Natural Resources and Institutional Performance - Linking Social and Ecological Systems in Fisheries

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One of the most important concepts in understanding sustainable use of renewable natural resources, such as fish resources, is that of *resilience*. Resilience is the ability of a resource system to survive disturbances, and its capacity to undergo stress and yet to recover (Folke and Berkes, 1998:21). Resilience can also be seen as a measure of robustness and buffering capacity in the face of changing conditions. Conventional resource management policy emphasises stability through equilibrium, low variability, resistance to and absorption of change, whereas a management policy influenced by resilience emphasises "events far from the balanced position, high variability, and adaptation to change" (Holling, 1986:294).

Conventional resource-management can be successful in the short run, but this success can cause inadvertent changes in the functioning and resilience of the ecological system. This is because the management strategy aims to remove disturbances and reduce variability in the ecosystem.[1] From this perspective, resources become "manageable" and yield predictable. Management of fish resources is often built upon the assumption that fish is a "linear resource", in which a fixed sustainable yield is predictable, rather than a fluctuating, or chaotic natural resource (Wilson et al., 1991, 1994, in Ostrom 1998b:12). Thus, conventional resource-management presumes that a maximum sustained yield of fish resources can be calculated and that disturbances can be controlled and excluded from the resource system (Berkes and Folke, 1998:12). Consequently, conventional resource-managers seem to share a belief in the feasibility of designing close-to-optimal rules by which to govern and manage common-pool resources (CPR) for a large domain, utilising top-down regulations. However, if resilience (i.e. buffering capacity) of a resource system declines, flexibility is lost, and both the social and ecological systems become more vulnerable to surprises and crisis. If the management system applies fixed rules for achieving constant yields (e.g. fixed sustainable yield of fish), independent of scale, this leads to an increasing lack of resilience. This system can suddenly break down when it is confronted by disturbances that previously could be absorbed (Holling et al., 1993:2). According to Holling, environmental problems can become aggravated by conventional resource management, thus

[1] Ecosystems can be seen as "moving targets, with multiple futures that are uncertain and unpredictable" (Walters 1986, in Holling et al., 1993:3).

resulting in reduced resilience. A static and inelastic system cannot change when it becomes necessary. The very success of conventional resource management may "freeze" the ecosystem "at a certain stage of dynamic change, making it more fragile and inviting unpredictable feedbacks from the environment" (Holling 1986, in Berkes and Folke, 1998:100).

If an institutional arrangement is too inflexible to cope with changing ecological conditions, it is unlikely to prosper. It is, therefore, important that the depletion of a particular resource serves as a signal for change in management responses, but the critical aspect is the ability of management institutions to detect and respond to those signals. Consequently, given the variable and fluctuating nature of fish resources, proper functioning is sustained when the management system is "allowed" to develop and renew itself, and ecological resilience is combined with institutional resilience. This is the working hypothesis in this paper.

The fishing of vendace (*Coregonus albula*), in the northern part of the Gulf of Bothnia, is a good illustration of this type of problem. Vendace (*siklöja* in Swedish) is a local species of whitefish and belongs to the salmon family. The roe from the fish, known as *bleak-roe*, is of high commercial value. Fresh-water species like vendace are caught in salt-water fishing in this area (the Swedish County of Norrbotten) because the water is highly desalinated, owing to the inflow of fresh-water from the major rivers (Olsson, 1997:11). As we will see later, the vendace fishing now has problems, catches have decreased dramatically, and there is considerable fear that the resource is about to be depleted. How has this happened?

The aim of this paper

This paper aim at analysing the present management policy of the Swedish bleak-roe fishing, how the present institutional arrangement affects collective action and why political solutions seem to have failed? The answer to these questions can be assumed to be relevant to many other resources with similar characteristics, such as groundwater basins, grazing areas, irrigation canals and forests. A further aim is to test the analytical power of explicitly combining CPR theory with resilience theory. Consequently, this study focuses on the management of a complex common-pool resource system and whether a multi-stakeholder system is compatible with flexible and adaptive management practices that contribute to resilience and sustainability.

The research problem

For the commercial fishers in northern Sweden, catches of vendace are of primary importance, both in terms of landed weight and economic yield. It is also one of the most important species by catch and value, of Swedish commercial fisheries in general (Olsson, 1997:13). It is a seasonal fishery and the fishing is restricted to the period between 20th September and 31st October. Bleak-roe fishing is characterised by its multi-stakeholder quality. There are a number of different authorities involved in managing and regulating the fishery, and there are also many recreational fishers who use the resource during the fishing season. Recreational bleak-roe fishing does not have much in common with the traditional picture of an angler fishing for leisure and recreation. It is more like intensive household or part-time fishing.

At the beginning of the century, catches of vendace were between 50 and 100 tons per year. With the introduction of nylon nets and bottom trawling in the 1950s and 1960s, a large increase in catch-effectiveness occurred. Especially in the 1960s, catches increased considerably as the number of trawling groups expanded, and from the mid-1970s to the mid-1980s the catches increased to approximately 1,500 tons per year, but then in 1991 the catches started to decrease (Karås et al., 1994:2). For example, catches during 1996 and 1997 were 655 and 615 tons respectively, and the figure for 1998 was even worse: according to the catch statistics from the National Board of Fisheries, the landings were only 390 tons. Consequently, many commercial fishers are worried that pressure on the resource has been too hard – that is, fishing has gone beyond the critical maximum and out of bounds. Governmental authorities are also worried that fishing has exceeded a sustainable level (Lundgren 1999-07-06, Thoresson and Sandström, 1997:3f, *Norrbottens Kuriren* 1997-10-03; 1999-09-30; *Norrländska Socialdemokraten* 1999-09-30; 1999-10-27). It has been estimated that the total stock of vendace has been declining from 12,000 tons in 1973 to around 2,100-2,700 tons in 1992-1996. If catches are at a sustainable level, the stock is constant. But the situation is the opposite; according to the National Board of Fisheries, the stock of vendace is over-exploited, or close to being so.[2] Given the fact that vendace fishing is subjected to extensive regulation, how could this happen?

Many different factors can create incentives for individual fishers to overexploit the resource. For example, demand for bleak-roe creates short-term pressures to over-utilise the resource. However, eventually a point will be reached, at which the cost of fishing

[2] If the stock is under the critical minimum size, the fish stock often becomes non-viable, i.e. reproduction does not take place and "the stock is likely to die out without reproduction" (Turner et al., 1994:206).

exceeds the value of the catch, and when catches decrease, the fishing effort should also decrease. If this is the case, the resilience of the adaptive renewal cycle will be maintained and the risk of resource collapse reduced. Thus, the system should be reorganised as a result of a trial-and-error process of social-ecological adaptation:

> [T]he potential for exploring novelty and innovation and to reorganize depends on the existence of resilience in the social-ecological system. If redundancy, variability and memory is reduced or lost, resilience is reduced or lost and the social-ecological system may not be able to absorb disturbance and create novelty and innovation (Folke and Berkes, 1998:14).

To sum up: the catch statistics and the decline in total stock size indicate that the resource is not utilised in a sustainable way, and, thus, that the management system has been unable to adjust to changes in the ecosystem. How can this be explained?

Elinor Ostrom discusses three similar models that are commonly applied to CPR use (Ostrom 1990): that in Garret Hardin's article *The Tragedy of the Commons* from 1968; different versions of *The Prisoner's Dilemma*; and that in Mancur Olson's *The Logic of Collective Action* (1965). These types of models are useful tools to explain how rational individuals can produce outcomes that are not collectively rational. Fishers will try to take what they can, when they can, before anyone else catches it. A fisher who tries to conserve the stock by leaving fish in the sea has no reason to think that he will gain by his investment. According to these frameworks, someone else will probably catch the fish he has left.

The bleak-roe from the vendace resource is of high commercial value, and the fishers who extract bleak-roe for sale do not want it for themselves (or certainly not very much of it), but rather as a source of cash income. Indeed, there would be little fishing if the people who caught the fish were the only ones who consumed it. A "tragic situation" can, therefore, occur whenever individuals make independent choices, and the maximisation of short-term interest (in this case, cash income) yields outcomes that leave the collective worse off than would feasible alternatives (Ostrom, 1998a:1ff). The effective functioning of a management system for bleak-roe fishing, as well as other renewable natural resources, depends on the existence of appropriate institutions.[3] Without appropriate institutions and, accordingly, without incentives for individual fishers to limit their landings, a situation might occur in which catches, voluntarily reduced by one fisher only result in increased catches by another. Too many fishers take too much from the sea, and even if individual fishers understand the importance of sustainable use of the resource, the short-term rational action for

[3] In this paper, institutions are defined as "rules, enforcement characteristics of rules, and norms of behaviour that structure repeated human action" (North in Pejovich, 1997:87).

the individual fisher is to maximise his catch. The individual fisher gets all the benefit from his over-fishing, but the costs of his behaviour are divided between all the fishers using the resource (e.g. the "1/n problem"). Thus, the temptation to overextract from the resource is compelling and the "rule of capture" prevails. The outcome a single fisher achieves depends not only on his actions, but also on the actions of other fishers using the same grounds. The resource is mismanaged and, ultimately, due to the loss of resilience, the vendace resource might be exhausted.

State regulation and changes in the ecological system

Even before the 13th century, the Swedish State was expanding its power over fishing in Norrbotten, particularly over the salmon fisheries in the big rivers, in order to increase tax revenue. King Gustav Vasa (1496-1560) continued this consolidation of state power, and during his reign (1523-1560) the state expanded its control and taxation of natural resources, partly through its implementation of a national economic policy, but also by using its control of the church to mould public opinion (Söderberg, 1996; Behre et al., 1985). The state consolidated its power over the fish resource in Norrbotten in the 15th century (Lundgren 1987:34). Hence, one could say that the institutional arrangements concerning our topic, characterised by state control (state property) over the fish resource in Norrbotten, started to develop 700 years ago.

Since Sweden joined the EU on 1 January 1995, the Swedish sea fishery has been formally regulated by international agreements within the framework of the EU's Common Fisheries Policy (CFP), and responsibility for resource management has been largely transferred to the EU (Gustavsson, 1997:7). The National Board of Fisheries is the central government agency working with fisheries and fish conservation in Sweden. The Board seeks to promote responsible use of fish resources and, accordingly, for the maintenance of an abundant and diverse fish stock. Research carried out by the Board of Fisheries provides the scientific basis for the preservation and exploitation of fish resources (SOU, 1998:24 p. 106-119). It is not only the EU and the National Board of Fisheries that have responsibilities in the administration and design of Swedish fishing policy. The County Administrative Boards, the Fishing Unit at the Ministry of Agriculture, the National Environmental Protection Board, the National Administration of Shipping and Navigation, the National Food Administration, the National Juridical Boards for Public Lands and Funds, the National Board of Trade, and the Swedish Coast Guard all have additional roles (ibid.).

A substantial part of the coastal fisheries, as well as fishing in lakes and rivers, are not regulated by the CFP. Fishing within 12 nautical miles from the coast is generally regulated by national laws, and bleak-roe fishing in Norrbotten, which is mostly performed within the coastal line falls into this category. However, as a member of the EU, the overall character of the CFP still affects the design of Sweden's fishing policy, even in these areas. For instance, the EU decides the levels of subsidies paid to commercial fishers, which naturally affects the economic prerequisites for commercial fishing in all Swedish waters. Therefore, in sum, the national authorities regulate bleak-roe fishing in Norrbotten under the "CFP umbrella".

As already mentioned, there are both commercial and recreational fishers participating in bleak-roe fishing, and licences for commercial fishers are obligatory. The general supply of fish in the area is considered only the first time that someone applies for a licence, and, if the applicant fulfils its conditions, the commercial licence is valid for a maximum of five years before it has to be renewed. Withdrawal or non-renewal of a licence can occur if the fisher breaks the laws (Ds, 1998:2 p. 22f). It is also necessary for all commercial vessels that are participating in bleak-roe fishing to obtain a permit to trawl. These trawl permits are valid for three years and, in 1995-98, 52 commercial vessels have held them. All trawl permits had to be renewed after the 1998 fishing period, and 47 vessels obtained permits for the next period (Hasselborg 1999-06-22). Thus, the National Board of Fisheries has tried to limit the input into fishing by reducing the number of trawl permits by five units. In 1999, approximately 20 trawl groups participated in the fishery (*Norrländska Socialdemokraten* 1999-09-30).

Recreational fishers are allowed to use six nets with a total length of 180 meters; intensity of use is thus regulated through effort limitation. By contrast, the intensity of commercial fishing is not restricted during the fishing season. Due to the absence of quotas or other output limitations, both recreational and commercial fishers can adapt a maximising strategy. To sum up, a commercial fisher must have a commercial fishing licence and, if he uses his own vessel, a trawl permit for vendace, while a recreational fisher can perform bleak-roe fishing with a maximum of six nets and without a licence.

Financial aid can be granted, for example, for the purchase of new vessels, modernisation of vessels and for scrapping of vessels. Subsidies are also given through unemployment insurance, which, in the case of fishing is, to a large degree, an "off-season" subsidy. Finally, commercial fishers can obtain tax relief to make the economic conditions for fishing more favourable (Ds, 1997:81).

After the decreasing catches during the last few years, many commercial fishers are worried that the pressure on the resource has been too hard and that bleak-roe fishing has been pushed, unsustainable, over the regeneration rate. There is also criticism of the bureaucratic system and its comprehensive regulations. In a local newspaper, a commercial fisher described the regulations and bureaucracy as "a confiscation of my natural right to fish" (*Norrbottens Kuriren* 1998-07-16, my translation). Another commercial fisherman questioned the centralised decision-making structure. According to him, the people employed at the National Board of Fisheries in Gothenburg are novices regarding fishing in the Gulf of Bothnia: "[T]hey do not understand how trawl-fishing should be performed without risking the survival of the resource… today's bleak-roe fishing lacks conscience" (*Norrbottens Kuriren* 1999-09-30, my translation). Furthermore, he expressed the opinion that too many of those involved in bleak-roe fishing look only at today's catches, and that this will have catastrophic consequences for the long-term survival of the vendace resource (ibid.). Another commercial fisher expressed similar views recently:

> The fishery must change, otherwise there will not be any bleak-roe fishing in the future… together, all fishermen must find new ways to perform bleak-roe fishing… I have not spoken to one single fisherman who is of the opinion that the fishery should continue in the same way as today. No one is more interested than we are in bleak-roe fishing remaining an option in the future (*Norrländska Socialdemokraten* 1999-09-30, my translation).

It seems that recreational fishers are more willing to withdraw from fishing in times of declining catches. In discussions with three recreational fishers last year (1999), they all said that they had not participated in bleak-roe fishing in 1998, due to the scarcity of the resource – "it wasn't worth the effort". This view was confirmed in interviews with commercial fishers this autumn (1999). They expressed the opinion that recreational fishers only participate when they have the ability to "make money" from the fishery (interviews 1999-08-16 – 1999-08-28). Ought it not to be the opposite, that due to decreasing returns commercial fishermen would withdraw while recreational fishing continues? This possible paradox will be discussed later.

It is not only the commercial fishers who are worried about the long-term survival of the vendace resource. Officials from the National Board of Fisheries are also concerned and, consequently, the Board is considering restrictions on the fishery. So far, there is only preliminary information and no official statistics for 1999. But, according to some of the fishers, bleak-roe fishing has been even worse than in the disastrous fishery of 1998. The preliminary taxation of the total stock of vendace is down to 1,000 tons, compared to 12,000

tons in 1973 (*Norrländska Socialdemokraten* 1999-10-27; Thoresson and Sandström 1997:4). As a response to the bad performance of the fishery, officials at the Board's office in Luleå consider three different strategies to prevent further over-fishing:

1. Stop all trawl fishing during a limited time period.
2. Reserve important areas for non-mature vendace.
3. Construct a self-restraint programme together with the fishers.

Considering the economic importance of bleak-roe, a total suspension of fishing is not a realistic alternative, according to the Board's representative in Luleå. He prefers an agreement with the trawl-fishers on self-restraint, i.e., the third alternative (*Norrländska Socialdemokraten* 1999-09-30). In order to reduce the number of undersized and non-mature vendace being ensnared in the trawls, the Board has decided that nets must have a bigger mesh on the trawls for bleak-roe fishing in 2000.[4] According to the Boards' office in Luleå, this regulation will not be enough, "but it is a good start" (*Norrländska Socialdemokraten* 1999-10-06, my translation).

Obviously, bleak-roe fishing is not working well. Without a well-functioning fishery, the prospects for commercial fishers in Norrbotten look bad, given the economic importance of bleak-roe. Why does the management system, combined with the ecological system, perform so badly?

Both the commercial and recreational bleak-roe fishers in Norrbotten have an opportunity to "run for the catch" when fishing is allowed. The high demand and value of bleak-roe (probably) creates strong incentives for catch-maximising behaviour. The state has continued the historical pattern of increasingly centralised control over the vendace resource. The method used in regulating bleak-roe fishing is effort control, in which the central authorities regulate in detail how, when and at what intensity fishing is undertaken. Furthermore, the central authorities also take some responsibility for the commercial fishers' economic survival, through various subsidies. This explains why fishers stay in business even when catches are regarded as too low. Together with the technological development, all this has caused a situation in which too many actors are acting in the arena. At the same time, the regulations are designed in such a way that it encourages catch-maximising behaviour among the fishers during the bleak-roe season. A mentality may have evolved, whereby an individual fisher just tries to maximise his catch, because the state is seen as a guarantee that the vendace resource will be used sustainably. It is a system in which the users do not need to take any

[4] Commercial fishers can make some profit from non-mature vendace by selling it to mink farmers in Finland. However, non-mature vendace is much less valuable than bleak-roe.

responsibility for the design of a sustainable fishing policy. Consequently, an individual catch-maximising strategy is superior to a collective sustaining strategy, and all the prerequisites of a "tragic" situation are present.

The probability is high that the vendace resource is doomed to the "Hardin tragedy" if the institutional arrangement for bleak-roe fishing is not changed. As we have seen, it is not enough to implement government control over fish resources; given the multi-stakeholder qualities of bleak-roe fishing, this has not solved the problem of overexploitation. If effective managerial institutions are to be implemented at reasonable costs, the individual fisher must be convinced that these rules are functioning well so that today's sacrifice will result in benefits in the future. How can this be done? How to persuade people to put their collective interests above their short-term individual interests?

Successful management needs appropriate institutions

Ostrom has concluded that observers of institutions tend to make two errors. The first is the assumption that rules-in-use are the same as formal laws or procedures. The second is the assumption that no institutions exist except for those formally created through government action. "Both errors reflect a lack of understanding of how to create, maintain, and use social capital" (Ostrom, 1992:22).

The migratory nature of fish stocks and the huge area to be monitored in coastal and ocean fisheries make it very important that the institutional arrangement has legitimacy among users. Monitoring has proved to be hard, and conflicts of interests can always arise, for instance, over the right to use a fishing ground. The ability to solve conflicts depends on the shape of the institutional arrangement, the framework within which fishers can try to work collectively to achieve a desired goal. An institutional arrangement is usually created as a response to a situation in which joint outcomes are preferable to outcomes that could be achieved independently by the actors - in our case, a sustainable use of vendace.

In fisheries management, the regulatory aspect of institutions is generally the one emphasised. But institutions do not only create restraints. They confer rights as well as responsibilities, for example, by providing fishing licenses. Institutions also define what is appropriate for a particular person to do, what is required of the fishers, what is morally acceptable and justified, and so on. Consequently, institutions include different patterns of interaction between individuals, in, for example, the way that business, administration and the legal system are managed, but also relating to religion, traditions, ideologies and norms of behaviour in society (Lundgren, 1987:12f). Unlike orthodox neo-classical theory, this view of

institutions emphasises the importance of these informal and formal patterns as determinants of human action.

> The depletion of fishery resources relates to the weakness of social structures (values as well as institutions and technical practices) under market and technical innovation incentives […] (Bailly and Collet, 1999:3).

The bureaucratic aspect is, accordingly, not the only relevant aspect of institutions. As North puts it, "[w]e are interested not in the institutions per se, but in their consequences for the choices individuals actually make" (North, in Pejovich, 1997:87). History, socio-economic factors and socio-cultural factors determine institutional performance, and the same formal institutions may operate differently in different contexts (Putnam, 1993:8). Therefore, understanding formal institutions is not sufficient for determining outcomes from a management regime. "History matters. It matters not just because we can learn from the past, but because the present and the future are connected to the past by the continuity of a society's institutions" (North, 1990:vii). This form of institution - norms and culture - changes more slowly than formal rules, and this makes a transition from one management regime to another sometimes more problematic than it first appears.

> Informal norms and culture change more slowly than formal rules, and tend to remold those formal rules so that the external imposition of a common set of formal rules will lead to widely divergent outcomes (Putnam, 1993:180).

To create appropriate formal institutions that enjoy legitimacy among the collective of bleak-roe fishers, the rules must be sensitive to the social context and the specific local circumstances in which they operate. At present, the situation seems to be the opposite, with a centralised bureaucratic system of general rules and regulations governing not only bleak-roe fishing in Norrbotten, but also Swedish fisheries in general.

Lack of managerial resilience

Conventional management of fish resources has tried to emphasise stability through top-down regulation of CPRs in a large domain. This has not been successful. Throughout the world, conventional management of fish resources has created systems that are static and inelastic, and in which subsidies are paid to fishers. Together with technological development during the last century, this has caused an overcapitalisation of the fishing fleet, resulting in overfishing of many major stocks. Fishery management, in general, seems to react to crises, rather than preventing biological decline. Thus, it has failed to create sustainable fishery policies.

This also applies to bleak-roe fishing in Norrbotten. It has all the features of a CPR "dilemma". The institutional arrangement does not correspond to the notion of resilience in the management system, which seems to be unable to change even when ecological circumstances obviously call for this. The ecological resource is currently on a "downward loop", while the management system is still acting as if there were plenty of fish to be caught. The National Board of Fisheries' answer to the alarming decrease in catches has been a withdrawal of five trawl permits, reducing the total from 52 to 47, and a new regulation that aims to prevent non-mature vendace being caught in the trawls. But, not even the Board's representative believes that these actions will be enough to prevent further overfishing. It can, of course, also be politically difficult to withdraw licences and create unemployment among fishers, and several existing subsidies are designed to keep fishers in business. Due to technological development, too many fishers are now appropriating from the fishery, and the present policy is counter-productive from the perspective of resource conservation, as it subsidises depletion of stocks. Indeed, the management system seems to aggravate the problems of overexploitation instead of solving them. Without changing the system, it can be concluded that there is an obvious risk that bleak-roe fishing is doomed to the "Hardin tragedy".

Even without a properly designed management system it should be in the individual fishers' interest to produce a sustainable fishery. This paper has clearly demonstrated that rules-in-use are not always the same as formal laws or procedures, but also that while appropriators can produce their "own" sustainable management practices, this has not yet occurred in the bleak-roe fishery. Obviously, the institutional arrangement does not correspond to Ostrom's eight design principles for long-enduring CPRs.[5] Fishers are waiting for action from the authorities instead of putting their collective interests above their short-term individual interests. The management system is not only centralised and inflexible, it

[5] According to Elinor Ostrom (1990, 1992, 1993), the types of institutional variables that affect users' incentives to manage CPRs successfully are as follows. (1) *Clearly defined boundaries*. The boundaries of the resource system and of those individuals with the right to use the resource should be clearly defined. (2) *Proportional equivalence between benefits and costs*. Appropriation rules are related to "local conditions and to provision rules requiring labour, material and/or money" (Ostrom, 1990:92). (3) *Collective-choice arrangements*. "Most individuals affected by operational rules can participate in modifying operational rules" (Ostrom, 1993:2). (4) *Monitoring*. Monitors "are accountable to the appropriators and/or are the appropriators themselves" (ibid.). (5) *Graduated sanctions*. "Appropriators who violate operational rules are likely to receive graduated sanctions…" (ibid.). (6) *Conflict resolution mechanisms*. "Appropriators and their officials have rapid access to low-cost, local arenas to resolve conflicts among appropriators or between appropriators and officials" (ibid.). (7) *Minimal recognition of rights to organise*. "The rights of appropriators to devise their own institutions are not challenged by external governmental authorities" (ibid.). (8) *Nested enterprises*. "Appropriation, provision, monitoring, enforcement, conflict resolution, and governance activities are organized in multiple layers of nested enterprises (ibid.).

also generates incentives to use the resource in a catch-maximising way. How can this be explained?

Bleak-roe fishers do not constitute a homogeneous group. Different groups have different intentions, preferences and strategies in their fishing. According to the first design principle, the individual's right to use a resource should be clearly defined, and the absence of such a definition in recreational fishing is a serious problem. Anyone can participate as a recreational fisher. Without clearly defined boundaries, the free-rider problem will always be present, and since bleak-roe is a valuable product, this creates catch-maximising incentives for recreational fishers. If recreational users can enter and withdraw from the arena whenever they like, the likelihood that commercial fishers will develop some form of sustainable management practices is probably very low. Why should they? If the commercial fishers were limiting their catches and the fishery started to recover, it would be worthwhile for recreational fishers to enter the arena again.

The governing authorities take full responsibility for how fishing should be performed and for the survival of the vendace resource. The regulations encourage catch-maximising behaviour among both commercial and recreational fishers when bleak-roe fishing is in season. An individual fisher's only objective is to maximise his catch. It is, thus, an arena in which individual catch-maximising behaviour is superior to a collective strategy for sustainability.

In addition, bleak-roe fishing accounts for more than half of the annual turnover for commercial fishing. Individual fishers' incentive to limit their catches is, therefore, probably very low when short-term individual strategies are in command. In a market economy, decreasing supply creates higher prices, which only increases the resources attractiveness to its harvesters, which puts further pressure on the resource. Recreational fishers have more scope to vary the intensity of use. If a recreational fisher is not rewarded for his effort, he can always retreat from fishing for some years until the catches increase. This causes a paradox: the people who are most dependent on bleak-roe fishing also have the biggest incentive to behave in a way that destroys the resource. Subsidies worsen the situation. Without these, fishers would probably go out of business when catches decrease. With diminishing returns, fishers would have no incentive to increase their effort, and the fishery might stabilise and start to recover. With subsidies and the maintenance of over-capacity, the fishery could easily collapse.

Is there any flexible, adaptive and sustainable management alternative to the present system?

A successful and sustainable management system for a common-pool resource like vendace relies on many different factors, including the combination of property rights, the physical attributes of the resource, and socio-economic and socio-cultural factors. A lot depends on the institutional arrangement. If bleak-roe fishing were designed after Ostrom's eight design principles (Ostrom 1990), it would generate incentives for fishers to sustain the vendace resource. With recourse to a short implementation structure, bottom-up processes for the construction of rules, and fishers' own monitoring of the resource system, the incentive to follow rules would probably be higher. If incentives to follow rules were high, it would also be easier to adjust them when disturbances in the ecosystem occurred; resilience in the management system would, thus, increase. Obviously, these design principles correspond very well with resilience theory. Experience from long-enduring CPRs and the theory of resilience in management systems both emphasise the importance of local knowledge and the participation of local users in management of renewable natural resources. A local fisherman with experience and knowledge of vendace could probably observe signals from the resource system at an earlier stage than could government authorities, which must wait for catch statistics to be compiled. Similarly, if fishers were involved in the design of rules for the management of vendace, they would probably take more responsibility for the resource and respond more willingly to signals from the system. To achieve an adaptive and flexible management system; responsible users, who immediately react to changes in the ecosystem – and who, thus, act according to collective rationality – are necessary.

It seems clear that a small and well-defined CPR system, without free-rider problems, is better able to receive and respond to signals from the ecosystem. If appropriation rules are related to local conditions, the management system will probably be more sensitive to changes in this specific ecosystem than would general rules for the whole fishery sector. With a short implementation structure, the scope to adjust operational rules to new conditions would probably also increase, and local fishers could reorganise the management system more quickly than under the prevailing institutional arrangement, which aims to make fishery regulations as general as possible. If the fishers themselves performed monitoring and imposition of sanctions, it would be easier to detect and fine "cheaters", and if such incentives to follow rules were high, the system would be more flexible and adaptive when changes in the ecosystem occurred.

However, one basic question remains: how to incorporate these positive experiences from long-enduring CPR systems into bleak-roe fishing in Norrbotten? Originally developed for irrigation systems, it is important to bear in mind that these design principles may not be sufficient to solve the bleak-roe problem. To function effectively in a large and complex society and given the migratory and fluctuating nature of fish resources, the bleak-roe system would also need support from its surroundings. With Stiglitz I agree that "[the] social and organizational capital needed for the transition cannot be legislated, decreed, or in some other way imposed from above. People need to take an active and constructive role in their self-transformation; to a large extent, they need to be in the driver's seat" (Stiglitz, 1999:9).

Co-management as a solution to the "bleak-roe dilemma"

All the evidence suggest that the state authorities cannot successfully continue to manage the vendace resource without the participation of the fishers. Maintaining the government's responsibility for the ecological survival of the resource could be important, because the state has developed its institutional structure over a long period. A possible way to implement this co-operation might be through co-management. In a co-management system, some units are general-purpose governments, while others may be highly specialised (Ostrom, 1998b:26). Consequently, in today's world, and as described in Ostrom's last three design principles, the support and co-operation of the authorities is required.

> Co-management helps reduce the management problems of overinvestment, overfishing, inequitable allocation, and inadequate data collection; as well, it allows local groups to take advantage of specific local management opportunities and address specific local concerns. Co-management reduces conflict between government and fishermen and among fishermen's groups by involving fishermen in enforcement and the development of overall policies which benefits them as well as the resource (Pinkerton, 1989:30).

If both commercial and recreational fishers are to be involved in future bleak-roe fishing, they should also be involved in the decision-making process and have the authority to construct and implement regulations. These regulations should, therefore, be implemented with bottom-up instead of top-down processes, because there is a higher probability of finding appropriate rules, which enjoy legitimacy among the users, if the fishers are involved in decision-making (Ostrom, 1998b:3).

Co-management could reduce conflicts and potential conflicts between government and fishers, and among fishing groups, by involving fishers in the development and enforcement of overall policies. Governance of a renewable natural resource like vendace is an adaptive process, involving multiple actors at diverse levels, and co-management could

be an institutional response to the problem of how to persuade people to put their collective interests above their private interests. The long-term ecological survival of the vendace resource is dependent on a change in the individual behaviour of bleak-roe fishers; they need to redirect their individual catch-maximising strategies towards a long-term collective rationality. If responsibility is divided between the state and the users, the likelihood is high, in comparison with a top-down and centralised management system, that fishers would start to develop a collective rationality. If local bleak-roe fishers were more influential in administering the resource, their responsibility for its survival in the long run would probably increase. Without this division of power, fishers (recreational and commercial) have no incentives to change their strategy. Co-management would also increase the legitimacy of the regulations by involving fishers in enforcement and the development of overall policies, which would benefit them as well as the resource (Pinkerton, 1989:30; Ostrom, 1990:88,ff).

To sum up, it is no longer enough for fishers simply to know how to operate a boat and catch fish. The fishers need to be actively involved in managing and conserving the resource. Thus, co-management can be a successful alternative to centralised and bureaucratic government regulations. From this paper it can also be concluded that resilience theory and experiences from long-enduring CPRs correspond very well with each other. Well-defined local management systems have the qualities of being sufficiently flexible and adaptive to adjust to changes in the ecological system. Ecological resilience appears to be deeply dependent on the management system, and, thus, the wider social system. These long-enduring systems have obviously been able to develop sustainable management practices for chaotic resources such as fish.

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