REVIEW ON
MANAGEMENT POLICY AND ENERGY USE
IN THE FISHERIES SECTOR

0. INTRODUCTION

Fisheries management, determining access conditions to a resource, application of effort, landing regulations and thereby the longer-term sustainability fish stocks, has the potential to exert a significant influence on catching efficiency and sector profitability including fuel use and operating costs.

However, such management systems may also act to reduce fleet size and activity levels, limit rights to resources, and reduce community access to income and food benefits.

Based on current literature and on recent experience in the sector, the aim of the review will be to provide a background introduction to the key issues, and set out how in strategic terms how fisheries management policy could affect capacity, effort, fuel use, market returns and profitability, through controlling effort, improving market returns and through longer term potential stock recovery.

1. BACKGROUND

A recent study by the FAO and World Bank, *The Sunken Billions* (World Bank, 2009), estimates that, if world ocean capture fishery resources were managed optimally, they would yield "resource rents" in the order of US$50 billion per annum. The study continues that these same fishery resource are currently yielding no "resource rents" whatsoever. As a consequence, *The Sunken Billions* calls for a programme of positive investment in fishery resources and reduction in fishing fleets.

Historically, fishery resources have been exploited on a "common pool" (i.e., open to all belonging to a certain social group) basis. The "common pool" nature of the resources has created a set of economic incentives for fishermen that are highly perverse from society's point of view, leading inevitably to resource overexploitation and economic waste. Fishery management, both national and international, has been dominated by attempts to counter the baleful impact of the "common pool" nature of the resources.

The purpose of this report is to explain different kinds of catch rights based management (CRBM) and to analyse under which conditions this management system can achieve socially beneficial outcomes (section 1).

Catch Rights Based Management (CRBM)[1]

The FAO (1998), in its discussion of fisheries management, makes a distinction between:

I. Incentive blocking approaches.
II. Incentive adjusting approaches.

As discussed by Bjorndal and Munro (2012), resource managers initially relied upon what the FAO calls incentive blocking measures, in which fishermen are hopefully blocked from responding to perverse incentives. As these approaches overall met with limited success, greater emphasis is currently being placed on what the FAO terms incentive adjusting measures, in which the management measures are designed to adjust the incentives facing fishermen, so that these incentives are more compatible with the goals of society. In other words, the purpose is to change fishermen's incentives so that a socially optimal outcome is achieved rather than that of the "common pool" fishery.

The most common approach of II consists of fishing rights often in the form of harvesting rights, popularly referred to as "catch shares." Under the heading of fishing rights /"catch shares", we include:

i. individual harvest quotas (IQs)
ii. territorial use rights fisheries – "TURFs"
iii. fishermen cooperatives.
iv. sectoral TAC programmes.

Far from being mutually exclusive, one can often find blends of the four.

One of the first to discuss the concept of ndividual quotas (IQs) was Christy (1973).

Individual harvest quotas

By mid-2010, the number of states adopting individual harvest quotas (IQs) had increased to 22, accounting for almost 25 per cent of global capture fishery harvests, as measured by the FAO (Arnason, 2012).

IQs, which were originally designed to curb the "race for the fish," are now seen as doing much more. If properly designed, and administered, they will serve to give the fishermen an incentive to invest in the resource.

The IQ scheme facilitates a fisherman cooperative game by providing a means of sharing the TAC among the fishermen. The limited entry with Olympics style total allowable catch quota (TAC) scheme compelled the fishermen to compete. Having said this, the IQ TAC sharing mechanism is not sufficient to ensure a cooperative fishermen game that is stable through time.

With this in mind, let us consider the following aspects of IQs:

a) IQs as property rights to the fishery resource.
b) IQs, short term or long term in nature.
c) IQs expressed in fixed quantities over time, or as percentages of the TACs.
d) IQs, non-transferable or transferable – ITQs.
e) IQs and the implications for equity.
f) IQs and multispecies fisheries.
g) IQs as cooperative games, and problems of surveillance and enforcement.

The reader is referred to Bjorndal and Munro (2012) for a thorough discussion of these aspects. One distinction is, however, made, that between Individual Transferable Quotas (ITQs) and Individual (non-transferable) Vessel Quotas (IVQs). In the first instance, vessels are able to adjust their quota holdings – seasonally, by leasing extra quotas, or permanently, by purchase/sale of quota rights. Firms will optimise their activities given these constraints.

In the case of IVQs, a vessel has a fixed quota to be harvested for the year. If product price is given, the objective will be to minimise the cost of harvesting the given quota. If price is variable, e.g. depending on quality, the objective is to maximise net revenue for the given quota.

Other rights based harvesting schemes must also be considered:

Territorial use rights fisheries (TURFs)

Christy was also the first to introduce the concept of TURFs (Christy, 1982). Christy recognised the infeasibility of ITQ schemes in most, if not all, artisanal developing coastal state fisheries. He was at the same time impressed by traditional community based fisheries management arrangements in many developing states. He had also become aware of the centuries old coastal based cooperative fisheries management arrangements in Japan. All of this led him to develop the concept of TURFs.

TURFs involve the granting of harvesting privileges to one, or a set of, fishing coastal communities. An example is provided by the Japanese Fishery Cooperative Associations (FCAs), which can trace their origins back to the 16th century fishermen guilds. The FCAs focus on inshore and near shore coastal fishery resources. The Japanese federal government lays down broad resource management guidelines, and then devolves harvesting rights upon the FCAs (Cancino *et al.* 2007).

The typical FCA may cover many diverse fishery resources. Within FCA, fisheries management organisations (FMOs) merged to focus on specific species and or gear types. Thus, the management unit, or TURF, consists of a FCA and a subset of FMOs (Cancino *et al., ibid.*).

A TURF is, almost by definition, a cooperative fisherman game. Christy (2000) sets out the problems to be addressed and solved, if the solution to the cooperative fisherman game that is the TURF is to prove to be stable through time. The problems to be faced will, with one possible exception, be found to be identical to those faced by ITQ based fisherman cooperative fisherman games.

First, the TURF must develop a mechanism for the sharing of the economic benefits from the fishery in an equitable manner. Second, the TURF must ensure compliance among TURF participants. Third, the TURF must be protected against free riding by fishermen outside of the TURF (Christy, 2000).

Fourth, the TURF must face, the so called "new member" problem. Essentially this is how to allow new participants into the fishery.

The final problem identified by Christy (2000) (and one that also applies to ITQ schemes) is that conditions surrounding the TURFs may change over time and may do so in an unpredictable manner. If the TURF scheme does not have sufficient resilience to absorb these shocks, the TURF scheme could well disintegrate. This is the game theory version of the time consistency problem.

The time consistency problem does arise as changing social and economic conditions stand as a threat to the stability of the TURFs.

Fishermen cooperatives

Fishermen cooperatives can be thought of as similar to TURFs, except that there is no particular geographical location.

The United States provides an example of fisherman cooperatives, and their close relative, sector TAC allocations. This is the Pollock Conservation Cooperative (PCC), established in 1999, with the express approval and support of the American government.

The PCC consists of a group of companies operating catcher/processor vessels in the offshore pollock fishery in the Bering Sea. The PCC is allocated a quota, a segment of the overall pollock TAC, which the company members allocate among themselves. Thus, by definition, the PCC is a cooperative fisherman game. As such, it led to results similar to those in British Columbia groundfish ITQ fisheries.

As a result of the establishment of the PCC season length was greatly increased and the product quality was substantially improved[2] (At Sea Processors Association, 2011; Holland, 2010).

2. CASE STUDIES OF RIGHTS BASED MANAGEMENT

2.1 Denmark: ITQs for the demersal fleet[3]

Main demersal species, in terms of landings value[4] are cod, European plaice and other flat fish. The most important fishing grounds are found in the North Sea.

Over the years, different regulations have been in effect for this fleet. Since 1994 all vessels with a permit are registered. Before 1994 only vessels above 5 GRT were registered. Days at sea per vessel restrictions were introduced in 2001 as individual transferable days at sea. If a vessel was removed from the registry, the days were lost. As noted above, ITQs – in the form of Vessel Quota Shares (VQSs) - were introduced for the demersal fleet on January 1st, 2007. It concerned largely vessels 12 – 35.9 metres.

To ensure an effective ITQ management it is important with ownership and transferability. A way to do this is by using 'fish pools'. These pools are made on a private basis but there must be approved by the Directorate of Fisheries. Within the pool the vessels can lease and swap quotas within the quota-year (Samudra report no. 55, March 2010).

From 2007 the ability to join pools was introduced and it made the fishing more flexible. A vessel can fish more than its quota and lease the rest from another vessel (Eurofish magazine 4/2009). There are now (March 2010) seven pools in operation and most of the demersal fisheries are undertaken by the vessels within these pools. The pool system is also reducing discards as there is a rule that no fish must be discarded as long as one fisher in the pool has a quota (Samudra report no.55 (March 2010)).

The demersal fleet includes a number of vessel groups. Here we will present information for two, namely vessels of length 30-35.9 m and vessels of length 24-29.9 m.

The number of boats of length 30-35.9 metres has shown a steady decline since 1990 but we are interested in the development after the introduction of the ITQs (see figure 1). The number of boats has been reduced from 38 in 2006 to 30 in 2008. This is a reduction of 26.6 %.

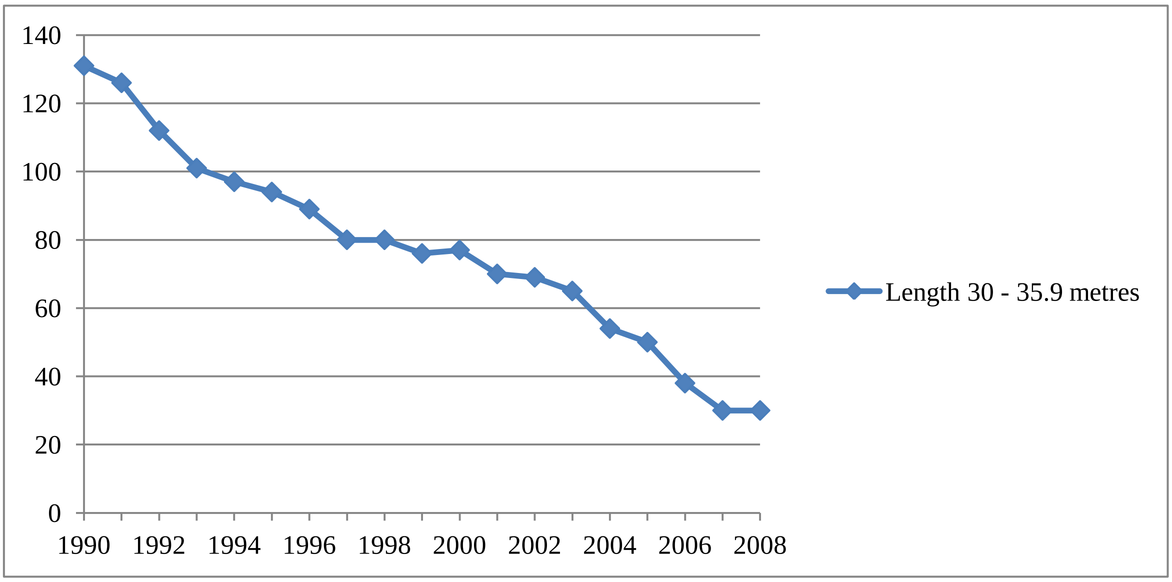

Figure 1. Registered boats, length 30 – 35.9 metres.
Source: Eurostat: Fisheries.

Looking at GT and kW for boats of length 30 – 35.9 metres (figure 2), GT has been reduced from 8,992 in 2006 to 7,303 in 2008. This makes for a reduction of 18.8 %. Engine power has declined from 22,585 kW in 2006 to 17,911 kW in 2008, a reduction of 20.7 %. Here it seems that the reduction in GT and engine power has been more or less the same as the reduction in boats. Thus the boats are probably the same but 26.6 % have been taken out of the fishery after the introduction of ITQs.

For boats of 24 – 29.9 metres the number declined from 43 in 2006 to 32 in 2007 and remained at 32 in 2008 (figure 3). Thus the year that the ITQs were introduced 11 boats were taken out which makes a reduction of 25.6 % in just one year. The same is true for GT and engine power, the reduction largely happened in 2007 (figure 4). GT changed from 7,666 in 2006 to 5,614 in 2008. This is a decline of 26.7 %. Engine power was reduced from 20,937 kW to 15,632 in the same period, representing a decline of 25.3 %. Thus, it appears that the boats have remained the same but declined in numbers, thus the fleet consists of fewer boats to catch the quota.

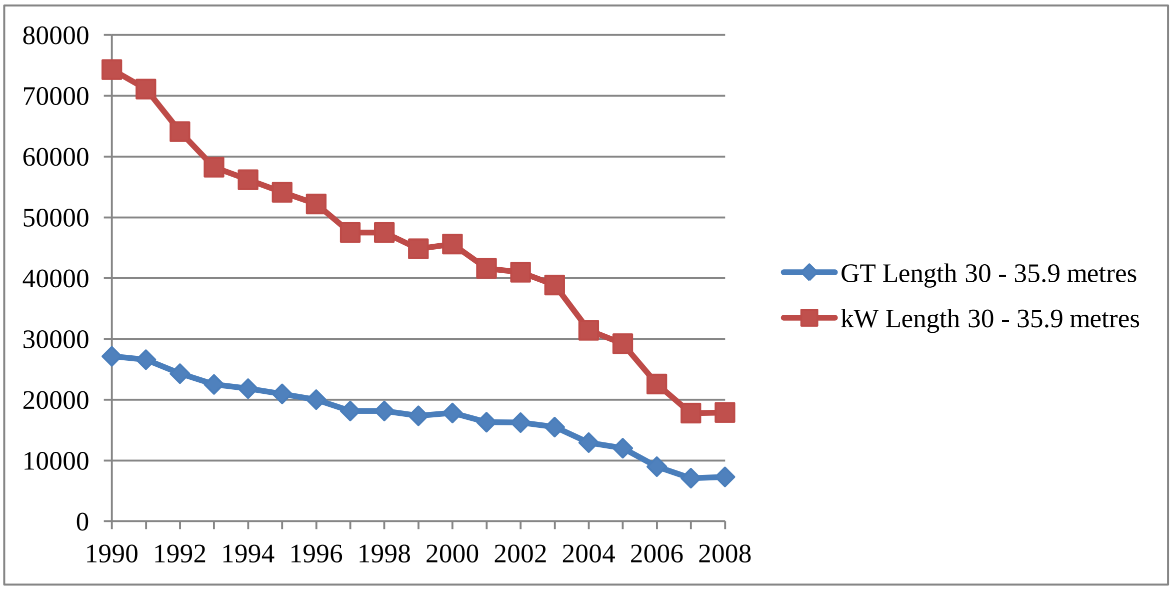

Figure 2. GT and kW for boats of length 30 – 35.9 metres.
Source: Eurostat: Fisheries.

For the demersal fleet the 30% overcapacity vanished during the two first years after the implementation of the VQSs (Eurofish magazine 4/2009).

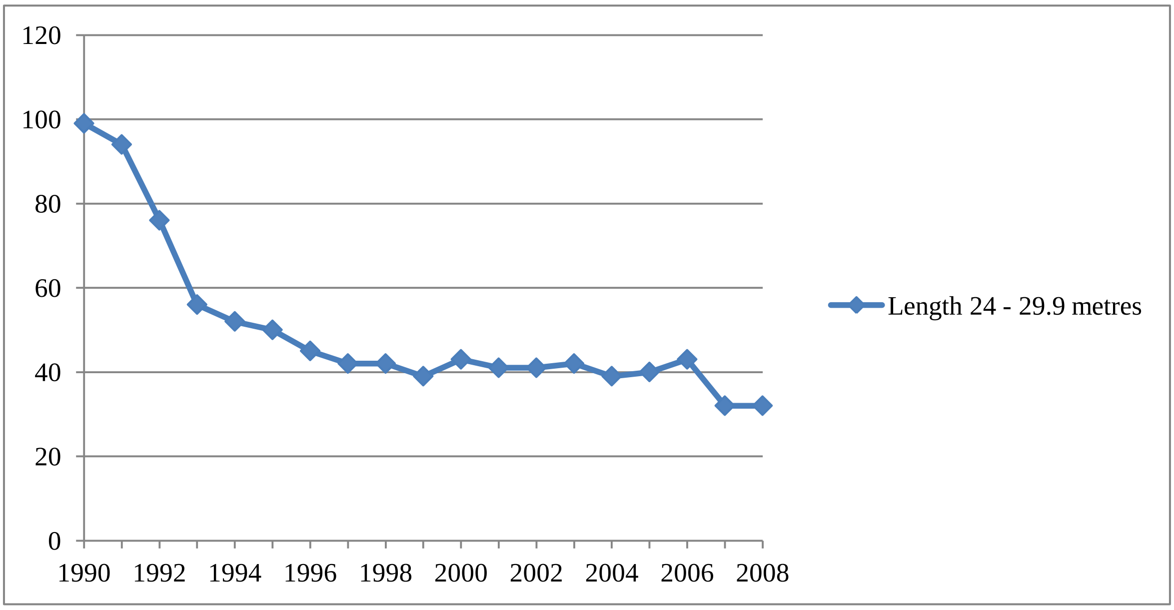

Figure 3. Registered boats, length 24 – 29.9 metres.
Source: Eurostat: Fisheries.

The introduction of ITQs met with substantial opposition from numerous sources including fishermen's organisations. Arguments against included "capitalisation of the resource", and claims that ITQs represented "privatising a common resource" and that the coastal fishery would be "eradicated". Currently the vast majority of fishermen cannot see another system than the ITQ system in place.

Although the number of fishermen may have declined, the average number of operating vessel-days has increased. In addition, it is now common for vessels to fish with 1½ or even two crews. Thus, total employment – e.g. measured as aggregate man days per year – will have decreased substantially less than what is indicated by the reduction in the number of vessels.

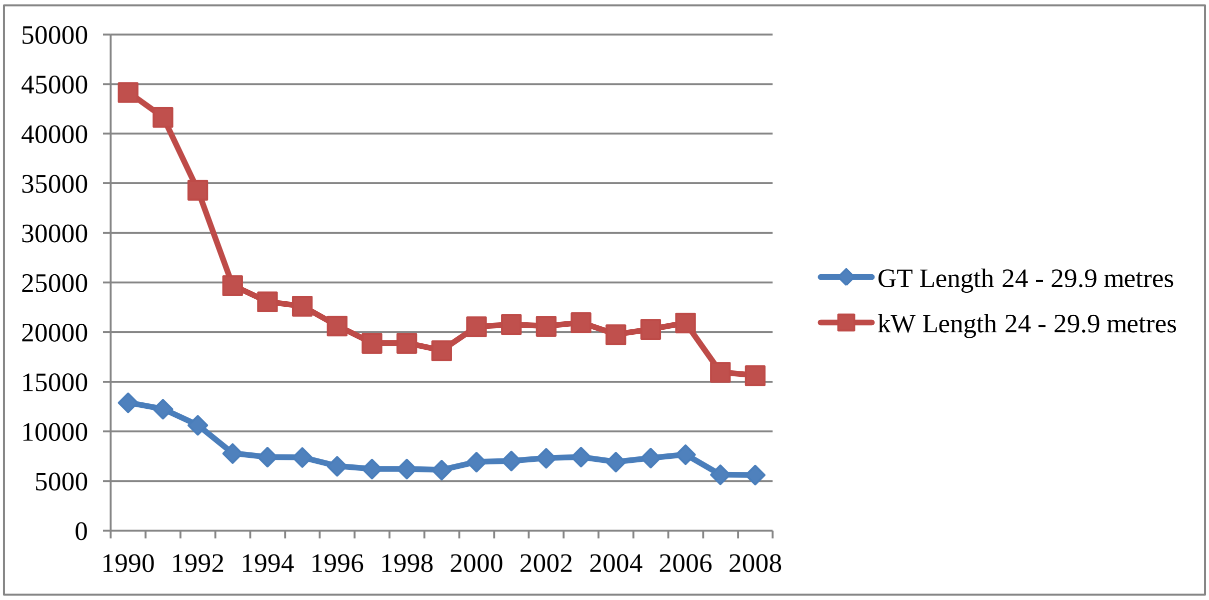

Figure 4. GT and kW for boats of 24 – 29.9 metres.
Source: Eurostat: Fisheries.

In summary, for Denmark, the introduction of ITQs has led to a decrease in the number of fishing vessels as well as in other measures of fishing capacity such as gross tonnage and engine horsepower.

2.2 ITQs in The British Columbia Groundfish Trawl Fishery[5]

In the past, many economists held the view that, while ITQ schemes could be expected to work well in single species fisheries, they could not be expected to do so in multispecies fisheries.

This pessimistic view of ITQs has been proven, by experience, to be wrong. One of the motivations for the recantation was the experience with the groundfish trawl fishery off British Columbia, Canada.

The groundfish trawl fishery (GTF) is the largest in terms of both the value and the total catch. It lands about 100,000 tonnes of fish per year. Important species in terms of catch are rockfish, hake, Pacific cod, thornyheads, sole and lingcod. In terms of volume, hake is most important, but its average price is a lot less then many other species. Because there are so many species it makes it more difficult to determine stock size and abundance (Grafton *et al.*). This is an extremely complex multi species fishery, with a large number of species, and over 50 different stocks.

In 1997, an ITQ scheme was established. Under the scheme, 55 stock TACs were established. The Canadian Department of Fisheries and Oceans proceeded to allocate quotas to all 55 stocks to all vessels licenced to operate in the fishery, and then hoped for the best.

There has been a commercial groundfish trawl fishery (GFT) in British Columbia for about 70 years. In 1976 limited licensing introduced for the GTF in the form of groundfish trawl licences which were allocated to 142 vessels. With this licence they could catch multispecies and harvest anywhere along the Canadian west coast. The fishing fleet experienced a significant expansion in the late 1970s; even if there were higher landings, the fishery was unprofitable, with low prices and overcapacity. In the 1990s many TACs were constantly exceeded and the fisheries managers had troubles controlling and monitoring catches because of underreporting and discards. The TACs were decreased and the duration of fishing trips declined. This led to impacts on sustainability of some species, rising cost for the fishermen and increasing the race to the fish (Grafton *et al.*, 2007).

ITQs were introduced in 1997 for the BC groundfish fishery initially as a trial system. 80% of the species' TACs were allocated to licence holders and 20% to a newly created non-profit society called the Groundfish Development Authority. They were going to promote regional development, market and employment objectives, sustainable fishing practices and fair and safe treatment of fishing crews. The ITQs within the TACs were given on the basis of catch history and vessel length. After the introduction, there are still 142 licence holders but only about 60-70 boats operating. The very small boats and larger boats have exited the fishery. The ones that stayed have been able to specialise. The introduction of ITQs has made it possible for the fishermen to specialise in area and species, while earlier they would fish all areas to make sure they would get some catch before the limits were reached (Grafton *et al.*, 2007).

The value of the groundfish harvest has increased from around 40 million dollars in 1993 to about 65 million dollars in 2002. The value is higher although the groundfish harvest in tonnes has gone down. In 1993 about 120 000 tonnes were landed and in 2002 about 100 000 tonnes (Grafton *et al.*, 2007). The increase in value comes from better quality of the fish, which is often marketed fresh rather than frozen. The fishing section had also been extended.

A sophisticated quota market quickly emerged. The licence holders, working through the market, solved the allocation problem.

The licence holders became, if effect, quota portfolio managers. Many of the vessels specialised to some degree by species and/or area, and/or gear. Such specialisation required the licence holders to rebalance their quota portfolios. The required portfolio balancing was, and is, effected through the quota market. As of 2009, up to 3,000 ITQ transfers occurred annually in the fishery.

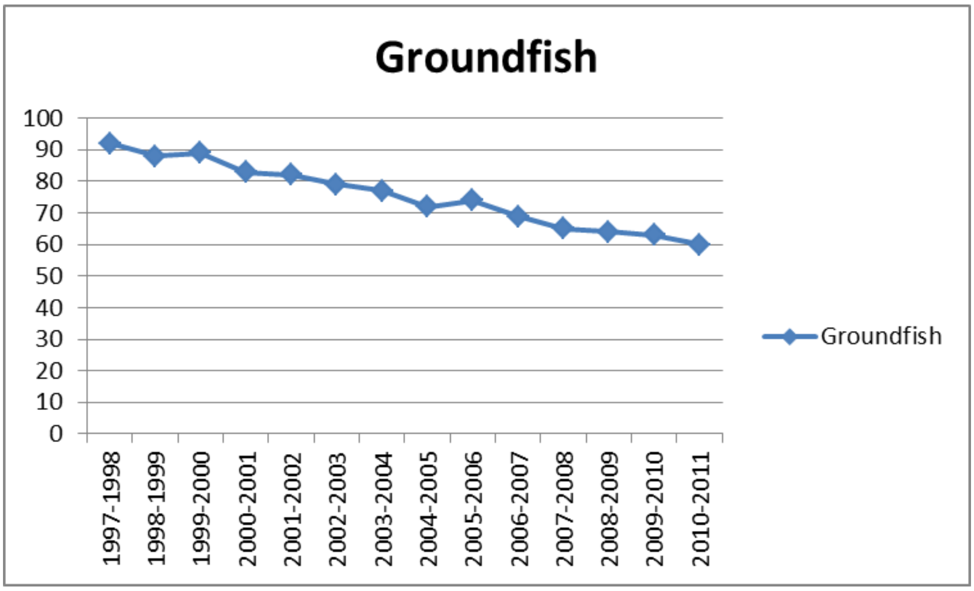

Figure 10. Total number of vessels for groundfish trawls industry 1997-2011.

Figure 10 shows that the total number of vessels for groundfish trawl has steadily decreased since the introduction of ITQs in 1997. The number of vessels was 92 in 1997 and in 2011 it was down to 60. This is a reduction of 34.8%.

In the halibut and groundfish trawl ITQ programmes the majority of fishermen were opposed to ITQs when the concept was first discussed. The reasons varied from those who did not know what their allocation would be, to those who did not understand the system, to those who did not trust government advice, to those who did not want any individual limits on their fishing (other than a TAC), to those who did not want change, and those who did not think it could work. In both cases it look only a few years for the fishermen who remained in the industry to realise it was a better system and provided them with improved operational flexibility, safety and economic opportunity.

3.6 The Bering Sea / Aleutian Islands crab fisheries[6]

The Bering Sea / Aleutian Islands (BSAI) crab fisheries target a total of eight species with Bering Sea snow crab and Bristol Bay red king crab most important. The BSAI rationalisation programme, which was adopted in June 2004 (Report; Five-year Review of Crab Rationalisation 2010), builds on the experience of the Individual Fishing Quota (IFQ) programmes for sablefish and halibut and also the American Fisheries Act cooperative programme for Bearing Sea pollock. The programme allocates harvest rights to BSAI crab resources among harvesters, processors and coastal communities. The programme wanted to address conservation and management issues, reduce bycatch and discard mortality and increase the safety of the fishermen. All these issues were associated with the race for crab that existed in the crab fishery due to overcapacity.[7]

The rationalisation programme set out to get rid of the current problem of the race for crab and at the same time satisfy the stakeholders dependent on the fisheries. Before the implementation of this programme the eight major BSAI crab fisheries were managed under the License Limitation Programme. This was a limited entry programme under which licenses were allocated based on historic participation.

There were stock declines leading to seasons as short as a few days or weeks because the fishermen were racing to catch the annual quota. Some of the crab fisheries even had to be closed because of the low resource abundance. In 2002, the Bristol Bay crab fishery was only open for 68 hours; in this brief period of time 250 vessels harvested more then 8.5 mill pounds of crab. A race like this leads to the neglect of safety and lower quality, as it is difficult to process this amount of crab in such a short period of time (Fina 2004).

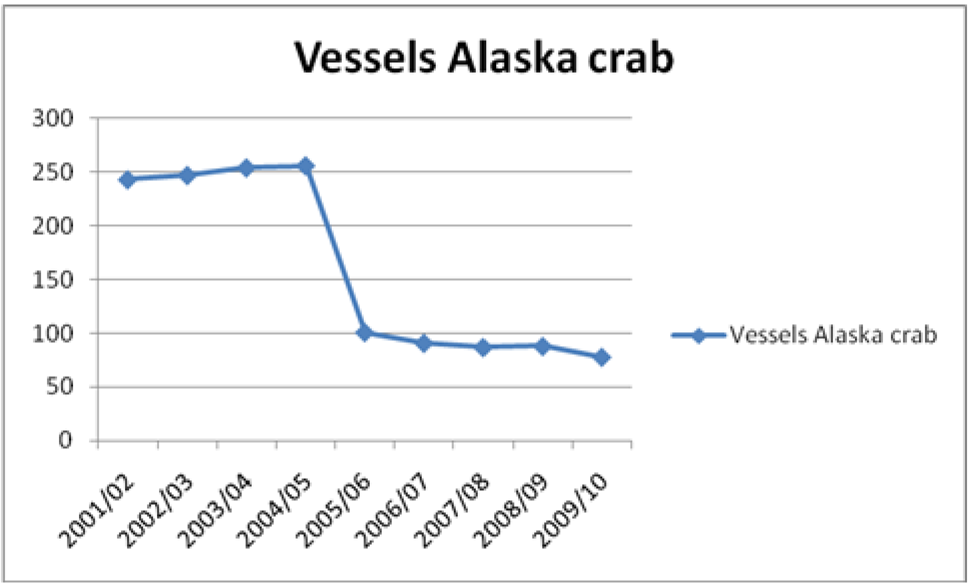

Figure 13. Vessels in the Alaskan crab fishery 2001-2010.
Source: Report; Five-year Review of Crab Rationalisation 2010.

Figure 13 shows that after the implementation in 2004, the number of vessels dropped from 256 in 2004/2005 to 101 in 2005/2006. That is a reduction of 60.5%. In 2009/2010 the number of vessels was 78; this gives a total reduction of 69.5% from 2004 to 2010.

Abbot, Garber-Yonts and Wilen (2010) use a census of vessels before and after implementation of catch shares in the BSAI fisheries to examine the effects of catch shares on employment and remuneration of crew. The reduction in the number of vessels has caused a roughly commensurate decrease in the number of individuals with some degree of employment in the fishery. Nonetheless, the overall employment – measured in crew hours (man days) spent fishing – has stayed roughly constant. With this comes a smoother, less seasonably pattern of employment. Remuneration has increased (often substantially) on both a seasonal and daily basis for the majority of fishermen relative to the period before rationalisation.

It is likely that these effects can be observed also for other fisheries where catch rights based management has been introduced.

1. ALASKA

The halibut and sablefish (black cod) fisheries in Alaska are among the more valuable fisheries in the North Pacific, with stocks managed jointly with Canada. In the late 1970s, the North Pacific Management Council started to consider a different management plan than open access. The season was getting shorter, and the fishery was characterised as a very strong 'derby' where the safety for the fishermen was at stake, the equipment was misused and product quality was deteriorating. The fleet was getting larger than what was economically sensible which made it difficult to manage.

The individual fishing quota (IFQ) management plan was approved November 9th, 1993 for the Pacific halibut and sablefish (black cod) fisheries of Alaska.

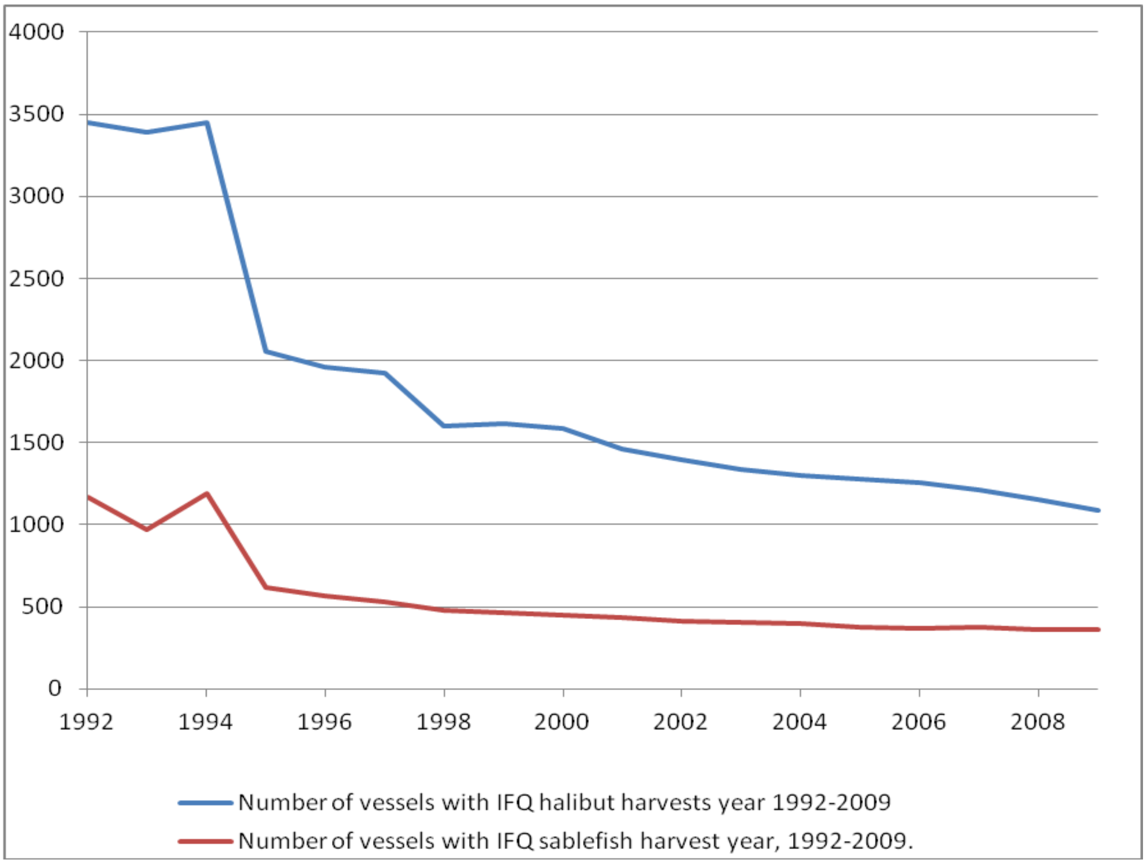

Figure 1. Number of vessels with IFQ halibut and sablefish harvest year 1992-2009.
Source: Taken from [22].

Figure 1 shows the development in numbers of vessels for 1992-2009. For halibut the number of vessels fell drastically from 3,450 in 1994 to 2,057 in 1995. Similarly, for sablefish, the number of vessels was reduced from 1191 (1993) to 616 (1995). This is a decrease of 40.4% in just one year for halibut and of 48.2% for sablefish. Thereafter, one can observe a gradual decline in the number of vessels in both fleets. In 2009 there were 1,090 vessels left in the halibut fishery or less than a third of the number of vessels when the IFQs were introduced. The median vessel length for halibut vessels has had a slight increase from 40 ft in 1995/1996 to 42 ft in 2005. The median vessel size was still at 42 ft in 2009 [22].

Although not directly applicable to these fisheries, Abbot *et al.* [23] show for the Alaskan crab fisheries that while crew numbers were significantly down after the introduction of vessel quotas in line with the number of vessels, total number of manyears was virtually unchanged. This provides an indication that a significant part of the overcapacity is capital, and that most of the reduction in effort is a reduction in capital rather than labour.

3. BRITISH COLUMBIA

The halibut fishery in British Columbia is the Canadian counterpart to the Alaska halibut fishery discussed in the previous section. The individual fishing quota system was introduced somewhat earlier, in 1991, and has been the focus of several studies [24,3,13]. Prior to the introduction of individual vessel quotas, the fishery was operating under a limited entry programme. This programme started in 1979 and had 435 licenced vessels.

During the 1980s the fishing capacity increased despite the limited entry programme, as the crews were getting larger and vessels invested in more efficient gear. Because of the better technology and equipment, the fishing season kept getting shorter, as the fishermen caught the TACs faster and faster. In the late 1980s it was down to 1-2 days in some major areas, even with a larger overall harvest quota. The fishery was at this time characterised by the race for fish, with dangerous fishing conditions for the fishermen, equipment being lost and ruined and reduced quality of the fish [24].

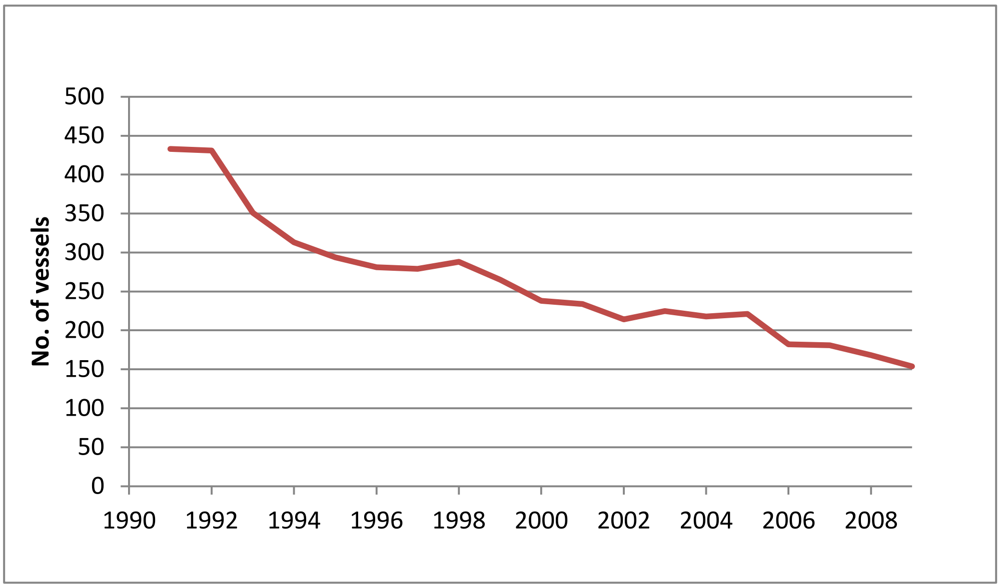

Figure 2. Total number of vessels in the halibut fishery 1991-2009.
Source: Taken from [25].

The development in vessel numbers from 1990, two years before the individual vessel quotas took effect is shown in figure 2. In the first year, the number of vessels was reduced from 433 to 350, or by 19.2%. Subsequently, there has been a steady decline in numbers of vessels, although with slight increases in some years. The number of vessels was reduced from 433 in 1991 to 154 vessels in 2009, a reduction of 64.4%.

As noted above, Grafton, Squires and Fox [13] observed that full adjustment to a change in management system takes time, and this is certainly the case in this fishery. The number of vessels is still declining, and although this development is likely to be influenced also by other factors such as technological innovations, this development would not be possible under other management regimes than individual vessel quotas.

4. CHILE

The southern pelagic fishery in Chile is an industrial fishery that historically has been focused on pelagic species to be reduced to fish meal and oil. The vessels in the fleet are relatively large, on average over 18 m long and more than 50 gross registered tonnes. Until the 1990s, the fishery was basically an open access fishery.

Regulations in the fishery started in December 1997, when the fishery was closed to secure the sustainability of the fish stocks. For the next three years vessels could participate in 'experimental' fishing expeditions for jack mackerel, where they would sweep a pre-determined stretch of sea and locate existing schools of fish [26]. After the expeditions and based on the landings, the authorities would determine quotas that could be caught by the participating vessels. The race for fish was still going on for other species like anchovies and sardines.

The individual quota system was introduced in February 2001. Licensed boats had a right to harvest a percentage of the annual TAC. This was calculated from an average of catches that the companies had landed between 1997 and 2000. The quotas were originally given for two years but in December the same year they extended the quotas to 10 years [26].

The development in vessel numbers is shown in figure 3. As one can see, the number of vessels in the southern fishery was rapidly reduced from 149 in 2000 to 65 in 2002. During the next two years another eight vessels was removed, reducing the fleet to 57 vessels in 2004. This is a reduction of 61.7 % from 2000 – 2004.

Fleet size data are not available after 2004. However, according to industry insiders, fleet size has shown little change after 2004.[1]

[1] Source: Dr. J. Pena, private communication, April 2011.

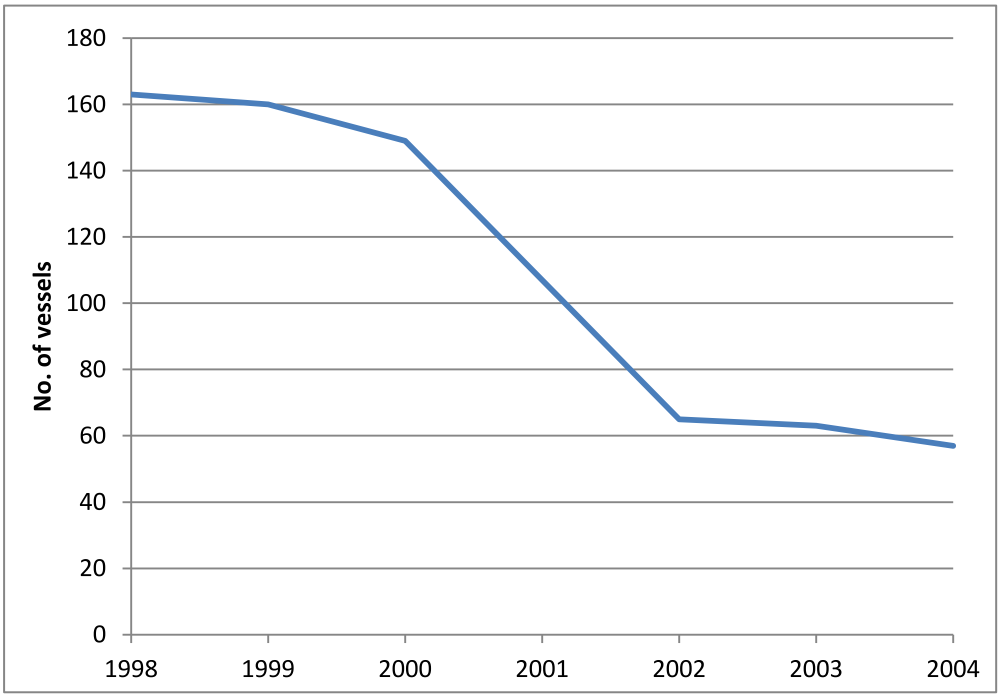

Figure 3. Number of vessels in the Southern Pelagic industrial fishery 1998-2004. Source: Taken from [26].

5. NORWAY

The cod fisheries are the most important as measured by value in Norway, and while cod is the most important species a number of other whitefish species such as saithe, haddock, redfish, etc are also caught. While most studies have focused on the trawlers [27,28,29], it is the coastal fleet that take the largest share of the catch and it has been showed to obtain a higher unit value for it's catch [30]. The Norwegian TAC is divided between the trawler fleet and the coastal fleet using what is called the "trawl ladder". This is a rule that specifies that if the total cod quota is 100,000 tonnes or smaller, the coastal fleet gets 80% of the quota. As the quota increases, the trawlers gets a larger share to a maximum of 35% for a TAC at 300,000 tonnes or higher.

The coastal fleet consists of a large number of smaller vessels using a variety of gears such as long lines, troll nets and Danish seine. Over the years, a number of effort restriction have been in operation, and the coastal fleet has also been divided into different groups, leading to substantial economic inefficiencies [31]. Individual vessel quotas were introduced from January 2004 for the vessels larger than 15 metres, and expanded to include vessels down to 11 meters from 2007. This made individual vessel quotas the prevailing management system for all but the smallest vessels in the Norwegian fisheries.

The development in number of vessels is shown in figure 6. Through the 1990s, there was a slow increase in vessel numbers, with a peak of 1,169 in 1998. Buyback programmes and other capacity reducing measures had an impact in the period 1998 to 2003. This reduced the number of vessels to 1,029 vessels in 2003, the last year before the individual vessel quotas. Between 2003 and 2004 there is a clear kink as vessels are leaving the fleet much faster. From 2003 to 2006 the fleet was reduced by 256 vessels. The figure also clearly shows how the extension of the IVQ system to smaller vessels in 2007 led to a new wave of vessels leaving the fleet, whereafter vessels continued to leave the fleet at a slower pace. In 2010 the coastal fleet consisted of 629 vessels, a reduction of 38.9% since the introduction of the individual vessel quotas.

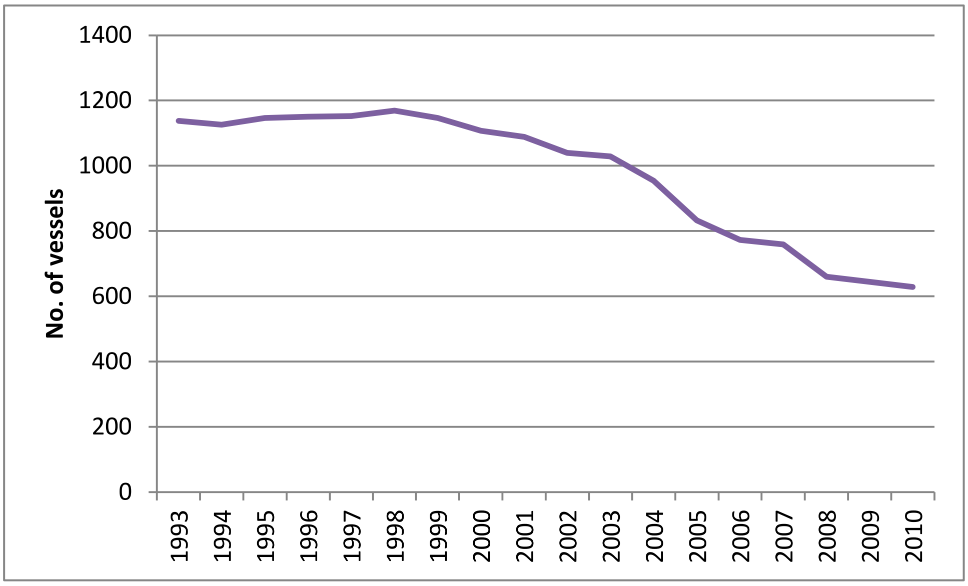

Figure 4. Number of vessels in Norwegian coastal whitefish fisheries.
Source: Data from [32].

8. SUMMARY AND DISCUSSION

INTRODUCION

As is well known, open access fisheries are characterised by stock depletion and excessive harvesting effort that lead to dissipation of resource rent [1]. This is evidenced by the *Sunken Billions* report, which estimates an annual rent loss in world fisheries of around $ 50 billion [2]. Stock depletion can, at least in principle, be addressed by implementing and enforcing Total Allowable Catch quotas (TACs). However, unless there is also effective management of fishing effort, the economic waste associated with excessive effort remains. Increasingly, this is recognised as a serious problem in itself that may even contribute to overfishing if quotas are set endogenously in the management system [3]. As noted by Hannesson [4], the situation can be exacerbated by Illegal, Unregulated or Unreported (IUU) fishing.

Early attempts to deal with excessive effort include entry restrictions such as limited entry (licensing) and regulations of vessel size and fishing days as well as gear restrictions. However, these measures work poorly as fishermen find ways to substitute away from the regulated factors, giving rise to the class II open access fishery [5] or the regulated open access fishery [6]. While theory clearly predicts that effort will be too high under sub-optimal management, until the late 1990s there was limited knowledge with respect to what magnitudes were involved. Homans and Wilen [3] used a bioeconomic model to show that effort was ten times higher than optimal under regulated open access in the BC halibut fishery, while Weninger [7] indicated that two thirds of the fleet was redundant in the US Mid-Atlantic surf clam and ocean quahog fisheries. Asche *et al.* [8] show that the potential reduction in fleet size due to optimal management in five European fisheries is between one and two thirds. In addition, a large number of studies have shown that many of the worlds fishing fleets can be characterised as having substantial over-capacity [9, 10, 11]

In the last three decades, rights based fisheries management systems where fishermen get individual quotas, have been introduced in a number of fisheries around the world to address the problems of excessive effort and stock depletion. These systems change fishermen's incentives from maximising their share of the harvest to minimising the cost of harvesting a given quantity of fish [12]. This is likely to lead to a reduction in fishing capacity and effort over time. Grafton, Squires and Fox [13] and Newel, Sanchirico and Kerr [14] note that when introducing individual quotas, the transition can take time, and this can be further augmented by uncertainties with respect to the regulations [15] and the sunk capital in the vessels [16,17,18].

Rights based fisheries management also comes in different forms. With Individual Vessel Quotas (IVQs), vessels have individual quotas which may or may not be transferable. In the case of Individual Transferable Quotas (ITQs), fishing quotas are fully transferable through sale, lease or exchange, and in principle the quota market can lead to optimal effort levels [19]. In practice, the duration of the ITQs may be variable, from a few years to being permanent [20,1].

IVQs as fisheries management systems were introduced in the 1980s, and have become increasingly popular. As of today, about 25% of the world harvest of capture fish comes from fisheries managed with individual quotas [21]. There has been a discussion with respect to what extent individual quota systems actually reduce fleet size [8]. As many of these systems have been in operation for a decade or more, we are now in a position to see how actual vessel numbers have developed in such fisheries.

In this paper we will report the results from an investigation on the effect on vessel numbers of the introduction of individual vessel quotas in six different countries, namely the USA (Alaska), Canada (British Columbia), Chile, Norway, Denmark and Australia (Tasmania). This does not provide a final answer with respect to the impact of individual quotas systems on fleet size, particularly since there is substantial variation in the details of the management systems in these fisheries. However, it should be a useful complement to empirical studies focusing on specific fisheries and more theoretical studies, and the potential impacts of individual vessel quotas that are reported in such studies. The fisheries reported here are selected primarily because of easy data access, but are also fairly well spread over the world. The reporting period is chosen to show the situation before the introduction of quotas as well as the effect of quotas, subject to data availability, and as such, in some cases we have the fleet development for a period before the individual quotas were introduced, while in other, we primarily have the data from the time when the individual quotas were introduced.

FAO [37] characterised more than 80% of the world's fisheries as fully utilized, overfished or recovering. It is than not surprising that many of the world's fishing fleets are characterised by excessive effort and overcapacity [2]. When the starting point is a fishery characterised by excess effort or over-capacity, management systems with individual vessel quotas are predicted to reduce this wasteful use of resources. Moreover, with a sufficient degree of transferability, such regulatory schemes can in theory deliver the optimal fleet to harvest a given quota of fish. However, in practice there are a number of concerns with respect to IVQs, and many actual systems have limitations on the degree of transferability, the duration of the quotas etc. With substantial variations in the design of the different IVQ systems, it is of interest to shed light on the degree to which these management systems deliver reductions in fleet size.

A number of studies have predicted relatively dramatic reductions in vessel numbers if the management system provides such incentives, as overcapacity has been substantial. This is to a large extent confirmed for the six case studies in this paper, which provide examples of individual quota systems with a substantial variation in the specific structure as well as the state of the management system prior to the implementation of individual vessel quotas. In cases under consideration the number of vessels was reduced by at least 30% within a few years of the implementation of individual vessel quotas. Hence, there is no doubt that traditional management schemes that have tried to control effort such as limited entry have allowed substantial overcapacity to build up. Moreover, the total effect on vessel numbers is surprisingly similar despite the different degrees of transferability that are built into the different cases.

The halibut and sablefish fisheries in Alaska are the cases where the reduction in the number of vessels was most rapid. This is not too surprising given that these were the cases where the harvesting season was shortest and the race to fish was strongest and accordingly, where most effort was wasted in the competition for fish. In all cases, it is also clear that it takes time to reap the full benefits of the individual vessel quota systems. For the earliest case, the Canadian halibut fishery where individual vessel quotas were implemented in 1992, one can still observe that the number of vessels in the fleet is being reduced. The reduction in vessel numbers over time can be quite substantial. We provide examples and there are also examples in the literature where more than two thirds of the fleet before IVQs were implemented leaves the fishery.

There is often concern that introduction of ITQs will lead to a reduction in employment in the fleet. If the result of Abbot *et al.* [23] that the number of man years in a fishery is not reduced very much by the introduction of individual vessel quotas holds in general, this provides evidence that the overcapacity perceived to exist in most poorly managed fisheries is primarily related to capital. As such, the fleet reduction is technological non-neutral. This issue, which is important for fisheries dependent coastal communities, is worthy of further research, as it implies that total employment may not be too much influenced by a better management regime.

It is also worthwhile to not that while the numbers reported in this article indicate a substantial reduction in over capacities, they do not show the additional benefits captured by higher revenues. Casey et al [24] noted that with less of a race to fish, more effort was expended to serve better paying markets. This revenue effect is documented also in recent studies [38], and the potential seems to be substantial as it is well documented that switching fishing gear can enhance value [39], as do a number of other attributes from physical quality to the provision of documented sustainable management by ecolabels [40].

[1] This section draws heavily on Bjørndal and Munro (2012).

[2] Producer Organisations in European fisheries may also be considered community based management.

[3] This is taken from Asche, Bjørndal and Bjørndal (2012).

[4] Source: http://webfd.fd.dk/stat/Faste%20tabeller/Landinger-10aar/tab713b.html

[5] This is taken from Asche, Bjørndal and Bjørndal (2012).

[6] This section is largely based on Asche, Bjørndal and Bjørndal (2012).

[7] http://www.alaskafisheries.noaa.gov/sustainablefisheries/crab/rat/progfaq.htm#wicr Accessed 24.05.11.