as economists would express it, excessive disinvestments in the fishery resources as 'natural' capital.

Economists have now come to regard fishery resources, like all other natural resources, as natural capital. The resources are seen as assets, coming as endowments from nature, which are capable of yielding a stream of economic benefits (market and non-market) to society through time. A set of fishery resources (along with the surrounding aquatic ecosystem), in a particular region, can be viewed as a 'portfolio' of natural capital assets.

[2] The FAO and Milazzo differed in terms of their definitions of subsidies. But the differences in definitions do not fully explain the gap between the two sets of estimates, however.

These natural capital assets can obviously be subject to disinvestment. If natural capital is renewable, then one can, within limits, engage in positive investment in the natural capital assets, as well, e.g. by refraining from harvesting. The restoration of capture fishery resources in the North Atlantic, which plays an important role in the Sea Around Us Project (Pauly and Pitcher, 2000), is, from the economist's perspective, an exercise in resource investment. Optimal economic management of capture fishery resources does, in the first instance, involve establishing of a resource investment/ disinvestments program that will (given the appropriate social rate of discount [interest rate]) yield the maximum economic returns to society through time (Bjorndal and Munro, 1998; OECD, 1997).

Capture fisheries have in the past been characterized as being common pool, in that property rights to the resources are ill defined, or simply non-existent (NRC, 1999; OECD, 1997). The mobility of the fish, and their lack of observability prior to capture, has made the assignment of property rights to the resources difficult. As economists have explicitly recognized for almost 50 years, it is the absence of effective property rights that results in a system of perverse (from society's point of view) incentives confronting fishers (Gordon, 1954; NRC, 1999). The rational fisher is given every incentive to discount very heavily any future economic returns arising from investment in the resource, or any future costs arising from resource disinvestments.

The common pool problem manifests itself in two major ways. The first is what is often termed 'Pure Open Access',[3] in which there are no official regulations governing the fishery, domestic or international. High seas fisheries have, over the past decade and a half, provided prominent examples. In such fisheries, overexploitation is the inevitable outcome in that disinvestments in the resource, or resources, will go far beyond that which is optimal from society's point of view (Bjorndal and Munro, 1998). If the resource is subsequently placed under the control of the resource manager, it will appear to the resource manager that he/she is confronted with a fishery resource that has been overexploited, and with a fishing fleet that has been overcapitalized. The fleet will exceed that which would be required to harvest the resource on a sustainable basis, if the fishery resource were to be stabilized at the optimal level.

[3] The term 'Pure Open Access', and the term which we shall subsequently use, 'Regulated Open Access', were introduced by Wilen (1987).

The second manifestation of the common pool problem is often termed Regulated Open Access. In this case, the total season-by-season harvest is controlled by a resource manager. Thus, the fishery resource is, hopefully, stabilized and protected from excessive exploitation. The resource manager does not, however, exercise effective control over the fleet competing for the restricted harvest. The restricted season-by-season harvest now becomes the common pool. The almost inevitable result will be that fleet capacity will expand to the point that a significant portion can be deemed to be genuinely redundant. The fleet capacity will exceed, more often than not by a wide margin, that required to take the allowable catch, even when allowing for catch fluctuations through time. The excess fleet capacity results in certain economic waste, and may serve as a threat to resource managers' ability to control total harvests, and conserve the resource (Bjorndal and Munro, 1998). North Atlantic fisheries provide an abundance of examples.[4]

Subsidies, if they have a negative impact upon resource management, create perverse (from society's point of view) incentives, over and above those arising from the common pool nature of the resources (see: Arnason, 1999). Subsidies having a positive influence upon fisheries management can be thought of, in the first instance, as countering the perverse incentive effects of the common pool nature of the resources.

Obviously those subsidies having negative consequences will add to the perverse incentives arising from common pool fisheries, thereby making a bad situation worse. It is important to ask as well, however, whether such subsidies could have significant consequences if the common pool aspects of a fishery were effectively removed. If the answer is yes, then subsidies have to be taken very seriously indeed. If the answer is no, then, while subsidies can be seen as a significant irritant, most attention and effort should be focused on addressing the common pool aspects of capture fisheries. We shall, as have other authors, e.g. Arnason (1999), conclude that, all in all, subsidies having a negative impact are likely to do greatest damage under common pool fisheries. We shall also conclude, however, that, if the common pool aspects of the fishery are removed, these subsidies can still result in damages, which society ignores at its peril.

Impact of subsidies under conditions of pure open access

[4] The major decommissioning schemes of the European Union provide testimony to this fact. See: Hatcher (1999).

We proceed by considering the consequences of subsidies under conditions of Pure Open Access. The Regulated Open Access case will be considered in a later section of the paper.

As a first step, we shall examine the optimal management of the fishery under an all powerful resource manager, in which the state is effectively exercising its full property rights to the resource. This will provide us with a benchmark against which we can assess the consequences of Pure Open Access, with and without subsidies.

Following our assessment of the consequences of Pure Open Access, with and without subsidies, we shall suppose that, while not managing the fishery directly, the government, as resource manager, eliminates the common pool aspect of the fishery by effectively 'privatizing' the fishery. This will then allow us to ask what the consequences would be, if any, should the government at large undertake to subsidize the 'privatized' fishery.

Prior to undertaking our first step of examining the theory of optimal management of the fishery by an all powerful resource manager, we must digress to deal with a preliminary issue, which pertains to the 'malleability', or lack thereof, of conventional capital embodied in the fleet. Perfectly malleable vessel capital consists of vessel capital, which can, quickly and costlessly, be removed from the fishery.[5] Non-malleable vessel capital is vessel capital, which cannot be so removed. Most economic models of the fishery assume, explicitly or implicitly, that vessel capital is perfectly malleable. This is done on grounds of analytical ease, and most certainly not on grounds of realism. Perfectly malleable vessel capital is the exception, not the rule. One can add, moreover, that the concept of fleet overcapacity becomes essentially meaningless, if vessel capital is perfectly malleable (Gréboval and Munro, 1999). Since we can find no legitimate grounds for assuming that vessel capital is perfectly malleable, we shall not accept the assumption.

We now present the bare bones of an economic model of a fishery incorporating non-malleable vessel capital,[6] which will enable us to describe the optimal resource exploitation program, and then to examine the consequences of Pure Open Access. For a detailed discussion of the model, the reader should consult Clark et al. (1979) and McKelvey (1986).

[5] This is a concept which is analogous to that of 'liquidity' in finance.

[6] See Sumaila (1995) for a computational model that incorporates non-malleability of fleet capital.

Let us commence by denoting fishing effort by $E(t)$ and the stock of vessel capital by $K(t)$, where $K(t)$ can be thought of in terms of the number of 'standardized' fishing vessels. We then have (Clark et al. 1979):

$$0 \leq E(t) \leq E_{max} = K(t) \tag{1}$$

which asserts that maximum fishing effort capacity, equals the number of vessels and that actual effort cannot exceed E_{max}. Actual effort can be less than E_{max}, because some of the vessels may be used to less than capacity.

Given the initial stock of vessel capital $K(0) = K0$, adjustments in the stock of K are given by:

$$dK / dt = I(t) - \gamma K \tag{2}$$

where $I(t)$ denotes the rate of investment (gross) in vessel capital, and γ (a constant) the rate of depreciation of such capital.

Now let c_1, a constant, denote the unit purchase price of vessel capital, and c_s the unit 'scrap value' (resale value) of vessel capital. We deem vessel capital to be perfectly malleable if:

$$c_s = c_1 \tag{3}$$

and to be perfectly non-malleable if:

$$c_s = \gamma = 0 \tag{4}$$

i.e., the capital has no re-sale value, and never depreciates.

Intermediate cases – sometimes referred to as quasi-malleable capital – are given by:

$$c_s = 0; \quad \gamma > 0 \tag{5}$$

$$0 < c_s < c_1; \quad \gamma \geq 0 \tag{6}$$

Next, suppose that the fishery resource is appropriately modeled by the standard Schaefer model (see Clark, 1990):

$$dx / dt = F(x) - h(t) \tag{7}$$

where $x = x(t)$ denotes the biomass, $F(x)$ the natural growth rate of the biomass, and $h(t)$ the rate of harvest. In the Schaefer model, the natural growth function is a pure compensatory one (Clark, 1990). The harvest production function is given by:

$$h(t) = qE(t)x(t) \tag{8}$$

where q, a constant, is the catchability coefficient. We simplify this by assuming that all harvested fish is sold into the fresh fish market. The flow of net operating profits, at each point in time, can thus be expressed as:

$$\pi(t) = (pqx(t) - c)E(t) \tag{9}$$

where p, a constant, is the price of harvested fish, and c, a constant, is the cost of fishing effort (exclusive of the price of fleet capital).[7] Hence, c can also be seen as denoting unit operating costs.

For future reference, the flow of net operating profits at any point in time can also be expressed as:

$$\pi(t) = (p - c_{var}(x))h(t) \tag{9a}$$

where *c*var(*x*) denotes unit variable cost of harvesting:

$$c_{var}(x) = c / qx \tag{10}$$

Also for future reference, let us note that, if vessel capital were perfectly malleable, we could talk meaningfully of unit total cost of harvesting, which would be given by:

$$c_{total}(x) = \frac{c + (\delta + \gamma)c_1}{qx} \tag{11}$$

where δ denotes the social rate of discount. It will be recalled that γ denotes the rate of depreciation. The expression: $(\delta+\gamma)c_1$ is sometimes referred to as the 'rental' cost of vessel capital (Clark et al., 1979).

Let it now be supposed that the vessel capital is characterized by Eq. (5). The capital has a resale value of zero, but it has a positive depreciation rate. As an aside, because this point will prove to be relevant to our examination of actual subsidies in the North Atlantic, investment in 'vessels' should really also include investment in port facilities, such as piers and warehouses.

Let it also be supposed, for the sake of convenience, that we commence with an unexploited resource, $x(0) = x_0$. Finally, and also for the sake of convenience, it will be assumed that investment in vessel capital, broadly defined, can take place instantaneously.

Let it be assumed that the objective of the resource manager is that of maximizing the net economic returns from the fishery through time. The resource manager's objective functional can thus be expressed as:

$$\max J = \int_0^\infty e^{-\delta t}\{\pi(t) - I(t)c_1\}d(t),\ x(0) = x_0 \tag{12}$$

where, once again, δ is the social rate of discount (interest).

Theory tells us (see: Clark et al., 1979) that it will be optimal for the resource manager to deplete the resource, below its unexploited level, and that the resource will, in the long run, be stabilized at a level *x**, given by the following equation:

$$p - c_{total}(x^*) - \frac{1}{\delta}\cdot\frac{d}{dx^*}\{(p - c_{total}(x^*))F(x^*)\} = 0 \tag{13}$$

The expression:

$$\frac{1}{\delta}\cdot\frac{d}{dx^*}\{(p - c_{total}(x^*))F(x^*)\}$$

is the present value of sustainable profits, or economic 'rent', that would be gained (lost) by marginal investment (disinvestments) in the resource. It is sometimes referred to as the 'user cost' of, or, more commonly, as the shadow price of the resource.

The theory demonstrates that, once *x** is achieved, it will be optimal to reinvest in vessel capital to a level that will allow harvesting to take place on a sustained yield basis at *x* = *x**. In other words, while gross investment in vessel capital will be positive, net investment will equal zero.

For future reference, let it be noted that Eq. (13) can be re-written as:

$$F'(x^*) + \eta(x^*) = \delta, \tag{14}$$

[7] That is, it is being assumed that the demand for harvested fish, the supply of vessel capital, and the supplies of all other inputs constituting *E* , are perfectly elastic.

where $$\eta(x^*) = \frac{-c'_{total}(x^*)F(x^*)}{p - c_{total}(x^*)}$$

The key remaining question is the decision rule that should be followed by the resource manager in investing in fleet capacity at $t = 0$, $x(0) = x_0$. Once a vessel is purchased, the cost of the vessel acquisition, c_1, becomes a 'sunk' cost, that is a cost, which can be considered a bygone, in the sense that it cannot be recouped. From thereon in, the focus must be on the operating profits to be derived from the vessel over its economic life. With this in mind, it can be stated that the optimal initial fleet size, which we can denote by K_0, will be given by the following simple investment decision rule, expressed as:

$$\frac{\partial PV^*}{\partial K} = c_1 \tag{15}$$

where PV^* denotes the present value of fleet *operating* profits, at $t = 0$, given that the harvesting strategy, which will lead to the resource eventually being stabilized at $x = x^*$, is followed. The decision rule states: invest in vessel capital up to the point that the resultant marginal present value of operating profits is equal to the unit cost of vessel capital.

With the benchmark case of optimal resource management, by an all seeing, all powerful resource manager in place, we can proceed to examine the consequences of Pure Open Access. We shall suppose, as before, that we commence with a virgin biomass, $x(0) = x_0$, and that vessel capital is quasi-malleable, in that $c_s = 0$; $\gamma > 0$. Finally, we assume that we commence with an unsubsidized fishery, and that the p, c and c_1 confronting the fishers are identical to the p, c and c_1 facing the resource manager in our benchmark case.

McKelvey (1986) has demonstrated that a pattern will emerge which is similar in nature to that to be found in the optimal management case. The resource will be depleted and then stabilized at a level, which we shall denote as x^0, which corresponds to what is referred to in the fisheries economics literature as Bionomic Equilibrium (Gordon, 1954). The Bionomic Equilibrium biomass, x^0, will be given by an equation that is similar to Eq. (13), but with one fundamental difference. The second term on the left hand side of Eq. (13), it will be recalled, is the *shadow price* of the resource, which is, in turn, the present value of sustainable profit, or economic rent, that will be gained (lost) as a result of a marginal investment (disinvestments) in the resource. Under Pure Open Access, the rational fisher will, from his/her perspective, perceive the aforementioned marginal sustainable economic rent to be equal to zero. Hence, the fishers collectively will deem the shadow price, itself, to be equal to zero. The biomass level x^0, corresponding to Bionomic Equilibrium, is thus given by the following equation:

$$p - c_{total}(x^0) = 0 \tag{16}$$

Return to Eq. (13). From this equation, one can infer that there are two 'brakes' on exploitation of the resource confronting the all-seeing resource manager. The first is that the unit cost of harvesting steadily increases as x is depleted. The second brake is contained within the *shadow price* of the resource. The resource manager must be constantly aware of the impact of resource depletion today, upon the economic returns from the resource tomorrow.

Under Pure Open Access, the second of the two brakes upon exploitation is eliminated. We can, therefore, with confidence, be assured that $x^0 < x^*$. Pure Open Access will lead, unequivocally, to overexploitation of the resource from society's point of view. The McKelvey (1986) analysis also assures us, not surprisingly, that the investment in fleet capacity at $t = 0$, under Pure Open Access, will exceed the optimal investment in such capacity that would be undertaken by the all-seeing resource manager.

Now return to Eq. (16) and consider the impact of the introduction of subsidies. Recall that both unit operating costs c and the purchase price of vessel capital, c_1 enter into $c_{total}(x)$. We can then say that *any* subsidy, which

i) increases p, as perceived by the fishers;
ii) reduces c, as perceived by the fishers;
iii) reduces c_1, as perceived by the fishers.

will result in a more intense exploitation of the resource. Let $x^{0\prime}$ denote the long run equilibrium biomass under Pure Open Access, given a subsidy, or subsidies, that lead to i, ii, iii, or some combination of the three. Then, it will certainly be the case that: $x^{0\prime} < x^0$. Thus, a bad situation will indeed be made worse.

To emphasize the point, consider an extreme case, in which the government introduces a super cost-reducing subsidy, which effectively reduces c and c_1 to zero. The consequence would be that the one brake on resource exploitation would be removed. Eq. (16) would have no solution, implying that the resource would be sent hurtling towards extinction.

Impact of subsidies in an effective private property rights fishery

Next consider the following. Instead of permitting the development of a Pure Open Access fishery, and instead of direct management of the resource by the resource manager, the 'authorities' succeed in creating effective private property rights to the resource. While the resource is not directly managed by the resource manager, the common pool aspects of the fishery are eliminated, and thus good resource management should be expected to prevail. The question then to be asked is what effect, if any, would the introduction of subsidies have upon resource management and resource sustainability.

Various means have been suggested for attempting to create property rights among fishers (OECD, 1997). Individual transferable harvest quotas (ITQs) provide one such example (see, for example, Munro and Pitcher, 1996).

Suppose then, that a fully fledged ITQ system is established, and suppose further that the ITQ holders coalesce and begin to act and to behave as a 'corporation,' which effectively owns, not just the harvest shares, but the resource itself. The government, as resource manager heretofore, while maintaining nominal control of the resource, does, to all intents and purposes, relinquish resource management rights to the 'corporation.' While all of this may sound far fetched, there are, in fact, clear signs that the management of fisheries in at least one fishing nation, New Zealand, is evolving in just this direction (Munro et al. 1999). We would, in any event now have a fishery, effectively privately owned, in which all vestiges of the common pool had been removed, and which closely resembled the mythical 'sole owner' fishery described by the pioneering fisheries economists, H. Scott Gordon and Anthony Scott (Gordon, 1954; Scott, 1955).

Suppose, initially, that the corporation is not subsidized, and suppose, as before, that we commence with an unexploited stock, $x(0) = x_0$. Suppose, as well, that the p, c, and c_1 facing the corporation are identical to the p, c, and c_1 facing the resource manager in our benchmark case. Finally suppose that the rate of discount (interest rate) used by the corporation is identical to the social discount rate, and that the objective of the corporation is to maximize the net economic returns from the fishery over time.

The problem facing the corporation would be exactly the same as that facing the resource manager in the benchmark case. The economic model of the fishery established for the benchmark case – Eqs. (1) to (15) – would apply to the 'corporation,' without modification, and, not surprisingly, the results would be the same. The corporation, beginning with an unexploited stock, $x(0) = x_0$, would deplete the stock and eventually stabilize at a long run equilibrium level which we shall denote as x^{**}, given by:

$$p - c_{total}(x^{**}) - \frac{1}{\delta} \bullet \frac{d}{dx^{**}}\left\{(p - c_{total}(x^{**}))F(x^{**})\right\} = 0 \tag{17}$$

or alternatively

$$F'(x^{**}) - \frac{c'_{total}(x^{**})F(x^{**})}{p - c_{total}(x^{**})} = \delta \tag{18}$$

Equations (17) and (18) appear to be identical to Equations (13) and (14), and indeed they are. Given our assumptions about the p, c, c_1 and δ confronting the 'corporation,' it will be found that $x^{**} = x^*$, the socially optimal long run equilibrium biomass level (see Eqs. 13 and 14). The 'corporation', as private sole owner of the resource, would follow a socially optimal policy, as has been predicted by fisheries economists from Gordon (1954) and Scott (1955) onwards.

We can now consider the impact of the introduction of subsidies. The government, we might suppose, introduces subsidies for distributional purposes (fishers' incomes are seen as being 'unfairly' low), while assuming that, since the fishery is 'well-managed', the subsidies can be counted upon to have no negative resource consequences. Everything else is assumed to remain the same.

The consequences of the introduction of subsides are straightforward. Return to Equations (17) and (18). It is clear that *any* subsidy which has the effect of increasing the p, perceived by the 'corporation,' or of reducing either c or c_1, or both, as perceived by the 'corporation,' will reduce the level of x^{**}, leading to the result that $x^{**} < x^*$. The corporation will overexploit the resource, as seen from the point of view of society, and do so in an unequivocal manner.

The introduction of subsidies does not make a bad situation worse, as is the case in Pure Open Access. Rather, the introduction of subsidies undermines, what would otherwise be socially optimal resource management program, by introducing a new set of perverse incentives.

While the introduction of subsidies will, admittedly, have a negative impact upon the resource, perhaps the impact will prove to be trivial. One has, in fact, no justification for assuming that this must necessarily be the case. It takes no great skill, or imagination, to construct a scenario in which the introduction of subsidies into the 'well managed' fishery would lead to the result: $x^{**} < x^{o}$, i.e., a scenario, in which the introduction of subsidies would lead to an outcome that was, from society's point of view, worse than an unsubsidized Pure Open Access fishery.[8]

In our discussion of subsidies under Pure Open Access, we attempted to drive home our points by taking the extreme example of a super cost- reducing subsidy that effectively reduced both c and c_1, as perceived by the fishers to zero. The consequence was resource extinction. Let us apply the extreme example to the corporation fishery, for comparative purposes.

If the super cost-reducing subsidy is introduced to the corporation fishery, Equation (18) will reduce to:

$$F'(x^{**}) = \delta \tag{19}$$

As in the case of Pure Open Access, the subsidy would eliminate the brake on exploitation arising from the fact that unit harvest costs rise, as the resource is depleted. The second brake, however, arising from the 'corporation's' concern about the impact of resource exploitation today upon economic returns from the resource tomorrow, appears to remain in place. Thus, we are protected from the threat of resource extinction, or so it would seem. Clark (1990), however, presents us with a stern warning.

The underlying biological model, which we have employed, is the Schaefer model. In the Schaefer model, we have $F''(x) < 0$, which implies that $F'(x)$ will steadily increase as x is diminished. In the limit, as x approaches 0, $F'(x)$ will approach what is referred to as the intrinsic growth rate, which we denote by w, a constant (see: Clark, 1990). Clark has demonstrated that, in circumstances such as we have described, there will be no solution to Eq. (19), if $\delta > w$.[9] The second 'brake' would prove to be inoperative and the resource would, in fact, be driven to extinction (Clark, 1990). In other words, it would pay the corporation to mine the resource to extinction, perhaps with the objective of reinvesting the proceeds from the fishery in some other form of capital investment. Thus, while extinction would not be assured, as it would be in the case of a Pure Open Access fishery, it remains an uncomfortable possibility.

Of course, the assumption of the super cost - reducing subsidy is extreme. So are the assumptions that the resource is perfectly understood, and can be perfectly modeled, however. The introduction of less extreme subsidies to the corporation-run fishery could still result in the resource being driven down to a level which could be seen after the fact as dangerously low.

In conclusion, we agree with all those who argue that the introduction of subsidies under conditions of Pure Open Access can be very damaging. We also conclude, however, that to assume that the impact of subsidies introduced to a fully privatized, 'well run', fishery can safely be dismissed as trivial is folly. In a recent paper, Gareth Porter argues that "it would be unwise ... to base the international policy toward the fisheries subsides regime on the theoretical proposition that well-managed fisheries can neutralize the negative impacts of subsidies" (Porter, 2001, p. 14). We would agree, and would offer the counter theoretical proposition that, under the right set of circumstances, the introduction of subsides to an apparently 'well-managed' fishery can lead to the destruction of the resource.

The basic economics of the impact of subsidies in fisheries: Part Two

In this section, we consider the impact of subsidies under Regulated Open Access, in which the resource managers control the annual catch, but have in the past exercised, or do now exercise, inadequate control over the fleet size. The limited harvest becomes the 'common pool.'

One question, which can be dealt with readily, is the following. Suppose that the authorities, while retaining control over the total catch, remove the

---

[8] Maximum sustainable yield, in the model occurs at the biomass level, x_{MSY}, at which $F'(x_{MSY}) = 0$, by definition. Depending upon the level and nature of harvesting costs, it is quite possible that Bionomic Equilibrium will occur at a stock level above the MSY level, i.e. $x^{o} > x_{MSY}$. Suppose that this is indeed the case, and now return to Eq. (18), and evaluate it at $x^{o} = x_{MSY}$. Suppose, for the sake of argument, that $\delta = 0.05$, and suppose that the subsidies affecting p, c and c_1 lead to the result that: $\left[\dfrac{-c'_{total}(x_{MSY})F(x_{MSY})}{p - c_{total}(x_{MSY})}\right] = 0.05$

Since $F'(x_{MSY}) = 0$, it will indeed prove to be the case that $x^{**} = x_{MSY}$. Hence $x^{**} < x^{o}$.

[9] A slow growing resource, such as whales, provides a case in point (Clark, 1990).

'common pool' aspects of the fishery through the granting of individual harvest quotas, or some other scheme, and that the ITQ scheme, or alternative, works well. What then would be the consequence of introducing subsidies? The answer is that the subsidies should have very limited negative consequences, and, in many cases, will prove to be neutral. Consider, as an example, a well managed ITQ scheme. The individual quota holder cannot influence the size of his/her quota, except by buying quotas from others. He/she will attempt to harvest the assigned quota in the most efficient manner possible, in order to maximize profits. A subsidy affecting some inputs, but not others, would cause the quota holders to substitute, where possible, the subsidized input, or inputs, for the unsubsidized ones. This could be inefficient from society's point of view. Be that as it may, the consequences of subsidies should be far less severe than in our case of the 'corporation,' which was enabled to assume the full rights of resource management (Hannesson, 2000).

A cautionary note is in order, however. The discussion in the previous paragraph rests critically upon the assumption that the 'authorities', as resource manager, retain iron control over the total catch, and thus over the management of the resource itself. Should the ITQ fishery evolve in a manner, such that more and more of the power of resource management becomes vested in the ITQ holders, then we shall move towards a 'corporation' type of fishery described in the previous section, with all that that implies

Be that as it may, the key subsidy question pertaining to Regulated Open Access arises when the 'common pool aspects remain, and the resource manager reacts to the emergence of excess capacity by introducing a buyback, or decommissioning, scheme.

The purpose of a buyback scheme is quite simply to persuade a given number of fishers to sell their boats and licenses, and retire from the fishery, thereby eliminating the excess capacity.

The expenditures on buybacks constitute subsidies, and are clearly designated as such by the OECD (2000). At an earlier point, we noted that Milazzo, in his study on subsidies for the World Bank (Milazzo, 1998), argued that some subsidies had a positive impact upon resource management, and that he designated such subsidies as 'conservationist' subsidies. His prime example of a 'conservationist' subsidy is a subsidy used for buyback purposes (Milazzo, 1998). Milazzo is not alone. Schrank and Keithly, in the article already cited, point out that recent American legislation pertaining to fisheries explicitly supports the view that subsidies used for buyback purposes are beneficial (Schrank and Keithly, 1999).

Decommissioning schemes have often been criticized on the grounds that they are, over the long run, ineffective. Vessel capacity, once removed from a fishery by such a scheme, tends to seep back in, over time (see, for example, Holland, Gudmundsson, and Gates, 1999). We will commence by assuming, initially at least, a 'best case' outcome for the decommissioning scheme. Once the vessel capacity is removed, the resource manager proves to be entirely effective in blocking all seepage.

In our examination of this issue, we shall draw heavily upon a recent paper by Clark and Munro (1999). In so doing we shall use much the same economic model of the fishery as we did in Section III. There are two differences. In Section III we found a continuous time model to be more convenient. In this section, we find that a discrete time model is more appropriate. We shall, after all, have to deal explicitly with season-by-season fishery. Secondly, we shall be able to make our points with greater clarity by supposing that the rate of depreciation, and the 'scrap value,' are equal to zero. Finally, we also assume, for simplicity, the absence of 'crowding' externalities.

Now let us assume that the resource managers specify an annual Total Allowable Catch (TAC), which remains fixed for all future time. Let Q denote this fixed annual TAC in tonnes. Assume, initially, that entry into the fishery is unrestricted. Thus, we commence with true Regulated Open Access. As before, let K denote the actual fleet size. The harvest rate is z tonnes/day/vessel. Thus, if K vessels fish for D days during the year, the fleet's total annual harvest is: zKD .

Let $D_{\max}$ denote the maximum length of the annual fishing season. If the fleet size is such that $zKD_{\max} \leq Q$ the fishing season will be at its maximum length. If $zKD_{\max} > Q$, then the actual number of days fishing must be: $D < D_{\max}$, if the TAC is not to be exceeded.

As before, let p, a constant, denote the price of harvested fish, and c, unit operating profits. Thus Fleet Annual Net Operating Profits are given by:π_{An}

$$\pi_{An} = (pz - c)KD \tag{20}$$

If the TAC is fully taken, then we have $zKD = Q$ and Eq. (20) can be re-written as:

$$\pi_{An} = (p - c/z)Q \tag{20a}$$

Next let r denote the annual rate of interest, let K_0 denote the minimum fleet required to take the allotted TAC = Q, i.e. $Q = zK_0D_{max}$. Let K_{ROA} denote the 'equilibrium' fleet size under Regulated Open Access. Finally, as before, let c_1 denote unit price of fleet capital.

Given that Q is taken year in, and year out, the present value of fleet operating profits will be equal to: $[\pi_{An}] \bullet (1+r)/r$. We shall assume that the vessels (and crew) are identical. Consequently, an owner of a unit of fleet capital (a vessel) can expect to enjoy an average share of the aforementioned present value, i.e., $\{[\pi_{An}] \bullet (1+r)/r\}/K$. Thus investment in additional fleet capital will be profitable, if it is true that:

$$c_1 < \{[\pi_{An}] \bullet (1+r)/r\}/K \tag{21}$$

Hence, we would predict that the 'equilibrium' fleet size, K_{ROA}, would be given by

$$c_1K_{ROA} = [\pi_{An}] \bullet (1+r)/r \tag{22}$$

which can be re-expressed as:

$$K_{ROA} = [\pi_{An}] \bullet (1+r)/rc_1 \tag{22a}$$

Unless, it should be the case that the fishery is strictly a 'break even' fishery, i.e.

$$c_1K_0 = [\pi_{An}] \bullet (1+r)/r$$

we shall certainly find that $K_{ROA} > K_0$, and we can argue that Regulated Open Access will lead, as standard fisheries economics would predict (see, for example, Bjorndal and Munro, 1998), to the complete dissipation of net economic returns (resource 'rent') from the fishery. The magnitude of the dissipated resource rent is given simply by:

$$\{[\pi_{An}] \bullet (1+r)/r - c_1K_0\}$$

We shall refer to the above measure as the Redundancy Deadweight Loss arising from excess fleet capacity emerging under Regulated Open Access. Let it be noted that the Redundancy Deadweight Loss is incurred the *instant* that the excess, redundant, capital is acquired. Once incurred, this loss cannot be reversed.

Now, let us consider the economic consequences of a buyback scheme. The scale of the impact will depend critically upon whether the scheme is, or is not, anticipated by the vessel owners. We illustrate with the aid of a simple numerical example.

Let it be supposed that D_{max} = 200 days. We assume in addition, that:

Q = 10,000 tonnes;
z = 1 tonne per vessel per day;
p = $1,000 per tonne;
c = $500 per vessel per day;
c_1 = $500,000 per vessel;
r = 0.10 – i.e., 10% per annum.

Total annual fleet net operating profits will be:

$$\begin{aligned}\pi_{An} &= (p - c/z)Q \\ &= \$5{,}000{,}000 \text{ per year}\end{aligned} \tag{23}$$

while the optimal fleet size will be:

$$K_0 = Q/zD_{max} = 50 \text{ vessels} \tag{24}$$

Let it be supposed that the fishery commences at time period t = 0. It is not unknown for resource managers to react to an 'excess' capacity problem, only after the problem has emerged. Therefore, let it be supposed that, if 'excess' capacity does emerge, the resource managers will react at, say time period t = 10, by introducing a buyback/license limitation scheme, with the objective of reducing K to 50 and of maintaining that fleet level thereafter.

Let us commence by also assuming that, at t = 0, the resource manager's future responses are wholly unanticipated by vessel owners. They assume, incorrectly, that regulated open access fishery will continue forever. We can thus anticipate that at t = 0, investment in capital capacity will be given by:

$$\begin{aligned}K_{ROA} &= (p - c/z)Q\left(\frac{1+r}{c_1r}\right) \\ &= (\$1000 - \$500) \bullet \frac{10{,}000(1.10)}{c_1r} \\ &= 110 \text{ vessels}\end{aligned} \tag{25}$$

Thus there is excess capacity of 60 vessels, representing a Redundancy Deadweight Loss of $30 million.

At t = 10, the resource managers do introduce a ‘sudden death’ buyback program, to the surprise of the vessel owners. The vessel owners are, however, convinced that the authorities will do whatever is necessary to reduce the fleet to 50 vessels and are further convinced that the accompanying limited entry program will be effective forever.

The present value of the operating profits of the remaining 50 vessels, discounted back to t = 10 will be $1,100,000. Thus, we can be assured that the resource managers cannot offer less than $1,100,000 per vessel. We shall assume, somewhat unrealistically, that the authorities are able to achieve their goal by offering a purchase price of $1,100,000 and the accompanying limited entry program is indeed fully effective. The fleet remains at $K = K_0$ from henceforth.

The government has thus spent $66,000,000. Immediately prior to the buyback, each vessel was worth its original purchase price, $500,000. Those who sold out received $1,100,000, a windfall gain of $600,000. Those who remained in the fishery found that the value of their vessels had appreciated by $600,000 to $1,100,000. Both those who leave the fishery and those who remain have benefited from the subsidy. Those who left the fishery collectively receive $36,000,000, while those who remain collectively receive $30,000,000.

The consequences of the emergence of excess capacity, under Regulated Open Access, are, we had said at an earlier point, twofold. First it will result in economic waste. Secondly, it will act as a threat to the ability of the resource managers to control the total harvest. Up to this point, we have implicitly assumed that the resource managers are able to exercise full control over the total harvests. This is a very strong assumption, which we must be prepared to relax. With regards to the elimination of economic waste, the subsidy, in the example developed to this point, does no good. The Redundancy Deadweight Loss remains unaffected.

In terms of the threat to the resource managers, should the managers in fact lack full control, the subsidy will indeed ease the pressure, and can be seen as having a positive or ‘conservationist,’ impact. This outcome, however, rests upon the vessel owners being caught by surprise, and rests as well upon the assumption that the resource manager can introduce, and maintain, a wholly effective limited entry program.

Now let us change the example by supposing that, at t = 0, the vessel owners have perfect foresight. They anticipate, correctly, that, at the inception of the fishery, the resource manager will initially do nothing about the possible emergence of ‘excess’ capacity. They anticipate further that, by t = 10, the resource managers will react to the appearance of excess capacity by introducing a ‘sudden-death’ buyback program and that the resource manager will, moreover, offer a price of $1,100,000 per vessel. The vessel owners also know that the fleet will be stabilized at 50 vessels, and that the accompanying limited entry program will be entirely successful.

We can now calculate the level of investment in vessels at t = 0, which we shall denote by K'_{ROA}. Equilibrium will be achieved when:

$$c_1 K'_{ROA} = \sum_{i=0}^{10} (p - c/z)\frac{Q}{(1+r)^i} + \frac{c_3}{(1+r)^{10}} \bullet K'_{ROA} \tag{26}$$

where c_3 denotes the resource manager’s offer price at t = 10. Observe that it is a matter of indifference whether an individual vessel owner sells his/her vessel at t = 10, or whether his/her vessel continues on as one of the remaining 50. Also observe that Eq. (26) can be re-written as:

$$K'_{ROA} = \left[\sum_{i=0}^{10} (p - c/z)\frac{Q}{(1+r)^i}\right] \bullet \frac{1}{c_1 - c_3/(1+r)^{10}} \tag{26a}$$

In any event, in our example, we have:

$$K'_{ROA} = \$35{,}722{,}836 \bullet \frac{1}{\$75{,}093} \approx 476 \tag{27}$$

The implication is that the eminently ‘successful’ buy-back program would lead to a Redundancy Deadweight Loss of $500,000 • (476-50) = $213 million. Recall that, if the ‘authorities’ had done nothing, i.e., had foregone a buyback program, the Redundancy Deadweight Loss to the economy would have been $30 million, less than 15 per cent of the loss brought on by the buyback program.

Note as well that, what we might term the ‘do nothing’ policy, results in the net economic returns from the fishery being reduced to zero – the usual result from the standard fisheries economics model. The present value (at t = 0) of net operating profits from the fishery is $55 million, while total expenditure on vessel capital would be $55 million. In our example of the anticipated buyback program, the net economic benefits from the fishery to the economy at large (discounted back to $t = 0$) will be equal to *minus* $158 million.

The reason that the anticipated buyback program induces a large investment in fleet capacity is made transparent by the right hand side of Eq. (26a). The effective purchase price of vessel capital, for would be vessel owners, at $t = 0$ is: $c_1 - [c_3/(1+r)^{10}]$, which carries with it the implication that the vessel owners would be receiving a subsidy, indeed a very substantial subsidy equal to just under $425,000 per vessel, which is equal, in turn, to 85 per cent of the purchase price.

With respect to economic waste, the buyback subsidy, when anticipated, is a disaster. In terms of a threat to the resource manager's ability to control the total harvest, the anticipated subsidy, obviously intensifies the threat, until the buyback actually comes into effect. Thus, when anticipated, the 'good' buyback subsidy is, in fact, a very bad subsidy indeed.

The anticipated subsidy case can best be thought of as a fisheries example of what in macroeconomics is referred to as 'Rational Expectations.' (See, for example, Sargent 1986, and Turnovsky 2000). The argument put forth is that members of an economy, e.g. firms and households, do not react passively to changes in macro-policy, but will rather take into account all relevant information about the future course of macro-policy. From this follows the famous proposition that Monetary Policy, for example, will be effective in terms of having an impact upon the level of national income, only to the extent that it is unanticipated. Fully anticipated Monetary Policy will have no impact upon the level of national income (Turnovsky, 2000).

Our last example is, of course, exaggerated in that we assume perfect foresight. Vessel owners always remain uncertain about the course of future government policy. Nonetheless, the point remains. It is foolish to suppose that vessel owners will simply ignore the knowledge they have acquired about the behaviour of resource managers, and, thus neglect to incorporate such knowledge in their investment decisions.[10]

To this point, we have assumed a 'best case' outcome, namely that the resource managers, upon introducing a limited entry program, can enforce the limited entry program with complete effectiveness. More often than not, the 'best case' does not prevail. The consequence, as we noted earlier, is that, when a buyback program is implemented, and is accompanied by a limited entry program, capacity will tend to seep back into the fishery. Eventually a new round of buybacks will be called for. There is ample evidence that capacity does indeed seep back into fisheries after buy-back/decommissioning programmes (see, for example: Holland et al. 1999).

There are two consequences for our analysis, arising from the relaxation of the assumption that limited entry programs are perfectly enforceable. The first is that the size of the subsidies associated with anticipated buybacks will be less. Imperfect limited entry programs imply lower expected future resource rents. The second is that, while vessel owners may be taken by surprise by a buyback program the first time around, one cannot expect them to go on being taken by surprise. Once future decommissioning schemes come to be anticipated, the trickle of capacity back into a fishery can be expected to turn into a flood.

In a recent paper, Jorgensen and Jensen (1999) report on an empirical study, which they undertook on European Union vessel decommissioning (buyback) programs. They argue that EU fishers, and, in particular, their bankers, are not at all myopic with respect to investment in vessel capital. Decommissioning schemes, if repeated, will come to be anticipated and will influence investment decision making. The authors then argue, on the basis of a simulation model, that decommissioning schemes are likely to destabilize, rather than stabilize, the fishery (Jorgensen and Jensen1999).

Estimates of fishing sector subsidies in countries of the North Atlantic region

We now turn to estimates of fisheries subsidies in the North Atlantic region (NA). The definition of North Atlantic adopted by the SAUP (see Watson et al., this volume) includes 25 countries (see Table 2). For our purposes, these countries are divided into two sub-groups, those within the OECD – 16 – and those without- 9.

The OECD has recently published a thorough study on fisheries subsidies within the OECD region, to which we have repeatedly referred (OECD, 2000). Our estimates of fisheries subsidies in the OECD countries are, needless to stress, drawn from that study. As a consequence, we have a reasonably high degree of confidence in these estimates. By way of contrast, we have very limited sources of information about, and data on, fisheries subsidies in the non-OECD countries

[10] Nobel Laureate Robert Lucas, one of the founders of the Rational Expectations School, is famous for the comment that you do not find 50 dollar bills lying on the sidewalk.

Table 1. Estimates of Government subsidies to marine capture fisheries in OECD countries that are also member of the North Atlantic: 1997 (US $Million)[a]

Country	*MRE*	*FI*	*IM*	*TE*	*DLR*	*AOC*[c]	*ISU*	*OT*	*Total*[c]	*Landed value (LV)*	*Subsidy as % of LV*
Belgium	2.0	-	3.0	-	-	-	-	-	5.0	99.0	5
Denmark	46.1	2.8	11.3	-	7.5	-	-	9.4	77.1	489.7	16
Finland	21.0	-	1.0	-	1.0	-	-	3.0	26.0	29.0	90
France	65.1	5.3	11.4	-	4.4	-	-	36.1	122.3	665.3	18
Germany	45.1	5.9	2.0	-	2.0	-	-	7.8	62.7	190.1	33
Ireland	19.3	0.4	0.6	0.6	-	-	-	-	21.0	46.2	45
Netherlands	24.5	6.9	1.0	-	2.9	-	-	-	35.3	456.7	8
Portugal	15.8	4.4	5.7	-	13.2	-	-	2.5	41.6	201.0	21
Spain	18.5	8.0	40.0	-	98.0	-	-	7.5	172.0	1722	10
Sweden	38.2	0.9	2.7	-	1.8	-	3.6	0.9	48.2	117.4	41
United Kingdom	82.2	14.9	4.0	-	22.8	-	-	4.0	127.7	1,002	13
European Union	*377.7*	*49.4*	*82.7*	*0.6*	*153.6*	*155.0*	*3.6*	*71.2*	*893.9*	*5,018*	*18*
Iceland	18.0	-	-	18.0	-	-	-	-	36.0	877.0	4
Norway	98.0	-	14.0	34.0	-	-	3.0	14.0	163.0	1,343	12
Poland	5.8	-	-	-	-	-	-	-	5.8	157.0	4
Non European Union	*121.8*	-	*14.0*	*52.0*	-	-	*3.0*	*14.0*	*204.8*	*2,377*	*9*
Atlantic Canada	80.0	28.0	-	-	-	-	198.4	17.6	324.0	971.2	33
Atlantic United States	292.2	4.8	13.2	66.0	1.8	-	-	7.9	385.9	1,122	34
North America	*372.2*	*32.8*	*13.2*	*66.0*	*1.8*	-	*198.4*	*25.5*	*709.9*	*2,094*	*34*
Total	**871.7**	**82.3**	**109.9**	**118.6**	**155.4**	**155.0**	**205.0**	**110.7**	**1,809**	**9,488**	**19**

Notes to Table 1

a) Sources: OECD (2000); Flaaten and Wallis (2000).

b) MRE: management, research, enforcement and enhancement;
FI: fisheries infrastructure;
IM: investment and modernization;
TE: tax exemption;
DLR: decommissioning of vessels and license retirements;
AOC: access to other country's waters;
ISU: income support and unemployment insurance;
OT: other.

c) Subsidies under the heading of access to other countries' waters are relevant to the EU only. The data source, the OECD, does not provide a breakdown of these subsidies on a country by country basis. Consequently, the totals shown for some EU members are certainly understated. The authors deem the access subsidies to be similar in nature to decommissioning subsidies in that they are used to deal with 'excess' vessel capacity. About 54 per cent of total EU landed values is accounted for by the adjusted landed values of EU members in Table 1. It is assumed, for want of a better assumption, that 54 per cent of the access subsidies are also accounted for by these EU members.

d) Subsidy estimates for Canada, the U.S.A. Spain, Poland, and Portugal, UK, Denmark, Netherlands, Ireland, Germany and Sweden were estimated by the OECD for the entire countries. It was assumed that the percentage of subsidies in each country devoted to the Atlantic region was proportional to that region's share of the national harvest (in value terms).

(e.g., APEC, 2000). Our estimates of fisheries subsidies in the non-OECD countries are thus essentially educated guesses.

We adopt, therefore, a two-stage approach in our estimation of fisheries subsidies in the North Atlantic (NA). In the first stage, we make an estimate of subsidies for the 16 OECD countries. In the second stage we deal, as best we can, with the remaining 9. Details of the steps taken are presented below.

Stage 1:

We use data on the different types of subsidies and the value of landings for each of the 16 OECD countries in the North Atlantic region (OECD, 2000) (see Table 1). The OECD presents subsidy estimates for two years, 1996 and 1997. Since there are negligible differences between the two sets of estimates, we confine our attention to the estimates for 1997. Not even the OECD data are complete, however. The OECD estimates exclude subsidies arising from price supports (OECD, 2000, p.129). We shall comment on this omission at a later point.

Not all of the landings of the 16 OECD countries are taken in the NA, and consequently, not all of the fisheries subsidies reported by the OECD are relevant to the NA. We are thus required to adjust the OECD estimates, and do so by a process of pro-rating. If, for example, half of the value of landings (1997), of a particular OECD country is found to be accounted for by NA fisheries, then it is assumed that one half of the subsidies reported by the OECD are attributable to the NA. The subsidy estimates of 12 of the 16 OECD countries have to be adjusted in this fashion. The percentage of total value of landings (1997) accounted by NA fisheries are as follows for the 12: Canada (80), USA (44), Spain (50), Poland (73), Portugal (63), UK (99), Denmark (94), Netherlands (98), Ireland (21), Germany (98), France (88) and Sweden (91).

Stage 2:

Value of landings for the non-OECD 9 countries are obtained from the SAUP catch database (Watson et. al., 2001).

We calculate the total OECD subsidies, attributable to the NA, as a percentage of the value of landings of the 16 OECD countries from NA fisheries (19%). We then assume, to begin with, that subsidies as a percentage of the value of landings for the 9 non-OECD countries is the same as it is for the 16 OECD countries. Given this assumption, and the value of landings of the 9 countries, we proceed to estimate the fisheries subsidies for the 9 (See Table 2). We readily concede that this method of estimating subsidies suffers the usual criticisms and caveats that apply when a mean is used to estimate values for a given population. Our justification lies in our claim that no superior method is known to us. Non- OECD data sources, e.g., APEC (2000), provided scant assistance.

To provide a lower bound for an estimate of the fisheries subsidies for the 9, we re-calculate using the lowest of estimates of subsidies as a percentage of value of landings for the individual OECD countries. The lowest such estimate is the percentage for Iceland, 4%.

Now, consider Table 2. Total subsidies for the OECD countries for 1997 were estimated to be U.S.$1.8 billion. Subsidies for the 9 non-OECD countries were estimated to be not less than U.S.$0.2 billion, and as high as U.S.$0.7 billion. Thus, we estimate that total fisheries subsidies in the NA are in the range of U.S. $2.0 – 2.5 billion per annum.

Is it the lower or upper end of the estimate that is likely to be correct? According to a recent report (World Wildlife Fund for Nature 2001), subsidies to the fishing industry globally amounts to about 20 per cent of the total landed value of fish catch. Our upper estimate of US$2.5 billion for the North Atlantic is about 19 per cent of the landed value of fish caught in this region in 1997, while the lower estimate is much lower than 20 per cent. Hence, if one were to give weight to the recent estimate, US$ 2.5 billion is more likely to be closer to the actual amount of subsidies in the North Atlantic than U$ 2.0 billion. In fact, one may argue that even this estimate is low for the North Atlantic because the 20 per cent estimate is a global mean. Thus, some regions of the world would contribute more than this percentage, while other regions would contribute less. One would expect countries in the North Atlantic region to be one of the regions that would contribute a higher percentage to the global mean, simply because this is one region of the world that can most afford subsidies to its fishing sector. Furthermore, our estimate looks conservative if compared to the estimate of subsidies of about US$ 50 billion at the global level reported by FAO (1992).

We now turn and consider Table 1, OECD fisheries subsidies, in detail.

We first note that, of the total NA subsidies of U.S.$2,500 million (excluding those arising from price supports), approximately 36 % was accounted for by the European Union. Arnason (1999) commented that, if prizes were to be awarded to countries or entities in terms of the extent to which they subsidize their fisheries, the E.U. would be strong contender for top prize.

With regards to the breakdown of total OECD subsidies by programs, we commence by observing that approximately 48 per cent of the subsidies are accounted for by MRE (management, research, enforcement and enh-ancement) (U.S. $870 million). We agree with Flaaten and Wallis (2000) that most of these should probably be deemed to be neutral, or even positive. On the other hand, those subsidies falling into the three categories FI (fisheries infrastructure), IM (investment and mod-ernization) and TE (tax exemptions) we would certainly deem to be negative in terms of their impact upon the resources. The three combined amount to approximately U. S. $310 million, just over 17 per cent of the total. The 'Other' category (OT), amounting to U.S. $110 million (6 per cent of the total) is simply unknown. This leaves three categories, namely:

Table 2. Estimates of Government Subsidies to marine capture fisheries in countries of the North Atlantic as defined by the SAUP: 1997 (US $Million)

Country	Landed value	Subsidies	Subsidy as % of landed value
Belgium	99	5	5
Denmark	490	77	16
Finland	29	26	90
France	665	122	18
Germany	190	63	33
Iceland	877	36	4
Ireland	46	21	45
Netherlands	457	35	8
Norway	1,343	163	12
Poland	157	6	4
Portugal	201	42	21
Spain	1,722	172	10
Sweden	117	48	41
UK	1,002	128	13
OECD Europe	**7,395**	**1,099**	**15**
Canada	971	324	33
USA	1,122	386	34
OECD North America	**2,094**	**710**	34
Total OECD	***9,488***	***1,809***	**19**
Bahamas	**45**	**10**	19
Bermuda	**0**	**0**	19
Estonia	**0**	**0**	19
Faeroe Island	**665**	**125**	19
Greenland	**600**	**115**	19
Latvia	**140**	**25**	19
Lithuania	**35**	**5**	19
Morocco	**600**	**115**	19
Russia	**1,600**	**300**	19
Non-OECD	***3,685***	**695**	***19***
Total	*13,170*	*2,500*	
Percentage	*0.19*		

Notes to Table 2

(a) Numbers in bold are estimates of landed values from the SAUP project, and estimates of subsidies using the average percentage of landed values that are paid out as subsidies in countries in the North Atlantic that are also members of the OECD, that is, 19%. (see also Table 1). To calculate the low conservative estimate of $2.0 billion reported in the text we used 4% instead of 19%.

(b) Landed values (and subsidies) for Bermuda and Estonia are US$ 10,000 and US $ 137, 000, respectively. They appear as zero in the table only because of rounding off.

decommission subsidies (DLR), access to other countries' waters (AOC), and income support and unemployment insurance (ISU).

We choose to lump together decommissioning subsidies and subsidies to obtain access to other countries' waters, since both are designed to eliminate fleet capital from NA fisheries. The two categories of subsidies together amount to U.S. $310 million –just over 17 per cent of the total. It will be recalled that such subsidies are widely believed to be positive in terms of resource conservation. Our preceding arguments indicate that the positive impact of these subsidies is likely to be fleeting, and that, in many cases, the subsidies will prove to be decidedly negative in their impact. We might add in passing that we do not even consider in this paper the possible negative impact of AOC subsides upon the resources of those countries persuaded to grant access to fleets shifting out of NA fisheries.

The final category of subsidies consists of income support and unemployment insurance (ISU), which amounts to U.S. $210 million, approximately 11.5 per cent of the total. The question that has to be raised with regards to ISU subsidies is whether or not they are linked to fishing activities. If they are linked, e.g., subsidies depend inter alia on the amount of fishing undertaken, and then the impact is unquestionably negative. The impact is basically not different from a subsidy designed to artificially raise the price of harvested fish. These subsidies, in 1997, were accounted for almost entirely by Canada. There is overwhelming evidence that most of these Canadian subsidies are directly related to fishing activities (see, for example, Poole, 2000).

In summing up, we would, for the year 1997, place 48 percent of the OECD subsidies in the probably neutral or benign category. We would place a further 46 percent in the decidedly negative, or to be viewed with deep suspicion, category (FI + IM + TE + DLR + AOC + ISU). The remaining 6 percent we would place in the unknown category.

It should be noted that, the OECD estimates do not include subsidies arising from price supports, with the consequence that our estimates do not, as well. Our previous analysis indicates that such subsidies should, without question, be placed in our negative category. We have, at this stage of the research, no means of determining whether the missing subsidies are large, or small. Thus our subsidy estimates for the relevant OECD countries should be seen as a lower bound. Further research will be required to allow us to establish a reasonable upper bound.

It is also worth noting that we provide only a point estimate, which means that we do not provide information on trends in subsidies. However, country case studies reported in OECD (2000) tended to show that subsidies to the fishing industry in OECD member countries appear to have been falling in recent years. This may mean that subsidies are likely to decrease into the future, but it has been recently reported that fuel subsidies to the fishing sector have been rampant in certain EU member countries. This is said to be because of political pressure from the fishing industry, due to the recent fuel price increases (see the May 9, 2000 issue of WorldCatch News Network: www.worldcatch.com).

Finally, with respect to the breakdown of fisheries subsidies of the 9 non-OECD countries by programs, we can do no better than to assume that the breakdown mirrors that reported for the 16 OECD countries.

Conclusions

In this paper, we have, with the assistance of economic theory, made an attempt to examine subsidies in fisheries in the North Atlantic. Such subsidies can be expected to have both an impact upon the distribution of income, and upon fishery resource management and sustainability. We have chosen to confine our attention solely to the second impact. Subsidies can have a positive, as well as negative or neutral, impact upon fisheries management and sustainability. Our primary source of data on subsidies in the North Atlantic is the recently published study by the OECD. We conclude, tentatively, that just under 50 per cent of the NA fisheries subsidies are benign, or neutral, in terms of their impact. We also conclude that just under 50 per cent are decidedly damaging, or are to be viewed, at best, with deep suspicion. The remainder, just over 5 per cent, we cannot classify on the basis of available information.

There is wide acceptance of the view that subsidies used in vessel decommissioning (buyback) programs also have a positive impact upon fisheries management and sustainability. By reducing fleet capacity such subsidies will reduce economic waste in the fisheries and reduce pressure on the resource, or so the argument goes. We take sharp issue with this widely held view. Such subsidies, if they come to be anticipated by industry, can, and will, have a decidedly negative impact.

Subsidies in fisheries, to the extent that their impact is negative, are seen as exacerbating the problems arising from the 'common pool' nature of many capture fisheries. We do not question this claim. We do, however, raise the question of whether the subsidies would continue to have a negative impact if the characteristics of the fishery were removed, e.g. by the establishment of effective property rights. The answer is unquestionably yes. Under the right set of circumstances, subsidies could drive a fishery resource, supporting a fishery free of all 'common pool' characteristics, to extinction.

Acknowledgements

We would like to thank the Environment Project of The Pew Charitable Trusts, Philadelphia, for their funding of the Sea Around Us Project. We also thank all the participants at the Sea Around Us Project Final Report Workshop in Nanaimo, B.C., Canada for their very helpful comments.

References

Asia Pacific Economic Cooperation, 2000. Study into the nature and extent of subsidies in the fisheries sector of APEC member economies. PricewaterhouseCoopers Report No. CTI 07/99T, pp.228.

Arnason, R. 1999. Fisheries Subsidies, Overcapitalization and Economic Losses. In Overcapacity and Subsidies in European Fisheries. Ed. by Aaron Hatcher and Kate Robinson. Portsmouth, Centre for the Economics and Management of Aquatic Resources, University of Portsmouth, pp. 27-46.

Bjorndal, T. and Munro, G. R. 1998. The Economics of Fisheries Management: A Survey. In The International Yearbook of Environmental and Resource Economics 1998/1999. Ed. by Tom Tietenberg and Henk Folmer. Cheltenham, Edward Elgar, pp. 153-188.

Canada, Department of Fisheries and Oceans (2000) http://www.dfo-mpo.gc.ca/communic/statistics/ landings/Smrx9699.htm.

Clark, C. W. 1985. Bioeconomic Modelling and Fisheries Management, New York, John Wiley and Sons.

Clark, C. W. 1990. Mathematical Bioeconomics: The Optimal Management of Renewable Resources, Second Edition, New York, Wiley-Interscience.

Clark, C. W., Clarke, F.H. and Munro, G.R. 1979. The Optimal Management of Renewable Resource Stocks: Problems of Irreversible Investment. Econometrica , 47, 25-47.

Clark, C. W. and Munro, G.R. 1999. Fishing Capacity and Resource Management Objectives. Food and Agriculture Organization of the U.N., Technical Consultation on the Measurement of Fishing Capacity, Mexico City, Mexico, 29 November–3 December 1999, Document #12.

Flaaten, O. and Wallis, P. 2000. Government Financial Transfers to Fishing Industries in OECD Countries. Paper presented to the Tenth Biennial Conference of the International Institute of Fisheries Economics and Trade, Corvallis, July 2000.

Food and Agriculture Organization of the U.N. 1992. Marine Fisheries and the Law of the Sea: A Decade of Change, FAO Fisheries Circular No. 853, Rome.

Food and Agriculture Organization of the U.N. 2001. Report on the Expert Consultation on Economic Incentives and Responsible Fisheries, Rome, Italy, 28 November – 1 December, 2000, presented to the Committee on Fisheries, Twenty-fourth Session, Rome, Italy, 26 February – 2 March 2001, http://www.fao.org/docrep/meetings/003/ X9342.htm

Gordon, H. S. 1954. The Economic Theory of a Common Property Resource: The Fishery. Journal of Political Economy, 62, 124-142.

Gréboval, D. and Munro, G.R. 1999. Overcapitalization and Excess Capacity in World Fisheries: Underlying Economics and Methods of Control. In Domingue Gréboval (ed.) Managing Capacity: Selected Papers on Underlying Concepts and Issues. FAO Fisheries Technical Paper No. 386, Rome, Food and Agriculture Organization of the U.N., 1-48.

Hannesson, R. 2000. Fisheries Subsidies in the Nordic Countries. Paper commissioned by the World Wildlife Fund for Nature.

Hatcher, A. 1999. The European Community's Structural Policy for the Fishing Industry. In: Aaron Hatcher and Kate Robinson (eds.) Overcapacity, Overcapitalisation in European Fisheries. Centre for the Economics and Management of Aquatic Resources, University of Portsmouth, 50-65.

Holland, D., Gudmundsson, E. and Gates, J. 1999. Do Fishing Vessel Buyback Programs Work: A Survey of the Evidence. Marine Policy, 23, 47-69.

Jorgensen, H. and Jensen, C. 1999. Overcapacity, Subsidies and Local Stability. In: Overcapacity, Overcapitalisation in European Fisheries. Ed. by A. Hatcher and K. Robinson. Centre for the Economics and Management of Aquatic Resources, University of Portsmouth, pp. 239-252.

McKelvey, R. 1986. Fur Seal and Blue Whale: The Bioeconomics of Extinction. In Applications of Control Theory in Ecology. Ed. by Y. Cohen. Berlin, Springer-Verlag, 57-82.

Milazzo, M. 1998. Subsidies in World Fisheries: A Reexamination. World Bank Technical Paper No. 406. Washington, World Bank.

Munro, G.R., Bingham, N. and Pikitch, E. 1999. 'Individual Transferable Quotas, Community-Based Fisheries Management Systems and 'Virtual' Communities. Fisheries, 23 (3), 12-15.

Munro, G.R., and Pitcher, T. J. (eds.) 1996. Reviews in Fish Biology and Fisheries, "Special Issue: Individual Transferable Quotas", 6(1).

National Research Council 1999. Sustaining Marine Fisheries, Washington, National Academy Press.

Organization for Economic Cooperation and Development 1997. Towards Sustainable Fisheries: Economic Aspects of the Management of Living Marine Resources. Paris.

National Research Council 2000. Transition to Responsible Fisheries: Economic and Policy Implications, Paris.

Pauly, D. and Pitcher, T.J. 2000. Assessment and mitigation of fisheries impacts on marine ecosystems: A multidisciplinary approach for basin-scale inferences applied to the North Atlantic. In Methods for evaluating the impacts of fisheries on North Atlantic ecosystems. Ed. by Pauly, D. and T. J. Pitcher. Fisheries Centre Research Reports 8(2), 1-12.

Poole, E. 2000. Income Subsidies and Incentives to Overfish. Paper presented to the Tenth Biennial Conference of the International Institute of Fisheries Economics and Trade, Corvallis, July 2000.

Porter, G. 2001. Fisheries Subsidies and Overfishing: Toward a Structured Discussion. Paper prepared for the UNEP Fisheries Workshop, Geneva, Switzerland, 12 February 2001, Economics and Trade Unit, United Nations Environment Programme, Geneva.

Sargent, T. J. 1986. Rational Expectations and Inflation, New York, Harper.

Schrank, W. E. 2001. Subsidies for Fisheries: A Review of Concepts. In: FAO Papers Presented at the Expert Consultation on Economic Incentives and Responsible Fisheries Rome, 28 November – 1 December 2000, Rome, 11-40.

Schrank, W. E. and Keithly Jr, W.B. 1999. The Concept of Subsidies. Marine Resource Economics, 14, 151-164.

Scott, A. D. (1955) The Fishery: The Objectives of Sole Ownership. Journal of Political Economy, 63, 116-124.

Steenblik, R. and Munro, G.R. 1999. Current International Work on Subsidies in Fisheries: A Survey. In. Overcapacity, Overcapitalisation in European Fisheries. Centre for the Economics and Management of

Aquatic Resources. Ed. by : A. Hatcher and K. Robinson. University of Portsmouth, 254-269.
Sumaila, U.R 1995. Irreversible capital investment in a two-stage bimatrix fishery game model'. Marine Resource Economics, 3, 263 - 283.
Turnovsky, S. J. 2000. Methods of Macroeconomic Dynamics, Second Edition, Cambridge, MIT Press.
United States of America 1995. Congressional Research Service, Natural Resource 'Subsidy' Issues, Washington, Library of Congress.
Wilen, J. E. 1987. Towards a Theory of the Regulated Fishery. Marine Resource Economics, 1, 369-388.
World Wildlife Fund for Nature 1997. Subsidies and Depletion of World Fisheries: Case Studies, Washington.
World Wildlife Fund for Nature 2001. Hard Facts, Hidden Problems: A Review of Current Data on Fishing Subsidies. A WWF Technical Paper.

Small Versus Large-Scale Fishing Operations In The North Atlantic

Ussif Rashid Sumaila[1,2], Yajie Liu[1] and Peter Tyedmers[1]

1. Fisheries Centre, UBC
2. Chr. Michelsens Institute, Bergen, Norway

Abstract: This paper compares small and large-scale fishing operations in the North Atlantic, by examining key policy relevant variables such as (i) the number of fishers they employ, (ii) the proportion of total annual catch that is landed by the two groups, (iii) the value of the catch they land, and (iv) annual catch that goes to the reduction industry relative to its use for direct human consumption. We gathered data from the literature to analyze the performance of the two sectors for the Canadian and Norwegian fishing fleets. We then used these country case studies to make inferences on how these two sectors perform at the level of the North Atlantic. Results from the analysis indicate, among other things that, small-scale fisheries employ more people for the same landed value, and that more of their catch is used for direct human consumption than large-scale fisheries. In some countries large-scale operations were more profitable (e.g., Norway) but there were countries in which small-scale operations did better (e.g., France). All in all, this study indicates that small-scale fisheries are better positioned to meet several of the policy goals set by both national governments and international organizations on the use of ocean resources.

Introduction

This paper compares small and large-scale fishing operations in the North Atlantic in similar fashion to Thompson (1980), who contrasted two classes of vessels for the developed and developing countries of the world. Thompson's work was later updated by FAO (see Maclean, 1988), leading to an iconic representation that was widely reproduced. In this paper, we develop a comparison of the two sectors in the North Atlantic, using Norway and Canada as case studies.

Table 1. Norwegian fishing fleets in 1998 divided into size categories.

Category	*Length (m)*
1	under 8
2	*8-12.9*
3	13-20.9
4	21-27.9
5	28-39.9
6	40 or over

Data on the following key fisheries variables were used to develop a similar comparison of the two fishing sectors:

- types and sizes of fishing vessels active in Norway and Canada;
- landings by small and large-scale fishing vessels;
- catch for direct human consumption by small and large-scale vessels;
- catch for industrial reduction to meal and oil by small and large-scale fishing vessels;
- landed values by small and large-scale vessels;
- number of fishers employed by the small and large-scale sectors;
- fishers employed for each $1 million invested in small and large-scale fishing vessels;
- total fuel consumed by small and large-scale vessels in Norway only; and
- mean fuel consumption per tonne of landings by small and large-scale vessels.

Other issues to be discussed are profitability of small and large-scale fishing vessels.

Materials and Methods

Definition of small and large-scale fisheries

In general there is no single definition of small and large-scale fisheries and/or commonly used definitions vary between countries. For many people, however, small-scale means artisanal and/or subsistence fisheries, both of these being made up of small vessels that operate in complex coastal areas. The first challenge for this paper is to find a reasonable definition of small and large-scale fishing operations that can be applied across countries in a given region. To do this, we follow the definition given in Ruttan *et al.* (2000). The cited paper categorizes fisheries as small or large on a relative rather than an absolute scale. The scale is based on vessel catch capacity, size or length, depending on the availability of data. The idea is that low catch capacity is a key attribute of 'smallness'.

To split the fisheries in Norway and Canada into large and small-scale, we prepare a list of vessel/gear types with their corresponding landed values. We then sort the data in ascending order of vessel/gear type, beginning with the smallest vessels. The cumulative landed value and corresponding cumulative percentage landed value are then computed. The cut off point between small and large vessels is taken to be the vessel size/type at which the cumulative percentage is 50. Note that this leads to cut off sizes that vary between countries.

Table 2. Landing and landed value data used to break down Norwegian fisheries into small-scale and large -scale, with the break at 50% of cumulative value of catch.

Gear/vessel type	Catch (t)	Value (1,000$)	Vessel	Crew	Energy Intensity (litres/tonne)	Cum. value (1000$)	Cum. % value
Others/1	295,273	172,986	10,903	13,084	-	172,986	12
Shrimp trawl/2	982	2,271	34	48	-	175,257	13
Shrimp trawl/com./2	1,111	2,175	35	49	-	177,432	13
Shrimp trawl/3	5,185	12,666	97	310	-	190,098	14
Bottom trawl/2	19,870	20,773	341	477	-	210,871	15
Gillnet/handline/2	36,744	35,758	530	742	-	246,628	18
Longline/2	16,032	17,519	187	262	-	264,148	19
Danish Seine/2	815	907	7	10	-	265,055	19
Shrimp trawl/com./3	7,906	9,028	55	176	1,500	274,083	20
Bottom trawl/3	22,095	18,678	100	320	589	292,761	21
Longline/3	20,699	22,752	80	256	572	315,513	23
Gillnet/handline/3	57,177	48,347	186	595	430	363,860	26
Seining/2	4,957	2,357	15	21	-	366,216	26
Danish Seine/3	46,990	38,610	113	362	478	404,826	29
Shrimp trawl/4	18,135	13,989	31	198	377	418,815	30
Bottom trawl/5	10,100	13,291	11	107	407	432,106	31
Danish Seine/4	41,232	24,885	39	250	298	456,991	33
Bottom trawl/4	49,127	34,581	45	288	248	491,572	36
Seining/3	80,310	29,983	66	211	159	521,555	38
Shrimp trawl/5	22,117	30,978	15	146	625	552,533	40
Shrimp trawl/6	13,450	27,452	9	119	1,309	579,985	42
Longline/5	87,819	130,866	58	563	382	710,851	51
Trawlers/5	80,842	80,604	47	456	434	791,455	57
Trawlers/6	84,173	96,274	39	515	495	887,729	64
Seining/4	95,637	34,625	42	269	133	922,354	67
Trawlers/6	86,270	124,662	21	277	640	1,047,016	76
Purse seining/6	231,792	67,509	34	449	96	1,114,525	80
Trawlers/5	423,429	62,749	54	524	95	1,177,274	85
Purse seining/6	126,155	38,693	16	211	126	1,215,967	88
Purse seining/6	864,361	168,736	41	541	85	1,384,704	100
Total	**2,850,785**	**1,384,704**	**13,251**	**21,834**	-	**16,425,165**	-

COUNTRY ANALYSIS: NORWAY

Fishing Fleet Structure

The Norwegian fishing fleet is reported to consist of 13,251 vessels in 1998, of which 10,870 were less than 8 meter in length. Thus, vessels of this size constituted about 82 percent of the total number of vessels active in Norway. About 2,348 vessels 8 meter length and over were fishing year-round, 1,199 of these were of 13 meter length and over. This group accounted for 9 percent of the total number of vessels (Anon., 1999 and Anon., 2000a).

The fleet could be divided into the following categories: (i) large purse seines fishing for pelagic species, for instance, herring, mackerel and capelin; (ii) large factory trawlers fishing either for shrimp or demersal species, such as cod and haddock; (iii) small steel trawlers, purse seines and shrimp trawlers fishing for small quantities of a number of different fish species; and (iv) a large number of highly diversified boats, known collectively as 'coastal' vessels that fish along the Norwegian coast (FAO, 1998).

Total number of crew fully employed in the Norwegian fishing industry was reported to be 15,141 in 1998. In addition, 6,157 fishers worked part time in the fishery, according to Norwegian Fisheries Statistics (Anon., 2000a).

Landing, landed values and profitability

The total catch by Norwegian fishing vessels in 1998, including crustacean and molluscs, was estimated at 2,850 thousand tonnes, with a landed value of about US$1,385 million. The demersal and pelagic fisheries accounted for 25 percent and 73 percent of total landings, respectively. These landings produced about 60 percent and 30 percent of the total landed values. The top four species fished in 1998 (in terms of landings) were herring (831,700 t); blue whiting (570,700 t); sandeel (343,400 t) and Northeast Atlantic cod (321,600 t). In terms of landed values, the top species are Northeast Atlantic cod (US$ 446 million); herring (US$ 194 million), saithe (US$ 139 million) and deep water prawn (US$ 107 million) (Anon., 2000b).

Vessels that operate year-round took nearly 90

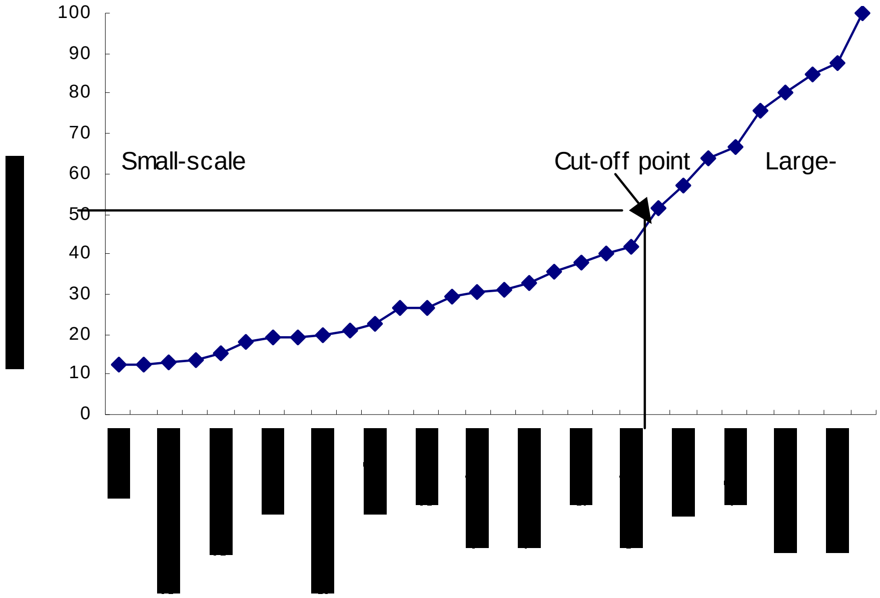


Figure 1. Gear/vessel type against cumulative percentage landed value. The 50 percent cumulative landed shown as cut-off point for small and large-scale fisheries

percent of the total landings and captured about 88 percent of landed values from Norwegian fisheries in 1998. Of these amounts, the vessels 13 meter length and over contributed 87 percent and 82 percent in total landings and landed values, respectively (Anon., 1999).

It is reported that in 1998, fishing vessels 8-meter length and over that operated year-round in Norway earned a total operating profit of (US$ 200 million). The average operating margin for vessels 8-12.9 meters was estimated to be 9.2 percent; the equivalent margin for vessels 13 meter and over was about 16.1 percent (Anon., 1999). It therefore appears that larger Norwegian vessels are more profitable than smaller ones.

Splitting fisheries into small-scale and large-scale

Data were mainly extracted from Anon. (1999), which gives a detailed survey of profitability for vessels 8 meters and over, operated year-round. As mentioned earlier, this group of vessels accounted for 90 percent and 88 percent of total landings and landed values from Norwegian fisheries. The rest of the landings and landed values were assumed to come from vessels less than 8 meter length, that is, coastal boats with diverse gears. To obtain landings, landed values, number of vessels and crew size for this group of vessels, we deduct from the totals of these values for vessels that are 8-meter length and over.

The vessel/gear categories employed in Norwegian fisheries are gill-net/handline, Danish seines, longline, purse seine, bottom (or factory) trawl, shrimp trawl, and other trawls. It should be noted that boats less than 8 meter in length are classified as 'others' because most of them are not operated year-round, and they use highly diverse gears. We divide the different vessels operating in Norway into six groups in terms of vessel length as shown in Table 1 below. Landings and landed values are sorted in ascending order of average vessel size.

Finally, average crew sizes of each vessel group are applied to compute total crew members for each vessel group. This gives total crew size of 21,834, very close to the 21,298 reported in Norwegian Fisheries Statistics for the 1998.

Table 2 presents landing and landed value data used to split Norwegian fisheries into small and large-scale following Ruttan et al. (2000). Other data reported in this table are number of vessels of the different groups employed and their crew sizes.

Reduction and human consumption

According to Anon. (2000a), 46 percent (that is, 1,308 thousand tonnes) of total Norwegian landings (excluding seaweed) go to reduction fisheries for fishmeal, oil and other similar uses. The key species destined for reduction are Atlantic herring, Atlantic mackerel, blue whiting, capelin, Norway pout, sprat and sandeel. Of these species, blue whiting, capelin, sprat, sandeel,

Table 3. Canadian fishing fleets in 1998 divided into size categories

Class	Tonnes
0	Not known
1	0-24.9
2	0-49.9
3	50-149.9
4	150-499.9
5	500-999.9
6	1000-1999.9
7	2000 or greater

FISHERY BENEFITS	**SMALL-SCALE**	**LARGE-SCALE**
Number of fishers	18,592	3,242
Number of vessels	12,957	294
Annual Catch (1,000 tonnes)	858	1,993
Annual catch (1,000 tonnes) of marine fish for human consumption	724	816
Annual catch (1,000 tonnes) of marine fish for industrial reduction to meal and oil, etc.	134	1176
Landed value (million US$)	711	674
Total fuel consumed (million litres)	350	300
Energy intensity (litres/tonne)	410	150
Fishers employed for each $1 million landed value	26	5

Figure 2: Comparison of small-scale and large scale fisheries for Norway in 1998.

Atlantic horse mackerel and Norway pout go in total for reduction. For the remaining species, 27 percent of total landings go to reduction, while 17 percent of landed values are derived from industrial use (Åse Mobråten, pers. comm.). We apply this information to calculate and report in Figure 2 the quantity of Norwegian fish landings used for industrial purposes.

Fuel consumption

From the analysis by Tyedmers (2001), estimates of the total fuel consumed and fuel consumption per tonne of landings (i.e., energy intensity) by all Norwegian fleet sub-sets comprised of vessels greater than 13m in length were available. As a result, while data were available regarding the fuel consumed by the entire Norwegian large-scale sector, fuel use data were only available for just over 55% of the small-scale sector's total landings (Table 2). However, by assuming that the rate of fuel consumption by Norwegian vessels smaller than 13m approximates that of the rest of the small-scale sector's fleet sub-sets, we were able to estimate the total fuel consumed by this sector.

Results

The results illustrated in Figure 2 show that (i) small-scale fisheries in Norway employ about five times more people than large-scale fisheries, while they land only 43 percent of the landings of the large-scale fishers, (ii) small-scale fisheries send only 15 percent of their landings to the reduction industry, the equivalent number for the large-scale sector is about 60%; (iii) small scale fisheries achieve nearly 150 percent more landed value per tonne than their large scale counterparts; (iv) in terms of total fuel consumed, the small and large-scale sectors consume roughly equal amounts, about 350 and 300 million litres respectively; (v) small-scale fisheries create 26 jobs for each US$1 million they generate, while the large-scale fisheries generate only 5 for the same amount of landed value; and (vi) small-scale fisheries consume, on average, almost three times more energy per tonne of fish or shellfish landed as do large scale fisheries. This is most probably because large-scale vessels in Norway target quite a lot of pelagic (schooling) species.

Table 4. Landing and landed value data used to break down Canadian fisheries into small-scale and large-scale, with the break (horizontal line) at 50% of cumulative value of catch.

Gear/vessel	Catch (t)	Value (1,000$)	Vessels	Crew	Cum. value (1,000$)	Cum. % value
Grappling /0	78	123	4	8	123	0.01
Mobile Seine/0	225	177	10	22	301	0.03
Other Gear/0	2,704	3,288	125	265	3,588	0.33
Hooks and Lines/0	7,870	9,920	363	772	13,508	1.25
Surrounding Nets/0	21,752	22,915	1,003	2,134	36,423	3.38
Gillnets /0	25,120	38,032	1,159	2,465	74,455	6.91
Traps and Lift Nets/0	88,143	133,624	4,065	8,649	208,079	19
Traps and Lift Nets/1a	70,993	307,859	3,274	6,966	515,938	48
Dredges/0	3,264	2,241	151	320	518,178	48
Other Gear/1	44,524	33,173	2,053	4,369	551,351	51
Bottom Trawls/0	41,229	53,910	1,901	4,046	605,261	56
Hooks and Lines/1	13,519	30,593	623	1,327	635,853	59
Bottom Trawls/1	10,930	15,421	504	1,073	651,274	60
Dredges/1	8,360	7,989	386	820	659,263	61
Surrounding Nets/1	3,991	4,062	184	392	663,326	62
Gillnets /1	72,204	69,155	3,330	7,085	732,481	68
Midwater Trawls/0	2,153	824	99	211	733,305	68
Grappling /1	390	1,827	18	38	735,132	68
Mobile Seine/1	1,590	1,346	73	156	736,478	68
Bottom Trawls/2	20,559	20,712	615	1,755	757,189	70
Midwater Trawls/2	10	5	0	1	757,195	70
Mobile Seine/2	2,810	2,277	84	240	759,472	70
Surrounding Nets/2	3,653	4,799	109	312	764,271	71
Gillnets /2	6,386	9,401	191	545	773,672	72
Hooks and Lines/2	6,614	11,415	198	564	785,087	73
Traps and Lift Nets/2	12,360	36,577	370	1,055	821,664	76
Dredges/2	3,646	3,255	109	311	824,919	77
Grappling /2	129	1,002	4	11	825,921	77
Other Gear/2	408	646	12	35	826,567	77
Bottom Trawls/3	56,296	68,097	472	1,638	894,664	83
Mobile Seine/3	629	533	5	18	895,197	83
Surrounding Nets/3	37,431	14,280	314	1,089	909,476	84
Gillnets /3	1,882	4,803	16	55	914,279	85
Hooks and Lines/3	2,287	5,764	19	67	920,044	85
Traps and Lift Nets/3	11,074	18,011	93	322	938,054	87
Dredges/3	5,293	4,635	44	154	942,689	87
Grappling/3	111	262	1	3	942,951	88
Other Gear/3	129	203	1	4	943,154	88
Bottom Trawls/4	6,338	4,924	11	85	948,078	88
Midwater Trawls/4	260	105	0	3	948,183	88
Surrounding Nets/4	57,726	22,936	99	775	971,119	90
Gillnets /4	65	104	0	1	971,223	90
Hooks and Lines/4	1,455	3,461	3	20	974,684	90
Traps and Lift Nets/4	1,404	4,326	2	19	979,010	91
Dredges/4	40,845	41,639	70	548	1,020,650	95
Bottom Trawls/5	10,613	8,838	14	197	1,029,487	96
Midwater Trawls/5	2,827	1,101	4	53	1,030,588	96
Dredges/5	3,092	3,142	4	58	1,033,730	96
Bottom Trawls/6	8,431	13,094	5	77	1,046,824	97
Dredges/6	9,471	6,377	5	87	1,053,201	98
Bottom Trawls/7	18,624	24,192	10	243	1,077,393	100
Total	**751,897**	**1,077,393**	**22,210**	**51,462**	**2,154,785**	**-**

COUNTRY ANALYSIS: CANADA

Fishing fleet structure

Data reported by Canada's Department of Fisheries and Oceans (DFO) shows that a total of about 22,100 vessels were used to exploit fish in Eastern Canada in 1998. Using the average crew sizes of the different vessel types active in the Scotia-Fundy and Gulf regions of Canada (W.J. MacEachern, pers. comm.), we determined that there were about 51,462 active crew-members on the east cost of Canada in 1998.

Most of the active fishing fleets on the east coast, that is, Atlantic Canada, are less than 65ft in length. In fact, this group makes up 99 percent of total Canadian fishing vessels in 1998 (Anon., 2000c). Most of these vessels operate 'inshore' (P. Fanning and S. Guénette, pers. comm.). The inshore fleet is usually split into three groups, those under 35ft length, those between 35 and 45 ft, and those between 45 and 65 ft. Amongst these groups, vessels under 35ft number around 15,000, representing 85 percent of licensed vessels operating in Canada in 1998. The vessels range from motorized, open-decked boats to small trawlers, Danish seiners and longliners with sophisticated equipment. Most inshore vessels are versatile, participating in the groundfish fishery as well as other fisheries such as those for lobsters, herring, mackerel and squid. Only 1 percent or 171 of the total number of fishing vessels are over 65ft in length, they operate offshore. These vessels are highly specialized, mobile, capital-intensive units, normally running year-round, depending on resource availability (FAO, 2000).

Landings and landed values

According to official Canadian statistics, a total of about 785 thousand tonnes of marine fishes were landed on the Atlantic coast of Canada in 1998, valued at about US$ 869 million. In terms of landings, the top four species were herring (191,144t), shrimp (107,909t), queen crab (75,219t) and scallop (63,035t). With respect to landed values, shellfish dominated, with lobster contributing US$ 299 million, followed by shrimp with a contribution of US$ 168 million, queen crab generated US$ 118 million, and scallop was forth with US$ 65 million landed value (Anon., 2000c).

Splitting into small-scale and large-scale fisheries

The catch data and tonnage/gear size definition we used for Canadian fisheries analysis are derived from Watson et al. (this volume), which is to a great extent based on official Canadian Fisheries Statistics and FAO Statistics.

The price per unit weight of each species is obtained by dividing their total landed values with the total landings for each species as reported in Canadian Fisheries Statistics for 1998. These prices are then applied to the catches, leading to the landed values reported in Table 4.

FISHERY BENEFITS	SMALL-SCALE	LARGE-SCALE
Number of fishers employed	25,972	25,491
Number of vessel	12,207	10,003
Annual Catch (1,000 tonnes)	265	487
Annual catch (1,000 tonnes) of marine fish for human consumption	265	487
Landed value (million US$)	551	526
Fishers employed for each $1 million invested in fishing vessels	47	48

Figure 4. Comparison of small and large-scale for Atlantic Canada fisheries in 1998.

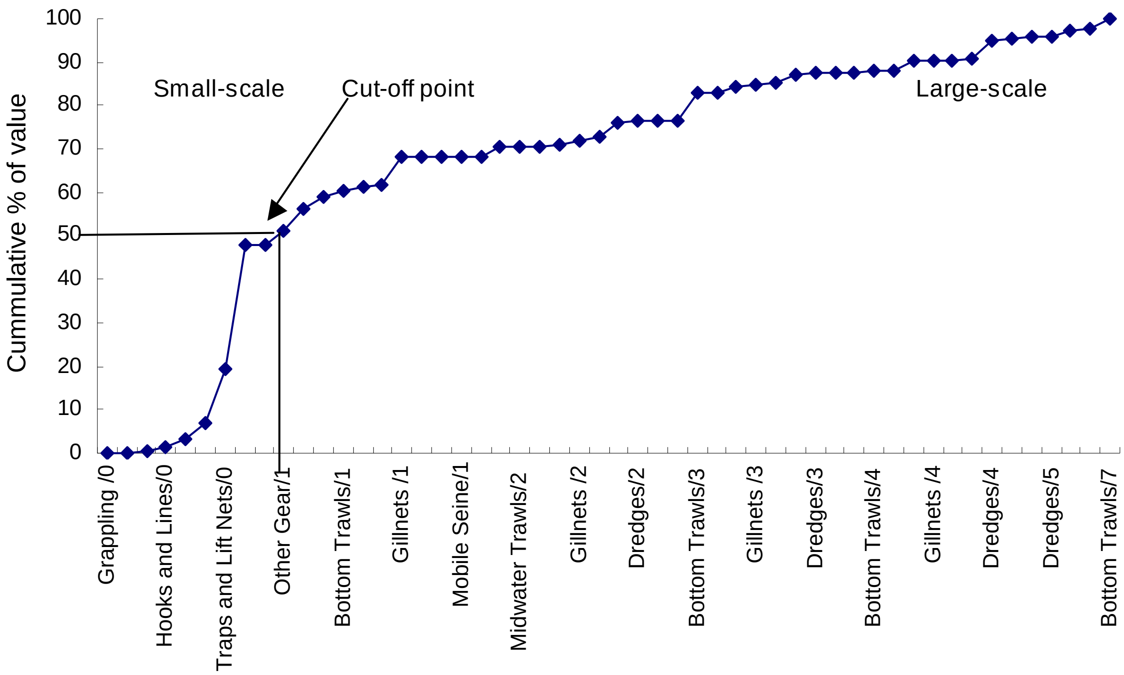


Figure 3: Gear/vessel type against cumulative percentage landed value. The 50 percent cumulative landed shown as cut-off point for small and large-scale fisheries

Reduction Fisheries

Currently, by law, there are no directed reduction fisheries in Canada,. The only reduction activities still taking place in Canada use fish wastes, such as offals and bones, and carcasses from some roe fisheries (SW Nova Scotia spring herring). There used to be foreign vessels operating reduction plants in Canada: vessels from the then USSR produced fishmeal from wastes, undersized or low quality silver hake. They also had a capelin fishery which was specifically for reduction, but that was terminated in the 1970's (P. Fanning, pers. comm.). Thus, both landings and landed values for reduction fisheries in Canada are zero, and hence the entire landings by Canadian fisheries are for direct human consumption.

Results

The results reported in Figure 4 below show that (i) small-scale fisheries in Canada employ slightly less people than the large-scale sector; (ii) large-scale fisheries land about 80 percent more tonnes of fish than small-scale fisheries; and (iii) small-scale fisheries achieve double the landed values obtained by the large scale sector per tonne of landings.

Discussion

A comparison of the results obtained for Norway and Canada show that Norwegian small-scale fisheries employ more people per dollar of landed value than Canadian small-scale fisheries. Also, the difference in employment between small and large-scale fisheries is smaller in Canada than in the case of Norway. This may be explained by the fact that Norway has a lot more small vessels, and that the difference between large and small among the Norwegian fleets is much greater than among Canadian vessels. Our study reveals that in both countries (taken together), and presumably in the North Atlantic as a whole, small-scale fisheries employ on average more people for a given amount of landed value they generate. In addition, more of their catches are used for direct human consumption than catches by large-scale vessels.

With respect to profitability, large-scale vessels in Norway appear to do better than the small-scale fisheries (Anon., 2000). On the other hand, small-scale fishers appear to be more profitable in other countries of the North Atlantic. For instance, Lery et al. (1999) reports that Spanish and French deep-sea trawlers achieved a return on investment of 7.3 and 3.1 percent, respectively. On the other hand Spanish coastal seiners (small-scale) and French handliners (small-scale) achieved returns on investment of 13.1 and 29.9 percent, respectively. In conclusion, this study shows that relative to large-scale fisheries, small-scale fisheries are more capable of meeting several of the policy goals formulated by various countries, for example, catching fish for direct human consumption, providing jobs to the population, and deriving a higher economic value from each tonne of fish caught.

Acknowledgement

We would like to thank all members of the *Sea Around Us* project (SAU), participants at the SAU Final Report Workshop, in Nanaimo, April, 2001, Paul Fanning, Aase Mobraaten, and W.J. MacEachern for their helpful comments, suggestions and/or review of this article. We are also grateful to the Pew Charitable Trusts for their support of this work.

References

Anon. 2000a. Fishing and fish farming, Statistical Yearbook of Norway 2000,

Statistics Norway, Oslo, Norway. Available at http://www.ssb.no/english/subjects/10/05/fiskeri_en/

Anon. 2000b. Traditional Fisheries Statistics. Directorate of Fisheries, Bergen, Norway, Available at http://www.fiskeridir.no/english/pages/statistics/statistics.html

Anon. 2000c. Landing information. Canadian Fisheries Statistics in 1998, Ottawa, Canada, Available from

http://www.dfo-mpo.gc.ca/communic/statistics/landings/land_e.htm.

Anon. 1998. Fishery Statistics 1996-1997, Official Statistics of Norway (NOS C 623), Oslo, Norway, 116p.

Anon. 1999. Profitability survey on Norwegian fishing vessels 1998. Directorate of Fisheries, Bergen, Norway, 133p.

FAO. 2000. Country profile – Canada, Fisheries-Socio-Economics, FAO, Rome, Italy. Available at http://www.fao.org/fi/fcp/canadae.asp

Lery, J.M., J. Prado and U. Tietze 1999. Economic viability of marine capture fisheries. FAO Fisheries Technical Paper No. 377. Rome, FAO, 130p.

Ruttan, L.M, F.C. Gayanilo Jr, U.R. Sumaila and D.Pauly, 2000. Small versus large-scale fisheries: a multi-species, multi-fleet model for evaluations and potential benefits. In Pauly, D. and Pitcher, T.J.(eds.) Methods for evaluation the impacts of fisheries on North Atlantic ecosystems. Fisheries Centre Research Reports, 8(2), 64-75.

Maclean, J.L. 1988. Thanks for using Naga. Naga, The ICLARM Quarterly, 11(3), 16-17.

Thompson, D. 1980. Conflict within the fishing industry. ICLARM Newsletter, 3(3), 3-4.

Tyedmers, P. (2001) *Energy Consumed By North Atlantic Fisheries.* Pages 12-34 in Zeller, D., Watson, R. and Pauly, D. (eds) (2001) Fisheries Impacts on North Atlantic Ecosystems: Catch, Effort and National/Regional Data Sets. Fisheries Centre Research Reports 9 (3): 254 pp.

Watson, R., S.Guénette, P.Fanning and T.J.Pitcher, 2000. The basis for change: Part 1, reconstructing fisheries catch and effort data. In: Pauly, D. and Pitcher, T.J. (eds) Methods for assessing the impact of fisheries on North Atlantic ecosystems, Fisheries Centre Research Report 8(2), 23-39.

Fisheries Science and Management in the North Atlantic

Jean-Jacques Maguire
Quebec City, Canada

Abstract

Institutionalised fishery management in the North Atlantic dates at least 100 years. The structure, processes and roles of major interested parties involved in fishery science and management (i.e., international entities: ICCAT, ICES, NEAFC, NAMMCO, NASCO, NAFO, EU, and Norway, Iceland, The Faroe Islands, Greenland, Canada, and the USA) and how they are linked are described. The deterioration of fishery statistics as a result of the imposition of management measures without the implementation of adequate monitoring, control and surveillance programs is almost universal. Strength and weaknesses of the various components in each fishery management processes are identified and discussed, with particular emphasis on the consequences of the single species approach generally used and for the involvement of interested parties. Improved arrangements for the provision of management advice are suggested.

Introduction

Fishery management activities have grown considerably in the North Atlantic over the last 50 years. After the Second World Ware, several fishery management arrangements were created for offshore, large vessels, distant water fisheries. With the large scale extension of Exclusive Economic Zone to 200 nautical miles in the mid to late 1970s, fishery management activities grew considerably and became applied to almost all fisheries, including small scale operations.

The organisation and processes of fishery management are described based, as far as possible, on up-to-date information available on the web sites of the various bodies involved. The discussion identifies some strengths and weaknesses of the various processes and institutions examined (see also Alder et al. this volume).

Northeast Atlantic

The main administrative separation in the Atlantic ocean is at 42º W, just eastward of the Flemish Cap. At 59º N, the boundary moves westward to 44º W to the southernmost tip of Greenland. There is a similarly jagged boundary in the Barents Sea where the main boundary is at 30º E, except from 72º N where it moves westward to 26º E to the northern tip of Norway. The Northeastern Atlantic extends to 36º N, while the Northwestern Atlantic extends to 35º N (note that this definion of the North Atlantic is is slightly different from that of the Sea Around Us project (see Pauly et al. 2000).

ICES

The International Council for the Exploration of the Sea (ICES) is an intergovernmental organisation created in 1902. There were, there are nineteen member country as of the year 2000: Belgium, Canada, Denmark, Estonia, Finland, France, Germany, Iceland, Ireland, Latvia, Netherlands, Norway, Poland, Portugal, Russia, Spain, Sweden, United Kingdom and, United States. Observer status has been granted to Australia (i.e., its Commonwealth Scientific Industrial and Research Organisation), South Africa (Sea Fisheries Institute), Greece (Institute of Marine Biology of Crete) and World Wide Fund for Nature (WWF). ICES currently operates under the terms of its 1964 Convention.

ICES is a multifaceted organisation. To many, it is a scientific organisation with almost half of the close to 80 meetings to be held in 1999-2000 being primarily of a scientific nature. To others, it is mostly an advisory organisation with its two main advisory committees, the Advisory Committee on the Marine Environment (ACME) and the Advisory Committee on Fishery Management (ACFM) and their associated Working Groups. ICES is a forum for the exchange of information and ideas on the sea and its living resources, and for the promotion and coordination of marine research by scientists within its member countries. "Since the 1970s, a major area of ICES work as an intergovernmental marine science organisation is to provide information and advice to Member Country governments and international regulatory commissions (including the European Commission) for the protection of the marine environment and for fisheries conservation. This advice is peer-reviewed by the Advisory Committee on Fishery Management (ACFM) and the Advisory Committee on the Marine Environment (ACME) before passing on" (http://www.ices.dk).

ICES being an intergovernmental organisation, most participants in its working groups, study groups and advisory meetings leading to the provision of fishery management advice are members of government fishery research institutes.

ICES currently provides traditional fishery management advice, mostly in the form of advice on Total Allowable catches (TAC), but also advice on technical measures (mesh size, closed areas and seasons, etc.) through its Advisory Committee on Fishery Management. ACFM relies on sixteen assessment working or study groups. Half of the assessment groups are area-based, i.e., including most species that occur in a given area, e.g. the Arctic Fisheries working group, and half are species oriented, e.g., the Mackerel, Horse Mackerel, Sardine and Anchovy Working Groups.

Somewhere between 170 and 200 scientists participate each year in the assessment meetings. The Pandalus assessment WG in 1999 had only three participants (chairperson included), the largest number was for the joint EIFAC/ICES (European Inland Fishery Advisory Committee) Working Group on Eels where 41 scientists from 27 countries attended. The heaviest workload was arguably that of the northern shelf demersal assessment working group, whose 8 participants had to provide information or assessment on no less than 14 stocks.

At its annual meeting in 2000, ICES created an Advisory Committee on Ecosystems (ACE). It "is ICES official body for the provision of scientific advice and information on the status and outlook for marine ecosystems and on the exploitation of living marine resources in an ecosystem context. ACE provides a focus for advice that integrates consideration of the marine environment and fisheries in an ecosystem context, such as the ecosystem effects of fishing." The Advisory Committee on Ecosystem will holed its first meeting in August 2001 (http://www.ices.dk/committe/ace/ace.htm). The creation of the Advisory Committee on Ecosystems shows that ICES recognise the need for an ecosystem approach.

In addition to the Advisory Committee on Ecosystem, ICES also created at its 2000 Annual Meeting, a Management Committee for the Advisory Process to interact with Partner Commissions and other clients, route the request for advice to the appropriate Committee, ensure adequate expert participation to review the questions at hand and co-ordinate the preparation and delivery of advice, among other things. The existence of two advisory committees (ACME and ACFM) was already an impediment to the provision of consistent integrated advice. It is doubtful that the creation of a third advisory committee (ACE) will simplify matters, decrease the workload, increase the quality of background analyses, etc. However, ACE might help focus research on the ecosystem effects of fishing.

NEAFC

"The origins of the North East Atlantic Fisheries Commission lie in an organisation known as the Permanent Commission which was founded in 1953. The Permanent Commission was formed under the 1946 Convention for the Regulation of Meshes of Fishing Nets and the Size Limits of Fish. However, by the early 1960s it was considered that the Commission needed a wider range of powers to regulate for the effects of the technological advances in fishing methods. In 1963 the North East Atlantic Fisheries Commission (NEAFC) was formed under the North East Atlantic Fisheries Convention to succeed the Permanent Commission. In addition to the powers of the Permanent Commission, NEAFC could also establish closed fishing areas and seasons, and regulate catch and fishing effort." (http://www.neafc.org/index.htm)

"The present NEAFC Convention entered into force in 1982 and there are currently six contracting parties: The European Community, Denmark (on behalf of the Faroe Islands and Greenland), Iceland, Norway, Poland and the Russian Federation.

NEAFC acts as a forum for the commissioning and dissemination of scientific advice on the state of fish stocks in the northeast Atlantic. The Advisory Committee on Fisheries Management of ICES supplies NEAFC with scientific advice and, on the basis of this advice, NEAFC establishes conservation and management measures. At present [1998] the main stocks to be regulated by NEAFC are Atlanto-scandian herring and oceanic redfish. However, the number of regulated stocks is likely to increase in the near future."

The role of NEAFC progressively diminished in the late 1970s and most of the 1980s as a result of coastal states extending their EEZs to 200 nautical miles. However, the rebuilding of the Atlanto-Scandian herring at the end of the 1980s, the development of fisheries for oceanic redfish and blue whiting, as well as the expansion of the mackerel fishery outside of national EEZs have provided a focus for the revival of NEAFC who now has a permanent secretariat.

NAMMCO

"NAMMCO - the North Atlantic Marine Mammal Commission - is an international body for cooperation on the conservation, management and study of marine mammals in the North Atlantic. The NAMMCO Agreement, which was signed in Nuuk, Greenland, on 9 April 1992 by Norway, Iceland, Greenland and the Faroe Islands, focuses on modern approaches to the study of the marine ecosystem as a whole, and to understanding better the role of marine mammals in this system. NAMMCO provides a mechanism for cooperation on conservation and management for all species of cetaceans (whales and dolphins) and pinnipeds (seals and walruses) in the region, many of which have not before been covered by such an international agreement." (http://www.nammco.no). Canada, Denmark (on behalf of the Faroe Islands and Greenland), Russia, and Japan normally send observers to NAMMCO meetings.

NAMMCO is hosted by the University of Tromsø, in Tromsø, Norway. NAMMCO has a Council, a Management Committee and a Scientific Committee. It was created to overcome the inability of the International Whaling Commission (IWC) to provide scientific and management advice for the harvesting of marine mammals.

National management (Within EEZ)

Iceland

Iceland's economy depends heavily on fisheries, with around 80% of the commodity exports in Iceland or 50% of the foreign exchange earnings originating from fishery products. The fishery's total direct and indirect contribution to the Gross Domestic Product (GDP) is estimated to be as high as 45% (Arnason 1995).

Six government bodies are directly involved in fishery management in Iceland: The Ministry of Fisheries, the Directorate of Fisheries, the Marine Research Institute, the Icelandic Fisheries Laboratories, the Icelandic Coast Guard, and the Ministry of Foreign Affairs.

"The Ministry of Fisheries is responsible for management of fisheries in Iceland and the implementation of legislation, and issues regulations to this effect. Its duties are general administration, long-term planning and relations with other fisheries institutions at the international level. The Minister of Fisheries is responsible for the annual TAC decisions." (http://brunnur.stjr.is/interpro/sjavarutv/english.nsf/pages/front).

The Directorate of Fisheries is a Government institution under the ultimate responsibility of the Minister of Fisheries. The Directorate is responsible for [...the] implementation of all laws and regulations covering fisheries management, administration of fishing activities and imposition of special fines for illegal catches. Enforcement of the laws regarding the handling and inspection of marine products. Collection, processing and publication of data relating to fisheries management, marine research and all relevant statistics on fishing and processing." (http://www.hafro.is/dirfish/dirfish/mandate.html).

The Marine Research Institute provides fishery management advice to the Minister of Fisheries, either directly or through the Advisory Committee on Fishery Management of the International Council for the Exploration of the Sea (ICES) (http://www.hafro.is/hafro/intro.html).

"The Icelandic Fisheries Laboratories is a research institution in the field of foodstuffs, with specialisation in marine resources and products. The role of IFL is to increase the competitiveness of its customers through research, services and dissemination of information. IFL emphasises high quality in all operations. In carrying out this role, the laboratories may work independently or in co-operation with other parties such as universities, institutions and enterprises." (http://www.rfisk.is/general/aboutifl.htm).

The Icelandic Coast Guard is responsible for monitoring, control and surveillance of the fishing activities while the Ministry of Foreign Affairs is responsible for international agreements.

In 1973, Iceland had implemented effort controls in its fisheries. By 1983, it was clear that the effort controls had not limited fishing mortality and the cod stock was in decline. Individual transferable quotas (ITQs) were introduced in 1984 with the objectives of limiting the total catch and increasing efficiency through rationalisation of the fleets. The ITQ system underwent several adjustments to rectify shortcomings and unintended negative side-effects. The quota represent a share of the Total Allowable Catch (TAC) of all regulated species, and the quotas can be sold and bought without restrictions between licensed fishing vessels registered in Iceland.

The ITQ system and the associated TAC decision are the cornerstone of Iceland's fisheries management, but there are a number of other measures including:

- A tonne-for-tonne withdrawal of fishing capacity when a new vessel is introduced into the fleet;
- Control on fishing gear e.g. minimum mesh sizes;
- Trawl bans in large coastal spawning and nursery areas;
- Sorting grids in shrimp fishing to limit the catches of juvenile fish;
- Extensive provision for temporary closures of fishing areas to protect spawning fish from all fishing;
- Provisions giving the Marine Research Institute the

authority to close fishing areas temporarily without prior notice if the proportion of small fish in the catch exceeds certain limits.

These measures, however, were insufficient to protect the cod stock and the agreed TAC consistently exceeded the catches advised either nationally or through ICES from 1987 to 1996. Over this period, catches decreased from 392 000t in 1987 to 169 000t in 1995. Extensive simulation work and consultation with interested parties were held nationally and in 1997 a catch rule whereby the TAC is automatically set at 25% of the stock biomass was implemented. Although this appeared to have resulted in stock recovery (ICES 1999), and a stock size in the order of one million tonnes, very recent developments (as of July 2001) suggest that cod biomass and the extent of the recovery may have overestimated.

According to Runolfsson and Arnason (1996 and hag.hi.is/~bthru/iceitq1.html), for ITQ species, most landings are accounted for. Although there are some violations of the various regulations, these are considered negligible.

Norway

Norway prides itself with one of the most effective fishery management system in the world. Contrary to Canada whose management was unsuccessful at protecting their Northern cod, Norway's quick reaction in decreasing the agreed TAC (from 560 000t in 1987 to 451 000t in 1988, 300 000t in 1989 and 160 000t in 1990), the fishing activity of the fleets, and strict surveillance of fishing activity combined with favourable environmental conditions allowed the Northeast Arctic cod to successfully rebuild in the 1990s. Unfortunately, this stock rebuilding was short lived, and by 1997, TACs again had to be reduced substantially.

We have not found a concise description of how fishery management works in Norway, but apparently, the organisation is very similar to that described for Iceland. However, "eighty per cent of Norwegian fisheries is harvesting stocks shared with other countries, Russia and the EU being the most important" (OECD 1997). Therefore, most Norwegian TAC decisions are the result of bilateral international negotiations, and contrary to the Icelandic Minister of fisheries who has authority over such issues, the Norwegian Minister can only decides on the mandate for the Norwegian delegation to the international negotiations. This is normally based on discussions involving interested parties, including scientists and the industry. However, "The internal distribution of the national quotas are determined by the Ministry of Fisheries, on the basis of recommendations from an advisory board, representing different sectors of the industry, and other relevant organisations. Considerations of conservation and distributive aspects are the main background for the national distribution of the national share of the agreed TAC. While local interests play an important part in this process, local fishery administration is restricted to advisory activities. The management system is based on a number of laws, the important being the Salt Water Fisheries Act. On the basis of this law a number of measures controlling the fisheries are left to the discretion of the Ministry of Fisheries in Oslo, and the Directorate of Fisheries in Bergen. These two bodies have the power to decide upon – partly on a day-to-day basis – a number of management measures. The control of the implementation of the management decisions is made by the National Control Board and the Coast Guard. The latter inspects both Norwegian and foreign vessels in Norwegian fishing areas. The coastal guard also surveys activities in international waters. Non-compliance with regulation in Norwegian waters are punished by fines and withdrawals of licences. [...] On the basis of the Salt Water [Fisheries] Act, the Ministry of Fisheries and the Directorate of Fisheries have at their disposal a wide variety of management instruments – fishing permits, quotas, gear regulations (mesh size), by-catch regulations, minimum fish size, time and area closures, etc. Considerations on resource conservation, efficiency and distribution are the background for the use of these instruments (OECD 1997).

European Union member countries

Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom are presently members of the European Union (EU). Their fisheries are managed under the EU Common Fishery Policy (CFP).

OECD (1997, p. 43) provides a succinct and useful description of the EU Common Fishery Policy: "The Common Fisheries Policy (CFP) of the European Union is based on the Treaty of Rome signed in 1957. Article 39 specifies the general objectives: a) to increase productivity; b) to improve fishing communities standards of living; and c) to stabilise markets, supply and prices to the benefit of the consumers. More recently the Treaty of the European Union (the Maastricht Treaty) has inserted Article 130R which requires that environmental impacts be taken into account in all community policies. The environmental aspects therefore also have to be taken into account in the implementation of the CFP.

The CFP covers markets, structures (including fleets), the management of external resources fished in the EEZ of the Member States ('Community waters'), and access to 'external' resources located in international waters or in the waters of third countries.

The structural policy was originally designed to assist the modernisation of the fishing fleets and to improve the processing and marketing sectors. In recent years the reduction of overcapacity of the fishing fleet has, however, been given increasingly higher priority.

Policy on the conservation and management of resources is the cornerstone of the CFP. Technical measures (mesh sizes, minimum landing sizes, closed areas, etc.), have always played an important role. Before 1983 decisions were taken within the framework of international agreements on the management of the fish resources. In 1983 the first framework regulation supplementing a 1976 Community agreement was adopted to regulate access by fishing vessels to Community waters. Based on this regulation, decisions are taken annually on technical measures and on limitation of catches (Total Allowable Catches or TACs) and on their allocation among Member States according to the Principle of Relative Stability, i.e., by the use of fixed allocation keys. This principle is of crucial importance to the smooth operation of the CFP. It leaves to each Member State a broad margin of freedom to decide how to exploit the allocated fishing opportunities."

"The Common Fishery Policy in its present form was adopted in 1983 for a 20 year period, to last to the end of 2002. The review of the CFP in 1992 resulted in a new basic regulation (Reg. 3760/92). This revision provides the framework at the EU level:

- For complementing output controls (TACs) with input controls (restriction on effort);
- For establishing a better integration between management of resources and measures to restructure the fleet;
- For multi-annual decisions on the exploitation of resources;
- For reinforced inspection and monitoring of the fisheries.

Effort constraints on vessel capacity and restrictions on the number of days at sea have for demersal fisheries been implemented according to this regulation since 1 January 1996 (OECD 1997, p. 44)."

Three different bodies are involved in the EU decision-making process. "The Commission has the right of initiative, i.e., of making proposals to the Council. In most cases the European Parliament must be consulted, but the final decision is made by the Council. [...] Whereas TACs are decided and allocated between Member States at the EU level, further allocations of quotas and other fishing rights between individual fishers or groups of fishers (e.g. Producer Organisations) are decided at a Member State level. Also the responsibility for implementation and control remain the competence of the Member State (OECD 1997, p. 44)".

Producer organisations (POs) are present in every EU country, but their role vary from country to country. They are in fact organised groups of fishers who "are given legal responsibility to ensure that fishing is carried out 'along rational lines' and conditions for sale are improved. They may also be charged with ensuring the proper management of catch quotas. To be recognised, POs are to be 'sufficiently active economically' and the economic area covered is to be of 'sufficient importance'. EC start up grants (under FIFG) encourage the formation of POs although uptake has varied considerably between the Members States. In the UK there are 20 POs, compared to 31 in Germany and only three in Greece (Coffey 1999, p. 30)."

"All POs throughout Europe are now involved, to a greater or lesser extent, in the implementation and administration of the EU marketing regulations. Some POs have become involved in related activities such as the establishment of quality control systems, the marketing of fish and the establishment of fish processing plants. It is only within the UK, however, that POs have come to play a central role in fisheries management. This new role for POs was recognised in 1993 when the EU marketing regulation was amended to allow POs, at the discretion of member states, to manage national catch quotas. With this change in the relevant regulation, the EU has clearly signalled its approval of fisheries management by the PO sector. It will therefore be interesting to see if other member states follow the UK approach and develop fisheries management systems based on PO participation. [...] In terms of fish quotas it is estimated the PO sector manages over 95 percent of all quotas (Goodlad 1999 p. 6)."

As indicated above, there is considerable scope for variability in the way that the national allocations are distributed and/or managed within any given EU country. ITQs are explicitly used in The Netherlands and in Belgium in the flatfish fisheries and in Portugal for distant water cod and redfish fisheries and for hake in national waters in 1993 and 1994 (OECD 1997), and to a certain degree in the UK. "The system of UK fisheries management is firmly based on quota allocations and is therefore a classic resource based management system. The development of the SQ [sector quotas] system, and especially the recent introduction of FQAs [fixed quota allocation], has resulted in fish quotas being bought, sold and leased. Although there is no legal title to UK fish quotas, increasing numbers of fishermen are prepared to invest in an administrative system which actually confers most of the advantages of an ITQ system. For many people the UK system of fisheries management is virtually a system of ITQs by another name (Goodlad 1999, p. 19)." Generally speaking, the national systems are designed more to ensure that the national allocations will be actually taken (OECD 1997) than to ensure protection and conservation of the resources.

Technical measures such as spatial and seasonal restrictions, controls on gear type and size, as well as on fish sizes are an integral part of the Common Fishery Policy, and they are also used widely by individual Member States.

Monitoring Control and Surveillance had long been a shortcoming of the CFP and horror stories about 'blackfish' are widespread. In 1994, additional measures were introduced: "The monitoring and control system is designed to ensure the legality of activities on board fishing vessels, as well as during landing, selling, storing, transporting and importing fish. It also aims to ensure that effective sanctions are applied wherever legislation is breached. Unlike many of the CFP's provisions, it applies to the activities of all EC fishing vessels, and all activities in the territory or under the sovereignty of Member States. Member States retain responsibility for enforcement, but there is also an EC inspectorate to oversee their activities and ensure some parity between national enforcement approaches." (Coffey 1999, p. 42).

The Faroe Islands

The Faroe Islands belong to the Kingdom of Denmark but are not part of the European Union. The Faroese economy, like that of Iceland, is highly dependent on fisheries. Despite its small size and population (about 50 000 inhabitants), the Faroe Islands had a significant distant water fishing fleet in the 1960s and 1970s. With the widespread extension of fisheries jurisdiction during the second half of the 1970s, much of that fleet had therefore to search fishing opportunities in the Faroese EEZ.

The Faroe Islands is one of the few western jurisdiction where input controls, in terms of fishing days, is one of the principal means of regulating fisheries. As with most other fishery management processes, other tools, including gear, time and area restrictions are used.

For most of the 1980s and the first of the 1990s, the main fishery management measure was by technical measures (mostly closed areas and seasons) and by limiting investment. "In 1987 a system of fishing licences was introduced. The demersal fishery at the Faroe Islands has been regulated by technical measures (minimum mesh sizes and closed areas). In order to protect juveniles and young fish, fishing is temporarily prohibited in areas where the number of small cod, haddock and saithe exceeds 30% in the catches; after 1-2 weeks the areas are again opened for fishing. A reduction of effort has been attempted through banning of new licences and buy-back of licences.

A new quota system, based on individual quotas, was introduced in 1994. The fishing year started on 1 September and ended on 31 August the following year. The aim of the quota system was, through restrictive TAC's for the period 1994–1998, to increase the SSB's of Faroe Plateau cod and haddock to 52 000 t and 40 000 t, respectively. The TAC for saithe was set higher than recommended scientifically. It should be noted that cod, haddock and saithe are caught in a mixed fishery and any management measure should account for this. Species under the quota system were Faroe Plateau cod, haddock, saithe, redfish and Faroe Bank cod. (see also Zeller and Freire 2001).

The catch quota management system introduced in the Faroese fisheries in 1994 was met with considerable criticism and resulted in discarding and in misreportings of substantial portions of the catches. Reorganisation of enforcement and control did not solve the problems. As a result of the dissatisfaction with the catch quota management system, the Faroese Parliament discontinued the system as from 31 May 1996. In close cooperation with the fishing industry, the Faroese government has developed a new system based on within fleet category individual transferable effort quotas in days. The new system entered into force on 1 June 1996. The fishing year from 1 September to 31 August, as introduced under the catch quota system, has been maintained.

The individual transferable effort quotas apply to:

1) The longliners less than 100 GRT, the jiggers, and

the single trawlers less than 400 HP;
2) The pair trawlers; and
3) The longliners greater than 100 GRT.

The single trawlers greater than 400 HP do not have effort limitations, but they are not allowed to fish within the 12 nautical mile limit and the areas closed to them, as well as to the pair trawlers, have increased in area and time. Their catch of cod and haddock is limited by maximum by-catch allocation. The single trawlers less than 400 HP are given special licences to fish inside 12 nautical miles with a by-catch allocation of 30% cod and 10% haddock. In addition, they are obliged to use sorting devices in their trawls. One fishing day by longliners less than 100 GRT is considered equivalent to two fishing days for jiggers in the same gear category. Longliners less than 100 GRT could therefore double their allocation by converting to jigging." (ICES 2000)

There are also other geographical restrictions to limit fishing mortality such as not allowing trawlers to fish inside the 12 nautical mile limit, and allowing only longliners less than 100 GRT and jiggers less than 100 GRT to fish in the nearshore areas.

The effort quotas are transferable within fleet categories (e.g. between various sizes of longliners) but not between fleets (e.g. from longliners to trawlers).

Fishery management advice for the commercially most important stocks is provided directly by the Faroese Fisheries Research Laboratories but the assessment and analyses are reviewed by the North Western Working Group of ICES and the ACFM does provide advice which normally guides national advice.

Greenland

Greenland, like the Faroe Islands, belongs to the Kingdom of Denmark without being a member of the European Union. Greenland is governed by a Home Rule administration since 1979. Foreign affairs and justice are still under the Danish authorities, but it has been agreed with the Danish government that Greenland must be consulted on all matters of relevance to Greenland. Fishery management is under the responsibility of the Ministry of Industry, but fishery research is in the Ministry of Health and the environment (http://www.gh.gl/).

Greenland in fact straddles the Northeast and Northwest Atlantic boundary at (mostly at 42° West, except at 59° N when it moves to 44° W) and therefore must be heavily involved in both the ICES and the NAFO fora through which stock assessments and fishery management advice for the most commercially important species are reviewed.
The domestic fisheries are relatively underdeveloped except for shrimp and Greenland halibut. Fishing activities in Greenland's waters have decreased substantially with the decrease in cod biomass, but there is considerable fishing activities in are Sub Area XIV, mostly for redfish.

Northwest Atlantic

The Northwest Atlantic witnessed rapid development in fishery science and in fishery management during the 1950s to the early 1970s through the work of the International Commission for Northwest Atlantic Fisheries (ICNAF) the predecessor of NAFO.

NAFO

ICNAF ceased to exist shortly after Canada (1977) and the USA (1976) extended their EEZ to 200 nautical miles. It was replaced in 1977 by the Northwest Atlantic Fisheries Organisation whose Convention applies to all fishery resources of the Convention Area, i.e., outside of the Canadian and US EEZs. The following species are excluded from NAFO: salmon, tunas and marlins, cetacean populations managed by the International Whaling Commission or any successor organization, and sedentary species of the Continental Shelf, i.e., organisms which, at the harvestable stage, either are immobile on or under the seabed or are unable to move except in constant physical contact with the seabed or the subsoil. (Article I.4, NAFO Convention)

NAFO has a General Council for co-ordinating and administrative functions, a Fisheries Commission for conservation and fishery management decisions, and a Scientific Council to provide scientific advice for fishery management.

As of September 1999, Bulgaria, Canada, Cuba, Denmark (representing the Faroe Islands), Estonia, European Union (EU), France (Saint Pierre et Miquelon), Iceland, Japan, Republic of Korea, Latvia, Lithuania, Norway, Poland, Romania, Russian Federation; Ukraine, and the United States of America are member of NAFO. Before joining the EU in 1986, Portugal and Spain where also member of NAFO.

Most of the traditional groundfish fisheries in the NAFO area have been severely curtailed, except for Greenland halibut, and northern shrimp. The yellowtail flounder stock has recovered after being closed in the mid 1990s.

National management (within EEZ)

The fishery management processes described below for Canada and the United States of America are for their East Coasts. There may be slight differences in their West Coasts processes.

Greenland

The situation for Greenland is briefly described above in the section on the Northeast Atlantic.

Canada

In Canada, the Minister of Fisheries and Oceans (DFO) has almost exclusive powers in fisheries management, except for fish processing where the provincial governments also have responsibilities. All fishery management activities related to resource conservation and allocation, including stock assessment, licensing, monitoring, control and surveillance are solely assigned to the DFO. In the past, the inspection of fishery products for health and safety standards was also part of DFO's mandate but a Canadian Food Inspection Agency began operation in 1997-98 for both fishery and agriculture products.

DFO is geographically divided in six administrative regions (Newfoundland, Maritimes, Gulf (of St. Lawrence), Laurentian, Central and Arctic, Pacific). Aside from the Canadian Coast Guard, previously with the Department of Transport Canada, DFO has three main operational branches (Science –1203 person-years (PY), Fisheries Management – 1488 PY, Oceans – 503 PY), and a policy group (DFO 1999). Each administrative region is lead by a Regional Director General, and normally, each would have a Regional director for Science, one for Fishery Management, one for the Coast Guard and one for Oceans.

For many years DFO had a virtual monopoly on fishery science, but with the collapse of the groundfish stocks in the early 1990s, the Fisheries Resource Conservation Council (FRCC) has been created in 1993 to advise the DFO Minister on Conservation measures for groundfish (the FRCC also provided advice on lobster conservation measures in 1995) based largely on stock assessments provided by DFO's science branch, but taking into account comments gathered through large scale consultations of fishing communities. Subsequently, a Pacific Fisheries Resource Conservation Council (PFRCC) was created to advise on Pacific salmon.

Prior to the groundfish collapse, few non-DFO scientists participated in the assessment process. However, since the collapse, the process has become considerably more transparent, partly in an effort to increase the credibility of, but also to increase the quality of the data used in the assessment. Fishers have co-authored stock assessment documents and some are actively involved in the peer-review meetings.

USA

The fishery management system in the USA has been designed to provide checks and balances between the various interested parties. Ultimate responsibility rests with the Commerce Secretary who is responsible for the National Oceanic and Atmospheric Administration (NOAA) to which the National Marine Fisheries Service (NMFS) belongs, but fishery management plans are developed by the Regional Fishery Management Council (New England and Mid-Atlantic in the area under interest). The Regional Fishery Management Councils have some research staff, but depend heavily on NMFS for scientific advice. "The councils membership is a balance of commercial and recreational fishermen, marine scientists and state and federal fisheries managers, who combine their knowledge to prepare Fishery Management Plans (FMPs) for stocks of finfish, shellfish and crustaceans. In developing these FMPs, the Councils use the most recent scientific assessments of the ecosystems involved with special consideration of the requirements of marine mammals, sea turtles and other protected resources. The FMPS are prepared through a planning process that includes the public comments provided by fishers and other persons concerned with the management of these resources. (http://www.nmfs.gov/councils/)." The fishery management plans are developed by the councils, but must be approved by the Secretary of Commerce.

"Groundfish resources in the Northeast occur in mixed-species aggregations, resulting in significant bycatch interactions among fisheries directed to particular target species or species groups. Management is complex because of these interactions. [...] The principal regulatory measures currently in place for the major New England groundfish stocks are allowable days at sea for fishing coupled with closed areas, trip limits (for cod and haddock), and target total allowable catch corresponding to target fishing mortality rates. (Anderson et al. 1999)"

In the North Eastern USA, the Stock Assessment Review Committee process is open to participation by fishers and other interested parties. The final recommendations are discussed at widely-advertised public meetings. The assessments are done by individuals or by small groups, generally involving NMFS scientists often with input from others. States have started some surveys and do employ their own scientists.

Until the mid 1990s, the New England Fishery Management Council did not appear overly preoccupied with science and conservation. After an initial recovery of the stocks in the late 1970s following extension of jurisdiction, stocks rapidly declined and remained low. Highly restrictive fishery management measures in terms of number of days fished and area closures were introduced in the mid and late 1990s with some positive signs for cod, haddock and yellowtail on Georges Bank (NMFS 1999).

Highly migratory species

ICCAT

"The International Commission for the Conservation of Atlantic Tunas is an inter-governmental fishery organization responsible for the conservation of tunas and tuna-like species in the Atlantic Ocean and adjacent seas. The organization was established in 1969, at a Conference of Plenipotentiaries, which prepared and adopted the "International Convention for the Conservation of Atlantic Tunas," signed in Rio de Janeiro, Brazil, in 1966. The Convention is open for signature, or may be adhered to, by any Government which is a Member of the United Nations or of any specialized agency of the United Nations. Instruments of ratification, approval, or adherence may be deposited with the Director-General of the Food and Agriculture Organization of the United Nations (FAO), and membership is effective on the date of such deposit. The official languages are English, French and Spanish. " (http://www.iccat.es/wiccat.htm). " Currently, there are 28 contracting parties: Angola, Brazil, Canada, Cap Verde, Côte d'Ivoire, Croatia, European Union, France (Dependent Territories), Gabon, Ghana, Equatorial Guinea, Japan, Korea, Libya, Morocco, Namibia, Panama, People's Republic of China, Republic of Guinea, Russia, S. Tome & Principe, South Africa, Trinidad & Tobago, Tunisia, United Kingdom (Overseas Territories), United States of America, Uruguay, Venezuela" (http://www.iccat.es/iccat2.html).

"The Commission currently has the following Standing Committees: on Finance and Administration (STACFAD), on Research and Statistics (SCRS), and on Conservation and Management Measures. There is also a Permanent Working Group for the Improvement of ICCAT Statistics and Conservation Measures (PWG). [...] The Permanent Working Group for the Improvement of ICCAT Statistics and Conservation Measures (PWG) was specifically established to review compliance, by non-contracting parties, of the regulatory measures recommended by the Commission. (http://www.iccat.es/wiccat.htm)."

"About 30 species are of direct concern to ICCAT: Atlantic bluefin (*Thunnus thynnus*), yellowfin (*Thunnus albacares*), albacore (*Thunnus alalunga*) and bigeye tuna (*Thunnus obesus*); swordfish (*Xiphias gladius*); billfishes such as white marlin (*Tetrapturus albidus*), blue marlin (*Makaira nigricans*), sailfish (*Istiophorus albicans*) and spearfish (*Tetrapturus pfluegeri*); mackerels such as spotted Spanish mackerel (*Scomberomorus maculatus*) and king mackerel (*Scomberomorus cavalla*); and, small tunas like skipjack (*Katsuwonus pelamis*), black skipjack (*Euthynnus alletteratus*), frigate tuna (*Auxis thazard*), and Atlantic bonito (*Sarda sarda*).

Through the Convention, it is established that ICCAT is the only fisheries organization that can undertake the range of work required for the study and management of tunas and tuna-like fishes in the Atlantic. Such studies include research on biometry, ecology, and oceanography, with a principal focus on the effects of fishing on population abundance. The Commission's work requires the collection and analysis of statistical information relative to current conditions and trends of the fishery resources in the Convention area. The Commission also undertakes work in the compilation of data for other fish species that are caught during tuna fishing (i.e., bycatch, principally sharks) in the Convention area, and which are not investigated by another international fishery organization." (http://www.iccat.es/iccat2.html).

NASCO

"The North Atlantic Salmon Conservation Organization (NASCO) is an international organization established under the Convention for the Conservation of Salmon in the North Atlantic Ocean which entered into force on 1 October 1983. The objective of the Organization is to contribute through consultation and cooperation to the conservation, restoration, enhancement and rational management of salmon stocks subject to the Convention taking into account the best scientific evidence available to it. The Convention applies to the salmon stocks which migrate beyond areas of fisheries jurisdiction of coastal States of the Atlantic Ocean north of 36°N latitude throughout their migratory range.

Contracting Parties: Canada, Denmark (in respect of the Faroe Islands and Greenland), European Union, Iceland, Norway, Russian Federation, United States of America. Twenty-five Non-Government Organizations (NGOs) have observer status to NASCO. Inter-Governmental Organizations and media representatives may also attend NASCO meetings." (http://www.nasco.org.uk/html/about_nasco.html).

NASCO receives scientific advice for the management of salmon fisheries from ICES through ACFM.

Discussion

The fishery management processes examined share several similarities. They are all science-based with essentially the same functions, implemented through a similar sequence of steps: the fishery management process starts with the provision of scientific advice, interested parties are consulted on the advice, the fishery management agency makes a decision, a management plan is developed, and fishing takes place under monitoring, control and surveillance. Everywhere, there is an implied objective to protect the resources and the environment they depend on, but generally explicit protection of the environment is only beginning to be incorporated in fishery management. Fishery science is considered highly important in all jurisdictions and it is usually dominated by biologists. The need to incorporate social sciences in fishery management has long been recognised, and attempts have been made to attract social scientists in the process, but the day to day provision of fishery management advice remains firmly grounded in the biological stock assessment science with little room for social science and/or economics. Yet, fishery management is about managing the activities of human beings, not those of the fish (Maguire, et al. 1995). In addition, fisheries science has become reduced to stock assessment science for advisory purpose, with little consideration given to multispecies interactions or ecosystem considerations.

Beyond those functional similarities, however, there are structural differences. For example, Iceland and Norway can be considered to be at one end of the structural spectrum with responsibilities for the various fishery management functions distributed across several ministries, departments and agencies providing a system of checks and balance dear to the drafters of the American Constitution. At the other end, Canada is concentrating almost all the powers in a single department, under a single minister. While such a concentration of powers in a single department can have definite advantages in terms of efficiency and consistency of action, it has drawbacks in terms of transparency and it has been argued that fishery science in Canada would be better served by being independent from the agency making decisions on quotas and allocations (Hutchings et al. 1997). This reasoning can easily be extended and it can be argued that the agency allocating the resource should be independent of the one implementing the monitoring, control and surveillance. The USA, not surprisingly, also has a system of checks and balances with the Regional Fishery Management Councils drafting the management plans in a transparent and open process where all interested parties can have the possibility of being involved if they so wish. On paper, the USA arguably has one of the best fishery management processes. In practice, the system is bureaucratic and it can be slow to react.

The scientific advisory processes also share several similarities in terms of tools, products and organisation. In North America, the tendency is for a single individual to have assessment responsibility for the technical analyses of one or several stocks. There is a similar tendency in ICES, mostly to increase efficiency, but the multinational nature of the ICES WG sometimes make it impractical. In most cases the final assessments are done by the WG. In all the fora reviewed, the assessments are subjected to a detailed examination through a peer review process.

Considerable effort and energy is spent discussing the reliability of the input catch and effort data, but the assessments are always finalised, regardless of the (lack of) reliability of input data. In the early 1990s, the statistics on landings were believed to be so unreliable as a result of large scale misreporting and discarding because of restrictive TACs, that ICES concluded that lack of reliability of the basic statistics was jeopardising its ability to provide advice. The ICES General Secretary of the time wrote to national fishery authorities, alerting them of this situation and implying that there was a real possibility ICES would not be able to provide fishery management advice if the situation did not improve. Very little changed in terms of data availability, and ICES nevertheless continued to provide advice twice a year. Admittedly, however, programs to estimate discards, funded by the European Commission, have been initiated in several countries. These should fill and important gap, but these studies do not address the issue of over quota landings.

The peer-review process is time-consuming, it concerns itself mostly with the details of individual assessments, and it rarely rejects assessments that have been accepted in the past, even if new information cast doubts on the reliability of input data. This stems from the view that some advice, even if it is based on faulty data (and assumption) is better than no advice. The process cannot be described as 'independent' peer review as there is considerable inbreeding. The US NMFS has recognised this problem and it has developed a special project to enhance peer review by obtaining the services of independent experts they remunerate to review specific documents and participate in certain stock assessment reviews (http://www.rsmas.miami.edu/info/cimas-announce.html). The influence of these independent experts may be limited by the format of the process they participate in: generally the invited expert is one independent voice amongst the other 15 to 20 who have been involved in these assessments in the past. The formulation of advice normally also falls in the so-called peer review process. In cases where the technical experts have an in-depth knowledge of the fisheries issues, they may indeed be the best qualified to formulate the advice, but this is progressively less and less the case. With recent developments in assessment methodology, partly motivated by the unavailability or unreliability of information on stock status, the assessment processes have become dominated by 'number crunchers.' More time is now spent on trying to develop analyses that are scientifically defensible, rather than try understand what is happening or has happened in the fisheries. This means that most advisory processes have lost their intelligence (*sensu* understanding) of the fishing scene.

The reduction of fishery science to stock assessment science for advisory purpose is an unfortunate development. Fishers and fishery management agencies, traditionally the main clients of fishery management advice, know that the data on landings are faulty, and they know stock assessment scientists use these data in the assessments. This makes it very difficult for them to have any faith in the results. In, addition, the majority of fishers believe in multispecies interactions: they witness them daily in their fishing operations. The fact that fishery scientists openly admit not taking multispecies considerations into account add to the lack of credibility of stock assessment and the derived management advice.

There are an increasing number of constituencies interested in fisheries science and fisheries management, including environmental non-governmental organisations, academic research institutions, industry researchers etc. Current advisory processes do not lend themselves easily to incorporating these newly interested parties.

Current wisdom in traditional fishery management circles is that limiting the catch removed from a population is the best means of ensuring its sustainability. This wisdom has been derived from large volume single-species fisheries, or multispecies fisheries with a relatively small number of species involved such as in the North Sea with cod, haddock, and whiting. This belief, over the years, has led to an elaborate system to set TACs on all species in all areas even when the information was insufficient to provide reliable advice. But a TAC being needed, and based on the above mentioned view that any advice is better than no advice, advice was provided, and TACs have been set. This problem continues to exist despite the fact that large scale misreporting is known to have occurred (Coffey 1999), including over-reporting for the purpose of artificially increasing the value of fishing licences (Goodlad 1999). This problem, mentioned above, greatly reduces the credibility of the scientific advice (Coffey 1999).

Insufficient monitoring, control and surveillance, given restrictive TACs, have resulted in the aforementioned large scale misreporting. TAC management to be effective in protecting resources, implies that TACs are properly set and enforced, neither of which is believed to be happening. In most EU countries, there are numerous reports to national parliaments, TV and other media indicating that the actual landings are substantially higher than those reported, and add up to totals higher than the TACs. There is therefore a direct link between the type of management measures applied, the investment in monitoring, control and surveillance and the quality of the data that are available to evaluate the success of fishery management. Most ICES assessment Working Group reports give unallocated landings which can easily reach 50% or more of the official landings. As an example, a herring stock with estimated average landings in the order of 40,000t for 1981 to 2000 shows, for 1984, unallocated landings of 16,500t (catches that were not reported) and area-misreporting of minus 19,000t (catches caught from another stock but reported for the one in question). Values for unallocated and area-misreported catches vary considerably from one year to the next indicating that the fisheries respond very quickly to changing regulations. There is reason to believe that misreporting of landings is a smaller problem in those TAC-managed fisheries in North America where dockside monitoring has been implemented, but there is no reason to expect discarding and high-grading to be a lesser problem. The reliability of catch data therefore remains a problem there as well. It might be possible to temporarily relieve the symptoms of the illness affecting the current fishery management system by investing more in monitoring, control and surveillance. It is doubtful that such increased investments would be cost-effective, however, and they are unlikely to provide more than temporary relief. Drastic changes in the roles and responsibilities of the various interested parties are required in order to cure the system.

TACs appear a satisfactory means of allocating the resources amongst the various participants. However, as a resource conservation tool, the stock assessments and the implementation of the TACs are insufficiently precise to guarantee the protection of the resources unless very low fishing mortalities were used as targets. (Note that low fishing mortalities reduce even further the precision of stock assessments). In addition to these shortcomings current fishery management has been unable to adequately take into account the multispecies nature of many fisheries and the ecosystem impacts of fishing.

Conclusion

Considerable investments have been and continue to be made to manage North Atlantic fisheries. Yet, despite these substantial investments, the fishery management processes, including scientific advice, can hardly be described as successful, particularly for the important cod fisheries that have been the backbone of demersal fisheries in the North Atlantic. The collapse of the Northern cod off Newfoundland in the early 1990s was not predicted by scientists, it caught management authorities by surprise, and a collapse of such magnitude was not considered possible before it occurred. In the eastern Atlantic, the Northeast Arctic cod, fished mostly by Norway and Russia, provides another example. The spawning stock biomass increased rapidly from about 120 000t in the late 1980s to close to 900 000t in 1992. The increase was attributed to the stringent management measures adopted, but increased growth and maturity also played a large role. The spawning stock biomass has since decreased to 250 000t in 2000, considerably below the 500 000t threshold below which management action should be taken. Fishing mortality was notably decreased only in 1991 and 1992 and current values are not sustainable. Both North Sea and Icelandic cod recently joined the list of cod stocks in imminent danger of collapse.

Countless person-hours are invested in doing stock assessments, peer-reviewing them and using them to formulate management advice. These assessments are, in the greatest majority of cases, as good and reliable as can be expected given the data available. But, at the end of the day, it may be the wrong science to do.

Bauer (2000, p. 19-20) discussing the use of mathematics and statistics in an essay titled *Disregard of Reality* dealing with development economics makes several points that are directly relevant to fishery science. He states (p. 19) that the use of mathematics and statistics " has led to unwarranted concentration [...] on variables tractable to formal analysis. As a corollary it has led to the neglect of influences which, even when highly pertinent, are not amenable to such treatment. Similarly, it has encouraged confusion between the significant, on the one hand, and the quantifiable (often only spuriously quantifiable), on the other. It has contributed to the neglect of background conditions and historical processes where they are indispensable for understanding." Bauer's statements that "the acceptance of quantitative methods as the most respectable procedure has permitted the burgeoning of incompetent or inappropriate econometric studies, including those based on seriously flawed data" describes the situation for many stock assessments where landing statistics are unreliable. His observation that "studies based on direct observation or detailed examination of slices of history are apt to be dismissed as anecdotal, unscholarly, or unscientific, even if they are informative" also applies to fisheries science in the North Atlantic.

Fishery management has not been universally unsuccessful. Smaller scale fisheries, such as the crustacean fisheries in Eastern Canada have remained very profitable with healthy resource bases. In those fisheries, common sense has not been entirely taken over by quantitative methods. The biological basis for management, particularly for shrimp and snow crab has continued to be investigated with the objective of understanding, not only on quantifying.

Although the theory and some tools are available to apply a multispecies approach, fishery management in the North Atlantic and the scientific advice it uses remains largely single species. This does nothing to improve the credibility of the scientific advice because receivers of the advice, and particularly fishermen, are fully aware that species interact and influence each other.

Fishery management has neglected the influence of the environment. It would benefit from a more humble evaluation of what it can reasonably expect to achievable, recognising the large role of oceanographic and hydrographic variability. Fishery management should formally and explicitly incorporate the social, economic and environmental components of fishery management in addition the presently dominating stock assessment component. This should help put back the fishermen as one of the component of the ecosystem whose functions fishery management is trying to protect.

Acknowledgements

I thank Villy Christensen and Daniel Pauly for the interactions leading to this contribution, and the *Sea Around Us* project for support. As well, I thank the colleagues, too numerous to be individually named, which over the years, have provided me with the knowledge summarized here.

References

Alder, J., Lugtgen. G. Kay, R. and Ferris, B. 2001. Compliance with International Fisheries Instruments in the North Atlantic. Pages 55-84 in Pitcher, T.J., Sumaila, U.R. and Pauly, D. (eds) (2001) Fisheries Impacts on North Atlantic Ecosystems: Evaluations and Policy Exploration. Fisheries Centre Research Reports 9 (5): xx pp.

Anderson, E.D., Mayo, R.K., Sosebee, K., Terceiro, M., and Wigley, S.E. 1999. Northeast Demersal Fisheries *in* Our living oceans. Report on the status of U.S. living marine resources, 1999. National Marine Fisheries Service. U.S. Department of Commerce, NOAA Technical Memorandum. NMFS-F/SPO-41. 301 p.

Arnason, R. 1995. The Icelandic Fisheries: Evolution and management of a fishing industry. Oxford: Fishing News Books.

Bauer, Peter. 2000. From subsistence to exchange and other essays. Princeton University Press, 153pp.

Coffey, C. 1999. Sustainable development and the EC fisheries sector. An introduction to the issues. IEEP, 60pp. London, UK.

DFO. 1998. Gulf of St. Lawrence Marine Fisheries Overview. DFO Sci. Stock Status Rep. G1-01 (1998).

DFO. 1999. Fisheries and Oceans 1999-2000 Estimates. A report on Plans and Priorities. http://www.dfo-mpo.gc.ca/communic/comm1_e.htm#Reports/Policies

Goodlad, J. 1999. Industry perspective on rights based management – the Shetland experience. Fish Rights Conference 99, Western Australia, 20pp.

Griffith, D.G. 1999. Opening Lecture to the 1999 ICES Annual Science Conference. Available at http://www.ices.dk

Hutchings, J.A., C. Walters, and Headrich, R.L.1997. Is scientific inquiry incompatible with government information control? Can. J. Fish. Aquat. Sci. 54: 1198-1210.

ICES. 2000. Report of the ICES Advisory Committee on Fishery Management, 1999. ICES Cooperative Research Report no 236.

Maguire, J.-J., Neis, B., and Sinclair, P.R.. 1995. What are we managing anayway?: The need for an interdisciplinary approach to managing fisheries ecosystems. Dalhousie Law Journal 18(1):141-153.

NMFS. 1999. Our Living Oceans. [ref to be completed]

OECD. 1997 Towards Sustainable Fisheries, Economic aspects of the management of living marine resources. 268pp. Paris, France.

Pauly, D., V. Christensen, R. Froese, A. Longhurst, T. Platt, S. Sathyendranath, K. Sherman and R. Watson, R. 2000. Mapping fisheries onto marine ecosystems: a proposal for a consensus approach for regional, oceanic and global integration . Pages 13-22 in: Pauly, D. and T.J. Pitcher (eds.). Methods for Evaluating the Impacts of Fisheries on North Atlantic Ecosystems. Fisheries Centre Research Reports 8(2), 195pp.

Runolfsson, B. and Arnason,R. 1996. Evolution and Performance of the Icelandic ITQ System. Icelandic Economic Papers, February, 1996.

Zeller, D. and Freire, K. 2001. A North-East Atlantic Marine Ecosystem Model For The Faroe Islands (Ices Area Vb): Input Data. Pages xxx-xx in Guénette, S., Christensen, V. and Pauly, D. (eds) (2001) Fisheries Impacts on North Atlantic Ecosystems: Models and Analyses. Fisheries Centre Research Reports 9 (4): 254 pp.

Sustainability Ranking of North Atlantic Fisheries

Ratana Chuenpagdee[1] **and**
Jackie Alder[2]
[1]*VIMS, Virginia, USA*
[2]*Fisheries Centre, UBC*

Abstract

This paper describes a scaling method employed to aggregate three independent rankings of the sustainability of fisheries from eleven countries in the North Atlantic. These fisheries were first scored and ranked using three measures, (a) *Rapfish* assessment of sustainability, (b) compliance of fisheries with the FAO Code of Conduct, and (c) compliance of nations with the international fisheries agreements. These rankings were then tested for significant correlations and the aggregation of scores were performed accordingly. The ranking of sustainability based on the aggregated scores, while allowing the comparison of different fisheries through the same unit, serves as an additional perspective for a thorough discussion on the sustainability issues of North Atlantic fisheries.

Introduction

The question "how sustainable are North Atlantic fisheries?" is one important aspect of the Sea Around Us Project (SAUP). The answer, however, is not a simple one since sustainability has many definitions and can be measured in various ways, for example, ecologically, socially and economically. There is also no single measure or approach to assessing sustainability and therefore a range of measures is used depending on the nature of the ecosystem and the management objectives. In the SAUP, four approaches to assessing sustainability have been used. One is the direct valuation of the state of the resource, as in Christensen et al. (2001). The other three are indirect approaches, i.e. Rapfish, the FAO Code of Conduct, and International Instrument, which measure different aspects of sustainability. As there is currently no single measure reflecting the overall level of sustainability for North Atlantic fisheries, we develop a method to aggregate the scores obtained from the three indirect approaches into a single measure of relative sustainability of fisheries at the national scale. This paper focuses on the description of the aggregating method using fisheries from eleven countries in the North Atlantic as an illustration, and provides a discussion on the use of this information in policy design.
Similar to the Brundtland Commission and Agenda 21 (United Nations, 1994), the three approaches employed in this study use environmental, economic, social and institutional criteria to measure sustainability. *Rapfish* is a rapid appraisal technique for evaluating the sustainable of fisheries, using attributes related to ecological, economic, technical, social and ethical considerations (Pitcher & Preikshot 2001; Pitcher 1999; Pitcher et al. 1998). The FAO Code of Conduct addresses the responsibility for the practices of fisheries. The International Instrument focus on compliance on fifteen articles, including the Convention on Biological Diversity, the Common Fisheries Policy, and the Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas (see complete listing in Alder et al., this volume).

The first step in the analysis is to standardise the scores obtained from the three measures such that they are comparable. As the Rapfish and the FAO Code of Conduct scores are reported on the scale of zero to 100, we use a simple proportional procedure (Dunn-Rankin, 1983) to normalise the International Instrument scores, also to the scale of zero to 100, where 0 indicates relatively low sustainability and 100 indicates relatively high sustainability. Next, we develop an independent ranking of sustainability based on these scores and use the nonparametric statistics to test the agreements of these rankings. Finally, we aggregate the scales, based on this analysis, to present an overall ranking of the eleven North Atlantic countries. This aggregation facilitates an interpretation of the ranking results, such that they become useful information to fishery managers, policy makers and the general public.

It should be noted that the resulting analysis is based on preliminary unadjusted scores and is only indicative of the relative sustainability. These results may change as Rapfish and FAO Code of Conduct scores are finalised for different fisheries and International Instrument scores (e.g. Iceland has just returned to the International Whaling Commission) are revised.

Sustainability Measures

Rapfish

Rapfish uses multidimensional scaling, an ordination method, to appraise the relative sustainability of fisheries (Pitcher *et al.* 1998; Pitcher and Preikshot 2000). Rapfish relies on a scoring of a number of easy-to-score attributes in five dimensions, i.e., ecological, economic, social, technological and ethical. Attributes in each dimension are chosen and defined to reflect the notion of sustainability (Pitcher and Preikshot 2000). All criteria may be refined or substituted as improved information arises. Two hypothetical reference entities, which are scored at the extreme lower end (minimum scores for all attributes, 0%) and extreme upper end (maximum score for all attributes, 100%) for all evaluation fields also provide reference points for comparing the sustainability scores. Separate ordinations are performed on each set of sustainability attributes (evaluation fields) and the results expressing the relative sustainability in each of the fields are reported on a scale from zero to 100%.

FAO Code of Conduct Compliance

Compliance with the FAO Code of Conduct uses the multidimensional scaling approach employed in Rapfish. In this case, six different sets of attributes articulate the clauses in the Code are used (Pitcher, 1999). These evaluation fields reflect national management intentions and management practices for each fishery that is assessed. Two hypothetical reference entities are also used as reference points for comparing compliance on a scale from zero to 100%.

International Instrument Compliance

A specific set of criteria based on the provisions or work program of each instrument is used and is described in this volume (Alder et al., this volume). The assessment criteria focused on measuring either qualitatively or quantitatively the level of compliance with the fisheries management provisions contained within an instrument. Generally criterion scores ranged from 0 (low compliance) and 3 (high compliance) and the total criteria were limited to approximately six per instrument. Only those countries where the instrument applied were assessed, irrespective of whether they were party to the instrument or not. Published reports, scientific papers and telephone contact with staff from the various secretariats of the conventions, as well as stock assessments from ICES were used to obtain scoring information

The North Atlantic Case Study

This analysis includes eleven fishing nations in North Atlantic, each was scored three times, using Rapfish (RAP), FAO Code of Conduct (FAO) and International Instrument (II) as criteria. Table 1 shows the scores and the assigned ranking of '1' for the country with highest score and '11' for that with the smallest score. Independent ranking of these fisheries based on each criterion, while informative on its own, does not allow direct comparisons within nations in terms of the overall sustainability. For example, Greenland has the highest score when evaluated using Rapfish, but is ranked fourth on FAO score and second on AGR score (figure 1). Germany, on the other hand, is ranked first on the FAO score, but seventh on RAP and AGR. Although it might be possible to conclude at this point that Greenland is doing better on the measure of sustainability than Germany, further analysis of these rankings based on various methods of aggregations will provide additional support for such statement.

Aggregation of rankings

Nonparametric tests, such as rank correlation analysis, are generally performed to determine if the two sets of rankings are related. In this paper, we employ the Kendall rank-order correlation coefficient (T), which is a measure of correlation between two variables that are measured on at least an ordinal scale (Siegel and Castellan, 1988). The coefficient T determines the degree of correspondence between the two sets of rankings, such that T would equal +1 for perfect agreement and –1 for perfect disagreement. Increasing values from –1 to 1 thus correspond to increasing agreement between the two sets of ranks (Kendall and Gibbons, 1990). Test of significance of the value of rank correlation indicates if the two sets of ranks are unrelated. When the null hypothesis is rejected, it can be concluded that the two ranks are related at a certain level of significance.

The first step in our analysis involves the rank correlation test of the three rankings, RAP, FAO and II. The result indicates that these three rankings are not significantly correlated. This is not surprising as the distribution of the nations along the sustainability scale is rather different in each sustainability measure (Figure 1). With an exception of the Faroe Islands, the top three countries on the sustainability scale vary from one criterion

Table 1. Scores and rankings of fishing nations, based on Rapfish (RAP), FAO Code of Conduct (FAO) and International Instrument (II) criteria.

Country	RAP	FAO	II
Greenland	60.8 (1)	51.1 (4)	73.5 (2)
Faroe Is.	60.3 (2)	55.7 (2)	77.0 (1)
Norway	57.9 (3)	44.5 (6)	69.3 (4)
Iceland	56.1 (4)	53.4 (3)	54.6 (10)
USA	52.1 (5)	50.7 (5)	55.3 (9)
UK	50.5 (6)	31.8 (11)	61.1 (6)
Germany	45.2 (7)	57.5 (1)	58.3 (7)
Denmark	45.2 (7)	38.9 (8)	69.4 (3)
Spain	45.1 (9)	38.1 (9)	52.9 (11)
Canada	41.4 (10)	41.3 (7)	63.8 (5)
Netherlands	34.1 (11)	36.7 (10)	57.8 (8)

to the next. The scores on the RAP scale and on the FAO scale cover both below and above 50% point (i.e. from 34 to 61 on RAP scale and from 32 to 58 on FAO scale). On the contrary, all scores on the II scale are above 50%, i.e., from 53 to 77. It should be noted, however, that in all three cases, the range of the scores is comparable with the smallest range of 24.1 on II scale and 26.7 on the RAP scale.

We next examine the possibility of combining the scores between any two sets of criteria. Based on the rank correlation coefficients in Table 2, the correlation between RAP and FAO is highest (T = 0.404), followed by that of RAP and II (T = 0.330), while the correlation coefficient between FAO and II is 0.164. This suggests that RAP scores may share common characteristics with the other two scores. It is thus not surprising that we find a significant correlation at P = 0.05 between the combined score of FAO and II; and RAP. No significant correlation is found between any other combinations of scores (Table 2).

Based on the above analysis, we combine the FAO score and the II score to a single scale using simple averages. We then compare this combined scale (FAO-II) with the RAP scale, as in Figure 2. Here we find that we can roughly separate the eleven countries analysed into two groups of a high-level sustainability (greater than 50%) and a low-level sustainability (less than 50%). Those always on the high end are Greenland, the Faroe Islands, Norway, Iceland, and USA, and those always on the low end include Spain and the Netherlands. On the *Rapfish* scale, however, Germany, Denmark and Canada fall below the medium score of 50, while the score for UK & Wales is higher at 51. The reverse is found in the FAO-II scale where Germany, Denmark and Canada are ranked higher on the scale (all above 50), while the UK score is below 50.

As the correlation between RAP and COMBINE FAO-II rankings is significant, we are able to combine these two scales into one scale illustrating the distribution of countries according to their sustainability rankings. As seen in figure 3, the Faroe Islands and Greenland remain on the top of the scale, while the Netherlands is lowest on the scale. Of those in the medium level, we have one group with scores above 50%, including Norway, Iceland, USA and Germany. The other countries, namely Denmark, UK & Wales, Canada, and Spain, fall slightly below the 50% point, although their scores are in the medium range.

Table 2. Correlation Tables, Kendall T correlation coefficient (n = 11).

1) Rank correlation of individual criteria

	RAP	FAO	II
RAP	1		
FAO	0.404	1	
II	0.330	0.164	1

2) Rank correlation of RAP with the average of FAO and II

	RAP	FAO-II
RAP	1	
FAO-II	0.550*	1

3) Rank correlation of FAO with the average of RAP and II

	FAO	RAP-II
FAO	1	
RAP-II	0.309	1

4) Rank correlation of II with the average of RAP and FAO

	II	RAP-FAO
II	1	
RAP-FAO	0.257	1

** Correlation is significant at p = 0.05*

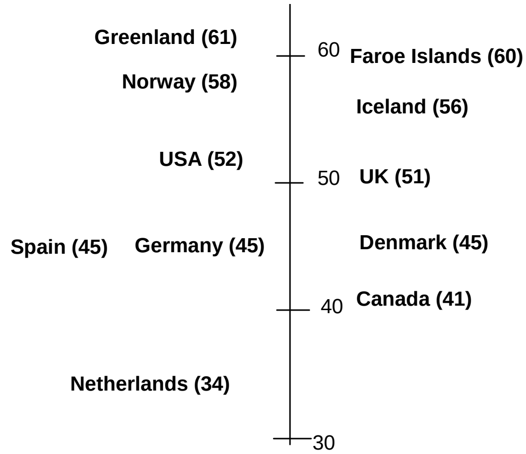
Discussion

As stated above, while the range of sustainability scores measured using the three sets of criteria is approximately the same, the distribution of the scores, however, is rather different. In using the scaling method, we normally expect the distribution of the scores to follow the pattern observed on the RAP and FAO scales, i.e. some countries are scored above the 50% point and some below. When all or most scores are either above or below the mid-point, it prompts us to examine the scoring method and its validity. In the case of II scores, where all countries score higher than 50, we note that the scores are obtained from applying fifteen international agreements to the fisheries, but not all countries are evaluated for each agreement.

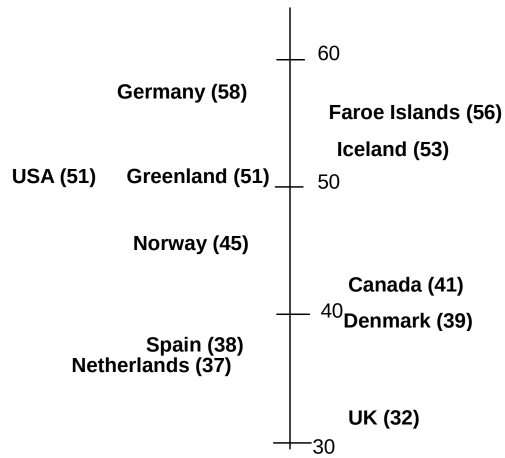
While on average, about seven out of eleven countries are scored under each agreement; the number of countries considered can be as low as two (as in the Fishing Cooperative Agreement), three (as in the Capelin and Herring Agreements) and four (as in the Northeast Atlantic Fisheries Commission). Further, the number of criteria applied for each agreement varies from two to six. It is thus possible that either the number of countries involved or the number of criteria used influenced the final II scores. Rapfish and FAO scores are less subjected to this problem because of its total of 47 and 44 criteria respectively, and because all countries were evenly assessed. In any case, as the II scores are consistently high for all countries considered, their contributions to the final aggregated scores are evenly distributed.

On its own, the three independent scales are not significantly correlated. Thus, the direct aggrega-

RAP	SCORE	RANK
Greenland	60.8	1
Faroe Is.	60.3	2
Norway	57.9	3
Iceland	56.1	4
USA	52.1	5
UK&Wales	50.5	6
Germany	45.2	7
Denmark	45.2	7
Spain	45.1	9
Canada	41.4	10
Netherlands	34.1	11



FAO	SCORE	RANK
Germany	57.5	1
Faroe Is.	55.7	2
Iceland	53.4	3
Greenland	51.1	4
USA	50.7	5
Norway	44.5	6
Canada	41.3	7
Denmark	38.9	8
Spain	38.1	9
Netherlands	36.7	10
UK&Wales	31.8	11



II	SCORE	RANK
Faroe Is.	77.0	1
Greenland	73.5	2
Denmark	69.4	3
Norway	69.3	4
Canada	63.8	5
UK&Wales	61.1	6
Germany	58.3	7
Netherland	57.8	8
USA	55.3	9
Iceland	54.6	10
Spain	52.9	11

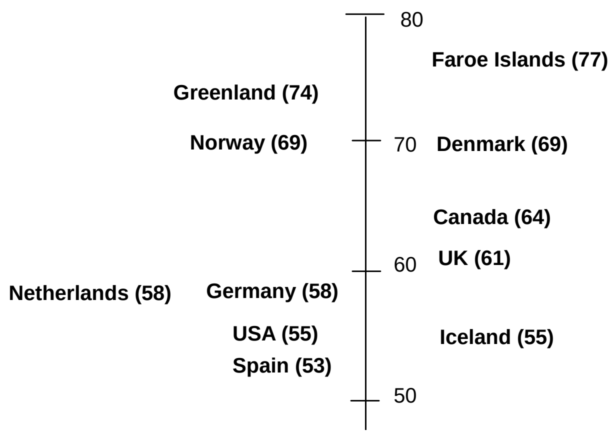
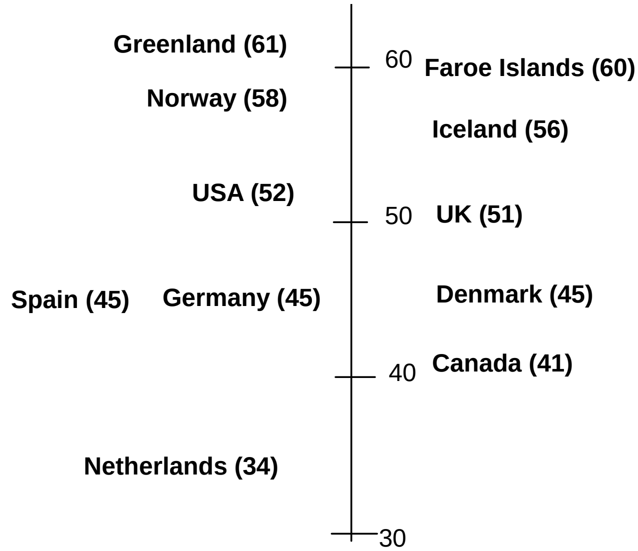


Figure 1 Ranking of fisheries sustainability based on (a) Rapfish; (b) FAO Code of Conduct and (c) International Instrument (II) criteria.

tion of scores is not warranted. Further scrutiny of these scores, however, suggests that it is possible to combine some of them, which then result in significant correlations as seen in the above analysis. The aggregated scores described here are different from the direct average of the three sets of scores, which we cannot do prior to the rank correlation analysis. The single aggregated scale and ranking of sustainability, as in Figure 3, allows the interpretation of the results to be more informative for policy makers. Yet, careful considerations of other factors that might contribute to the rankings, particularly those associated with individual scoring system, must be taken into account.

The sustainability scores for all three measures as well as the aggregated measure place a number of

RAP	SCORE	RANK
Greenland	60.8	1
Faroe Is.	60.3	2
Norway	57.9	3
Iceland	56.1	4
USA	52.1	5
UK&Wales	50.5	6
Germany	45.2	7
Denmark	45.2	7
Spain	45.1	9
Canada	41.4	10
Netherlands	34.1	11



FAO-II	SCORE	RANK
Faroe Is.	66.4	1
Greenland	62.3	2
Germany	57.9	3
Norway	56.9	4
Denmark	54.2	5
Iceland	54.0	6
USA	53.0	7
Canada	52.5	8
Netherlands	47.2	9
UK&Wales	46.4	10
Spain	45.5	11

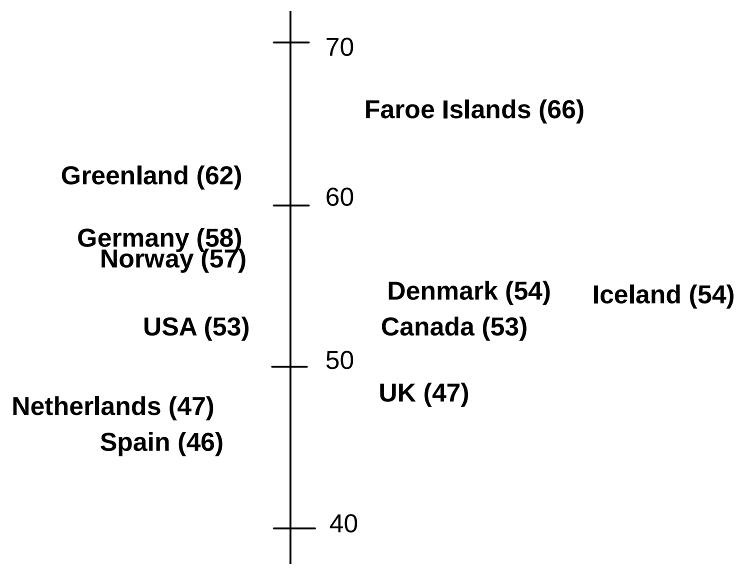


Figure 2. Ranking of fisheries sustainability based on RAPISH and on a combined score between FAO and FAO-II.

countries in the upper or positive zone (score greater than 50) of sustainability, especially for compliance with international instruments. Those countries in the lower or less sustainable zone still perform positively for international instrument compliance. Reports from management agencies and conservation organizations, however, indicate that many of national fisheries are over- exploited and fisheries are under threat. This is in contrast to the study outcomes and published reports, highlighting the fact that high Rapfish, FAO and international instruments scores, singly or combined, do not always necessarily imply sustainable fisheries. Further analysis is needed, in particular to compare the ranking indicated in this study with the direct evaluation of the fisheries resources performed by Christensen et al. 2001. For the time being, we can however state that we might worry less about the fisheries of Greenland and the Faroe Islands, but we should be concerned more about the fisheries of the Netherlands, and of the other eight countries included in this study.

Finally, we recommend that further research on the scoring of the sustainability using different methods should be pursued. As shown in Chuenpagdee et al. (2001), various groups of people can provide useful information to develop rankings of importance, which can be used to formulate app-ropriate resource use policies. The 'damage schedule' approach employed by Chuenpagdee et al. (2001) can be easily modified to measure the sustainability of fisheries, with the most important feature being the involvement of experts, i.e., scientists, researchers and managers, and user groups in the scoring of the fisheries under various criteria. The rankings obtained from such application will also be an interval rather than ordinal ranking, which can provide further insights. More importantly, involving experts and user groups in the process enhances the transparency of the results and consequently facilitates policy implementation.

AGGRE	SCORE	RANK
Faroe Is.	63.3	1
Greenland	61.6	2
Norway	57.4	3
Iceland	55.1	4
USA	52.6	5
Germany	51.6	6
Denmark	49.7	7
UK&Wales	48.5	8
Canada	47.0	9
Spain	45.3	10
Netherland	40.7	11

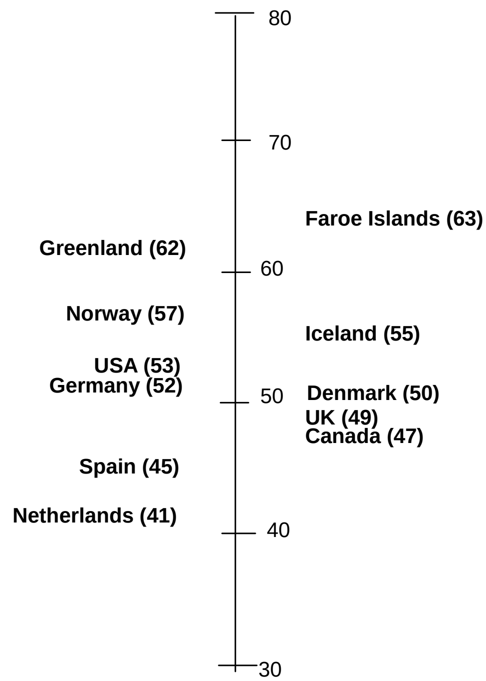


Figure 3. Aggregated ranking of fisheries sustainability of 11 countries, based on Rapfish scores and the Combined (FAO-II) scores.

Acknowledgments

This paper was initiated based on a series of discussions between the authors and Dr. Daniel Pauly, whom we wish to thank for suggestions and for insightful comments. We also acknowledge the funding of this study by the Sea Around Us Project.

References

Alder, J., Lugten, G., Kay, R. and Ferriss, B. 2001. Compliance with International Fisheries Instruments. Pages 55-83 in Pitcher, T.J., Sumaila, U.R. and Pauly, D. (eds) Fisheries Impacts on North Atlantic Ecosystems: Evaluations and Policy Exploration. Fisheries Centre Research Reports 9 (5): 94pp.

Christensen, V. , S. Guénette, J. Heymans, C.J. Walters, R. Watson, D.Zeller and D. Pauly. Estimating fish abundance of the North Atlantic, 1950 to 1999. In Guénette, S., Christensen, V. and Pauly, D. (eds) (2001) Fisheries Impacts on North Atlantic Ecosystems: Models and Analyses. Fisheries Centre Research Reports 9 (4): *in press.*

Chuenpagdee, R., Knetsch, J.L., and Brown, T.C. 2001 Environmental damage schedules: community judgments of importance and assessment of losses. *Land Economics* 77(1): 1-11.

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

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

Pitcher, T.J., Bundy, A., Preikshot, D.B., Hutton, T. and Pauly, D. (1998) Measuring the unmeasurable: a multivariate interdisciplinary method for rapid appraisal of health of fisheries. Pages 31-54 in Pitcher, T.J. Hart, P.J.B. and Pauly, D. (eds) Reinventing Fisheries Management, Kluwer Academic, Dordrecht. 435pp.

Pitcher, T.J. (1999) Rapfish, A Rapid Appraisal Technique For Fisheries, And Its Application To The Code Of Conduct For Responsible Fisheries. FAO Fisheries Circular No. 947: 47pp.

Pitcher, T.J. and Preikshot, D.B. (2001) Rapfish: A Rapid Appraisal Technique to Evaluate the Sustainability Status of Fisheries. Fisheries Research 49(3): 255-270.

Siegel, S. and Castellan, N. J., 1988. Nonparametric Statistics for the Behavioral Sciences. 2nd Edition. McGraw-Hill Book Company. 399 p.

United Nations, 1994. Agenda 21:Program of Action for Sustainable Development. Rio Declaration on Environment and Development. United Nations Publications, New York. 294 p.

Compliance with International Fisheries Instruments

Jackie Alder[1], Gail Lugten[2], Robert Kay[3] and Bridget Ferriss[4]
1 *Fisheries Centre, UBC;* 2 *Univ. of Tasmania, Australia;* 3 *Kay Consulting, Australia;* 4 *School of Marine Affairs, UW, Seattle*

Abstract

This report provides an assessment of the level of compliance with international fisheries instruments for countries bordering the North Atlantic. Fifteen instruments (conventions, treaties or agreements) were assessed for 17 countries. Overall the level of compliance is moderate to high for most instruments, and for most countries. There tends to be a latitudinal gradient of compliance, with the northern countries scoring higher than those to the south. The study revealed that few regional fishery bodies have a systematic program in place to monitor and assess compliance with their instruments. The most important result of this study, however, is that despite, at least moderate levels of compliance, most of the fisheries that are managed under these instruments are overexploited and at risk of collapse. In some cases, fisheries such as the cod in the western Atlantic are not showing signs of recovery after a 5-year moratorium on commercial fishing.

Introduction

Many fisheries cross national boundaries while others are focused in international waters. The management of these fisheries requires a multinational approach that is often undertaken through a range of international instruments such as conventions, treaties and agreements between countries. Such instruments have been used since 1351 (Committee on Fisheries 1999), but it was not until the ratification of UNCLOS, when nations began to declare their EEZs, that international instruments became common place. Until the introduction of the Bruntland Report and its concept of sustainable development as well as the Rio Declaration, many of these instruments were focused on the allocation of resources amongst member countries, with conservation or sustainable resource use a secondary purpose. However, the current purpose of these instruments is sustainable use, which is anticipated through the various provisions specified in the instruments. This has led to the assumption that if nations are complying with the provisions of these instruments then their fisheries will be sustainable. This assumption is the focus of this report, which investigates compliance with international instruments that are used to manage marine resources in the North Atlantic.

There are few published studies focused on compliance with international fisheries instruments (Anon. 2001, Honneland 2000, Lugten 1998, Ausubel and Victor 1992). The present study found that a lack of standardized methods, limited data and a reluctance of nations to provide information have contributed to the lack of assessments to date. This raises serious questions on the effectiveness of the instruments and the role of regional fisheries bodies (RFB). The FAO also recognizes the need for monitoring and evaluating instruments, RFBs and national compliance. In response to this need, the Second Meeting of FAO and Non-FAO Regional Fishery Bodies or Arrangements drafted performance indicators for the objectives (e.g. management, governance and benefit distribution) and functions (e.g. capacity development, training and information management) of RFBs and their members (Anon. 2001). The report suggests that national compliance be measured using a range of variables such as participation (e.g. meeting attendance, training), contributions (e.g. in-kind and financial support), information delivery and implementation (e.g. decision compliance, acceptance of dispute settlements). However, findings from this study indicates that few of these variables could be measured because the information is not publicly available, or RFBs and national governments are unwilling to provide the information. Nevertheless, this study was able to develop and implement a methodology based on existing information, and questioning of RFB to assess the compliance of 17 countries to 15 international instruments.

Methodology

Selection of Instruments

Treaties, conventions and agreements were identified using the FAO FARISIS database (Committee on Fisheries 1999), searches of internet sites specializing in ocean policy and law (e.g. http://www.oceanlaw.net/texts/index.htm) and literature searches. Any instrument that contained a fisheries, pollution, conservation or marine wildlife component was identified as a potential instrument for assessment. Instruments that were superceded or out of date were eliminated from the study. Bilateral agreements were also eliminated because they usually focused on countries providing access rights to fishing grounds and rarely contained provisions for managing fisheries.

Table 1. Summary of the Fisheries Instruments reviewed for the North Atlantic (acronyms are indicated in the brackets at the end of the title).

ASSESSED INSTRUMENTS	NOTES
UN Convention on Law of the Sea (UNCLOS)	-
Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (UNCLOS Fish Stocks)	Not in force, waiting for 3 signatures
Agreement to promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas (UNCLOS Compliance Agreement)	Not in force, there are only 12 signatures out of the required 25
Convention for the International Council for the Exploration of the Sea (ICES)	Provides scientific advice to regional fisheries bodies in the NE Atlantic
International Convention for the Conservation of Atlantic Tunas (ICCAT)	Manages tuna and billfish in the entire Atlantic area
Convention on Biological Diversity (CBD)	The CBD includes the Jakarta Mandate which is addressing the issues of biodiversity in marine environments
Convention for the Conservation of Salmon in the North Atlantic Ocean (NASCO)	Management of salmonid fisheries throughout N Atlantic
Convention for the Protection of the Marine Environment of the North East Atlantic (OSPAR)	Adressing marine pollution in the NE Atlantic, in particular the North Sea
Convention on Future Multilateral Cooperation in the Northwest Atlantic Fisheries (NAFO)	Management of mostly groundfish in the NW Atlantic
Convention on Future Multilateral Co-operation in Northeast Atlantic Fisheries (NEAFC)	Management of mostly pelagic fish in the NE Atlantic
Common Fisheries Policy (CFP)	Management of more than 100 species of fish within the EEZ's or Fishing Grounds of EU countries
Agreement Concerning Certain Aspects of Cooperation in the Area of Fisheries which also includes the following three agreements	This group of agreements address management of the major fisheries in the Barents Sea that are not encompassed in NEAFC or CFP
Agreement Concerning Cooperation in the Field of Fisheries Between Norway and the USSR (1975)	-
Agreement Concerning Mutual Fisheries Relations Between Norway and the USSR (1976)	-
The Grey Zone Agreement Between Norway and the USSR (1978)	-
Agreed Record of Conclusions of Fisheries Consultations on the Management of the Norwegian Spring Spawning Herring (Atlanto-Scandian Herring) Stock in the Northeast Atlantic for 1997 (Including Supplementary Agreements)	Management of Herring stock that is fished primarily in the Norwegian Sea
Negotiations on Allocating the Capelin Stock Between Norway, Iceland and Greenland	Management of capelin stock that is fished primarily in the Jan Mayan area
International Convention for the Regulation of Whaling (IWC)	-
Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS)	-
Instruments of Limited Relevance	
Declarations from International Conferences on the Protection of the North Sea	Ministers from the North Sea reconfirmed their commitment to improving the resources of the North Sea through cooperation with existing structures. No actions or initiatives taken.
Convention on the Continental Shelf	Focused on sedentary species and the seabed
US Canada Agreement on Fisheries Enforcement	Mutual cooperation in setting enforcement standards, policies, strategies.
Convention on Conduct of Fishing Operations in the North Atlantic	Focused on gear and associated equipment, it is implemented by other agreements where gear or other equipment is specified
Agreement on Sealing and the Conservation of Seal Stocks in the Northwest Atlantic (amended 12-Dec-75)	Bilateral between Canada & Norway, does not appear to be used today by either party, each party sets own quota
Agreement on the Measures to Regulate Sealing and to Protect Seal Stocks in the Northeastern Part of the Atlantic Ocean	Bilateral between Norway & Russian Federation, appears to be used to set annual quota for harp and hooded seals.
Agreement on Cooperation in Research, Conservation and Management of Marine Mammals in the North Atlantic	Greenland; Iceland; Norway ;Faroe Islands
Convention on the International Maritime Organization	Conduct of vessel operations, no role in management
Agreement Concerning Cooperation in Marine Fishing	Signed in 1963 between Russia, Cuba, Poland and Bulgaria. Its currency is unknown. Focused on open seas and the development of new fisheries.
North American Agreement on Environmental Cooperation	It is between Canada and the USA; no commercially important marine fish are included
Regional Convention on Fisheries Cooperation Among African States Bordering the Atlantic Ocean	10 parties from African Nations, primarily dealing with fisheries in the mid to South Atlantic
Agreement on Fisheries Between Norway and the Faroes	Focused on giving mutual rights to fish in each country's EEZ, does not manage shared stocks
Convention on International Trade in Endangered Species of Wild Fauna and Flora	Does not include commercially important marine fish
Convention on the Conservation of Migratory Species of Wild Animals	Does not include commercially important marine fish
Convention on the Conservation of European Wildlife and Natural Habitats	Does not include commercially important marine fish

***Table** 1 continued.* **Instruments Superceded.**

Convention on the Territorial Sea and the Contiguous Zone	Replaced by UNCLOS
Convention on Fishing and Conservation of the Living Resources of the High Seas	Replaced by UNCLOS
Convention on the High Seas	Replaced by UNCLOS
Convention for the Regulation of the Meshes of Fishing Nets and the Size Limits of Fish	Replaced by Northeast Atlantic Fisheries Convention
Fisheries Convention	Replaced by UNCLOS and CFP
Agreement on the regulation of North-East Atlantic Cod	Replaced by Cooperation in the Area of Fisheries
Reciprocal Fisheries Agreement	Replaced by NASCO on the east coast of North America, and Pacific Salmon in the west coast.
Agreement on the Regulation of Fishing of the Atlantic Scandinavian herring (1973)	Replaced by the 1980 Herring Agreement
Agreement on Fisheries and the Continental Shelf Between Norway and Iceland (1980)	Replaced by 1996 and 1997 Herring Agreement

If the instrument did not contain provisions for managing fisheries, marine wildlife, marine biodiversity or pollution it was also eliminated. This elimination process resulted in the preliminary assessment of 19 instruments (Table 1). The relationship between these instruments is illustrated in Figure 1.

Assessment Criteria

The assessment criteria for each instrument is focused on measuring either qualitatively or quantitatively the level of compliance with the various fisheries management provisions contained within an instrument. The provisions in each instrument were examined to identify the assessment criteria. Some instruments contained few provisions for management, in these cases the current management or work programs were used to develop the assessment criteria. The criteria were specified to ensure maximum differentiation between the levels within a criterion. Generally a range of scores between 0 and 3 was used for a criterion.

A specific set of criteria for each instrument was formulated since each instrument has specific provisions (Tables 3a to 3p: see at end of text). Where possible criteria were limited to approximately 6 per instrument. Some instruments such as the Fish Stocks Agreement had less than the 6 criteria due to their broad nature and application.

Scoring

Published reports from the various secretariats of the conventions, agreements and treaties as well as stock assessments from ICES were used to obtain information against which countries were scored for their compliance with the agreement. In some cases journals were also used to gather the necessary information. If information was not published, then officers for the instrument were contacted for the appropriate information. Only those countries where the instrument applied were assessed, irrespective of whether they were party to the instrument or not.

Results

Fifteen of the 19 potential instruments were fully assessed (Table 2). In the North Atlantic, compliance varies considerably between countries and treaties. Overall the Convention for Multilateral Cooperation in the North East Atlantic had the highest level of compliance, with an average score of 81% based on five countries (the EU score was used to represent the respective scores). The Fisheries Compliance Agreement had the lowest level of compliance with an average score of 33% based on the 15 countries where it applies. There was a distinct difference in compliance with the Compliance Agreement; either countries have ratified the agreement and are actively implementing it or they have signed it but not ratified it. Morocco had the lowest level of compliance with a score of 27% based on the 5 instruments that apply, while the Faroe Islands, Norway and Greenland shared the highest average score (69%).

FISHERIES INSTRUMENTS

United Nations Convention on Law of the Sea (UNCLOS)

Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (Fish Stocks Agreement)

Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas (Compliance Agreement)

The level of compliance for these instruments ranged between 100% for the Fish Stocks Agreement and 0% for the Compliance Agreement (Tables 3a, 3b and 3c).

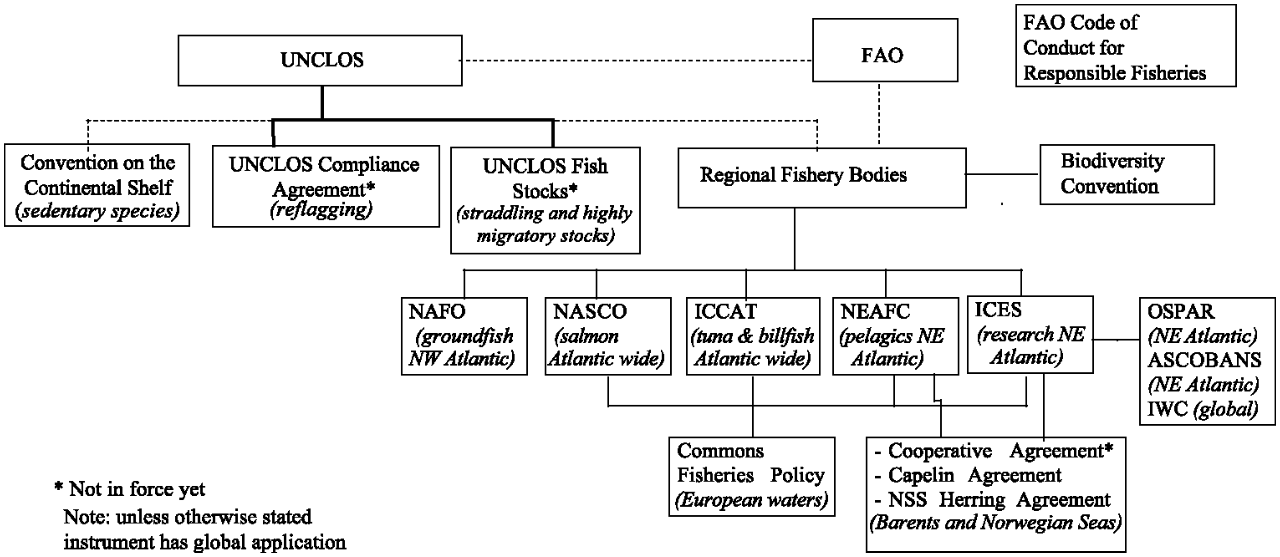


Fig. 1. Network of North Atlantic Fisheries International Instruments.

Canada, Morocco and the United States have yet to fully ratify UNCLOS. The status of the Faroe Islands and Greenland with respect to these instruments is unclear, therefore they were not included in this part of the analysis.

The overall level of compliance with the Fish Stocks and Compliance Agreements is much less than for UNCLOS (Table 2). The European Union as an entity representing the countries in the Union has not ratified the Fish Stocks Agreement and therefore represents a major proportion of those countries in this study (11/15) exhibiting a poor level of compliance. Other countries such as Canada, Iceland, Norway and the United States have ratified the agreement and are actively implementing it even though it is not in force. The agreement has 27 signatures and requires 30 to come into force. The extent of this agreement is shown in Figure 2a.

The Compliance Agreement has been accepted by many of the countries in the study with the exception of Morocco, Russia and Iceland. This agreement is also not in force yet because it has not reached the 25 signatures that required.

These instruments were difficult to assess because there is no single agency responsible for the implementation of any of UNCLOS instruments. Although the United Nations is the depository for these instruments, other conventions such as

Table 2: Summary of National Compliance (% scores).

	Belgium	Canada	Den-mark	Faroe Is'ds	Germany	France	Iceland	Greenland	Ireland	Morocco	Netherland	Norway	Portugal	Russia	Spain	UK	USA	EU	Mean
UNCLOS	90	50	90		90	90	80		90	45	90	90	90	80	90	90	25	-	79
Fish Stocks	25	100	25		25	25	100		25	25	25	100	25	50	25	25	100	-	47
Compliance	33	33	100		33	33	33		33	0	33	33	33	0	33	33	33	-	33
NAFO		80		69	46		73	77				64	75	79	75	44	68	-	68
NEAFC*	78		78		78	78	89	78	78		78	89	78	89	78	78		78	81
ICCAT		83				38			52	25			56		38	44	92	-	54
ICES**	0	90	60	60	50	30	60	60	10		70	90	40	0	40	70	100	-	52
CFP	47		40		60	45			55		55		59		35	45		-	49
Coop Agree												41		41				-	41
NSS Herring				75			75					86		75				100	78
Capelin							50	64				100						-	71
IWC	-	16	80	75	-	-	58	75	-	-	-	67	-	67	-	100	83	-	69
ASCOBANS	46		50		79	12.5					58	12.5				75		-	48
CBD	54	58	58	58	58	67	33	58	46	42	58	58	50	50	50	85	17	-	53
OSPAR	57		77	77	83	53	67	77	67	-	73	70	83		92	100		-	75
Average	47.8	63.8	65.8	69	60.2	47.2	65.3	69.9	50.7	27.4	60	69.3	58.9	53.1	55.6	65.8	65	-	58

** EU (European Union) countries treated as one. ** FI and GL as per Denmark*

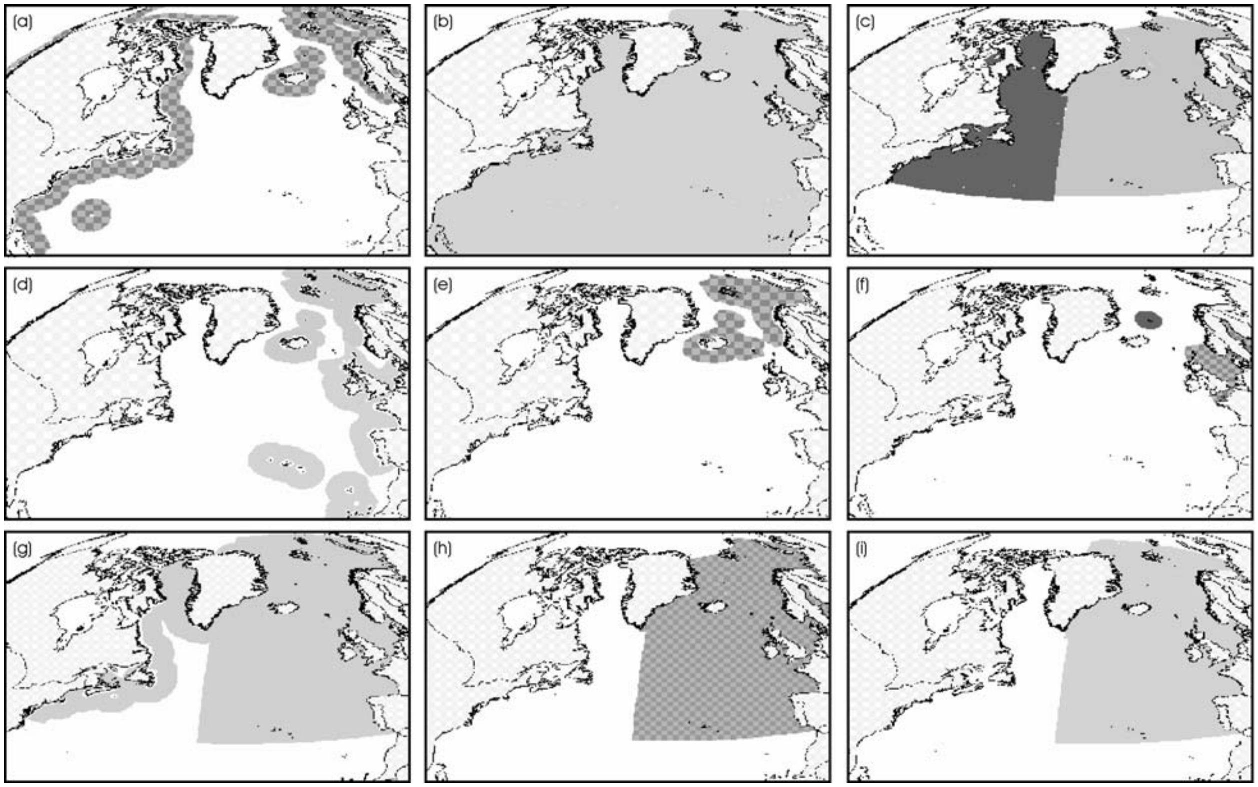


Fig. 2. Parts of the North Atlantic covered by various international instruments devoted to the management of North Atlantic resources. (a): Fish Stocks Agreement; (b): International Convention on the Conservation of Atlantic Tuna (ICCAT); (c): Conventions on Future Multilateral Cooperation in the North East Atlantic (light shading) and the North West Atlantic (dark shading). (d): Common Fisheries Policy (light shading) and Agreement Concerning Certain Aspects of Cooperation in the Area of Fisheries (around Iceland and Norway). (e): Norwegian Spring Spawning Herring Stocks Agreement; (f) Capelin Fishery in the Jan Mayen area (dark shading) and Agreement on the Conservation of Small Cetaceans in the Baltic and North Seas (chequered); (g): Convention for the Conservation of Salmon in the North Atlantic; (h):Convention for the Protection of the Marine Environment of the North East Atlantic (OSPAR); (i): International Council for the Exploration of the Sea (ICES) Convention.

North Atlantic Fisheries Organization (NAFO) have a secretariat that deals with the Convention on Future Multilateral Co-operation in Northwest Atlantic Fisheries on a day-to-day basis, however, there is no equivalent agency within the UN. UNCLOS is a highly complex instrument and is administered by the Division for Ocean Affairs and Law of the Sea within the United Nations Office of Legal Affairs. Through various articles such as 63 to 67, it is the Fish Stocks and Compliance Agreements that are used to implement those parts of UNCLOS that pertain to living resources.

Several difficulties were encountered in assessing these three instruments. Because of their broad nature and lack of specific provisions for fisheries management it was difficult to draft a comprehensive set of assessment criteria compared to other instruments such as ICCAT and NAFO (Tables 3d and 3f). A search of the literature also revealed little information on country-specific activities to implement these instruments. There was considerable literature, however, on the arguments used to debate whether the United States should sign UNCLOS and the Compliance Agreement. Because there is no single agency devoted to the instruments, each country was contacted for the appropriate information. Few countries responded to our request for specific information and therefore the assessable criteria were reduced to just a few that could be assessed using existing information. The criteria and scores are detailed in Tables 3a, 3b and 3c.

International Convention on the Conservation of Atlantic Tuna (ICCAT)

The ICCAT only applied to 8 of the 17 countries in the study. Although many other countries which border on the Atlantic are also signatories to the convention but they are outside of the study area (Figure 2b). However, some countries in the study such as Denmark, Faroe Islands and Iceland are starting to target bluefin tuna in the Atlantic and there is increasing concern amongst member countries (NOAA 2001). The United States (91%) and Canada (83%) have a high level of compliance, while countries such as Morocco (25%), Spain (37.5%) and France (37.5%) have a low level of compliance (Table 3d). Despite a reasonable level of compliance by many member countries that have ratified the convention, most tuna stocks in the North Atlantic are still considered to be over-exploited (DFO 1998).

Convention on Future Multilateral Cooperation in Northeast Atlantic Fisheries

This instrument (NEAFC) applies to those countries bordering the east Atlantic but not the Baltic (Figure 2c), Black or Mediterranean Seas. Management is focused on demersal fisheries such as blue whiting, oceanic redfish, herring mackerel and capelin. Highly migratory species such as tunas, and anadromous stocks such as salmon are dealt with in other instruments contained within this report. The Convention established the North-East Atlantic Fisheries Commission. Though the commission has the power to recommend a wide variety of conservation and management measures it generally only used a few measures such as setting TACs for the various stocks it manages.

The Commission would only provide compliance information at the European Union level and not on a country by country basis (Table 3e). Overall compliance is high for all countries that have signed the convention. However, the management provisions such as the use of logbooks and VMS are easy to comply with for these countries, while TACs are generally set by the consensus by member countries and do not necessarily reflect the catch levels needed to maintain the stocks or a precautionary approach to setting the TAC.

Convention on Future Multilateral Cooperation in Northwest Atlantic Fisheries

This instrument (NAFO) applies to those countries bordering the west Atlantic, primarily Canada, USA, Faroe Islands, Greenland and Iceland as well as Germany, Norway, Portugal, Russia, Spain and the United Kingdom due to their long history of fishing in the area (Figure 2c). There are several other countries outside of the North Atlantic who are signatories to the convention but they are outside of the *SAU* project study area. The convention applies to all fish stocks except anadromous fish such as salmon or highly migratory stocks such as tunas and cetacean stocks managed by the International Whaling Commission. Much of the focus is on groundfish stocks such as cod, redfish, flounder, capelin, shrimp and Greenland halibut.

The commission sets quotas as well as time and spatial restrictions for the harvest of a range of species, and compliance is low to moderate among the North Atlantic countries that have ratified the agreement (Table 3f). Canada has a high level of compliance (80%) while the compliance levels of the UK and Germany's are low (44% and 46% respectively). Despite these levels of compliance, several stocks, especially cod, are still at critically low levels. The 2000 Annual Report noted that the Scientific Council had reviewed and assessed 19 fish stocks and concluded that groundfish abundances are still low and that "there should not be a direct fishery for those stocks in 2001" (NAFO 2000, pg. 9). Consequently in specific areas of the northwest Atlantic cod, redfish, American plaice, Witch flounder and capelin fisheries were closed for 2001.

Commons Fisheries Policy (CFP)

The CFP is the main instrument for managing fish stocks in European Union waters (Figure 2d), and has 4 main objectives that include maintaining sustainable fisheries. This objective is accomplished through the cooperation of member states, however, it appears that this policy is of limited effectiveness with 67% of stocks within EU waters overfished, 50% depletd and 37% overfished and depleted (Anon. 2000).

The CFP uses a range of measures to implement the sustainable fisheries objective: the Mulit-Annual Guidance Program (MAGP) which is aimed at reducing the fleet size in each member country, TACs and quotas, VMS and logbooks. Although the MAGP has reduced fleet size, this was counterbalanced by increasing effort, so that the net effect has been an increase in fishing efficiency and catches. The EU is trying to address this problem, but has had limited success until now (Schorr 2000). There are 103 TACs and quotas set for fish stocks by the EU each year. Despite recommendations from ICES to further reduce quotas, member states are unwilling to reduce the quotas and continue to extract marine resources at unrealistic rates. In the area of enforcement and the use of logbooks, the effectiveness of these activities is highly questionable since the EU has only one vessel and few inspectors to oversee this component of the CFP (Long & Curran 2000).

Compliance with the CFP is low to moderate among member states (Table 3g) due to the continued high levels of exploitation that some countries continue to practice. Countries such as Germany and the Netherlands scored higher than

50% because of their commitment to meet the MAGP targets, while Ireland and Portugal scored above 50% due to their limited fishing activities in the areas where stocks are under threat of overfishing (Table 3g). The remaining North Atlantic EU members scored below 50% the lowest score being recorded by Spain (35%) with one of the highest levels of violations recorded, as well as one of the highest levels of quota hopping of member states (Long & Curran 2000).

Agreement Concerning Certain Aspects of Cooperation in the Area of Fisheries

This agreement is specific to managing fish stocks shared by Russia, Iceland and Norway in the Barents Sea (Figure 2d). The agreement facilitates the use of a TAC to manage cod, capelin, haddock, tusk, ling and blue ling and the bycatch associated with these fisheries. The Agreement allows Iceland to access these stocks in the EEZ of Norway and Russia in exchange for ceasing to fish in the Barents High Sea area ("Loop Hole" or "Grey Zone"). This agreement allows Norway and Russia to also manage other countries who want to access fish stocks in the Barents Sea (Table 3h).

The Agreement will soon come into force once all three parties have finalized their domestic arrangements to accommodate the agreement. The scoring criteria developed for this instrument can also be applied to previous instruments, and this was done for the above countries based on their performance under the previous agreement. The compliance scores for Norway and Russia were low because both countries exceeded their TAC and lacked observers (Table 3h). Information on Iceland's activities in relation to this agreement could not be found and requests for information to the Icelandic Fisheries Department did not yield any results.

Norwegian Spring Spawning Herring Stocks Agreement

Five countries (Table 3i) are party to this agreement which manages the Norwegian spring spawning herring in the Norwegian Sea (Figure 2e). The stock is managed using a TAC and quotas across the five contracting parties. Protocols formulated in 1996 and 1997 are used to implement the agreement. There is no organization that oversees this agreement, the TAC and quotas are based on advice from ICES and set at an annual meeting of all parties.

Country compliance for this agreement is based on three criteria; the national quota, logbook system and vessel inspection levels. Using these three criteria there is a high level of compliance among the five contracting parties (Table 3i). The EU scored the highest (100%) while Iceland and Russia scored the lowest (75%).

Agreement between Iceland, Denmark (with respect to Greenland) and Norway about Capelin in Jan Mayen

This instrument attempts to address the problem of overlapping EEZ's between Norway and Iceland (Figure 2f). Three criteria were used for this instrument: the quota, logbook system and vessel inspection levels (Table 3j). The level of compliance for the three countries varied between 50% (Iceland) and 100% (Norway) with Greenland having a compliance level of 65% (Table 3j).

Convention for the Conservation of Salmon in the North Atlantic (NASCO)

As the name implies this instrument is focused on the management of salmon stocks throughout the North Atlantic (Figure 2g). There are a number of countries who are contracting parties, however, when the secretary of this convention was approached for information to make an assessment, he advised that such information was not available and that activities regarding the precautionary approach were still in the initial stages (Table 3k). Consequently, it was not possible to assess this instrument. Nevertheless, the consensus among scientists indicates that salmon stocks throughout the North Atlantic are at critically low levels, suggesting that either the management measures taken under this instrument have not been effective or the level of compliance with measures taken under this instrument is low.

Marine Wildlife Instruments

There are two primary instruments used to manage marine wildlife in the North Atlantic that were assessed as part of this study: the Whaling Convention and ASCOBANS. Canada and Norway have a bilateral agreement in place to set the annual quota for harp and hooded seals, but this does not appear to be actively used since each country sets its quotas independently. There is also a bilateral agreement between Norway and Russia on setting the annual quota of harp and hooded seals, however, little information could be found on the current level of activity within this agreement.

International Whaling Convention (IWC)

Many countries within the study area are signatories to this instrument. The notable exceptions is Canada. Canada left the Convention in 1982 and Iceland left in 1992 but returned in 2001. Overall compliance was found to be moderate to high among contracting parties with a history of whaling (Table 3l). The UK had the highest compliance level (100%) while Canada was the lowest with 16%. All other countries in the study had compliance levels above 58%. This relatively high level of compliance was also noted by Ausubal and Victor (1992) in their assessment of international environmental instruments.

Agreement on the Conservation of Small Cetaceans in the Baltic and North Seas (ASCOBANS)

This relatively new instrument which was signed in 1992 has been very active in addressing its objective of conserving small cetaceans in the defined area (Figure 2f). Norway and France are the only remaining countries bordering the agreement that have not ratified the agreement. The level of compliance among contracting parties ranged between 46% (Belgium) and 79% (Germany) (Table 3m).

Pollution and Biodiversity

Only two instruments, The Convention for the Protection of Marine Environments of the North Atlantic (OSPAR) and the Convention on Biological Diversity, were identified as having any significant relevance to the *Sea Around Us* project and the North Atlantic (Table 3m and 3n).

Convention on Biological Diversity (CBD)

This global convention has been ratified by all the countries in this study, however, not all countries have ratified the Cartagena Protocol (Table 3n). The Jakarta Mandate within the CBD is the framework for marine and coastal biodiversity conservation to be implemented within each contracting party. The level of implementation of the Jakarta Mandate has been low for the countries in this study (Table 3n). Some countries have submitted their second report to the secretariat for the convention and in this report they indicated that implementation of the work program for marine biodiversity is a medium to high priority but also that resources to implement the work program were limited (see CBD web site for national reports).

Protection of Marine Environments of the North Atlantic (OSPAR)

Although this instrument is focused on the prevention and elimination of pollution in the area of the convention (Figure 2f), Annex V emphasizes the need to conserve and protect ecosystem and biological diversity of marine areas, and is therefore of interest to the SAUP. The convention has signed a memorandum of understanding with ICES based on their concern over the state of fish stocks in the North Atlantic. The convention has a well defined monitoring and evaluation system in place to assess country compliance with the conventions decisions and recommendations (Table 3o). The level of compliance by contracting parties was high overall with 5 of 11 countries having a score of more than 75%. The lowest compliance score was by France (53%).

Other

International Council for the Exploration of the Sea Convention (ICES)

ICES is the oldest recorded regional fishery body and dates back to 1902 (Maguire, *this volume*). It is an intergovernmental marine organisation that undertakes scientific study of the sea (Figure 2i) and its resources and provides management advice as requested by various international commissions, the European Union and national governments. The Council is primarily an advisory body and does not implement any management recommendations. The convention requires each contracting party to provide the Council with information as requested and to assist in carrying out the research programs coordinated by the Council. Recently, the Council has been encouraging contracting parties to take a precautionary approach to fisheries management, and to assist these parties, the Council has attempted to incorporate precautionary principles in both its technical and advisory roles.

According to the Council, compliance with the major provisions of the Convention such as financial contributions is high. Other compliance information, such as timeliness and quality of the information provided, however, was difficult to obtain from the Council and was not published in any of the reports of the Council. The reports of the Council did provide an indication of which countries are active participants in the organization through hosting of meetings, chairing committees etc.

Consequently, the assessment of countries compliance with this instrument was based primarily on a country's level of participation in ICES and its application of the precautionary approach in accordance with ICES CM1997/Assess 7 (Table 3p). Based on these criteria compliance ranged from 0% for Russia to 100% for the United States. The average level of national compliance was 50% (Table 3p).

Discussion

The most startling fact revealed by this study is that high compliance does not necessarily equate

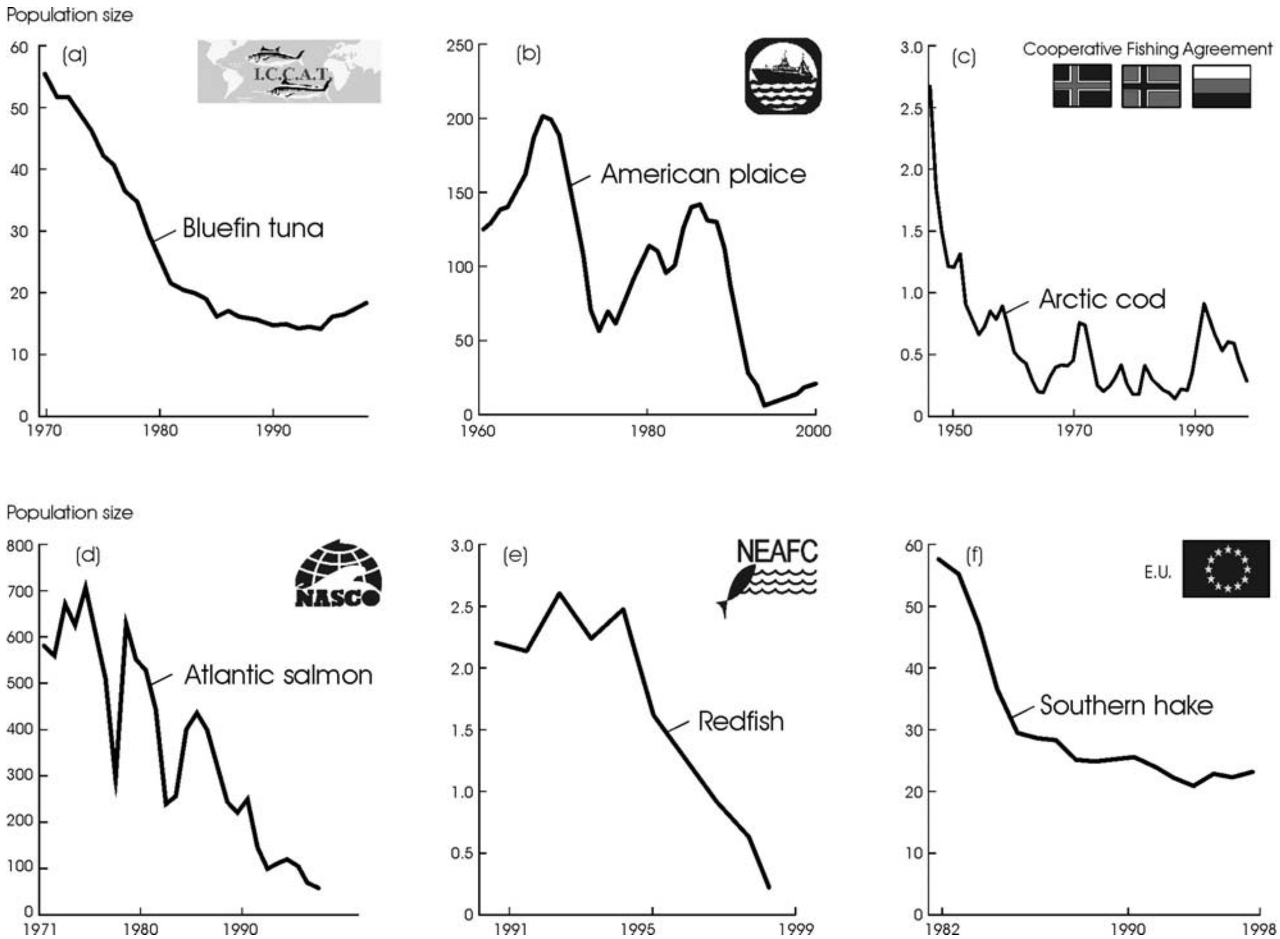


Fig. 3. Time series of the abundance of some species under the care of six international bodies tasked with managing North Atlantic fisheries: (a) Western Atlantic Bluefin tuna (*Thynnus thunnus*), managed under the International Commission for the Conservation of Atlantic Tuna (ICCAT); (b) American plaice (*Hippoglossoides platessoides*) in Division 3LNO of the North Atlantic Fisheries Organization (NAFO); (c) Arctic cod (*Boreogadus saida*), managed under a 'Cooperative Fishing Agreement' between Iceland, Norway and Russia; (d): Atlantic salmon (*Salmo salar*) in areas 1SW & 2SW of the North Atlantic Salmon Conservation Organisation.(NASCO); (e); Atlantic red fish (*Sebastes mentella*), managed under the North East Atlantic Fisheries Commission (NEAFC); (f) Southern hake (*Merluccius merluccius*) in Divisions VII & IXa of the International Council for the Exploration of the Sea (ICES), and managed under the Common Fisheries Policy of the European Union.

to sustainable fisheries management. Many of the stocks that are managed under the various instruments assessed are still overexploited, considered under threat or collapsed despite high compliance levels (Figures 3a to 3f). The status of many of the tuna stocks (Figure 3a) in the North Atlantic along with cod stocks (Figure 3c) and salmon stocks (Figure 3d) are a clear contrast to the compliance levels that this study has described. There are a number of reasons for this contrast: countries are reluctant to reduce their share of the resource, lack of reliable information, considerable uncertainty associated with the information that is currently available, and limits in the methods used in stock assessments and catch allocations. Many conventions are heeding the advice of ICES and conservation groups in a precautionary approach; however, it appears that an even more conservative, more precautious, approach is needed for most stocks in the North Atlantic.

The scores also reveal a North-South gradient of compliance, with countries in the north generally exhibiting a higher level of compliance than those in the south for the different instruments and well as the national average. The northern countries of Faroe Islands, Norway and Greenland had the highest overall scores (69%), they were followed by Canada, Denmark, Germany, Iceland, Netherlands, the United Kingdom and the United States with average scores of above 60%. Spain, Portugal, Ireland and Russia had average scores between 50% and 60%, and Belgium (48%) and Morocco (27%) were below the 50% mark (Table 2).

Spain is often given as an example of a country that does not respect, or abuses, international fishing agreements, and for a number of instruments in this study Spain's level of compliance is relatively low. However, it should be noted that countries such as France and Portugal can be just as reluctant to comply. Often these countries scored low because they fail to provide the necessary information needed for management rather than exceed the quotas that had been set. This may be due to the structures, with the national fisheries agencies not efficient or effective in collecting and disseminating catch and effort information. There is a perceived lack of understanding amongst fisheries managers on the importance of forwarding this information or there is a reluctance to collect this information for fear of it being used to further reduce access to the resources. Nevertheless, it is important that the information collection and dissemination components of these instruments be strengthened for a number of instruments.

This study involved a thorough search and review of a number of instruments, reports on the Common Fisheries Policy raise serious concerns about the effectiveness of this policy. One report indicated that several stocks are either depleted, overfished or both (Anon. 2000), and several reports indicate that countries are reluctant to reduce their quota and therefore their share of the resource, despite calls by ICES and conservation groups to do so. Considerable research and debate amongst managers occurs before the final decision is made. The consistent disregard of the advice combined with limited enforcement of the policy makes the CFP of limited effectiveness. The Common Fisheries Policy is scheduled for review in 2002 and this presents an opportune time for conservation groups to lobby for more realistic quotas and in some cases moratoriums to be set for the survival of many fish stocks in the North Atlantic.

References

Anon. 2000. Preparation for a mid-term review of the Multi-annual Guidance Programmes (MAGP). Report from the Committee to the Council, COM(2000): 272 final. Brussels: Committee of the European Communities.

Anon. 2001. Indicators to Assess the Performance of Regional Fishery Bodies: Second Meeting of FAO and NON-FAO Regional Fishery Bodies or Arrangement. Rome: FAO. 26pp.

Ausubel, J. H. and D. G. Victor. 1992. Verification of Internatinal Environmental Agreements. Annual Review of Energy and Environment 17:1-43.

Committee on Fisheries. 1999. FAO's Fisheries Agreement Register (FARISIS): COFI/99/Inf.9. Rome: FAO. 8pp.

Fisheries and Oceans Canada. 1998. Canadian Integrated Fisheries Management Plan:Bigeye (*Thunnus obesus*), Yellowfin (*Thunnus albacara*) Albacore Tunas (*Thunnus alalunga*) 1998-1999. Department of Fisheries and Oceans Canada, Ottawa.

Honneland, G. 2000. Compliance in the Barents Sea fisheries. How fishermen account for conformity with rules. Marine Policy 24:11-19.

Long, R. J. and Curran, P. A. 2000. Enforcing the Common Fisheries Policy. Oxford: Blackwell Science. 379 pp.

Lugten, G. 1998. A Review of Measures Taken by Regional Marine Fishery Bodies to Address Contemporary Fishery Issues. FAO Circular. No. 940. Rome: FAO. 97pp.

Maguire, J-J. 2001. Fisheries Science and Management in the North Atlantic. Pages 36-48 in Pitcher, T.J., Sumaila, U.R. and Pauly, D. (eds) (2001) Fisheries Impacts on North Atlantic Ecosystems: Evaluations and Policy Exploration. Fisheries Centre Research Reports 9 (5): xx pp.

NOAA. 2001. International Agreements Concerning Living Resources of Interest to NOAA Fisheries. Silver Springs, USA: National Marine Fisheries Service, NOAA.

Northwest Atlantic Fisheries Organization (NAFO). 2000. Annual Report 2000. Dartmouth, Canada: NAFO. 216 pp.

Schorr, D. 2000. Fishing Subsidies: Hidden payments, depleted stocks. In Fishing in the Dark. http://www.fishing-in-the-dark.org/docs/proceedings.html

Gordon R. Munro, G.R. and Sumaila, U.R. (2001) Subsidies and their potential impact on the management of the ecosystems of the North Atlantic. Pages xx-xx in Pitcher, T.J., Sumaila, U.R. and Pauly, D. (eds) (2001) Fisheries Impacts on North Atlantic Ecosystems: Evaluations and Policy Exploration. Fisheries Centre Research Reports 9 (5): xx pp.

Watson, R.A., Gelchu, A. and Pauly, D. (2001) Mapping Fisheries Landings With Emphasis On The North Atlantic. Pages xx-xx in Zeller, D., Watson, R. and Pauly, D. (eds) (2001) Fisheries Impacts on North Atlantic Ecosystems: Catch, Effort and National/Regional Data Sets. Fisheries Centre Research Reports 9 (3): xxx pp.

Tables 3a to 3p follow.

Table 3a. Features, Scoring Criteria and Scores for the Instrument: **United Nations Convention on Law of the Sea.**
Acronym: LOSC Signed: 10th December, 1982. Ratified: 16th November, 1994.

Description	The codification of a universally accepted regime for fisheries regulation as a part of the codification of the law of the sea. The Convention deals with a comprehensive range of subjects contained in 320 articles and nine annexes. Specifically with regard to marine capture fisheries, the Convention deals with the exclusive economic zone (EEZ), the rights and jurisdiction of the coastal state, conservation and management of the living resources of the high seas, maximum sustainable yield (MSY), optimum utilization, and the establishment of regional fishery bodies (RFBs) for transboundary and highly migratory stocks.
Relevance SAUP	The 1982 Convention remains the parent Convention of all International Fishery Instruments. The core provisions of the fisheries regime are contained in its Part V provisions dealing with the Exclusive Economic Zone (i.e. Articles 55-75). In addition, Article 87 recognises freedom of high seas fishing and Articles 116-120 describe the status of high seas fisheries. Articles 61 and 119 of the Convention provide for cooperation in fisheries management through competent sub-regional, regional or global organisations. To that extent, the SAUP Evaluation of North Atlantic Marine Ecosystems complies with regional cooperation requirements.
Major Provisions	In exercising EEZ rights and duties, state parties shall have due regard to the rights and duties of other states. (Article 56) Coastal state is responsible for determining allowable catch of living resources within its EEZ in accordance with "proper conservation and management measures." (Article 62) Coastal state shall promote the objective of optimum utilization of living resources within the EEZ. (Article 62) Coastal state and states fishing for trans-boundary stocks are required to seek to agree upon measures necessary for conservation of stocks in the EEZ adjacent area. (Article 63) Coastal state shall cooperate to ensure conservation and optimum utilization of highly migratory stocks "throughout the region, both within and beyond the exclusive economic zone." (Article 64) States to cooperate with a view to the conservation of marine mammals within the EEZ and in the high seas, and in the case of cetaceans, to work through appropriate international organisations for their conservation, management and study. (Article 65 and 120) All states have the duty to take, or to cooperate with other States in taking, such measures for their respective nationals as may be necessary for the conservation of the living resources of the high seas. (Articles 117 and 118) In determining the high seas allowable catch, and for establishing conservation measures, states shall take measures designed on the best scientific evidence available, to maintain or restore populations of harvested species at levels which can produce the MSY, as qualified by environmental and economic factors. States shall also take into consideration the effects on species associated with or dependent upon harvested species. Available scientific information, catch and effort statistics, and other data relevant to the conservation of fish stocks, shall be contributed and exchanged on a regular basis through competent fishery organisations. (Article 119)
Significant Programs, Decisions and Recommendations	Since the ratification of the LOSC two subsequent and significant agreements have been introduced: the Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, and the; Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas. These two documents are the mechanisms for implementing the major fisheries articles (Articles 61 to 65, and 116 to 120) contained within LOSC.

Criteria	Provision/Decision/Program	Criteria	Max. Score
1	Signature/Ratification including declarations made at signing or ratification	0 not signed; 1 has signed with Declaration; 2 has signed without Declaration; 3 has ratified with Declaration; 4 has ratified without Declaration	4
2	Implementation of Convention Requirements	0 no activity; 1 partial activity; 2 full activity	2
3	Implementation of Part XI of the Convention	0 not signed; 1 has signed with Declaration; 2 has signed without Declaration; 3 has ratified with Declaration; 4 has ratified without Declaration	4
	TOTAL		10

Criteria	BEL	CAN	DMK*	FGR	FRA	ICE	IRE	MOR	NED	NOR	RUS	POR	SPA	UK	USA	EC
1	3	2	2	3	3	3	3	2	3	3	3	3	3	3	0	3
2	2	1	2	2	2	1	2	.5	2	2	1	2	2	2	.5	2
3	4	2	2	4	4	4	4	2	4	4	4	4	4	4	2	4
Total	9	5	5	9	9	9	9	4.5	9	9	8	9	9	9	2.5	9
%Score	*90*	*50*	*60*	*90*	*90*	*80*	*90*	*45*	*90*	*90*	*80*	*90*	*90*	*90*	*25*	*90*

** Greenland and Faroe Islands under Denmark*

Table 3b. Features, Scoring Criteria and Scores for the Instrument: **Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas.**
Acronym: Compliance Agreement. Signed: 24th November, 1993. Ratified: 18 states out of 25.

Description	An international agreement arising out of Declaration of Cancun (1992), and Agenda 21 of UNCED (1992) for states to take effective action, consistent with international law, to deter the practice of reflagging of vessels as a means of avoiding compliance with applicable conservation and management rules for fishing activities on the high seas. Accordingly, the Compliance Agreement was negotiated under the FAO Constitution, and adopted by the FAO Conference on 24th November, 1993. The Compliance Agreement will enter into force when 25 instruments of acceptance have been deposited with FAO.
Relevance SAUP	The international legal regime for marine fisheries cannot operate effectively if fishing vessels are permitted to reflag to a flag state of convenience to escape the applicable conservation and management measures of high seas fishing.
Major Provisions	Flag States to take the necessary measures to ensure that fishing vessels entitled to fly its flag do not engage in any activity that undermines the effectiveness of international conservation and management measures.(Article III) Parties to maintain a record of fishing vessels. (Article IV) Exchange of information with FAO. (Article VI) Parties shall cooperate with Developing Countries at global, regional, sub-regional, or bilateral levels. (Article VII)
Significant Programs, Decisions and Recommendations	This agreement has not been ratified yet, however, countries and regional fisheries bodies recognise the agreement. These countries and RFB are incorporating the provisions of the agreement in their operations (see current NEAFC Scheme and “Agreed Record of Conclusions of Fisheries Consultations on the Management of Norwegian Spring Spawning Herring (Atlanto Scandian Herring) Stock in the Northeast Atlantic for 1997”)

Criteria	Provision/Decision/Program	Criteria	Max.Score
1	Instrument of Acceptance	0 Not Lodged; 1 Lodged	1
2	Implementation of the Agreement	0 No Implementation / No response; 1 Partial Implementation; 2 Full Implementation	2
	TOTAL		3

Criteria	BEL	CAN	DMK	FGR	FRA	ICE	IRE	MOR	NED	NOR	POR	RUS	SPA	UK	USA
1	1	1	1	1	1	1	1	0	1	1	1	0	1	1	1
2	0	0	2	0	0	0	0	0	0	2	0	0	0	0	0
Total	1	1	3	1	1	1	1	0	1	3	1	0	1	1	1
%Score	*33*	*33*	*100*	*33*	*33*	*33*	*33*	*0*	*33*	*33*	*33*	*0*	*33*	*33*	*33*

Table 3c. Features, Scoring Criteria and Scores for the Instrument: **Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks.**

Acronym: Fish Stocks Agreement. Signed: 4th December, 1995. Ratified: 30 days after the 30th instrument of ratification or accession deposited. At March 2001, 27 instruments ratified.

Description	An intergovernmental agreement called for at the United Nations Conference on Environment and Development to elaborate on, and provide guidance for, the implementation of the LOSC fisheries regime for straddling fish stocks and highly migratory fish stocks.
Relevance SAUP	Despite the LOSC's central principle of conservation, by the time the Convention came into force in 1994, over 70% of the world's marine capture fisheries were fully exploited, over-exploited or in a state of recovery. The over-fishing crisis is particularly problematic with regard to high seas fish stocks, straddling fish stocks, and highly migratory fish stocks where the LOSC provides an inadequate legal and management regime. The Fish Stocks Agreement is an intergovernmental legal agreement constructed under UN auspices and subsidiary to its parent treaty – the LOSC. It represents the most significant development in international fisheries law since the creation of the LOSC.
Major Provisions	• Provides the first treaty definition of the terms "conservation and management" as meaning "measures to conserve and manage one or more species of living marine resources that are adopted and applied consistent with the relevant rules of international law as reflected in the Convention and this Agreement." • A mandate for coastal states and distant water fishing states to cooperate to achieve compatibility of conservation and management, including a framework on how this is best to be achieved. (Article 7) • Describes a number of specific ways by which the "duty to cooperate" can be effectuated. (Article 5) • Endorses the Precautionary Approach and provides examples on how it can be applied. (Article 6) represents a significant departure from the LOSC recognition of maximum sustainable yield. • Provides measures to be taken by coastal states and states which fish the high seas to facilitate cooperation between the parties including the establishment of regional fishery bodies and arrangements. Where a competent regional fishery body exists, States should either become members of the body, or they should agree to apply the relevant RFBs conservation and management measures. In recognition of the Northwest Atlantic Fisheries Organization (NAFO) that had effectively closed membership to new entrants, the Agreement includes the provision that membership of relevant RFBs was open to States having a "real interest" in the fisheries concerned. The term "real interest" is not defined.(Article 8) • Strengthens arrangements for sharing of information and cooperation in scientific research. (Article 14) • Provides for the peaceful settlement of disputes and makes them apply mutatis mutandis with respect to any dispute between States Parties to the Agreement, whether they are parties to the LOSC or not. (Part VIII) • States are not permitted to authorise the use of their flag to vessels fishing on the high seas unless they are able to effectively exercise responsibility over such vessels for the purpose of the LOSC and the Fish Stocks Agreement. (Article 18) • The flag state must ensure compliance by its vessels with regional conservation and management measures. (Article 19) • A state that is party to the Agreement, and a member of a relevant regional fishery body, has the right to board and inspect fishing vessels of another state party in order to ensure compliance with conservation and management measures, even where the flag state is not a member of the regional fishery body. (Article 21) • When a fishing vessel is voluntarily in a port, the port state may inspect documents, fishing gear, and any catch on board the vessel in order to ensure compliance with subregional, regional and global conservation and management measures. (Article 23)
Significant Programs, Decisions and Recommendations	This agreement has not been ratified yet, however, some countries that have signed up and other regional fisheries bodies recognise the agreement. These countries and RFB are incorporating provisions such as developing agreements for fishing straddling stocks (see "Agreement Concerning Certain Aspects of Cooperation in the Area of Fisheries"), using the precautionary approach and developing monitoring, control and surveillance systems to ensure compliance by vessels under their flag.

Criteria	Provision/Decision/Program	Criteria	Max. Score
1	Status of Signature/Ratification	0 has not signed; 1 has signed; 2 has ratified	2
2	Implementation of Convention Provisions	0 no activity / no response to questionnaire; 1 partial activity; 2 full activity	2
	TOTAL		4

Criteria	BEL	CAN	DMK	FGR	FRA	ICE	IRE	MOR	NED	NOR	POR	RUS	SPA	UK	USA
1	1	2	1	1	1	2	1	1	1	2	1	2	1	1	2
2	0	2	0	0	0	2	0	0	0	2	0	0	0	0	2
Total	1	4	1	1	1	4	1	1	1	4	1	2	1	1	4
%Score	*25*	*100*	*25*	*25*	*25*	*25*	*25*	*25*	*25*	*100*	*25*	*50*	*25*	*25*	*100*

Denmark has concluded the internal ratification process, but as a member of the European Union (EU) Denmark will deposit the ratification instrument simultaneously with the EU as the competence of the agreement is mixed between the EU and its member states.

Table 3d. Features, Scoring Criteria and Scores for the Instrument: **International Convention for the Conservation of Atlantic Tunas**
Acronym: ICCAT Signed: 14-May-66 Ratified: 21-Mar-69.

Description	The Convention objectives are to maintain or restore populations of tuna in the Atlantic Ocean. The Convention also undertakes research in tuna and tuna-like fishes (the Scombriformes with the exception of the families Trichiuridae and Gempylidae and the genus Scomber) and other species of fishes exploited in tuna fishing in the Convention area as are not under investigation by another international fishery organization.
Relevance SAUP	The ICCAT Commission has the authority to recommend management actions to sustain or restore populations. These recommendations are binding for all members of the Convention. There is a Compliance Committee that monitors compliance with recommendations by member states. Current recommended management measures are primarily geographically based quotas for each species and minimum size limits for tunas and tuna-like species. Recent actions by the Commission to encourage members and nonmember to comply with these measures include the boycotting of tuna products from countries that disregard the Commmission's recommendations. This Commission has the potential to effectively manage a number of fisheries in international waters of the North Atlantic.
Major Provisions	• The Contracting Parties hereby agree to establish and maintain a Commission to be known as the International Commission for the Conservation of Atlantic Tunas. • The Contracting Parties agree to take all action necessary to ensure the enforcement of this Convention and to transmit to the Commission, biennially or as required, a statement of the action taken by it for these purposes. • Each recommendation made by the Commission shall become effective for all Contracting Parties six months after the date of notification. • The Contracting Parties will provide any available statistical, biological and other scientific information the Commission may need for the purposes of the Convention. • Contracting Parties are to collaborate with each other implement effective measures to ensure the Convention is implemented and in particular to set up a system of international enforcement in the Convention area except the territorial sea and other waters of a State is entitled under international law to exercise jurisdiction over fisheries. • Each Contracting Party shall contribute annually to the budget of the Commission.
Significant Programs, Decisions and Recommendations	Madrid Protocol was introduced in 1992 to reduce the financial burden on less developed countries. This protocol requires additional signatures before it can be ratified. A number of recommendations are current within the Convention, the most recent that are of interest to the SAUP are: • 98-16 Bigeye Rebuilding Plan ; 98-4 Closures for North and South Atlantic Swordfish to be identified by 2002; 98-2 Rebuilding of North Atlantic Swordfish by setting a TAC for 2000, 2001 and 2002 that would reduce individual quotas for each Contracting Party; 98-7 Establish Rebuilding Program for Western Atlantic Bluefin with current TAC (including discards) used for the next 10 years or until scientific evidence indicates otherwise. A size restriction of 30 kg or 115 cm will also be imposed; 98-5 Catch Limits in East Atlantic and Mediterrean Bluefin set for TAC for 2000; 98-4 Amending 2 Bluefin minimum size of 3.2 kg; 98-10 Catch Limits for Year 2000 set at 1999 level for blue and white marlin. • 97-6 Supplemental Catch Quota for North Atlantic Swordfish set the quota for 1998 and 1999; 97-2 Undersized Bluefin limit of 1.8 kg. • 96-3 Minimum Size Bluefin limit of 1.8 kg. • Possible Management Measaures for North Atlantic Albacore focusing on reducing fishing capacity.

Criteria	Provision/Decision/Program	Criteria	Max. Score
1	Vessel Monitoring	0 none or no information provided; 1 partial; 2 full	2
2	Observer Program (Bigeye and Yellowfin)	0 none; 1 partial; 2 full	2
3	Catch Limits Exceeded in North Atlantic for 1998	0 more than 1% of quota or no information provided; 1 less than 1% of the quota; 2 met quota; 3 below by more than 1% of quota	3
4	1998 Catch Limits Exceeded for E. Bluefin or W. Bluefin (single score for EU given therefore all EU countries score the same)	0 more than 1% of quota or no information provided; 1 less than 1% of the quota; 2 met quota; 3 below by more than 1% of quota	3
5	Compliance with minimum size (based on average score for relevant species and Raymakers & Lynham 1999 report)	0 exceeded or no data provided; 1 not exceeded but no data provided; 2 not exceeded and data provided	2

Criteria	CAN	FR	IRE	MOR	POR	SPA	UK	USA
1	2.0	1.0	1.0	0.0	1.0	1.0	1.0	1.5
2	2.0	0.5	1.0	0.0	0.5	0.5	1.0	2.0
3	3.0	0.0	1.0	3.0	2.0	0.0	0.0	3.0
4	2.0	3.0	3.0	0.0	3.0	3.0	3.0	3.0
5	1.0	0.0	0.3	0.0	0.3	0.0	0.3	1.5
Total	10.0	4.5	6.3	3.0	6.8	4.5	5.3	11.0
%Score	*83.3*	*37.5*	*52.1*	*25.0*	*56.3*	*37.5*	*43.8*	*91.7*

Table 3e: Features, Scoring Criteria and Scores for the Instrument: **Convention on Future Multilateral Co-operation in North-east Atlantic Fisheries *.** Acronym: NEAFC Signed: 18 November 1980. Ratified: 17 March 1982

Description	The Convention applies to all fishery resources of the Northeast Atlantic, except marine mammals, sedentary species and, insofar as they are dealt with by other international agreements, highly migratory species and anadromous stocks. The Convention established the North-East Atlantic Fisheries Commission, which is charged with performing its functions "in the interests of the conservation and optimum utilization of the fishery resources of the Convention area The Convention applies to the Northeast Atlantic, including dependent seas, but not the Baltic Sea and the Belts or the Mediterranean Sea and its dependent seas
Relevance to SAUP	NEAFC is the primary fisheries treaty for the region. There are specific conservation and management measures for key species: Blue Whiting, Oceanic-type Redfish, Norwegian Spring Spawning (Atlanto-Scandian) Herring and Mackerel.
Major Provisions	• The North-East Atlantic Fisheries Commission may adopt recommendations concerning measures of control and providing for the collection of information relating to fisheries conducted beyond the national jurisdiction of member countries. The Commission may also adopt recommendations concerning fisheries conducted within the national jurisdiction of a contracting party, but only if the contracting party in question specifically requests and approves the recommendation. • Any Contracting Party can object to recommendations made by the Commission. In doing so, the Contracting Party is not bound to that recommendation. • In exercising its power, the Commission must ensure consistency between: (a) any recommendation that applies to a stock or group of stocks occurring both within the national jurisdiction of a contracting party and beyond, or any recommendation that would have an effect, because of species interrelationship, on a stock or group of stocks occurring in whole or in part within national jurisdiction of a contracting party; and (b) any measures or decisions by such contracting party for the management and conservation of that stock or group of stocks concerning fisheries conducted within the Party's national jurisdiction. • NEAFC is empowered to recommend a wide variety of conservation and management measures, although it has yet to: (a) regulation of fishing gear and appliances, including the size of mesh of fishing nets; (b) regulation of the size limits of fish that may be retained on board vessels, or landed or exposed or offered for sale; (c) establishment of closed seasons and of closed areas; (d) improvement and increase of fishery resources, which may include artificial propagation, the transplantation of organisms and the transplantation of young. • Recently it has: (a) establishment of total allowable catches and their allocation to Parties; and (b) regulation of the amount of fishing effort and its allocation to Parties. • The responsibility for enforcing management measures adopted under NEAFC rests with the Parties, which are required to take such action, including the imposition of adequate sanctions for infractions, as may be necessary to implement any recommendations adopted by the Commission. In 1999, however, a Scheme of Joint International Inspection and Surveillance was adopted, which closely followed the models provided by the UN Fish Stocks Agreement and NAFO.
Significant Programs, Decisions and Recommendations	There are two major schemes: Control and enforcement in respect of fishing vessels fishing in areas beyond the limits of national fisheries jurisdiction in the convention area (which came into force 1 July 1999) Scheme promote compliance by non-contracting party vessels with recommendations established by NEAFC Since 1998 NEAFC has produced annual reports on the implementation of these Schemas.

Criteria	Provision/Decision/Program	Criteria	Max. Score
1	Information on Vessels Entering/Exiting Regulatory Area Received?	0=never; 1=irregular; 2=fully automated	2
2	Information on Vessels Position on Regulatory Area Received?	0=never; 1=manual; 2=fully automated	2
3	Logbook System 0= no logbook system.	0=no system; 1=NEAFC standards met	1
4	VMS system?	0=only has manual system; 1=not all boats automated; 2=fully automated	2
5	TAC of Redfish, Norwegian Spring Spawning herring, Blue Whiting, Mackerel exceed?	0=quota exceeded for any of the above; 1=quota met for all of the above or objected to quota of any of the above; 2=catch below quota for all 4 fish	2
	TOTAL		9

Criteria	EC	FI	GL	ICE	NOR	RUS
1	1	2	1	2	2	2
2	2	2	2	2	2	2
3	1	1	1	1	1	1
4	2	2	2	2	2	2
5	1	1	1	1	1	1
Total	7	8	7	8	8	8
%Score	*78*	*89*	*78*	*89*	*89*	*89*

**Assessment of this treaty has proven difficult. It has been hard to obtain meaningful information from the Convention's internet site, and lack of response to email requests to its Secretariat[11], When emails have been followed up, limited information has been provided by the Secretariat. In addition, the Commission's annual reports do not make country by country evaluations of contributions to the Convention and the Secretariat refused to give information on EU countries on a country by country basis.*

[11] North East Atlantic Fisheries Commission (NEAFC); 22 Berners Street, London W1P 4DY UK; Tel: +44 (0)20 7631 0016 Fax: +44 (0)20 7636 9225 ; E-mail: info@neafc.org; Website: www.neafc.org

Table 3f. Features, Scoring Criteria and Scores for the Instrument: **Convention on Future Multilateral Co-operation in Northwest Atlantic Fisheries**. Acronym: NAFO. Signed: 24 Oct 1978. Ratified: 1 Jan 1979

Description	This Convention, establishing the Northwest Atlantic Fisheries Organization (NAFO), replaced the 1949 International Convention for the Northwest Atlantic Fisheries and the International Commission for the Northwest Atlantic Fisheries (ICNAF). The prime objective of NAFO is to contribute through consultation and cooperation to the optimum utilization, rational management and conservation of the fishery resources of the Convention Area. NAFO promotes contemporary ideas for international collaboration in the high seas based on the scientific research fundamentals. NAFO is an international organization whose object shall be to contribute through consultation and co-operation to the optimum utilization, rational management and conservation of the fishery resources of the Convention Area. NAFO consists of: a General Council, a Scientific Council, a Fisheries Commission and a Secretariat. The Convention applies to all fishery resources of the Convention Area, with the following exceptions: salmon, tunas and marlins, cetacean stocks managed by the International Whaling Commission or any successor organization, and sedentary species of the Continental Shelf, i.e., organisms which, at the harvestable stage, either are immobile on or under the seabed or are unable to move except in constant physical contact with the seabed or the subsoil. In addition to fisheries management issues of the Parties, a NAFO Standing Committee: Fishing Activities on non-Contracting Parties in the Regulatory Area (STACFAC): a) obtains and compiles all available information on fishing activities of non-Contracting Parties in the Regulatory Area; b) obtains and compiles all available information on landings, and transshipments of fish caught in the Regulatory Area by non-Contracting Parties; c) examines and assesses all options open to NAFO Contracting Parties including measures to control imports of fish caught by non-members and to prevent reflagging of fishing vessels to fish under flags on non-Contracting Parties; and d) recommends measures to resolve the problem
Relevance to SAUP	NAFO is the primary fisheries treaty for the Regulatory Area, it is used to manage many of the ground fisheries in that area. The Organisation also coordinates with adjacent states in the management of shared stocks.
Major Provisions	The convention applies to all fishery resources in the regulatory area excluding salmons, tunas, marlin, cetacean stocks managed by the International Whaling Commission and sedentary species. Currently 25 fish stocks are managed by the convention. The international organization Northwest Atlantic Fisheries Organization is established to implement the convention and to coordination actions by the contracting party in implementing the convention and its recommendations as well as establishing a Scientific Council. The Scientific Council undertakes stock assessments, coordinates research and communicates the research results to the Convention. The Scientific Council has a similar role to ICES in the Northeast Atlantic. Each Contracting Party is to provide statistical and scientific advice as requested by the General Council. Any country can object to a proposal or recommendation and therefore not be bound to that recommendation.
Significant Programs, Decisions and Recommendations	The current scheme includes a comprehensive monitoring, control and surveillance that includes the use of VMS, logbooks, hailing, onboard and port inspections and air surveillance. Each year stocks are reviewed and quotas are set for the various stocks. The Precautionary Approach is in the development stage within the Convention with three stocks currently used as case studies. Quotas can also be further controlled by gear restrictions and minimum size requirements for specific species. The Convention has a program to address the problem of Non Contracting Parties fishing in the Regulatory area which includes onboard and port inspections, and landing and transshipment restrictions if NCP have breeched NAFO recommendations and rules. Diplomatic demarches have already been written to Belize, Honduras, Sao Trome and Sierra Leone protesting ships fishing in the Regulatory Area.

Criteria	Provision/Decision/Program	Criteria	Max. Score
1	Submission of information to assist in stock assessments etc.	0=never ; 1=irregular or incomplete; 2=regular and complete	2
2	Commission receives monthly data reports?	0=no reporting; 1=irregular or ad hoc reporting; 2=full reporting	2
3	The level of implementation of a VMS system.	0=not established; 1=partly established; 2=fully operational with all appropriate vessels fitted with equipment	2
4	Surveillance & inspections activities	0=no activity; 1=less than 1% of vessel trips observed or inspected; 2=more than 1% but less than 5%; 3=more than 5%	3
5	Compliance with quotas for Redfish, Yellowtail Flounder, Shrimp and Greenland Halibut	0=quota exceeded or no information provided; 1=quota met for 4 fisheries; 2=catch below quota for all 4 fisheries	2
	TOTAL		11

Criteria	CAN	DMK (FI)	DMK (GL)	FGR	ICE	NOR	POR	RUS	SPA	UK	USA
1	2	1	2	1	2	1	2	2	2	1	1.5*
2	2	2	2	0	2	2	2	2	2	0	2
3	1	1	1	1	1	1	1	1	1	1	1
4	2	2	2	2	2	2	2	2	2	2	2
5	1.75	1.5	1.5	1	1	1	1.25	1.7	1.25	NA	1
Total	8.75	7.5	8.5	5	8	7	8.25	8.7	8.25	4	7.5
%Score	*80*	*69*	*77*	*46*	*73*	*64*	*75*	*79*	*75*	*44*	*68*

** adjusted based on NAFO annual financial and administration report (see Statistical Section)*

Table 3g. Features, Scoring Criteria and Scores for the Instrument t: **Common Fisheries Policy**
Acronym: CFP Initiated: 1970. Full Agreement (re stock conservation): 1982

Description	The CFP provides common system for management of fish stocks in EC waters through the cooperation of Member states. The 1992 CFP 10 year-review resulted in the formulation of 4 long term objectives: Sustainable fishing; Avoidance of undesirable side effects on fishing communities that rely on fishing; Stable supplies at reasonable prices Contribution to economic and social cohesion in the context of the single European market; And three short-term objectives: Reduce fishing levels to be consistent with sustainability Reduce fleet sizes to be consistent with those permissible by the requirement of sustainability Reduced employment in the fishing sector and to provide alternative work in areas dependent on fishing (Rodgers and Valatin 1997); The CFP appears to be of limited effectiveness with approximately 67% of their stocks overfished, 50% depleted, and 37% overfished and depleted (CEC 2000). The CFP is scheduled for a major review in 2002; current objectives and programs may change to halt this deterioration of fish resources.
Relevance SAUP	The CFP is the primary instrument for managing fisheries within each Member State's waters, especially inshore fisheries and on the continental shelves. The CFP considers the EEZ as a unified one, it also allows Member States to fish in each others territorial waters either through historical access rights or through fishing licences. The CFP sets a TAC for the major species which is then distributed in the form of a quota to each Member State. Access with the territorial limits (6 or 12 miles) is reserved for fishers of the coastal state or those who have historical access rights. The coastal state can also use national legislation to conserve and manage stocks in addition to EC measures, however, the measures only apply to fishers of the member states. Outside this limit Member States have access based on the TAC and quotas.
Major Provisions	There are four major components or provisions that are used to meet its objectives: Structures – initially to strengthen the fishing capacity of Member States, now a Multi Annual Guidance Program is used to reduce the fleet size and effort to conserve stocks; Markets – to provide a system of market support including subsidies for products, both import and export; External fisheries – to negotiate on behalf of Member States for access rights for EC vessel to fish in the waters of non-EC countries; Conservation – to introduce measures, primarily TAC and quota management system, to conserve and rebuild fish stocks in EC waters. These components are implemented through legislation and regulation, financial assistance, observer programs, monitoring (on and offshore).
Significant Programs, Decisions and Regulations	**MAGP4** – this the fourth program. MGP3 was aimed at reducing the fleet size in each country, the size of the fleets were reduced, however, there was very little reduction in effort and in some cases fishing efficiency increased (technical creep (WWF 2001)). The current MAGP seeks to do both reduce the size of the fleet and effort. The EC has established the PESCA fund to assist in retraining and reemployment of labour displaced by the fleet reduction program. **TAC & quota** – the TACs among member states is allocated by historic exploitation rates. Each year 103 TACs with sufficient data for only 39 are set. These 39 are 'analytical' TACs and the remainder are 'precautionary' TACs (Karagiannakos 1996). Despite call from ICES to further reduce the quotas, member states are unwilling to reduce the quota and continue to extract fisheries resources. Therefore countries that fish at high levels (i.e. high catch rates) negligent in their responsibility to sustainably use the resources. Those that fish over their quota are negligent and not complying with this component of the CFP. **Market Policy** seeks to stablilise the market and supplies for fish as well as keeping process reasonable (Rodgers and Valatin 1997). Subsidies are included in this policy, however, they are not a major component of the subsidies provided by the EC. **Subsidies** – the EC subsidies to the fishing industry was US$1.4 billion (OECD 2000 in Coffey and Cator 2000). The subsidies include structural adjustments to the fishing fleet, marketing and processing. The subsidies are funded through the EC budget, national budgets and private funding. The largest current single subsidies are to the Spanish Fleet that had access to fisheries in Moroccan waters but lost that right recently and cannot fish in EU waters. **VMS and logbooks** - these measures were introduced recently for some fisheries to reduce overfishing and fraud violations. Vessels over 24 m must carry a vessel monitoring system (VMS), vessels over 10 m must record all fishing operations in a logbook and species landed in a landing declaration. There are EU inspectors who monitor surveillance and enforcement activities of member states, however this is limited since there is one vessel and few inspectors (Long & Curran 2000). The system, however, effectiveness and fairness in applying EC regulations is not consistent throughout the Community (National Strategy Review Group on Commons Fisheries Policy 2000).

Criteria	Provision/Decision/Program	Criteria	Max.Score
1	Contribution of activity reduction to the overall targets of the MAGP4, average of capacity and activity (CEC 2000)	0 no contribution; 1 less than 5%; 2 5 to 10%; 3 greater than 10%	3
2a	Level of adjusted catches in North Sea, Skagerrak and Kattegat (based on Watson & Pauly 2001) <if stocks in this area are so depleted then countries that take a considerable share of the catch are not contributing to sustainability of the stocks which is a major objective of the CFP irrespective of the TAC and quota>	0 greater than 1 million (metric ton); 1 100,000 to 1 million; 2 10,000 to 100,000; 3 less than 10,000	3
2b	Level of adjusted catches in Norwegian Sea (based on Watson & Pauly 2001)	0 greater than 1 million (metric ton); 1 100,000 to 1 million; 2 10,000 to 100,000; 3 less than 10,000	3
2c	Level of adjusted catches in Community western waters (based on Watson & Pauly 2001)	0 greater than 100,00 (metric ton); 1 10,000 to 100,000; 2 less than 10,000	2
3	Problematic in over-quoting (based on pers comm. EC officer) waiting for further details to provide better differentiation	0 problematic; 1 no problems	1
4	Subsidies to the fishing sector as a % of the total landed value (Sumaila and Monroe 2001)	0 greater than 25%; 1 11 to 25%; 2 1 to 10 %; 3 0%	3
5	Level of violations 1990 to 1996 (based on Long & Curran 2000)	0 more than 10 ; 1 less than 10; 2 less than 5; 3 no violations	3
6	Quota Hopping (based on Long & Curran 2000)	0 more than 100 vessels; 1 less than 100 vessels; 2 no vessels	2
	TOTAL		20

Criteria	BEL	DMK	FGR	FR	IRE	NL	POR	SP	UK
1	0	1	3	1	2	3	1	1	2
2a	2	0	1	2	3	1	N/A	N/A	1
2b	N/A	1	1	2	2	1	2	2	1
2c	2	2	2	1	1	1	3	1	1
3	0	0	1	0	0	0	0	0	0
4	2	1	0	1	0	2	1	2	1
5	2	1	2	0	1	2	1	0	1
6	2	2	2	2	2	1	2	0	2
Possible	17	20	20	20	20	20	17	17	20
Total	8	8	12	9	11	11	10	6	9
% Score	*47*	*40*	*60*	*45*	*55*	*55*	*59*	*35*	*45*

Table 3h. Features, Scoring Criteria and Scores for the Instrument: **Agreement Concerning Certain Aspects of Cooperation in the Area of Fisheries.**
Acronym: Fishing Coop. Signed: 15-May-99. Ratified: Not Yet Ratified

Description	This Agreement specifies the exchange of quotas between Iceland, Norway and Russia. The Agreement places a TAC for cod, capelin, haddock, tusk, ling and blue ling and restricts the bycatch associated with these fisheries. In particular the bycatch for halibut, Greenland halibut and deep sea redfish are specified. Reflagging of vessels in order to avoid the measures contained in the Agreement is considered. Iceland is allowed access to some of the above stocks in the EEZ of Norway and the Russian Federation in exchange for ceasing to fish in the high seas area of the Barents Sea (known as the "Loop Hole" or Grey Zone). This agreement extends three previous agreements between Norway and Russia concerning fisheries in the Barents Sea. These agreements set the yearly TAC for cod, haddock and capelin and regulate the fishing activities of third countries. Under the agreement the cod and haddock TAC is distributed equally (50:50) while capelin is distributed in Norway's favour (60:40). • **Agreement Concerning Cooperation in the Field of Fisheries Between Norway and USSR** (1975), set up the Joint Norwegian-Russian Fisheries Commission and agreed to share responsibility for fish stocks and to cooperate in the management of these stocks. • **Agreement Concerning Mutual Fisheries Relations Between Norway and the USSR** (1976), recognized each others EEZ; provided for mutual access outside the 12 nautical mile boundary; and set mutual quotas. This agreement is considered more of a political gesture than a management gesture (Floistad, 1991). • **The Grey Zone Agreement Between Norway and the USSR** (1978), this agreement sought to clarify the ambiguities of the 1975 and 1976 agreements and to introduce regulations regarding the operation of third country vessels that were taking advantage of the disputed "Grey Zone" and thereby fishing outside of the Commissions TAC. Third country vessels were now required to be licensed and to report on their catch on a weekly basis.
Relevance to SAUP	This Agreement has the potential to sustainably manage a number of important fish stocks in one of the most productive marine areas in the North Atlantic. In particular it will assist in managing the fisheries within the Grey Zone which has been out of the Commissions TAC since 1978.
Major Provisions	-
Significant Programs, Decisions and Recommendations	The Agreement Concerning Certain Aspects of Cooperation in the Area of Fisheries will not come into force until all three parties have notified the depository that their internal arrangements to accommodate the agreement have been made. The criteria has been developed so that once the agreement is in force it can be evaluated. The score for the countries is based on their performance under the previous agreements since most criteria can be applied.
*** Notes**	The setting of the TAC and other recommendations has been focused on short-term single species decision-making. Multispecies interactions have been discussed with minimal impact on the decisions made (Jakobsen 1999). According to Jakobsen (1991) the Commission will make severe cuts in the TACs to maintain fish stocks.

Criteria	Provision/Decision/Program	Criteria	Max.Score
1	Cod Quota exceeded	0 exceeded quota; 1 met quota; 2 below quota	2
2	Haddock quota exceeded	0 exceeded quota; 1 met quota; 2 below quota	2
3	Capelin quota exceeded	0 exceeded quota; 1 met quota; 2 below quota	2
4	Level of reporting	0 no reporting; 1 ad-hoc or irregular reporting; 2 regular reporting	2
5	Level of observers	0 no observers; 1 low level; 2 med; 3 high level	3
	TOTAL		11

Criteria	NOR	RUS
1	2.5	0.5
2	0	1
3	0	1
4	2	2
5	0	0
Total	4.5	4.5
%Score	*41*	*41*

Table 3i. Features, Scoring Criteria and Scores for the Instrument**: Agreed Record of Conclusions of Fisheries Consultations on the Management of the Norwegian Spring Spawning Herring (Altanto-Scandian Herring) Stock in the Northeast Atlantic for 1997 (including supplementary agreements).** Acronym: NSS Herring. Signed and Agreed: 14-Dec-1996

Description	This Agreement is used to manage the Norwegian spring spawning herring in the Norwegian Sea using a TAC and quotas for the 5 countries that are party to the agreement. Iceland, Faroe Islands, European Community, Norway and The Russian Federation have signed the agreement. There is no specific organization to oversea the agreement, meetings are used to negotiate the TAC and quotas based on scientific advice from ICES.
Relevance to SAUP	This Agreement has the potential to sustainably manage herring in the Norwegian Sea one of the most productive marine areas in the North Atlantic.
Major Provisions	The 1997 and 1996 Protocols have a number of provisions that outline how the stock will be managed. These include: • Setting the TAC and each country's quota • Specifying areas where each country can fish the quota • Cooperate in inspection and control to ensure compliance with conservation measures • Controlling the reflagging of vessels
Significant Programs, Decisions and Recommendations	1997 and 1996 Protocols that specify how the quota will be distributed between the five Contracting Parties.

Criteria	Provision/Decision/Program	Criteria	Max. Score
1	Herring Quota exceeded	0 exceeded quota; 1 met quota; 2 below quota	2
2	Level of logbook reporting (if it applies)	0 no reporting; 1 ad-hoc or irregular reporting;2 regular reporting	2
3	Level of inspections of vessels or catches (if it applies)	0 no observers or inspections; 1 low level; 2 med; 3 high level – 5% or more of the vessel trips are either inspected or have observers on board	3
	TOTAL		7

Criteria	ICE	FI	EU	NOR	RUS
1	1	1	2	1	1
2	2	2	2	2	2
3	N/A	N/A	N/A	3	N/A
Total	3	3	4	6	3
%Score	*75*	*75*	*100*	*86*	*75*

Table 3j. Features, Scoring Criteria and Scores for the Instrument: **Agreement between Iceland, Greenland/Denmark and Norway about the capelin stock in the area between Greenland, Iceland and Jan Mayen.**

Acronym: Capelin Signed: 18-Jun-1998

Description	This Agreement was intended to address the problem of overlapping EEZ's between Norway and Iceland. specifies the allocation of the capelin TAC that is caught in the area of Jan Mayen. The orginal TAC was allocated with 78% to Iceland and 11% to each of Norway and Greenland. The current allocation of the TAC is 81% to Iceland, 11% to Greenland and 8% to Norway The current agreement is the result of a number of previous agreements (1980 and 1989) that divided the capelin between these countries.
Relevance to SAUP	This Agreement has the potential to sustainably manage capelin fish in one of the most productive marine areas in the North Atlantic.
Major Provisions	Agreement only around Jan Mayen. Excludes Norwegian fishers from exploiting other stocks in Iceland's EEZ
Significant Programs, Decisions and Recommendations	The TAC for capelin is set each year based on advice from ICES.

Criteria	Provision/Decision/Program	Criteria	Max.Score
1	Capelin Quota exceeded	0 exceeded quota; 1 met quota; 2 below quota	2
2	Level of logbook reporting	0 no reporting; 1 ad-hoc or irregular reporting; 2 regular reporting	2
3	Level of observers	0 no observers; 1 low level; 2 med; 3 high level	3
	TOTAL		7

Criteria	ICE	GL	NOR
1	0.5*	1.5**	2***
2	2	2	2
3	1	1	3
Total	3.5	4.5	7
% Score	*50*	*64*	*100*

* exceeded quota by 3%; ** quota not reached by 2.5%; *** well below quota 5.4%

Table 3k. Features, Scoring Criteria and Scores for the Instrument: **Convention for the Conservation of Salmon in the North Atlantic Ocean**
Acronym: NASCO. Signed: 2-Mar-82. Ratified: 1-Oct-83

Description	NASCO aims to promote the conservation, restoration and enhancement and rational management of salmon stocks in the North Atlantic Ocean (north of 36°N) throughout their migratory range through international cooperation. NASCO also promotes the acquisition, analysis and dissemination of scientific information pertaining to salmon stocks in the convention's region.
Relevance to SAUP	NASCO is a region-specific single purpose treaty. As such, its implementation is of interest for the development of similar targeted international instruments.
Major Provisions	Regulatory measures for salmon fisheries under the jurisdiction of Parties are proposed and reported on. Salmon fishing is banned beyond areas of fisheries jurisdiction of Parties, and beyond 12 nautical miles from coastal baselines. Regional Commission areas are established with additional salmon fishery restrictions. Scientific research proposals are development.
Significant Programs, Decisions and Recommendations	Key NASCO Resolutions and Guidelines are: • Resolution to Minimise Impacts from Salmon Aquaculture on the Wild Salmon Stocks; (the Oslo Resolution) • Agreement on Implementation of the Oslo Resolution • Agreement on Adoption of a Precautionary Approach • Resolution on Fishing for Salmon on the High Seas • Resolution Concerning Scientific Research Fishing • Minimum Standard for Catch Statistics • Guidelines for Action on Transgenic Salmon

Criteria	Provision/Decision/Program	Criteria	Max.Score
1	Status of ratification	0 not signed; 1 has signed; 2 partially ratified; 3 fully ratified	3
2	Participation in Convention Activities (e.g. leading a study etc.) <based on available annual reports, meeting reports and other recent documents>	0 no activity; 1 attends meeting; 2 lead role	2
3	Degree to which Parties are implementing Article 7 of the Agreement on Adoption of a Precautionary Approach (adopted June 1998)	0 not implementing any measures; 1 implemented 1-4 measures; 2 implemented 4-6 measures; 3 fully implementing all measures	3
4	Parties meet reporting requirements for Minimum standard for catch statistics Adopted June 1993	0 not met; 1 partially met; 2 fully met	2

Following consultation with the Secretary of NASCO it is considered premature to apply relative country ratings to Parties at this stage. There are two linked initiatives planned for June-July 2001 which should allow such rating. First, in the words of the NASCO Secretary[12]:

With regard to the Agreement on Adoption of a Precautionary Approach, it has been used as a basis to develop a decision structure for the management of salmon fisheries and the Parties will be reporting back to the Commissions on actions taken in June and to the Council in June 2002. We have also developed recommendations on application of a Precautionary Approach to salmon habitat protection and restoration which will be considered by the Council in June. Again it is likely that there will in future be reporting by the Parties on actions taken and these reports might then be used as a basis for assessing each Parties commitments.

Once these reporting procedures are in place it might be possible to use the information to assess relative commitment although this would inevitably be subjective and a balanced assessment would require considerable background knowledge of the situation in each country. (email dated 7 March 2001)

[12] *Malcolm Windsor, Secretary NASCO, 11 Rutland Square, Edinburgh EH1 2AS, Scotland, UK Telephone : + 44 131 228 2551, Facsimile : + 44 131 228 4384, URL : www.nasco.int, email: hq@nasco.int*

Table 3l. Features, Scoring Criteria and Scores for the Instrument: **International Whaling Convention**
Acronym: IWC Signed: 12 Dec 1946

Description	The convention aims to conserve whale stocks by setting limits on the species, number and size of animals that can be taken. The convention also prohibits the capture of whales with calves.
Relevance to SAUP	Whales are a major component of the North Atlantic ecosystem and therefore their populations should be conserved through international efforts.
Major Provisions	In 1977 commercial hunting of all whale species was stopped to allow stocks to recover. Any Contracting Party can object to IWC recommendations which does not bind them to that recommendation. There are provisions in the convention to allow aboriginal groups to hunt whales, these hunts are usually managed through a quota system that is closely monitored.
Significant Programs, Decisions and Recommend-ations	• The last IWC meeting in 2000 was very controversial with nations divided between allowing commercial hunting of certain species to be resumed and those nations wanting to maintain the current hunting moratorium. • Aboriginal hunting is conducted in the Canadian Arctic, Greenland, Faroe Islands, Pacific Northwest in the USA, and the north Pacific in Russia. • Scientific hunting is undertaken by Japan, this activity is highly controversial since the meat from animals hunted for scientific purposes are sold to the restaurant market.

Criteria	Provision/Decision/Program	Criteria	Max.Score
1	Signature	0 not signed or left the convention; 1 not ratified; 2 ratified without reservation	2
2	Financial contribution	0 no contribution; 1 required contribution; 2 above required contribution	2
3	Hunting	0 commercial hunting ; 1 aboriginal hunting or no hunting	1
4	Permits – accurate and timely records of animals hunted sent to IWC	0 no information provided; 1 information provided as required	1
	TOTAL		6

Criteria	CAN	DEN	FI	GL	ICE	NOR	RUS	UK	USA
1	0	2	2	2	1.5	1	2	2	2
2	0	1	1	1	0	2	.5	2	1
3	1	1	N/A	1	1	0	1	1	1
4	0	N/A	N/A	.5	0	1	.5	N/A	1
Total	1	4	3	4.5	1	4	4	5	5
%Score	*16*	*80*	*75*	*75*	*58*	*67*	*67*	*100*	*83*

Table 3m. Features, Scoring Criteria and Scores for the Instrument: **Agreement on the Conservation of Small Cetaceans in the Baltic and North Seas.**
Acronym: ASCOBANS Signed: 1992

Description	This agreement is specific to the conservation of small cetaceans in the Baltic and North Seas. The agreement is an extension of the Convention on the Conservation of Migratory Species of Wild Animals (Bonn 1979) which encourages agreements on wild animals that cross national jurisdictional boundaries. Although "cetaceans" are not specified in the International Whaling Convention, the small cetaceans encompassed in this agreement are usually not the subject of the IWC. The Annex to this agreement sets the agenda which is currently focused on reducing cetaceans caught as by-catch in commercial fishing operations and reducing pollution levels which are thought to affect the health and longevity of cetaceans.
Relevance to SAUP	The agreement, through its Annex, also addresses the issue of by-catch which is considered to be a significant issue in the sustainability of fisheries in the North Atlantic.
Major Provisions	The agreement requires each contracting party to submit an annual report on progress made and difficulties encountered in implementing the agreement The agreement makes provisions for organizations qualified in cetacean conservation and management to have observer status at meetings. Contracting parties are to contribute to the cost of the budget for the Agreement.
Significant Programs, Decisions and Recommendations	The Annex outlines the following measures that contracting parties should be applying in their countries: • Develop a system for the reporting of animals caught in by-catch and stranded animals • Passing of legislation that prohibits the intentional taking or killing of small cetaceans, if it does not already exist • Pollution prevention to reduce the threat to the health of animals • Development and modifications to gear to reduce by-catch in fishing operations • Establishment of protected areas for breeding, feeding and migration • Prevent other disturbances to the animals especially acoustic disturbances • Parties should coordinate in assessing the stock of the animals

Criteria	Provision/Decision/Program	Criteria	Max Score
1	Signature	0 not signed ; 1 signed but not ratified; 2 ratified without reservation	2
2	Financial contribution	0 no contribution; 1 required contribution; 2 above required contribution	2
3	Legislation changed	0 legislation does not protect ; 1 legislation introduced; 2 legislation passed or already existed	2
4	System to monitor cetaceans that are caught as by catch	0 no system; 1 fishers self-report catches of cetaceans; 2 fishers self-report as well as an observer program	2
5	System for reporting strandings	0 no system; 1 partial system; 2 full system	2
6	MPA established for protection and conservation of small cetaceans	0 no MPA; 1 proposed at least one MPA; 2 at least one MPA established	2
	TOTAL		12

Criteria	BEL	DMK	FGR	FR	NL	NOR	UK
1	2	2	2	0	2	0	2
2	1	1	2	0	1	0	2
3	0	0	2	0	2	0	2
4	.5	1	0.5	.5	.5	.5	1
5	2	1	1	1	.5	1	1.5
6	0	1	2	0	1	0	0.5
Total	5.5	6	9.5	1.5	7	1.5	9
%Score	*46*	*50*	*79*	*12.5*	*58*	*12.5*	*75*

Table 3n: Features, Scoring Criteria and Scores for the Instrument: **Convention on Biological Diversity**
Acronym: CBD Signed: 5-Jun-92. Ratified: 20-Dec-93

Description	The Convention provides for the management of biodiversity including marine biodiversity through the Jakarta Mandate.
Relevance to SAUP	Coastal states are required to take action to protect components of marine biodiversity within its national jurisdiction. Article 22.2 provides that the Convention shall be implemented consistent with rights and obligations under UNCLOS. The Convention also requires Parties to cooperate to achieve sustainable use of biodiversity outside national jurisdictions, as well as on other matters of mutual interest.
Major Provisions	The convention establishes an overall umbrella of generic obligations that Parties are to detail at the national level. The majority of provisions allow flexibility in implementation, recognizing that biodiversity conservation and loss may vary widely. The Convention also establishes a new international system for the transfer of 'genetic resources'. The COP identified marine and coastal biological diversity as an early priority the result being the Jakarta Mandate on Marine and Coastal Biological Diversity. Five key thematic issues were identified in the Jakarta Mandate: *1. Integrated marine and coastal area management (IMCAM); 2. Marine and coastal living resources; 3. Marine and coastal protected areas; 4. Mariculture; 5. Alien species and genotypes*
Significant Programs, Decisions and Recommendations	Parties must: create national plans, strategies or programs for conservation and sustainable use; inventory and monitor the biodiversity within their own territories; identify and regulate destructive activities; and, integrate consideration of biodiversity into national decision making. Parties must also take additional steps to protect customary resource uses and local and indigenous communities' traditional knowledge, innovations and practices, where they carry on sustainable traditions. There is an overarching administrative structure to support national implementation including: a permanent Secretariat; a Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA), and a Clearing House Mechanism. (CHM) to support scientific and technical cooperation. Also Parties shall undertake their obligation sto cooperate through other international organisations where appropriate. Each of the five thematic issues in the Jakarta Mandate have an associate work programme, which sets out specific activities and timeframes for the achievement of operational objectives established for each theme.

Criteria	Provision/Decision/Program	Criteria	Max. Score
1	Status of ratification	0 not signed; 1 has signed; 2 partially ratified (approved, accepted or accession); 3 ratified Convention; 4 ratified Convention and Cartagena Protocol	4
2	National reporting	0 No First National Report; 1 First National Report produced; 2 First National Report and Thematic Report on Alien Species produced	2
3	Contribution to Trust Funds • General Trust Fund for the Convention on Biological Diversity (BY) • Additional contributions to the General Trust Fund for the Convention on Biological Diversity (BY) • Trust Fund for Additional Voluntary Contributions in Support of Approved Activities under the Convention on Biological Diversity (BE) • Trust Fund for Additional Voluntary Contributions to Facilitate the Participation of Parties in the Process of the Convention on Biological Diversity (BZ)	0 No minimum/additional contribution to BY, BE, BZ 0.5 Partial minimum contribution to BY with outstanding debts 1 Minimum contribution to BY; no additional contributions to BY; BE or BZ 1.5 Minimum contribution to BY (but outstanding debts); no additional contributions to BY; BE or BZ 2 Minimum contribution to BY and additional contribution to BY; no contribution to BE or BZ 3 Minimum contribution to BY and additional contribution to BY; contribution to BE no contribution to BZ 4 Minimum contribution to BY and additional contribution to BY; contribution to BE and BZ	4
4	Address 5 thematic issues in the Jakarta Mandate: *4.1. Integrated marine and coastal area management; 4.2. Marine and coastal living resources; 4.3. Marine and coastal protected areas; 4.4. Mariculture; 4.5. Alien species and genotypes*	0 Not addressing the issues 1 Partially addressing the issues 2 Fully addressing the issues	2
	TOTAL		12

Criteria	BEL	CAN	DMK	FGR	FR	ICE	IRE	MOR	NL	NOR	POR	RUS	SP	UK	USA
1	4	3	4	4	4	3	4	4	4	4	4	3	4	4	1
2	1	1	1	2	1	0	1	0	2	2	1	2	1	2	0
3	1.5	2	2	1	3	1	0.5	1	1	1	1	1	1	3	1
4.1		1												1	
4.2		1												1	
4.3		1												1	
4.4		1												2	
4.5		1												1	
4 Average	0	1	0	0	0	0	0	0	0	0	0	0	0	1.2	0
Total	6.5	7	7	7	8	4	5.5	5	7	7	6	6	6	10.2	2
% Score	*54*	*58*	*58*	*58*	*67*	*33*	*46*	*42*	*58*	*58*	*50*	*50*	*50*	*85*	*17*

Table 3o. Features, Scoring Criteria and Scores for the Instrument: **Convention for the Protection of the Marine Environment of the North East Atlantic (replacing Oslo and Paris Conventions)**
Acronym: OSPAR Signed: 22-Sep-92 Paris. Ratified: 25-Mar-98

Description	The Convention is focused on the prevention and elimination of pollution from the OSPAR area which encompasses much of the northeast Atlantic. It also seeks to protect marine areas from human activities and where practicable restore affected marine areas. Contracting parties are obliged to adopt programmes and measures made under the conventions as well as to harmonise national policies and strategies.
Relevance SAUP	Initially the focus of the convention was on specific pollution issues which in the long term will compliment direct fisheries management measures. However, recently Annex V (Protection and Conservation of the Ecosystem and Biological Diversity of the Maritime Area) was opened in 1998 for ratification of the Contracting Parties. This has resulted in the convention taking a broader look at marine management issues, in particular the development of a strategy for the Protection….., the development of Ecological Quality Objectives (currently for seabirds and sea mammals), the issue of deep sea fisheries and the signing of an memorandum of understanding with ICES. This convention, therefore, has the potential to affect fisheries management in the OSPAR area.
Major Provisions	Contracting shall • take all possible steps to prevent and eliminate pollution and shall take the necessary measures to protect the maritime area against the adverse effects of human activities so as to safeguard human health and to conserve marine ecosystems and, when practicable, restore marine areas which have been adversely affected. • individually and jointly, adopt programmes and measures and shall harmonise their policies and strategies. • adopt programmes and measures which contain, where appropriate, time-limits for their completion and which take full account of the use of the latest technological developments and practices designed to prevent and eliminate pollution fully. • apply the measures they adopt in such a way as to prevent an increase in pollution of the sea outside the maritime area or in other parts of the environment. • report regularly on compliance with decisions Note many of the above provisions are implemented through programs, decisions and recommendations made by various working groups within OSPAR
Significant Programs, Decisions Recommendations	• Recommendation 89/4 on a Coordinated Programme for the Reduction of Nutrients • Recommendation 92/7 on the Reduction of Nutrient Inputs from Agriculture into Areas where these Inputs are Likely, Directly or Indirectly, to Cause Pollution • Recommendation 94/6 on Best Environmental Practice for the Reduction of Inputs of Potentially Toxic Chemicals from Aquaculture Use OSPAR Action Plan 1998 – 2003 – two of the 4 main areas are relevant to the SAUP, the protection and conservation of ecosystems and biological diversity , eutrophication. In the area of protection and conservation of ecosystems and biological diversity much of the work is preliminary with no recommendations or decisions made by the convention have been published.

Criteria	Provision/Decision/Program	Criteria	Max. Score
1	Status of ratification	0 not signed but within the OSPAR operating area; 1 has signed; 2 partially ratified; 3 fully ratified (signed for Annex V)	3
2	Participation in Convention Activities (e.g. leading a study etc.) Based on available annual reports, meeting reports and other recent documents	0 no activity; 1 attends meeting; 2 lead role	2
3	Implementation of PARCOM Recommendation 94/6 on Best Environmental Practice for the Reduction of Inputs of Potentially Toxic Chemicals from Aquaculture Use	0 Reservation; 1 Intention but no report submitted; 2 agreement/admin action; 3 legislation introduced or pre-existing	3
4	Recommendation 92/7 on the Reduction of Nutrient Inputs from Agriculture into Areas where these Inputs are Likely, Directly or Indirectly, to Cause Pollution	0 Reservation; 1 Intention but no report submitted; 2 agreement/admin action; 3 legislation introduced or pre-existing	3
5	Recommendation 89/4 on a Coordinated Programme for the Reduction of Nutrients	0 Reservation/no action; 1 reduction target not met; 2 target met	2
6	Implementation of OSPAR Action Plan 1998-2003 - Guidelines for Artificial Reefs in Relation to Living Resources	1 reservation/guidelines not accepted; 2 guidelines accepted	2
	TOTAL		15

Criteria	BEL	DMK	FGR	FR	ICE	IRE	NL	NO	POR	SP	UK
1	2	3	2	2	2	2	2	2	2	3	3
2	1	2	2	2	1	1	2	2	1	2	2
3	0	1	3	1	1	1	N/A	2	3	2	3
4	2	2	2	1	N/A	N/A	2	2	N/A	N/A	N/A
5	1.5	1.5	1.5	0	2	2	1.5	1.5	2	2	2
6	2	2	2	2	2	2	2	1	2	2	2
Total	8.5	11.5	12.5	8	8	8	9.5	10.5	10	11	12
*% Score**	*57*	*77*	*83*	*53*	*67*	*67*	*73*	*70*	*83*	*92*	*100*

** adjusted for N/A*

Table 3p. Features, Scoring Criteria and Scores for the Instrument: **International Council for the Exploration of the Sea Convention.**
Acronym: ICES. Signed: 12th September, 1964. Ratified: 31st December, 1964.

Description	ICES constitutes the oldest recorded regional fishery body and dates from 1902. It was created in response to nineteenth century fish stock shortages in the North Sea as an intergovernmental marine organisation for scientific study of the sea and its resources. The 1964 ICES Convention identifies the Council's principal functions as: • To promote and encourage research and investigations for the study of the sea particularly related to the living resources thereof, • To draw up programs required for this purpose and to organise, in agreement with the Contracting Parties, such research and investigations as may appear necessary; and • To publish and otherwise disseminate the results of research and investigations carried out under its auspices or to encourage the publication thereof. (Article 1)
Relevance SAUP	Since the 1970s a further major task of ICES has been the provision of scientific information and advice to intergovernmental regulatory commissions (including the North-east Atlantic Fisheries Commission, the International Baltic Sea Fishery Commission, and the North Atlantic Salmon Conservation Organisation, plus the European Commission, the governments of ICES Member countries, and to the Faroes and Greenland which are not member countries in their own rights, for the purposes of fishery conservation and the protection of the marine environment. The geographic area of competence of ICES is the Atlantic Ocean and surrounding seas, with particular reference to the North Atlantic. (Article 4)
Major Provisions	Each contracting party undertakes to furnish to the Council information that will contribute to the purposes of the Convention and can reasonably be made available, and, wherever possible, to assist in carrying out the programs of research co-ordinated by the Council. (Article 5)
Significant Programs, Decisions and Recommendations	In 1978 ICES established an Advisory Committee on Fishery Management (ACFM), which is comprised of experts from each of the ICES Member Countries, together with the chairperson of the Standing Committees that deal with Pelagic, Demersal and Baltic fish respectively. Advice is provided in response to requests from members, but the ACFM is also empowered to provide unsolicited advice if the Committee believes it to be required. ICES CM 1997/Assess:7 Report of the Study Group on the Precautionary approach to Fisheries Management examines the implications for ICES at both the technical and advisory level of implementing the precautionary approach to marine capture fisheries. The Report concludes the need for contracting parties to utilise the precautionary approach as it is defined in international instruments. A large scale fisheries sampling program investigating the problems of by-catch and discards has led to data being analysed for use in future ICES models. • Promotion of Integrated Coastal Zone Management • Monitoring marine habitats using biological and contaminant methodologies • Develop tools to assess marine habitat quality • Develop and improve fisheries assessment tools that utilise environmental information, consider biological interactions, and address issues of uncertainty, risk and sustainability • Improve the accuracy and precision of abundance survey methods • Develop improved technical measures for fishery management

Criteria	Provision/Decision/Program	Criteria	Max.Score
1	Participation in ICES meetings, workshops etc.	0 = little participation; 1 = basically attends meetings and nothing more; 2 = attends meetings as well as leading committees; 3 = attends meetings, leads committees and hosts meetings	3
2	Utilisation of the Precautionary Approach to Marine Capture Fisheries in Accordance with ICES CM 1997/Assess 7.	0 no application; 1 partial application; 2 full application	2
	TOTAL		5

Criteria	BEL	CAN	DEN	FRA	GER	ICE	IRE	NETH	NOR	POR	RUS	SPA	UK	US
1	0	3	2	1	2	1.5	0	3	3	1.5	0	1.5	3	3
2	0	1.5	1	.5	.5	1.5	.5	.5	1.5	.5	0	.5	.5	2
Total	0	4.5	3	1.5	2.5	3	.5	3.5	4.5	2	0	2	3.5	5
%Score	*0*	*90*	*60*	*30*	*50*	*60*	*10*	*70*	*90*	*40*	*0*	*40*	*70*	*100*

Estimating Illegal and Unreported Catches from Marine Ecosystems: Two Case Studies

Robyn Forrest, Tony J. Pitcher, Reg Watson, Hreiðar Þór Valtýsson* and Sylvie Guénette
Fisheries Centre, UBC, Vancouver, Canada
**University of Akureyri/The Marine Research Institute, Akureyri, Iceland*

Abstract

Estimation of total harvests of marine organisms is essential if true impacts of fisheries are to be evaluated. Such estimates are difficult to obtain because, for many of the world's fisheries, an unknown proportion of the catch is not reported. Components of the unreported catch may include discards, deliberately misreported catch and unmandated catch (catch that it is not required to be reported). For many fisheries, estimates of misreporting or discarding exist, but may not apply to all periods of interest. Here we demonstrate a methodology for estimating unreported catches over time, based on knowledge of factors that influence misreporting in the fishery and on independent (published and unpublished) estimates of misreporting. Independent estimates and knowledge of influence factors are combined to assign quantitative estimates of misreporting to different periods so that time-series of misreporting can be obtained. The method is demonstrated for two national fisheries: Iceland and Morocco. The Icelandic analysis is a by-species approach for cod and haddock. The Moroccan analysis divides catches into demersal and pelagic categories, rather than individual species. Preliminary results suggest that Icelandic cod catches may have been underestimated by between 1% and 14% at different times, and haddock catches by between 1% and 28%. Underestimation of Moroccan catches appears to have been by as much as half in some cases. Uncertainty has been incorporated into our analyses by using multiple sources of information to provide upper and lower estimates of misreporting and by using a Monte Carlo simulation. These case studies show that it is possible to obtain some estimate of misreporting, even when rigorous data are lacking. Sources of information are presented so that areas where information is lacking are easily identified, offering a basis for comment, discussion and, it is hoped, collaboration that will lead to provision of further information and improvement of the estimates.

Introduction

Estimation of total harvests of marine organisms is essential if the true impacts of fisheries on marine ecosystems are to be evaluated. This is difficult because, for many of the world's fisheries, an unknown proportion of the total catch is not reported to any official body. In some cases, unreported catch may be deliberately concealed by individuals or organizations and in some cases there is no obligation to report (i.e., catches are unmandated). A number of methodologies have been used by researchers in an attempt to quantify unreported catches. For example, estimates of discarding are often obtained using some sort of observer program. Illegal landings are more difficult to quantify but may be estimated by comparison of reported landings with market sales, by interviews with fishers (e.g. Anon., 2001a; Gunnarsson 1995), or by tracing techniques (e.g. ISOFISH 1999). Estimates of bycatch and discarding for different fisheries have been obtained using models of the fishery (e.g. Stratoudakis *et al*, 1999; Ortiz *et al.*, 2000; Medley 2001) and in some cases economic models have been used to estimate incentives to discard (Anderson 1994; Arnason 1994). A number of other methodologies are discussed in Alverson *et al.* (1994). It would be advantageous to make use of all the available specialist studies of unreported catches in a fishery and synthesize them into a single analysis. A proposal for such a methodology, based on adjustments to reported catch for a specified fishery, place and time, has been presented in a previous Sea Around Us project report (Pitcher and Watson 2000). Its workings are demonstrated in detail here with two preliminary case studies. Formal publication of the results will be presented elsewhere.

Estimation Method

We present a procedure to adjust reported catches, based on a spreadsheet, divided by decade (or other appropriate time-periods) and by category of misreported catch (discarded, illegal and unreported). Quantitative values are assigned to adjustment factors, based on reports and information explicitly attributed to a variety of sources, published and unpublished (e.g. from newspaper reports in some cases). All sources of information are clearly presented in such a way that areas where information is lacking can be easily identified, offering a basis for collaboration and discussion. Confidence intervals around estimates of total misreporting for each period in the analysis are obtained using a Monte Carlo simulation taking account of stated or estimated uncertainties. The procedure can be easily adapted as more species or fisheries are added to the analysis. Here, we demonstrate application of the method for two national fisheries: Iceland, where there are plentiful, reliable data on landings by species; and Morocco, where data are sparse.

Table 1. Summary of influences on the incentives to misreport catches from Icelandic waters from 1950 to 1999. Arrows indicate whether the influence is expected to increase or decrease incentive to discard/misreport.

Category	1950-1959	1960-1969	1970-1979	1980-1989	1990-2000
Mesh size	110 mm in codend enforced in 1954 (↓)	120 mm in codend enforced in 1963 (↓)	135 mm (1976) and 155 mm (1977) in codend enforced (↓)		
Fisheries control	EEZ to 4 miles in 1952 and 12 miles in 1958 (↓)		EEZ to 50 miles in 1972 and 200 miles in 1975 (↓), TAC introduced in 1976 (↑), Effort control on Icelandic boats in 1978 (↓), Real time areas closures to protect juveniles (1976) (↓)	ITQs for the main groundfish species in 1984 (↑), Small boats excluded and effort option on others until 1991 (↓)	Groundfish fishery changes to full ITQ system in 1990 (↑)
Other			Undersized fish confiscated (until 1984) (↑)	Undersized fish not in quota (1984-1987) (↓)	
New technology	Radar (↑), Sounders (↑), Nylon nets (↑)	Sonars (↑), Powerblock (↑)	Loran (↑)	Computerized jigging reels, Rockhoppers (↑), Headline and codend sensors (↓)	Computers (↑), GPS (↑), Sorting grids (↓)

Case Study 1: Iceland

Fisheries are central to Iceland's economy and have provided Icelanders with a high standard of living through much of the twentieth century. In general, Icelandic fisheries are believed to be well-managed, and, with ITQs, they are thought to have overcome many of the economic problems often associated with fisheries (Arnason 1995). Major fisheries exist for both pelagic and demersal species. The pelagic fishery (mainly capelin (*Mallotus villosus*), herring (*Clupea harengus*) and blue whiting (*Micromesistius poutassou*) provides the bulk of the catch, although the demersal fishery provides most of the revenue, generating approximately 75% of the total value of catches (Arnason 1995). Major demersal species are cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), saithe (*Pollachius virens*), redfish (*Sebastes* spp.) and Greenland halibut (*Reinhardtius hippoglossoides*). Today, most of the catch in Icelandic waters is taken by Icelandic vessels, although foreign fleets have fished in the region for several centuries. Foreign catches have been reduced considerably since 1950, when Iceland began to expand its exclusive economic zone (EEZ). For detailed descriptions of the history of Icelandic fisheries since the beginning of the last century, see Arnason (1995) and a *Sea Around Us* report by Valtýsson (2001).

Table 2. Incentives for Icelandic vessels to discard based on changes in management and technology given in Table 1. L= Low; M= Medium; N = N. *NOTES: Illegal catch refers to illegal landings rather than discards. Unmandated catch refers to fish legally eaten or taken home by fishers*. See also footnotes.

Fleet	Species	Type	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89	90-94	95-00
Iceland	Atlantic Cod	Discards	L/M[a]	L/M[a]	L/M[a]	L[b]	L[c]	L/M[d]	L/M[d]	M[e]	M[e]	M[e]
		Illegal	N[f]	N[f]	N[f]	N[f]	N[f]	N[f]	N[f]	L[g]	L[g]	L[g]
		Unmandated	N[h]	N[h]	N[h]	N[h]	N[h]	N[h]	N[h]	N[h]	N[h]	N[h]
	Haddock	Discards	L/M[a]	L/M[a]	L/M[a]	L[b]	L[c]	L/M[d]	L/M[d]	M[e]	M[e]	M[e]
		Illegal	N[f]	N[f]	N[f]	N[f]	N[f]	N[f]	N[f]	L/M[i]	L/M[i]	L/M[i]
		Unmandated	L/M[j]	L/M[j]	L/M[j]	L/M[j]	L/M[j]	L/M[j]	L/M[j]	M[k]	M[k]	M[k]
Foreign	Atlantic Cod	Discards	L/M	L/M	L/M	L	L	L/M	L/M	M	M	M
		Illegal	N	N	N	N	N	N	N	L	L	L
	Haddock	Discards	L/M	L/M	L/M	L	L	L/M	L/M	M	M	M
		Illegal	N	N	N	N	N	N	N	L/M	L/M	L/M

a. EEZ to 4 miles introduced in 1952 and 12 miles in 1958, many areas closed to trawlers and Danish seiners. Introduction of radar, fish-finders and nylon nets. b. 120 mm cod end enforced. c. EEZ extended to 50 miles, reducing trawling. d. Undersized fish confiscated. EEZ extended to 200 miles. Effort control on Icelandic boats. Real-time area closures to protect juveniles. e. Introduction of ITQs in 1984. f. No ITQ system in place, mandatory to report all landings. g. Introduction of ITQs in 1984. h. Cod rarely eaten locally. i. Introduction of ITQs in 1984. Probable local black market for haddock. j. Fish legally taken home by fishers. k. Greater incentive to land more fish in this way after introduction of quotas.

Table 3. Estimates of discarding/misreporting of cod and haddock, by gear-type. Estimates are presented as percentages of reported catch of each gear-type (over and above reported catch) and refer to catches taken by Icelandic vessels. All figures are percentages. Sources are footnoted. *Note: Bottom Trawl includes lobster trawlers and shrimp trawlers*

Species	Gear	1980-1984	1985-1989	1990-1994	1995-1999
Cod	Handline		4[a]		2[b] - 22[b]
	Longline		4[a]		3[c] - 9[c]
	Danish Seine			2[b]	22[c] - 36[b]
	Gillnets		4[a]	1[d]	2[c] - 9[c]
	Bottom Trawl	6[d]	5[d] - 10[a]	0.4[d] - 4[c]	1[b] - 6[c]
Haddock	Longline		3[a]		3[c] - 14.7[e]
	Danish Seine			4[c] - 16[b]	2.3[e] - 22[c]
	Gillnets		3[a]		2[c] - 9[c]
	Bottom Trawl		0.8[e] - 8[a]	8[e] - 19.6[e]	5.2[e] - 22.3[e]
	General (*unmandated catch*)				12[f]

a. Gunnarsson (1995): Results of questionnaire returned by 591 fishermen: b. Pálsson (2001): Comparison of size composition from landings and those observed at sea; c. Anonymous (2001a): Results of Gallup International questionnaire returned by 1638 fishermen; d. Anonymous (1993): Comparison of landed catch of trawlers and catches observed at sea; e. Pálsson (2002) Comparison of length distributions measured at sea with landings; f. Anonymous (1999a; 1999b): Comparison of processing statistics and survey data (*see text*).

Discarding in Icelandic waters has been illegal since 1996. There is, however, little doubt that discarding still occurs, although its magnitude is widely debated. Other forms of misreporting are also believed to occur in some fisheries, but there is no official estimate of their magnitude. Changes to the management of Icelandic fisheries over the past fifty years have had varying effects on incentives to misreport. The following case study demonstrates our methodology for estimating unreported catches for two of Iceland's most important species, cod and haddock. A complete study of Icelandic fisheries would involve applying the methodology to all commercial species and include efforts to quantify total catches of non-commercial species for which official statistics do not appear. It should be noted that a major project has recently been initiated by the Icelandic government to compare catches by boats with observers with landings by boats without observers, in order to gain better estimates of the magnitude of discarding. Important changes to Iceland's regulatory regime are shown in Table 1.

Factors influencing discarding

Economic incentives to discard can occur whenever there are constraints on the amount of fish that can be officially landed. Constraints can be technological, where catching power exceeds onboard storage or processing facilities, or regulatory, where quotas restrict landings of certain species (Anderson 1994). In both cases, there is incentive for fishers to discard fish of lower value in order to fill the hold or quota with fish of the greatest value (this process is called high-grading; see Rettig (1986); Squires and Kirkley (1991); Anderson (1994); Walters and Pearse (1996); and Turner (1997) for discussion of the effects of quotas on discarding).

Technological advances that increase the likelihood of bumper catches are therefore likely to increase the incidence of discarding. There have been several major technological improvements in fishing power in Iceland during the past fifty years (see Table 1). For example, increases in horsepower and fish-finding and catching abilities have had a large impact on the size of hauls, especially of trawlers, and it would be very surprising if this did not lead to increased high-grading of catches. On the other hand, regulatory increases in mesh size since 1954, and the introduction of devices such as sorting grids on trawl nets have probably reduced bycatch and discarding. Another important factor influencing catches in Icelandic waters has been the introduction and dramatic increase in size of Iceland's exclusive economic zone (EEZ) since 1950, which has limited trawling in large areas around Iceland. Real time area closures used since 1976 have had similar effects. Each can last for up to 2 weeks if catch composition for a given area has high proportions of juvenile fish.

In 1976, the cod fishery was subjected to an overall catch quota, followed in 1977 by the introduc-

Table 4. Proportion of mean total catch of cod and haddock taken by five different demersal gear types. Proportions are rounded to two decimal places. *Note: Catches taken by other gear types (driftnets, seiners, mid-water trawlers and others) were each less than 0.5% of total catch and are not listed.*

Species	Gear	1980-1984	1985-1989	1990-1994	1995-1999
Cod	Handline	0.03	0.05	0.07	0.10
	Longline	0.09	0.10	0.17	0.20
	Danish Seine	0.01	0.03	0.03	0.07
	Gillnets	0.32	0.25	0.21	0.21
	Bottom Trawl	0.55	0.58	0.52	0.43
Haddock	Longline	0.12	0.13	0.16	0.19
	Danish Seine	0.00	0.03	0.05	0.09
	Gillnets	0.11	0.16	0.09	0.05
	Bottom Trawl	0.76	0.68	0.70	0.67

Source: ICES and Iceland National Data, provided by H. Valtýsson

Table 5. Estimates of discarding of cod and haddock by different gear-types, as a percentage of the total reported catch by all gear types. Estimates were obtained by multiplying the estimates in Table 2b with (unrounded) proportions in Table 2d. All figures are percentages. *Note: proportions shown in Table 2c were rounded for presentation: unrounded proportions were used to calculate the percentages in this table.*

Species	Gear	1980-1984	1985-1989	1990-1994	1995-1999
Cod	Handline		0.20		0.21 - 2.26
	Longline		0.39		0.59 - 1.76
	Danish Seine			0.06	1.48 - 2.42
	Gillnets		0.99	0.21	0.42 - 1.88
	Bottom Trawl	3.29	2.88 - 5.77	0.21 - 2.08	0.43 - 2.55
Haddock	Longline		0.38		0.58 - 2.82
	Danish Seine			0.21 - 0.82	0.20 - 1.94
	Gillnets		0.48		0.09 - 0.42
	Bottom Trawl		0.54 - 5.43	5.6 - 13.73	3.49 - 14.96

tion of individual effort restrictions for all demersal fisheries. In 1984, an individual quota system was applied to all demersal fisheries (but fishers could choose between this system and a restricted effort system until 1990: Arnason 1996). The introduction of quotas in the demersal fisheries is expected to have increased the incidence of high-grading of catches, especially in recent years, as quotas have been unexpectedly expensive.

It should be noted that not all operators of small boats work under the same quota system, even if they fish with the same gear, and therefore incentives to discard are not uniform within sectors of the fishing industry. For example, a recent Icelandic supreme court ruling stated that boats no longer require special fishing licences (of which limited numbers were available), and, as a consequence, there is now a growing number of operators who previously could not acquire fishing licences who now lease quotas for high prices. In order to be profitable, some operations such as this are inclined to retain only the most valuable fish. A rather sensational example of this occurred recently, when journalists participated on a trip on one of these boats and they reportedly discarded 20 tonnes of cod on a single two-day trip (Anon. 2001b). This type of misreporting is very difficult to quantify as it is often hard to verify the accuracy of such reports.

Other forms of unreported catch

Another side effect of the quota system is the deliberate misreporting of catches of valuable species that have low or expensive quotas. For example, since the introduction of ITQs, some vessels have been caught concealing catches of cod under layers of saithe, which has a lower value than cod, and then falsely reporting the whole catch as saithe. Since cod catches are so much higher than saithe catches, this type of misreporting is unlikely to have had a large effect on assessment of cod harvests. On the other hand, saithe catches may actually be overestimated.

A further source of error occurs with certain species that are consumed locally. According to Icelandic government processing statistics (Anon. 1999a), haddock, Atlantic halibut, common skate, and Greenland shark are the species for which the greatest proportion of total catch goes to domestic consumption. These species are commonly eaten by fishers at sea and a certain amount can also legally be taken home for their family. These amounts are unmandated, in that they are not required to be reported in any landing statistics. Comparison of estimates of local consumption of seafood obtained from official processing statistics (5,523 tonnes; Anon. 1999a) and estimates obtained by a survey of Icelanders' diets (12,352 tonnes; Anon. 1999b) reveal a discrepancy of 6,829 tonnes, implying that many more fish are landed than are reported. More than 70% of locally-consumed fish is haddock (Anon. 1999a), and the above figures would suggest that haddock landings are underestimated by almost 5,000 tonnes (equivalent to approximately 12% of the reported catch). Species which are mainly exported (such as cod) are monitored much more closely from place of landing through processing to final place of export (Halliday and Pinhorn, 1996) and the same types of errors are not expected to affect them.

There is also evidence of a black market for locally-consumed fish. Some fishers have been

Table 6. Interpolated percentage estimates of discarding by gear (*shaded cells/italics*). Estimates are presented as percentages of total reported catch (over and above reported catch) and refer to catches taken by Icelandic vessels.

Species	Gear	1980-1984	1985-1989	1990-1994	1995-1999
Cod	Handline		0.20	*0.20 - 2.26*	0.21 - 2.26
	Longline		0.39	*0.39 - 1.76*	0.59 - 1.76
	Danish Seine		*0.06 - 2.42*	0.06	1.48 - 2.42
	Gillnets		0.99	0.21	0.42 - 1.88
	Bottom Trawl	3.29	2.88 - 5.77	0.21 - 2.08	0.43 - 2.55
	TOTAL	3.29	4.52 - 9.77	1.07 - 6.37	3.13 - 10.87
Haddock	Longline		0.38	*0.38 - 2.82*	0.58 - 2.82
	Danish Seine		*0.21 - 1.94*	0.2 - 0.82	0.2 - 1.94
	Gillnets		0.48	*0.09 - 0.48*	0.09 - 0.42
	Bottom Trawl		0.54 - 5.43	5.6 - 13.73	3.49 - 14.96
	TOTAL		1.61 - 8.23	6.27 - 17.85	4.36 - 20.14

Table 7. Interpolation of estimates of misreporting of cod and haddock, from 1950 to 1999. Lower and Upper refer to the top and bottom of the estimated range of proportion of misreporting for each period.

Fleet	Species	Type	Limits	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89	90-94	95-99
Iceland	Cod	Discards	Lower	0.02	0.02	0.02	0.01	0.01	0.02	0.02	0.0452	0.0107	0.0313
			Upper	0.06	0.06	0.06	0.03	0.03	0.06	0.06	0.0977	0.0637	0.1087
		Illegal	Lower	0	0	0	0	0	0	0	0.01	0.01	0.01
			Upper	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.03	0.03
		Unmandated	Lower	0	0	0	0	0	0	0	0	0	0
			Upper	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	Haddock	Discards	Lower	0.02	0.02	0.02	0.01	0.01	0.02	0.02	0.0161	0.0627	0.0436
			Upper	0.06	0.06	0.06	0.03	0.03	0.06	0.06	0.0823	0.1785	0.2014
		Illegal	Lower	0	0	0	0	0	0	0	0.02	0.02	0.02
			Upper	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.06	0.06	0.06
		Unmandated	Lower	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03
			Upper	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.12	0.12	0.12
Foreign	Cod	Discards	Lower	0.02	0.02	0.02	0.01	0.01	0.02	0.02	0.0452	0.0107	0.0313
			Upper	0.06	0.06	0.06	0.03	0.03	0.06	0.06	0.0977	0.0677	0.1087
		Illegal	Lower	0	0	0	0	0	0	0	0.01	0.01	0.01
			Upper	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.03	0.03
	Haddock	Discards	Lower	0.02	0.02	0.02	0.01	0.01	0.02	0.02	0.0161	0.0627	0.0436
			Upper	0.06	0.06	0.06	0.03	0.03	0.06	0.06	0.0823	0.1785	0.2014
		Illegal	Lower	0	0	0	0	0	0	0	0.02	0.02	0.02
			Upper	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.06	0.06	0.06

caught with far more fish than they or their families could have eaten themselves, and a particular fisher admitted that he had sold, on the black market, 200 tonnes of fillets in one year, equivalent to about 500 tonnes of live fish (Anon. 2000). Although the extent of this practice is not known, a recent poll found that 20% of 1,638 fishers interviewed have witnessed illegal landings of fish in Iceland and 76% believe that illegal landings occur (Anon. 2001a).

Estimating the effects of influence factors

Clearly, there are complex influences on incentives to misreport catches, some of which seem to have conflicting effects. Table 2 gives qualitative estimates of incentives to misreport for Icelandic fisheries between 1950 and 2000. These estimates are based on knowledge of the history of the fishery, as discussed above and listed in Table 1. In the absence of information about discarding by foreign vessels, incentives for foreign vessels to discard are considered to be the same as for Icelandic vessels. We acknowledge that this may be a poor assumption in some cases.

The magnitude of the influence factors (low, medium, high) is, at this stage, arbitrary. Factors are meant to give a relative indication of differences in the magnitude of misreporting among periods. To convert these qualitative estimates into meaningful figures, informed estimates are needed for at least some periods. There are several reports that could be used to guide conversion of influence factors into quantitative estimates for recent periods. Table 3 gives estimates of misreporting of cod and haddock by gear-type, according to six different studies. As in Pitcher and Watson (2000), we refer to these estimates as 'anchor points'. Percentages are of reported catch, and hence are over and above reported catch. To allow meaningful comparison of estimates-by-gear, proportion of mean total catch taken by each gear-type (Table 4) was used to rescale the estimates (Table 5).

Because the estimates were now proportional to the total catch taken by all gears, they could be added to gain estimates of total discarding by all gears as a percentage of the total reported catch. This was easily done for the period 1995-1999 because estimates were available for all types of gear. For the other periods, some blank cells needed to be filled. Table 2 shows that factors affecting discarding were relatively stable between 1985 and 2000 (according to our estimates).

Table 8. Mean reported landed catches of cod and haddock in Icelandic waters (tonnes). Please note that data for official foreign catches are only provided until 1997.

Fleet	Species	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89	90-94	95-99
Icelandic	Cod	237541	284755	251557	232095	251103	311180	369110	361764	267408	210549
	Haddock	20143	26044	51199	39312	32490	39905	57376	50274	54180	+48953
Foreign	Cod	182815	202586	162513	144424	165175	39563	5692	2469	1343	583
	Haddock	34862	41295	52024	24607	11150	5385	2239	1283	1174	588

Source: ICES and Iceland National Data, provided by H. Valtýsson

Table 9. Estimates of missing catch (tonnes) for cod and haddock. Lower and Upper refer to top and bottom of the estimated range of misreporting for each period. Note that data for official foreign catches are provided only until 1997.

Fleet	Species	Type	limit	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89	90-94	95-99
Iceland	Cod	Discards	Lower	4751	5695	5031	2321	2511	6224	7382	16352	2861	6590
			Upper	14252	17085	15093	6963	7533	18671	22147	35344	17034	22887
		Illegal	Lower	0	0	0	0	0	0	0	3618	2674	2105
			Upper	2375	2848	2516	2321	2511	3112	3691	10853	8022	6316
		Unmandated	Lower	0	0	0	0	0	0	0	0	0	0
			Upper	2375	2848	2516	2321	2511	3112	3691	3618	2674	2105
	Haddock	Discards	Lower	402.9	520.9	1024	393.1	324.9	798.1	1148	809.4	3397	2134
			Upper	1209	1563	3072	1179	974.7	2394	3443	4138	9671	9859
		Illegal	Lower	0	0	0	0	0	0	0	1005	1084	979.1
			Upper	201.4	260.4	512	393.1	324.9	399.1	573.8	3016	3251	2937
		Unmandated	Lower	402.9	520.9	1024	786.2	649.8	798.1	1148	1508	1625	1469
			Upper	1209	1563	3072	2359	1949	2394	3443	6033	6502	5874
Foreign	Cod	Discards	Lower	3656	4052	3250	1444	1652	791.3	113.8	111.6	14.37	18.26
			Upper	10969	12155	9751	4333	4955	2374	341.5	241.2	90.93	63.41
		Illegal	Lower	0	0	0	0	0	0	0	24.69	13.43	5.833
			Upper	1828	2026	1625	1444	1652	395.6	56.92	74.08	40.3	17.5
	Haddock	Discards	Lower	697.2	825.9	1040	246.1	111.5	107.7	44.77	20.66	73.62	25.62
			Upper	2092	2478	3121	738.2	334.5	323.1	134.3	105.6	209.6	118.4
		Illegal	Lower	0	0	0	0	0	0	0	25.67	23.48	11.75
			Upper	348.6	413	520.2	246.1	111.5	53.85	22.39	77	70.45	35.26

Blank cells were therefore filled in by interpolating literature estimates from the adjacent cells into blank cells for the periods since 1985 (Table 6: shaded cells).

The totals in Table 6 suggest that total discards for the period 1985 - 2000 were in the range of 1% - 11% of reported catch for cod and 2% to 20% of reported catch for haddock (over and above reported catch). While the estimates for cod appeared to be within the same general range for the three most recent periods, the upper estimates for haddock for the periods 1990-1994 and 1995 - 1999 were much higher than for the preceding period, 1985 - 1989 (Table 6). Incentives to misreport for both species were ranked as 'Medium' for the periods after 1985 (see Table 2). As there was fairly good agreement among the cod estimates for these periods, the cod estimates were used to set the percentage values for the category 'Medium'. The estimates for haddock, post-1990, were used to set the percentage values for the category 'Medium-High'.

Estimates of the amount of discarding (and other forms of misreporting) for periods prior to 1985 were obtained by extrapolating the ranges found in Table 6 back to previous periods, using the percentages in Table 6 as a guide. The following ranges were assigned:

Table 10. Estimated total extractions of cod and haddock obtained by adding reported landings (Table 2g) to estimated missing catch (Table 2h). Lower and Upper refer to the top and bottom of the estimated range of misreporting for each period. Unreported is percentage (rounded) of the total estimated catch not reported (over and above estimated total catch). Note that official data for foreign catches are only provided until 1997.

Fleet	Species	Limit	50 - 54	55 - 59	60 - 64	65 - 69	70 - 74	75 - 79	80 - 84	85 - 89	90 - 94	95 - 99
Iceland	Cod	Lower	242292	290451	256588	234416	253614	317403	376492	381733	272943	219244
		Upper	256544	307536	271682	243700	263659	336074	398638	411579	295138	241857
	% Unreported	Lower	2.0	2.0	2.0	1.0	1.0	2.0	2.0	5.2	2.0	4.0
		Upper	7.4	7.4	7.4	4.8	4.8	7.4	7.4	12.1	9.4	12.9
	Haddock	Lower	20949	27085	53247	40492	33464	41501	59671	53597	60286	53535
		Upper	22761	29429	57855	43243	35739	45093	64834	63461	73604	67624
	% Unreported	Lower	3.8	3.8	3.8	2.9	2.9	3.8	3.8	6.2	10.1	8.6
		Upper	11.5	11.5	11.5	9.1	9.1	11.5	11.5	20.8	26.4	27.6
Foreign	Cod	Lower	186471	206638	165763	145868	166827	40355	5806.2	2605.5	1371	607.43
		Upper	195612	216767	173888	150201	171782	42333	6090.9	2784.5	1474.4	664.24
	% Unreported	Lower	2.0	2.0	2.0	1.0	1.0	2.0	2.0	5.2	2.0	4.0
		Upper	6.5	6.5	6.5	3.8	3.8	6.5	6.5	11.3	8.9	12.2
	Haddock	Lower	35559	42121	53065	24853	11261	5492.5	2283.4	1329.7	1271.3	625.04
		Upper	37303	44186	55666	25591	11596	5761.7	2395.3	1466	1454.2	741.28
	% Unreported	Lower	2.0	2.0	2.0	1.0	1.0	2.0	2.0	3.5	7.6	6.0
		Upper	6.5	6.5	6.5	3.8	3.8	6.5	6.5	12.5	19.3	20.7

None	=	0 – 1%
Low	=	1 – 3%
Low/Med	=	2 – 6%
Med	=	3 – 12%
Med/High	=	4 – 24%
High	=	5 – 25%+

Percentages for categories for which there were no anchor points were determined by following the trend set by the anchor points (i.e., doubling the upper estimate and increasing the lower estimate by 1%). These ranges will be refined as more anchor points are added to the analysis. Note that the upper estimates vary more than the lower estimates, resulting in increased uncertainty as incentives to misreport increase. This also results in some overlap between categories, which we felt was realistic. Table 7 shows estimated ranges of misreporting based on Table 2 and the percentage ranges given above. There is, unfortunately, no quantitative anchor estimate for the magnitude of illegal landings. Table 9 gives estimates of missing catch, obtained by multiplying mean reported catch (Table 8) by interpolated estimates of misreported catch (Table 7). Table 10 then presents estimates of total fishery extractions for these species at Iceland from 1950 to 1998. The results are shown in Figure 1.

Monte Carlo simulations

The procedure above has illustrated how upper and lower estimates of total extractions may be estimated for individual species. Gaining an estimate of variability in missing catch for more than one species is more difficult, especially if ranges between upper and lower estimates are very different. Upper and lower estimates of total extractions may, however, be a desired outcome of the analysis. We have attempted to capture these ranges using Monte Carlo simulation.

For each species and fleet (i.e., Icelandic and foreign), in each period, a triangular distribution was assumed between the lower and upper estimates of total missing catch (shown in Table 9). Five thousand samples were taken from each triangular distribution. Each time a sample was taken, results for cod and haddock were summed, resulting in two datasets, Icelandic and foreign, for each period. A third dataset (both fleets combined) was generated by adding the elements of the previous two datasets. Upper and lower 95% confidence intervals and the mean were calculated for each dataset. It did not make sense for lower estimates of total extractions to be lower than the reported catch, so in cases where this occurred, lower 95% confidence intervals were truncated at the level of reported catch. Results are shown in Figure 2. The routine that was used is flexible, and can easily be modified to accommodate more species as they are added to the analysis.

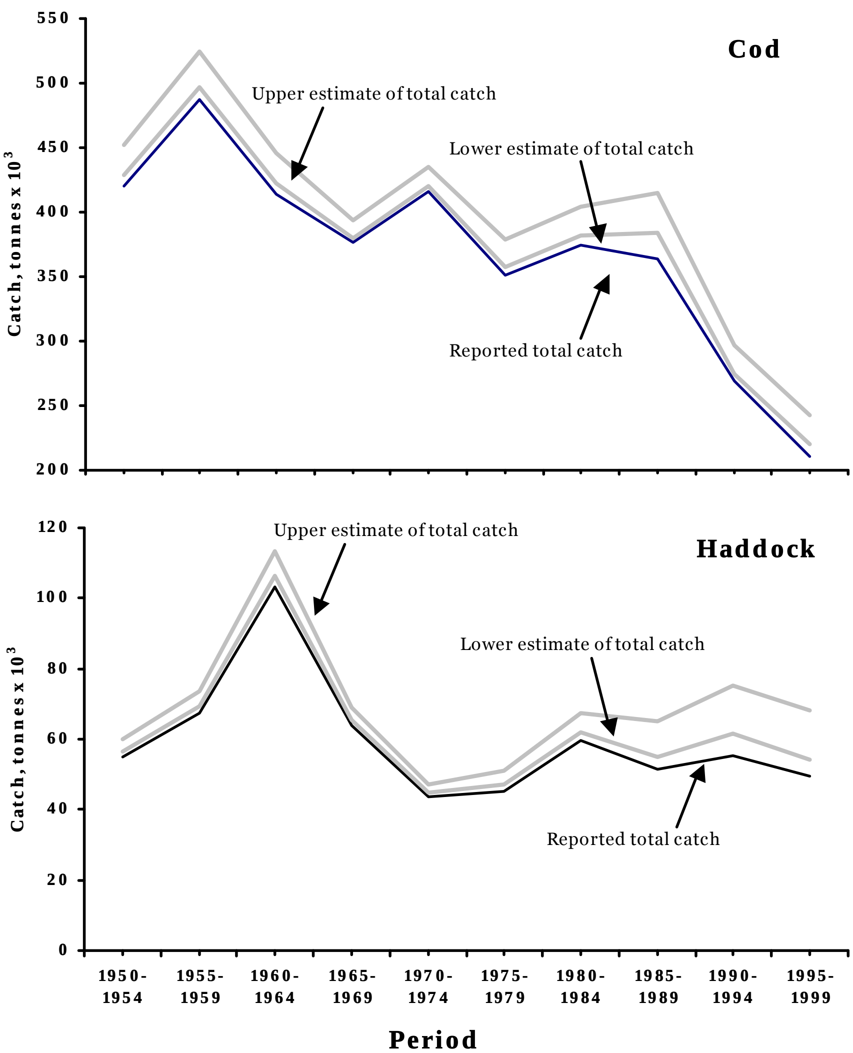


Figure 1. Estimates of unreported catch for cod and haddock in Icelandic waters. Note that catches include combined Icelandic and foreign catches. Note different scales for each species.

Extending the method to other species

As for cod and haddock, the biggest influence on amounts of discarding for many species is thought to have been the introduction of the ITQ system. It has not always, however, led to increased discards as is often expected. Some species, such as long rough dab (*Hippoglossoides platessoides*) and starry ray (*Raja radiata*), have a long history of being discarded due to their low value. Since the implementation of the ITQ system, however, they have been retained in greater numbers (or even targeted) because they either do not have a TAC or their quotas are relatively inexpensive compared to high-valued species like cod and haddock. As suggested above, official saithe landings may actually be overestimates due to instances of cod hidden under layers of saithe in catches that were reported wholly as saithe. Other vessels have been suspected of reporting witch flounder as lemon sole , which if true, could cause errors in estimates of catch of both species.

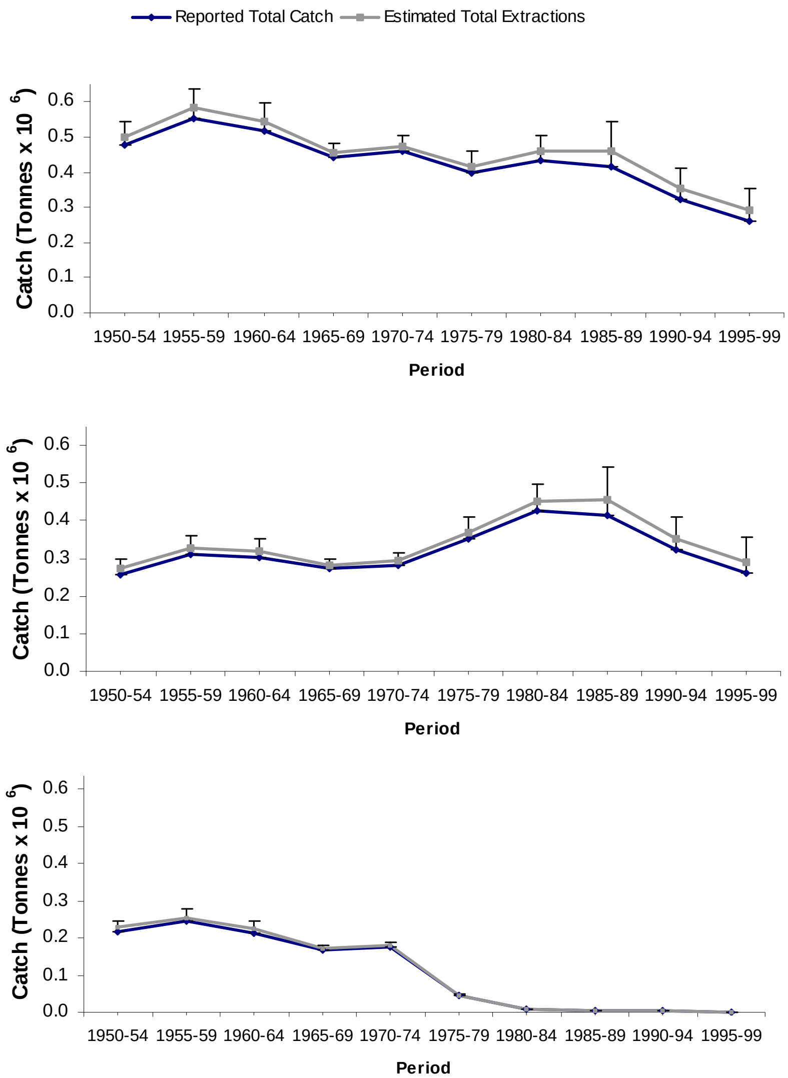


Figure 2. Estimated total extractions of cod and haddock from Icelandic waters, compared with reported catch, for a) Icelandic and foreign fleets; b) Icelandic fleet; and c) foreign fleet. The grey line shows the mean of 5,000 Monte Carlo samples (see text). Error bars represent upper and lower 95 per cent confidence intervals. Lower error bars are truncated at reported total catch.

Species living in deeper waters such as smoothhead (*Alepocephalus bairdii*), great silver smelt (*Argentins silus*), grenadiers *(Macrouridae*) and black scabbard fish (*Aphanopus carbo*) have been subjected to little fishing until relatively recently, and we can assume that discards and misreporting were low or non-existent for these species in the earlier years. When effort began to move to deeper waters in the 1960s (mainly to target Greenland halibut and redfishes), there were few or no reported landings for such species, which suggests that they were being discarded. This is confirmed by work by the French, who suggest that smoothhead discards may be 50% of the retained catch of targetted deep water fishes such as roundnose genadier *Coryphaenoides rupestris* (Lorance 1998; Lorance, pers. comm.). In recent years, however, more landings have been reported, implying that discarding of low-value deep water species may have decreased (Valtýsson 2001).

Sorting grids on prawn-trawl nets (introduced in 1996) have greatly reduced the incidence of bycatch of many species. While this is not expected to have had a great effect on the landing statistics of valuable species such as cod and halibut (which were always retained) it is certain to have reduced the amount of discarding of low-valued bycatch such as dab and starry ray and some of the deeper water species mentioned above.

Published estimates of discarding exist for some species other than cod and haddock (e.g. redfish: Gunnarsson 1995; and Agnarsson 2000; saithe: Gunnarsson 1995; and Anon. 1993) and for these species, the same procedure can be followed as for cod and haddock (above). For most species, however, there are no such estimates. In the absence of estimates anchored in the published literature (or other reliable sources), a detailed analysis of Iceland's fisheries would involve deciding which species can appropriately be grouped together, based on influences acting on them, and extrapolating estimates of misreporting obtained from reliable sources for similar species. This is not the purpose of the present report, however, although it will be addressed in the future. In the mean time, it is hoped that the publication of this report will lead to comments, advice, the provision of more anchor points and ultimately, refinement of the estimates.

Table 11. Estimates of discarding and unreported landings for Moroccan coastal and industrial fleets and foreign fleets fishing in Moroccan waters. Percentages of discards are percentages of estimated total catch (including reported landings, unreported landings and discards) as used by Baddyr and Guénette (2001). Percentages of unreported landings are percentages of estimated total landings (including reported and unreported landings) as used by Baddyr and Guénette (2001). Sources are footnoted.

Fleet	Fishery	Type	1970-1979	1980-1989	1990-1999
Coastal Morocco	pelagic	discards			0% - 4% [1]
	demersal	discards			5%[4] - 13%[1]
	all	unreported		23%[2]	47% [1] - 60%[3]
Industrial Morocco	pelagic	discards			0%[5]
	demersal	discards	66% [4]	46% [4]	30% [5]
	all	unreported			47% [1] - 60%[3]

1. El Mamoun (1999); 2. El Hannach *et al.* (1986); 3. Durand (1995);
4. Balguerias (1997); 5. Haddad (1994)

Case study 2: Morocco

It is not always possible to estimate unreported catches in as much detail as shown above. Icelandic law requires that landings of almost all species are reported and very detailed catch statistics are available for all types of fishing gear. Many other countries, particularly in low latitudes where mixed species fisheries are common, do not collect such detailed statistics. The following example illustrates an application of our methodology to a more data-poor fishery. This fishery has already been presented in detail in another report (Baddyr and Guénette 2001) and will only be briefly discussed here.

Moroccan fisheries can be classified under three headings: the Moroccan small-scale fleet, consisting mainly of small wooden dories; the more modern coastal fleet, which consists of medium-sized trawlers, purse seiners and long-liners; and the industrial fleet, which is almost exclusively made up of large freezer trawlers fishing for several weeks at a time. Foreign vessels, mainly from Spain, Eastern Europe, Japan and Korea have also fished extensively in Moroccan waters (see Baddyr and Guénette 2001). The number of vessels in the small-scale fleet is difficult to assess and the catch is largely unknown. Baddyr and Guénette (2001) have estimated the catch for this fishery. Baddyr (1989) concluded that discarding does not occur in the small-scale fishery, as the whole catch is sold. Estimates of unreported landings and discarding are therefore presented only for coastal, industrial and foreign fleets. Unreported landings include consumption by fishers (similar to the unmandated landings in Iceland), illegal sale of fish and weighing mistakes.

Table 11 shows estimates of discarding and underreporting obtained from several sources. These estimates were used as anchor points and interpolated into periods for which there was no information about misreporting (Table 12). Assumptions used to make the interpolations are footnoted and were discussed in Baddyr and Guénette (2001). Recall that in the Iceland example, anchor points were used to guide assignment of ranges which corresponded to different categories in the table of influences (Table 2). In this case, a slightly different approach has been adopted when fewer time periods are under consideration. Here anchor estimates were interpolated directly into blank cells if the influences were considered to be the same. For some periods, where there were two published estimates of misreporting, a possible range in the amount of misreporting was obtained (an 'anchor range'). Where there was no anchor range, interpo-

Table 12. Interpolation (shading/italics) of percentage estimates of misreporting for Moroccan fisheries from 1970 to 1999. Reasons for interpolations are footnoted. All estimates for which there was no 'anchor range' were assumed to be accurate to within ±5% (see text for discussion).

Fleet	Fishery	Type	1970-1979	1980-1989	1990-1999
Coastal	pelagic	discards	*0 - 4* [a]	*0 - 4* [a]	0 - 4
Morocco	demersal	discards	*30* [b]*±5*	*20* [c]*±5*	5 - 13
	all	unreported	*23* [d]*±5*	23±5	47 - 60
Industrial	pelagic	discards	No indust. fleet	*0* [e]*+5*	0+5
Morocco	demersal	discards	66±5	46±5	30±5
	all	unreported	*47 - 60* [f]	*47 - 60* [f]	47 - 60
Foreign	pelagic	discards	*0* [e]*+5*	*0* [e]*+5*	*0* [e]*+5*
	demersal	discards	*66* [g]*±5*	*46* [g]*±5*	*30* [g]*±5*
	all	unreported	*23 - 47* [h]	*23 - 47* [h]	*23 - 47* [h]

a. Discarding was never very high and is probably decreasing with the use of freezer boats; b. Assumed to follow the same trend as the industrial fleet (see below); c. Assumed to follow the same trend as the industrial fleet (see below); d. Assumed equal same as the 1980s because same economic context for market for fish in Morocco; e. Assumed to be the same as for the 1990s; f. Assumed higher than for coastal fleet because there were landings outside the country (Canaries); g. Assumed the same as for the industrial fleet because most observer information used for the industrial demersal fleet comes from foreign vessels; h. Assumed intermediate between coastal and industrial fleet. Although context is different, the incentives to cheat and opportunities to sell the fish are as high as for Moroccan boats.

Table 13. Estimates of total extractions (tonnes) of marine organisms from the Moroccan fishery for the period 1970-1999. Lower and Upper refer to the top and bottom of the estimated range of misreporting for each period.

			1970-1979		1980-1989		1990-1999	
Fleet	Fishery	Type	Lower	Upper	Lower	Upper	Lower	Upper
Coastal Moroccan	Pelagic	Reported landings	228924	228924	307267	307267	440044	440044
		Unreported landings	50252	89026	67449	119493	390227	660066
		Discards	0	13248	0	17782	0	45838
		% Unreported	*18*	*28*	*18*	*28*	*47*	*60*
		% Discards	*0*	*4*	*0*	*4*	*0*	*4*
		Total Estimated Extractions	279175	331198	374715	444541	830271	1145947
	Demersal	Reported landings	22615	22615	78913	78913	62900	62900
		Unreported landings	4964	8795	17322	30688	55779	94350
		Discards	9193	16913	16983	36534	6246	23497
		% Unreported	*18*	*28*	*18*	*28*	*47*	*60*
		% Discards	*25*	*35*	*15*	*25*	*5*	*13*
		Total Estimated Extractions	36773	48323	113217	146134	124926	180747
Industrial Moroccan	Pelagic	Reported landings	No industrial pelagic fleet		26394	26394	29294	29294
		Unreported landings			23406	39591	25978	43942
		Discards			0	3473	0	3855
		% Unreported			*47*	*60*	*47*	*60*
		% Discards			*0*	*5*	*0*	*5*
		Total Estimated Extractions			49800	69458	55272	77090
	Demersal	Reported landings	5998	5998	63460	63460	96771	96771
		Unreported landings	5319	8996	56276	95190	85816	145156
		Discards	17700	36709	83206	165126	60862	130268
		% Unreported	*47*	*60*	*47*	*60*	*47*	*60*
		% Discards	*61*	*71*	*41*	*51*	*25*	*35*
		Total Estimated Extractions	29016	51703	202942	323776	243449	372196
Foreign	Pelagic	Reported landings	850871	850871	832512	832512	724680	724680
		Unreported landings	254156	754546	248672	738265	216463	642641
		Discards	0	84496	0	82673	0	71964
		% Unreported	*23*	*47*	*23*	*47*	*23*	*47*
		% Discards	*0*	*5*	*0*	*5*	*0*	*5*
		Total Estimated Extractions	1105027	1689912	1081185	1653450	941143	1439286
	Demersal	Reported landings	431211	431211	238261	238261	146746	146746
		Unreported landings	128803	382395	71169	211288	43833	130133
		Discards	875920	1991931	215028	467898	63526	149089
		% Unreported	*23*	*47*	*23*	*47*	*23*	*47*
		% Discards	*61*	*71*	*41*	*51*	*25*	*35*
Total Estimated Fishery Extractions			1435934	2805536	524458	917448	254105	425967

lated estimates were given an upper and lower bound of ±5% (Table 12). Although this was somewhat arbitrary, we feel this was not an inappropriate figure. Anchor ranges, where obtained, ranged from 4% to 13% in any particular period (see Table 11) and our upper and lower bounds of ±5% are within this region. Estimates of unreported catch, discards and total extractions are shown in Table 13. Estimates of the range of total misreporting for each period were obtained using a similar Monte Carlo simulation as described above. Results are shown in Figure 3.

So far, this analysis has not attempted to identify the composition of the unreported catch. Indeed, for many of the world's fisheries, including Morocco, records of exact compositions of landings do not exist. For example, reported landings of demersal species in Morocco were dominated by an unidentified mixture of species and a large part of the foreign catches were unidentified (Baddyr and Guénette 2001). When the composition of the reported catch is not even known, it is probably not possible to quantify the magnitude of misreporting for individual species. It is possible, however, to at least identify some of the species that make up the unreported catch. These are briefly discussed below.

Discarding

Sardines comprised the majority of the pelagic catch and also the majority of discards (approximately 94% of the total catch: Oueld Taleb 1988). These are discarded either at sea if they are damaged in the nets or during net cleaning (El Mamoun 1999). As discarding by pelagic fleets is considered to be less than 5% of the total catch (Table 12, 13), the quantity of discards of other pelagic species is probably not significant (less than 0.3% of the total catch). In demersal fleets,

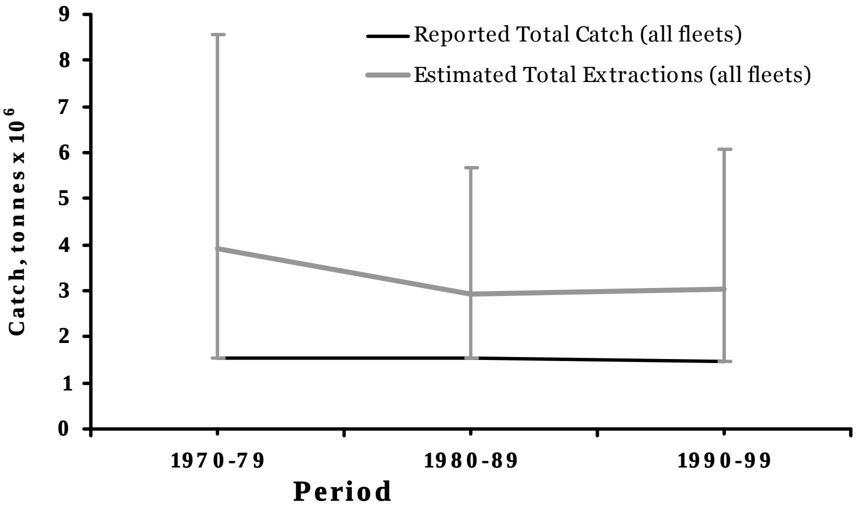


Figure 3. Estimates of total extractions of all species from Moroccan waters, compared with reported total catch, for all fleets combined. The grey line shows the mean of 5,000 Monte Carlo samples. Error bars represent upper and lower 95% confidence intervals. Lower error bars are truncated at the reported total catch .

coastal bottom trawlers (which landed more than 90% of the Moroccan commercial catch) discarded undersized and putrefied commercial species (cephalopods and a number of species in the families Trichiuridae, Sparidae, Merluccidae, Pleuronectiformes, Scianenidae, Haemulidae and Gadidae). A range of other species were also discarded, including boarfishes (*Macrorhamphorus scolopax* and *M. gracilis*), small-spotted cat sharks (*Scyliorhinus canicula*), sabre argenté (*Lepidopus caudatus)*, conger eels (*Conger conger*), crabs, rays and rockfishes (El Mamoun 1999).

The composition of species discarded by Spanish cephalopod trawlers consisted mainly of seabream, other unidentified demersal finfish and members of the families Chondricthyes and Triglidae and invertebrates other than cephalopods (Balguerías 1997). It is probably appropriate to assume a similar composition for other types of demersal trawlers and also for Moroccan industrial demersal vessels.

Underreporting

Durand (1995) reported that up to 60% of Moroccan catch may be processed through illegal channels to avoid taxes. This particularly applies to mackerel and anchovies and other valuable commercial species. Cephalopods and crustaceans are also very susceptible to underreporting (El Mamoun 1999). In the 1970s and 1980s, a large proportion of the Moroccan industrial fleet's catch was landed outside Morocco (e.g. in the Canaries) and we can assume that the composition of species unaccounted for in this period is similar to the composition of today's commercial catch.

These very broad groups of species can be used as a starting point for a more complete analysis of species for which catches are underestimated or unknown.

Knowledge of Morocco's marine ecosystems and the demography of its different species will assist in determining which species are most likely to be caught in which fisheries. Examination of markets and prices for different species should indicate which species are more likely to be discarded and for which species there is likely to be a black market. As with all analyses of this type, it is most important to maintain contact with individuals who have detailed knowledge of the fishery, who can provide information to fill in gaps where data are missing.

Discussion

The results obtained for Icelandic cod and haddock must be considered as preliminary, as more information is needed for periods prior to 1985. More information is also needed about factors influencing foreign fleets, which were assumed to have been under the same influences as Icelandic fleets. For example, it is of interest that when the foreign trawlers began operating in Icelandic waters in the end of the 19th century, they quickly became notorious for only retaining flatfishes and haddock but discarding large amounts of cod (Thor 1992).

The most problematic and subjective part of the analysis was assigning percentage values to the influence factors. In analyses such as these, there will inevitably be occasions when estimated influence factors do not seem to agree with the anchor points, as was the case for haddock for the periods 1990-1994 and 1995-1999. In this case, because the anchor points were considered to be reliable, we chose to recognise this as a real trend and upgraded our estimate of the influence factors for this period. In other cases, the source of these anchor point may be considered less reliable than the table of influences. For the present, problems such as this need to be treated on a case-by-case basis, until there have been enough case-studies to develop a more formal framework for dealing with them. More information is needed about influences acting upon other species, including susceptibility to different gears and economic factors such as cost of quotas and market value.

The Moroccan case study illustrated that it is possible to obtain estimates of underreporting, even when quantitative data are lacking, and that in some cases, underreporting may be significant. Coarse estimates of species compositions of unreported catches were obtained and it is hoped that these estimates will be refined as more information comes to hand. The advantage of the methodology is that it allows the available information to be laid out, such that gaps in our knowledge and areas that need to be addressed can be clearly identified. So far, most of the information used to anchor estimates has come from published reports, newspapers or university theses, although there is no reason that personal comments or other sources deemed reliable could not be used. Ideally, there should be at least one independent estimate of misreporting for each category of unreported catch. The final estimate obviously improves as more independent estimates are included.

Uncertainty is an intrinsic part of the issue of misreporting, especially when catches are illegal and information is sparse. Uncertainty has been incorporated into our analyses by using multiple sources of information to provide upper and lower estimates of misreporting. Where this was not possible, as in the Moroccan case, we have chosen a degree of uncertainty of ±5%, which we did not consider unreasonable. Estimates of uncertainty were extended to multiple species and fisheries using a simple Monte Carlo simulation, which captured upper and lower bounds of total estimated misreporting, within the limits obtained for individual species and fisheries. As more information comes to hand, we expect to be able to reduce the amount of uncertainty associated with the analysis by adding more anchor points. In many cases, however, there will always be limited information available.

In these two case-studies, we considered all sources of information to be equally reliable (i.e., we did not weight estimates according to our opinion of the reliability of the source). This was because the estimates, in this case, all came from scientific papers, scientific reports, theses or large-scale surveys, with one exception, Pálsson (2001), which was a newspaper article. Newspaper articles would normally be treated with some suspicion in terms of reliability. In this case, however, the author was an Icelandic fisheries scientist, with numerous scientific publications. In future work, it may be necessary to use newspaper reports or personal comments as anchor points and the reliability of these will have to be decided on a case-by-case basis.

Despite inherent uncertainties associated with this methodology, we reinforce Pitcher and Watson's (2000) assertion that it is unacceptable to settle for a zero adjustment of unreported landings just because they are difficult to quantify, or because of political pressure to do so. The results presented in this report should be considered as preliminary and are presented in the hope that they will generate comments and discussion of the methodology and the estimates.

References

Agnarsson, S. (2000) Stjórnun fiskveiða á Íslandi. In Auðlindanefnd - Álitsgerð. Edited by Jóhannes Nordal. (Fisheries management in Iceland. In: The Natural Resource committee - Report). A report for the Icelandic parliament. Reykjavík, Iceland. [In Icelandic.]

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

Alverson, D.L. *et al.* (2000) Report of the Fishing Technology and Fish Behaviour Working Group (FTFB) on unaccounted mortality in fisheries. ICES, FTFB, Haarlem, the Netherlands, April 2000. 76 pp.

Anderson, L.G. (1994) An economic analysis of high-grading in ITQ fisheries regulation programs. Marine Resource Economics 9, 209-226.

Anonymous (1993) Nefnd um mótun sjávarútvegsstefnu (A committee on the development of fishing industry) - Skýrsla til sjávarútvegsráðherra - drög (A report to the Ministry of Fisheries). Reykjavik, Iceland, April 1993, 173 pp. [In Icelandic.]

Anonymous (1999a) Fisheries Statistics 1998. Statistics Iceland, Reykjavík, Iceland. 354pp.

Anonymous (1999b) Iceland in figures 1999-2000 Volume 5. Statistics Iceland, Reykjavik, Iceland. 33pp.

Anonymous (2000) Ekkert mál að koma fiskinum út (No problem getting rid of the fish). Morgunblaðið June 6 th 2000. [In Icelandic.]

Anonymous (2001a) Brottkast fisks á sjó (Fish discarding at sea). Gallup Iceland - A report for the Ministry of Fisheries, Iceland. 68 p. [In Icelandic.]

Anonymous (2001b) "Nauðbeygðir til að henda afla fyrir borð (Forced to discard catch). Morgunblaðið Nov. 9 th, 2001. [In Icelandic.]

Arnason, R. (1994) On catch discarding in fisheries. Marine Resource Economics 9: 189-207.

Arnason, R. (1995) Icelandic fisheries and fisheries management. Adaptation to a limited resource base. Pages 237-266 in R. Arnason and L. Felt (eds) The North Atlantic Fisheries. Successes, Failures and Challenges. Institute of Island Studies, Prince Edward Island, Canada. 317pp.

Arnason, R. (1996) On the ITQ fisheries management system in Iceland. Reviews in Fish Biology and Fisheries 6 (1) 63-90.

Baddyr, M. (1989) The biology of the squid Loligo vulgaris in relation to the artisanal fishing site of Tifnit, Morocco. Ph.D. Thesis. University of Michigan, Ann Arbour.

Baddyr, M. and S. Guénette (2001) The fisheries of the Atlantic coast of Morocco 1950-1997. In S. Guénette, V. Christensen and D. Pauly (eds) Fisheries Centre Research Reports 9(4): 191-205 (*in press*).

Balguerías, E. (1997) Discards in fisheries from the Eastern Central Atlantic (CECAF region) In: Technical consultation on reduction of wastages in fisheries, Tokyo, Japan. FAO Fisheries Report No. 547 Supplement, Rome, pp183-214.

Durand, M. -H. (1995) La gestion des ports de pêche, analyse et dévelopment de la capacité institutionnelle. Rapport intérmediaire. Rapport complémentaire: La fonction commerciale des ports de pêche. Rapport d'une mission de la Banque Mondiale, 42 pp. [In French.]

El Hannach, A. (1986) Estimation d'une partie des captures de la pêche traditionnelle non enregistrée au long de l'Atlantique Marocain (de Tangier a Agadir). Actes Institute Agronomique et Vétérinaire Hassan II, 6(1): 41-52. [In French.]

El Mamoun, M. (1999) Les hors-circuits dans la pêche côtière au Maroc: Cas des ports de Casablanca, d'Agadir, de Nador et de Tanger. Honours Thesis, Institute Agronomique et Vétérinaire Hassan II, Rabat. 128pp. [In French.]

Gunnarsson, P. (1995) Umgengni um auðlindir landsins - Mælingar segja eitt en reynslusögur annað. Morgunblaðið June 14th 1995. [In Icelandic: Utilization of marine resources measurements show one thing but practice another]

Haddad, N. (1994) Evaluation de l'expérience de l'observateur scientifique Marocain. Ph.D. Thesis, Institute Agronomique et Vétérinaire Hassan II. 140pp. [In French.]

Halliday, R.G. and Pinhorn, A.T. (1996) North Atlantic fishery management systems: A comparison of management methods and resource trends. Journal of Northwest Atlantic Fishery Science 20: 117 pp.

ISOFISH (1999) The Chilean Fishing Industry: its involvement in and connections to the illegal, unreported and unregulated exploitation of Patagonian toothfish in the Southern Ocean. ISOFISH. Hobart, Tasmania, ISOFISH Occasional Report No. 2: 98pp.

Lorance P., Dupouy H. and V. Allain (1998) Assessment of the roundnose grenadier (*Coryphaenoides rupestris*) stock in the Rockall Trough and neighbouring areas (ICES sub-areas V, VI and VII). ICES C.M. 1998/O:60, 16pp.

Lorance P. (2001) Pers. Comm. Oral paper presented at Gestão da Pescas. 20th Semana das Pescas dos Açores. Horta, Azores, Portugal. 27 March 2001.

Medley, P. (2001) Estimating Discards from Catch Species Compositions. Pages 46-51 in Zeller, D., Watson, R., and Pauly, D. (eds) Fisheries Impacts on North Atlantic Ecosystems: Catch, Effort and National/Regional Data Sets. Fisheries Centre Research Reports 9(3): 254 pp.

Ortiz, M., C.M. Legault and N.M. Ehrhardt (2000) An alternative method for estimating bycatch from the U.S. shrimp trawl fishery in the Gulf of Mexico, 1972-1995. Fisheries Bulletin 98: 583-599.

Oueld Taleb, Oueld Sidi, M. (1988) Etude des rejets de la pêche côtière en Atalantique Marocain (Assila a Agadir). Honours Thesis. Institute Agronomique et Vétérinaire Hassan II, Rabat. 96pp. [In French.]

Pálsson, Ó.K. 2001. Mat á brottkasti þorsks og ýsu. Morgunblaðið Sept. 27th. c11 [In Icelandic: An estimation on discardings of cod and haddock].

Pálsson, Ó.K. (2002) A length-based analysis of haddock discards in Icelandic fisheries. Fisheries Research (in press).

Pitcher, T.J. and R. Watson (2000) The basis for change 2: estimating total fishery extractions from marine ecosystems of the North Atlantic. In Pauly, D. and Pitcher, T.J. (eds) Methods for Evaluating the Impacts of Fisheries on North Atlantic Ecosystems. Fisheries Centre Research Reports 8(2): 40-53.

Pauly, D. (1998) Rationale for constructing catch time series. European Community Fisheries Cooperation Bulletin 11 (2), 4-5.

Rettig, B.R. (1986) Overview. In: N. Mollet (ed) Fishery Access Control Programs Worldwide: Proceedings of the workshop on Management Options for the North Pacific Longline Fisheries. Alaska Sea Grant Report, pp 8-64.

Stratoudakis, Y., R.J. Fryer, R.M. Cook and G.J. Pierce (1999) Fish discarded from Scottish demersal vessels: estimators of total discards and annual estimates for targeted gadoids. ICES Journal of Marine Science 56, 592-605.

Squires, D. and J. Kirkley (1991) Production quota in multiproduct Pacific fisheries. Journal of Environmental Economics and Management 21: 64-76.

Thor, J.Th. (1992) British trawlers in Icelandic waters. History of British steam trawling off Iceland 1889-1916 and the Anglo-Icelandic fisheries dispute 1896-1897. Fjölvi, Reykjavik. 264 pp.

Turner, M.A. (1997) Quota-induced discarding in heterogeneous fisheries. Journal of Environmental Economics and Management 33: 186-195.

Valtýsson, H. (2001) The sea around Icelanders: Catch history and discards in Icelandic waters. In Zeller, D., Watson R. and Pauly, D. (eds) Fisheries Impacts on North Atlantic Ecosystems: Catch, effort and national/regional datasets. Fisheries Centre Research Reports 9(3): 52-87.

Walters, C.J. (1995) Fish on the Line: the future of Pacific fisheries. Suzuki Foundation Report, Vancouver, Canada. 87 pp.

Walters, C. and P.H. Pearse (1996) Stock information requirements for quota management systems in commercial fisheries. Reviews in Fish Biology and Fisheries 6: 21-42.

Addresses of Contributors

Jackie Alder
Fisheries Centre
University of British Columbia
2204 Main Mall
Vancouver BC
Canada V6T 1Z4
E-mail: j.alder@fisheries.ubc.ca

Ratana Chuenpagdee
Department of Coastal and Ocean Policy
Virginia Institute of Marine Science
College of William and Mary
1208 Greate Road
Gloucester Point
P.O. Box 1346
Gloucester Point, VA 23062
USA
E-mail: ratana@vims.edu

Bridget Ferriss
School of Marine Affairs
University of Washington
3707 Brooklyn Avenue
Seattle, WA
USA
E-mail: ferriss@u.washington.edu

Robyn Forrest
Fisheries Centre
University of British Columbia
2204 Main Mall
Vancouver BC
Canada V6T 1Z4
E-mail:r.forrest@fisheries.ubc.ca

Sylvie Guénette
Fisheries Centre,
University of British Columbia,
2204 Main Mall,
Vancouver BC,
Canada V6T 1Z4
E-mail: s.guenette@fisheries.ubc.ca

Gail Lugten
Justice Studies
Edith Cowan University
100 Joondalup Drive
Joondalup, WA,
Australia
E-mail: Gail.Lugten@utas.edu.au

Robert Kay
Kay Consulting
PO Box 191
Mosman Park, WA
Australia
E-mail: kays@coastalmanagement.com

Yajie Liu
Fisheries Centre
University of British Columbia
2204 Main Mall
Vancouver BC
Canada V6T 1Z4
E-mail:y.lui@fisheries.ubc.ca

Jean-Jacques Maguire
1450 Godefroy
Sillery, Québec
Canada, G1T 2E4
E-mail: jjmaguire@sympatico.ca

Gordon R. Munro
Fisheries Centre,
University of British Columbia,
2204 Main Mall,
Vancouver BC,
Canada V6T 1Z4
E-mail:g.munro@fisheries.ubc.ca

Tony Pitcher
Fisheries Centre
University of British Columbia
2204 Main Mall
Vancouver BC
Canada V6T 1Z4
E-mail: t.pitcher@fisheries.ubc.ca

Peter Tyedmers
School for Resource and Environmental Studies
Dalhousie University
1312 Robie Street
Halifax, Nova Scotia
Canada B3H 3E2
E-mail: peter.tyedmers@dal.ca

Hreiðar Þór Valtýsson
University of Akureyri/
The Marine Research Institute
Akureyri
Iceland
E-mail:

Reg Watson
Fisheries Centre,
University of British Columbia,
2204 Main Mall,
Vancouver BC,
Canada V6T 1Z4
E-mail: r.watson@fisheries.ubc.ca

Ussif Rashid Sumaila
Fisheries Centre
University of British Columbia
2204 Main Mall
Vancouver BC
Canada V6T 1Z4
E-mail: r.sumaila@fisheries.ubc.ca