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Editorial

Introduction

Concerns about global warming have been with us now for more than 10 years. Global warming will affect not just atmospheric temperatures; the ocean will also warm up, and ocean currents may change. In some places, such as the Northeast Atlantic, ocean temperatures may even fall instead of rising, due to changes in currents (weakening of the Gulf Stream and the thermohaline circulation).[1]

From early on in the debate about global warming it has been recognized that it will have economic consequences, both benign and disadvantageous.[2] This is particularly true of activities that are directly and critically affected by the weather, such as agriculture. The fisheries are even more dependent than agriculture on climatic conditions. While agriculture does up to a point compensate for the shortcomings of nature (through irrigation and fertilization), the fisheries, which essentially are an advanced form of hunting, are totally dependent on what nature will or will not provide.

The effects of climate change on fisheries are likely, therefore, to be more severe than for agriculture. Nevertheless, it appears that little research has been done on the possible consequences of climate change for fisheries. One reason could be that the effects of global warming on fish stocks and their migrations are extremely difficult to predict. This is illustrated by the above-mentioned two, diametrically opposed scenarios being envisaged for the Northeast Atlantic. The prevailing view seems to be that these waters will become warmer, so much so that, before the end of this century, the Arctic Ocean could become ice-free during the summer (see the paper by Stenevik and Sundby, this issue). But there is also the possibility that the Gulf Stream and the thermohaline circulation could be weakened, leading to a drastic fall not just in ocean temperatures in the Northeast Atlantic but to a colder climate in general in northwestern Europe, despite global warming. Clearly, when there is no agreement even on whether temperatures will rise or fall, the analysis is bound to be hypothetical. Those who like clear-cut results will find this intimidating.

In June 2005, a workshop on the economic effects of climate change on fisheries was convened at the Institute for Research in Economics and Business Administration (SNF) in Bergen, Norway. Four policy-oriented papers from this workshop are published in this issue (a collection of model-oriented papers will be published in *Natural Resource Modeling*) together with two other papers on climate change and fisheries. In the event, the workshop turned out to be just as much or more about the effects of climate variability as global warming. This is not necessarily a drawback. Global warming, if it really is happening, is likely to occur gradually but with considerable variations, like the climate has displayed in the past. Past variations in the climate should therefore offer a clue to the likely effects of global warming, and the way people have coped with the consequences of past changes should suggest how the consequences of global warming could be dealt with.

A recent and comprehensive study of the possible effects of climate change is the Arctic Climate Impact Assessment (ACIA) [1]. Even if the Arctic is a marginal area in terms of human habitation and economic activity there are some good reasons for focusing a study of global warming on the Arctic; it appears that the Arctic is getting warmer more rapidly than other areas, with correspondingly greater effects on the environment. To its credit, ACIA made an honest attempt to study the impact on fisheries, but it turned out to be a difficult undertaking. There are two main uncertainties in the causal chain from global warming to the fisheries. First, the impact on ocean temperature and currents is uncertain, not just in magnitude but possibly also with respect to direction. Second, even if we knew the change in temperature and ocean currents we would not necessarily know the effect on abundance and migrations of fish stocks. ACIA's analysis is based on a set of plausible scenarios, which rely heavily on the observed climatic fluctuations in the Arctic in the 20th century and their impacts on the fish stocks. The first of the papers in this issue is by William Schrank and discusses the ACIA process, from the vantage point of one who was involved in this study.

The Northeast Atlantic, comprising the North Sea, the Norwegian Sea, and the Barents Sea, is a part of the Arctic and the subarctic and an area where fisheries have been an important industry for a long time. The second paper, by Stenevik and Sundby, discusses likely future temperature scenarios for this area and how the fish stocks in the

[1]On possible changes in the oceanic climate in the Northeast Atlantic, see [1], Chapter 9.2.

[2]An early assessment is [2].

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Norwegian economic zone and the conditions for aquaculture in Norwegian coastal waters might be affected. They expect that the temperature will rise, perhaps even to the point of making the Arctic ice free during the summer after 50 years. Generally speaking, fish stocks will be displaced in a northerly direction and their productivity improved, but these effects are difficult to quantify. An ice free Arctic during the summer could be beneficial not just for fisheries in this area but also for shipping and extraction of oil and gas. In the North Sea we are likely to see a change in species composition, with an influx of herring, mackerel, anchovy and sardine, while the cod stock will decline, being at the warmer edge of its preferred habitat. While the productivity of the North Sea may not be much affected, the change in species composition could adversely affect the economics of the fishing industry through highly valued kinds of fish being replaced by lower valued species.

As discussed by Stenevik and Sundby, ocean temperatures in the Northeast Atlantic have varied in the past. There was a warm period in the 1920s and 1930s while the 1970s were a cold period; ocean temperatures in the first years of this century at various points along the Norwegian coast were no higher than in the late 1930s. The third paper by Hannesson examines whether the temperature fluctuations in the past have caused changes in fish catches, reflecting a displacement of stocks as a result of temperature changes and which could indicate what to expect from a warming trend. He finds little evidence for such displacements. The catches of cod are, however, related to temperature variations; positively in the Norwegian Sea and the Barents Sea and negatively in the North Sea. The latter indicates that the present sorry state of the North Sea cod may not be due simply and solely to overfishing; climate change may also play a role.

The time series of catches in this paper may be too short to detect displacements of stocks or changes in productivity. The series start in 1945 or later and thus do not include the warm period in the 1920s and 1930s. From other sources we know that the changes in ocean climate that have occurred in the not too distant past have in some cases had dramatic effects on abundance and migrations of fish stocks. One such is the disappearance of the California sardine, discussed in the paper by Herrick et al., the last in this issue. Another is the collapse of the Atlanto-Scandian herring stocks [3]. To what extent these events were the result of a climate change or overfishing is difficult to judge; we know that both events occurred and both were potential causes of a collapse, but their simultaneous occurrence may have been necessary for the collapse to take place. There is evidence that the abundance of both of the said stocks has varied considerably over time before the modern age of intensive exploitation, so the influence of climate change should not be ignored.

Both of these collapses caused tremendous dislocation in the industries affected. The California sardine was in its heyday one of the world's largest exploited pelagic fish stocks and the basis of a large reduction and canning industry, made famous by Steinbeck's Cannery Row. After the sardine disappeared, fishermen and fish workers had to seek other employment. Equipment for which there was no longer any use in California was shipped to South Africa and Peru, whose emerging fish meal industries replaced the Californian industry [4]. The buildings could not be moved, but some previous canneries now house the aquarium in Monterey.

Likewise, the collapse of the Atlanto-Scandian herring caused major dislocations in the fishing industries of Iceland and Norway.[3] This was particularly problematic in Iceland, which at that time was extremely dependent on its fishing industry, not least the herring industry. In Norway unemployment increased and tax revenues fell in herring-dependent communities. Yet these problems turned out to be transient. People found other employment opportunities, and new fish resources, especially capelin, replacing the herring as a source of fish for the meal industry, were discovered.

The cases of the California sardine and the Atlanto-Scandian herring should indicate how the problems arising from climate change could be dealt with. As stated, they did not last long. Is this a reason for complacency with regard to the economic effects of climate change on fisheries? Perhaps it is, and perhaps not. On the positive side is the fact that societies, at least the ones that were affected by the said changes, are much richer now than they were in the middle of the last century and hence should be better able to cope with any exogenous shocks, such as the disappearance of fish stocks. They are also less dependent on fish resources for their material welfare. On the other hand, economic development usually means greater specialization; there is less need for raw muscle strength, which has been replaced by machines, and more need for the special skills involved in operating these machines and everything behind them. Such skills are much less transportable between different sectors of the economy than the raw muscle strength of fishermen and fish workers. To some extent this may be compensated for by the fact that the fishery itself is nowadays often conducted with sophisticated computer-controlled equipment, which it takes technical training to operate. Nevertheless, the increased specialization overall is likely to mean that displaced fishermen and fish workers would have a harder time than 50 years ago to find new employment. It would not necessarily be of help that the societies around them have become richer; they need not have grown more compassionate at the same time, and handouts of money are not necessarily a perfect substitute for a job and all that goes with it.

Another reason why adjusting to climate change might be more difficult now than it was in the past is that the fisheries in many parts of the world have become more regulated. While the need for regulation is not in doubt it often comes at the cost of flexibility, making it more

[3]The Icelandic experience is briefly discussed in [1], Chapter 13.3.5. On the Norwegian experience, see [5].

difficult to enter another fishery if one collapses. The rigidity imposed by regulation is one of the points stressed in the paper by McGoodwin, the fourth in this issue. He has studied fishermen's adjustment to climate variability in three fish-dependent communities, two relying on modern technology and exporting their produce, located in Iceland and Alaska, respectively, and a traditional community in Alaska. He finds that the traditional community where the fish is consumed locally and used for supporting the traditional lifestyle shows a greater resilience and adaptability, but that this comes at the cost of a much lower standard of living.

What other problems are likely to emerge as a result of climate change? Since the late 1970s, much of the ocean has been divided into exclusive economic zones where fishing is at the discretion of the state that controls the zone. Many fish stocks migrate between the zones of two or more countries, or into the high seas where no single state has jurisdiction. The management of such shared stocks, such as there is, necessarily involves cooperation between the states in whose jurisdiction the fish are found. The sharing formulas for such stocks are related to the migrations of the stocks; a country which has only a small part of a stock, or in whose jurisdiction the stock spends little time, is likely to also have a small share of the total catch, although there is not any mechanical linkage between "zonal attachment" and the share of the total agreed catch that will be acceptable to any given country [6]. Changing migrations of fish stocks are likely to put existing agreements under stress and perhaps to lead to their total breakdown. The Norwegian spring spawning herring is a good hypothetical example [3]. Much of the catches from this stock used to be taken north of Iceland where it migrated to feed in the summer. An international agreement on this stock in the 1950s and 1960s would most likely have given a sizable share of the total catch to Iceland; it was known in many markets as "Iceland herring", because that was where it was caught in the optimal stage for being salted and pickled. After the sudden cooling of the waters north of Iceland in the 1960s and the collapse of the stock it has mostly been found in Norwegian waters, making only limited feeding forays to the west and north. The Norwegians have consequently claimed the lion's share of the total permitted catch, and their realization that they might have been unduly good neighbors led to a breakdown in 2003 of an agreement from 1999 on sharing this stock. A substantial warming of the Northeast Atlantic might lead to a breakdown of the Norwegian–Russian half and half sharing formula for the Northeast Arctic cod, or force the Norwegians to agree to a less advantageous sharing of the herring than the one they recently reneged on.

The California sardine also offers an example of how climate changes might undermine international agreements on fish sharing. During its low phase, the California sardine contracted south and was almost exclusively found in Mexican waters (Herrick et al., this issue). In its more abundant state it migrates further north, even as far as into Canadian waters. If a sharing agreement on the sardine had existed in the 1950s it would surely have broken down; there would have been little incentive for Mexico to share a fish exclusive to its home waters with the Americans. One could envisage a scenario of climate change where a stock gradually moves out of the waters of one country and into the waters of another, but with an intermediate phase where it is located in the waters of both, and perhaps in varying proportions, because climate change is likely to occur as a trend with variations. Would both countries share the stock in a sensible manner in this intermittent phase? What incentive would Country A have to conserve a stock that it knew would end up as an exclusive asset of Country B? Would Country A, in its best interest, deplete the stock beyond recovery, or would Country B realize what was happening and bribe Country A to let its fish go? This is a complicated story with much uncertainty and guessing and one that is not guaranteed a happy ending (a technical paper on this will appear in the special issue of *Natural Resource Modeling*).

We do have one good example of an international sharing treaty on fish that has broken down as a result of changes in fish migrations due to climate change, the sharing between Canada and the United States of salmon returning to their home rivers on the Pacific side of the North American continent [7]. In the late 1970s there occurred what usually is referred to as a regime shift in the Northeast Pacific. The returning salmon began to take a more northerly route, and much of the fish heading for rivers in Canada could be intercepted by Alaska. Similarly, the salmon heading for the Fraser River in Canada began to take a northerly, all-Canadian route, instead of passing in part through US waters. This led to a breakdown of the US–Canadian agreement on sharing the salmon, which was based on a different migratory behavior of the fish.

The effects of changed fish migrations and distribution caused by climate variability and climate change are likely to be most difficult to deal with for highly migratory species, such as tuna. The challenge is to devise institutions and treaties with built-in mechanisms to handle such changes, a mechanism which the earlier US–Canadian salmon treaty did not have. The paper by Kathleen Miller, the fifth in this issue, deals with the management of tropical tuna and how the regional organizations managing these stocks could cope with climate variability. She suggests making the allocation of catches among nations independent of climate variability, but allowing flexibility to respond to changing stock distributions by trading fish catch quotas or fishing effort quotas. While this could work well for recurrent, if irregular, changes, it is less clear how it would cope with secular displacements where stocks might disappear entirely from some areas.

The resilience of fish sharing treaties, and whether or not they can be revised in a timely fashion, will depend on whether the effects of climate change occur gradually or suddenly, and, especially in the latter case, whether they can be predicted or not. More generally, these will also be critical issues for designing policies to cope with the effects of global warming, be they in the fishing industry or elsewhere. If these effects occur gradually, it may be argued that little is needed by way of policy; adjustment will occur automatically and by small steps that cause little disruption. The collapses of the California sardine and the Atlanto-Scandian herring occurred suddenly and were not predicted, although concerns had been raised about overfishing, especially for the sardine, that might result in a collapse. If events like these can be predicted, the response can be more timely and better prepared and the dislocation will be less. The paper by Samuel Herrick et al., the sixth and last in this issue, discusses methods of predicting changes in the Pacific climate regime that would affect the sardine stock. How well this methodology would work and whether it (or something similar) could be applied in other settings is still unknown, but it would seem to be a fruitful area of inquiry.

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