Fisheries Management and the Domestication of Nature

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THE INTRODUCTION OF 200 mile Exclusive Economic Zones (EEZs) towards the end of the 1970s led to a redistribution of global fisheries resources. While the regime of Mare Liberum was beneficial to a small club of industrial nations engaged in high seas fishing, most stocks within the new regime were controlled by a multitude of coastal states at different stages of development. Institutional innovations of such redistributive potential are rare. The new regime was successfully established only because it was connected to a powerful myth concerning the problem of global fisheries and how it could be solved. The conclusive argument was that the reform would improve resource management. Where the anarchy of Mare Liberum had led to a relentless 'arms race' on international fishing grounds that would not end until the last fish had been caught, the EEZ promised to install nation states as responsible fisheries managers. Thus, the inevitable tragedy of the ocean commons would be replaced by order and rationality so easily imposed under the property owner's self-interested guidance (Copes 1981; FAO 1981; FAO 1995).

After nearly twenty years the promise of rational fisheries made on behalf of the new regime has not been fulfilled. The world's fish resources are in a dismal state. As a result of over-exploitation, marine catches are now in decline after the 100 million tons peak production of 1989. The FAO (1995) has concluded that almost 70 percent of total fish stocks are fully to heavily exploited, or overexploited. The anticipated retrenchment in distant water fishing after extended jurisdiction did not occur (FAO 1981, 1995). Indeed, the world's fishing fleet has grown unabated. The result is excessive harvesting capacity, which exerts severe pressure on heavily exploited stocks. Instead of the responsible owner, portrayed by advocates of the new regime, overcapacity has exposed the state as a highly irrational being. On the one hand, the mismatch

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between resources and harvesting capacity is the basic cause of state involvement in fisheries management, necessitating an elaborate and expensive system of regulations. On the other, this overcapacity has to a large extent been created by and is maintained through state subsidies (FAO 1992).

Why has the promise of the new regime not materialized? Two paths of reasoning, leading in opposite directions, can be followed in trying to answer this question. The first starts from the premise that the reform was built on the right idea, but was not implemented with enough energy and foresight. The regime left loopholes through which vulnerable resources could be tapped beyond the reach of the coastal states, as exemplified by the recurring problems of straddling stocks and highly migratory species, and the growing number of vessels operating under 'flags of convenience' (FAO 1995). The coastal states were also reluctant to take on the management role within their jurisdiction. The principle of open access continued after the new regime was established; only foreign fishermen were excluded. Even where stricter resource regulations were imposed, as in Norway, Iceland, Canada and the United States, the measures were incomplete and ineffective (Moore and Sætersdal 1987; Schmidt 1993; Alverson and Larkin 1994). This pattern of non-commitment and impotence suggests that the coastal states' exclusion of foreigners was crucial for the establishment of the new regime, while the more visible altruism of responsible management had largely symbolic significance. Still, according to this reasoning, the road to responsible utilization of the fisheries lies in taking seriously the management idea inherent in the new regime. Several initiatives consonant with this idea can be observed on the international scene. One example was the attempt to fill the loopholes left open during the UN negotiations on high seas fishing. Another was the bid to improve management by codifying guidelines for "responsible fisheries" (FAO 1995). A third was the quest to insulate fisheries management from political pressures through institutionalization of private property rights and individual transferable quotas (Schmidt 1993).

A second path of reasoning is that the problem lies in the notion of management itself. Thus, the basic question is whether fisheries management really is a good idea. For this question to be meaningful, the term fisheries management must be more narrowly defined. In the following it will refer only to the specific form of management institutionalized in the new regime and codified in the Law of the Sea Convention: a science-based management regime embedded in state bureaucracy and compatible with intensive utilization of ocean resources. This management model was committed to a simplistic image of marine ecosystems, and a faith in the human capacity to predict and control them. With the establishment of the new regime, such notions of nature and society were built into the core of the modern fisheries management institution. In this way, the disappointing achievements of modern management can be sought in the mismatch between simplistic management models and the complexities of real life fisheries.

Constructing fisheries resource management

In general, management is a control strategy by which processes or people are handled indirectly through a system of representation. For example, the development of the capitalistic enterprise was based on the invention of double entry book-keeping. This allowed the manager – without leaving his desk – to keep track of the flows of goods and money in and out of the company through their representation as numbers in a system of accounts (Weber 1978; Carruthers and Espland 1991). Taylor's scientific management is another example. When procedures and workers had been properly standardized, the engineers could take control, precisely because the system allowed the most complex of work processes to be simplified and presented symbolically as flowcharts and work diagrams (Taylor 1911; Merkle 1980). Management is thus based on the existence of a symbolic system that corresponds to, but greatly simplifies, some 'real' system, which can thereby be brought under rational control (Emmanuel, Otley and Merchant 1985; Latour 1987).

In the same way, modern fisheries management was premised on the creation of a theoretical model representing the fishery. This was a slow and cumbersome process. It started during the second half of the nineteenth century and was not completed until well after the Second World War (Smith 1994). In short, modern fisheries management was made viable by the acceptance of two interconnected assumptions. The first was the recent idea that human activity is a primary determinant of the state of fish stocks. During the last century, the prevailing view was that human activities would have no effect on marine ecosystems. As T.H. Huxley put it in 1883:

> The cod fishery, the herring fishery, the pilchard fishery, the mackerel fishery, and probably all the great sea fisheries, are inexhaustible: that is to say that nothing we do seriously affects the number of fish. And any attempt to regulate these fisheries seems consequently, from the nature of the case, to be useless (Quoted in Gordon 1954, p. 11).

Although the utility of regulating the fisheries was the subject of heated debate (Burkenroad 1953; Smith 1994), the management idea gradually won acceptance. Two events were of particular importance. One was the regulation of the Pacific halibut fishery during the 1930s where depleted stocks apparently responded positively to fixed catch limits imposed under an agreement between Canada and the United States (Thompson 1950). Another was the perceived effects on the North Sea demersal fishery of the two world wars. The larger catches in the immediate post-war years suggested that lower fishing efforts, in this case imposed by the war conditions, would produce larger yields (Beverton and Holt 1957). Together with the Pacific halibut case, the wartime experience was accepted as evidence that human activities could impact negatively on marine fish stocks, and – equally important – that fish stocks would respond positively to restrictions on fishing efforts (Smith 1994).

The second assumption on which fisheries management rests concerns the possibility of quantifying the human impact on fish stocks. Even if it was positively established that human activities could affect marine ecosystems, this was of little significance as long as the impact was unpredictable and uncertain. The construction of fisheries management required a theoretical model complete with methods of data collection and analysis that would make it possible to calculate an optimal level of fishing effort. Although the scientific theory of fisheries management has had many contributors, the 1957 volume by Beverton and Holt was the crowning achievement (Larkin 1977). By 1950, the community of fishery biologists had accepted the idea that fish stocks could be seen as systems, the state of which was determined by the relationship between reproduction, growth, natural mortality, and fishing mortality. Only partial theories existed as to how these variables interacted, however. One example was Schaefer's surplus production theory (1954), which did not specify the exact relationship between recruitment, growth, and natural mortality on the one hand and the total stock size on the other. Another example was Ricker's spawner and recruit theory (1954), which was based on the unlikely assumption that growth and natural mortality were constant.

From such partial theories, Beverton and Holt (1957) constructed an integrated model where the major determinants were allowed to vary with population density. Although Beverton and Holt by no means solved all problems and, in their actual calculations, reverted to the practice of holding variables constant in order to overcome a lack of data (Smith 1994), their fishery based model fulfilled basic requirements for management purposes. It was complex enough to accommodate the fluctuation of fish stocks, in particular that caused by fishing. At the same time, it was simple enough to allow the scientist to predict the future size and yield of fish stocks for different catch regimes on the basis of readily available data. A key to this achievement was the assumption that fish stocks are reasonably stable and behave predictably under moderate levels of exploitation:

> One essential aspect of this synthesis is the recognition of a fish population or community of populations as a self-maintaining *open system*, exchanging materials with the environment and usually tending towards a steady state (Beverton and Holt 1957, p. 23, italics in original).

Today, Beverton and Holt's model may seem simplistic with its single minded focus on fishing effort, and its implicit rejection of ecological interactions and environmental changes as major determinants of the status of fish stocks. However primitive, their model nevertheless was a symbolic representation of the fish that was more than adequate at this stage in the development of fisheries management. The major obstacle for management at this time was that the model treated the fishermen as an external factor. This would not have been a problem if the fishermen automatically had followed the scientists' advice, reducing their efforts to the level where the yield would be optimal. Such was not the case, however. As Beverton complained in 1952:

> It is . . . clear that factors exist in a fishery without external regulation, particularly the fundamental competitive element in fishing, which make it difficult if not impossible for the industries to regulate themselves to obtain a more favourable balance (Beverton 1952, p. 1 quoted in Smith 1994, p. 323).

In addition to the symbolic representation of the fish, fisheries management required a symbolic representation of the fisherman and a model of how the two would interact. While fishery science developed in response to social and economic problems, fishery biologists have been hesitant to include humans in their models. The completion of the fisheries management model was therefore undertaken with crucial assistance from economists. The result was the classic bio-economic model developed by Gordon (1953, 1954). Figure 1 outlines one

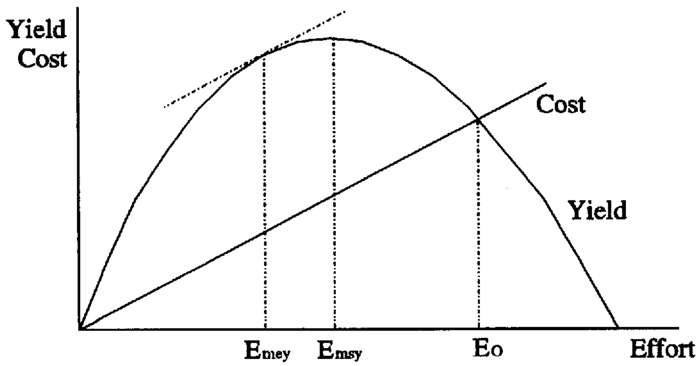

Figure 1: *Gordon Schaefer Model*

version of this model, where Gordon's assumptions of the behavior of fishermen are coupled to Schaefer's (1954;1957) surplus production model.

The model describes how a fish stock will develop under different harvesting intensities, assuming that each effort level gives a stable stock size and a stable output. Starting from zero, increasing fishing effort produces higher output – up to the E_{msy} point. Beyond that, the stock's ability to reproduce starts to decline, and catches go down. Adding assumptions regarding harvesting costs and the behaviour of the fishermen, the model can also predict at which level fishing effort will stabilize. With a linear cost curve, implying fixed unit cost of harvesting, under free access to the fishery and rational profit-seeking fishermen acting independently, effort will increase to E_0. At this point, the economic profits are zero, and there is no reason for established fishermen to increase their effort or for new ones to enter. This, however, represents too much effort from almost any point of view, since it wastes both protein and profits. From a food supply perspective, the harvest should be at E_{msy}, the point maximizing the sustainable yield. From an economic point of view, the harvest should be at E_{mey}, the point maximizing the resource rent. To get to either of these points, the parameters of the model – and the fishery – have to be changed. There are several ways of doing this. The stock can be sold or given away to a single actor, who will, if he is rational, aim for E_{mey}. The curves can be manipulated by imposing resource or effort taxes; or direct effort limitations in the form of quotas, licenses, or gear restrictions can be introduced.

While bio-economic models came with specific recommendations of how the fisheries should be regulated, they were also important in persuading governments that management should be a state responsibility and would bring social gains. According to these models, a fishery left to itself will always be suboptimal. The combination of free access and individual rationality leads to overexploitation and poor fishermen. The structure of the situation thus requires external intervention. This point was later forcefully expressed by Garrett Hardin (1968). To avoid 'the tragedy of the commons,' fish, like all common property resources, must be managed. Left on their own, rational actors are 'locked into a system' that compels them to increase their effort, even when they know that they are on a path that leads toward resource depletion. In practice, the tragedy could be avoided by allocating state power behind explicit management, as prescribed by the model. Resource management thus builds on a partnership between science and the state. Science must establish the facts: how large are the stocks? which effort level will give the optimum return? The state must, besides funding science, regulate the fishermen's activities and prevent them from destroying their economic basis.

In fisheries, however, a major problem for the establishment of a resource management system was the lack of state power. Within Mare Liberum, the state did not control access to international fishing grounds. The anarchy of international relations barred the state from taking on the role as responsible resource manager, and forced it into a role as self-interested guardian of domestic industry. Thus the tragedy of the commons was acted out on two levels: among the fishermen on the fishing grounds, and among the states around the negotiation tables in international fisheries organizations. The structure of this situation is important for understanding the features of modern resource management in the fisheries. Reform was directly premised on a change in the international regime, by which management powers were invested in the state. The new regime, and therefore the emerging resource management model, were intimately tied to the promise of science to provide knowledge and the state to provide power (Dahmani 1987; Sanger 1987). In this way, the institutionalization of resource management forged strong bonds between science and the state. At the same time, it built a particular image of fish and fishermen – of nature and society – into the core of the management institution. While this image was crucial for the creation of modern fisheries management, it is far from obvious that it allows modern fisheries management to accommodate the complexities of real world fisheries.

Are the assumptions of fisheries management reasonable?

Under the Mare Liberum doctrine, modern industrial technology had virtually unlimited access to international fishing grounds. Without reform, this no doubt would have created an overexploitation tragedy in the global ocean commons. It does not, however, mean that the new regime solved all problems. The assumptions on which modern fisheries management was built must be questioned. Are they reasonable? Have they been substantiated? Can they carry the institution of fisheries resource management?

The basic assumption of fisheries management, that fishing constitutes an important determinant of the state of fish stocks, is basically sound. The evidence that this is the case has accumulated during the post-war period. In the Norwegian context, for instance, the depletion of the herring stock in the late 1960s revealed nature's vulnerability in the face of modern fishing technology (Christensen and Hallenstvedt 1984). Twenty years later, the crises in the cod fisheries across the Atlantic reaffirmed this (Garrod and Schumacher 1994). Despite evidence that stocks can be depleted, the notion that regulation will bring a depleted stock back remains in doubt. The paradigmatic case of the Pacific halibut fishery may not have proved the effectiveness of regulation, since the fishing effort was larger during the period of quota regulation when the stock recovered, than during the earlier period when it declined (Burkenroad 1948). Objections have also been raised to the conclusion that larger returns from the North Sea demersal fisheries after the two world wars prove the effectiveness of regulation (Burkenroad 1953, p. 306–7). But even if it did, the general validity of this experience seems to be limited, since North Sea demersal stocks exemplify a fairly stable ecosystem. As argued by Caddy and Gulland (1983), management efforts, in addition to stable stock systems like those of the North Sea, also must allow for the existence of stock systems showing cyclical, irregular and spasmodic patterns of variation. Thus, while the experiences of the post-war period have confirmed that fish stocks are vulnerable to fishing pressures, the conclusion that fishing is the only, or even the primary, determinant of the state of the stocks is under increasing pressure. The 1995 FAO review of the state of the world's fisheries, for instance, observed that:

> The most dramatic marine fisheries population fluctuations appear as decadal-scale 'regime' changes. Moreover, these changes have appeared to be in synchrony in very widely separated regions of the world's oceans. Global climatic 'teleconnections' appear to be the most likely explanation (FAO 1995, p. 2).

This hypothesis, that there may be important connections between climate and fisheries, has been pursued in different contexts. The 1993 ICES symposium in Reykjavik, discussed the extent to which climatic factors can explain the decline of the North Atlantic cod stocks (ICES 1994), while Glanz (1992) considered the potential implications for fisheries of global warming. The conclusions from such investigations are divergent and indefinite, but they cast doubt on the assumption that fishing is the primary determinant of the state of fish stocks.

The assumption that the state of fish stocks under different catch regimes are predictable, has also come under fire. Even if fishing were a primary determinant of the state of the stocks the validity of this assumption is not self-evident. Modern fisheries management was constructed as if the relation between fishing effort and stock size was direct, simple and reversible. Beverton and Holt (1957) proceeded from the idea that fish stocks would tend toward a steady state. When fish were harvested from a stock, compensatory mechanisms would restore the balance, albeit on a lower biomass level. The existence of such relationships is crucial. Without them, the effects of fishing on the state of fish stock cannot be calculated. The evidence in support of the most important self-compensatory mechanism in the model, the stock-recruitment relation, is not overwhelming (Holden 1994, p. 172–3; Wilson et al. 1994). Furthermore, the stock-by-stock approach advocated by Beverton and Holt represents a radical simplification, ignoring most interactions between species within marine ecosystems. In realizing the importance of such interactions, there have been attempts to build multi-species management models. Instead of focusing on the single reproductive unit – the stock – the idea is to model the ecosystem of which the stock forms a part. The problem is that such interactions quickly become extremely complex and difficult to model (Nielsen and Helgason 1993). Under conditions that seem at least as realistic as those on which Beverton and Holt built their model, multi-species systems will display chaotic properties (Wilson et al. 1991; Wilson et al. 1994). Where the simplifications of the single species model undermine predictive capabilities, the realism of multi-species model creates unmanageable complexities. In any case, this suggests that the relationship between fishing effort and stock size is anything but direct, simple and reversible; hence, there are substantial difficulties in calculating the future state of a stock under different levels of fishing effort.

Finally, modern fisheries management rests heavily on the idea that fishermen are rational individualists with low capacity for collective action. Such actors will, under open access conditions, expand their efforts without restraints. Hence, the tragedy of overexploitation can only be avoided by leaving management responsibility in the hands of science and the state. This cluster of assumptions has also been subject to attack. Against the simplistic rational actor model, sociologists and anthropologists have proposed a more complex and realistic image of fishermen as responsible social persons, who often act rationally with regard to their own interests, but are also bound by their membership in a community (Berkes 1985; McCay and Acheson 1987; Berkes et al. 1989; Feeny et al. 1990). Further, the idea that fishery resources are common property, and therefore in free access, has been contradicted (Berkes 1989; Ostrom 1990; Bromley 1992). Instead, the utilization of fishery resources has often been subject to informal, but substantial access restrictions. Many case studies document the fishermen's ability to establish their own successful resource management systems (Acheson 1975; Berkes 1987; Jentoft and Kristoffersen 1989; Pinkerton 1989; Ruddle 1989).

This does not mean that fisheries management in itself is a technically impossible and socially undesirable project that should be given up altogether. Fish stocks are vulnerable to overexploitation and must be explicitly managed. Whether the present state centred, science based regime is up to the task, is more doubtful, since it is committed to drastic simplifications of the complexities of real world fisheries.

Towards new images of nature and society?

Modern fisheries resource management was built with faith in nature's benevolence, and confidence in man's capacity for planning and control. The images of nature and society on which fisheries management relies belong to the postwar era; they reflect the optimism of a time when all growth curves pointed upwards. With the establishment of a new oceans' regime during the 1970s, these images were rebuilt into modern fisheries management. Since then, much of the optimism and faith in progress has dissipated. Phenomena like global warming and depletion of the ozone layer suggest that nature is threatening and chaotic rather than benevolent and controllable. Economic depression and the existence of permanent 'war zones' in many metropolitan areas suggest that fragmentation and decay rather than growth and progress represent the predominant direction of societal change. The light and orderly images of the postwar era have gradually been replaced by darker, post-modern visions of chaos and fragmentation (Dickens and Fontana 1994). Clearly, the foregoing critique of fisheries management provides further evidence for this more general view.

Such ideas threaten the established management regime, but they have so far been systematically rejected. Starting from scratch, it might be easy to devise management institutions appropriate to more complex ecosystems and less omnipotent managers than those assumed by the present regime. Relying on large safety margins in resource exploitation, and low specialization and investment levels, a robust, flexible and low-cost management regime might be constructed on the basis of co-management principles (Jentoft 1989; Pinkerton 1989; Ostrom 1990; Wilson et al. 1994). Within such a regime, local communities and self-management would assume greater importance, while centralized bureaucratic organizations, the scientific community, and large scale industrial enterprises would be relegated to more peripheral positions. The problems with this proposition do not concern its technical effectiveness or economic efficiency. On a world scale, fisheries now run with a deficit of about US$ 50 billion. In 1989, the landed value of the catch in world fisheries covered only 56 per cent of harvesting costs (FAO 1992). Industrialized fisheries account for the bulk of the deficit. A management strategy based on low-tech flexibility and co-management would no doubt be environmentally safer and less costly, and could hardly do worse. But this is not enough to make it politically viable, particularly since it is premised on the exclusion of core institutions and actors from the fisheries. Modern fisheries management was established as the state and science entered the fisheries to discipline industrial capitalism which, left unchecked, threatened to destroy the resource. Until sufficient power can be mobilized behind alternative management regimes, undoing the present package is fraught with dangers.

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