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UNLOCKING THE CONCEPT OF CAPACITY IN MODERN FISHERIES MANAGEMENT

F/T Ramoen and a twelve year old boy, may be the next generation of fishermen?
(photo:D. StandaL, 2005).

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Preface

After writing an array of SINTEF reports on behalf of different clients about various aspects of Norwegian fisheries, I thought it was time to write an article with the purpose of publishing in an internationally refereed journal. The first attempt was not particularly successful. However, after some rounds of serious rewriting, my first article was accepted for publication in the journal Marine Policy, The International Journal of Ocean Affairs (Standal and Aarset, 2002).

I regarded the acceptance of the article as a reward for hard work, but also a reflection of the fact that I was able to communicate current topics in a way that, was interesting for other people to read. The first published article was thus a strong inspiration. I felt that I had broken an important barrier, which provided me the confidence to formulate new articles for publication.

Six years and eight published articles later (financed by the Norwegian Research Council), the idea of collecting the papers into a doctoral degree had matured into action plan. I am thankful to Håvard Røsvik and research director Vegar Johansen for providing me with the opportunity to carry out this work. During the writing, I have received profound and thoughtful commentaries from my former teacher, Professor Bjørn Hersoug at the Norwegian College of Fishery Science, University of Tromsø. Bjørn has been patient, reading several proposals over again and provided me with inspiration to complete this work. Thanks Bjørn! My sincere thanks are also addressed to Assistant Professor Bernt Aarset at the Norwegian University of Life Science for his co-authorship on two articles and for fruitful commentaries to my writings.

In my opinion, writing a doctoral thesis is more or less a lonesome work. However, luckily, I am surrounded by good colleagues who have provided friendly quarrelling and debates in the lunchroom, salmon fishing trips at the river Gaula, and days of grouse hunting with Vegar and Stein Ove. My gratitude also extends to Jessica Marks for excellent language corrections.

Once this process is completed, I plan to take a break from late nights and weekends in front of my computer. Instead, I will spend more time together with Trygve, Ingvild and Synnøve, friends and my hobbies.

Finally yet importantly, my sincere respect goes to my mother Marit; for bearing your status as widow since 1968 with strength, and for persuading me to start high school (if not for this, maybe I would still have been working onboard a factory trawler). My feelings are best summed up by a phrase from a rock music melody: Pain is temporary but glory is forever!

Trondheim, October 10, 2009
Dag Standal

Contents

1 Introduction

In 2002, a new combined cod- and shrimp trawler was introduced into the fisheries industry in Norway. The length of the vessel was 64 metres while the breadth was 16 metres. The main engine had a capacity of 8.064 horsepower and the cargo holds a volume of 1000 $m^{3.}$ The gross registered tonnage (GRT) was estimated at 2.574 tons, thus giving the vessel superb buoyancy for operating heavy fishing gear. The vessel was constructed for the strongest ice class, i.e. for year-round fishing in the High Arctic. Further, it was specifically designed for operating two sets of triple trawl-systems on a continuous basis and is equipped with state-of-the-art electronics for navigation, fish finding and catch operations (Illustert norsk skipsliste, 2003).

The vessel described above replaced a vessel built in 1986– 16 years earlier. This vessel had an overall length of 47 metres and a breadth of 11 metres. The main engine had a capacity of 3.264 horsepower while the cargo held a 450 m^3. The gross registered tonnage was estimated to 999 tons, creating a buoyancy congruent with the total volume of the vessel. The limitations on physical size and the volume of the vessel translated into a restriction for the vessel in terms of ice-class hull and the ability to operate fishing gear, especially as regards stern trawling. Hence, this vessel was designed for operating only a single trawl system when fishing for cod or shrimp in the Barents Sea (Illustrert norsk skipsliste, 1993).

According to experts in the trawling industry (e.g. vessel designers, skippers, trawl mates and vessel owners) the latest generation of trawlers equipped with a double set of triple-trawl systems is nearly three times more effective than trawlers that were built in the mid 1980s for shrimp trawling that have only a single trawl.

This simple description and randomly chosen example of the two latest generations of fishing vessels, illustrates a major development concerning changes in technical capacity. Although the listing above refers only to dull technical parameters, it symbolizes much more than the “nuts and bolts” related to the construction of fishing vessels. The above example also illustrates the difficult task of managing capacity. In a historical perspective, fisheries policy has been a vital part of the overall coastal regional policy. For years, it was a goal to reduce or at least stabilize the number of vessels in the fleet. As demonstrated, keeping the numbers of registered fishing vessels stable would be insufficient. If the goal were to keep the actual catch capacity stable, then the introduction of this new vessel would require the scrapping of three older vessels.

For a variety of reasons, fisheries historians and accounts of social scientists have mainly dealt with the institutional aspects of fisheries development (e.g. Hersoug & Leonardsen 1976, Hallenstvedt 1982, Hersoug 2005, Holm 2001, Johnsen 2002 and Jentoft 1984, 2004). With a few notable exceptions that emphasize the importance of technological innovations as a vital part of the fishing fleets’ strategic adaptations (Løken 1984, Bjarnar *et al*., 2006), focus has been to see technological development as a ‘black box’– something external to the fishing fleets. This viewpoint has in turn resulted in a lack of consideration of the interplay between institutional and technological development with researchers neglecting important, ongoing dynamic processes.

This thesis contributes to the understanding of the interplay between institutional and technological development. Here, I present several articles that focus on the relationship between the regulatory regime and technological adaptations. The overall theme of this thesis can be summarized as: How does technological development adapt to and affect the management of capacity in Norwegian fisheries and what are the major drivers for such adaptations?

As a reference to the Norwegian management model, known as the individual vessel quota system (IVQ), the coherence between technological adaptations (input regulations) and the individual vessel quota (output regulations) are of vital importance. Within the frame of the IVQ model, the two variables are integrated into one regime. Hence, policy that addresses the management of fisheries capacity in a sound manner can be formulated by balancing input- and output regulations.

While the articles presented here deal with specific fleet groups and development trajectories (see section 7 for a brief review of the attached articles), this introduction will focus on five specific research questions that provide a comprehensive background and perspective on technological development in the Norwegian fishing fleet:

1. *What is meant by "capacity" in the international literature on fisheries management?*
In the public debate about surrounding fisheries management, the concept of capacity is high on the political agenda. The notion of capacity however may encompass different meanings, values and norms, depending on the participants' fixed place in the fisheries sector. Capacity is a standard reference in the economic literature, but due to unique conditions in the fishing industry, the concept must be dealt with differently when dealing with this sector. Thus, I first address the key concept of capacity (and overcapacity), and review how the concept has been defined in important works on fisheries management.

2. *How has capacity been used and defined in Norwegian fisheries in modern times (1930-2008)?*
The second section of this introduction will deal with the capacity concept as it has been used and understood in the context of Norwegian fisheries policies, from the 1930's to the present day. Here I review key documents where capacity adaptations have played a central role.

3. *To what extent has the institutionalization of Norwegian fisheries management channeled technological development into specific trajectories?*
In the third section, I briefly demonstrate how various institutional arrangements have channeled technological development in specific directions. The existence of paragraph vessels has been well known for many years, both in the offshore fleet and the coastal fleet, but the regulatory regime has had a much more profound influence on technological development, in terms of design, use of fishing gear, processing on board.

4. *To what extent has technological development changed the management of institutions (put pressure on existing management institutions)?*

In the fourth section, I reverse the perspective the other way around, trying to illustrate how technological development (often based on imported ideas and technology) has influenced institutional arrangements in fisheries. Part of this development is clearly economically motivated, either to drive down the costs of fishing or to utilize new opportunities. At present either of these influences has been strictly regulated (here I site examples such as the expansion into the blue whiting and shrimp-trawling fisheries where there were no quota regulations).

5. *What are the chances of maintaining the existing institutional borders in the Norwegian fisheries (trawl vs. coastal fleet, large vs. small, active vs. passive gear) in light of recent institutional changes and technological development?*
This research question addresses present-day policies; here I will discuss the dynamics of the interplay between technology and institutional development. Is it possible to maintain specific political goals relating to size, gear, geographical distribution, etc., through specific institutions, or will we see development that parallels the aquaculture industry, where most of the previous regulations pertaining to ownership, size and locality have been discarded?

With the introduction of modern fisheries management in the mid 1970’s, the concepts of capacity and capacity adjustment have become key issues in fisheries policy. Capacity must necessarily be adjusted to the resources available (within the EEZs). When subsidies were dramatically reduced in the early 1990’s, the focus turned to overcapacity. Excess capacity became expensive for fishermen when the state was no longer willing to pay for price subsidies and scrapping schemes. At the same time, the fishing authorities concentrated their efforts on a modern fleet that was able to contribute to year-round fishing (providing the industry with a steady supply of fish), and with all the amenities that would secure recruitment, provide safety, capacity to handle offal.

That means continuous technological development to get the best and most efficient vessels. In addition to these contradictory requirements, the fisheries policies also had to cater to specific goals regarding fleet structure (size, geography and employment). No wonder capacity and capacity development became a centre piece in practical fisheries policy. Unfortunately, very few researchers focused on capacity and even fewer bothered to define what was actually meant by capacity and how capacity adjustments could best be achieved.

The introduction of new and more effective technology in a given arena is likely to create substantial management challenges for the public policy makers. New technology that increases efficiency not only solves old problems but also creates new management challenges as well (Rycroft, 2006).

If we apply these ideas to Norwegian fisheries, we see that balancing old and new technology on a continual basis without creating an increase in unprofitable overcapacity has proved hard to manage. Given the severe complexity of the entire sector and the built-in contradictory goals in public policy, the concept of capacity constitutes a complex web of different meanings. In the same manner that the individual vessel quota system (IVQ) can be defined as a meeting place for bundled transactions of quotas and vessels, the concept of capacity can be interpreted as a meeting place between institutions and technology. Moreover, the concept of capacity can be regarded as a passage for balancing individual versus collective action or within the frame of a bargaining economy; among state, organized interests and the market as allocation mechanism. In this context, economists claim that market failure leads to non-optimal use of accessible resources, and regulations must be implemented to remedy the failure (Sandmo, 1992).

However, an institutional argument that rests on organisation theory claims that political systems are based on values and norms, and that such systems will raise political objectives that are not necessarily achievable by the use of the market mechanism alone (Seip, 1981). Hence, we can address the concept as a question about defining the boundaries for the division of responsibility between private actors and public responsibility.

When we define the concept of capacity in such a broad context, it encompasses many variables at different analytical levels. However, given the fact that the Norwegian fishing industry is a closed and thoroughly regulated sector, it may be plausible that governing capacity should be sufficiently framed within the entire management system. Nevertheless, despite powerful management tools (such as the allocation policy and the entire quota regime, the system for licenses and the IVQ model, integrating input-and output regulations within the framework of one model), managing capacity is still not an easy task.

However, the complexity of managing capacity also reminds us about the strong dynamics of fisheries, fish resources shifting independently of markets, ongoing processes of technological development and the sector's need to follow economic welfare in line with the rest of the society.

In 1983, Hersoug (1983) was the editor of a book analyzing different aspects of fisheries management in Norway. The title of the book has the following direct but rhetoric to-the-point formulation: "*Can the fishing industry be governed*?" (my transl.).

I do not have the ambition to answer the question, but inspired by the title, I wonder why it is so difficult to manage catch capacity or avoid overcapacity in regulated fisheries with such a strong and strict regime. May be the explanation is in line with Hatch's (2001) simple definition of an economists' perspectives on technological capacity; "black boxes" that produce an output from a given input. From this perspective, capacity remains locked in as the number of vessels, and we do not get a full sense of how different variables affect the regime.

Therefore, as an attempt to answer my ambitious question, the perception of capacity as black boxes, could be my springboard to try to unlock at least part of- the concept of capacity. Given the fact that technological development and adaptations are a crucial element of balancing input regulations within the framework of the IVQ regime, I focus on how technology affects capacity adaptation in fisheries.

When referring to my own works (the 7 numbered publications annexed to this thesis), I use the following format: (authors (s) year #no.) e.g. (Standal and Aarset 2002 #1).

2 The concept of capacity in fisheries management

2.1 Introduction

The closure of the commons represents a fundamental type of government intervention (Ostrom, 1990). Thus, for the public authorities it was crucial to anchor regulatory measures to normative knowledge, and an objective truth based on scientific methods (Schwach, 2000). From the fishermen's point of view the visible result was the introduction of TACs (Total Allowable Catch) for different stocks, allocation of fish resources and limited quotas. According to the new regime, fishermen would act as economically rational actors. The aim was to establish a mechanism for capacity adjustment, which could maximise the economic profit of allocated quotas.

However, during the 1960s and 1970s the concept of sustainability appeared on the agenda. Nature is expressed as the sum of complex ecosystems and the need to balance each entity (Murawski, 2007). Commercial fish resources are part of complex ecosystems[1]. Rationality expanded to more complex issues than sole economic profit. Both public administration and the fishermen had to base their behaviour on ecologically rational premises (Hersoug, Holm and Maurstad, 1993). Fishing was no longer an isolated relationship between fish and fisherman, but a complex interaction between nature and society. The extended rationality concept made it clear that sustainability was also a question of interaction among actors, and between private interests and the public sphere (Olson, 1971; Holm,1991).

Hence, the concept constitutes somewhat more than the isolated relationship between the individual fisherman and his allocated quota. Instead, the capacity concept is complex, and a carrier of different norms and values among the stakeholders. The concept has many interpretations and definitions, depending upon the type of participant and their interests. Further, it is difficult to measure and complicated to administer (Asche, 2007[2]; Standal 2005 #3).

With reference to modern fisheries management, however, the capacity concept has a fundamental foundation in the meeting of principles between resource and participant, and between different participants (Asche, op.cit.).

2.2 The "Common Property" theory.

In the article entitled "The tragedy of the commons", Hardin (1968) outlines the collective effects of a situation where an unlimited number of agents adapt to the non-restricted use of scarce natural resources. Hardin argues for increased management and control in relation to the harvesting of common natural resources. This argument is founded on the anticipation that individual and collective rationalities work against each other. There is a structural connection between free access and an unlimited demand for limited resources. The current problem can be analogous to the ideas proposed in game theory known as "the prisoner's dilemma". This expression can

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1 See for example Sakshaug *et al*., 1992.

2 For a new survey of the concept of capacity in fisheries, see Marine Resource Economics, Volume 22, No. 1, 2007.

also be conceptualised to external effects (Flåten, 1983), a form of systematic coercion (Hersoug, 1990) and to adversary consequences (Elster, 1979). The relationship between individual and collective rationality has been the source of important theoretical contributions, with the “common property” theory as the most central (e.g. Hoel, 1987; Berkes, 1985). The popularity of this theory is also linked to the fact that it justifies both liberal and conservative political solutions to management problems (Sander, 1991).

The common property theory fronts an inevitable conflict between individual and collective interests; no actors have well-defined or exclusive rights to natural resources. Consequently, destructive over-harvesting in both the economic and ecological sense is due to a given rationality context and to an insufficient institutional framework. The common property theory rests on microeconomic theory whereby the actors concerned act as rational individuals and have complete information on all the alternative routes of action. All actors endeavour to maximise their economic profit. Further, it is a prerequisite that resources are limited and that over-fishing is possible.

The theory’s fundamental institutional assumption is that fish resources are common property (res omnius). The lack of institutional control systems has granted free right of use and access to everyone (Hoel, 1987). Everyone has the right to make use of the sea but no one is responsible for its administration. Consequently, none of the participants see any reason to rationalise voluntarily. The actors lack incentives to limit their own fishing. The reason for this is the lack of collective action and institutional framework, which would limit their fishing efforts. Consequently, the actors cannot expect to reap a future reward because of their own limitations in fishing. On the contrary, the single fisherman will find it rational to increase his fishing efforts. The profit resulting from his increased efforts will benefit the single fisherman, while the costs of over-fishing are shared with all others. Thus, the gains resulting from increased fishing effort will be greater than the costs. As long as the catch profits that are accrued from fishing exceed the costs, increased catch effort will be a rational strategy for the individual (Standal 2006 #4).

Because of the increased capital costs of fishing and the reduction of resources, the system will contribute to increased competition for limited resources. The visible result is that fishing drifts towards a state of over-harvested, depleted resources, with over-investment and unprofitable over-capacity in the catch segment. In a situation like this, it is not possible to extract the potential resource rent from fishing[3].

This imperative or system restraint is known as “The tragedy of the commons” (Hardin 1968). The theory states, “Freedom in a commons brings ruin to all”. Thus, Hardin assumes the main problem is free access to the commons. The proposed solution utilizes increased control to limit access to fish. According to Ostrom (1990), common property theory puts forth two fundamental strategies within the fisheries sector; the establishment of private property rights, or; the establishment of an external sphere of authority with the right to rule over common fish resources. For both of these strategic options, new institutional frameworks are required to change the actors’ basic context of rationality (McCay and Acheson,1987).

[3] Economic rent or resource rent. Financial profit exceeds “normal profit” (Flåten 1983).

Hardin's (1968) article made a fundamental theoretical contribution to the understanding that individual and collective rationality are in conflict; the effects of collective behaviour lead to economic over-exploitation of limited natural resources. Hardin contributes to the fundamental debate on the interaction between human behaviour and natural resources and assumes that the human race is not capable of co-operating (leading to over exploitation), However, he provides no alternative harvesting strategies. Instead, Hardin refers to Adam Smith's (1937) "invisible hand", and argues in favour of letting a free-market mechanism creating a balance in the relationship between harvester and resources.

2.3 The Gordon-Schaefer model

The Beverton and Holts (1957) population-dynamics model for fish resources and the Gordon-Schaefer model (Gordon, 1954; Schaefer, 1957) outline the same paramount consequences as Hardin's (1968) description of the commons. Contrary to Hardin's article, however, the Gordon-Schaefer model deals specifically with fish and fishermen. The model links together the biological and economic effects of a given fishing effort on a limited fish resource. According to Holm (2005) Gordon-Schaefer model illustrates what happens in a meeting between fish and fisherman. The model has been constructed to examine how fish and fisherman adapt to each other.

In the figure below, the semi-circle represents a limited fish stock. It purportedly represents the sustainable yield that a fish stock can produce with an increased fishing effort (Fishing Effort = E). The extremities of the semi-circle show that the profit is practically zero, either because the catch effort is equal to zero, or because the effort is too high and the stock is depleted. Between these two extremities, there is an equilibrium, which gives maximum sustainable profit from a given fishing effort (labelled as Emsy').

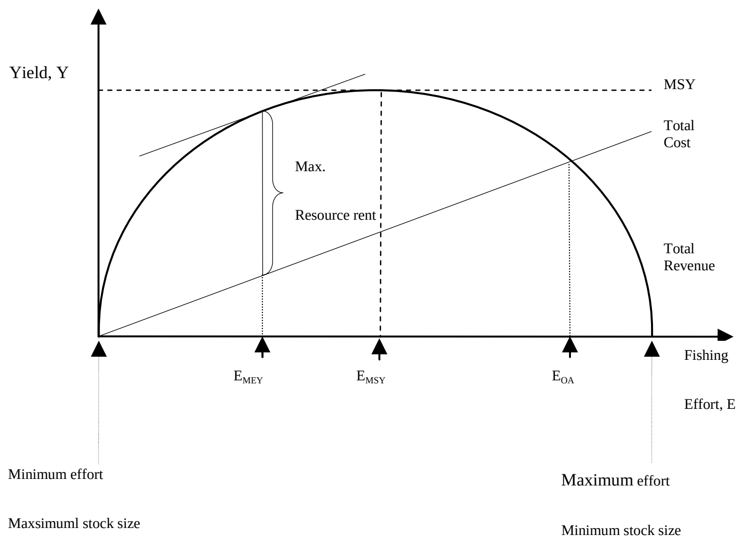

Fig.1. The Gordon-Schaefer Model[4]

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[4] For a more-detailed account of the Gordon-Schaefer Model, see Andersen (1979), Hannesson (1978; 1993) and Holm (2005).

The figure illustrates that fish resources are limited resources and vulnerable to over-harvesting. The fishermen in the figure are represented by the straight line cost curve. The curve indicates that a greater fishing effort costs more than a lower fishing effort. This is because the model presupposes that costs are constant for every unit of effort. Thus, marginal costs are assumed to be constant. This assumption also applies to income (the price of fish).

The difference between the income- and costs curves represents profit. This will increase as long as catch income is greater than costs. Point Eoa on the x-axis indicates the level of effort where catch costs are equal to catch income. Consequently, there will be no profit. At this level of fishing effort, all income is used to cover costs. If the income–and thus the costs–are reduced, the largest profit (resource rent) will be achieved at point 'Emey'. Due to natural variation in the resource base combined with time-consuming structural changes in the catch segment, fishing costs can exceed income from time to time. A period like this can be extended by the fishermen who continue to fish pending improvement in the resource base. Fishermen would not achieve normal profits, unless the government subsidises the fishing. Government-subsidised fishing would in turn create a new artificial balance. Under these conditions, costs would be higher and the growth of profit would be lower than the 'natural-balance level' would indicate. This kind of adaptation is illustrated in Figure 1 by a change in the incline of the cost curve.

The Gordon-Schaefer model tells us how we should manage fish resources; when fisheries are open and not regulated, the model shows that rational actors increase their fishing efforts until income is equal to costs (Eoa). This means that unregulated fisheries lead to unprofitable over-capacity, depleted stocks and no profit. According to the Gordon-Schaefer model, unregulated fisheries represent an inefficient adaptation. To achieve Emsy, fisheries must be closed and collective effort limited. Such an approach requires that the government impose restrictions on the fishing fleet and their access to fishing.

Once the regime is closed and access to fish is limited, income from fishing increases at a greater rate than costs, which again generates a profit. Consequently, the profit from fishing creates a demand and a willingness to pay for fish quotas reflected in the anticipated profit. Hence, we see a certain degree of correspondence between the Gordon-Schaefer model and the reality that the model describes. By closing the commons, fishing has moved away from the point at which income is equal to costs (Eoa) and towards the left on the x-axis. This means that economic rent can be extracted. Thus, a market is created for transactions of vessels and profit is put into circulation (Holm, 2005; Standal and Aarset 2002 #1; Standal 2007 #5; Standal and Aarset 2008b #7) .

However, the common property theory and the Gordon-Schaefer model are objects of criticism. For example, Holm (2005) refers to the Gordon-Schaefer model as a radical simplification of the relationship between fish and fishermen. We also find corresponding criticism in Hardin's (1968) postulate that the "tragedy of the commons" leads to ruin for all. For example, social anthropologists demonstrate that open access to natural resources can function as a social arena for joint responsibility, democracy and participation for joint problem-solving (Berkes *et al*., 1989; Feeny *et al*., 1990).

Nevertheless, the common property theory and the Gordon-Schaefer model both represent a fundamental understanding of today's resource management. Both contributions have provided important input to the establishment of a new institutional framework that has changed the actors' rationality context. The introduction of TACs, the closure of the commons and the IVQ system are the visible expression of state intervention (see e.g. Standal and Aarset 2002 #1). Before we enter into the complexities of managing capacity, we need a working definition of what the term 'capacity' implies. The next section will therefore deal with how the concept of capacity is defined in the fisheries management literature.

2.4 Defining capacity

Capacity in fisheries is a complex term and one that is weakly defined as an element of the sustainability concept (Cunningham and Greboval, 2001). However, the term capacity is defined precisely within single professional sectors such as economics and technology. At the same time, we lack a more general common definition that would be accepted across professional borders (Cunningam and Greboval, op.cit). Large variations in fish resources, which often fluctuate more quickly than changes in the fleet structure, also introduce time as a variable for the capacity term. Cunningham and Greboval (2001) suggest that one should differentiate between capacity in a short-term and long-term perspective. Additionally, variations in fish availability can be considerable and vary independent of stock volume. An important aim is that fishing fleet should be optimally adapted to stock size or quota basis. However, different vessels have different approaches to fishing. For example, there are a considerable number of vessels that hold fishing licences for several types of fisheries. These stocks vary independently of each other and generate a different catch base, capacity adaptations and utilisation of the vessels (Ward *et al*., 2004; Standal 2003 #2; Standal 2006 #4).

The capacity concept may additionally be connected to the design of the quota regime itself. In the Norwegian coastal fleet, which is entitled to vessel quotas for cod, the size of quotas was originally determined by the length of the vessel (St.meld. Nr. 21, 2006-2007). However, this kind of allocation regime does not differentiate between new and old vessels, which have different capital costs or catch capacity. Thus, the formulation of the institutional regime has relevance for capacity adaptation among the actors (Standal and Aarset 2002 #1).

The complexity of managing capacity also includes several important factors that are relevant to catch efficiency but to which it is difficult to assign a value. Such factors include differences in competence among the crews of the fleet, or between electronic instruments for fish finding, and catch operations.

Despite these difficulties, the FAO have identified a common definition of fishing capacity (FAO, 2000b):

> "*The amount of fish (or fishing effort) that can be produced over a period of time (e.g. a year or a fishing season) by a vessel or a fleet if fully utilized and for a given resource condition. Full utilization in this context means normal, but unrestricted use, rather than some physical or engineering maximum.*"

From this definition it follows that capacity can be expressed both in relation to input (potential catch effort) and output (potential catch).

On the other hand, Cunningham and Greboval (2001), Pascoe et al. (2004), NOU 2006: 16 and St. meld. No. 21 (2006-2007), have defined capacity as based on technical and economic criteria. Common to this approach is the monitoring of capacity development and identification of a catch capacity that is adapted to a sustainable harvesting of fish resources. This assumes that it is possible to determine a potential long-term yield for a given stock (MSY).

Yet another measurement of capacity that has frequently appeared in the technical literature, refers to the scope of the fishing vessels' utilisation of capacity (Greboval, 1999). An important basis for the degree of capacity utilisation is that there is an *institutional connection between output and input* regulation of fishing. Input-based measures of capacity (e.g. Ward *et al.* ,2004) assume that the level of output relates to the level of physical input employed in the fishery. If these inputs are fully utilised, it follows that the capacity of the fleet would be a function of such inputs. The level of utilisation in this case would relate to the level of activity (e.g. days in fishing and the vessel's technical standard). Hence, the capacity of the fleet is related to the fixed inputs employed, i.e. capacity is assumed to reflect technical parameters such as size of vessel(s), amount of engine power and other technical specifications relevant to a vessel's fishing capacity (see e.g. Standal 2005 #3).

According to FAO (2001), there is a need for developing management regimes that integrate both input- and output measurements. The importance of identifying the relationship between the different measures is a key component for an effective management regime. Still, in the general FAO fisheries management literature, there is a consensus that input regulations refer to variables such as number of fishing vessels, the amount of fishing gear, licenses and technical regulations like area restrictions while output regulations refer to TAC's and quota allocations at different levels.

Despite the clarification of capacity as linked to input and output regulations, Cunningham and Greboval (2001) and Kirkley and Squires (1998) provide only vague definitions of the concept of fishing capacity. Hence, this complexity also reflects the difficulty of defining optimum capacity or overcapacity in a simple and unambiguous manner. Still, a few countries have developed a formal definition for the purpose of monitoring and managing fishing capacity. In Australia, fishing capacity is defined as the amount of fishing effort that a given boat, or fleet, could exert if fully utilised, that is if vessels were not constrained by restrictive management measures. In the European Union, capacity is defined in terms of two vessel characteristics: gross tonnage (GRT); and main engine power assuming full utilisation of the vessel. In Canada and in the USA, capacity is primarily defined as the amount of fish that a vessel or fleet can harvest if unrestrained by regulations or consideration of a sustainable harvesting level.

In the USA, the National Marine Fisheries Service (NMFS) has proposed two definitions of fisheries capacity, which also lend support to the previously mentioned FAO definition–a technical definition and an economic definition (NMFS, 1999).

Technical definition: Technical capacity is:

"the level of output of fish over a period of time (year, season) that a given fishing fleet could reasonably expect to catch if variable inputs are utilised under normal conditions, for a given resource condition, state of technology, and other constraints. Under this definition, excess capacity exists when technical capacity exceeds a target catch level set to rebuild or maintain the stock at a long-term target size".

Economic definition: Economic capacity, based on cost minimisation, is:

"the level of output of fish caught over a period of time (year, season) where short-run and long-run average total costs are equal, for a given fleet size and composition, resource condition, market condition, state of technology, and other relevant constraints".

A cost function describing the optimal level of output given a particular production technology can be estimated by calculating the fishing firm's short- and long-term average costs. However, cost minimisation is not the only objective that can govern a fisherman's behaviour.

As discussed in FAO (2000a), capacity may be defined with reference to fishing input (fishing vessels, potential effort) or to fishing output (potential catch). In both cases, it is essential to further clarify the word "potential", as reflected in some of the examples of definitions provided above.

2.5 Technical capacity

A strong technological development of fishing vessels has taken place over time. This refers to both coastal and deep-sea fishing vessels and to different vessel- and gear types. After World War II, navigational and fish-finding equipment was commercialised for civil purposes. Artificial materials were used in fishing gear and mechanical equipment was introduced as hauling systems. In addition, freezer technology was developed for on board conservation of the fish. This resulted in larger and more mobile vessels being able to keep their catch on board and increase the number of catch days at sea (Hersoug, 1990). From 1950 to 1970, world catches increased from 20 million tons to 70 million tons, a growth rate of 8 – 9 % per year. After the 1970s, however the growth in catch rates has declined and the total volume reached 91 million tons in 1987. As early as in the 1970's Gulland (1971) expressed the view that stagnation could be expected in catches throughout the world's fisheries. Troadec (1983) outlined several features of the global stock development that would mean the end of the strong post-war model of fisheries development. Most of the commercial fish resources had become fully exploited. Thus, further growth could only be attained by new adaptations to less valuable or (then) non-commercial resources.

This development is clearly associated with the modernisation processes in the fishing fleet. It is easy to link technological developments to the increase in catch rates. In respect to the deep-sea fleet, three fundamental innovations have occurred; the change from side trawling to stern trawling, the change from man-power to the use of hydraulic power blocks in pelagic fisheries and the introduction of automatic baiting in the line fleet. All subsequent development of fishing vessels occurred within the framework of the above innovations.

The considerable increase in the amount of fishing gear, however, cannot be viewed in isolation from other technological developments in fishing vessels. The design of both coastal and deep-sea vessels has changed over time. First, the breadth to length ratio of the vessels has increased. This resulted in greater area and increased buoyancy to handle larger amounts of fishing gear and to provide increased space for processing equipment on the factory deck. Moreover, increased buoyancy and volume resulted in greater cargo capacity and increased space for larger fuel- and freshwater tanks. Mobility of the vessels improved and the area of operation was extended in relation to fishing on new grounds. Increased buoyancy and stability are also prerequisites for vessels to strengthen ice reinforcement of the hull, facilitation year-round fishing in icy waters. There were also considerable developments in the form of new materials and design, including trawl equipment, purse seines, Danish purse seines, gill nets and hooks for line fishing. The total result is an increased catch per unit effort (CPUE)[5].

New electronic instruments for navigation and searching have made catch operations more efficient in the broadest sense of the word. For the part of the fleet using trawls, gill nets, lines and Danish seines, the use of GPS for exact localisation of stationary fishing gear and specific fishing areas, has contributed to efficiency. Likewise, development of sonar has extended the range in the search phase for pelagic fish and in distinguishing different species. This also applies to the echo sounder, used for precise vertical steering of both floating- and bottom trawling[6].

Another important factor is that the need for the number of crew has either been reduced (e.g. purse seiners) or is stable compared to earlier generations of vessels. Consequently, the amount of fishing gear per fisherman has increased considerably over the years.

Thus, an important element is that technical capacity is not a static concept. On the contrary, technological development illustrates a dynamic process, where catch capacity per meter length has increased. Nonetheless, it is difficult to convert this kind of indicator into real catch capacity. A series of natural variable factors such as availability, fish density and weather conditions can affect catch efficiency. Hence, technical capacity is not solely attributable to a few main variables such as engine power and gross tonnage. Rather, it is the total range of components that function in a complex interaction between vessel, fishing gear, electronic equipment and the fishermens' professional qualificationsto exploit technology in the best possible way. According to St. meld. No. 21 (2006-2007:45):

> *"It is difficult or even impossible to define stable aims for optimal technical catch capacity. Technical capacity, as we have seen, is affected by a series of factors, and it is not very practical to regulate and measure capacity in relation to technical criteria in the individual vessel. For this reason, during the past ten years, there has been a movement away from regulating vessel design and size in detail"(own tranl.).*

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[5] For an expression of the technical capacity development, see Standal (2003), footnote no. 9,

[6] For a review of technological trends in fisheries, see Valdemarsen (2001).

Nonetheless, technological development in the fishing fleet is fundamental to understand capacity development in any given fishing fleet. Corrected for the number of vessels, analyses of the technological development can serve as an important indicator of the fleet's catch capacity (see e.g. Standal and Aarset 2002 #1; Standal 2003 # 2; Standal 2005 #3; Standal 2006 #4; Standal 2007 #5). This is also the background for Cunningham and Greboval's (2001) suggested use of time series studies to illustrate the development of a number of vessels combined with technological changes. The Office of the Auditor General has also analysed the development of technical capacity in the Norwegian fishing fleet; this analysis forms the foundation for important structural measures in the Norwegian coastal fleet (St.meld. Nr.20, 2002-2003).

2.6 Economic perspectives of the capacity term

An evaluation of capacity in fisheries can also be based on various economic criteria. Within the framework of a closed and quota-regulated regime, an economic approach will have greater relevance than a one-sided focus on technical capacity (Clark 1985). An important question is to what degree investments generate a sufficient salary for the crew and profit to the owners. However, this kind of requirements does not refer to the fishing industry alone. Profit from fishing must also be viewed in relation to potential profit from alternative investments from other business sectors.

Based on economic theory, profitability from a given fishery will be greatest when the allocated quota is harvested with the lowest possible cost. This means that if the goal is the greatest possible profit, over-capacity will result when fisheries are not run at the lowest possible cost and the rates of return do not reflect maximum possible profit (Conrad, 1999).

In fisheries, we consider resources as an input factor that we are free to utilize. This kind of free production factor allows the fleet to realise an economic rent above normal compensation for capital investment, labour and other relevant input (Hannesson, 1978). The question of realising economic rent in fishing is also linked to the formulation of the quota regime. This kind of approach affects the distribution of limited resources between different participants. For example, the aim of achieving the highest possible yield from fishing can be in opposition to regional political considerations, or a distribution of fish resources that results in a lower efficiency and profit.

Over-capacity can also be considered as the sum of adaptations among individual actors. Although it is possible to realise an economic rent in conjunction with the harvesting of fish resources, collective behaviour can generate increased effort and over-establishment in the fishing sector. Even though these adaptations may look rational to the individual actor, collective behaviour may contribute to a reduction in total productivity. Thus, the existence of resource rent may contribute to over-capacity, and a lower economic yield than if the aim of fishing was solely maximum economic profit (Clark, 1985; Conrad, 1999).

At the same time, the existence of resource rent might contribute to a high economic yield. The resource rent can also be used to achieve regional political aims. For example, it is possible to allocate a higher catch capacity and greater employment rate in fishing than would be necessary to realise maximum economic gains from scarce fish resources.

In economic theory, the degree of profitability is closely connected with the utilisation of the vessels' overall capacity. Pascoe and Greboval (2003) define the degree of capacity utilisation as the ratio of actual output (catch landings) for a given fleet and a potential biomass level. Overcapacity may be defined as the situation where capacity output is greater than target output. In this context, underutilised capacity translates to vessels fishing fewer than their expected number of operating days, and thus catching less than their technical potential. In a closed regime, catch or effort restrictions may cause such a situation. While management tends to regard the concept of capacity in terms of inputs, an economic perspective considers capacity to be the product of the potential output produced if the vessels were operating at maximum profits. Thus, the economic definition of full utilisation considers that additional revenue must be equal to or exceed the additional cost of catching more fish. From this, it follows that full utilisation in an economic perspective may be less than what is technically possible for a vessel (Cunningham and Greboval, 2001). Nonetheless, despite differences between the technical and economic perspectives on capacity, the concepts can be considered to be complementary (Pascoe *et al*., 2004).

2.7 The complexity of managing capacity

As a starting point, the term "capacity management" can be defined as the implementation of a series of political and technical measures aimed at ensuring a desired balance between fishing inputs and production from capture fisheries (Cunningaham and Greboval, 2001). Despite the closure of the commons, the introduction of quota systems, market-based structural measures and detailed control over the fisherman's day, problems created by over-capacity have persisted (Anderson, 2007; FAO, 1998). The Norwegian fishing fleet is no exception (Riksrevisjonen, 2004; Asche *et al*., 2008). According to the FAO (1998), over-capacity in fishing leads to increased pressure on fish resources and high administrative management costs. In addition, the fishermen are economically marginalised and over-capacity leads to conflicts regarding allocation of fish resources among actors.

The FAO stated that the majority of the commercial fish stocks were already fully exploited or over-exploited by 2001 (FAO, 2001). The analyses and statistics prepared by FAO for 2005 showed that about 25% of all commercial fish resources were over-exploited whilst as much as 50% of fish resources were exploited to full capacity. Only 25% of fish resources were under-utilised in relation to biological reference-points for sustainable management (FAO, 2005).

The world's fisheries are characterised by an enormous lack of profitability and over-capacity is maintained through considerable subsidies (FAO, 1992). While the FAO stipulated total income from fisheries in 1992 was stipulated at USD 70 000 mill., costs were calculated at USD 124 078 (FAO, 1992). In order to balance the income from fishing with the total costs (i.e. break-even), catch capacity would need to be reduced by more than 50% (Garcia and Newton, 1997). The OECD (2006) also pointed out that subsidising the fleet would only contribute to maintaining the status quo in respect to unprofitable over-capacity.

The poor status of the world's commercial fisheries has led to the recognition that over-capacity is a major problem, a subject becoming more frequently an item on the agenda (Ward *et al*., 2004).

In relation to the domestic debate, it is easy to recognise the FAO's findings; throughout the sixties, seventies and eighties, a large part of Norwegian fisheries was characterised by negative resource rent. Such a long-term adaptation was made possible because the state subsidised the fishing fleet, buffering it from losses. However, this does not preclude that some fisheries were able to attain profit during certain periods.

In Norway, allocation conflicts are continually on the agenda and expressed through considerable conflicts between different gear- and vessel groups (Norges Fiskarlag, 2007). The debate has dimensions that refer to regional considerations and to the need to prioritise regions (which are dependent upon fishing) to a form of a zero-sum game among actors (Thurow, 1982). In the latter case, it is argued that different technological adaptations create different rates of profit, employment and sustainability concerning rural areas and the fish resources. Finally, fisheries management binds up considerable public funds for research, management, and distribution and inspection of the entire segment (Fiskeri- og kystdepartementet, 2005).

However, the initiation of realising organisational gains in the form of reduced catch capacity and increased profitability has created severe conflicts among different vessel- and gear groups. Furthermore, allocation conflicts lead to pressure upon the stability of established institutions, and conflicts hamper the aims of collective action and reorganisation in a given arena (Young, 1982; 1989).

Thus, the debate surrounding capacity becomes an arena that reflects different perceptions of the capacity concept. From the economic perspective, profit is an indicator for capacity adaptation in fishing (Fiskeridirektoratet, 2006). A technological approach refers to changes in the technical capacity that are relevant to the catch- and processing capacity of a given vessel or group (St.meld. nr 20, 2002-2003; SINTEF Fiskeri og havbruk, 2005; Riksrevisjonen, 2004). In a social perspective however, the concept has a wider application than technology and economic profit. For example, the coastal fleet's time ashore, outside the cod season, is not necessarily congruent with a malfunctioning adaptation or technical over-capacity. Time ashore can be a natural adaptation to the fishes' migration pattern. Seasonal fishing can also be regarded as an adaptation to the employment systems in local societies, or that fishing is combined with other land-based business activities (Brox 1966, 1989; Høst and Wadel, 1980; Maurstad, 1997).

At the same time, the debate does not refer solely to internal characteristics of the fleet. In other areas of society, for example in the oil- and gas sector, new employment systems have led to increased efficiency in manufacturing. Increased production has resulted in a strong increase in income and welfare (Statistisk sentralbyrå, 2007). In the period following the Second World War, the fishing fleet followed the general development of welfare in society in the form of increased catch rates. At the end of the 1970's, however, fish resources were more or less fully exploited. Since then, there have been further welfare developments in fisheries connected to technological development and structural changes in the catch segment. The structural benefits are manifested as increased efficiency per unit by reducing the number of vessels and an ever-decreasing number of fishermen (Fiskeridirektoratet, 2007).

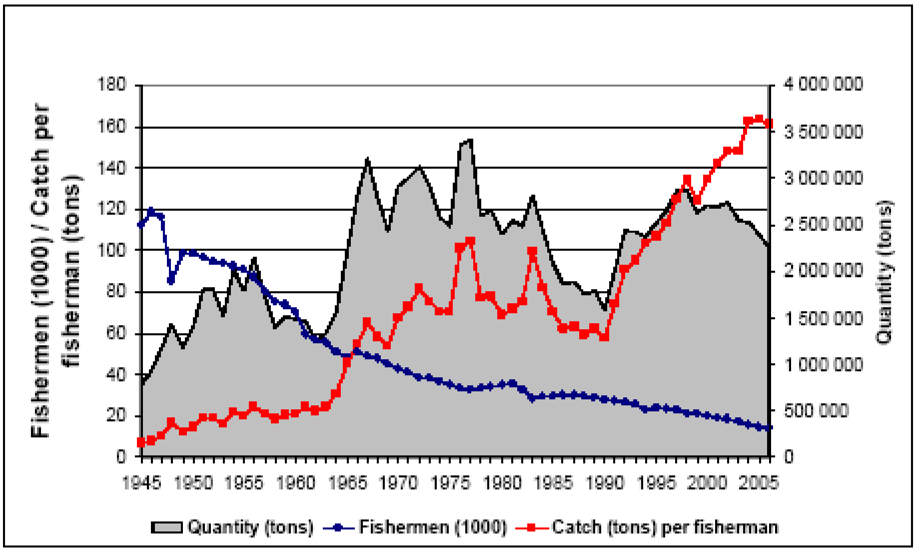

Figure 2. Norwegian catches, number of fishers and catch per fisherman, 1945-2005.

Source: Gullestad (2004), NOU 2006:16.

From 1945 to 2005, the number of fishermen was reduced from 120 000 to 11 692 full-time fishermen. At the same time, total Norwegian catches increased from 1 million tons per years to an average of 2.5 million tons per year. Hence, the total catches per fisherman increased from less than 10 tons per year in 1945 to an average of 160 tons per fisherman in 2005.

When the productivity and the salary level in other competitive industries and alternative employment systems increases, the fishing fleet is pushed to maintain its competitive edge. This is fundamental for the fishing sector because it affects its relationship to profitability, the recruitment of labour to the fleet and for the development of regions that depend upon fisheries. According to The Central Bureau of Statistics (Statistisk Sentralbyrå, 2007) the level of education in Norwegian society is increasing. This also applies to rural populations. Heggen and Clausen (2005) point out the increasing mobility amongst the working population and thus a higher degree of competition among potential employers. As an element in the maintenance of the employment systems in the entire fisheries segment, the increased mobility intensifies the demands on the fishing fleet as a competitive alternative.

The demand for a competitive fishing fleet also promotes an alternative application of capital. Thus, the fishing fleet does not exist as an isolated enclave that is decoupled from developments in the rest of society. On the contrary, the general wage- and welfare development in society exerts pressure and makes demands on continuous changes in the fishing fleet.

In this context, the fishing fleet is in an exceptional position in relation to the debate on capacity adjustment. Whilst other industrial sectors may have unlimited and predictable access to input factors for a given production, fish resources are limited. This means that the total production cannot increase beyond the level that is sustainable for a given fish stock. In addition, the individual fisherman does not have control over the development of fish resources. In contrast, other industrial sectors can compensate for increased efficiency with increased production. It is thus possible to maintain employment in the sector. Here, other producers can control input factors for a given production, an adaptation that allows for increased planning and coordination, maintaining full utilisation of the production capacity (Thompson, 1967).

We can thus outline two fundamental differences between fishing and other industrial production. As indicated by the Gordon-Schaefer model, investments in a limited fish stock involve limiting catch efforts in order to strengthen the fish stocks (Gordon, 1954). On the other hand, as far as ordinary industrial production is concerned, it is possible to increase investments to solve general capacity problems or bottlenecks in the value chain, an investment strategy that is oposite to the responsible management of limited fish resources (Nicholson, 2007; 2008).

Capacity adjustment within fisheries is further complicated by the need for modernisation processeses. Outdated vessels are replaced by new vessels that have a much higher catch capacity. Hence, a reduction in the number of vessels does not need to be congruent with a decrease in the overall capacity. The dynamics in respect to fleet renewal must be balanced with a sustainable resource management and the requirement of economic profitability. However, new investments should also follow the general increase in efficiency in society. Another complicating aspect of the fisheries segment is the strong mutual dependency between the catch- and the processing segments (Jentoft, 1984). Capacity in the catch segment does not refer solely to internal conditions within the fleet, but it also affects the relationship with the rest of the value chain. Finally, it applies to capacity being adapted to a variable resource base, whereby allocated quotas and market prices tend to vary independently of each other. Hence, managing capacity reflects a series of issues and areas at different levels of society.

2.8 Summary

In summary, adjusting capacity adaptations is a project that involves the balancing of input- and output regulations were the aim is to achieve an acceptable harvesting rate that does not exceed a scientifically based reference point for total fishing mortality (F).

Strong institutions have been organised to anchor fishery management to scientifically based stock assessments. The Institute of Marine Research (Bergen, Norway; IMR) has established biological reference points for all the commercial fish stocks. They have carried out annual economic analyses on the entire Norwegian fishing fleet. Additionally, the Norwegian Directorate of Fisheries monitors the technical development of the fishing fleet.

Despite the input- and output regulations that are integrated in the IVQ model, a fundamental characteristic is that technology and biology are independently variable factors. Nevertheless, the fact that they are expressed through the IVQ system reflects a mutual inter-dependency and indicates that technology and biology function as a reference to each other.

The complexity of the multi-disciplinary approach of governing capacity is effectively highlighted by considering the fisheries managers' responses to problems of excess capacity. If the vessels fished for fewer days, then the level of effort would decrease. From the fisheries scientists' point of view, the problems of overcapacity would disappear. However, reduced utilization of the vessels would result in lower levels of profitability. Hence, the problem would remain for fisheries managers and would worsen from an economic point of view. Another option for responding to excess capacity is to reduce the number of vessels, causing a reduction in the overall fishing effort. The remaining vessels would then operate on a more effective basis, making scientists, managers and economists more satisfied (Utne, 2007).

In a broader context, the concept of capacity connects to the concept of sustainability (Bell and Morse, 2000). Thus, different perspectives on sustainability are become relevant when the needs of legitimate stakeholders in the fisheries sector are analysed (Jentoft and Mikalsen, 2001). The conflicting needs leads to divergent views and difficulties in achieving a sustainable use of fish resources (Rosenberg *et al*., 1993).

The FAO report on capacity triggered a strong interest in developing capacity measurements in fisheries (FAO, 1998). This interest follows directly from the seminal work of Gordon (1954) who predicted that in a poorly managed fishery, one will observe rent dissipation and a level of effort that is too high to be sustainable. (Asche, 2007).

However, it is difficult to establish a common definition of optimal capacity in the fisheries sector (Asche, 2007; Wilen, 2007). Measurements of capacity reflect a ratio that spans from actual utilisation to 'full'utilisation, or optimal use of the fishing vessels. Nevertheless, according to the nature of fisheries, optimal capacity is difficult to identify. Even when it is possible to establish specific reference points, it is difficult to measure them empirically. A variety of approaches has been taken to reduce overcapacity, such as buy-back programmes and decommissioning programmes (Wilen, 2007). However, these different measures have not solved the problems inherent in this system (FAO, 1998).

In the Norwegian fisheries industry, it is easy to show that there is no direct connection between profitability and the degree of capacity utilisation. The profitability term may additionally have different interpretations. For example, shrimp trawling is regulated to limit the number of participants (input-regulations) but there is no TAC, a very capacity-driving arrangement (Standal 2003 #2). Participating vessels conduct maximum capacity utilisation on a year-round basis. Even so, economic surveys for recent years show that the fleet is operating at an economic loss. At the same time, shrimp trawling generates a considerable economic profit for the crew. Correspondingly, we find vessels that have a very low technical capacity utilisation throughout the year, but that nonetheless generate a solid economic profit for both ship owners and crew (e.g. purse seine vessels fishing for herring and mackerel (Fiskeridirektoratet, 2006).

Given the difficulties involved in measuring and managing capacity, Asche (2007) questions whether it is possible to provide anything other than simple indications of the magnitude of the management problem. This is also supported by Pascoe (2007), Roheim (2007) and Anderson (2007), stating that managing capacity should be broadened in scope and integrated as a part of overall fisheries management.

Fisheries management has been exposed to considerable political pressure (St. meld. Nr. 58, 1991-92). Consequently, the aims of controlling capacity have developed into a conflict of power between scientifically based findings and political motives. Regulation controlling catch capacity ares not determined soley on one-sided scientific knowledge such as biology, but are also based on political and administrative judgement.

In the next section, I describe how the capacity concept has been put on the agenda in Norwegian fisheries and how the subject is transported through different phases of the modernisation process that confer different meanings.

3 Phases of capacity in Norwegian fisheries

3.1 Export organisation and the use of labour force

The capacity concept was first introduced into the fisheries debate as early as the 1930's. In important export markets such as Spain and Portugal, this was a period characterised by trade barriers and regulations (Meidell Gerhardsen, 1964). At this time, Norway was in a a general state of depression, characterised by high unemployment and a considerable element of social hardship. Because of the economic crisis and the chaotic situation in the fish-export markets, the need for more efficienct capacity adaptations was put on the political agenda (Hallenstvedt and Dynna, 1976; Hallenstvedt, 1982; Hersoug, 1983).

Key concepts on the polical agenda included increased efficiency and stronger emphasis on year-round fishing, a strategy that also meant increased capitalisation of the fleet (Furre, 1991).

In 1937, the Profitability Commission (Lønnsomhetsutvalget, 1937) presented a comprehensive report. The report emphasised that focus should be on the profitability of the fisheries; it communicated what fishermen had been, what they were and what kind of actors they should be (Johnsen, 2002). Their ambition was to create a fishing industry that is as predictable as other industries in Norwegian society.

The Profitability Commission's findings were largely a confrontation with what Holm (1996) defined as the rural model. The commission launched the radical idea of industrially based mass-production through a value chain. This new capacity adaptation presupposed stable supplies of fish and land-based processing that would then represent the core of an industrial model. The report presented theoretical calculations showing that 200 large trawlers and 6,000-8,000 fishermen could achieve higher catches in the cod sector than the 60,000-70,000 fishermen fishing at the time.

However, the majority of the commission expressed that such a structure would not be realistic, emphasising that the old and new structures would have to complement each other. Nevertheless, the commission contributed by putting capacity and structure issues on the agenda. The old rural business model and the mass production of standard commodities (here represented by 200 larger trawlers) drew a dividing line between radically different norms, values and adaptations.

The modernist perspectives of the Profitability Commission never materialised in the 1930s. Instead, the Trawler Acts of 1936 and 1939 fixed the number of trawlers at the existing number of 11, not allowing any new trawlers into the Norwegian fisheries.

In the 1930s the concept of capacity related to structural aspects of the fleet. The report from the Profitability Commission (op.cit) linked the problems to seasonal fisheries, referring to the coastal fleet as an obstacle to increased efficiency. Limited fish resources were not on the political agenda. Instead, a new type of catch capacity, which could increase the economic efficiency of Norwegian exports to limited international markets, was put on the agenda.

Prior to the end of the World War II, the Norwegian government in exile (the 'London Government'), started planning the rebuilding of the northernmost regions (Drivenes and Tjelmeland, 997). Following the Second World War the economic framework underwent a radical change. While the primary industries were used as employment systems in the 1930s, having to absorb a surpluss of labour, the fish industry was now affected by a shortage in the labour force. Now, the export markets were open (St. Meld. Nr.10,1947). Compared with the recommendations of the profitability commission of 1937, a change in focus was seen in the definition of capacity. Whereas the question of introducing trawling in 1937 was based on difficult export markets, changes in the national budget necessitated trawling as a strategy to liberate the labour force from fishing and transfer it to other industrial sectors of society. However, such a strategy could not be carried out without a rationalisation of the fleet structure.

The aim of this new order was to realise the great economic potential linked to the cod resources in the Barents Sea. Throughout the post war period the use of state planning and socio-economic models gained a strong position (Østerud, 1979; Østerberg, 1999). This public investment strategy was based on Keynes'(1936) economic models to mitigate fluctuations in the economy whilst contributing to the growth in gross national product (GNP). A series of white papers followed in the wake of the national budget of 1947. These were developed according to the modernisation way of thinking[7]. The reports suggested a mass-production industrial model, and trawling represented a year-round fishing activity for increased efficiency.
The Rationalisation Committee was established in 1949. Its mandate was to propose further measures to improve the efficiency of the fish industry (Rasjonaliseringskomiteen, 1949). The committee's proposals opened for growth in the trawler fleet. However, there were no definite statutory provisions limiting the number of trawlers.

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[7] The Rationalisation Committee (1949), Vessel Committee (1949, 1963-65) and Commission for the Recovery of the Fishing Industry in North Norway (1948). (Rasjonaliseringskomiteen, Fartøykommiteen, Komiteen for gjenreising av fiskeindustrien I Nord-Norge).

Capacity was linked to different realities before and after the war, but the understanding of the concept was basically a crude technological calculation of catch ability, number of days at sea and the number of fishers required to do the job. Indirectly, this technical understanding coupled economic efficiency in terms of producing limited export quotas with lower costs in the 1930's. In the 1950's however, the rational calculations were integrated into the plan to obtain economic efficiency in the new vertically integrated fishing industry, based on the export of frozen fillets.

3.2 Catch capacity and modern fishing industry

Unfortunately, bad times continued in the cod sector. In 1957, a new public commission was established, the Cod-fishing committee (Torskefiskeutvalget or 'T 57'). Their mandate was to outline short- and long-term measures to improve the efficiency of the entire cod-fishing segment.

Their final recommendation was presented to the Norwegian Parliament in 1959 (St. meld. No.71, 1959). Now, the authorities would subsidise the modernisation of the cod sector in a value chain perspective. The strategy was to construct a profitable industry both at sea and on shore.

A central starting point of T 57 was that the land-based freezing industry utilised only 50% of the total production capacity. Consequently, a series of proposals were aimed at increasing the utilisation of capacity in the fillet industry. In line with the previous white papers, the T 57 defined the seasonal coastal fishing as outdated. Seasonal fishing with a simple and open technology adapted to the arctic cod's migration pattern, was unable to secure maximum capacity utilisation in the land-based industry.

Additionally, by "removing old and irrational capacity adaptations" (as T 57 described it) the new strategy connected trawling to the industry as a stable supplier. However, T 57's conclusion went even further. The future Norwegian fleet should also be able to compete with an international fleet of trawlers, fishing close to the Norwegian coast. The new capacity adaptation would promote a larger Norwegian share of fish resources in the open sea. Deep-sea fishing would not only make use of the traditional fishing grounds, but also expand to new areas when fishing on the old grounds declined (Ulfstein, 1982; Hersoug and Leonardsen, 1979; Torskefiskeutvalget, 1957).

In reality, the T 57-report was a major breakthrough for a new and modern trawler fleet (Hersoug and Leonardsen, 1979; Sagdal, 1982). The recommendations of T 57 were followed up by the proposal of an investment programme for the fishing fleet in 1963-65, the "Investment commission" (Attachment no. II to St. meld. No. 75, 1962-63). These proposals were also expressed in St.meld No. 79, (1960-61), which dealt with the implementation of a development programme for North Norway (Holm and Johnsen, 1990). Further, the 'Subsidy commission' formed the basis for the establishment of the Main Agreement (Hovedavtalen) between the government and the Norwegian Fishermen's Association in 1964. The mandate of this agreement was that the government would contribute conditional financial support for the implementation of capacity adaptations that would promote both year-round fishing and the best possible utilisation of the processing industry (St. prp.143 (1963-64); Holm 1991).

Due to adoption of vertical integration as a corporate strategy, trawling as a capacity adaptation was strongly linked to the needs of the land-based processing industry. The development programme included considerable governmental participation in the form of financial support and part-ownership in a new business structure. According to the new strategy, important innovations would be put into use (Lien, 1975a, 1975b). Centralised large-scale operations were now the new capacity adaptation. In this way, it would be possible to realise the economics of scale linked to an industrial mass-production model. All together, twelve large fillet factories were established and located along the coast of Finnmark and North-Troms (Lien, 1975; Jacobsen, 1996).

These vertically integrated enterprises represented a radical break with the old capacity adaptation (Hersoug, 1982). The new structure not only implied a considerable centralisation of the processing activity, but also a strong capitalisation of the value chain. In order to strengthen control of access to the resource base, it was now a basic requirement that the land-based industry should ensure ownership of a large segment of the trawler fleet (Dreyer, 1998).

An important aspect of the new strategy was the use of public institutions. Governmental institutions with technical insight and an administrative capacity were set to realise the aims of the policy. The State Fishermen’s Bank client ideology played a major role in reshaping the fleet (Handegård, 1982). In total, the structure rationalisation and the image of the year-round fisherman had triumphed over the seasonal-based fisheries (Holm, 1996).

During the 1960s and 1970s, the new capacity adaptation became apparent. More than 50 new fresh-fish trawlers were built. The new vessels, with 300 DWT and barely 50 meters long, represented a new dimension in Norwegian fisheries. This was a considerable contribution to technical structural development. In general, the 1960s and 1970s represented a major breakthrough in terms of technological innovations (Robinson, 1996; Wigan, 1998, Bjarnar, 2006). Stern trawling, the introduction of hydraulic power blocks in the pelagic fisheries and the use of automatic baiting machines in the line fleet represented major innovations.

The strategy of increased catch capacity and new adjustments had been on the agenda from the time of the Profitability Commission in 1937. Now this strategy was finally realised as part of the general modernisation policy. In this perspective, there had been a one-sided focus on techno-economical capacity and a general lack of resource management. In this open-access fishery, the term “capacity” did not refer to fish as a limited resource. Instead, the term referred to old technical bottlenecks and the need to establish a new value-chain based structure in the entire cod sector (Standal 2007 #5; Standal and Aarset 2008 #7).

Throughout the late 1960’, there was a strong decline in commercial fish resources. The previously rich herring fishery crashed completely in 1968 and was closed for the next 20 years. A similar development was seen for cod in the Barents Sea (Breivik, 1996; Warner, 1983). Terms such as resource crisis were now on the agenda, and the unprofitable over-capacity became apparent. The post-war optimism surrounding the development of the deep-sea fleet turned to pessimism for the future (Sagdal, 1982;

Løken 1984). A political epoch in which the capacity concept was solely linked to techno-economic rationality had thus ended. Specifically, the capacity concept was now primarily connected to the technical aspects of the fleet. The fisheries authorities intended the massive public investments and subsidies to contribute to a long-term profitable vertically integrated industry, that is, profitable for private as well as public owners.

3.3 200 mile zone, modern resource management and the concept of capacity

Prior to the establishment of the 200-mile economic zones, most of the world's fishing took place in the open sea. Deep-sea fishing developed into a race for resources. The number of participants and the catch capacity increased considerably (Ulfstein,1982). Of the total quotas established by the North East Atlantic Fisheries Commission (NEAFC) in 1975, only 16% were within the recommendations of the International Council for the Exploration of the Sea (ICES) (Underdal,1980).

During the 1970s, there was a gradual change in the interpretation of the capacity concept. Fleet adaptations and profitability problems were connected to limited resources and expressed in the 'Long-term plan for fisheries' (St. meld. No. 18, 1977-78; Hersoug et al., 1993).

The Long-term plan (op.cit) suggested reduction in the trawler fleet and in purse seiners, as well as removal of the entire factory-trawler fleet (Standal 2008 #6). The long-term plan also extended the general aim of securing employment in rural districts. However, whilst public plans focussed on sector aims, concern for the general settlement pattern was given a wider and vaguer definition of what could be appropriate means. The long-term plan did not prioritise between the various aims. Capacity-related problems were hardly addressed. As far as the industry's economy was concerned, reference was made to the conservation of the settlement pattern. This was expressed as a legitimisation of the considerable public funding of the industry through the Main Agreement (Hersoug, 1983; Hernes, 1999).

On November 11, 1977, a bilateral fisheries agreement was signed between Norway and the former Soviet Union, an agreement that involved an equal division of the fish resources in the Barents Sea and a joint management regime. The establishment of the 200 mile exclusive economic zones (EEZ) in 1977 represented a major breakthrough in the nationalisation of fish resources and the introduction of modern resource management. In addition, national control was the key for a national allocation of resources among different vessel- and gear groups (Ulfstein, 1982; Holm, 2001).

From now on, fish resources were to be managed in accordance with the measurements of maximum sustainable yield (MSY). This was a new, scientifically based method of stock management that linked together the biological and economic effects of a given catch effort (Hannesson, 1978; Andersen, 1979).

This new management strategy started with the regulation of the herring fishery in 1968, and the subsequent total moratorium in 1972. With the collapse of the Atlantio-Scandinavian herring stock, the authorities introduced dramatic restrictions in the fisheries. The control of catch capacity and resource concerns were linked to the law regulating participation in the fisheries (Deltakerloven, 1972). This law allowed the introduction of a licencing system for the purse-seine fleet in 1973. The aim was to regulate participation and ensure that catch capacity corresponded to the resource base (Ørebech, 1984). Other offshore fisheries, such as shrimp and saithe, followed later in the 1970s.

However, problems related to overcapacity continued. The vague and unclear policy as to how catch capacity should be reduced was also expressed by the Norwegian Fishermen's Association (NFA) 'consultative statement on the Long-term plan' for 1977-81 (Norges Fiskarlag, 1977). According to the Fishermen's Association the Long-term plan lacked a systematic analyses of how different control mechanisms such as licenses as input regulations functioned in regard to managing the catch capacity (Christensen and Hallenstvedt, 2005).

By the end of the 1980s, stock assessment became more precisely defined. Due to the introduction of total allowable quotas (TACs) and the Salt Water Act (Saltvanns-fiskeloven) of 1983[8], limited fish resources were specifically linked to the overall allocation policy, dividing fish resources among major groups. With reference to the allocated resources and the numbers of participants, the foundation was laid for an increased precision in defining the concept of capacity.

At the same time, economists argued that the maintenance of major transfers of public funds to the fisheries would neither promote resource management nor increase the profitability of the industry. On the contrary, the large-scale transfers contributed to the maintenance of unprofitable over-capacity and a lack of incentives to reduce catch capacity (Brochman, 1980, 1981). Despite warnings from fisheries economists, the white paper for 1982-83 (St.meld.no. 93, 1982-1983) formulated the protection of the settlement pattern and the need to secure employment via state subsidies. Nevertheless, the need for protection of the resource base and increased profitability was given higher status on the fisheries political agenda.

Parallel to the introduction of modern principles for fisheries management, Norway extended an agreement with the Soviet Union granting free fishing for the coastal fleet, a practice which lasted until the mid 1980's (Hønnesland, 2007). Hence, the purse-seine fleet and cod trawlers were the first to become a reference for a more precise understanding of the capacity concept in fisheries management.

In the 1980s, the legitimacy of government subsidies was gradually reduced. This period was characterised by increased political pragmatism and lack of ideology. The focus on profitability and on scientific models for resource management gained a more prominent position (Hersoug, 2000). Pressure increased against the Main Agreement and funding was reduced, a development which increased the demand for a profitable capacity adjustment without state subsidies.

Following this increased focus on economy, capacity- and allocation conflicts were linked more closely together (Holm and Johnsen, 1990). Still, there was no specific policy for the implementation of a reduction in catch capacity. For example, in 1982

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[8] The Saltvannsfiskeloven is a credentials law that gives legal authority for the allocation of fish resources and technical regulation of the fisheries (Ørebech, 1984).

the law that regulated on-board freezing was repealed, a liberalization that triggered the installation of freezing plants throughout most of the trawler fleet. This was a new technological development, which increased the vessels' overall capacity. Throughout the 1980's, there were optimistic prognoses for the cod stock in the Barents Sea. In response, the current government awarded 30 new licences for cod trawling. In addition, the Norwegian Fishing Vessel Owners Federation (Fiskebåtredernes Forbund) obtained a breakthrough whereby a changeover to factory trawling would undoubtedly improve the profitability of the trawler fleet (Fiskebåtredernes Forbund, 2005).

Over the course of four years (1985-89), more than NOK 2 billion was invested in new factory trawlers. The number of vessels increased from 11 vessels in 1985 to 25 vessels in 1989, a modernisation process that heavily increased capacity in the sector (Standal, 1989; Standal 2008 #6).

3.4 Cod crisis and new structural adjustments

However, the optimistic prognoses for stock development in the Barents Sea were not realised. As a result, the Norwegian total quotas for Arctic cod were reduced from barely 300,000 tons in 1987 to 113,000 tons in 1990. Free cod fishing was revoked for the conventional fleet. In 1989, the coastal fleet became regulated with free fishing within the framework of a group quota. The coastal fleet was awarded 64% of a Norwegian quota of barely 180,000 tons of cod (1989). But the coastal fleet's group quota was fished up as early as the 18th of April of that year.

In order to establish a firm and predictable quota allocation regime, the Fishermen's Association proposed the introduction of the so-called trawl ladder (Paulsen and Steinshamn, 1994). The regulation came into effect in 1990. The system outlines the division of cod quotas between conventional gears and the trawler fleet according to the different sizes of the total Norwegian quota. This principal is also the model for the division of pelagic fish resources (Norges Fiskarlag, 2001, 2007).

Table1[9]
The trawl ladder, allocation of Norwegian cod quotas among the conventional fleet and the trawler fleet.

Total quota (tons)	conventional fleet (%)	trawl (%)
Less than 100 000	80	20
100 000 – 150 000	75	25
150 000 – 200 000	72	28
200 000 – 300 000	69	31
Over 300 000	65	35

Source: Norges Fiskarlag (2001).

[9] The division between the trawlers and conventional vessels from 1989 was revised in 1995-2000 and 2002-2007. The revision contained smaller percentage changes in both extremes of the quota allocation (Norges Fiskarlag 2007, NOU 2006:16).

However, as early as 1987 the Fisheries Department established the 'Contact committee for structural issues in the fishing fleet' (Kontaktutvalget for strukturspørsmål i fiskeflåten), also known as the 'Kjønnøyutvalget'. Its mandate was to identify measures that could reduce capacity and ensure a profitable balance between catch capacity and the resource basis. The committee had based its work on the extensive use of government financial support to the fleet and evaluated the effects. The committee pointed out that the transfer of funds had a paradoxical effect; whilst considerable funds were earmarked for the scrapping and reduction of the number of vessels, the subsidies contributed to the maintenance of over-capacity in the fleet (Kjønnøyutvalet, 1989).
The committee concluded that there was a massive over-capacity in both groups, especially in the trawler fleet. This was based on empirical calculation of the catch capacities at fleet level and of the numbers of the coastal- and deep-sea vessels, as well as different options for available group quotas according to regulations under the trawl ladder. The use of public financial support was no longer a viable option. Instead, the solution to the capacity problems was to be found in the relationship between market-based structural incentives and a limited-resource basis that would be divided at fixed rates between different gear- and vessel groups.

The Kjønnøy-committee granted extended access to the merging of quotas between deep-sea vessels within the same group. The structural gains would be credited to different groups. In order to reduce catch capacity, a vessel would be removing from the fishery and the system would strengthen the quota basis for the remaining participants. The system would act as an incentive for market-based transactions of vessels and quotas. In addition, the committee proposed stricter conditions for the coastal fleet regarding ownership of vessels and stricter activity requirements to qualify for quotas as a year-round fisherman (Kjønnøyutvalget, 1989).

The Kjønnøy committee's proposals were extended in a new white paper (St.meld. No. 58,1991-92) also known as the "Strukturmeldingen"[10]. The revised version of the report proposed the fundamental introduction of an individual vessel quota system (IVQ) whereby a given quota would be allocated according to the size of the vessel. This was intended to apply to the majority of the coastal fleet (St.meld. No. 58, 1991-92).

Compared to previous reports, this white paper (St, meld nr. 58,1991-92) succeeded in obtaining support for what was to become the future fisheries policy. Whilst the post-war reports outlined a series of contradictory objectives balanced with the use of government subsidies, the new white paper succeeded in putting resource management, capacity adjustment and profitability considerations at the top of the agenda.

The new white paper represented the final break with the open and unregulated fisheries in the cod sector. Individual quotas as a privilege system would now function as an important incentive for a new capacity adjustment. Capacity adjustments would

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[10] The first draft of the Structural Report launched a radical proposal for the introduction of individual transferable quotas (ITQ). However, the proposal was unanimously rejected by coastal Norway. The proposal for individual vessel quotas and structural measures, however, was adopted in the revised version of the structural report.

no longer be solely a public responsibility. Largely, it would be the fisherman himself, as an economically rational actor, who would have to adjust his individual capacity. This should form the foundation of an economically viable fishing fleet, with no structural dependency of public subsidies. From now on, capacity adaptations were to be a form of individual and autonomous self-regulation under the rule of a closed regime (St. meld. nr. 58, 1991-92).

3.5 Structure policy and the coastal fleet

The NFA opposed the introduction of vessel quotas for the coastal fleet, but accepted the system as a temporary arrangement pending the normalisation of the resource situation, opening for free fishing (Norges Fiskarlag 1990; Christensen and Hallenstvedt, 2005). However, after a few years, the NFA accepted that vessel quotas should be the permanent model for allocating cod quotas in the coastal fleet (Hersoug, 2000; Holm, 2000).

A short time after the introduction of the IVQ model, it was apparent that the system did not capture the diversity of the coastal fishermen's adaptations to fishing. Smaller vessels were granted larger quotas than their traditional catch. Larger vessels were granted smaller quotas than their historical catch. New and old vessels within the same length group carrying differing debt burdens were granted equal quotas. The new manangement regime served to intensify the allocation conflicts. In 1995, the smallest coastal fleet utilised only 45% of its allocated quotas. In contrast, the largest coastal fleet had the capacity to fish considerably more than their allocated quotas (Landsdelsutvalget, 1996). Thus, the Landsdelsutvalget (op.cit.) suggested fundamental changes in capacity adjustment. The aim was to create larger and fewer units. The NFA and the Ministry of Fisheries (Fiskeridepartement, 2005) supported this strategy. Because the IVQ model integrates the size of vessel and quota into one system, two fundamental measures were introduced; the use of a cut-off date, and over-regulation (overbooking) in fishing[11].

The cut-off date system connected the use of financial measures to increase the number of larger vessels. Financial priority was given to the building of vessels that were between 15 and 28 meters (St. Meld. No. 51, 1997-98). The combination of financial incentives and the awarding of larger quotas based on length of the new vessel had a considerable effect on the fleet structure. From 1990 to 2000, the number of vessels under 10 meters in length was reduced from 1940 units (in 1990) to 818 units (2000). However, the number of vessels between 20 and 24.9 meters increased from 95 (1990) to 159 (2002) whereas the number of vessels between 25 and 28 meters increased from 24 to 55 (Standal and Aarset 2002 #1). The smallest group experienced a real reduction in catch capacity whereas the largest group increased its

[11] Cut-off date: A system of incentives for structural changes in the fleet. Participants who exchanged a small vessel for a larger one were awarded a quota according to the length of the new vessel. This arrangement was practised through the last half of the nineties (Fiskeridepartementet, 1998, Standal and Aarset 2002 #1).

technical catch capacity by more than 100%, representing a massive change in the fleet structure (Aasjord, 2000).

However, parallel to the changes in fleet structure and the increase in capacity, the cod stock also increased in the Barents Sea. From 1990 to 1997, the cod quotas for the conventional fleet increased from 84,750 tons to 267,330 tons (Norges Fiskarlag, 2001). Thus the mis-match of fleet structure and allocated vessel quotas continued; the smallest vessels did not manage to fish their allocated quotas whilst the largest had the capacity to fish much more than their allocated quotas. In response to this situation, the Regulatory Council (Reguleringsrådet) implemented the extensive use of over-regulation (overbooking) of the fishing[12]. Starting in the mid-nineties, coastal cod fishing was characterised by more or less quota-free fishing for several years (Standal and Aarset 2002 #1; St. Meld. No. 20, 2002-2003).

The strong growth in the cod stock combined with over-regulation, however, resulted in a barely visible increase in catch capacity. The use of a cut-off date combined with over-regulation served only as a diversion from the aim of limiting catch capacity. The system contributed to a paradoxical effect; the connection between allocating quotas according to a vessel's size was used as a strong incentive to increase catch capacity in the coastal fleet. Additionally, structural changes in the coastal fleet contributed to a massive increase in capital costs (Budsjettnemda for fiskere, 1998; 1999). The system of over-regulation had nonetheless produced an adequate catch basis to make the investment worthwhile.

From 1997 to 2001, however, the coastal fleet's cod quota was reduced from 267,330 to 137,457 tons (Norges Fiskarlag, 2001). This reduction in quotas removed the basis for over-regulation in the coastal fleet. The largest vessels experienced a dramatic decrease in the catch basis. The over-capacity, enhanced by public financial support, the cut-off-date system and the vessel quota system, became visible. At its national meetings in 1998 and 2002, the NFA announced that a considerable over-capacity had been established in the coastal fleet (Norges Fiskarlag, 2001). In order to prevent any further capacity increase, the authorities introduced new measures, which would block any quota-related advantage gained by changing from smaller to larger vessels[13].

The changes in the quota system increased the internal tension between the different types of fishing vessels (length groups) in the coastal fleet. The need to reduce

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[12] Over-regulation/overbooking: A system to secure that the coastal vessels group quotas were fished by coastal vessels and not transferred to the trawler fleet. A high degree of over-regulation is close to free fisheries within the framework of a group quota while no over-regulation means guaranteed vessel quotas.

[13] Correction date introduced as a parameter in the regulations: The reference to the system of correction date is that the vessel quota system distributes quotas in tons according to the vessel's length (0-28 meters). At the time when the correction date was introduced, there would no longer be a quota advantage from smaller vessels being exchanged for larger ones. Nonetheless, the owner of the vessel can exchange his existing vessel for a larger or smaller vessel, but the original quota will remain unchanged. Thus, the owner who has exchanged a smaller vessel for a larger one will have a smaller quota basis than the length of the new vessel. Because of the extensive transactions of vessels and quotas, there are barely 600 vessels, which have a quota basis that is different from the vessels actual length (Fiskeridirektoratet, 2008).

unprofitable over-capacity developed into an internal allocation conflict. Whereas the larger vessels wanted to maintain the system of over-regulation, the smaller vessels demanded guaranteed vessel quotas. In order to ensure a diverse structure in the coastal fleet and to hinder the survival of the largest vessels at the expense of the smallest, a system was introduced that blocked the transfer of quotas between length groups (Norges Fiskarlag, 2001)[14].

Because of the “Finnmark model”, the largest and most modern vessels did not have a sufficient quota base to ensure a profitable fishery. Therefore, new and comprehensive measures were introduced in 2004 to reduce catch capacity. Based on the grouping in the Finnmark model, opportunities opened up for new and radical structural measures. Transactions of quotas and vessels were introduced within the respective length groups. The arrangement allowed the concentration of up to three quotas per vessel on a permanent basis (structure quotas)[15]. Vessels, which are the object of transactions, were permanently taken out of the fishery. The conversion from vessel quotas to structure quotas produced a reduction in the quota basis. When quotas are exchanged, 20% of the quota basis is returned to all actors in the respective group. The structure arrangement has resulted in 211 vessels withdrawn from fishing (NOU 2006:16). An important characteristic of the structure arrangement is that the market-based transactions of vessel and quotas are limited to the respective counties. In addition, a new initiative of scrapping vessels smaller than 11 meters was introduced in 2004.

Based on the transactions of quota and vessel, the structure arrangement could be viewed as a privately financed or market-oriented initiative aimed at reducing catch capacity. However, the scrapping system is based on a mixed market economy perspective. This initiative is financed in equal shares from a fee paid by all fishermen and from a direct government subsidy[16]. Since the scrapping arrangement came into effect in 2004, 170.8 mill. NOK and 330 vessels under 15 meters have been withdrawn from fishing (St. Meld. No. 21, 2006-2007)[17]. However, scrapping as a means of reducing catch capacity is nonetheless no novel strategy. As early as the 1960s, a similar arrangement was introduced for the coastal fleet. In total, more than 3500 coastal vessels have been withdrawn from fishing. During the period 1998 to 2002, more than NOK 200 mill. were spent on the scrapping of vessels in the coastal fleet. The new feature of the 2004 system was that the government was no longer

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[14] The Finnmark model: Coastal vessels (Group 1) from 0-28 meters are divided into four different length groups, 0-9.9 m, 10-14.99 m, 15- 20.99 m and 21-28 m (Norges Fiskarlag, 2007).

[15] The structural arrangement: 3 quotas per vessel apply if the vessel carries out specialised fishing for cod, saithe and haddock, or within pelagic fishing. However, should the vessel operate with a combination of the above, up to 2 + 1 structure quotas or 3 + 1 structure quotas can be concentrated, dependant upon the size of the vessel. Originally, the system included vessels between 15-28 meters. This length rule has however been extended to vessels between 11-14.9 meters. The latter group is allowed to concentrate up to 2 quotas per vessel. Quota or vessel transactions between different counties are forbidden (St. Meld. No. 21, 2006-2007).

[16] The fishermen’s share of the scrapping system is financed as a 0.25% tax on the primary turnover of fish. The public institution “Innovation Norge” administers this duty today.

[17] The scrapping arrangement was originally meant for vessels less than 15 meters.

willing to take full responsibility for over-capacity in the fleet. The government's requirement for user participation was also related to the discontinuation of government subsidies to the industry. The principal of privately financed capacity reduction no longer refers exclusively to the structure system. Today, it also includes the traditional scrapping of coastal fishing vessels (NOU 2006:16; St.meld. no. 21, 2006-2007).

3.6 Structure policy and the deep-sea fleet

Prior to the 1970's, there was a relative absence of capacity-reducing measures in the deep-sea fishing fleet. The reduction in the number of vessels and fishermen was a consequence of technological improvements, an increasing range of employment opportunities and alternative investment opportunities (Løken, 1984). The collapse in the Atlanto-Scandinavian herring stock at the end of the 1960's illustrates the problems linked to unprofitable over-capacity and the need to reduce (Johannessen and Misje, 2002).

During the seventies, actions to reduce capacity referred to the regulation of participants and scrapping measures in the purse-seine fleet (Ørebech, 1984; Hersoug, 1985)[18]. In the absence of total quotas, these measures could also be described as a form of one-sided input-regulation. Public subsidy plans and natural retirement led to a reduction in purse-seine vessels, from 460 units in 1967 to 150 units in 1985. The practice of scrapping vessels continued during the 1980s. In 1991, the fleet was reduced to115 vessels (St. Meld. Nr. 58, 1991-92). During 1980-85, more than NOK 200 mill. were earmarked for the scrapping of purse seiners. However, parallel with the reduction in the number of vessels, there was an increased liberalisation of the rules for permissible cargo volume. The purse-seine fleet was the object of considerable structural modifications in the form of fewer and larger units. Consequently, the reduction in total cargo capacity was considerably lower than the reduction in the number of vessels (Hersoug, 1985).

Later in the 1990s, the trawl ladder originally intended for the cod sector, was introduced to the pelagic sector, and became the core element for the unit-quota system in the deep-sea fleet (Kjønnøy-utvalget, 1989; St. meld Nr. 58, 1991-92; Hersoug 2005). Compared with Norwegian management practice, the unit quota system was considered to be an extraordinary measure. The aim was to reduce the number of vessels in a group in which catch capacity exceeded the available quota basis in the foreseeable future. Should the number of vessels in a group be reduced, the quota basis of the remaining vessels would be strengthened. Consequently, the system would contribute to improved profitability for the remaining vessels in the group (Standal 2007 #5; Standal and Aarset 2008 # 7).

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[18] Licencing obligations include all fishing with trawl, shrimp trawl and purse seine as well as all vessels over 15.68 meters (50 feet). Other fishing activities are regulated through annual participant regulations, ref. Deltakerloven §21(Norsk Fiskerilovgivning, 2003).

The introduction of structural measures also represented a change from a publically financed capacity reducing system, to a type of privately financed capacity adjustment. Now, structural measures were linked to market-based transactions of vessels and quotas (Fiskeridepartementet, 2005; Rånes, 2003; Norges Fiskarlag, 2001; 2007).

The unit quota system was first introduced into the cod trawler fleet. As early as 1984, fresh fish and freezer trawlers were given the opportunity to concentrate up to 1.5 quotas per vessel (Rånes, 2003). Ownership of purchased quotas was limited to 13 years. Early in the 1990’s, the system was introduced for the factory trawler fleet as well (Norges Fiskarlag, 2007). Because of the crisis in the cod sector, the authorities additionally established support systems aimed at stimulating fishing in distant waters. As a part of the governement’s ‘distant waters strategy’, requirements for participation in Norwegian fishing were also liberalised. The opportunity was now open to remove the trawler fleet from Norwegian fishing for a period of up to four years (Fiskeridepartementet, 1990)[19].

In 1996, the unit quota system was extended to cover the purse seine fleet and all groups within cod trawling[20]. In order to increase market-based quota transactions, the small trawlers and freezer trawl groups were united to form a single market. The opportunity now existed to concentrate up to two quotas per vessel. At the same time, the duration of quota ownership was increased from 13 to 18 years[21].

Despite these changes, the system had a limited effect on the development of capacity. In 2000, the system was extended even further, allowing the merging of up to three quota factors per vessel. But the lifetime for purchased quotas was still limited to 13 and 18 years respectively (Fiskeridepartementet, 2000). Regulations were introduced to reduce the quota basis in respect to vessel and quota transactions in the purse-seine fleet. Here, the structural measurements were clearly anchored in a regional political profile; transfers from north to south resulted in a 40% quota reduction whilst internal transfer within a region gave a reduction of 5% (north) and 15% (south). The quota basis that was freed through such transactions and the resulting reductions was returned to the participants in the group as a whole (Norges Fiskarlag, 2007).

However, the system still had a limited effect on the trawler fleet. The number of vessels was reduced from 109 to 95 units during the period 1997-2005 (Fiskeridirektoratet, 2006). As an additional initiative to reduce catch capacity, the unit quota system was converted in 2005 to a system with so-called structure quotas. The limited duration for the purchase of quotas was extended from 13 to 18 years (scrapping), to permanent ownership on an unlimited basis. The opportunity to

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[19] According to the Deltakerloven (Law on Participation), fishing rights have to be used within a maximum period of 3 years (Norsk Fiskerilovgivning, 2003).

[20] In 1996. the trawler fleet was divided into three groups: small trawlers, fresh-fishtrawlers, and freezer-/ factory trawlers.

[21] If the vessel subject to quota transaction was permanently taken out of Norwegian fisheries, the ownership of quotas was extended to 18 years (NOU, 2006:16).

concentrate up to three quotas per vessel continued. Furthermore, the separate quota markets were merged into one large market for the entire trawler fleet (Fiskeridepartementet, 2004). Regulations were introduced for the reduction of quotas subject to transactions. Percentage reduction was be awarded when converting to permanent quotas, based on how long participants had used the old unit quota system (Fiskeridepartementet, 2005). The volume of quotas released by converting from unit quotas to structure quotas was to be distributed among the trawler fleet. Additionally, strong political regional guidelines were incorporated. As a principle, acquisition permits were not granted for the transfer of quotas from north to south.

The introduction of permanent structure quotas had a dramatic effect on the number of cod trawlers. The number of vessels dropped from 95 to 51 units from 2005 to 2006 (Standal 2007 #5). A corresponding development applied to the purse-seine fleet (subject to licencing) and to conventional vessels over 28 meters (auto-line fleet). Today, 84 purse seine vessels are registered and 37 vessels are registered in the auto-line fleet. For the latter group, this number is about one-third of what it was in 1990 (Fiskeridirektoratet, 2007).

In 2006, there was a change in government in Norway. The new government established a public commission to report on the problems related to the entire quota allocation policy and structural measures in the fishing fleet. Pending the completion of the report, a temporary “structure stop” for the fleet was introduced [22]. The report was completed in august 2006 (NOU, 2006:16) and the main elements of the report were expressed in St. meld. Nr. 21, 2006-2007. Permanent quotas were revoked. Instead, quotas with a duration of 25 years were now granted to vessels that had already benefited from the structure system. For future transactions, quotas with a 20-year duration were granted (St. meld. Nr. 21, 2006-2007). These rules also applied to Greenland shrimp trawlers, industrial trawlers, purse-seine vessels and conventional vessels over 28 meters (auto-line fleet). However, the number of quotas that could be merged on any one vessel varied among the different vessel and gear groups.

[22] The Commission was appointed on January 6, 2006, and was given a mandate to draw up a general structure policy for the Norwegian fishing fleet.

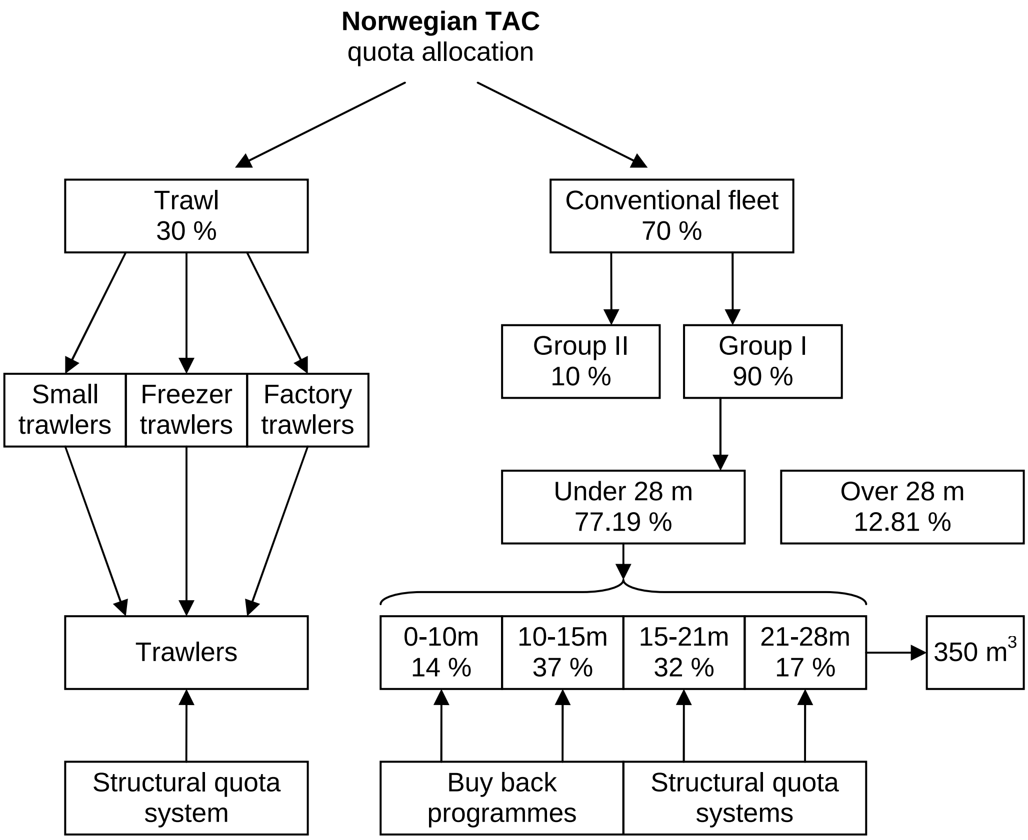

Fig.3. The cod-quota allocation system, different gear- and vessel groups, 2007.
Source: NOU, 2006:16.

As a first step, the total quotas were allocated among the trawler fleet and the fleet fishing with conventional gears. While the trawlers have been merged into one vessel/quota market, the coastal fleet remain separated into several markets or length groups. The structural policy designed for the coastal fleet combined a buy-back (scrapping) programme with the possibility of assigning merged quotas to the remaining vessels.

3.7 Summary

By reviewing Norwegian fisheries policies from 1937 to date, we see that the capacity concept refers to different dimensions at various levels. In the 1930s, the capacity concept was linked to the need for increased efficiency, operating in difficult export markets. During the post war period and right up to the end of the seventies, the argument for new capacity adaptations was linked to the modernisation processes in the land-based processing industry, and to society in general. At this stage, capacity was thus decoupled from resource management. Further, it was linked to the replacement of old rural norms and values, and the need to increase capacity in order to compete with the international trawler fleet. Increased catch capacity became institutionalised through public institutions.

This new adaptation was also expressed as a central element in a bargaining economy[23]. Decisions were made through negotiations and compromises among a segmented government, industry and organisations (Olsen, 1978; Egeberg 1981). Hence, in the establishment of the Main Agreement in 1964, capacity was once again the key concept , as the state guaranteed profitability for a vertically-integrated industrial model (Holm, 1991).

The establishment of the 200-mile economic zones in 1977 and the introduction of modern resource management represented a paradigm change in the capacity debate. Resource considerations were placed at the top of the agenda, followed by a gradual reduction in government subsidies. Scientifically based methods for measuring fish stocks were employed, total quotas were introduced and open-access fisheries were closed. Now, the capacity term was linked to limited fish resources and became a central aspect of the allocation regime. Due to the allocation of scarce resources and the introduction of the IVQ regime, over-capacity became visible and took on a more precise meaning.

While the capacity-reduction measures of the seventies refer to scrapping regimes and governmental responsibility, capacity reduction shifted from the public sphere to the private market in the late eighties. Market-based quota and vessel transactions were put into effect. Adjustment to capacity became more of a private matter. Thus, within the frame of the overall, stable allocation policy, catch capacity had been transformed into a zero-sum game with autonomous self-regulation among actors in different vessel-and gear groups.

However, the tension in the structure debate varied among groups. Capacity- reducing measures in the coastal- and deep-sea fishing fleets have developed at different rates. While the original groups within the deep- sea fleet were integrated into one large market for transaction of vessels and quotas, the development of the coastal fleet has been the opposite[24]. In order to secure a diverse fleet structure, the structure policy in the coastal fleet represents a strong division into several markets. The merger of the different trawler groups into one large market, however, has resulted in the absence of a varied fleet structure. Consequently, the structure policy in the deep-sea fishing fleet refers solely to a strategy of reducing the number of vessels.

Capacity-reduction measures in the relationship between the coastal and the deep-sea fleets are also related to an inequality between public and private responsibilities. The structure policy in the deep-sea fishing fleet is exclusively dependent upon the extent of privately financed transactions of bundled vessels and quotas. In the coastal fleet, however, the state and the (entire) fleet share responsibility for the scrapping scheme.

From an historical perspective, the concept of capacity refers to the fundamental division between two different regimes; before and after 1977 (Holm, 1996; 2001). At

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[23] "The Power Report" was initiated by the Royal Resolution of September 22, 1972, with the mandate to "carry out a survey of the real division of power in the Norwegian society".

[24] Today, the conventional fleet is divided into six groups: four length groups within group 1 (0-28 meters); vessels over 28 meters that fish with conventional gear, and; group II (with no right to guaranteed vessel quotas; Norges Fiskarlag, 2007).

the juxtaposition of these two political perspectives, no joint understanding of the problem has been reached. On the contrary, the capacity debate has led to conflict about interpretation, implementation, adjustment and the suspension of key values. The growth of the new resource-management regime, therefore, cannot be regarded as an isolated movement decoupled from the previous growth phase. The values and norms from the old adaptations have been integrated into the new order. The merger of industrial political aims and resource concerns may also be interpreted as a new (and incompatible) meeting point between organized interests and society in general (Holm, 1996).

Under the new management regime, economic and biological considerations are integrated. Integration of biology and economics is expected to make it possible to calculate both the economic and biological effects of a given catch effort (Flåten, 1983; Hannesson, 1993). In the meeting between fishermen and limited resources, it was thought that bio-economics would contribute to increased predictability and better control of catch capacity.

The introduction of modern resource management led to radical changes in the view of nature-based industries; whereas fishermen at one time had to be protected from greedy fish buyers, fish now had to be protected against the fishermen (Holm, 2001; Johnsen, 2002). Holm (2000) and Johnsen (2005) refer to the resource-management model as the total of a heterogeneous network. Fishermen were transformed from free, unregulated actors into anonymous and thoroughly regulated actors whose function it was to fulfil the aims of the fisheries policy. The resource-management model had become the fisheries policy’s new ideological foundation; a new arena in which the focus was based on scientific knowledge and resource considerations. From now on, the fisheries segment as part of the regional politics was of less importance (Johnsen, op.cit).

The resource management model was meant to stabilise the relationship between output regulations and capacity as input regulations. In this context, the IVQ regime was the very platform for the structural policy as a capacity-reducing measure. In brief, the new quota regime would not only frame the conditions for individual fishermen’s daily life, but would also be the main strategy to secure maintenance and development of the social fabric along the coast (Jentoft and Mikalsen, 2003; Hersoug, 2005).

In this process, Holm and Nielsen (2005) describe the development of modern resource management and the vessel quota system as a framing process. A frame is a boundary and framing is the process of producing this boundary. The development of capacity-reducing measures has taken place within the framework of the IVQ model and the structural policy. One might also describe the development of the structural policy as a form of path dependency that originates from the IVQ regime, or as a road map to solve capacity problems (Standal and Aarset 2002 #1; Standal 2007 #5; Standal and Aarset 2008 #7).

Since 1977, two fundamental state interventions have been established; the production of sustainable total quotas (TAC) and a stable resource allocation regime among the participating actors. With reference to before and after the introduction of the IVQ model, the concept of capacity has been transported through three fundamental phases; open access fisheries, one-sided input regulation, and integrated input- and output regulation.

Consequently, the complexity of the capacity concept has increased and the market-orientated structure policy has gained profound importance. However, while the overall allocation regime remains stable, as a prerequisite for developing the structural policy, the latter has been in a constant movement. In brief, the legitimacy of the TAC-regime and the stability of the allocation regime, have become critically dependent on the structural policy having a strong grip on capacity development.

In the next section, I present various institutional approaches to fisheries management in Norway, laying the foundation for the claim that technology is largely considered as a black box. In the remaining sections, I sketch an alternative approach suggested by the social construction of technology (SCOT) perspective.

4 Accounting for managing technology in modern fisheries

4.1 Institutional theory and the concept of technology

We can consider capacity adjustment to be a reflection of the institutional framework in the management system. The definition of problems, proposal of solutions, and the extent of the institutional framework thus have a decisive significance for the actors' adaptation to fishing. This strategy is based on institutions intercepting and defining relevant approaches to specific problems. Concerning managing capacity within the frame of the IVQ model, institutions are organized to influence desired behaviour in a given arena (March and Olsen, 1989).

Modern fisheries are managed by and through institutions (Jentoft, 2004; 2007). Hersoug (2005) presents an institutional perspective on the growth and effects of the Norwegian quota regime. Such processes do not refer to simple and isolated administrative resolutions. They are the result of negotiations among actors such as the government, industry and organisations (Hersoug, op. cit). The period prior to the introduction of licences and quotas was characterised by a free adaptation that was analogous to a free-market mechanism (Mikalsen, 1982). According to economic theory, the introduction of regulation and the transition to a political-administrative regime might be regarded as a response to possible market failure that requires public intervention (Myles, 1995; Etzioni,1988).

However, there is no generally accepted definition of regulation (Mitnick, 1980). Nevertheless, regulations can be characterised in that they include the rationale for implementing regulations, which refer to changes to the regime. This includes features of the administration, which is to carry out regulations, and they apply to the enforcement of the regulations.

The introduction of the vessel quota system does not refer to unilateral administrative decisions. Analyses of the power structures in Norwegian society indicate that decisions are the result of bargaining processes between the government, private actors and organised interests. In this context, the government's role is to encourage

the use of the market mechanisms but also to mitigate the effects of competition when the market mechanism fails (Hernes, 1978).
Mikalsen (1982; 1987) points out that the allocation of fishing rights does not eliminate the effects of the market mechanisms. Rather, it is access to competition that is regulated through the allocation of limited rights. The transition from a market mechanism to a system of government regulation in respect of criteria for participation in limited fisheries, transfers greater responsibility to the public sector. This emphasises the importance of how management organises and defines the area of responsibility for government policy and the aims it delineates.

With reference to Dahl and Lindblom (1953) and Lindblom (1977), the development of the Norwegian management system can be describes as a stepwise process. Changes in administration are carried out via adaptation of old institutions or by the establishment of new ones. According to Peters (1999), however, institutions can be characterised by the following basic qualities. Institutions:

- are a structural part of society, formal or informal
- exist over time
- affect individual behaviour
- demonstrate some sense of shared values and meaning among the members of an institution

As a reference to the capacity debate, institutions can be viewed as constructions that are designed to achieve specific goals. These instruments can be expressed through incentives and regulations. There may be different restrictions and standard operating procedures that ensure equal treatment of clients. The institutions can also be the arenas that unite structures and regulations, and define the standards for the affected actors. One fundamental assumption is that institutions should contribute to stability, routines and predictability (March and Olsen, 2005). Even though institutions are meant to function as a stabilising regime, they cannot be perceived as static units (Weaver and Rockman, 1993). They change over time and they are carriers of historical events that stabilise the desired course in relation to future challenges.

However, institutions are not only formal instruments aimed at solving specific tasks in a predictable fashion. March and Olsen (1989) also describe institutions as an embedded part of larger social structures. In a study of the cod fisheries, Holm *et al*. (1998) show how fishermen act as both economic actors who pursue their own interests within the framework of existing institutions, and as political actors who attempt to influence the institutions that control their own economic behaviour.

Jentoft (2004) points out that the institution as a concept has many interpretations and definitions. To what extent fisheries management functions well or poorly may therefore be a question of institutional design and the ability to accommodate future adaptations. In spite of different views as to what constitutes good and well-functioning institutions, it is nevertheless generally accepted that institutions are permanent establishments in society.

As for other sectors and for society as a whole, institutions are key elements in the operation of the fishing fleet, its structure and its field of action. As problems arise (e.g. allocation conflicts or severe side effects as a result), we both invoke and employ institutions to solve the unintended problems. In this context, it might be necessary to change existing institutions or establish new ones. Thus, institutions can represent both the problem and the answer meant to solve the problem.

Also relevant for fisheries, Parsons (1990) perceives institutions as systems of norms that "regulate the relations of individuals to each other", which again regulate what the relations of individuals ought to be. According to Elster's (1989) definition, it is not the rules themselves that define institutions, but the instruments that guarantee that one abides by the rules. Institutions are also interpreted as rule-enforcing mechanisms (Jentoft, 2004). Applied to fisheries management and the need for capacity adaptations, institutions use rules to move actors towards defined aims. Additionally, rules act to organise actors in respect to a functioning institutional body. The connection between rights and rules, and organizations as operational agencies, are highly recognized in fisheries management (FAO, 1998). Thus, institutions reflect rules for determining who and what are included in a decision-making process, what action is taken within the frame of the regime, and how individual action will be transformed into collective decisions. In this perspective, a property right constitutes the main element in structuring social relations among actors. Transformed into fisheries, "property" gives actors access to limited fish resources (Ostrom, 1990).

As an element of managing catch capacity, the design of institutions takes on even greater significance. This applies to both the content and extent of the incentive structures built into the institutional framework. A fundamental prerequisite is that the institutional field of activity intercepts the actors' behaviour in a given arena (Peters, 1999). This is the only way that institutions will achieve the necessary effect and legitimacy among the target groups they attempt to manage (Degnbol *et al*., 2006).

In another respect, Scott (1992) points out that institutions function at different levels of jurisdiction in society. This definition is congruent with Ostroms (1990) idea of "nested systems", a perspective where institutions are linked to each other and form networks (Jentoft 2004; 2007a). Scott argues that institutions should be regarded as open systems, in the sense that other institutions can affect a specific institution. Hence, institutions do not exist or survive in a social vacuum, without contact with the surroundings of the arena they are set to serve.

Another aspect relevant to fisheries management is that institutional changes might be an irreversible process in the sense of passing a point of no return. A clear example is the Norwegian quota system that grants actors a rights-based quota within a regulated sector. Of course, the insiders will resist any changes that might threaten their privileged position. With reference to Norwegian fisheries, the fisheries authorities and the Fishermen's Association have tried to solve all the capacity-related problems within the framework of the existing IVQ model and the structural policy (Standal and Aarset 2002 #1; Standal 2007 #5; Standal and Aarset 2008 #7).

Such management goals are collective, but they also affect individual actors. At the same time, fishermen perceive institutions as restrictive to their own business. For example, many coastal fishermen regard state regulations through institutions as the sole protector of their business, while others- such as the ocean going shrimp trawling fleet- fear the introduction of a potential TAC as a worst-case scenario (Standal 2003 #2).

Given that fish resources are defined as common societal resources and not private property, institutions might be regarded as representing a contract between society and the fishermen. However, from time to time, fishermen experience a slow institutional response to crucial problems, creating high transaction costs[25]. Examples include: fluctuations in the fish stocks and the need to adjust quotas via the structural policy; the availability of fish for a given period; the need for reallocation of quotas, or; new opportunities in regard to new and more effective technology. Parameters that are crucial to fishermen's daily life often work independent of each other, having the potential to create complex management problems. The fishermen's real-time experiences may result in pressure for changes in a quota regime that they often perceive as outdated or as an institution that lags behind in addressing present challenges. In summary, capacity adaptations can be regarded as a response to the institutional set-up of the quota regime as a governance system.

However, within the framework of an increasingly stricter regime, the detailed and complex system of vessel quotas is under continuous pressure. First, the vessel-quota regime was supposed to be an alternative to individual transferable quotas (ITQ). However, in order to cope with unprofitable overcapacity, the system was forced to make use of an increasing amount of market-based transactions. The number of fishers and vessels was heavily reduced. The system has led to great structural changes in the fleet and a massive concentration of quota rights (Standal and Aarset 2008 #7). Hersoug (2005) claims that the fish resources, publicly defined as society's resources, are privatized. At the same time, there is great variation in the profitability of the fleet (Fiskeridirektoratet, 2006). The high pressure on fish resources has continued, with built-in allocation conflicts among various stakeholders. The vessel-quota system has not functioned in relation to the basic aim of controlling the capacity development in different fisheries.

As a step in the reduction of catch capacity in Norway, Hersoug (2005) points out that the authority has mainly focussed on *reducing the number of vessels.* Consequently, a reduction in the number of vessels is assumed synonymous with a reduction in catch capacity. This strategy has a strong focus on the number of units and ignores the dynamics of technological development. In such an approach, the overall effects of technology remains locked in –and overshadowed by– the narrow focus on the number of units.

Despite a reduction in the number of vessels, analyses indicate that the problems of over-capacity continue. A survey of the technical capacity development over time shows that newer vessels have a far greater catch capacity, which more than compensates for the reduction in the number of vessels (Aasjord 2000; Aasjord *et al.* 2003a, St.meld. Nr. 20, 2002-2003, Riksrevisjonen, 2004). This suggests that the technical aspects of capacity development in fishing were greater than the effects of structural policy as a capacity-reduction measure (Standal 2007 #5; Standal and Aarset 2008 #7).

Why does the vessel-quota system not intercept capacity development in the fleet segment? Is there a built-in mis-match between input- and output regulations or do

[25] For a definition of transaction costs, see Williamson (1975).

the institutional boundaries fully represent technological adaptations? Holm (1995) finds that institutions in fisheries are slow changers, with a built-in inertia maintaining old and outdated norms and values. Old institutions do not easily "surrender" and necessary reforms may thus not be implemented (Holm, op. cit). As a supplement to the rate of institutional response to the degree of changes in the institutional surroundings, Lindblom (1977) states that institutions develop incrementally or stepwise. The concept of path dependency, the small changes and the willingness to search for solutions close to existing models, is supported by Cyert and March (1963) and Sejersted (1991); they state that organisations are wary of radical thoughts and thus will continue to search for alternatives that only marginally deviate from their current routines or modes.

In the sense of rapid changes to the use of new and more effective technology, the historian Tjelmeland (1993) describes fishers as highly "technology friendly". In contrast, the use of structural policy to cope with capacity adaptations in closed fisheries might be described as a complex and politicised processes with a built-in inertia. Fishermen often describe the structural policy as a set of "delay-mechanisms" that lags behind the need for a flexible response to change in the fisheries sector. Thus, the institutional set-up in terms of the structural policy does not respond in concert with rapid technological adaptations to the overall resource base. On the other hand, institutions can integrate strong incentives for structural changes among actors (e.g. the cut-off date system described in section 2.5). Here, changes in the institutional set up lead to politically desired changes in the fleet structure, but also to an unintended and underestimated increase in the coastal fleet capacity (Standal and Aarset 2002 #1).

However, among major contributors of research and science within the field of institutional aspects in fisheries management, the concept of technology does not seem to have any prominent position or explanatory power. In Jentoft's (2004) illustrative and thorough survey of major institutional theory, the concept of technology as a driving force, tool, problem or solution, is not mentioned as a key factor. Of course, technology can be perceived as a given or embedded element or as a natural part of the fishermen's position in an institutional context, but technology is not explicitly visible as a critical source for problems or solutions related to governance in general.

The role of technology is ambiguous in the institutional literature. According to Scott (1992), institutional theory does not have any specific definition or consensus about the concept of technology. A great many specific measures of technology have been proposed; some of these emphasise different phases of the work process, (such as input, throughput or output) while others focus on different facets of the process (e.g. materials, operation or knowledge). The most important factor in explaining differences in structural characteristics of organisations are three dimensions of technology: *complexity, uncertainty and interdependence.*

As regards the role of technology in the institutional literature, Scott (op.cit) states that empirical studies on the relation between technology and structure often show mixed and conflicting results. Among the factors contributing to this confusion are methodological problems such as a lack of consensus on measurement strategies. Other problems are theoretical in nature, including misspecifications of the level of analysis at which the measures apply, disagreements among participants about the nature of the technology employed, and a lack of clarity about the causal connection between technology and structure.

The idea that the concept of technology is poorly defined is also supported by Perrow (1986) who claims that the most prominent problem related to organisational theory is the measurement and definition of technology itself. A consensus about the definition of technology has not been feasible and refers to that organizations vary in these terms independently of what we vaguely mean by technology (Perrow, op.cit). In addition, many studies of technology in production systems are based on industries where raw materials are abundant. In such situations, capacity-related problems, technological adaptations and bottlenecks in the production line can be solved by increasing investments for a more efficient technology (Thompson, 1967; Hatch, 2001). However, such an approach refers to the opposite of investments in limited fish resources, illustrated by the Gordon-Schaefer model in section 2.3. Given the fact that fish resources are limited, managing capacity should not only pay special attention to the number of vessels, but also emphasise technological development and adaptations as input regulations.

4.2 An open-ended approach

In this part, I present the argument that there should be an increased focus on how technology functions concerning fisheries management. Here, I highlight a theoretical concept that explains how technology appears in society. The increased need to give technological adaptations a more prominent position is also supported by Frost and Andersen (2006). They state that EU's Common Fisheries Policy (CFP) emphasises the need to pay stronger attention to the fleet segments' technological performance. Here, technology is central to the analytical model. As an attempt to "open up or unlock technology", I hope to give more explanatory power to how technology stands in relation to the concept of capacity adaptations and fisheries management.

The social construction of technology (SCOT) is a theory within the field of Science and Technology Studies. Advocates of the SCOT perspective are social constructivists and argue that technology does not determine human action, but that human actions are shapers of technology. A constructivist approach suggests that technological adaptations are embedded in a social context (Bijker *et al*., 1987). Hence, technology is not uncoupled from its own function in a given social arena.

Contrary to this approach, Smith (2001) defines technological determinism as "technological development as an autonomous force, which is completely independent of social constraints". Hughes (2001) perceives technological determinism as "the belief that technical forces determine social and cultural change". Hence, a perspective of how technology is embedded in a social context can also be perceived as a response to a soley deterministic view of technology. Actors within the field of social constructivism have been concerned with moving away from the individual inventor (or "genius") as the central explanatory concept, from technological determinism, and from making strict distinctions among technical, social, economic and political processes of technological adaptations. Instead of a deterministic approach, social constructivists claim that technological adaptations do not stem from “nowhere” (living their own lives), but are connected to social, economic and political structures (Bijker *et al*., 1987).

The theory of technology as a social construct suggests that the reason for acceptance or rejection of a given technology can be found by examining the social world. It is not enough to explain the success of a given technology by saying that it is simply “the best”, but researchers must investigate how the criteria of “being the best” is defined and what groups and stakeholders participate in creating the definition. In particular, they must ask; who defines the criteria by which success is measured? How are technical criteria defined? In addition, who is included or excluded in the process?

The social constructionist perspective is based on how social phenomena develop in a particular social context, a concept that may appear to be natural and obvious to those who accept them as inventions or artefacts of a particular culture or society. A critical element of social constructivism is the analysis of how individuals and groups participate in the construction of their perceived social reality. This approach involves looking at the ways social phenomena are created, institutionalized and made into tradition. Further, socially constructed reality is regarded as an ongoing process in which reality is reproduced when people act on their interpretations and knowledge (Berger and Luckman, 1966). It is in this context, that Berger and Luckman (op. cit) claim that reality is socially constructed.

4.3 Technological systems in a SCOT perspective

The term of “technology” has many interpretations and definitions. In daily life, we perceive technology as nuts, bolts, instruments, machines, tools, etc. that are used for different purposes. In a social constructive perspective, technology is defined as artefacts, but this perspective also emphasises the social elements of technology. If we go to the *Concise Oxford Dictionary*, the definition of technology is expressed as the “science of practical or industrial arts; ethnological studies of the development of such arts and application of science.” In this context, technology is defined as knowledge. But such a definition does not include the ‘hardware aspect’ that is the common perception of technology in our daily lives. Thus, one working definition of technology might be to integrate technology as artefacts and knowledge, e.g. “artefacts and knowledge about their operations” (Olsen and Engen, 2007).

However, according to the SCOT perspective, such definitions omit the context in which all technologies exist. For example, Galtung (1979) describes artefacts and knowledge as the visible tip of a huge iceberg and includes structures as a part of technology. Most authors dealing with technology agrees that technology does not come out of nowhere. Instead, technological developments are based on existing technology, knowledge and practices that are embedded in ongoing production. Thus, the framework for the study of technology is based on the assumption of existing technology as a starting point.

Hughes (1987) claims that large technological system contains messy, complex and problem-solving components that are socially constructed. Technological systems also include organisations at different levels and legislative artefacts, such as regulatory laws. This is an open-system approach, which is the opposite of the economic- or deterministic perspective on technology. Economists often take technology for granted; they perceive technology as “black boxes” that produce an output from a given input (Hatch, 2001). Others such as Latour (1987), Callon (1987), and Law (1997) have developed an actor-network theory (ANT) to study how different actors constitute heterogeneous networks, explaining how science produces nature, which, in turn, is transformed into quotas for fishermen (Johnsen, 2004). Latour’s ANT-theory might be regarded as a response to or an alternative to the “black box” discourse of technology (Myklebust, 1996).

In an ANT-perspective, building a “machine” is about connecting different social and natural forces to each other and transformming the alliance to an entity. In the book Science in Action (1987), Latour provides the following example illustrated by the mortar and the windmill; while a mortar can be used as a tool, a single element that can be used directly by mankind, a wind mill is a machine that connects nature (wind, grain) and people (farmers, carpenters, mechanics, etc.) to each other. Hence, the windmill constitutes an *obligatory meeting place* for both people and nature. In this way, Latour (op.cit) provides a contribution to opening up technology and the need to regard technology in a constructivist perspective.

Within the framework of a constructivist perspective, Hughes’ (1987; 2001) perspectives are more macro-oriented and focuses on technology as “*technological systems”*. He aims to understand the evolution of technology and how technology adapts in society; the focus on technology must include the surroundings of the hardware definition. Here, structures are the modes of production or the social relations where tools become operational and the cognitive structures in which knowledge become meaningful. Furthermore, this approach emphasises how social relations surround technology, affecting the nature of the resulting technology and its effect on society.

The recognition that technology has some social aspects and determinants has led to the conclusion that it is difficult to regard technology and society as two separate entities. Hughes (1987) points out that technical object are embedded in large technological systems. In the book *Networks of Power* (1983), Hughes develops and elaborates this approach further. During analysis of the development, diffusion and consolidation of electrical systems in the large cities (Chicago, London and Berlin) he found striking differences in the choice of technical solutions for distributing a commodity product such as electrical power. According to Hughes (op.cit), technological choices and status can only be understood with reference to how political, economic and social factors affect development and adaptation of technology within a given society. Hence, in the process of establishing and gaining acceptance for specific technological solutions, entrepreneurs have to overcome problems not only related to technical questions, but also to an array of other factors related to law, economics and politics. Thus, one of Hughes’ (1987) main points is that technology can not be regarded as an isolated part of society, but rather that technology and society constitute *”a seamless web”* that are interconnected and interdependent to each other.

Elements of large technological systems are also interconnected and dependent upon each other. For example, an artefact functions as a component in a system interacting with other artefacts, all of which contribute directly or through other components to the commons system goal. If a component is removed from a system or if the characteristics of one component change, the other artefact in the system will alter characteristics accordingly. Additionally, as technological systems emerge, they develop new opportunities and problems. Here, conservative inventions solve the problems close to existing solutions while radical solutions may give birth to new systems.

4.4 Processes of technological development.

The open-system approach to technological studies is regarded as one of the SCOT-perspectives' strongest potential contributions to analyzing technological development and how technology adapts to society. In the SCOT perspective, technological development is regarded as the collective effects of social interactions among relevant social groups and the result of an internal power relationship among stakeholders (Pinch and Bijker, 1987). In this setting, a relevant social group could be defined as a group that is affected by, or is a legitimate stakeholder of issues related to the artefact. However, according to Pinch and Bijker (op.cit), it is essential to state that different actors or social groups are carriers of different interests, values and norms. Hence, their perception of what might be defined as problems and solutions are reflected in their position in society. Such perceptions are connected to what Bijker *et al*. (1987) describe as the *"interpretative flexibility of technology"*. This concept refers to the way in which different relevant social groups can have different understandings of a given technology, including its technical characteristics. This also includes variation in the criteria for judging whether a technology "works" or not. Further, different social actors are defined according to their participation in both developing and using technology. A core element in the SCOT-perspective postulates that technological development, and thus the status of a given technology, is the result of continuously ongoing negotiating processes among relevant actors.

The status of technology is influenced by the distribution of interest directed by a certain technological purpose, its strategy and knowledge among the participating actors. Here, the concept of *technological frame* refers to the ways in which relevant social groups attribute various meanings to an artefact. The frame is defined as a set of goals, problems, knowledge and practices linked to certain artefacts. Further, a technological frame is composed of the concepts and techniques employed by a community in its problem solving. The latter is a broad concept, encompassing within the recognition of what counts as a problem as well as strategies available for solving the problems and the requirements a solution has to meet (Bijker, 1987). A technological frame consists of a combination of current theories, tacit knowledge, engineering practice, testing, goals, and handling and using practice. The latter are variables that strengthen an artefact and establish its position in society (Standal 2007 #5).

While drawing a connection between what Bijker (op.cit) defines as the "process of power" to the stakeholders participating in the technological frame, he proposes an approach for understanding the close relationship of how politics, organised interests and markets affect technological adaptations in society.
This concept is not a fixed or pre-defined entity; technological frames emerge through innovations and the use of technology. Participants of the technological frame are heterogeneous and they are carriers of different norms, values and identities through

scientific knowledge and a user-perspective. With reference to changes in the environment surrounding technology, new values give rise to new frames and the formation of new and relevant social groups (Law and Bijker, 1992).

An important element in such processes is that technology is defined as developed when the most influential actors accept it as developed. After this stage, technological solutions gain acceptance among different interests and interpretations of problems. To use Bijker *et al*.'s (1987) own terminology: after a given technology is accepted by the most influential actors, technology is stabilised as an element in a given arena. However, this process does not mean that problems are solved in the common sense of the word, but it refers to the fact that the most dominant actors have gained the greatest influence in the process. After technology is stabilised through acceptance, Pinch and Bijker (1987) find that it is hard to remove technologies from the arena in which they are set to serve. Thus, the choice of technology that prevail in society, does not necessarily need to be based on true or objective values; it depends of who has the power, the strategy and the knowledge to define the technological problems and present the right solution (Bijker *et al.*, op. cit; Standal 2007 #5; Standal 2008 #6).

After technologies are accepted in specific arenas, *technological systems gain momentum*. Technological momentum represents systematised knowledge, and its culture is embodied in a variety of economic organisations and social institutions. It is the culture of technology, expressed both in large-scale organisations and institutions (and in the career commitments of individual practitioners) that creates technological momentum (Edwards, 1987). Hughes (1987) states that technological systems, after prolonged growth and consolidation in society, do not become autonomous, but they acquire momentum. Large technological systems develop a mass of technical and organisational components; they possess direction or goals, and display a rate of growth. Such systems can be both a cause and an effect. They can both shape and be shaped by society. As they grow larger and become more complex, technological systems become shapers of society and are less shaped by it.

Large technological systems arise especially from the organisations and actors committed by various interests to the system. Such interests could be public and private utilities, investment and banking houses, scientific societies, manufacturers and public regulatory bodies that add greatly to the use of specific technological systems. However, a high level of momentum often causes observers to assume that technological systems have become more autonomous; pressuring the arena it is set to serve. Thus, as a comment to the poles of social constructivism and determinism, Hughes (2001) places the impact of technological momentum more or less in between these two concepts.

Another important input to the shaping of technologies is the amount or rate of innovations. These might be dependent on the number of different social groups participating in the process; if no dominant social group controls the innovation process and resources are distributed among many different relevant actors, many innovations may occur. However, if only a few social groups are participating and strongly defining their perception of problems and solutions, the technological solutions and rate of "new thinking" tends to be more conventional and less radical.

The latter is what Bijker *et al.* (1987) describes as a cumulative process of technological change– with only a few social groups participating, technological innovations are only a result of traditional functional failures. Hence, innovations are incremental and do not represent any “paradigmatic” change. Such processes tend to be less visible than radical changes driven by a greater number of heterogeneous stakeholders in an open arena. Without using the expression “path dependency” explicitly, Bijker at al (op.cit) claim that further development of technology might follow incremental steps from one generation of technology to the next (Standal 2008 #6).

4.5 Summary

This chapter highlights important institutional aspects of governance systems. Here I draw up some major guidelines to aid understanding of main variables for managing capacity in modern fisheries. The Norwegian management system is anchored in an array of strong institutions. The guidelines contain built-in restrictions and incentives for moving the fisheries towards desired goals that reflect political values and the overall aim of sustainability.

However, despite the strong institutional set up, managing capacity is a complex topic that is continuously high on the fisheries political agenda. The main institutional focus has been on design of the management framework. In this perspective, capacity has adaptations have been a congruent with the number of vessels. However, within several sectors of Norwegian fisheries, there has been an increase in capacity even though the number of vessels is reducd. Thus, the vessels’ technological performance has been underestimated and technology has been regarded as a black box.

In order to ‘unlock’ the capacity concept and reveal the dynamic processes of technology, a stronger focus on fishing vessels as technological systems is needed. The perspective of social construction of technological systems places technology in the centre of the analytical model. The aim of this approach is to provide a reference for the understanding of how technological adaptations emerge on a given arena and the dynamic effects of technological choices. Thus, unlocking technology in an open perspective, which is not only congruent with a focus on the number of vessels, can serve as an input to understanding the tension between institutional design and the effects of technology as a crucial part of input regulations.

In the next section, we will see how technological innovations were born, implemented and gradually changed, in close cooperation with the institutions that were established to manage fisheries. However, unlike the institutional approach described in the previous section, this interpretation stresses the dialectic interplay between technology and institutions; trying to unpack the black (technological) box.

5 Dynamics of technological adaptations

5.1 Stabilising fisheries technology

Fishing gear such as purse seines, trawls and conventional gears (such as long lining and coastal fleet adaptations) have an ancient history. However, they have all taken huge steps in terms of modernisation and efficiency. While conventional fishing traditionally refers to simple and open coastal technology that is based on the fish' migrating pattern, purse seining and trawling refer to larger vessels and industrial adaptations. As described in part 3.2, the introduction of trawl fisheries in Norway was a disputed process, causing severe conflicts among the fishers. However, the question of trawling did not only refer to a choice of technology, it was also a core element in the overall strategy for shaping the future of coastal Norway after World War II. The trawl technology gained a strong momentum as part of the post-war modernisation process.

The strategic choice was part of a strong state policy that also provided financial support for the build-up of a capital-intensive trawler fleet to secure steady supplies to the land-based filleting industry. Thus, state authorities, land-based industry and local communities where the processing factories were located (including the supply industries), supported the emerging trawler fleet. In addition, the many shipyards along the Norwegian coast supported the new policy, benefiting from the spin-off effects from this new strategy.

The network or alliance between state policy and private initiatives established in order to create a new industry can also be seen as a response to the emerging international fisheries outside the Norwegian coast. Neither the state authorities nor the fisheries sector would quietly accept that foreign vessels would outcompete the traditional coastal adaptation. Even though the emerging offshore fleet was intended to "supplement" the coastal fisheries, state policy and infrastructure investment for the modernisation of the fisheries segment moved cohesively to establish an offshore fleet.

The establishment of trawl technology and purse seining as new technological adaptations are examples of how new technology is introduced on a specific arena (Bijker *et al*. 1987). Strong social groups gained acceptance for their own definition of both the problems and the solutions for how to increase efficiency in the fisheries (and in processing). Their perceived values and norms for the efficiency problem weighed more strongly than that of the opposition, represented by the seasonally based coastal fleet and the rural lifestyle. In this context, new technological adaptations, advocated by dominating groups, while the old solutions were defined as outdated and unable to fulfil future demands for a modern industry based on marine resources (Standal 2007 #5; Standal 2008 #6).

5.2 A predictable pattern for technological development?

When modern trawling technology was put on the agenda after World War II, it was in a state that can be described as 'an open system'. This was long before the UN processes of establishing the 200 miles exclusive economic zones for coastal nations and the subsequent introduction of TACs and limited quotas. Strong fishing nations such as the UK, Germany, France, Spain and Norway were all taking part in developing the trawl technology, creating an array of many different participants, each perceiving trawl technology from a different perspective. According to Bijker *et al*. (1987), the rate of innovation is dependent upon the number of social groups participating in the process. The most important innovations of trawl technology emerged during the 1960s and 1970s. At the time there was a large number of participants in both development and use of the trawl and other ocean-going fisheries technology.

Major innovations in modern fisheries include the move from a dangerous and less effective side-trawling adaptation, to modern stern trawling; the change from operating one single trawl to double trawl lanes; the introduction of freezing technology; mechanic power blocks for pelagic fisheries, and; automatic baiting machines for the ocean-going long lining fleet. They represent a paradigm shift in technological development, leading to increased efficiency and new adaptations to fisheries, all contributing to placing the fisheries in a value-chain perspective (catching, processing, marketing).

However, following the introduction of the 200-mile economic zone in 1977, the subsequent “nationalisation” of fish resources, and the continuous efforts to cut down overcapacity, there was a shift in innovation processes. Many of the former nations mentioned above lost their old positions in the North Atlantic fisheries. The trawl sector in Germany and UK hardly exist anymore and the number of trawlers in Norway was reduced from 130 vessels in the 1980s to 50 vessels in 2007. This pattern also applies to purse seiners, the long-lining fleet and coastal vessels. A strong reduction in the number of vessels has taken place for all relevant groups (Fiskeridirektoratet, 2007). Thus, on both an international and a national basis, there has been a strong reduction in the number of actors participating in the innovation processes for accepted technologies.

In a study of the Norwegian oil and gas industry from 1970 and onwards, Olsen and Engen (2007) consider technological development as an evolutionary process where innovations follow cumulative and predictable pathways. In this context, the evolution of technology follows a trajectory, which specifies a “curve” describing technological development. Olsen and Engen (op.cit.) describes how further development was guided by knowledge embedded in existing technology, the supply industry and strong communities of practice in the oil and gas industry. The strongest stakeholders were politicians, government institutions, oil companies, suppliers and labour unions. All together, they constituted a complex web of different interests in which common technological frames emerged. The technological adaptations described in the oil and gas industry are regarded as extremely expensive adaptations. However, while the state paid most of the costs through tax exemptions, this offered few incentives for new thinking or paradigmatic shifts. Accordingly, vast resources were invested in incremental technology development that neglected more cost-efficient alternatives. Although most stakeholders realised the urgent need for development of a new technology, they were more or less locked in by former decisions, sunk costs and a strong dependence on the old paradigms.

This approach is also relevant for the technological development in the fishing fleet; an initial period of major innovations was followed by a period of fewer innovations; the industry became increasingly capital intensive, largely path dependent and had only incremental technological improvements. The owners of factory trawlers have not been able to further develop their own concepts for the future, or convince state authorities about their own legitimacy as part of a viable concept. The strong reduction in the number of vessels, the high concentration of quotas and the fact that the remaining owners were regarded as a steadily more exclusive part of Norwegian fisheries, have pushed the trawler fleet out of the national innovation system. Thus, within this old paradigm, their chance for survival was a demand for increased quotas. Given an ever stricter regime, however, this has not been a viable strategy for the survival of factory trawlers as a segment of the Norwegian fleet (Standal 2008 #6).

This approach is not only of relevance for the cod trawlers in general or for the factory trawlers. Olsen and Engen's (op.cit.) description of the oil and gas industry, following a development based on old and expensive solutions, is of relevance for the entire fishing fleet in general. The lack of new technology or the absence of paradigmatic shifts in the sense of new and more cost-efficient technology can be understood as a reflection of the state policy. Within fisheries, this refers to the fact that fishers are exempted from public fees related to the use of mineral oil and entitled to public subsidies of the vessels' fuel costs. Thus, heavy fuel consumption and innovations to reduce fuel consumption have not been on the agenda. In turn, this has reduced the overall incentives for developing more cost-effective adaptations in the fisheries (Standal 2003 #2; Standal 2006 #4).

The SCOT-theory operates with terminology such as *stabilized technology* and a *cumulative rate of innovations.* Nonetheless, this is not congruent with a state of stagnating efficiency. It indicates that further development occurs within the frame of existing technology, a predictable path with a technological dependency from one generation to the next. Indeed, the Norwegian fishing fleet has strongly increased its efficiency since the 1980s. This has, however, been through dynamic processes that have occurred without any major innovations or paradigmatic shifts. Due to changes in vessel design, *a greater number* of the *existing technologies* are installed on board (Standal 2008 #6).

The aggregate effects are expensive technological solutions based on traditional knowledge. Nevertheless, this strategy should not come as a surprise. It merely follows another old hallmark of Norwegian fisheries; compensating increased costs through the traditional strategy of increasing catch rates. Thus, the qualitative aspects of technological innovations are reduced. Value added strategies for increased income for a given amount of quotas and increased cost-effective solutions have still not gained sufficient momentum among fishers or in the national innovation system. Hence, within the framework of a closed regime, costly technological adaptations develop faster than changes in the IVQ system and a shifting resource base; this long-term strategy puts increased pressure on the management regime and lack of sufficient capacity adaptations.

5.3 Shaping coastal fisheries

The closure of the unregulated coastal fisheries and the introduction of a rights-based quota regime represented a fundamental state-imposed intervention to the coastal fleet's basic adaptation to fishing. The introduction of the quota regime contributed to convert coastal fishing from a state of "inherent resource responsibility" to an economically rational participant (Maurstad, 1990; 1997). Maurstad (op.cit.) claims that the quota regime constructed a problem to be addressed that was a prerequisite for Hardin's (1968) postulate; open access leads to over-fishing and depletion of the fish stocks. Since the introduction of the vessel-quota system, coastal fishermen have changed their way of fishing (Karlsen, 1998). Because of institutional constraints and the political goal of the full-time fisherman, fishermen have been forced to intensify their activity. In order to meet the quota regime's demands, increased efficiency has become a normative requirement. This works both ways; catching your quota is a prerequisite for maintaining your right to fish, while catching as much as possible for an unregulated species is considered important in order to qualify when a new fishery is going to be closed (Standal and Aarset 2002 #1; Standal 2006 #4).

Karlsen (op.cit.) explains this by the fact that economic and cultural processes have supported each other and created an internal dynamic for increased efficiency in fishing. Originally, the open and season-based coastal fishing was adapted to the land-based employment systems, including their relationship to the household and local society. Technological adaptation and catch efficiency were not only based on the cods' seasonal migration pattern, but also local employment systems. Following the introduction of the vessel-quota regime, however, capacity adaptation in fishing was given a universal definition. Now, efficiency and profitability are the ultimate goals, also in the coastal fisheries.

Politicians and administrators had powerful ambitions of creating an egalitarian fisheries regime. The egalitarian mindset was strongly anchored in the institutional design of quota distribution. The idea was to construct and standardise the behaviour of coastal fishermen, thus using a homogeneous perspective of the participants.

The visible expression of standardisation of the coastal fishermen was an equal allocation of the quota basis according to the size of their current fishing vessel. Regardless of age or the extent of capital costs of a vessel, the age of fishers or varying needs for income from fishing, participants with the same vessel length were awarded identical quotas. This principle constituted the profound structural element of the IVQ model.

However, a basic characteristic of the coastal fisherman was precisely that he did not belong to a homogeneous group of participants. Among all types of fisheries, the coastal fisherman's adaptations represents the strongest diversity of fishing, with a variable set of adaptations depending on age, technological status, capital tied up in operating equipment, size of household and employment opportunities in the local fishing village. Thus, within the framework of the IVQ model, *unequal fishermen were treated on an equal basis.* Many fishermen were allocated larger quotas than their previous catch, whilst others were allocated far smaller quotas than their previous average catches.

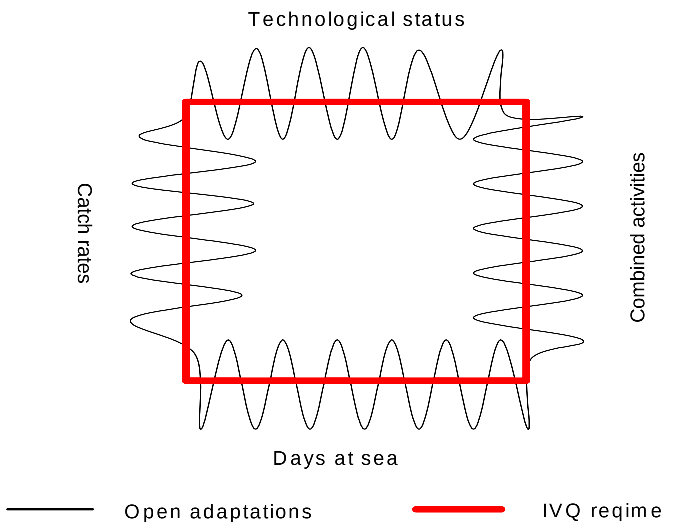

Fig 4 Closing the coastal fisheries; open adaptations and the IVQ model

The authorities constructed a map that did not correspond to the original terrain. The new project represented a form of institutional mismatch between the aims of the individual fishermen and the political goals of the fisheries authorities.

In order to adapt coastal fisheries to the new order, new technological adaptations became a core element to fulfil the aim of the regime. The introduction of the entire quota regime and the underlying goal of the rational full-time fisherman was the momentum for reshaping and adapting technology to fulfil the aim of the state intervention.

The introduction of the quota regime aimed at the coastal vessels can be interpreted as a technological momentum for a new fleet structure. The ongoing processes of technological adaptations are clearly expressed by the changes in the institutional framework. As described in section 3.5, technological adaptations have been important elements to fulfil the goals of the new regime when shaping the coastal fishermen to fit the new rationality (Standal and Aarset 2002 #1). However, in the next section we shall see that the new IVQ regime also implied an increased demand for liberalisation of technological adaptations.

5.4 Liberalisation of technology

Fishers compensate for regulations by a process called “technological creep”. This means that actors adapt their gear, vessels and behaviour to maximise profit when effort restrictions are imposed, processes that not necessarlily leads to any reduction in the overall catch capacity (Jennings *et al*., 2001). In earlier years, the building of so-called “paragraph vessels” was a common feature used to describe state-imposed measures on technological development. Technological limitations were actively used to reduce (or stabilise) the total catch capacity in various vessel groups (Utne, 2007). Since the 1970s, the number of “paragraph vessels” has increased. Due to advances in technological development, the fisheries management used physical parameters of the vessels, such as length, gross tonnage and cargo hold volume, to adjust catch capacity to available resources.

However, the use of “paragraph vessels” generated an array of negative side effects. The vessels owners, lawyers and ship designers used their creativity to design and adapt vessels to evade state-imposed regulations. In addition, actors holding quota rights in different fisheries designed their vessels for dual operations. When the quota base consisted of different species that varied independently, the fishers tried to maximise catch capacity. Here, technological adaptation to different fisheries caused the development of “paragraph vessels” with a negative impact on overall capacity adaptation, safety, profitability and fuel consumption (Aasjord *et al*., 2003b).

Because of the negative side effects, the vessel owners were free to make their own design regarding renewal and the actual size of vessels. As described in Standal (2003 #2), this process began in 1998. Prior to 1998, shifting governments practised a regulation aimed at controlling the *volume of fleet renewal* of all vessels longer than 34 m, being part of the license system. The regulations implied that the total annual costs for building new vessels (in the limited entry system) should not exceed a total of NOK 1 billion[26]. The result was a slow renewal rate in the fleet. However, because of a strong opposition from both the NFA and the Fishing Vessel Owners Association (FVOA), the government abandoned these restrictions. In addition, only two years later the government repealed the regulations related to vessel size.

Thus, from the end of the 1990s, there was a strong liberalisation and deregulation with regard to state governance of fleet renewal, the size of fishing vessels and the overall fleet structure. Later, the liberalisation in terms vessel size, was also applied to the coastal vessels. The authorities have abandoned length regulations as regulatory parameters. Due to strong pressure from the relevant vessel owners and the NFA, this group is now regulated only by restrictions on the volume of the cargo hold. Thus, many of the vessel owners have exchanged their former vessels of 20-27.9 meters to vessels ranging from 35 to 55 metres (Fiskeribladet-Fiskaren, 2008a).

The result in terms of actual catch capacity has been considerable, given the fact that the liberalised legislation covers both coastal vessels and the entire ocean-going fleet. New and more efficient vessels have been introduced within all vessel categories, generating opportunities for new adaptations in the fisheries sector and for further technical capacity increases, even though the number of vessels has been reduced (Riksrevisjonen, 2004; Standal 2005 #3).

5.5 Institutional limits and open technology

The next development in Norwegian fishery management was the division of catch capacity into specific sectors. Specifically, a single-species management regime and institutional boundaries between the different species. The introduction of the IVQ system for different fisheries was the definition of borders or the very universe for the

[26] If, for example, each vessel was estimated to cost 100 mill. NOK, then ten vessels could be built per year.

quota regime and the participants' functional sphere of activity. As biology and technology are integrated into a single entity in the IVQ model, it follows that technology should be adapted to the quota basis that was allocated to vessels within the different fisheries (cod, herring, mackerel, etc.).

The actors who intended to adhere to the institutional boundaries, as a prerequisite for coping with capacity allocation, expanded to other sectors that lie outside the defined institutional framework. This is illustrated by vessels that were originally awarded rights within a single species (for example, cod, herring or mackerel) also carried out intensive fishing for other species using the same vessels. The original arena has become a part-time arena that no longer encompasses the participants' year-round adaptation to fishing.

As an example, the resource base for the purse seiners refers to herring, mackerel and capelin. However, as an expanding strategy, the same vessels have developed an intensive trawling for blue whiting in the North-Atlantic basin (Standal 2006 #4). We see the same pattern in the cod-trawling fleet. While their original foundation was based on demersal white fish trawling in the Barents Sea, the same vessels have expanded into shrimp trawling (Standal 2003 #2). Additionally, part of the coastal fleet that is regulated by the vessel quota system for cod fishing, has adapted its year-round activity to a combination of closed and regulated fisheries and more or less unregulated species (regulated access, no TAC).

Table 2
Catches (tons); restricted access, unregulated species with no TAC, Norwegian fisheries, 2004.

Species	catches (tons)	%
Blue whiting	958 768	
Horse mackerel	10 748	
Tusk	11 897	
Ling	14 554	
Northern prawn	58 961	
Total, TAC unreg. species:	1054 928	**41.80**
Total Norwegian catch:	2524 008	100.00

Source: Fisheries Directorate, 2007.

The Norwegian catches of unregulated species are restricted open-access fisheries. While blue whiting is fished by vessels holding licences for herring and mackerel, tusk and ling catches refer to the long-lining fleet and shrimp catches to the specialized shrimp trawlers and combined cod-trawler fleet. In total, more than 40 % of the entire Norwegian catch refers to more or less restricted-access fisheries without fixed TACs, an adaptation that is known to be very capacity expanding (Homans and Wilen, 1997).

Consequently, for many of the most important commercial gear- and vessel groups, the year consists of an adaptation to both closed and unregulated TAC fisheries. The free adaptation for each participant thereby refers to a framework that protects a privileged few, but which has allocated free fishing for stocks not regulated by TACs.

Thus, a few participants are protected by a regime that reduces competition by limiting the number of participants.

The opportunity for expansion within the framework of “free fishing” was a particularly attractive combination for the participants who had originally operated within a strictly regulated regime for purse-seine fishing for herring and mackerel and trawling for cod. Throughout the 1990s, this combination became even more apparent through the choice of technological adaptation to fishing. The latest generation of vessels, which combine purse-seine fishing for herring and mackerel with trawling for blue whiting, have adapted their vessels for blue whiting trawling rather than for the strictly regulated herring and mackerel fishery (Standal 2006 #4).

A similar development can be observed for the cod-trawler fleet in Norway. In order to strengthen the vessels’ overall resource base, the combination of strictly regulated cod fishing with regulated open-access shrimp trawling have become a capacity-expanding combination. As a technological adaptation to shrimp trawling, the existing cod trawlers were reconstructed from vessels that were fishing with a single-trawl system to fishing systems with a double trawl system, a new adaptation that requires stronger main engines, new factory lines, electronics and winch systems. Furthermore, it is apparent that a series of the largest cod trawlers have bought licences for shrimp trawling from smaller and technologically outdated vessels (Standal 2007 #5). Thus, major structural changes have taken place in the shrimp-trawler fleet. The number of smaller vessels has been reduced, whereas the number of larger vessels has increased (Standal 2003 #2).

Combined fisheries as a source of capacity increase and complex adaptations are also highly relevant for the coastal fleet. According to statistics from the Fisheries Directorate (2007), more than 400 coastal vessels are conducting combined fisheries. The most prominent adaptation is the combination of demersal cod fisheries and purse seining for Norwegian spring-spawning herring (122 vessels). While the quotas for cod have been fairly stable over the last ten years, the quotas for herring have increased from a Norwegian TAC of 150,000 tons in 1992 to more than 925,980 tons in 2008 (Norges Sildesalgslag, 2008). Due to the strong increase in quotas for herring and a strategy for an increased focus on economics of scale, the new adaptations are linked to seasonal fisheries for herring rather than the cod fisheries.

5.6 Capacity feedback from combined- and regulated open-access fisheries

New adaptations such as trawling for blue whiting and shrimp would be perceived as beneficial to the original sectors of herring/mackerel and cod. Existing vessels within the respective sectors have strengthened their operating basis through new adaptations that lie outside the original quota system’s area of activity. This has undoubtedly contributed to easing the pressure on the original sectors that were already characterised by over-capacity. For example, the cod-trawler fleet involved the acquisition of licences for shrimp trawling and the rebuilding of vessels to accommodate double trawls and the processing of shrimp on the factory deck. Investments totalled roughly 40 mill. NOK per vessel. From the mid-1990s and onward, the shrimp sector was characterised by considerable optimism. It was a sector with no TAC on catches, good prices for shrimp and low oil prices for the most energy-intensive fisheries. In total, the strategy for obtaining permanent shrimp-trawling licences as combination was regarded as a cheaper alternative for full-time use of the vessels than buying expensive and time-limited ownership of cod quotas for the same purpose.

However, just a few years after the cod trawler fleet’s heavy investments to strengthen its operating basis, the price of shrimp was severely reduced. During the year 2000, prices were halved and energy prices more than doubled. This combination was bad news for the most energy-consuming fishery. In addition, most cod trawlers lacked sufficient ice-classification for year-round fishing in icy waters, limiting their activity in the high north. Finally, strict by-catch regulations on juvenile cod and red fish in the shrimp catches led at times to the closure of important areas for shrimp trawling.

The strategic investment in shrimp trawling was thus a fiasco for the cod trawlers. After a few years of trial fishing and extensive losses, shrimp trawling in combination with trawling for cod was ended. Instead, fishers were left with their original cod-trawling arena, but now with considerably greater capital costs and increased catch capacity because of investments in double-trawl systems. This also increased the need for a higher income *followed by enhanced pressure for new structural measures in the cod trawler fleet.*

Whilst the shrimp-trawling crisis refers to market failure and a considerable increase in oil prices, the development of fishing for blue whiting was characterised by a decline in resources and increased oil prices. A long-standing conflict between nations claiming their rights to fishing for blue whiting has resulted in the practice of unregulated fishing for several nations. Over the years, this situation has functioned as a strong capacity-driving force and as a strategy for growth among the participants. During the period 2005-2006, the total catch for blue whiting was as high as 2.2 mill. tonnes. In 2007, following warnings from ICES and IMR, a joint agreement was successfully negotiated on the future distribution of the stock. For the subsequent year (2009), ICES suggested a TAC of 409,000 tons blue whiting, a proposal that reflects the poor condition of the blue whiting stock and the heavy economic losses for the fleet.

As with the case of the cod trawlers’ unsuccessful attempts at shrimp trawling, we see that the strong decline in blue whiting stocks makes over-capacity in this fleet even more apparent. Hence, when the open arena declines, the capacity build-up affects of both the original and closed arena appear (Standal 2003 #2; Standal 2005 #3; Standal 2006 #4; Standal 2007 #5).

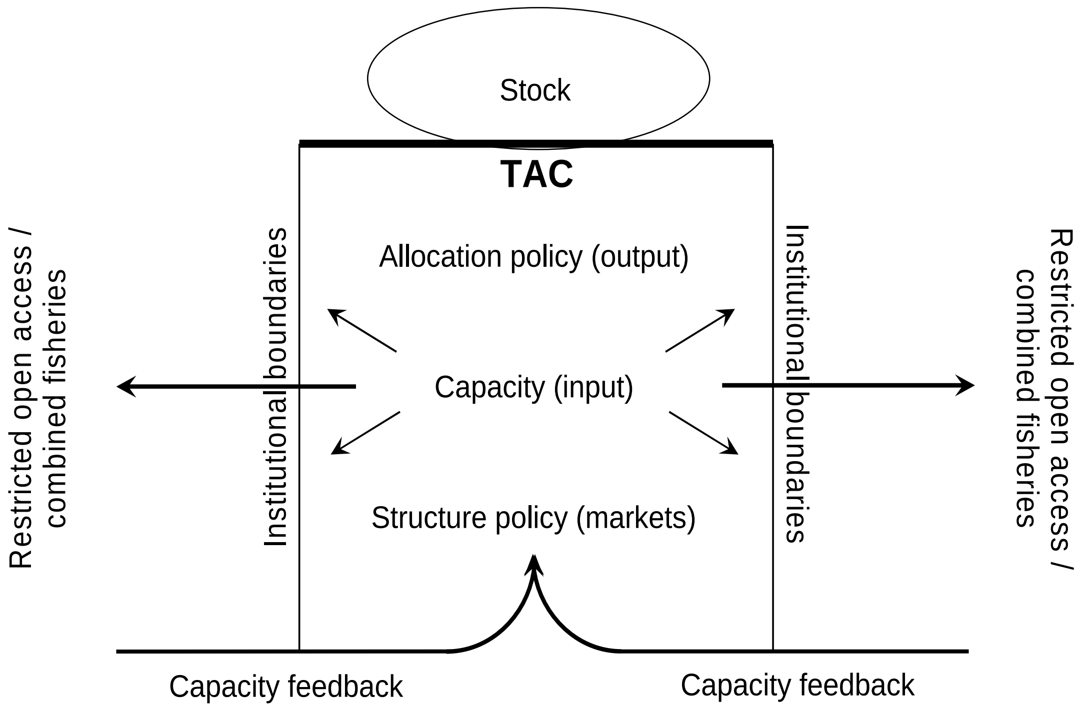

Fig.5 Capacity adaptations and capacity feedback from combined fisheries and restricted access fisheries with no TAC.

The cases from the fleet combining regulated open-access fisheries with no TAC and strictly quota-regulated fisheries like cod, herring and mackerel, illustrate core elements of managing capacity. An important element is that modern fishery technologies do not follow the institutional boundaries of fisheries management. Instead, fisheries technologies are open systems and they work across institutional limits. Thus, much of the effort of governing catch capacity within strictly regulated fisheries has been severely disturbed by new adaptations to unregulated species throughout the North Atlantic. Institutional limits within the closed sectors have not managed to restrict external capacity adaptations in other fisheries. In sum, managing actors who combine mobile and open technologies for operating in several arenas with different institutional frameworks, has proven difficult. In retrospect, the technological expansion and increasing mobility have been underestimated by the governance system (Caddy, 2000). In addition, the range of technological adaptations has been wider than the boundaries of the arenas from where the vessels originated.

5.7 Decoupling technology

Rules regulating vessel design and restrictions of cargo-hold capacity and vessel length in particular, have always been a crucial part of the IVQ system. Now, however, the state authorities have given away the management of vessel capacity. Technical capacity as a part of the input regulations is still a crucial part of the bundled IVQ system. However, within the framework of the IVQ system, the layout of technical capacity has been ‘opened-up’ and largely privatized. State authorities have withdrawn from managing the technical layout of the fishing fleet as a capacity issue, and technology has now gained a new momentum, putting further pressure on the institutional framework of the IVQ system. Hence, the closing of the commons coupled with the introduction of licences and quotas as an institutional arrangement to manage for sustainable fisheries have not been sufficient. Given the strong dynamics of technology and individual technological adaptation, we must also consider how technology affects the input regulations of the IVQ-model.

Despite the state authorities decoupling of technology management from the input-regulations, the authoroties still has strong ambitions to adjusting overall capacity to shifting fish resources. Hence, when capacity problems arise due to collective effects of privatised capacity build-up, the problems are collectivised in terms of state action and expanded market-based structural policy interventions. These processes are very much in parallel with current trends in the private banking sector (Standal and Aarset 2002 #1: Standal and Aarset 2008 #7).

Decoupling and liberating technology as one of the core variables in an IVQ system can be perceived as a paradoxical situation that disturbs the total balance of the IVQ equation. Seen from an institutional perspective, this might be regarded as a system failure or we might assume that the public policy system has used up their available options within the IVQ system. On the other hand, loosening governance of technology from the public sphere can also be perceived as a general pattern of a new public policy; the decentralisation and market orientation of a former public domain.

The public reforms known as New Public Management (NPM) are characterised by disintegration, decentralisation and market orientation of decision-making processes (Christensen and Lægreid, 1998; Christensen *et al*. 2007). The NPM advocates a stronger user-group participation to cut public costs and to achieve a more efficient state bureaucracy. Transformation of technological adaptation from rigid state governance to the fishers own rationale might be in line with the NPM strategy. However, if the decoupling of technology from state governance is the result of decentralisation of a former public domain, the new technological frame will face profound questions related to balancing individual freedom and the boundaries for state responsibility. Thus, it turns out to be a question of fishermen’s autonomy within the framework of public governance.

In this situation, fishers are both economic and political actors, trying to gain political influence over the arena where they conduct their own business. Allowing fishermen to make their own choices in regard to time for fleet renewal and capacity adaptations in general, is not necessarily to be seen as a result of an isolated public-policy delegation. It might also reflect the bargaining power of the NFA and its associated member, the FVOA.

5.8 Towards a numerical structure policy

The trawl ladder is the most profound management tool to secure the quota basis for the coastal fleet segment. The allocation regime serves as a fundamental prerequisite for the aim of a diverse coastal fleet structure, represented by the Finnmark model. However, besides the reduction in number of vessels, an important effect of the structural policy is the huge structural change in the entire fleet segment. In addition, a large part of the institutionally defined “coastal vessels”, are no longer coastal vessels. Their quotas stem from the coastal-vessels quota base, but they have in reality become deep-sea vessels. With reference to the system described as the “cut off date” in section 3.5, and the liberalisation of vessel design in 5.4, technology has decoupled the basic reference between length groups and quota allocation. Hence, both the effect of the institutional barriers enacted to secure a diverse fleet structure, and the basis for capacity adaptations as input regulations have been reduced. In total, profound elements of the structural policy that was designed for securing a specific fleet structure have lost their function. Instead, the structural policy has become numeric, with no qualitative content.

In this context, the structural policy designed for the coastal fleet, follows in the footsteps of the trawler fleet in terms of institutional design. The trawler fleet originated from three separate quota markets. As the need for structural measures has been enhanced, the different groups were merged into one large quota market, a strong incentive for market-based quota/vessel-transactions and a reduction in the number of vessels. In comparison, the entire coastal vessel segment is moving in the same direction but lags behind the homogenisation of the trawler fleet’s structural policy. While the trawler fleet has come to an end-station in terms of one common quota market, the coastal vessels are still divided into several sub-markets. Thus, within the coastal segment, one option could be to ‘build down’ existing but outdated barriers for more flexible adjustments among different gear- and vessel groups. However, with reference to the trawler fleet, further loosening up barriers into fewer but bigger quota markets will lead to increased market transactions and concentrating the quota base among even fewer vessels and actors (Standal and Aarset 2002 #1; Standal and Aarset 2008 #7).

The description above takes into account that the structural policy functions as a profound buffer for the politically based allocation of fish resources, a crucial element of the TAC-machine. However, technical regulations and allocation of scarce fish resources attracts attention from different stakeholders, such as the NFA, the vessels owners’ organization and the organised fish-processing industry. These groups address their own needs, which are not necessarily congruent with the maintenance of the TAC-machine. As a reference to the publicly appointed Regulatory Council, many different stakeholders are represented[27]. Hence, allocation is as an arena that is receptive to other factors than a strict focus on scientifically based fish resource management. Allocation becomes a meeting place for different stakeholders, possessing different amounts of bargaining power.

In this arena, the main pattern is that strong interests contribute to a division of short- and long-term policy instruments, a division of the public policy that is congruent

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[27] Members of the Regulatory Council are appointed by the Fisheries department. In total, 17 different organisations make up the board, representing fishers, research institutes, the processing industry, county municipality and organisation for the preservation of natural resources. In recent years, the meetings have become open for public participation. From 2006, The Regulatory Council, constituting representation from specific organisations are replaced by the Regulatory Meeting. The latter is open for all participants.

with input- and output regulations. Here, annual quota regulations refer to short-term regulations while the structural policy refers to long-term strategies.
With reference to balancing input- and output regulations as the main vehicle for the IVQ model, we have seen that technological adaptation as part of the input regulations has broken the institutional regime for securing a diverse fleet structure and reduced the possibility of balancing capacity. Short-term strategies for resource management combined with a long-term structural policy have proven insufficient to stabilise the fishers' adaptations. From my point of view, this is why capacity issues and the structural policy are kept high on the political agenda; we are searching for traditional solutions applied the old regime. Here, the structural policy is invaded by industrial policies and actors pursuing their own interests. In sum, it turns out to be a narrow-minded view, limiting new solutions and participants, inhibiting more innovations that might herald a paradigm shift. If this is the case, perhaps it is time to consider new reforms.

5.9 Decoupling technology and structural regulations; from IVQs to ITQs?

Now that the authorities have given up the management of vessel size as part of the input regulations, it is time to ask whether the entire IVQ system should be dismantled. This could mean the creation of two separate markets instead of today's complex market, based on technology and biology in terms of bundled access rights and quotas. Within the framework of today's allocation policy (e.g the trawl ladder), such a solution might mean an individual transferable quota system (ITQ) with strict boundaries between different gear- and vessel groups. The introduction of ITQs does not automatically imply one national market for all species, independent of fishing gear and vessel size. However, the advantage of introducing ITQs is a less cumbersome system, as the close connection between the right to fish a given species and the quota for that species will be loosened. Fishermen would not have to buy and sell vessels (with adjoining fishing rights) in order to adjust their total catch quotas.

In a survey of New Zealand's fisheries management regime, Hersoug (2002) states that capacity adaptations within the frame of the ITQ model are not a matter of state responsibility. On the contrary, based on the logic of a regime with market-based quota transactions as an allocation mechanism, it follows that capacity adaptations are the fishermen's own responsibility.

This assumes that fishers act as rational actors trying to maximise the economic income from a given number of quotas. Within the principle of an ITQ model, many different types of restrictions can be built in to prevent the market from beoming the sole ruling order. Such boundaries may include; separate markets to ensure that a variety of different adaptations coexist (like today's trawl ladder); separate markets for different areas (e.g. north/south); and built in restrictions in terms of quota concentration per vessel or vessel group.

The ITQ model is based on the principled assumptions that market forces will maintain the best overall economic outcome by clearing the market with the correct market prize. This assumption is based on differences in economic efficiency among fishermen. Thus, an equal amount of quotas among actors with different efficiencies represents a higher value for the most efficient fisherman. In such a situation, leasing or selling quotas from the least efficient to the more efficient actor might represent an economic gain for both parts parties (Crafton, 1996).

However, the most profound criticism of the ITQ model is that the system leads to a strong concentration of quota ownership. In addition, the system does not emphasise the importance of securing fish resources to areas that are most dependent upon fisheries. In Norway, the original intention of choosing the IVQ model has been to avoid the empirical effects experienced in the Icelandic fisheries (Eythorsson, 2000).

Recent studies of the Norwegian management regime show that the IVQ model has not been able to prevent the concentration of quotas, secure a sufficiently diverse fleet structure or to stabilize the fleet structure (Hersoug, 2005; Standal and Aarset 2002 #1; Standal 2007 #5). Of course, the institutional framework of the "trawl ladder" separates and secures the coastal fleet from the ocean-going fleet as regards quota allocations and transactions. However, within this wider framework, the IVQ model has not managed to avoid quota concentration or to secure its original goals regarding the creation of a diverse fleet and a geographically dispersed fleet structure (Standal and Aarset 2008 #7).

In this context, the movement from today's market-oriented IVQ model to an ITQ model with built-in boundaries hardly represent any paradigmatic shift in terms of management regime. In 2005, Hersoug (2005) wrote a well-documented commentary to the former fisheries minister in which he stated that the fish resources in Norway still belong to society, that is to the Norwegian people. Hersoug (2005) concluded that the processes that occurred after the closing the commons were paramount to the privatisation of fish resources. With the exception of the important aspect that quotas do not last for eternity but are time-limited entities (20 and 25 years of duration), the end result of the market-oriented IVQ model does not differ significantly from an ITQ model with built-in boundaries.

Most likely, the Norwegian management model has passed a point of no return. The system is obliged to follow the existing pattern in the future. According to fisheries management authorities, the only way to solve the capacity problem is via a reduction in the number of vessels. A shift to an ITQ system will not change the direction towards further concentration of vessels and quota ownership. However, decoupling quota transactions from vessel transactions might lead to a more efficient and flexible allocation mechanism, a larger profit in the fisheries, lower transaction costs and lower public expenditures for administrating the fisheries segment.

5.10 Fewer actors and future innovations

In section 4.4 and 5.2, I have described the degree of innovation as a function of the number of users of a given technology. While a large number of heterogeneous actors might be congruent with a high degree of innovation, a low number of homogeneous users might lead to a lack of innovations and hence more conventional solutions. In Norwegian fisheries, the number of vessels has been dramatically reduced. For example, in both the trawler fleet fishing for cod and the combined purse-seining and blue-whiting trawler fleet, less than 40 vessels are left in each group. The factory trawlers that counted 25 vessels in the end of the 1980s have now been reduced to 8 vessels (Standal 2008 #6).

Parallel with the strong reduction in the number of vessels, the innovation rate has declined. In a recent study of fishing vessel fuel consumption, Ellingsen *et al*. (2008) find that fuel efficiency among trawlers has not increased. Even though deep-sea trawlers have strengthened their quota base via the structural policy as a strategy for economies of scale, fuel consumption per kilo catch has not improved. On the contrary, the catch rates have increased while fuel consumption has increased in a linear manner (Ellingsen *et al*., op. cit). Such technological adaptations might be a strong signal of a stagnating technology in the use of natural resources (Graedel and Allemby, 1995). While important parts of the fishing fleet have not increased in fuel efficiency, a great many other energy-consuming technologies have done so (Graedel and Allemby, op.cit). Due to a tradition of low fuel prices and state subsidies, high fuel consumption or the need for energy efficient innovations have not (until very recently) gained sufficient attention among the fishers.

Over the last few years, fuel prices have increased dramatically. In addition to salary for the crew and fixed capital costs, fuel costs have become the biggest single expenditure for the deep-sea fleet (Fiskeridirektoratet, 2006). Given the fact that fuel costs are a sole expenditure for the vessel owners, the heavy increase in fuel prices have removed part of the anticipated profit to be gained from the structural policy. Thus, the need for energy efficient innovations in the fisheries has become urgent. The need for future innovative development, especially in the deep sea-fleet might be approaching a *critical mass* in terms of participation in the public innovation system[28]. The increased diversity of specialized equipment producers to the fleet reflects the increased complexity of fishing vessels (Johnsen, 2005). However, a further reduction in the number of fishing vessels, might remove the market base for future innovations of specialised equipment to the fleet. Collectively, this could lead to technological stagnation in terms of innovations and hence a less cost efficient fleet. Such a trajectory might increase the pressure for further traditional structural measures and consequently, increase existing conflicts over resource allocation.

5.11 A goal-based approach for sustainable fisheries management?

However, the aims of future innovations and sustainable fisheries are not necessarily found within the frame of the traditional quota allocation and the structural policy. In an open-technology perspective, crucial factors such as oil consumption per kilo catch can function as input for identifying the most effective adaptations to the fisheries. In recent years, the reduction in greenhouse gas emissions from the fishing fleet has been high on the political agenda. This is because Norway has committed itself to international agreements such as the Gothenburg protocol (Statens Fourensingstilsyn, 2006).

[28] From 2005 and onwards, fisheries technology as a research programme is removed from the agenda of The Norwegian Research Council (NFR).

Utne (2006) describes the Norwegian governance system as pre-fixed barriers in terms of gear adaptations. The basis of this system is the single species TAC-machine and certain gear-and vessel groups that are ‘locked-in’ by the present allocation policy. Within the overall frame of allocating TACs for individual species, gear groups such as trawlers, purse seiners, gill nets, long lining, etc., are divided into several fixed groups. One of the main variables of new technological solutions is thus pre-fixed (or ‘locked-in’), before the start of the search to identify the most sustainable solutions. Each fisher is locked-in to his gear technology and size group in the IVQ regime.

A first step in an alternative approach is the identification of the users’ needs. At this level, conflicting objectives among users may be balanced and the best possible solution designed. The management policy can be related to performance requirements and specifications for a goal-based approach (Utne, 2006). The aim is to move from detailed rule solutions towards functional rule solutions directed at decision-making and management (Hovden, 2002). For example, a rule might specifiy, “specific limits for maximum fuel consumption in fisheries”, without indicating how the result is to be achieved. This implies an increased use of internal performance indicators that represent more hierarchical strategies (Utne, 2007). Such rules may be directed towards the use of technology, human performance, and organisational conditions (Graedel and Allemby, 1995).

Functional regulations and specifications of responsibility among legitimate stakeholders may contribute to the fulfilment of the rule objectives. In fisheries, technological development and rapid shifts in the resource base complicate the updating of current regulations. Hence, an important distinction is that functional regulations may handle rapid changes better than detailed regulations, because the focus is on the legislative objects and not on the instruments per se (Hovden, 2002).

In order to link capacity adaptations to effective fuel consumption, one strategy could be to introduce stronger restrictions or incentives to reduce energy consumption. In 2001, the Ministry of Fisheries and Coastal Affairs proposed green-house gas emissions quotas for the fishing fleet. The quotas are intended to be estimated and allocated based on fuel consumption of the most effective vessels in each vessel group. Consequently, most vessels will be assigned quotas that are unreasonably low. Hence, they will have to pay for excess emissions. Most likely, the suggestion will lead to increased taxes for the fleet, which is currently exempt from CO2-tax. In order to increase sustainability, such a goal-based strategy may encourage the use of less energy-intensive catching methods and contribute to the reduction of excess capacity in the fisheries.

The simple idea of using energy or emission quotas as a replacement for limitations on an array of specific gear adaptations is an attempt to introduce a greater number of functional legal regulations in fisheries. Here, the actors must decide for themselves how they can catch fish with as little fuel consumption as possible, and design a strategy for further technological development and increased focus on achieving sustainable solutions.

The goal-based perspective related to fuel consumption illustrates a more open regulatory approach towards sustainability. This approach can also serve as a contribution toards reducing the complexity in today's complex fisheries management. In principle, if the most fuel-effective technological solutions are found within specific gear- or vessel groups, which are locked-in by institutional boundaries, then we should consider an opening of these limitations. Hence, with a goal-based management strategy in terms of fuel consumption, the boundaries for technological adaptations should be built-down. In addition, state-imposed demands for fuel efficiency might function as strong incentives to promote increased innovation. As a logical consequence of the public fuel policy, the fishers' position in the national innovation system may be enhanced, creating new frames for increased research and a more prominent position for new technical solutions across existing institutional boundaries.

6 Concluding remarks

In Norwegian fisheries, capacity adaptations have been subject to various stages of the modernisation process, from capacity build-up in post-war open systems, to the need for capacity reductions within closed and regulated fisheries. In terms of modern fisheries management, these adaptations reflect processes whereby important variables have become institutionalised and interconnected. In this context, the construction of the IVQ model constitutes the formal reference for the capacity concept. However, from the scope of the debate surrounding public capacity, we see that governing capacity also concerns the balancing of contradictory goals, for example management directed towards maximising economic profit vs. allocating quotas to obtain maximum employment and a reasonably stable settlement pattern. In Norwegian fisheries management, the search for a strategy to manage capacity has been a project requiring a balancing act between these two incompatible goals (Standal and Aarset 2002 "1).

In order to fulfil the ambitious fisheries policy laid out by the IVQ model, the essence of the capacity concept has been subject to different interpretations, partly because both the state and organised interests have different perceptions and ideas about how capacity should be defined. Thus, a strict strategy to avoid unprofitable overcapacity has been sacrificed in order to cater for a rural policy and to secure Norway's future share of unregulated straddling fish stocks (Standal 2006 #4). Parallel to such capacity-increasing processes, Norway has addressed the modernisation of their fishing fleet and the need to reduce unprofitable overcapacity. This has been done by increasing the transactions of bundled vessel- and quota-rights to concentrate fish resources to fewer vessels, all within the framework of a stable allocation policy and a structural policy in constant movement.

In light of the IVQ model, the formal capacity concept refers to the integration of participants, the vessels' technical catch capacity and a given amount of limited quotas under one regime. This integration demonstrates the difficulties inherent in connecting the main management variables in a sustainable manner; the fluctuations of the TACs, the technological development and the number of vessels. Capacity adaptation is connected to the short term 'TAC-machine' and the long-term structural policy. While the consept of aTAC-machine refers to annual processes of scientific stock assessments and the production of a total allowable catch as output regulations, the structural policy is set to handle input regulations (the number of vessels and the vessels' technical capacity). Furthermore, the structural policy is based on a political but stable division of quotas among different gear- and vessel groups (the allocation policy). In order to adjust capacity in a sustainable manner to the allocated quotas, technology must gain a prominent position as a vital part of the input regulations. Thus, managing capacity has become a matter of balancing technical capacity and the number of participants as input regulations with the allocated quotas (TACs) as output regulations.

Because fish resources are still defined as "common property" (i.e. belonging to society/the Norwegian people) the responsibility for managing capacity clearly rests with the state. However, the fisheries segment is well known as a corporative arena where important decisions are made through compromises between state and organised interests. Thus, managing capacity can also be perceived as a bargaining policy between public policy and organised interests such as the Fishermen's Association and the Fishing Vessels Owners Association.

However, the IVQ model not only shows us the complexity of managing capacity in a sustainable manner, it also indicates the number of variables that can be used as an argument to fulfil legitimate stakeholders' interests. When we take into account all the different aspects of the fisheries policy as expressed by the IVQ model, the concept of capacity reflects a certain ambiguity, a concept that opens up for a definition by stakeholders, most often in terms of well-organised interests. Consequently, the process of identifying problems and solutions of capacity-related issues depends heavily on which social groups and stakeholders have the power to influence the main variables of the capacity concept and deliver the best solution (Standal 2008 #6).

In this context, technology as a vital element of the capacity concept has proved hard to manage. When large technological systems, such as the deep-sea fleet, gain acceptance by the authorities and stabilise in a given arena, they acquire a strong momentum and tend to spread out. As a result, technological systems become institutionalised as a legitimate part of a desired fleet structure in order to fulfil the overall aim for the current fisheries policy. However, an established fleet structure gains a mass of technical and organisational efforts, which also seek to fulfil their own self-interests. In order to define and tackle capacity-related problems, and to maintain and expand their own position, technological systems may thus deviate from fulfilling the original intentions of the public strategy, and instead pressure the existing regime. Thus, a specific fleet group may seek solutions that are not necessarily congruent with the original (political) intentions of technological adaptations (Standal 2007 #5; Standal and Aarset 2008 #7).

From this point of view, the fisheries authorities have underestimated the complexities of governing technological adaptations within the complex IVQ model. The narrow focus on *the number of vessels* as congruent with the fleet's catch capacity has lead to a 'black box perspective' of technological modernisation processes. Thus, the regime has not been sufficiently able to limit or catch up with the strong increase in actual capacity, even though the number of vessels has been reduced within several important gear- and vessel groups.

Recognising the lack of correspondence between the number of vessels and the development of the fleet's catch capacity is vital to understand how capacity adaptations affect the balance between input- and output regulations, as well as the overall management regime. Here, the annual production of a TAC forms the basis for the allocation policy, dividing the TAC into several group quotas among different gear- and vessel groups. Furthermore, within each group, the quotas are distributed among a limited number of vessels, which again forms the basis for concentrating several vessel quotas per vessel via the structural policy. Within this complex regime, the fishers are expected to adapt their catch capacity to their allocated quotas. Thus, if the capacity adaptations are not functioning in accordance with the need for a sustainable fishery, fisheries management may lose legitimacy among participating actors. Such a serious management system malfunction may threaten the important goal of maintaining a strict border between the fish stocks and the annual production of sustainable TACs. This situation may then lead to the over-fishing of limited fish resources (Holm and Nielsen, 2004).

However, both the TAC-production and the allocation policy as the basis for individual vessel quotas, refer to a regulated single-species management and a reference for capacity adaptations. Nevertheless, particularly within the deep-sea fleet, one of the most capacity-driving adaptations has been found among vessels conducting a combination of closed and regulated fisheries and fisheries with limited number of participants but with no TACs. In 2004, more than one million tons of the total Norwegian catch came from fisheries based on resources that were unregulated by TACs, that is, without quota control[29]. These fisheries provided strong incentives to increase capacity, even though other fisheries, where the same fleets participated, were strictly controlled by individual quotas through the IVQ system.

When non-quota regulated fisheries such as blue whiting and shrimp trawling decline in economic performance, the actors leave the capacity-expanding arena (*exit*) and return to their original arena. They bring with them a large overcapacity, expressing their needs for further structural reforms (*voice*) to cope with unprofitable overcapacity (Hirschman, 1970). Hence, adaptations to non-quota regulated fisheries with restricted access create capacity feedback mechanisms, which again affect the capacity adaptations within the closed, and quota-regulated fisheries (Standal 2003 #2; Standal 2006 #4; Standal 2007 #5). Here, the structural policies within strictly regulated fisheries are described as institutional inertia or "delay mechanisms", which lag behind the capacity adaptations from vessels operating on several arenas. In this context, the need for a regime that allows a flexible response to rapid changes in the resource base is hampered by the strong institutionalisation of the IVQ model and political processes to maintain a specific fleet structure. Thus, in principle, fisheries with no quota regime should be considered further regulated, not only in terms of restricted access but also by the introduction of a TAC regime (or alternatively by an effort regime).
The dynamics and impact of technological adaptations are also highly relevant for the coastal fleet. The original intention of the IVQ model was based on a strong coupling of specific vessel length and quota size, a regime that was supposed to improve the

[29] The total catch amounted to more than 40 % of the total Norwegian catch in 2004 (Fiskeridirektoratet, 2006).

predictability for the professional fisherman and to secure a diverse fleet structure. However, in order to transform and streamline the various adaptations within coastal fisheries into a homogenous group of year-round rational economic actors, new technological adaptations became a vital part of the strategy. Over time, the visible result related to institutional changes in terms of liberalisation of vessel-size regulations, a motion where the size of a given vessel no longer corresponded to the size of the vessel's quota base. Hence, central elements of the IVQ model that were established with the intent of securing a diverse fleet structure have lost part of their original intentions (Standal and Aarset 2000 #1).

Further, coastal vessels have increasingly become deep-sea vessels in terms of physical size and technical capacity, but their quota base nonetheless stems from the coastal vessel group. This issue has triggered a severe conflict in the allocation policy debate (FiskeribladetFiskaren, 2008b). Additionally, the transformation of coastal vessels into deep-sea vessels can be the first step towards merging coastal vessels and deep-sea vessels into fewer and bigger quota markets across the established institutional boundaries of the allocation policy (the trawl ladder).

The allocation policy and the structural policy have more or less relinquished qualitative aspects of regulation and currently focus only on the number of vessels. Hence, the management regime is drifting towards a position of just separating the trawlers from the rest of the fleet (table 1). In this context, the structural policy is reduced to drawing up rules regulating the number of quotas that can be concentrated for each vessel or deciding the framework for market-based transactions of bundled quotas and vessels. Thus, if the allocation policy is to retain the political aims of reflecting specific goals for a future fleet structure and 'protecting' the coastal fleet's quota base from the deep-sea fleet, then we need to redefine the institutional boundaries and the definition of coastal- and deep-sea vessels.

The difficulties of managing capacity adaptations can also serve as input to a new debate about state responsibility. The public policy system has increasingly transferred the responsibility for solving capacity problems over to the fishers themselves. Hence, the fishers have demanded increased freedom to solve the problems related to unprofitable overcapacity. In practice, the aggregate effects are expressed as more liberal rules for vessel size adaptations and increased market-based transactions. The development of this strategy has been a one-way project (based on path dependency and incremental steps), that has concentrated greater numbers of quotas to steadily fewer vessels. In addition, these long-term institutional changes passed the point of no return many years ago; the system is inevitably drifting towards a more market-based regime. Thus, within the existing allocation policy and the IVQ model, one can expect further structural changes in the same direction; increased possibilities for quota concentration per vessel; further concentration in terms of ownership, and as a consequence; fewer and bigger vessels with increased catch capacity.

Thus, in order to reduce unprofitable overcapacity within the closed and complex IVQ model, technological adaptations are liberated and their role strengthened as open and more autonomous systems, pressing the limits of existing institutional boundaries. Hence, the governing of technical capacity as part of crucial input regulations is reduced.

The need for capacity-adapting mechanisms, however, has not lost its importance. Therefore, when public policy has resulted in the decoupling the correspondence between quota size and vessel size in order to obtain a specific fleet structure, we can say that managing capacity itself leads to a *decoupling* of input and output regulations within the IVQ regime. One alternative strategy is the transition towards a modified ITQ model. As a fundamental contrast to the bundled IVQ model, ITQ-transactions of quotas and vessels can be transformed into two separate markets, which are institutionally distinct. The consequence is the dismantling of the IVQ model and the deconstruction of the capacity concept, a strategy in which capacity adaptations are taken out of the public sphere and become a private responsibility (Standal and Aarset 2008 #7).

Nevertheless, such an approach involves redefining the public sphere and the private actors' responsibilities concerning governing capacity. The major principles of the allocation policy were designed at a time when there existed profound differences between coastal vessels and the deep-sea fleet. State responsibility for governing capacity was a logical consequence of a regime that was based on built-in strong political goals and financial support for a specific fleet structure. Now, liberalised rules governing vessel design, partially privatised capacity adaptations and privatised fish resources could function as strong inputs for a new debate about redefining state responsibilities.

Rather than defining technology as merely a number of vessels within the frame of the allocation policy and the IVQ model, technological adaptations can be unlocked as a source for future sustainability. In this perspective, the Norwegian management system can be perceived as having 'locked-in' different gear- and vessel groups through the implementation of institutional boundaries such as the existing allocation policy (Utne, 2007). Hence, pre-fixed barriers already define new and future technological solutions that are geared towards more sustainable fisheries. In principle, the existing regime, in trying to solve all the problems within the allocation- and the structural policies can be replaced or supported with a strategy, implementing demands for e.g. fuel consumption as input for a more sustainable fleet structure. However, implementing such a strategy to pre-fixed gear allocations emphasises the need for a more open-ended technological approach that transcends the boundaries of the present allocation policy.

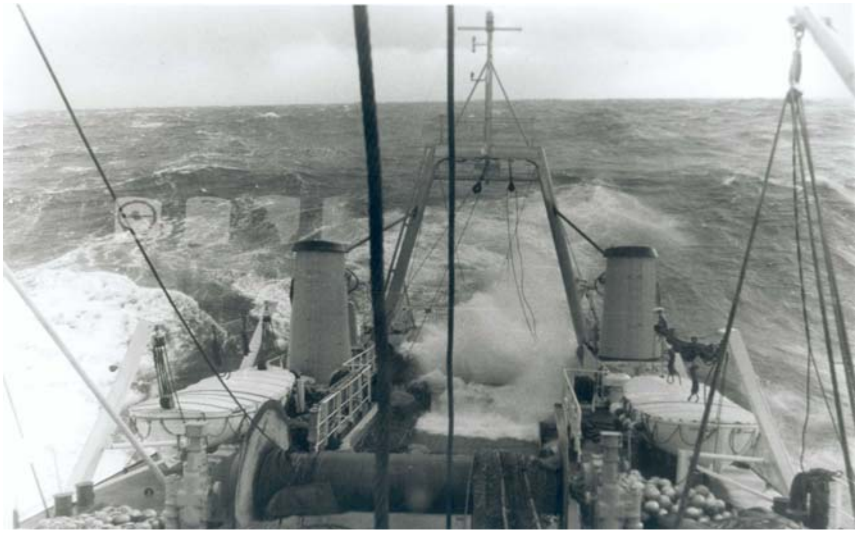
Holm & Nielsen (2004) raised the point that allocation- and the structural policy receive too much attention within the frame of the TAC-production. The allocation policy and the structural policy are easily influenced by organised interests, overshadowing the importance of resource management and the need for a future sustainable ecosystem approach. Hence the transition from the IVQ model to a modified ITQ model with built-in environmental obligations, could in principle involve the decoupling of the capacity concept from both allocation and structural policy. This approach could also involve a reduction in state responsibility and thus transform capacity adaptations into market-based adaptations that cross existing boundaries formed by today's allocation policy.

The introduction of a modified ITQ model is thus one possible response to the interconnection of open- and closed systems in the existing IVQ model. A deconstruction of the IVQ model would be congruent with a deconstruction of the capacity concept into several variables, each of which depend on each other but are institutionally separate. Additionally, this strategy results in the responsibility for sustainable capacity adaptations being delegated to the fishermen themselves. This has not previously been implemented in Norway (unlike New Zealand and Iceland) most likely because the fisheries authorities fear that overcapacity problems inevitably end up as a political responsibility, similar to the present banking problems (regardless of the private responsibility for the sub-prime crisis, the authorities will have to sort out the solutions).

Other management alternatives such as the forming of regional resource companies have been high on the political agenda, with many claims that these are viable alternatives to the existing IVQ model (e.g. Trondsen, 2004). The background for the regional resource company model is the perceived loss of fishing rights, particularly from the most fisheries-dependent districts in North Norway. Thus, the central idea is to acquire fishing rights and quotas and then lease them out to the fishers in the region, with an obligation to deliver the catches in the same region. In a leasing model system, the quotas are not institutionally linked to the vessels as they are in the IVQ model. However, even though the regional initiative represents a partial decentralisation of fisheries management from the state level to the regional level, the focus of the model is not a specific response to coping with capacity-problems. The extent to which the responsibility of formulating viable capacity adaptations rests on the regional authorities or solely on the fishers themselves (expected to behave like fully rational economic actors) remains unclear. Instead, the focus of the regional approach can be seen as an overall strategy to block transactions of fishing rights and quotas between regions. In this perspective, capacity adaptations are locked to the regional level but it is not a strategy where capacity adaptations have any prominent position.

The Norwegian experience confirms the need for a more open perspective on technological systems in fisheries. The role of fishing vessels is in constant movement in terms of increased technical efficiency, constantly pushing the boundaries that define the fishers' own framework. In addition, fishing vessels have become steadily more multipurpose vessels, integrating technologies for catching different species, which are institutionally separated from each other in management terms.

However, traditional variables in modern fisheries management do not need to be the sole force for shaping technological adaptations in fisheries. Important elements such as fuel consumption or environmental needs, tourist fisheries or industrially based cod farming as competitive element to traditional fisheries, can all function as external inputs for shaping the institutional design and future technological adaptations. For example, some of the latest deep-sea vessels are constructed as integrated technology platforms for combined fishing and research vessels (Liegruppen, 2008). Furthermore, the latest proposals for the next generation of deep-sea fishing vessels include the ability to operate in a combination of fishing and oil-service ships in the high Arctic. The Norwegian company Aker has proposed the build-up of a multifunctional fleet connecting the (paradoxical) combination of oil services and fisheries. This strategy will create new technological adaptations among a new combination of actors who meet at a common technological platform (Adressavisa, 2008).



F/T Labrador, winter 1981. Rough waters for future trawlers?
Photo: Dag Standal, 1981.

The future proposals for new fishing vessels include brand new combinations for capacity adaptations. Paradoxically, this reminds us of the *rural strategy* advocated by Brox (1966), but now with completely new combinations. Hence, the ideal capacity adaptation need not be found within the complex goal of establishing the full-time fisherman but may perhaps turn out to be occupational combinations to new and (so far) open sectors.

The articles that make up this thesis describe the complexity of different sectors constituting major parts of the Norwegian fisheries. Although the different fisheries are organised around a common management platform, they all differ in technological adaptation and institutional design in terms of regulations and historical context. The complexity surrounding capacity management demonstrates that there are no single "one size fits all" solutions. Governing capacity is not about "painting the floor with a hammer" (Degnbol *et al.* ,2006). Thus, to understand the driving forces behind capacity adaptations, I have suggested a novel approach. Defining technology as only "nuts and bolts" and equating capacity with the number of vessels will not be sufficient if the ultimate goal is to adjust catching capacity to the resources available, given a sustainable utilisation. Instead, technology in its traditional sense should be re-opened and defined as social science when fisheries management is discussed.

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Approach and articles in context

7. Approach and articles in context
7.1 Introduction

In this chapter, I briefly describe my background and my methodological approach, and place the different articles in a broader context. As a researcher, I attempt to be as objective as possible in terms of explaining how I have obtained information, how I deal with this information and how I have arrived at my conclusions. However, there is always a personal bias involved, something that becomes more apparent when attempting to do research on highly contested issues. Hence, I start by describing my way into working with fisheries-related issues in general and my interest for capacity issues in particular.

Most of the articles are case studies of different Norwegian fisheries. The articles focus on the fishermen’s technological adaptations to the institutional design of the management regime, but they can also be described as a process analysis. By following the capacity adaptations in individual fisheries, I focus on chains of events where one event may serve as a precondition for the next. In this context, the main variables are connected to the dynamics of technological adaptations and the design of the quota regime (IVQ).

The articles are also empirical studies. Many of the articles are more or less historical analyses of how the fishing fleet has developed in relation to modernisation processes in the fleet segment, from the post-war period and up to our time. I have often used an exploratory approach as a first step (in order to refine the design of the main study), followed by a descriptive and/or explanatory approach. In this inductive phase, knowledge of the field supports the selection of the appropriate case or cases (Aarset, 1997).

However, I do not here aspire to cover all aspects related to capacity adaptations in the Norwegian fisheries. For example, changes in the fleet structure that could be a reference for the vessels *mobility,* and function as input for a study of the interaction between fleet and shore-based processing industry, are not dealt with in the present study. My focus is rather to shed light on how technological adaptations affect the management of capacity within the Norwegian fisheries sector. More precisely, the project addresses the importance of managing capacity in a bundled IVQ system and the regime’s overall ability to adapt capacity in a sustainable manner.

7.2 Approach

My background as a fisherman and my familiarity with the deep-sea fleet of the northwestern coast, combined with my experience from the NFA and my present work as a senior researcher at SINTEF have influenced my selection of empirical case studies. All articles stem from issues related to the governance of fisheries that were controversial or even paradoxical. In this work, I focus on enduring patterns of how fishermen play out rational action in regard to the arena where they operate.

My home town of Volda is a small village located on the northwestern coast of Norway. Compared to other fisheries districts, the region is well known for its strong deep-sea activity. Growing up in such an environment, the fisheries became a natural line of work for many young people. At a young age, my first job onboard a fishing vessel was removing rust and repainting vessels while they were laid up for overhauling and reparations during summertime. Later on, as a 16 year-old boy, I joined a group of 4-5 friends for unloading the catches onboard vessels home from shrimp trawling in Greenland and cod trawling in the Barents Sea. This was a work we carried out during the summers, and during Christmas and Easter vacations.

While unloading catches, we stayed onboard the vessels. This meant that we got firsthand access to the exciting stories told by the crewmembers and, not least of all, we saw the money-making opportunities. Fishing provided an opportunity to get rich quickly, at least if you were lucky and hard working.

In the summer 1976, at the age of seventeen, I began as a fisherman onboard a purse seiner, fishing mackerel in the North Sea. The following year, I worked as a fisherman onboard a 60-metre trawler that was fishing cod in the Barents Sea. The onboard production was salted fish, demanding up to 16 hours of hard work per day on a two-month basis. After finishing secondary school, I worked as a fisherman onboard a 67-meter factory trawler fishing in the Barents Sea, around Spitzbergen, as well as for saithe in the North Sea. The work as a fisherman before and after secondary school provided me with a total of 2-3 years experience onboard on different vessels. Additionally, I now had 18 months of practical fisheries experience that was required in order to begin studies at the Institute of Fisheries, University of Tromsø.

In addition to in-depth studies of fisheries and aquaculture at the university level, the time in Tromsø was an important maturation process. I learned that the ‘universe’ of Norwegian fisheries encompassed far more than just deep-sea vessel adaptations from my own home region. Located in one of the most fisheries-dependent regions in Norway, the study in Tromsø provided me with a strong opportunity to understand an array of aspects related to the organisation of the fisheries. These included the tension between traditional versus modern fisheries, the difficult process of allocating resources among different vessel groups, and the conflicts that arise when balancing legitimate demands for profit with other concerns, such as employment and the maintenance of the rural settlement pattern.

In 1992, I started to work as a consultant at the administration of the Norwegian Fishermen’s Association (NFA). My deep-sea fisheries experience, the study at the University in Tromsø and my work as a research fellow at the research institute Fiskeriforskning in Tromsø, all contributed to a valuable background to understand the Norwegian fisheries in context. Compared to other fishermen’s organisations throughout the North Atlantic, the NFA is unique in terms of organising both deep-sea and coastal fishermen from northern and southern Norway, the crew employed on fishing boats, and vessel owners under the same organisational umbrella.

My work experience at the NFA from 1992 to 1998 was indeed a very informative period that provided me with a unique opportunity to gain insight into resource-allocation politics, the formation of the structural policy, and various regulatory aspects of fisheries politics in general. From my point of view, the NFA can be described as the organisation that best manages the art of making balanced compromises that all different members can (more or less reluctantly) accept. The close working relationships with insightful members of the association who were keen to fulfil their own self-interests, combined with participation in a formal dialog with the fisheries authorities, gave me greater confidence to try to comprehend and write about difficult institutional and technological aspects of the fisheries.

In 1998, I left the NFA and started at the research institute SINTEF, Fisheries and aquaculture division, as a research fellow. The research profile of the SINTEF institute is strongly anchored in technology and technological development. Colleagues with a background in engineering have given me important input to aid my understanding of the dynamic processes related to the tension between technological development as part of the modernisation processes and governance of the fisheries. In this context, 'technology' consists of much more than the nuts and bolts, but rather as large technological systems of a strongly regulated and dynamic arena. Hence, technological adaptations become complex systems that are not easy to manage in accordance with contradictory political goals.

Thus, the origins of articles that make up this study are partly constrained by the SINTEF research profile, but simultaneously inspired by 'technology-orientated' colleagues. Here, I highlight aspects of technological development as an important element of capacity adaptations within the framework of the Norwegian management model. I perceive technology as a vital part of the capacity concept, but it is also a key variable in fulfilling the aim of sustainable fisheries.

The common theme in the articles presented in this thesis is that I examine capacity adaptation as it regards the interplay between technological adaptations and the institutional design of the management regime. In Norway, fishing vessels and quotas are inter-connected and as such, they constitute the critical elements of the IVQ model. In addition to the number of vessels, the technology in the form of the *fishing vessels' catch capacity* is a crucial element of the models' input regulations.

7.3 Methodology

Studying different aspects of the fishing fleet with such a large cognitive component emphasises the need for collecting information from different types of sources. However, the case studies are not based on broad surveys such as structured interviews or a representative number of questionnaires. Instead, my approach consists of a combination of oral and written sources to understand the effects of relevant formal rules, political institutions and technological development. As stated by Brox (1991), the critical issue is to ensure a certain *distance* in order to be able to describe situations, and not take them for granted in the research process.

Case studies can be qualitative and/or quantitative. The articles presented here are combinations of both approaches. The analysis of long-term changes in the institutional design of the quota regime is congruent with a qualitative approach. Qualitative studies require data from various sources to cover different aspects of the cases. With reference to the processes of changes in the institutional design of the quota regime and the development of the structural policy, I have drawn on varied sources such as research articles, public policy papers, fisheries statistics and other legislative publications. In this part of the process, access to white papers, other public reports, and to fisheries statistics and regulatory decrees from the Fisheries Directorate have been of vital importance.

In studying the regulative aspects of fisheries management, one is of course also in fact analysing governing structures. In the case of Norwegian fisheries, normative elements communicate imperatives about how to organise the quota regime to achieve specific goals. Thus, the interpretation of normative instructions (such as the layout of the management regime) in combination with the actual results may reveal information about the strength of the norms.

In addition to focusing on changes in the design of the quota regime, an important part of my work has been to follow the fleets' overall technological response to changes in the regime. In this context, the aggregate development of number of vessels, the dynamics of technological development and changes in the fleet structure are a vital part of the case studies, making up the *quantitative aspect* of these studies.

The Fisheries Directorates' (2006) technical surveys of the Norwegian fishing fleet refer only to single technical parameters like horsepower (hp) and gross registered tonnage (GRT) in relation to the number of vessels. Thus, an important aspect of the technical analysis here has been to integrate several vital parameters that indicate something about the fishing vessels' overall technical performance. In addition, the analysis of the vessels' overall technical performance is crucial for the vessels' ability to handle certain amounts of fishing gear. By using an equation that includes several technical parameters and the average size or amount of fishing gear per vessel, we might be able to express the vessels' technical catch capacity. By calculating these conditions for each vessel at a given time and summarising the result of each vessel at different times (e.g., 1988 and 2003), we can shed light on technical capacity development per vessel or group of vessels. The longitudinal analysis of the technical capacity development can be expressed as[30]:

$$k_i = \frac{Loa \times breadth \times 0.35 + GRT \times 0.35 + HP \times 0.30}{500} + R_{2003\text{-}}\,\mathrm{R}_{1988}$$

$$K_{year} = \sum_{i=1}^{N} k_i$$

[30] The factors 0.35, 0.35 and 0.30 respectively are internal factors connected to each parameter included in the equation. The factors refer to a system of internal weighting of each factor depending on which type of fisheries the vessel is conducting. For example, the size of the main engine is of greater importance for stern trawlers than for a vessel conducting long lining. Thus, the engine factor for a trawler would be estimated higher than for a vessel conducting line fisheries. The gear factor (R) refers to the size of fishing gears (e.g., size of trawl opening) or the amount of gears (e.g., number of gill nets or hooks) operated by the vessel per day. The 500 factor has no specific meaning; it expresses the results of the calculations in a simple manner.

$$\text{Technical capacity development} = K_{2003} - K_{1988}$$

Source: Aasjord (2000), Aasjord *et al.* (2003).

The premise for conducting the calculations is the availability of technical data of each single vessel in a given gear- and vessel group at different times of measurement (e.g., 1988 and 2003). We have made use of the electronic database of all registered fishing vessels in Norway for various years (‘Illustrert norsk skipsliste’). The electronic database provides all technical parameters needed for these calculations (conducted in Microsoft Excel). Specifications of different types of fishing gears were obtained from different manufacturers. By combining the technical database with the Fisheries Directorate’s database for the individual vessels quotas, we were able to sort out and analyse the specific gear- and vessel groups respectively (e.g., the cod-trawler fleet, shrimp trawlers, combined vessels within the pelagic sector).

The quantitative approach for analysing the technical catch capacity corrected for the number of vessels can be useful in evaluating capacity development within the frame of the quota regime and the structural policy. Results of the analysis can serve as input for discussing the normative aims of the regime and the fleets’ response in terms of capacity adaptations to the fisheries. Likewise, this type of study can shed light on the extent to which capacity adaptations may deviate from social and political norms, with potentially substantial side effects.

7.4 Articles in context

I can summarise my overall interest on capacity related issues in fisheries with a reference to the FAO publication (1998). Overcapacity constitutes one of the most severe problems in the world’s fisheries. Excess capacity contributes to over-fishing and the fisheries become marginalised in terms of resource rent dissipation; excess capacity creates allocation conflicts among fishers and general stagnation in fisheries dependent districts. Empirically, overcapacity often demands an excess of administrative expenditures and an increasingly complex fisheries management to regulate the fisheries in detail. Thus, if we do not manage to solve the problems related to overcapacity, we will not reach the aim of running sustainable fisheries (FAO, 1998).

The common theme for the articles in this study is the dynamic relationship between technological adaptations in the fisheries and the institutional framework of fisheries management. With reference to different segments of the Norwegian fisheries, I try to shed light on technological adaptations as key elements of input regulations and as driving forces behind capacity adaptation, and to provide a meaningful reference to the complexity of integrating technology and biology in modern fisheries management.

All articles highlight long-term management processes for different aspects of the Norwegian fisheries. Changes in technical capacity development and the quota regime for different gear- and vessel groups have provided an opportunity to study the dynamic nature of different institutional fields over a given time span.

The first article (in chronological sequence) focuses on the implementation of the individual vessel quota system (IVQ) in the coastal cod fleet, and how changes in the IVQ regime have affected fleet structure and capacity adaptation in this segment. Further, to fulfil the aim of the IVQ regime, technological adaptations gained a prominent position and became a key element in the homogenisation of heterogeneous coastal fisheries adaptations (Standal and Aarset 2002 #1).

The second article deals with the shrimp-trawler fleet that fishes in the High Arctic. Histrically, shrimp trawling has been an important segment of the Norwegian offshore fleet. The shrimp trawler fleet is not restricted by any quota regulations, which is clearly an exception from today's modern fisheries management. The lack of quota restrictions has been a major capacity-driver for the restricted number of vessels participating in shrimp trawling. Technological adaptations are independent of quotas. Instead, technology aims to maximise catch rates and foster the year-round utilisation of vessels. However, the introduction of double- and triple trawl systems and the strong increase in catch rates led to the introduction of total allowable catches (TAC) as a *possible option* for shrimp resource management. With reference to a potential TAC, an assessment of different quota allocation models reveals a strong overcapacity in the shrimp-trawler fleet (Standal 2003 #2).

In the third article, I highlight various aspects of the capacity concept and how driving forces of technological development have affected the catch efficiency in certain fisheries. With reference to economic, technical and social aspects, I discuss the capacity concept, emphasising the importance of understanding or unlocking the dynamics of technological adaptations in fisheries. This article utilises data collected from shrimp trawling in the High Arctic and from trawling for blue whiting in the North Atlantic basin (Standal 2005 # 3).

The next article focuses solely on Norwegian vessels that are trawling for blue whiting. Since the fisheries commenced in the early 1980s, the blue-whiting fisheries have only been restricted by the number of participants. As with shrimp trawling in the High Arctic, TACs have not protected the blue whiting stocks. The migrating pattern of the blue-whiting stock takes them through several economic zones; the affected nations have been unable to reach any consensus in terms of allocating the blue-whiting resources among nations involved in the fisheries. Thus, this fishery has been characterised as a race among the fleets from different nations and a strong capacity-driving adaptation. However, for the last few years, a five-state allocation agreement was signed by the participating nations and a TAC regime has been implemented to reduce the overall catch rates. The closure of the fisheries and the resource-allocation regime among states has made the overcapacity visible. In addition, the vessels conducting blue-whiting fisheries are combined vessels and are thus adapted to strictly regulated fisheries for mackerel and herring. This combination strongly affects the overall capacity adaptations within the entire pelagic segment (Standal 2006 #4). The effect is often referred to as spill-over effects; capacity developed in the unregulated blue-whiting fishery has implications in the strictly regulated mackerel and herring fisheries.

The fifth article presents a study on the trawler fleet fishing cod and other white-fish species in the Barents Sea and the North Sea basin. In this article, I follow the development of the trawler fleet and the actors' responses to changes in the quota regime. The adaptations can be interpreted in light of the framework of the quota regime and the structural policy for cod trawling. However, the layout of the regime and the technological adaptations also show how the institutional design and technology affect other segments of the fisheries. An important finding is that technological adaptations work across institutional boundaries and affect capacity adaptations within different fisheries. Like the combined vessels fishing for blue whiting, herring and mackerel, the combination of cod trawling and shrimp-trawling technology is bridging or connecting different fisheries that are institutionally separate. Thus, even though fisheries are institutionally separate and managed in highly different manners, technological capacity adaptations within one segment affect other segments as well (Standal 2007 # 5).

The sixth article deals with one of the most disputed vessel groups in Norwegian fisheries; the factory trawlers with onboard filet production of cod and other white fish species. Throughout history, the factory trawlers have been both beloved and hated, depending on the background of the people you ask. To me, the factory trawlers represent the "paradoxical fishing fleet" in Norway; due to their onboard production, they are autonomous and decoupled from the constraints of the land-based processing industry. At the same time, their technological complexity as both catchers and processors makes them vulnerable to changes in the overall politicised framework. In this article, I describe the history of the Norwegian factory trawler fleet; how they emerged as a segment in the Norwegian fisheries, their technological adaptations and their response to an increasingly stricter resource management policy. Due to changes in their overall regulatory framework, the fleet segment has been unable to develop its own concept in terms of innovation. Today, the last few generations of factory trawlers are hampered by stagnation in core technologies and they have been unable to compensate for a steadily stricter quota regime with any kind of value-added strategy for their onboard production. Consequently, the fleet has reduced its rate of onboard production and become a steady supplier to the land-based processing industry (Standal 2008 #6).

The last article focuses on the Norwegian trawler fleet that fishes for cod and other white-fish species in the North Atlantic. As with the fifth article, which also deals with this same fleet segment (Standal 2007 #5), this article outlines the tension between capacity adaptations and the design of the quota regime. Here, we highlight the distributional effects of the management regime and discuss the findings with reference to the main aims of the IVQ model. One of the main findings is that the IVQ model has not been able to secure a diversified ownership- and fleet structure. On the contrary, the segment has developed a strong concentration of rights and quotas among very few actors. This is paradoxical because the main impetus for the implementation of the IVQ model was to avoid the distributional side effects of an ITQ model (such as those experienced by the Icelandic fisheries (Standal and Aarset 2008 #7).

Below, I summarise several of the main topics of the complex capacity debate, with reference to the articles in this thesis.

7.5 Findings

A framework for the capacity concept

Historically, fundamental drivers to overcapacity refers to open-access fisheries with no TAC implementation, the existence of resource rent, increased technological efficiency and public subsidies for investments and operation of fishing vessels. The concept of capacity is thus a complex issue that builds on ideas from biology, economics, technology and the social sciences (Standal 2005 #3).

The IVQ regime integrates both input- and output regulations into one bundled system. Output regulations can be perceived as the end product (allocated quotas) from the TAC-production as well as from resource allocation among different gear- and vessel groups. In contrast, input regulations consist of two main variables; the number of units participating in a given fishery, and the vessels' technical catch capacity. The interaction of input- and output regulations forms the basis for capacity adaptations in closed and regulated fisheries. Thus, technological adaptations represent two vital variables; they provide a central element of balancing input- and output regulations and as one of the main variables within the concept of input regulations. This also serves as an illustration of the complexity of the Norwegian management model (Standal and Aarset 2002 #1).

The institutionalisation of the capacity concept

Although the capacity concept has been transformed through different phases of fisheries management, technology has always held a prominent position in the modernisation processes of fisheries. Prior to the introduction of modern resource management, the capacity concept had no reference to limited quotas as output regulations. Instead, lack of technological efficiency was a reference to fulfilling the modernisation processes in the fisheries segment.

However, through the introduction of modern fisheries management the technology concept was turned up side down. Now, the former lack of technical capacity was turned into a reference of overcapacity and the need to reduce fishing effort.

The closing of the commons was indeed a strong state intervention anchored to the aims of the overall fisheries policy. Technology was now connected to strong institutional initiatives with built-in contradictory goals expressed as restrictions and incentives at the same time. In order to fulfil the aims of the complex quota regime, technology gained a prominent position to streamline capacity adaptations. Hence, the dynamics of technology is of vital importance to understanding the interplay between the fishermen's adaptations and the design of the quota regime.

However, it has proven difficult to connect the aims of this specific technological structure to a governance system that was influenced by slow political processes in combination with rapid changes in TAC implementation. This is why technology-friendly fishermen characterise the structural policy as a slow-working political processes. It is a system that is embedded in the overall fisheries policy and always lags behind the fleets' needs for changes in regard to a steadily more efficient and capitalised fleet, and rapid changes in the resource base.

An important aspect of the Norwegian management system is thus a strong institutionalisation that hampers necessary capacity adaptations. However, the complexity of the IVQ model also has built-in *incentive structures*; for example, to influence the composition of the fleet structure in the desired political direction. One specific example is the policy that allowed fishermen who exchanged their small vessels for bigger vessels to be awarded bigger quotas, in order to restructure the coastal fleet. Combined with public funding, the strong public incentive increased capacity within the coastal fleet segment. Thus, institutions not only restrict capacity increase, but institutions may also function as a *capacity driver* in fisheries (see e.g. Standal and Aarset 2002 #1; Standal 2003 #2).

Technology as open systems

Parallel to structural measurements to reduce the number of vessels, we can see the dynamics of technological change illustrated when newer vessels replace older, less efficient ones.

Surprisingly, we see a large increase in technical capacity despite the reduction in vessel number. Technological adaptations were supposed to be locked-in by a closed and complex IVQ regime with strict boundaries. The strong increase in technical catch capacity indicates that fisheries technology is an open system, expressed by dynamic processes of the *capacity creep* concept. When new technology gains acceptance for a given purpose, technological systems such as the fishing fleet expand and develop a mass of technical and organisational components that possess direction and goals. In this way, large technological systems can originate from a constructivist approach, but they may potentially become more autonomous, putting pressure on the regulated arena they were designed to serve (e.g., Standal and Aarset 2002 #1; Standal and Aarset 2008 #7).

Fishing vessels also represent multipurpose technologies that can be adapted to several institutionally distinct arenas. Thus, technology works across institutional boundaries that were established to manage single species. The fish stocks from different species develop in highly different manners and they require different regulatory regimes. While most fisheries are strictly regulated with a TAC, the allocation policy and vessel quotas, other fisheries are regulated as restricted access fisheries with no TAC. Empirically, we see that fishing vessels that operate in a combination of quota-regulated fisheries and restricted access fisheries (with no TAC), tend to expand their capacity adaptations to the restricted access fisheries with no TAC. However, declines in unregulated fisheries have brought to light biological and economic overcapacity. In essence, this provides feedback on capacity to the quota-regulated arena that implemented the regulations in the first place. Thus, fishing vessel technologies also serve as multipurpose adaptations that influence arenas constituting a totally different institutional layout (Standal 2003 #2; Standal 2006 #4; Standal 2007 #5).

However, capacity expansion refers to more than the design of the institutional layout or capacity expansion within the frame of regulated, restricted access fisheries with no TAC. The strong increase in the number of factory trawlers for the period 1985 – 1989 was clearly an adaptation resulting from a market-driven process with high expectations for future on-board production. However, the fleet segment has not been able to further develop its own concept concerning new innovations for value-added products or a decrease in production costs. Forty years after the factory trawlers were established as a modern fleet, representing new and radical innovations, the product categories (filet blocks and interleaved catering filets) and the number of crewmembers remains the same, when producing fillets.

Today, the most recent generation of factory trawlers has been reduced from 25 vessels in 1989 to fewer than ten vessels in 2008. These vessels are hampered by stagnation in core technologies, as well as a complex and costly factory deck and a steadily more restrictive quota regime. Consequently, the fleet has reduced its rate of onboard production and has become a steady supplier of frozen HG-fish blocks to the land-based processing industry. Paradoxically, the new adaptations to the land-based processing industry are in line with the original intentions of the trawler fleet. However, this transformation process is not solely due to stagnated technology or a stricter institutional framework. The new adaptations were also driven by changes in the market for frozen round HG-fish (headed and gutted), as well as the economic effects of a less costly factory deck, and a 50% reduction in the number of crewmembers (Standal 2008 #6).

Decoupling biology and technology?

The implementation of the ambitious and complex Norwegian IVQ model was intended to secure a specific fleet structure and diverse ownership of quotas, providing a clear alternative to a market-based ITQ model. The capacity concept within the framework of the IVQ model thus represents a strong state intervention, but also a high degree of mixed responsibility, which is expressed through a bargaining economy among state and organized interests.

However, in both the deep-sea fleet and the coastal vessel segment, the liberalized technological adaptations have been subject to strong reduction in the number of vessels and severe changes in the fleet structure. Within the deep-sea fleet in particular, the concentration of quotas and vessel ownership has been tremendous, a development that does not deviate from the market-based effects of an ITQ system (Standal and Aarset 2008 #7).

Within the deep-sea fleet, the qualitative aim of a specific fleet structure has largely been abandoned. Instead, the structural policy has become a one-sided numerical project aimed at reducing the number of actors, regardless of where they are living or what kind of fisheries they perform.

Within the coastal fleet segment, the maintenance of a specific fleet structure is still a viable goal. However, in line with liberated rules for vessel design in the deep-sea fleet, the transition from limitations in terms of length meters to cargo hold volume in the coastal fleet is in reality an invitation for a totally liberated design of the coastal fleet. Today, more than 600 coastal vessels hold a quota base that does not correspond to the size of the vessel. Hence, the close coupling between vessel size and size of quotas has partially lost its legitimacy, a development that illustrates the complexity of integrating technology (vessel) and biology (quotas) as a bundled governance system. Regulative agencies have more or less given up the use of an IVQ model to secure a specific fleet structure (in order to regulate employment levels, settlement pattern, fleet diversity, etc). When coastal vessels become deep-sea vessels in terms of physical size, the principles of the allocation policy to secure the coastal vessels as distinct from the deep-sea fleet have been opened-up and become less visible.

As a response to technological adaptations as open systems, the decoupling of technology and biology within the framework of the IVQ model, is a transition towards an ITQ-based system that involves separated transactions of quotas and vessels. Dismantling the IVQ model can be perceived as a strategy to remove the main pillars of the governance system. However, the introduction of a market-based allocation model is also an attempt to introduce a system that can respond more rapidly to environmental changes. Depending on the degree of market orientations, state responsibility for governing capacity may be reduced. Hence, capacity adaptations will be a matter of private responsibility among the fishermen. However, an increased market orientation for capacity adaptation may not solve all problems, but the concept of capacity will, to a lesser extent, be a complex matter of state responsibility. Defining capacity and identifying responsibility for capacity adaptations is thus a matter of defining the public sphere versus the free market, a matter that also reflects the power relationship in a bargaining economy and the stakeholders' ability to construct capacity related problems and address solutions (Standal and Aarset 2008 #7).

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