INSTITUTE OF FOOD AND RESOURCE ECONOMICS
UNIVERSITY OF COPENHAGEN

Fisheries Economics and Management – Future Challenges

100 Years after Warming's "On Rent of Fishing Grounds"

Conference:

Program, Abstracts, List of Participants, and Practical information

Skodsborg Kurhotel & Spa, Copenhagen, Denmark
September 1-3, 2011

Content

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Program

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September 1-3, 2011

Thursday, September 1, 2011

11:00	Registration & Accommodation In hotel reception	
12:00	**Lunch** Main building 3rd floor	
13:30	**Peder Andersen:** Conference Opening Danner Salonen 2nd floor, Conference building *Chair: Jon G. Sutinen*	
13:40	**Christopher Anderson:** Pathways to Better Economic Outcomes for Fisheries	**Discussants:** Gordon Munro Juan Carlos Seijo
14:40	**Dale Squires:** Microeconomic Foundations of Renewable Resource Models	**Discussants:** Jim N. Sanchirico Daniel V. Gordon
15:40	Break	
16:00	**Gordon Munro:** Fisheries Economics and the Management of International Fisheries Under the New Law of the Sea	**Discussants:** Pedro Pintassilgo Kathleen Miller
17:00	Break	
17:20	**Rognvaldur Hannesson:** Forty Years of Fisheries Economics	**Discussants:** Hans Ellefsen Christopher Anderson
19:00	Conference Dinner Søjlesalen Main building ground floor **Niels-Henrik Topp:** The Legacy of Jens Warming	

Friday, September 2, 2011

	Breakfast Main building 3rd floor	
	Chair: Ragnar Arnason	
09:00	**Jon G. Sutinen:** Fisheries Compliance, Enforcement, and Governance: Where to from here?	**Discussants:** Jesper Raakjær Linda Nostbakken
10:00	Break	
10:20	**Juan Carlos Seijo:** Bioeconomics of Stock Fluctuating Fisheries: Dynamics and Uncertainty	**Discussants:** Ralf Döring Jim Wilen
11:20	**Lee G. Anderson:** Arbitrary but not Capricious(?): A Bioeconomic Evaluation of the Mandated Risk Analysis Protocols to Set Allowable Catches in US Fisheries Policy	**Discussants:** Kurt Schneir Ola Flaaten
12:20	Lunch Main building 3rd floor	
	Chair: Gordon Munro	
13:30	**Ola Flaaten:** A Comparative Study of Fishing Nations' Catch Performance	**Discussants:** Le Kim Long Dale Squires
14:30	**Frank Asche:** The Global Market for Seafood: New Sources and Species	**Discussants:** Carl-Christian Schmidt Cathy Roheim
15:30	Break	
16:00	**Cathy Roheim:** The Importance of Product Attributes: Reflections on the Relevance of Recent and Future Seafood Market Research for Improved Fisheries Management	**Discussants:** Atle Guttormsen Frank Asche
17:00	Break	
17:20	**Daniel V. Gordon:** The Norwegian Winter Herring Fishery: A Story of Technological Progress and Stock Collapse	**Discussants:** Daði Mar Kristofersson Ragnar Arnason
19:00	Dinner Orangeriet/Orangery Main building ground floor	

Saturday, September 3, 2011

	Breakfast Main building 3rd floor	
	Chair: Ola Flaaten	
09:00	**Ragnar Arnason:** On Advantages and Disadvantages of Grandfathering Fishing Rights	**Discussants:** Niels Vestergaard Lee G. Anderson
10:00	Break	
10:30	**Jim Wilen:** Should We Be Talking About Distributional Effects of ITQs? Rents, Crew Pay, Consolidation and Concentration	**Discussants:** Håkan Eggert Rognvaldur Hannesson
	Moderator: Jon G. Sutinen	
11:30	Roundtable Discussion **Future Research Challenges in Fisheries Economics and Management**	All
	Closing remarks	
13:00	Lunch Main building 3rd floor	

Scientific Organizing Committee: Professor Ragnar Arnason, Professor Trond Bjorndal, Professor Ola Flaaten, Professor Gordon R. Munro, Professor Jon G. Sutinen, and Professor Peder Andersen.

Local Organizing Committee: Administrative Officer Elsebeth Vidoe, Research Assistant Frederik Møller Laugesen, and Professor Peder Andersen, Institute of Food and Resource Economics, University of Copenhagen.

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Pathways to Better Outcomes for Fisheries

Christopher M. Anderson
University of Rhode Island
University of Washington

As part of my imminent move to the University of Washington School of Aquatic and Fishery Sciences--where I will be the only economist--I have been thinking about how to more effectively combine the tools and perspectives of biology with those of economics to produce improved economic outcomes for consumers and people involved in harvesting, raising, processing and marketing fish. I am interpreting the charge of speakers at the Fisheries Economics and Management--Future Challenges workshop as identifying areas I see as being important to the future of fisheries economics, much as I might advise a PhD student who came into my office and asked about good questions to pursue for a dissertation. The emphasis here is on things that, through my research career, I have learned that I do not know (but believe to be interesting and important); I am not sure I will have time to present all of these concepts in detail at the workshop.

My aspiration is for our field to assume a leadership role in the public conscience and high-level political debates surrounding fishery resource use, rising to at least the level of influence fisheries biology has enjoyed. The time for this shift is right because a foundation of biological success has been built, as more fisheries are brought under biologically effective management and overfishing is being significantly curtailed. While there is a prominent biological perspective (with which not all biologists agree, but nonetheless receives prominent publication and press coverage) that all fishing is ecologically destructive and should be effectively eliminated, I see sustainability issues persisting primarily where there are complex incentive problems because of international common property or multispecies issues. Thus, in many important cases, fishing policymakers are now in a position to think not exclusively about avoiding collapse, but rather to try to create wealth for fishing industries, communities, consumers and anglers.

What follows is a tour of questions and insights which I feel can be built upon to make a future in which policymakers find the objectives and insights of fisheries economists even more relevant and influential, and public sees strong fishery resources and aquaculture as an engine for sustainable development and economic growth.

Cross-Fishery Analysis

One of the major trends in fisheries ecology has been to develop broad databases that code fishery characteristics and outcomes across a wide range of fisheries. They do simple analyses to statistically associate outcomes with characteristics. The results are compelling not in the quality or detail of the data, but the breadth of the datasets; they are published in Science and Nature and covered in the New York Times and become part of the national and international dialog on harvesting and eating fish. While most of these analyses initially focused on the extent of overfishing, more recently ecologists (and a very few economists) have been turning to management characteristics, and associating biological outcomes with management.

The next step in this trend is to associate economic outcomes with the management characteristics, and while enterprising fishery ecologists are asking these questions of broad datasets, few economists are. Like their biologically oriented predecessors, it is likely many of these studies will be prominently published, picked up in the media, and guide the social conscience and high-level political discussions of the economics of fishing. Macroeconomists do (or used to do) a lot of this kind of analysis across countries, but most fisheries economics analyses are essentially case studies, focused on the idiosyncracies of a single fishery and its management.

This represents both an opportunity and a threat to fisheries economics. As a threat, if economists do not recognize the rhetorical power of these studies, biologists may be more effective at reaching policymakers and the public with messages about fisheries economics. As an opportunity, if we can learn both the power and limitations of this type of analysis, fisheries economists can present economic data in a way that more effectively reaches the public than we do now. Key questions include: What feasible economic measures can be meaningfully collected and compared across fisheries? What measures cannot? What level of measure precision is necessary? What points do we most want to make to a broader audience? What hypotheses are of greatest interest? What methodological or econometric considerations arise?

Jim Anderson (The World Bank) and I are developing the Fisheries Performance Indicators, a rapid assessment instrument for measuring wealth creation in fisheries. The current draft uses 62 metrics, scored on a 1-5 scale by experts, to assess dimensions of where wealth accumulates to the harvest sector, the processing sector, and is sustained in the ecosystem. We also collect 44 metrics measuring dimensions conjectured to facilitated wealth creation, including property rights, co-management, management resources and post-harvest market integration. While each measure is coarsely assessed, by using several measures for each dimension, we can obtain an accurate picture of a fishery's performance on those dimensions. While the tool is useful for benchmarking the effects of management interventions within a particular fishery (e.g., development projects), our vision is to assemble a broad database of 100-200 fisheries measured with the same instrument, to allow testing of hypotheses linking wealth creation to wealth enabling factors.

Understanding Harvesting Behavior within Seasons

Economists' textbook models focus primarily on biological features of the stock, and how to optimize profit earned from growth of the stock between seasons. The recent successes in bringing stocks under guideline harvest management also means that these models, whose point is about setting annual guideline harvests, need to be built upon in future work. Forefront research is shifting to spend explore the effects of rights-based management on harvest patterns, and while there are theoretical and empirical models of harvest timing during the season, developing more such tools is a growth area.

One example of these models is that Hiro Uchida and I developed to evaluate a pilot catch share program Rhode Island implemented around summer flounder, or fluke, a state-managed species that is jointly harvested with the (US) Northeast Multispecies groundfish complex. A sector of eight vessels was given a historical landings-based fluke allocation to land when they wished, while the rest of the fleet was managed through sub-seasonal total harvest caps and daily trip limits.

This means a single fishery with a single set of overall total allowable catches is being managed by multiple management systems concurrently, a situation later replicated on a broader scale through implementation of sectors in the Northeast Multispecies fishery. The theoretical model captures the strategic response of sector members, not only to the incentives of other sector members, but to that of harvesters being managed by different rules. It predicts that common pool managed harvesters will still race to fish, and receive low prices during the ensuing market gluts. Individual quota managed harvesters--which approximates the RI sector--will wait for the closure of the common pool fishery, and evenly distribute their landings over the closed seasons, receiving higher prices for their fish because they do not land during gluts.

Testing this model in a controlled economic experiment where the change in management is the only variable changed between treatments, we find common pool managed subjects race-to-fish, exerting high levels of effort to secure landings but selling at correspondingly low prices. Individual quota managed subjects in the same fishery hold effort back until the common pool fishery closes, and use their quota over the balance of the season at a lower total landings level, receiving higher prices. In the field, sector members avoided fluke landings during seasonal fluke derbies, instead shifting landings to post-derby closures in the general fishery, when the price was higher. However, they also affected prices of species they targeted instead. We combine predictions of estimated counterfactual 2009 daily landings by sector vessels with a panel model of trip-level ex-vessel prices for 25 products targeted by the groundfish fleet to project what revenues would have been in the absence of the sector program. We find the increased fleetwide revenues by over $800,000, including benefits of over $250,000 to non-sector vessels.

Multi-species Fishery Issues

One insufficiently understood dimension to harvest behavior is how harvesting occurs in multispecies environments, such as the (US) Northeast Multispecies fishery. On the one hand, economists' theoretical profit maximization models suggest harvesters look at prices and plan trips that maximize profits subject to constraints; quota-based management ascribes further significance to precisely how much of which species are caught and landed because total species quantity is an explicit constraint. On the other hand, much of the current empirical literature on trip-level planning focuses on location choice. While these choice/outcome variables are undoubtedly linked through the expected species harvest at each available location, higher levels of uncertainty about species (especially limiting species) or gear that allows for selectivity at a given location can make location a better or worse proxy for expected landings. As management creates incentives to more precisely determine the species mix, it may be useful to have empirical models that whose choice variables align with those to which theoretical models ascribe significance. As an intermediate solution, it may be useful to know the limitations of using location as a proxy to intended catch in a stochastic environment.

Understanding targeting behavior in multispecies fisheries is especially important when one or more of the species is severely limiting, and accessing the bulk of the quota or value of the fishery requires successfully (or serendipitously) avoiding harvesting these choke species. Interestingly, it is possible harvesters could end up worse off by establishing individual quotas for these species, as small individual quota allocations might mean a single landing could exhaust a harvester's seasonal quota, and risk of future encounters might make other harvesters reluctant to selling the quota market. How do we manage the risk associated with early shutdown when choke species catch is lumpy? Can markets adequately smooth this risk, or do thin markets with risk-averse participants hoarding choke quota compound the risk? Can quota risk pools, where harvesters pool their small individual allocations in a common pool--precisely the instrument that lead to the fishery problem in the first place--actually improve outcomes? What rules for operating the risk pool make it more effective?

Evolution of Management Institutions

The Rhode Island Fluke Sector Pilot Program research has lead to a (to me) surprising insight about the process of implementing effective management. Economists have often been, or felt, stymied in implementation of the individual rights-based management systems our models predict should be most effective at generating economic rents. This opposition often comes from a subgroup of harvesters who are concerned about various effects of rights assignment or quota trading. In the experiments, we added an additional treatment in which subjects could choose the management system under which they operated, a common pool or an individual quota system. After experiencing both management systems, subjects choose to be in a group with individual quotas by a 3:1 margin, with the ratio increasing over successive experimental seasons.

While this result is not surprising to economists, its implication for progress towards implementing rights based management is: it is not necessary to move entire fisheries to ITQs through a single massive management action. Rather, it suggests it is possible to take a partial measure, to create an environment where every harvester can select their management system of choice. Successful management systems will attract additional participants from those that are less successful, leading to more efficient management through competitive selection. In some fisheries, these self-selecting systems may be more politically acceptable than a wholesale switch to rights-based management: there are elements of self-selection in New England Multispecies sectors, in Alaska-BSAI crab cooperatives, and in Chignik salmon.

For economists, key questions include how to identify what sorts of management is likely to emerge from these competitions? When does developing a management selection institution will lead to more efficient outcomes? Will it ever lead to less efficient outcomes? And what factors affect how quickly or how slowly less effective management systems die out?

Heterogeneity

As we ask these questions, I think it is useful to try to answer them with a greater focus on heterogeneity. Heterogeneity leads to both differences in strategy and differences in experienced outcomes. The former is important because developing accurate predictive models requires understanding the range of responses to policies, but the latter is crucial because differences in outcome drive agents' support for policies. In environmental policy, and fisheries in particular, industry support for management measures is often prerequisite for successful implementation. Therefore, appreciating the distributional consequences of a new policy is necessary to understanding its political economy, and thus whether further analysis will be of practical importance; ideally, this will provide insight into types of policies that may attract more broad-based support.

For example, looking at outcomes of the RI Fluke Sector Pilot Program on a vessel level is important because, while non-sector vessels benefitted from the program as a whole, the benefit distribution was far from uniform. Some vessels (especially other offshore trawlers participating in the Spring derby) benefited considerably, while others were made slightly worse off by the program. As the pilot program has come up for renewal, questions arise about how these distributional effects change as the sector expands.

As a second example, with Hiro Uchida, Cathy Roheim and student Hiroki Wakamatsu, I conducted experimental auctions for real ecolabeled salmon products in Tokyo, to assess the premium Japanese consumers are willing to pay for sustainable seafood. A representative agent model shows a considerable average premium, but when heterogeneity is incorporated into the statistical model, we find that about 20% of the people are driving that result, about 60% of the people have very modest premiums, and everyone else is indifferent, even as information about fish stocks and ecolabeling programs is provided. For a marketer of ecolabeled products, it is important to know not only how big the average premium is, but how the premium is distributed across the demand curve so they may identify the price level that is attainable in the market.

Other Things Worth Mentioning (but where I haven't done any work, yet)

- Production models for small fishing businesses, reflecting the labor-leisure tradeoff rather than agricultural production
- Recreational-commercial interface
    - Better estimates of recreational impacts on stocks and welfare
    - Inter-sector allocation (positive and normative) and transferability between sectors
- Commercial wild fisheries and aquaculture; stocking policies.
- Risk exposure to natural stock or market fluctuations induced by replacing multipurpose licenses with single-species or single-fishery harvest rights
    - Negative feedback loops created by prohibiting harvesters from targeting species B when species A is depressed, forcing them instead to harvest more of species A rather than allowing recovery.

Arbitrary but not Capricious (?): A Bioeconomic Evaluation of the Mandated Risk Analysis Protocols to Set Allowable Catches in US Fisheries Policy.

Lee G. Anderson

Maxwell P. and Mildred H. Harrington Professor

School of Marine Science and Policy

College of Earth, Ocean, and Environment

Department of Economics

University of Delaware Newark

The purpose of this presentation is to provide a bioeconomic evaluation of the protocols that have been developed by the various Fishery Management Councils in the US to implement the requirements in the revised MSFCMA to end overfishing. It will be shown that that while considerable thought and effort has been expended to develop protocols that follow the accepted paradigm of population dynamics analysis and satisfy the requirements of the law, the results will likely be arbitrary and non-comparable between cases. It is argued that these shortcomings are due to the lack of economic rational in the statement of principles of the law and the failure to include any analysis of opportunity cost in the risk analysis protocols used to implement the law.

According to the introductory material in the Act, "overfishing occurs whenever a stock or stock complex is subjected to a level of fishing mortality or annual total catch that jeopardizes the capacity of a stock or stock complex to produce MSY on a continuing basis". However, the formal guidelines state that overfishing occurs where actual catch exceeds the Over Fishing Limit (OFL). In turn the OFL is defined as "the annual amount of catch that corresponds to the estimate of Maximum Fishing Mortality Threshold (MFMT) applied to a stock or stock complex's abundance and is expressed in terms of numbers or weight of fish". To complete the cycle, MFMT is "the level of fishing mortality (F), on an annual basis, above which overfishing is occurring". For the most part, the MFMT is considered to be the fishing mortality rate (Fmsy) that will cause the stock size to reach an equilibrium at a level (Xmsy) where sustainable yield is maximized.

Let Xt represent the estimate of current stock size, then given the estimate of Fmsy:

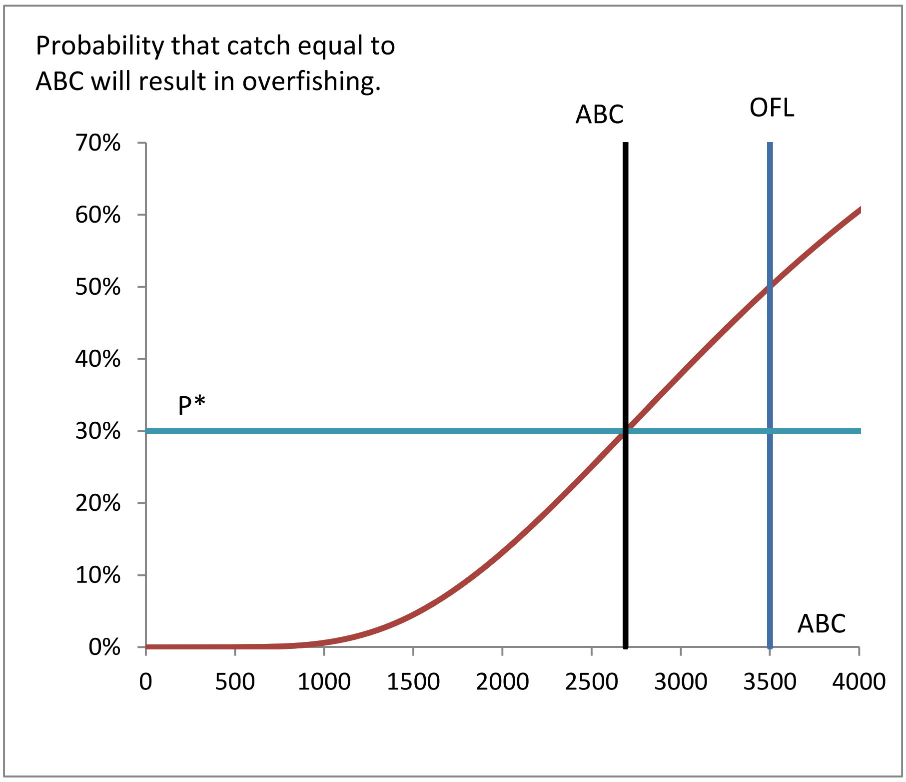
OFLt = Fmsy *Xt .

Overfishing occurs according to this definition whenever catch for period t is greater than OFLt.

This is a workable definition that provides a verifiable and consistent method of ascertaining whether overfishing is occurring. However, it can be argued that it does not completely capture the concept of preventing catch levels that jeopardize the capacity of a stock produce MSY on a continuing basis because of the failure to consider the existing stock size. Briefly if Xt >Xmsy, a catch greater that OFL (especially if it is set for one year only) will have little or no effect on the ability of the stock to produce MSY on a continuing basis. This, in addition, to the implicit assumption that Xmsy is always the appropriate stock size as opposed the perspective provided by the principles of fisheries economics, means that the framework fails to provide a solid economic framework for comparing the benefits and costs of different catch levels.

The more complicated policy issue is that the law requires the Councils to set a catch level called the Acceptable Biological Catch (ABC) that will be the binding constraint on harvest for the given year. "ABC is a level of a stock or stock complex's annual catch that accounts for the scientific uncertainty in the estimate of OFL and any other scientific uncertainty and should be specified based in the ABC control rule which is a specified approach to setting the ABC for a stock or stock complex as a function of the scientific uncertainty in the estimate of OFL and any other scientific uncertainty."

Basically this means it is necessary to set a "buffer" between the OFL and the ABC such that the probability of a catch equal to the ABC resulting in overfishing as defined above is reduced to an acceptable level, call it P*. The process can be explained conceptually using attached figure.



In this hypothetical case, the OFL is 3500 and the probability of a catch equal to OFL will result in overfishing is equal to 50%. If P* is set equal to 30%, the required buffer would be 800 and the ABC would be equal to 2700.

In order to perform this procedure, it is necessary to derive the appropriate probability curve and to specify a P* level or P* function. There are at least two ways to derive the probability function and an infinite number of ways to select the P* function and these will be described in the presentation.

But the main point from a bioeconomic point of view is that the concept of opportunity cost is ignored. The creation of a buffer means that some potential current harvest will be foregone so as to reduce the probability of overfishing. But there is no consideration for the actual cost to society of this foregone harvest. Nor is the any consideration of the even the conceptualization, to say nothing of the measurement of the benefits of reducing the probability of overfishing, or of the fact that meeting the strict definition of overfishing can have quite different effects with respect to the prospects of future harvests depending upon the current stock size. The presentation will also expand upon the above issues and show ways which have recently been discussed to correct for some of these deficiencies.

What conclusions concerning possible research challenges and drivers follow from this discussion? It can be stated without too much exaggeration that the basic law and the implementing guidelines were developed with little or no economic analysis or consideration. The same applies to the development of the protocols used to implement the law, although there have been some significant changes in the last stages of discussion and hints that more analysis will be forthcoming and will be welcomed. The actual driver for the research was the realization, in some quarters at least, that the current protocols could be improved by the inclusion of economic analysis.

I would like to think however that the process would be much further along in providing a balanced bioeconomic approach if economic analysis had been available and used in both the development of the actual law and the implementing guidelines. However, it is not possible to turn back the clock. But, it is not too late to provide more work in risk assessment in setting catch levels so as to provide the basis for future changes in the law.

But let us think ahead. Coastal and Marine Spatial Planning (CMSP) and Ecosystem Approaches to fisheries Management (EAFM) are two areas where new laws or changes in laws may be forthcoming around the world. I would suggest that since the basic laws are the spring board for actual policy implementation, Fisheries Economists need to be proactive and start providing conceptual analysis of how the laws should be structured so as to allow for the consideration of the economic ramifications of the allocation of resources that will be mandated or allowed under these laws. Fisheries laws that mandate MSY as the prime goal of fisheries management have prevented the consideration of economic analysis. It is important that the fundamental principles underlying any future changes be more broadly defined.

This will call for rigorous analysis of CMSP and EAFM legislation and policy that provides alternative objectives and practical approaches using a more broadly based framework including the necessary biological and legal detail but which also includes basic economic principles to be published in natural resource and fisheries management journals as well as more widely accessible policy journals.

On Advantages and Disadvantages of Grandfathering Fishing Rights

Ragnar Arnason

University of Iceland

It is widely recognized that basing fishing operations on fishermen's rights in the fishery, often referred to as rights-based fishing, promotes economic efficiency. The reason is simple enough. Rights are assets. With rights in the fishery, fishermen have an incentive to increase the value of these assets. Ignoring ill-designed rights, this usually implies increasing the long term value of the fishery which is generally in accordance with more efficient resource utilization paths. The strength of these effects depends, of course, on the quality of the rights granted: the higher the quality of the rights, the greater is the economic efficiency they generate. Most fishing rights are use rights and, therefore, indirect rights in the basic marine resources, i.e. the ecosystem and the ocean habitat. Nevertheless, experience shows that TURFs (Territorial User Rights in Fisheries) can generate a high degree of efficiency in certain fisheries. Similarly, ITQs (Individual Transferable Quotas), which are even weaker rights in the basic marine resources, can apparently greatly increase the efficiency of a fairly wide class of fisheries.

Taking it for granted that fishing rights are economically beneficial raises the issue of how to allocate the rights. There are several possibilities including (1) grandfathering — i.e. formally recognizing the rights of those already in the fishery, (2) selling the rights to the highest bidders by auctioning or other methods, (3) allocating rights on the basis of political/administrative considerations and (4) random allocations, e.g. by lottery.

Choosing the allocation principle is of importance because certain allocations of rights may be more efficient than others in the sense of generating more economic benefits. The theory of resource allocation by the market system is sometimes interpreted as suggesting that the initial allocation of endowments or assets does not matter for economic efficiency. By virtue of trades, the assets will simply migrate to the most efficient operators irrespective of their initial distribution. Therefore, the allocation of fishing rights, just as the allocation of any other endowments, is solely a matter of income distribution with no consequences for production. This argument, however, is too superficial. Among other things it ignores (i) the cost of reallocation the rights by trades (transaction costs) and, more importantly, (ii) the dynamics of creating (discovering, developing and producing from) the assets in the first place.

This paper discusses these issues. It argues that grandfathering fishing rights, and for that matter other resource use rights, is likely to minimize trading needs and, therefore, transaction costs. More importantly, it encourages investment in finding and developing such resources in the expectation that formal property rights in valuable resources will be obtained by grandfathering. The other methods of allocating fishing rights mentioned above provide these incentives to a much lesser extent or not at all. Also, grandfathering rights encourages discovering new and improved ways to exploiting resources, developing new products from them and markets for the products and so on. If, by contrast, resource use rights are insecure because of potential allocation according to other principles, these incentives are clearly reduced.

The paper further argues that allocation by selling rights to the highest bidder has an economically detrimental effect by raising the cost of capital to the resource user. This happens for two not unrelated reasons: First the buyer of resource rights is simply poorer than before by the amount he paid for the resource. Hence, he is a greater lending risk and the interest rates he is charged by financing agencies are correspondingly increased. Secondly, if resource use rights are sold to the highest bidder, especially if they are sold repeatedly, the retained profits from using the resource are correspondingly reduced. It follows that the ability to repay a loan is similarly reduced. The effect on the interest rates offered to the firm by financial institutes in the same direction as before. Clearly, this second effect primarily occurs if the resource use rights are periodically resold or rented, but it also occurs even for once-and-for-all sale. A higher cost of capital has obvious implication for resource use. It reduces the level of investments and it may affect the rate the resource use.

Counteracting these economic advantages of grandfathering, are certain potentially negative economic implications of the grandfathering principle. Grandfathering resource use rights may confer considerable wealth to the recipients. Depending on the exact form of the grandfathering principle, this wealth is gained by finding, developing and, to a certain extent, using the resources in question. This, as already mentioned, encourages the finding, developing and using activity. However, if the resources are finite, there will be a negative externality involved in this activity. What is discovered and developed by one economic agent cannot be found and developed by another. Therefore, if there is indeed limited number of resources to discover, the discovery and development activity may easily become excessive. In extreme cases the associated waste can be very great. In a sense this represents the re-emergence of the common property problem which fishing–rights are designed to correct for. In this case, however, the common property problem is not so much in using the resource but rather the activities necessary for qualifying for grandfathering. Needless to say, corresponding problems may also apply to the other allocation principles except perhaps random allocations. If valuable assets are to be allocated by whatever means, it pays to find ways to meet the allocation criteria.

This potential problem suggests that the application of a straight grandfathering principle might be reserved for resources that have already been developed and are being used. For currently unknown or undeveloped resources appropriate modifications of the grandfathering principle or the adoption of some other allocation principle might be preferable.

The paper concludes by discussing empirical examples of the allocation of rights in resource use. Broadly it appears that for already existing resources use, grandfathering is the most wide-spread allocation principle used, while for resource discovery and new resource use the principle of selling and auctioning is relatively more common.

New Sources and Species

Frank Asche

University of Stavanger

Seafood has been a traded commodity for thousands of years. From early on, the quantity traded was limited. A main reason for this was the perishability of seafood, and conserving fish (e.g., by producing dried fish) was time consuming, costly, and often inefficient. However, improved storage and preservation technologies and cheaper transportation have steadily increased fish trade. Still, there has been a virtual revolution in seafood trade over the last 30 years. After adjustment for inflation, from 1976 to 2006 world seafood trade value increased threefold, from 28.3 billion USD to 86.4 billion USD. During the same period, trade volume increased from 7.9 million tonnes to 31.3 million tonnes, or almost fourfold. Hence, the unit value of seafood has decreased, increasing seafood's competitiveness as a food source. Moreover, unit value for developing countries exports is significantly higher than imports, and while developed countries imports makes up almost 90% of value, they do not make up more than 60% of the quantity. This suggests a significant wealth generation in developing countries due to seafood trade.

A number of factors have caused the increased trade in seafood. Transportation and logistics have improved significantly. This has in many cases led to substantial reductions in transportation costs by surface and air, opening up for the trade of new product forms like, fresh seafood. Lower transportation costs have also given new producers access to the global market. Improved logistics has allowed economies of scale and scope on all levels in the supply chain, and particularly in the retail sector where supermarkets has replaced fishmongers and markets in a number of places. Progress in storage and preservation has continued, allowing a wider range of seafood products to be traded. Some developments in freezing technology during recent years has improved to such an extent that many product forms can be frozen twice. This is exploited by processing the products in locations with competitive advantages in processing fish rather than locations close to where the fish is caught.

The increased trade has also helped enable the development of aquaculture at the same time as the development of aquaculture probably is the most important factor in explaining the increased trade with seafood. The aquaculture revolution took place because improved control with the biology and the production process enabled systematic R&D work leading to a significant improvement in productivity and a associated reduction in production cost. By making aquaculture competitive in the market and with respect to land use, this has made seafood production increase faster than the global population and thereby increased the availability of seafood. However, it has also produced a number of user and environmental conflicts.

In addition to increased trade flows, the organization of the supply chain has also changed in a number of places. Most clearly this can be seen with growth of large supermarket chains. These chains emphasise efficient logistics and distribution and have, in many cases, removed a number of the intermediaries associated with traditional supply chains. Moreover, improved freezing technology has enabled processing to be set up in places far removed from where the fish is caught, such as China, Poland and Thailand. Air freight of fresh fish has opened up competition from producers located thousands of miles away to the high-end fresh markets that traditionally were served only by local fishermen.

The improved control with the harvesting process in aquaculture has enabled producers to better target the needs of the modern consumer, and to further innovate in the supply chains. Total seafood production has continued to increase, increasing the available supply of seafood globally. The imposition of 200-mile exclusive economic zones (EEZs) by coastal nations also gave strong incentives to increased trade. Countries with considerable distant-water fishing fleets, such as Spain and Japan, have been negatively impacted, as coastal nations expanded their domestic fleets to exploit the fisheries within their 200-mile EEZ. As a result, countries that relied on harvesting within the 200-mile EEZ of foreign nations had to increase their imports to meet domestic demand.

Trade, regulatory system, aquaculture production and supply chain organization are factors that tend to reinforce each other although the strength of each factor differs by market and species. While increased seafood production in itself gives incentives to increase trade, this is not a necessary consequence. It is primarily improved transportation and logistics and better storage and preservation together with competitive prices that enabled it. The increased trade has had a profound effect on seafood markets, as an increasing number of markets have gone from regional to global and as more species from widely different places becomes substitutes. Moreover, a growing share of producers have access to the global market as the global transportation systems improve and can take advantage of the new market opportunities. For those markets that have the ability to pay, this increases the available supply of seafood. Hence, the EU, Japan, and the USA continue to be the most attractive markets.

The increased trade competition and aquaculture production also amplify the difference in economic performance of fishermen in well regulated fisheries compared to poorly regulated fisheries. The price is in most cases exogenous to each individual fisher, but is often not exogenous to the regulatory system and it is certainly not a given parameter. As such, timing of landings but even more importantly, which market one can target depends on regulatory system and the competition. This is most clear in the transformation of many reduction fisheries to deliver fish for human consumption as the regulatory system changes. However, in the short run, this development can also lead to increased fishing pressure on unregulated species, as the redundant capacity that is removed when regulations are improved will normally be scrapped.

A Comparative Study of Fishing Nations' Catch Performance

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Fisheries developments of some countries are compared. Previously, surveys have shown that compliance with the FAO code of conduct for responsible fisheries vary strongly among fishing nations. With respect to actual performance it is a question if this is correlated with the code of conduct compliance. Why do some succeed and others fail with respect to catch performance? Since economic performance indicators based on a common set of definitions do not exist, catch volumes are used to compare development. Are good general institutions (GI) sufficient or are specific fisheries institutions (FI) required for good performance of fisheries? Is the resource curse working in fisheries?

48 major fishing nations were selected for this study, based on rank criteria of capture production, aquaculture production and fish export. This includes 22 OECD countries. Catch volume averages for 1986-7, 1996-7 and 2006-7 were obtained from the FAO database. For these countries fish landings vary, in 2006-7, from 14.6 to 0.1 million tonnes. The main indices used for comparison are compounded annual percentage changes in landings in the two decades from 1987 to 2007. Three GI indices and one FI index were chosen as independent variables, in addition to an OECD dummy, to investigate their effects on fisheries performance.

The GI indices are:

WGI - The Worldwide Governance Indicators

Average: Government Effectiveness and Regulatory Quality

CPI - Transparency International

The 2007 Corruption Perceptions Index

GCI - World Economic Forum

The competitiveness Report 2006 Score,

And the FI index is:

CCC - FAO Code of Conduct Compliance.

The effects on fisheries performance of the GI and FI indices prove to be spurious – and these indices are statistically correlated. The OECD dummy effect on fish landings development is negative (also statistically significant?).

The fishing nations are classified according to their development during each of the two decades and in total for 1987-2007. Winners and losers have positive and negative development, respectively, in all three periods. In addition three intermediate groups are also defined, such that each nation may be put in one, and only one, of the five groups. No OECD country is classified as a winner, based on the criteria developed, whereas 14 out of 22 losers are OECD countries.

There is a need for further Comparative analyses of fisheries performance and development across nations. Fisheries management objectives and instruments vary, but there seem to be a common goal to increase or stabilize catches. Economic performance analysis requires particular care, partly due to the existence of invisible resource rent (capitalized in the license values) and intra-marginal rent (for both vessel owners and crew) in many fisheries.

The Norwegian Winter Herring Fishery:

A Story of Technological Progress and Stock Collapse

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In the early 1970s, the herring stocks in the Northeast Atlantic were nearly fished to extinction. This collapse is usually attributed to a technological revolution in the herring fisheries that occurred in the 1960s. This revolution was two-pronged. Fish finding equipment (echo sounder) was developed that made it possible to detect shoals of fish underneath the surface of the sea. Second, a mechanical winch, usually called power block, was installed for pulling the seines used for catching the fish. This allowed the use of larger seines and, in turn, larger boats.

The effect of a productivity shock on a fish stock depends critically on how sensitive the fish catch is to the size of the stock. If the catch per unit of fishing effort is proportional to the size of the stock, catches will fall proportionally with the stock for a given level of effort, providing some protection as it were from increased effort or rising productivity. If on the other hand the catch of fish is not very sensitive to the stock size, catch could be maintained at a high level even as the stock is depleted, increasing the risk of depletion below the critical level of viability. Needless to say, this turn of events is predicated on the absence of any fish stock management, but that was indeed the reality before the advent of the exclusive economic zone when stocks were fished on the high seas by fleets from many different nations competing with one another.

At about the time when the herring stocks were heading for a collapse, fisheries biologists began to notice the low sensitivity of the catch per unit of effort to the size of the stock. Ulltang (1980) found this to be the case for the Norwegian spring spawning herring, using data from the 1950s and 60s. Bjørndal (1987), using a different methodology, reached a similar conclusion for the North Sea herring.

In this paper, we shall investigate the winter herring fishery in Norway, using data from the early 1900s until the crash in 1971. The fishery was exploited by three gear types; gill nets, land seines and purse seines. Interestedly, although the purse seines entered the fishery as late as 1925, it was the only one that remained in the end, due to technological development and dwindling of the fish stocks. The winter herring fishery exploited the spawning migration of the herring, which in winter comes in from the Norwegian Sea to the west coast of Norway. The duration of this migration varied with the stock size; sometimes it began as early as late December, but could begin as late as early February. By March or April the fishery was over.

Our investigation will focus on three principal factors in the herring fishery. First, is a descriptive analysis of the development of productivity in the fishery. We want to investigate how rapidly the new technology was taken up by vessels in the fishery. Second, what was the statistical impact of technological advancement on the stock of herring? Can we identify specific technological shocks with decline in the stock of herring? Finally, we look at the sensitivity of catch per unit of effort to the stock size and technological shocks. Is the stock elasticity low (close to zero), as often believed to be the case for stocks like herring that aggregate in shoals? This would mean that the catch per unit of effort can be maintained despite a dwindling stock, so increasing the risk of a crash such as the one that in fact took place in the late 1960s. Did the new equipment make the catch per unit of effort less sensitive to the stock size, thus increasing the vulnerability of the stock?

Research Challenges in Fisheries Econometrics

Good econometrics is needed for good policy advice. Good econometrics is based on two fundamental conditions: First, the proper application of econometric theory based on well specified, properly identified and correctly estimated econometric models; Second, having appropriate and high quality data to be used in estimation. Both of these conditions represent serious challenges for fisheries economists.

Econometric theory offers the applied econometrician a vast and rigours toolkit of alternative estimators, hypothesis testing procedures, and validation techniques. It has been 30 years since Leamer's famous paper 'Let's take the con out of econometrics' but has that happened in fisheries econometrics? Two examples will help illustrate the problem. The behaviour of fishermen is often modelled based on the profit maximizing assumption. This technique allows the full weight of ‘duality theory’ and all it’s economic restrictions to be used in estimating structural parameters of the fishery. But a survey of the literature shows that in many cases the regularity conditions are not satisfied in estimation, not tested or imposed on the model or in some cases reported incorrectly (negative supply elastisities). So by ignoring economic theory in our econometrics what do our estimated parameters tell policy people?

In many applied applications we do not have the richness of duality theory to guide model specification and the applied econometrician must rely on statistical techniques to define the model. But here we see that in many cases fishery econometricians seem satisfied with estimated results that are consistent with own prior beliefs rather than estimates that can withstand the rigours of testing. A good example is ‘econometric identification’ of estimating equations. Again a review of the literature shows few papers rigorously identifying econometric equations prior to estimation.

Fisheries economists have been lacks in demanding governments collect proper and high quality economic data. The data that is collected is based often on demands by biologists or accountants. Economists are left to try to run our models using data not designed for the purpose. A good example is the need for the price and quantity of fuel used on a fishing trip. The data is readily available but the government collects only aggregate fuel expenditure data. The use of such a combined variable or transformations there of to recover an approximation of price or quantity, introduces endogenous identification problems in estimation.

In my presentation I will discuss these issues further.

Forty Years of Fisheries Economics

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It must have been in 1970 or 1971 that I began to take an interest in the economics of fisheries. I had decided to go for a Ph.D. in economics and had to find a suitable thesis topic. In Iceland, where I grew up, fisheries were by far the most important industry, and the business cycles of the Icelandic economy were largely driven by the ups and downs of the fishing industry. Yet in the textbooks I had read (and they were mostly either English or American even if I was at the University of Lund in Sweden) the fisheries had not once been mentioned as far as I could recall. Was the fishing industry of no specific interest or just like any other industry and not worthy of any specific mention? Was there perhaps a lacuna in the academic literature waiting to be filled?

I decided to find out and began to read the academic literature on fisheries economics. Early on I came across the two papers by Jens Warming. The two Warming papers deal with the waste caused by common property. The 1911 paper is theoretical and shows how common property generates both a spatial misallocation between two fishing grounds and an overall waste for both grounds. Twenty years later Warming published his second paper. It seems to have come as a surprise to him that his earlier theoretical musings had an empirical application. When the second paper was written (1931), the Danish parliament was about to abolish private rights to eel fishing off the coast. Warming pointed out that this would probably lead to declining catches of eels and in any case an excessive number of eel traps and people engaged in the eel fishery.

I found the two Warming papers highly interesting and topical. In the early 1970s the law of the sea was in a state of flux. The factory trawlers from the Soviet Union and Eastern Europe had descended on the cod stocks across the entire North Atlantic and caused much worry among the coastal states. The Icelanders had begun to talk about a further extension of their fishing limits. I remembered the first Anglo-Icelandic cod war and had, of course, a certain disposition to sympathize with my countrymen, but I realized that arguments of fairness could cut both ways. The English pioneered trawl fishing off Iceland, and distant water trawling was an important industry in several English towns. But the lesson I took home from the Warming paper was that property rights were not just about fairness or the lack of it, they were also about efficiency. Property rights are productive; they provide incentives to take care of the property and make sure it continues to be productive. In the context of fisheries this means that the owner of a fish stock would avoid overfishing and excessive use of boats and manpower.

On the basis of this insight I wrote my first paper on fisheries economics. It put forward the thesis that both the country which appropriated a fish stock and the country which was barred from its previous fishing grounds would benefit in the long run. The country that would come to own the fish stock would of course appropriate the rent, but the country which used to catch fish for its own use would also benefit from more fish being available at a lower price.

Has this prediction withstood the test of time? That is not obvious. The fish stocks are in general not more plentiful than they were in the early 1970s, but I would go as far as saying that in the absence of extended jurisdiction of coastal states the world fisheries would be in a much worse condition than they are presently and fish catches probably smaller. Extended jurisdiction has probably prevented a further depletion of fish stocks and in some cases reversed it. The greatest problems in world fisheries are associated with fishing on the high seas where no single state has jurisdiction over fish resources.

Fishery dynamics--pulse fishing

There were, of course, many papers other than Warming's that I came across as I started exploring the literature on fisheries economics in the academic journals. Early on I came across the classic papers by Scott Gordon and Anthony Scott. I also discovered that this was a field of application that recently had become very active and exciting; there were papers by people such as Vernon Smith, applying what was at the time advanced economic dynamics to the fisheries problems. I realized that I had to get away from Lund for a while to broaden my horizons and solicit some good advice from people who were active in this field. I found out that Tony Scott was still at the University of British Columbia (UBC), so I decided to go to UBC and stayed there for the academic year 1972-73. UBC turned out to be just the right place. A lot was happening at UBC in resource economics in those days. Colin Clark was working on his first book and turning out papers every now and then. Gordon Munro was just getting involved with fisheries. And there was the Institute of Animal Resource Ecology, where I spent a lot of time; it had a small computer (it took up a whole room and probably had a small fraction of the computing power of a modern laptop) which I could have all for myself in the late evening and at night.

What did I use it for? I had asked Tony Scott for advice on a suitable thesis topic. I do not remember exactly what he said, but it was something about the discount rate and whether or not it would make sense to fish at an even rate or vary the exploitation rate over time. I set out to formulate a model along those lines. I was taking a course in fisheries biology at the time from Norman Wilimovsky and had been introduced to a number of yield models such as the Beverton-Holt age-structured model. On my way to Canada I had stopped in Iceland, talked to a few fisheries people and picked up an ICES report on the Icelandic cod. This report contained the necessary information on the biological parameters of the Beverton-Holt model, so I put together a simulation model and implemented it on the computer at the Institute of Animal Resource Ecology. After some time, this resulted in a paper on pulse fishing that I published in my dissertation and later in the Canadian Journal of Economics.

Lately there has been some revived interest in pulse fishing. People such as Olli Tahvonen and Stein Ivar Steinshamn have written papers on this, and I know of people in Spain who are also engaged in this. The modeling tools are orders of magnitude better than I had in the 1970s, and fresh minds see things in a new light and obtain new insights. There may well be more results out there waiting to be discovered. But there is one thing that has always bothered me about pulse fishing, also at the time I was doing my own work. The pulse fishing approach is not very practical. What it means is that a stock of fish is fished down heavily for a short period of time and then left to replenish itself for a longer period. But what does the industry do in the meantime? The retail stores depend on a steady supply of products, otherwise they are not much interested. And the industry would have some problems with opening and shutting down at irregular intervals.

The way I envisaged for making pulse fishing practical was that the fishing fleets could rotate between stocks of the same or similar species, a little bit like when timber is harvested from different lots at different times. This would ensure a reasonably even utilization of fishing fleets and flow of product. In fact the distant water fishing fleets were doing something a little bit similar at the time; there are several cod stocks in the North Atlantic (the Newfoundland one and the one at Greenland have since practically disappeared). They fluctuate strongly for environmental reasons, providing a reason for pulse fishing in addition to the theoretical one which holds even without natural fluctuations. The fleets appeared to be most attracted to the stocks that were most plentiful at each time.

Fish stock fluctuations

The subject of fluctuations in fish stocks is one that I have for long taken much interest in. Soon after I took up my position at the Norwegian School of Economics I published a paper on this, together with Stein Ivar Steinshamn. In the present day and age when the concept of sustainability has become a meaningless phrase for all things great and good it has of course become fashionable to talk about sustainable fisheries. But even in simple models of fisheries where surplus growth is a deterministic function of the size of the fish stock this concept does not get us very far. There is a range of sustainable yields (surplus growth) from zero to a maximum and then back to zero, from the lowest viable stock level to the one in pristine equilibrium. We need some further criteria for which one to choose. My impression is that people who talk sensibly about sustainable fisheries, despite the fuzziness of the entire concept, have in mind this deterministic fishery model. But fish stocks are not like that. Fish stocks fluctuate over time, sometimes wildly, for reasons that have nothing to do with fishing. These fluctuations can be amplified by fishing, but basically they are driven by variability in the survival of eggs and larvae, which depends on oceanographic circumstances over which we have no control (ocean temperature and salinity appear to be the critical factors, but the underlying phenomena probably are fluctuations in plankton which the larvae eat or in species which feed on the eggs and larvae). Hence, sustainable fishing is unlikely to mean a steady catch of fish over time.

The research questions on fish stock fluctuations have to do with how to adjust to the uncertainty in fish stock abundance. Should we try to stabilize catches? Sometimes stabilization at any feasible level may not be possible; the fluctuations could be so severe that sometimes we should not fish the stock at all. This is what happens in the capelin fishery from time to time. Then, what should our strategy be? Should we go for a given rate for exploitation, in which case the catches will fluctuate with the stock, or should we go for a minimum escapement, in which case the catches fluctuate even more? These questions have both an economic and a biological side. Much research has been done on this (I've done some myself), but the last word in unlikely to have been said, particularly not when we take into account how different stocks depend on each other.

Ecosystem-based management

The question of fishing interdependent stocks, so-called predator-prey models, was actually the one I first planned to write about in my dissertation, and I did in fact address it there but in a rather primitive way. This is still a hot and underresearched topic, especially those aspects that have to do with environmental fluctuations. One particular aspect of this is so-called forage fish, small, pelagic fish like sardine and anchovy that feed on plankton and are in turn eaten by other fish higher up in the food chain. You might have heard the phrase "fishing down the food chain" and you might have wondered if that is necessarily bad. We probably lose 80-90 percent of the biomass by having it pass from the small pelagics through the stomachs of cod or halibut or other fish-eating fish. Hence, if we were concerned with getting the largest possible amount of food from the sea, we should eliminate the top predators and fish the small pelagics. But the reason why we don't is the same as why we don't eat tortillas instead of beef. We simply like beef and are willing to pay a price for it that justifies feeding corn to cows. Similarly, we are not terribly fond of eating anchovy and sardine but willing to pay a lot for halibut and cod.

Nevertheless, sardine and anchovy are caught, not for direct human consumption but for reduction to fish meal used in feed blends for poultry and pigs and increasingly for farmed fish. These catches are likely to mean less food available for wild fish that feed on sardines and anchovy. Ideally the possible loss of biomass of wild fish further up in the food chain should be taken into account by a tax on the fishing of these small pelagics, to take into account the effect on the wild fish stocks. But nowhere in the world are such approaches implemented. The major reason for this probably is that next to nothing is known about the magnitude of this effect. We know the effect is likely to be there, and if it is, what direction it will have, but that's about all.

And there is more to it than that. Sardine and anchovy and other small pelagics also are feed for wildlife such as sea birds and marine mammals. Over time these animals have come to be valued as such. The additional question then is how much to set aside of the small pelagics to feed the birds and the sea lions. Even if we knew exactly how much these animals eat of small pelagics (and we certainly don't), there is the additional problem to put a value on the biomass lost of these animals by fishing the small pelagics. The wildlife species have no market value, and it probably makes little sense to value these species on a weight unit basis. What some investigations about willingness to pay have tried to elicit is people's valuation of protecting these species, which is more about ensuring viability of herds than putting a price on each additional animal whether the herd is viable or not. Furthermore, the contingent valuation methodology is problematic because it is all about willingness to pay and no money is ever parted with. This generates an incentive to exaggerate the willingness to pay for things one deems worthwhile to preserve. Moreover, one can use the same money many times over, so we might end up with everything being worth preserving. To put it shortly, one is valuing real losses against fictitious benefits that no one will ever pay for.

Everyone has probably heard about ecosystem management, and the problems just mentioned are about that. Perhaps it is this absence of data and objective valuation that has led people to increasingly talk about ecosystem-based management instead. Whatever that means, it appears to be the case that fact-based ecosystem management is still a long way off. That underlines a need for further research on the ecosystem relationships and the economic aspects thereof; for example, how much less cod flesh would we get if we catch more capelin and what is that cod flesh worth compared to the capelin we catch.

ITQs

I revert to the early 1970s. At that time I think I still suffered from illusions about what governments can be expected to do to run national economies efficiently. I did not realize until several years later that there are strong incentives for politicians to introduce all sorts of inefficiencies to promote their careers. I thought that governments of coastal states such as Iceland would be enlightened enough to jump at the opportunity to get the greatest possible economic benefit from their newly-gotten fish resources. But that was not the case. After the Icelanders got full control over their cod, they simply replaced the foreign overfishing by their own. They bought a multitude of unnecessary trawlers and fishing boats and continued to deplete the stock. In the early 1980s it finally dawned on them that they had to set up a management system that would give them the desired economic benefits. Fish quotas had come into vogue by that time, and some theoretical work had been done on this. I think the Icelanders had the good fortune that Ragnar Arnason was just back from the University of British Columbia, which at that time was the Mekka of fisheries economics research. I think he was influential in making these quotas transferable.

At about the same time New Zealand was establishing its system of individual transferable quotas (ITQs). I learned about this somehow, and visited New Zealand in 1984 when they were busy designing and debating this new system. I became convinced that this was the right thing to do. In fact this is a straightforward application of Warming's insights. It is unlikely that individual property rights to fish stocks will be established, but what we can do is establish individual rights to shares of an overall fish quota. Setting the overall quota will still be in the hands of governments under this system, but the industry as a whole has a strong incentive to persuade governments to set these quotas in a way that safeguards the productivity of the fish stocks. The decisions about how to fish, when and where, and how much to invest in fishing boats and equipment will be made by the industry, but a major advantage of the ITQ system is that it provides incentives to do so in an efficient way, that is, not to use more manpower and equipment than necessary.

At this point I will have to backtrack a little. The fact that crews on fishing vessels are paid a share of the catch value and not a fixed wage provides incentives to overinvest in fishing boats, as I showed in a paper from 2000. I came to that result in a funny way; I set out to demonstrate in a simple yet realistic model that ITQs provide incentives for optimal investment in fishing fleets. As the model refused to yield the desired outcome I realized that under the share system, which I put in there for realism, things aren't quite so simple. But the share system has other advantages, so I'm not saying that we should necessarily abandon it. Compared with open access, the overinvestment due to the share system is small.

Much research has been done on ITQs. Their advantage in terms of efficiency is, I think, undisputed, provided they can be effectively monitored and enforced and also provided that fish stocks can be assessed reasonably accurately. It is perhaps the distributional aspect of ITQs that still merits research. What is it that prevents societies from putting in place such eminently sensible systems, or promotes their abandonment despite their efficiency? Some people, in Iceland for example, have become quite well off from fish quotas. This has generated considerable resentment; Iceland is a small and transparent society with a low tolerance for unequal income distribution.

Game theory and fisheries

During my career game theory came to be extensively applied to fisheries. This happened partly because game theory established itself as a tool of the trade in economics from the late 1970s onwards. But it also happened because of the new law of the sea, that is, the exclusive economic zones (EEZs) that gave coastal states jurisdiction over resources up to 200 nautical miles from baselines (lines closing off fiords and bays). This gave the coastal states control over the resources in their zone (and for oil sometimes further out if the continental shelf stretches that far). Without this we are unlikely to have seen ITQs put in practice. But, as a famous Norwegian comedian put it, it is difficult to see the border underneath the sea surface (he posed as a captain of a Soviet submarine captured in Norwegian waters). The fish transgress borders at sea as they like. Any effective management of transboundary fish stocks requires agreements between the states involved. Since these states are sovereign, such agreements must be self-enforcing, which is an appropriate subject for game-theoretic analysis and the second reason why it came to be applied so widely to fisheries problems.

A lot of game-theoretic work on shared fish stocks has already been done (I have a survey of this in press). The most interesting outstanding questions are in two areas; (i) stocks with highly variable migrations, and (ii) fishing on the high seas. As to migrations, it turns out that some pelagic stocks such as mackerel, herring and blue whiting, which travel far and wide, also radically change their migratory behavior at certain intervals. All of a sudden they show up in the economic zones of countries where they have not been before, or have not been for a long time, and disappear partly or wholly from zones where they used to be found. This has often upset agreements on sharing of fish stocks or prevented such agreements from being reached. The research question is how to design agreements that can withstand such changes in fish migration. The possible effects of climate change on fish migration have generated some of the interest in this by myself and others.

On the high seas we are unlikely to see the otherwise logical solution of a further extension of coastal state jurisdiction. The question is then how can we design agreements not just between states that are engaged in fishing in a certain high seas area but also in a way that takes into account that fishing on the high seas is in principle open to everyone. Is there a scope for regimes such as ITQs in high seas fishing? I doubt it.

Technological progress

My final point is about technological progress in fisheries. Perhaps it is natural that one develops an interest in history as one grows older, having seen so many interesting things happen. Recently I've been involved with others in writing papers on the technological development in two

Norwegian fisheries, the Lofoten fishery and the winter herring fishery. The data in one paper end in 1988 and the other in 1970, so we are talking about history here. Technological development can be formidable but uneven; technology develops by fits and starts. In both fisheries the benefits of technological progress were largely neutralized by open access, and in the herring fishery it led to a dramatic collapse of the fish stock.

As an aside, one result from the herring paper is that as technology progressed, a latent "stock effect" gradually emerged, because with a primitive technology the stock was accessible only if and to the extent it came close enough to shore. In other words, we have an interesting interplay between technology and the spatial distribution of the stock. This draws attention again to the first Warming paper, because that paper has a spatial dimension to it; he was looking at the allocation of fishing effort between fishing grounds. Seen in this way, the Warming 1911 paper can be regarded as the first one on spatial fisheries economics, a subject that has been quite hot for some time and which deserves further research; fish are not evenly distributed over some area but distributed in patches which change according to oceanographic circumstances. Fish of different ages may be found in different patches. This has implications for their capture and for whether or not we should set aside some areas for fish protection. Furthermore, the large fish stocks that we often talk about may very well be agglomerations of sub-stocks, each with its own little home patch. Indiscriminate fishing could very well destroy some sub-stocks and reduce genetic diversity and resilience.

Coming back to technological progress, this is of course of a much greater interest than just as fishing history. Some people argue for effort controls instead of quota regulations. There may indeed be arguments for effort controls rather than quota regulations, but effort controls will have to deal with technological progress if they are to be effective. Some, even economists, talk about technological progress in the fishery as a "problem", and it is quite true that it makes the effort control more difficult. But in a wider sense technological progress is not a problem but an opportunity; it is technological progress that primarily lies behind the rise in living standards that we have experienced. One of the challenges in fisheries management is how do we turn technological progress into an opportunity? Economic institutions evolve in response to challenges such as the ones posed by technological progress, and we have seen that process at work in the fisheries. The increased power of fishing vessels to scoop up everything in their way led to the establishment of the exclusive economic zone. The individual transferable quota accommodates technological progress better than any other way of managing fisheries. For the effort controls it is a challenge; one often hears fisheries biologists and managers complain that “the fishermen beat us again” when the latter have procured better equipment to pack more power into any measure of effort they are allowed to use. It is an important task for economists who get involved with fisheries management to educate their fellow managers that technological progress is an opportunity and not a problem; a constructive approach to management is one that finds a way to make it so.

Fisheries Economics and the Management of International Fisheries under the New Law of the Sea

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The development of the economics of the management of international fisheries and the development of game theoretic economic models of the fishery are almost one and the same. While game theory is certainly being applied to the economics of domestic fisheries management, it is our interest in the management of international fisheries that has been the major driving force in the application of game theory to fisheries.

The reason for this is straightforward. In international fisheries, we are concerned with internationally shared fish stocks, where strategic interaction between and among the states exploiting the stocks is the norm – hence the need for the theory of strategic interaction (games). As such, we are no different from economists analysing the management of other internationally shared natural resources, e.g. water and the atmosphere. Indeed, fisheries economists at the cutting edge of the economics of the management of international fisheries have borrowed heavily from the game theory developed by environmental economists studying global warming, and other aspects of shared atmospheric pollution.

While significant management of international fisheries actually began immediately after the end of World War II, economists' interest in the international fisheries had to await the coming of the EEZ regime, under the New Law of the Sea, in the last half of the 1970s and the early 1980s. It was clear to all that the typical coastal state establishing one or more EEZs would find that some of the fishery resources would cross the EEZ boundary into neighbouring EEZs and/or into the adjacent high seas. The FAO now sets out three broad categories of internationally shared fish stocks: A. Transboundary stocks – EEZ to EEZ; B. Straddling stocks – stocks to be found both within the EEZ and the adjacent high seas, which are subject to exploitation by both coastal states and distant water fishing states (DWFSs); C. Discrete high seas stocks.

The development of the economics of international fisheries management has really followed the evolution of the international law of fisheries, commencing with the fisheries components of the 1982 UN Convention on the Law of the Sea. In the late 1970s and early 1980s, only transboundary stocks (Category A) were thought to be significant, with the consequence that they were was the focus of economists' analysis of international fisheries management.

Transboundary fish stocks are relatively easy to manage. The number of players is usually small and, if the fish stocks are strictly transboundary, the property rights to the resources are clear. One can think of the resource(s) being co-owned by the relevant coastal states on a condominium basis.

The first set of game theoretic based models dealing with the management of transboundary stocks appeared in 1979 and 1980, with the 1979 article dealing with the cooperative management of such stocks, and the 1980 articles dealing with the non-cooperative management of the stocks. Extensive use was made of John Nash's models of two player single stage cooperative and non-cooperative games. The 1980 articles conclude that the non-cooperative management of these resources will very likely lead to a Prisoner's Dilemma type of outcome. These conclusions have been validated many times over in the real world. Policy makers now, by and in the large, accept that cooperative management of these resources is essential.

The 1979 article on cooperative management of transboundary stocks, almost by chance, assumed that the players are asymmetric, which is the real world of cooperative fisheries management. The article also stumbled on to importance of side payments (transferable utility), which is now being accepted (gradually) in policy circles. The article did, however, have several restrictive assumptions. As well as assuming a two player Nash cooperative game, the article assumed that, if the players enter into a cooperative management agreement, the agreement will be fully binding over time.

Over the next decade and a half, many of these restrictive assumptions were relaxed, and thus economic models of transboundary stocks were produced that were more in accord with the complexities of the real world. Explorations were undertaken of the consequences of cooperative agreements being less than fully binding, which required the application of game theory much more advanced than that employed in 1979/80. One of the outcomes of this exploration was the identification of the time consistency problem in transboundary fish stock management, the fact that a cooperative resource management regime, which may appear to be stable initially, could prove to be unstable at a later time, because of shifting conditions.

Articles were written demonstrating that there are numerous alternatives to John Nash's theory of cooperative games, relevant to fisheries. Advances were made on single stage games, by introducing more realistic multi-stage and sequential games.

A major step forward was the development of models with more than two players. With more than two players, one now has to turn to coalitional game theory and raise the question of fair sharing rules. This has led to extensive use of characteristic function games, in which the payoff of each coalition is computed and compared with the Grand Coalition payoff. This then leads to possible sharing rules, with the Shapley value in which a player's share is based upon its average contribution to all possible coalitions, being the most widely used.

The development of the game theoretic economic theory of international fisheries management in the 1980s and 1990s was accompanied by extensive empirical work. Empirical applications of the theory can be found to transboundary fisheries in North America, Australia, Latin America and Europe.

Straddling stocks, seen as unimportant in 1982, became a major resource management problem over the ensuing decade, compelling the UN to convene an international fisheries conference. The conference brought forth the 1995 UN Fish Stocks Agreement, which is to be seen as a supplement to the 1982 UN Convention. Under the Agreement, straddling stocks are to managed by so called Regional Fisheries Management Organizations (RFMOs) that are to have as members both coastal states and relevant DWFSs.

While strictly speaking an RFMO is to confine its attention to the high seas segment of a straddling stock, in fact the RFMO has to address the management of the stock as a whole. In contrast to transboundary stocks, the property rights to the RFMO straddling stocks, within the high seas at least, are nebulous. This has led to an explicit free riding problem, and an implicit free riding problem in the form of the so called new member problem. A state, almost invariably a DWFS, not a “charter” member of the RFMO, has a right to apply for RFMO membership.

Two player games are all but worthless in analyzing the management of RFMOs, as numbers are typically large in RFMOs. Given the existence of free riding, this raises the question of the maximum number of players a RFMO can support, a question that is all but identical to the one raised with respect to international environmental agreements (IEAs).

While coalitional game theory is mandatory, characteristic function games are not adequate for the task at hand, because they ignore the question of externalities. In particular, will the formation of a RFMO have a positive or negative externality upon players outside of the RFMO? The answer is invariably - positive. Positive externalities enhance the appeal of free riding, for obvious reasons.

The biggest advance in dealing with this issue comes with the application of partition function games, which are used extensively in the analysis of the stability of IEAs, and which recognize externalities explicitly. The application of these games leads to the concept of internal stability. A coalition is deemed to be internally stable, if no player within the coalition has an incentive to defect and free ride. The question then is whether the Grand Coalition that is the RFMO is, or is not, stable. Recent work demonstrates that

If explicit free riding is uninhibited, a RFMO will be internally stable, only if the number of players is small, e.g. fewer than five players, far smaller than the typical RFMO. The threat of such free riding is now being taken very seriously in the policy world.

Even if explicit free riding is controlled, there still remains the new member problem. If new members are permitted to join the RFMO, and enjoy the benefits of cooperation essentially free of charge, this can undermine the RFMO, particularly if optimal resource management demands investment in the resource. This problem has been extensively debated in the literature. The most promising solution so far is to have new members "buy" their way in by buying and/or leasing harvest quota from "charter" members. The effect would be to grant "charter" members de facto collective property rights to the fishery resources encompassed by the RFMO, which does, of course, go to the heart of the problem. The solution is gaining traction in policy circles.

The post 1995 theoretical developments have been accompanied by extensive empirical applications. The Northeast Atlantic, the Mediterranean, and the south and central Pacific have seen the most empirical applications.

What, if anything remains to be done? The answer is that in some ways, we have only just begun. The international law of the sea, particularly with regards to straddling stocks continues to evolve. Our economic models will have to continue to evolve with it.

The work using partition function games, while of high quality, contains several very restrictive assumptions, which will have to be relaxed. In so doing, the collaboration with economists working on IEAs, which has developed to such good effect so far, should be intensified. One such economist has said to this author that he now sees a clear convergence between fisheries game theoretic economics and the game theoretic economics of IEAs.

The solution to the new member problem, involving trade in harvest quotas, has accompanying it several difficult game theoretical problems. They were actually raised many years ago, but this was when the solution was thought to be of academic interest only. The problems were forgotten. The time has come to address them.

Finally there is the time consistency problem, a problem that is relevant to internationally shared fish stocks of all kinds. The issue had been raised in the 1980s, but this was within the context of deterministic models. The real question is how to deal with time consistency under uncertainty. This is a very serious policy issue. The author can point to at least two cases in which the time consistency problem brought about the near breakdown of major cooperative fishery management regimes. To date, game theory has almost nothing to say about this problem.

The Importance of Product Attributes for Improved Fisheries Management

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A number of trends in the past 20 years in world seafood markets have created a variety of challenges and opportunities for fisheries management, and for the work of fisheries economists. Many of these trends have not been fully analyzed in the economics literature, nor have the dots been connected between the implications of these changes in seafood markets with fisheries management policy. The objective of this presentation is to discuss some of the trends, and outline the connections between the issues and implications for fisheries management. Several studies will be used to highlight past contributions to fisheries economics, and conclusions will be drawn which draw a suggested roadmap for future directions for research.

For example, an oft-cited fact is that more than 80% of the U.S. seafood supply comes from imports, with a similarly large share of the EU share also from imports (NMFS, 2010; FAO, 2008). Over the last 20 years, aquaculture production has accounted for an increasingly large share of those imports, approximately 50% in the U.S. The ability of aquaculture producers to control several product attributes through the production and processing stages has altered buyers' expectations of market characteristics of seafood – e.g. quality, packaging, processing, freshness. Yet in the face of increasing competition from aquaculture, we've heard for many years from economists such as Gunnar Knapp about how little attention has been given to the effect of current management policies on such quality characteristics (or the return to such) by fisheries managers. Studies by Valderrama and Anderson (2007), Martinez-Garmendia and Anderson (2005), Homans and Wilen (2005), Larkin and Sylvia (2004) are among the studies that show how accounting for market characteristics in fisheries management can improve returns to the fishery. Hedonic studies such as Carroll, Anderson, and Martinez-Garmendia (2001), McConnell and Strand (2000), Kristofersson and Rickertsen (2004) and Roheim, Gardiner and Asche (2007) show the marginal value of a variety of fish attributes, including attributes which can be influenced by changes in fisheries management, and could inform changes in management and processing practices that would enhance returns to fisheries.

Furthermore, characteristics of the supply chain are changing. Increasing consolidation is occurring in the retail sector, with the top 4 retail chains in the U.S. accounting for a larger share of total food sales (ERS, 2011). Traditional food markets are being replaced by supermarkets as well as warehouse clubs and supercenters. Similar trends are occurring in countries within Europe (e.g. Murray and Fofana (2002) show evidence for the UK in particular). The extent to which these buyers hold market power within seafood markets is largely unexplored in the economics literature, except in various papers by Asche and co-authors which focus primarily on purchases of farmed salmon at the import level. The need for such analysis becomes particularly evident when one considers the agenda set by the retail sector (including supermarkets, processors and large restaurant chains) on sustainability, which shows the extent of influence the market may have on fisheries if not fisheries management. Yet little is known about the costs and benefits of fisheries certification, and how such market-based approaches to 'sustainable' fisheries and aquaculture production alter current economic and environmental conditions. Other than several studies documenting factors which influence consumers' willingness to purchase ecolabeled seafood, only Tiesl, Roe and Hicks (2001) and Roheim, Asche and Santos (2011) have documented actual economic benefits of seafood ecolabeling. The cost factor has largely been unexplored except anecdotally.

Without presenting an exhaustive list of seafood attributes which have implications for fisheries management, and related studies, this abstract concludes by briefly mentioning a pair of related attributes: seafood safety and country of origin. These issues have also been at the forefront of health policy, and are also related to environmental and trade policies, internationally. Safety attributes can include contamination by microbial, chemical, organic, and inorganic sources and heavy metals. In some cases, this may be due to poor fishing practices, or fishing illegally in closed areas. Some countries are more often associated with food safety concerns than others, differentiation benefitted by country of origin labeling. In other cases, lack of information or misinformation about health risks may lead to reduction in demand which put downward pressure on exvessel prices. While in the poorly regulated fisheries, this may not be viewed poorly, it is not socially optimal if the product is healthful for consumers. Studies by Shimshak and Ward (2008) on effect of advisory information on tuna demand, and Wessells, Brooks and Miller (1995) on demand for mussels after an algal bloom highlight some of the analysis done in this area.

The presentation will discuss more fully these issues, adding a bit more background information, and provide concluding remarks regarding next steps for analysis.

Bioeconomics of Stock Fluctuating Fisheries: Dynamics and Uncertainty

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Historical long term changes in stock abundance have been related to climatic changes. Large fluctuations of fish stocks and long term changes in human harvest of marine resources are well known from long before modern exploitation started and harvesting technology became efficient enough to make significant stock reductions (Hjort, 1914; Jakobsson et al., 1995). Historical long term changes in stock abundance have been related to climatic changes as pointed out by Øiestad (1994), and fish stocks seem to fluctuate over time in relation to warm and cold periods in ocean waters. Andersen and Sutinen (1984) and Ishimura et al. (2005) acknowledged large fluctuations in stock levels and yields on a year to year basis due to stochastic recruitment processes, and Hanneson (1993) considered the choice of optimum fishing capacity of fish stocks that vary at random. Conklin and Kolber (1994) reported that stock assessment surveys consistently reveal fluctuating stock levels regardless of whether or not they are subject to exploitation. Steinshamn (1998) applied a dynamic Schaefer-Gordon model using a sine function, with alternative cycles of 4, 8 and 12 years, for the exogeneous disturbance affecting fish stock reproduction over time. A decade ago, Klyashtorin (2001) found that populations of the most commercially important Atlantic and Pacific fish species - Atlantic and Pacific herring, Atlantic cod, European, South African, Peruvian, Japanese and Californian sardine, South African and Peruvian anchovy, Pacific salmon, Alaska pollock, Chilean jack mackerel and some others - undergo long-term simultaneous oscillations. Concerning climate change effects on fish stocks, evidence reported by Cochrane et al. (2009) indicates that climate change is modifying the distribution of marine and freshwater species. Species are being displaced towards the poles and are experimenting changes in the size and productivity of their habitats. It is expected that ecosystem productivity will tend decrease in tropical and sub-tropical ocean areas and to increase in higher latitudes. Habitat effects of changes in water temperature are also critical. Any change in habitat temperature of marine species significantly influences its metabolism, growth rate, productivity, seasonal reproduction and, susceptibility to diseases and toxins.

Higher temperatures in marine and freshwater ecosystems are likely to affect physiological processes of species causing positive as well as negative effects in fisheries. This will depend on species sensitivity to changes in temperature and salinity as well as their mobility capacity to migrate to more suitable environments.

Possible impacts of climate change on fisheries can be summarized as follows (Cochrane et al. 2009, Anderson and Seijo, 2010): (i) Changes in species abundance because of effects on: reproduction and recruitment patterns, individual growth, productivity of ecosystems sustaining the fishery , (ii) Changes in species availability including effects on: spatial distribution of species, and spatial distribution of fishing intensity, and (iii) Changes in species catch composition over space and time.

Greater uncertainties in fluctuating stock fisheries with climate change

For responsible fluctuating-stock fisheries management it seems critical to consider, in addition of the well-known possible sources of uncertainty (FAO, 1995), long-term environmentally driven fisheries processes.

Climate change will increase uncertainties associated to fish harvest and fishery management because it is likely to further stimulate environmentally driven stock fluctuations and add to the complexities of managing unsustainable stocks (Caddy and Seijo, 2005). Such uncertainties impose new challenges to risk assessments which are usually based on knowledge of probabilities of occurrence of past events. Data to determine effects of previous climate changes in the best of cases cover some decades and would not be an appropriate guide for future expectations.

These factors pose two questions: How to manage fisheries with environmentally driven patterns of fluctuating stocks?, and how to deal with the associated uncertainty of possible environmental cycle periodicities determining stock abundance over space and time?

This paper presents a simple approach for including periodic fluctuations in carrying capacity and recruitment long term patterns. This is done first by relaxing the assumption of constant carrying capacity of the Schaefer Gordon model and secondly, by making dynamic recruitment a function not only of spawning stock but also of critical environmental factors such as water temperature or nutrient availability, in an age structured bioeconomic model. Because there is no equilibrium biomass or sustainable yield in a fishery with fluctuating carrying capacity and/or recruitment, dynamic biomass and catch target and limit reference points (TRP´s and LRP´s, respectively) are calculated to aid fisheries management. In both approaches, a sine function is used to represent the long term fluctuating pattern in stock abundance. The length of cycle and amplitude parameters of the periodic function is calculated using optimal control theory. For specific cases, appropriate periodic functions should be considered. Target biomass over time (TRPXt) is calculated proportional to the time varying carrying capacity. Fishing mortality is optimized (Fopt) to yield maximum net present values using alternative rates of discount, reflecting different prices of time. Fopt is then multiplied by time varying stock biomass to determine the corresponding optimum TAC over time. The approach has been applied to the Peruvian anchovy (Engraulis ringens) fishery and the fourwing flyingfish (Hirundichthys affinis) of Barbados. The stock fluctuating bioeconomic models, when linked to a risk analysis tool, are also useful to undertake risk analysis of alternative fisheries management strategies and regulations of this type of fisheries. To estimate such risks, we can use quantitative methods like Monte Carlo analysis to calculate the probabilities of exceeding LRP´s with alternative management strategies (Seijo and Caddy, 2000; Seijo, 2006). They are useful to estimate the probabilities of exceeding bio-ecologic and socio-economic LRP´s of performance indicators as a result of economic and/or environmental uncertainties arising over time (e.g. climate change effects on fluctuating fisheries).

Decision tables to deal with uncertainty of occurrence of alternative states of nature

An additional option for acknowledging the associated uncertainties in the decision-making process is the application of decision theory for systematic choice under uncertainty considering different risk attitude criteria, with and without mathematical probabilities. Under this approach, decision-makers in fisheries are expected to select one management strategy, d, out of a set of D alternative strategies. When selecting a strategy, the fishery manager should be aware of the corresponding consequences. These consequences are likely to be a function of the cause-effect relationships specified in the fishery model, the estimated bio-economic parameters, and the possible states of nature for the fluctuating stock fishery (Seijo et al., 1998; Seijo et al., 2004, Anderson and Seijo, 2010).

In decision theory, it is important to be able to estimate a loss of opportunities function, L(d,θ), also called regret matrix in the operations research literature, which reflects the resulting losses of having selected strategy d when the state of nature occurring is θ. In the absence of sufficient observations to assign probabilities to possible states of nature (e.g. climate change effects), there are three decision criteria reflecting different degrees of precaution concerning selection of fishery management strategies under uncertainty without mathematical probabilities: the Minimax, Maximin and Maximax (Seijo et al., 1998; Defeo and Seijo, 1999).

Some conclusions of this paper are:

(i) Because of exogenous fluctuations of carrying capacity, there are no possibilities for reaching equilibrium (including bioeconomic equilibrium) in the fishery.

(ii) Non-equilibrium conditions and stochasticity precludes the derivation of analytical solutions for the differential equations describing resource and fishers dynamics.

(iii) Calculation of values of state variables for resource biomass and fleet specific effort dynamics should be undertaken using numerical integration methods (Euler, Runge-Kutta, Sympson, etc..)

(iv) Effort, catch and profits will tend to fluctuate in response to oscillations of resource abundance through time.

(v) For stock fluctuating fisheries, target and limit reference points should not be scalars or discrete values of biologic and economic indicators. To be meaningful, they should become time varying hypothesis vectors of TRP’s and LRP’s with the corresponding vector of TAC´s

(vi) The application of decision theory criteria without mathematical probabilities offer a systematic approach for dealing with the uncertainty associated to climate change.

Future bioeconomic research associated with climate change should perhaps consider the following questions:

Are long-term stock fluctuations associated to changes in abundance predators and competitors targeted by other fleets? If so, is there a dynamic bioeconomic optimum level of effort and fishing capacity of the eco-technological interdependent fleets?

Is the cycle and/or amplitude of long-term fluctuating stocks changing with climate change? If so, what should the adequate vessel capacity be?

Are source areas of metapopulations shifting its location with climate change? If so, are MPA´s properly located?

Finally, long-term stock fluctuating fisheries and possible climate change effects upon them, could suggest the following management considerations:

Strengthening, through education, fishing community resilience and adaptability to fluctuating stocks and changes in resource accessibility,

Fostering vessel malleability and versatility to facilitate shifting of target species as required by stock fluctuations and climate changes effects on species distribution and availability and over space and time,

Fishing licencing should be for multiple species rather than for single species. This would allow fishermen to react intelligently to relative stock abundance/availability and associated profits.

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The Microeconomic Foundations of Renewable Resource Models

Dale Squires, Niels Vestergaard, and James Kirkley

Stronger microeconomic foundations to dynamic renewable resource models allow asking new questions and provide new answers to old questions. Stronger microeconomic foundations are fundamental to models that are consistent with economic theory and that reduce specification bias. Nonetheless, normative renewable resource economics models and analysis have been developed within a capital-theoretic framework with an eye on elaborating the basic conditions for optimal dynamic yield, effort, and resource stocks and their time paths to (no net-growth) steady-state equilibrium, or on extinction, or on the dynamics underlying the overexploitation of an open-access resource as it approaches a steady-state equilibrium (Deacon 1998, Wilen 2000).1 These research themes and their models have been developed while overlooking their microeconomic foundations.

Strengthened microeconomic foundations sharpen the specifications of bioeconomic models, can reorient them to allow addressing technological change and Debreu (1951)-Farrell (1957) economic efficiency, allow more comprehensive fundamental equations of renewable resource economics or Golden Rules, focus greater attention on optimum time paths rather than (no-net growth) steady-state equilibriums under static technology, shift the policy focus from nominal to effective effort, reorient models from autonomous to nonautonomous, and strengthen subsequent policy discussions. For example, the traditional approach overlooking the microeconomic foundations, and thereby relying upon ad hoc specifications of nominal effort and static technology rather than effective effort, can advocate accumulation of natural capital to levels greater than maximum sustainable yield (MSY) to create the marginal stock effect that

[1] Historically, the bulk of economic research on renewable resource models focused on fisheries was spent on developing rigorous dynamic conceptual models of fisheries using a notion of fishing effort that lacked a theoretically rigorous foundation. This research focused upon a rigorous examination of the characteristics of economically optimal solutions and the manner in which they depended upon parameters and structure. Eggert (1998), Brown (2000), Wilen (2000), and Squires (2009) give recent reviews of renewable resource models

lowers density-dependent harvest costs and maximizes economic rents.2 Yet, technical change also lowers density-dependent production costs without requiring maintaining as large of a stock of natural capital at an opportunity cost of foregone rents and also can lead to accumulating optimum levels of natural capital below MSY.3 Technical change is also one of the most critical factors contributing to problems of overfishing, overfished resource stocks, and overcapacity. But an enhanced microeconomic foundation is necessary to incorporate technical change into renewable resource models in a comprehensive and systematic manner and more accurately address these issues. Overlooking microeconomic efficiency also leads to solely dynamic scale efficiency rather than the more comprehensive dynamic Debreu-Farrell economic efficiency comprised of scale, allocative, and technical efficiency.

Because fishing effort and the corresponding production frontier are the basis of these microeconomic foundations, effort is the natural starting point to examine and then strengthen the microeconomic foundations of dynamic renewable resource models. The concept of fishing effort is central to fisheries management, population assessments, and renewable resource economics models for fisheries. Nonetheless, even given its centrality, the concept of fishing effort remains insufficiently developed from the perspective of microeconomic theory. Fishing effort is specified as nominal rather than as effective that accounts for changes in technology and Debreu-Farrell economic efficiency. Effort is typically specified as perfectly malleable without investment in nominal physical capital, with the exceptions of Clark, Clarke, and Munro (1979), McKelvey (1985), and Boyce (1995), among a few others. The specification of fishing effort is largely an afterthought to analyzing the approach paths to (no-net growth) steady-state equilibrium. Technical change, and more broadly, sound microeconomic foundations, are also largely overlooked in bioeconomic models, with much recent attention given to ecological and spatial processes and age-structured natural capital.

This paper strengthens and extends the microeconomic foundations of renewable resource economics model through more formally developing the concepts of fishing effort, disembodied and embodied technical change, Debreu-Farrell economic efficiency, and the catch

[2] A dynamic economic optimum with static technology and stock levels higher than MSY is most likely for demersal fisheries, but school fisheries even without technical progress may well have optimums at resource stocks lower than MSY, since the resource stock coefficient may be 0.

[3] Squires, D. and N. Vestergaard. In press. "Technical Change and the Commons." *Review of Economics and Statistics.*

or production frontier. We focus on industrial fisheries and vessels, whose fleets are largely built up (FAO 2010). Specifically, we develop different specifications of effective effort and the corresponding production technologies and bioeconomic models, including the corresponding fundamental equation of renewable resources or Golden Rule.4 For the sake of simplicity, the discussion, which is age-structured in vintages of physical capital, is framed within a surplus production framework for the population biology, but can be extended to a framework that is also age-structured in natural capital or treats spatially distinct processes; although these two topics represent the current frontier of renewable resource research, they are simply beyond the scope of our paper.5

Accounting for technical progress and time-varying technical efficiency allows formally developing effective effort and non-autonomous renewable resource models.6 We specify technical change that is both disembodied and investment-specific or embodied in the capital stock, following a framework formalized by Hulten (1992) and extended to renewable resource models by Squires and Vestergaard (in press).7 We further allow for technical inefficiency in the production frontier through either the stochastic production frontier approach or through a fixed effects panel data approach (Schmidt and Sickles 1984). We also allow for input and output allocative efficiency that enters through the effort and output aggregator functions. This specification of effective effort, along with the introduction of allocative and technical efficiency, allows a richer and more complete notion of the dynamic economic optimum, that of dynamic Debreu-Farrell efficiency

[4] Convenient constructs such as a “representative fishing firm” do not have a general justification, and following Blundell and Stoker (2006) we do not further belabor their lack of foundation or discuss them further. See the surveys by Stoker (1993) and Browning, Hansen and Heckman (1998) for background on these basic problems.

[5] See Deacon (1989) and Tahvonen (2009) for age-structured natural capital and Sanchirico and Wilen (1989), Smith et al. (2009), Costello and Polasky (2008), and Clark (2010) among others for spatial extensions of the bioeconomic model.

[6] Dynamic renewable resource models have been specified as static in technology and hence autonomous and built around nominal rather than effective effort. Non-autonomous renewable resource models have focused on changes in market prices (Clark and Munro 1975, Clark 2010).

[7] The vast bulk of technical change in fishing industries is exogenous (often with military antecedents), with the most important endogenous technical change not through formal R&D but regulatory induced as extensively discussed by Squires and Vestergaard (in press). Technical change embodied in different vintages of the physical capital stock, and introduced into the production process through investment in the Clark, Clarke, and Munro (1979) framework, is endogenous through the choice of investment. See also Murray (2007) and Fissel and Gilbert (2010).

allowing for technical change than the traditional dynamic scale efficiency of bioeconomic models under static technology.

To illustrate the impact of alternative microeconomic specifications upon bioeconomic models, we specify and estimate five cases of effective fishing effort and corresponding Graham-Schaefer yield frontiers for the Pacific albacore fishery through the Solow residual approach developed by Kirkley et al. (2004) and using the growth accounting framework for disembodied and embodied technical change of Hulten (1992) and the renewable resource stock of Squires (1992). We illustrate the effect of the different specifications through a bioeconomic model to show the implications for different time paths of optimum yield, effort, and resource stocks and dynamic Debreu-Farrell economic optimums based on direct use values in the form of economic rent. We discuss the implications of each approach for endogenous and exogenous sources of growth. We show the different corresponding specifications of the fundamental equation of renewable resources in which the marginal stock effect is modified by changes in technology and technical efficiency and in which there is a new marginal technology term accounting for these changes.

We specify five models and the resultant fundamental equations of renewable resources corresponding to the four specifications of effective effort and the production technology: (1) Leontief-Sono separability8 but without explicit investment in physical capital, corresponding to Clark and Munro (1975), and effort as an unobserved composite; (2) the same as (1) except effort measured as an observed composite by a Tornqvist index; (3) Leontief separability and technology with capital services as the limiting factor and no explicit investment in physical capital; (4) Leontief separability and technology with variable inputs represented by days as the limiting factor and no investment in physical capital; and (5), building off of CCM (1979), Leontief separability and technology with the stock of physical capital as the limiting factor and investment in physical capital. All five cases allow for Debreu-Farrell economic inefficiency and exogenous disembodied technical change, but only cases (1)-(3) and (5) allow for embodied technical change, with only (5) explicitly explaining through investment how this embodied technical change is introduced into the production process. The optimization problem, Hamiltonian, Golden Rule, and equation for the optimal resource stock for Cases (1)-(3) are alike; what differs is specification of the effort aggregator function, which is a flow variable in all three cases. The differences in Cases (1)-(3) will

[8] The notion of separability is central to the concept of fishing effort, since effort is an unobserved composite input formed by some type of effort aggregator function (Hannesson 1983, Squires 1987).

show up in the empirical estimation and results, and past investment is unexplained or modeled (the standard specification in the classic bioeconomic model). Case (4) has only disembodied technical change since physical capital does not affect production. Case (5), the CCM (1979) case, differs by the cost specification and the effort aggregator function, in which effort is specified as a stock variable requiring an implicit assumption of full capacity and capital utilization.

This overview of the literature and the importance of microeconomic foundations behing normative renewable resource models suggests several areas of research, that we turn to next.

Specific Areas of Research

1. Better measures of total factor productivity (TFP) and technical change, including a squared time trend to allow for non-constant rates when econometrically estimating technical change in a production frontier
2. In addition to fixed (random) effects (within estimator or dummy variables), additional approaches to panel data estimation to estimate technical change and the production function to account for endogeneity and entry/exit and omitted variables (Olley-Pakes (1996) and generalized methods of moments)

How relevant are the assumptions of Olley-Pakes?

How appropriate is GMM that combines the equation in differences and levels? This approach involves using lagged value of both the levels and the changes over time of capital, materials, labor, and output as instruments for current values of capital, labor, and materials. These lagged values are assumed to be correlated with current values but independent of the error term. The technique is an extension of Arellano and Bond (1991) along the lines suggested by Arellano and Bover (1995).

If the error term is white noise, one can use levels of capital, labor, materials, and sales lagged at least twice as instruments for the equations in differences. For the equation in levels, differences of these variables lagged at least one period are legitimate instruments under the additional assumption that the correlation between the level of the variables and the firm-specific, time-invariant component of the error term is constant. (See Arellano and Bover (1995).) The orthogonality condition associated with the equations in differences and levels are estimated jointly.

3. More research on embodied technical change to understand it better and to measure it better (but refer to general literature on how hard it is to tease out). There is a long and extensive literature on embodied technical change in other industries.

4.more studies of empirical bioeconomics incorporating tech change to have better understandings of where the Pareto optimum is

5. More work on the functional form and overall specification of the aggregator function to model technology.

6. Investigating the impact of changes in technical efficiency on bioeconomic models. Include specification and estimation of time-varying technical inefficiency along with time-invariant approach.

7. Policies to address technical change

8. More empirical studies on the nature of technical change in fishing industries and use of Baltagi-Griffen approach (dummy variables)

9. Impact of technical change, and productivity growth in general, on international environmental agreements through game-theoretical bioeconomic models.

10. One of the largest sources of productivity growth in the general economy in the past several decades is due to process and product innovations in information technology. Similarly, one of the largest sources of capacity and productivity growth in fishing industries is undoubtedly information technology. Understanding and measuring this should be a major research task.

Fisheries Compliance, Enforcement, and Governance: Where to from here?

Jon G Sutinen

University of Rhode Island

Compliance and enforcement issues continue to challenge fishery management programs around the globe. The research to date on these issues appears to have had little impact on policies and programs to strengthen compliance and improve enforcement. In this presentation I will review recent research on compliance and enforcement in fisheries and attempt to identify important research directions for fisheries economists to pursue in the near future. In addition, I will examine briefly some of the obstacles to reforming fisheries governance systems from a political economy perspective and suggest areas of research that may help overcome some of these obstacles.

Should We Be Talking About Distributional Effects of ITQs?

Rents, Crew Pay, Consolidation and Concentration

James E. Wilen

UC Davis

Should economists be talking about distributional effects of ITQs? The standard answer by economists to these kinds of questions is generally a cautious no------ on the grounds that we have little to say about distribution unless we are willing to make interpersonal tradeoffs. But some heated and important debate has arisen in a number of fisheries over the impacts of rationalization on crew, with a growing contention that crew are harmed by ITQs. In at least some cases, the issues in contention threaten to unravel existing ITQ programs, or catalyze draconian ex post changes in programs. Economists have an important role to play here, by grounding discussion in positive or predictive economics questions about the impacts of ITQs on crew.

The debates that have arisen over impacts on crew pose, first, a fundamental empirical question, namely: what do we know about what has happened to crew after ITQs have been adopted? This is an objective question that can be answered with appropriate data, and it would be useful to shed some data-based light on questions that have been largely addressed with anecdotes to date. Related to the empirical question is a conceptual question, namely: what should we expect to happen to crew as a consequence of rationalization? In other words, what does economic theory tell us ought to happen, and what are the mechanisms by which changes happen? These two related questions are under-researched, but important to helping policy makers understand what has happened to the crew sector and whether what has happened has been influenced by the design of various programs.

ITQ Impacts on Crew

Empirical Findings

To begin with the obvious, virtually all ITQ programs are purposefully designed to reduce excess capacity and consolidate remaining capacity on a smaller number of vessels. Hence a first principle is that some pre-rationalization crew will be displaced as vessels consolidate, and this is an unavoidable byproduct of vessel capital reduction. In terms of numbers, we should anticipate, to a first approximation, that total crew will be reduced roughly in proportion to the number of vessels retired. The degree of consolidation, in turn, will be driven largely by economies of scale associated with rational use of fishing inputs as well as program design. Many programs impose consolidation limits that are designed to ensure that single entities do not gain control over harvesting capacity. These consolidation limits, if they bind, impose an upper bound on consolidation and constrain the number of crew jobs that will be lost after rationalization. A second order impact affecting total crew jobs will be changes in crew use at the intensive margin after rationalization. In derby fisheries, extra crew are often added simply as a safety valve against crew being injured or ill or otherwise unable to contribute to an intensive race to fish fishery; rationalization removes the need for these extra crew.

Thus a first answer to the question of what we should expect to happen to crew after rationalization is that crew jobs will be lost as a result of consolidation. Those crew who exit may be worse off or not, depending upon whether there are substitute jobs available that compensate for lost fishing job opportunities. We know very little about the labor markets that crew are drawn from, or the transferability of the skills of crew to alternative occupations. A next question is how remaining crew fare after rationalization. In most cases, fewer total crew members will each work longer seasons. But it is less clear what happens to daily and seasonal pay for those that remain. In my presentation, I discuss results using data from the Alaska red king crab fishery. In that analysis, we find that remaining crew earn more seasonal pay over extended seasons, and pay per day is at least as much as before rationalization. This is similar to our earlier findings in the British Columbia halibut fishery.

Conceptual Findings

Whatever is being revealed by the small number of empirical studies on crew impacts, some observers are convinced that crew pay for remaining crew should be greater than it is. The culprit, some have argued, is the lease market for ITQs. Several papers have advocated banning leasing of quota, or imposing various inefficiencies in order to reduce lease and quota trading prices. Some proposals that have been suggested to reduce lease prices include: requiring lease owner to be aboard, capping lease prices, and restricting transactions by larger vessels. The view that lease prices are somehow the problem stems from the convention of computing crew shares on returns after some categories of costs have been subtracted. After ITQ are implemented, it has been the practice that most vessel owners subtract out of pocket ITQ lease costs from gross revenues before computing shares. Some also subtract the opportunity cost of grandfathered quota, a practice that has proven very contentious. As consolidation occurs, more vessels lease in quota from those that have exited, and hence lease payments grow on remaining vessels. Thus what crew gets paid appears to be determined by the practice of leasing and lease prices, and it further appears to some that crew pay is squeezed by rising lease payments. I show some of these trends using the Alaskan crab rationalization case.

The mechanisms behind the contention that crew pay is being squeezed by lease payments actually run counter to economic logic and Ricardian theories of the determinants of asset prices. In my presentation I discuss what economics has to say about the connections between quota share prices, lease prices, exvessel market prices, crew shares and crew pay. As I argue, the interconnections between these variables are subtle and not well understood, and I attempt to clarify these connections using some simple observations about the share system. The discussion of conceptual underpinning of the share system sheds light on the kinds of changes to crew pay that we should be witnessing after rationalization.

Topics for Future Research

Some issues raised for future research by my presentation include:

What are the fundamental mechanisms that determine crew pay in fisheries?

How does crew pay change as a result of rationalization, and what mechanisms drive the resulting equilibrium?

How are lease prices and crew pay in share systems interconnected?

How do various ITQ design features influence the crew sector?

What are the crew labor market implications of rationalization programs?

How does the demand for various skills change under ITQ adoption?

What are the opportunity costs for crew in the fishing sector?

What happens to crew that exit after rationalization?

How does the relationship between labor services, skipper services, and vessel capital change after rationalization?

Does the impetus for retaining the share system change under rationalization?

How do share systems adapt to rationalization programs?

INSTITUTE OF FOOD AND RESOURCE ECONOMICS
UNIVERSITY OF COPENHAGEN

Fisheries Economics and Management – Future Challenges

100 Years after Warming's "On Rent of Fishing Grounds"

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Skodsborg Kurhotel & Spa, Copenhagen, Denmark

September 1-3, 2011

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Fisheries Economics and Management – Future Challenges

100 Years after Warming's "On Rent of Fishing Grounds"

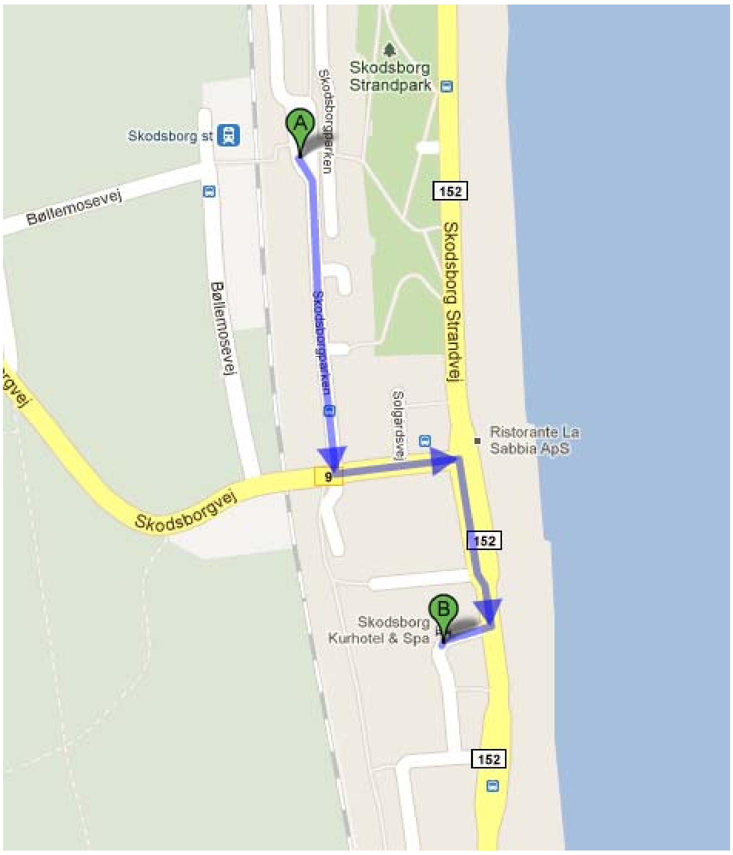
Practical Information

Skodsborg Kurhotel & Spa, Copenhagen, Denmark

September 1-3, 2011

Conference location: Skodsborg Kurhotel & Spa · Skodsborg Strandvej 139 · DK - 2942 Skodsborg · Telefon (+45) 45585800 fax (+45) 45585810. http://www.skodsborg.dk/uk/hotel.htm

Direct from Copenhagen Airport to Skodsborg Kurhotel & Spa, by train: Take the train from Copenhagen airport towards Nivå St and get off at Skodsborg st. It is 8 stops, 40 min ride, and trains departure the airport every hour at the minutes .02, .22, and .42. Then walk from Skodsborg st. to Skodsborg Kurhotel & Spa, approx. 5 - 10 min walk, see map. Tickets are available from the DSB ticket office in the arrival Terminal 3.



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From downtown Copenhagen to Skodsborg Kurhotel & Spa: Take the train from Copenhagen central station or Nørreport st. towards Nivå st, to Skodsborg st (approx. every 20 min). Then walk from Skodsborg st. to Skodsborg Kurhotel & Spa, approx. 5-10 min walk, see map. Train tickets can be bought at the stations.

From Skodsborg st. to downtown Copenhagen the train departure every hour at the minutes .16, .36, and .56.

Direct from Copenhagen Airport to Skodsborg Kurhotel & Spa, by taxi: It is possible to take a taxi from the airport to the hotel. It should costs approx. 400 DKK but remember to tell the driver to go through the center of Copenhagen. Normally, it is faster and 150 DKK cheaper.

Leisure time: You can enjoy Skodsborg Kurhotel & Spa fitness facilities, go swimming in Øresund or take a walk beautiful forest surroundings (Jaegersborg Dyrehave). And Copenhagen is only 20 minutes away.

Links:

(Hotel) http://www.skodsborg.dk/uk/hotel.htm

(Weather)http://www.dmi.dk/eng/index/forecasts/forecast_for_copenhagen.htm

(What to do in Copenhagen)http://visitcopenhagen.com/