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Challenging spatial and seasonal distribution of fish landings—The experiences from rural community quotas in Norway

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ABSTRACT

In most fisheries catch per unit effort shows significant seasonal and spatial variation. Traditionally, i.e. when vessels are free to choose their harvesting strategy, 80% of the Norwegian cod is landed during the winter in a limited geographical area. To alter the seasonal and spatial supply of cod to the fish processing industry, rural community quotas were introduced. In this paper, we develop a model to predict how different vessels will adapt to the quotas introduced. The hypotheses developed are mostly confirmed in an empirical study. Theoretical, methodological, and managerial implications of the findings are discussed.

1. Introduction

Harvesting patterns show considerable seasonal variation in many fisheries. This may well be economically efficient for the fishing fleet, but for the firms and communities involved in processing and marketing, however, the situation poses some serious challenges. Seasonality in landings of fish entails a shortage of essential raw materials and discontinuity in employment and in deliveries to the markets. It also complicates capacity planning for both fishing vessels and fish processing plants.

Some actors have adapted to the seasonal variations by increasing flexibility and keeping capacity costs low [1,2]. Others, however, are supplying markets that demand stability and continuity in production. These, in particular, face challenges when the supply of fish fluctuates strongly during the year.

The key variable explaining how such a pattern can persist is likely to be seasonal variations in catch rates, often measured as catch per unit effort (CPUE). This paper focuses on the utilization of Northeast Arctic cod, one of the most important species in Norwegian fisheries. For this species, the seasonal variation is quite pronounced. According to Eide et al. [3], the CPUE of stern trawlers is reduced by 70% from the high to the low season. As shown in Flaten [4], this pattern is even more pronounced for the coastal fleet.

To moderate the negative impacts of seasonality, the Norwegian fisheries authorities introduced a special scheme to the management system for Northeast-Arctic cod. Within the regime at the time, vessels were granted individual quotas, and the timely and spatial distribution of effort and landings were left to be defined in the markets between fishermen and processing firms. The new scheme was aimed at shifting this distribution of cod in order to gain political influence on the distribution of value added from this important resource. The expressed objective was to secure employment in particularly vulnerable areas through improving the supply of raw fish during the low season [5]. The scheme was named "rural community quota" (RCQ).[1]

In short, a relatively small share of the cod quota was reserved for fishing in the low season, traditionally the period from July to December. County governments distributed these quotas between different communities. Selected vessels were granted individual quotas, provided that the catch was landed in a specified community. A more detailed description of the scheme is provided later in the paper.

1.1. Research questions

A key requirement for the RCQ regime to be successful is that the number of fishermen finding these quotas attractive is sufficiently high. In a setting where high-season fishing is the preferred harvesting pattern, one cannot simply assume that this will be the case. There may also be free-rider problems, as many vessel owners may find it opportune to apply for quotas and not

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[1] A somewhat similar scheme was applied from 1984 to 1991, but only for ocean-going trawlers.

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utilize them. With experience from two years of RCQs, the purpose of this paper is to investigate how the RCQ regime performed in shifting the harvesting pattern towards the low season. In particular, we analyse how vessel decision makers adapted to the introduction of the quota regime.

The knowledge obtained may be important for further refinement of the RCQ system or as a basis for altering the harvesting pattern towards being more suitable for the consumer market, processing industry and local communities.

1.2. Methodology

The methodology chosen is driven by the empirical hypotheses to be tested and the context in which they are tested. We have collected data and information from several sources. Information on the implementation of the scheme was obtained through official documents and interviews with key officials in the Norwegian Ministry of Fisheries and Directorate of Fisheries. Data on landings of fish were provided by the fishermen's sales organization. These data and semi-structured interviews with fishermen were used to investigate how fishermen adapted to the RCQs.

1.3. Outline

The paper continues as follows: The following section presents a model for explaining the degree of seasonality in harvesting from wild fish. Based on the model, we describe the harvesting pattern of Northeast Arctic cod (*Gadus morhua L.*) in Norway that has prevailed for centuries. The subsequent section outlines the implementation of RCQs and proposes a set of hypotheses on how different vessels will adapt to these quotas. We then present our review of the performance of the RCQs and empirical tests of the proposed hypotheses. In the concluding remarks we summarize our empirical findings and discuss the theoretical, methodological, and managerial implications of our findings.

2. Seasonal harvesting

A general and reasonable assumption is that firms seek to maximize their profit in order to survive and prosper. In the short run, vessel size and gear type is given. How to achieve the above goal thus becomes a decision of where and when to apply the vessel. In fisheries we often observe that fishermen choose to concentrate their efforts in time and space. This is particularly prevalent in fishing for Northeast Arctic cod, which is the species selected for this study. Fishing effort is concentrated in winter when the mature part of the stock has gathered and migrated from the Barents Sea to coastal regions to spawn. This pattern has prevailed for centuries, even though market knowledge, fish finding equipment, vessels, and gear have developed considerably. Fig. 1 illustrates the seasonal catch profile of Northeast Arctic cod.

How can such a seasonal harvesting pattern be explained? With relatively large investments in vessels and processing plants and the demand for fish being relatively stable, one could reasonably assume that high capacity utilization throughout the year would be the dominant strategy. Fisheries, however, differ from traditional production processes, because key inputs, such as the fish stock, catchability, and quality parameters, are exogenously given.

In Fig. 2 we propose a simplified model for the spatial and temporal allocation of fishing effort. This allocation is the result of a complex utility maximizing problem. Maximizing profit means a trade-off between revenues and costs. In short, revenues are defined by landings and prices. Landings vary with the applied effort and catchability, the latter experiencing seasonal variations due to the migration patterns of fish. Migration also affects fish quality, which, in turn, has a significant impact on the price achieved.

For Northeast Arctic cod, the annual feeding and propagation migrations mean high catchability in the areas in which these stages occur. Prices are higher during the propagation migration period, due to the increased size of the fish and the availability of valuable byproducts, such as roe and liver. Catchability is also a key cost driver, as costs are reduced when the catchability is high.

Variations in catchability and sales prices thus promote a more seasonal application of effort. Any positive correlation between these two factors will strengthen the tendency to concentrate fishing effort. Some fisheries will entail alternative costs as well, as the application of effort in a particular period or place may exclude or reduce the value of other fisheries or activities. The extreme example is when the peak season for two types of fish coincide in time, mutually excluding each other.

The distance between fishing grounds and landing sites also plays a significant role in the decision making process. Migration patterns may cause large variations within this variable and

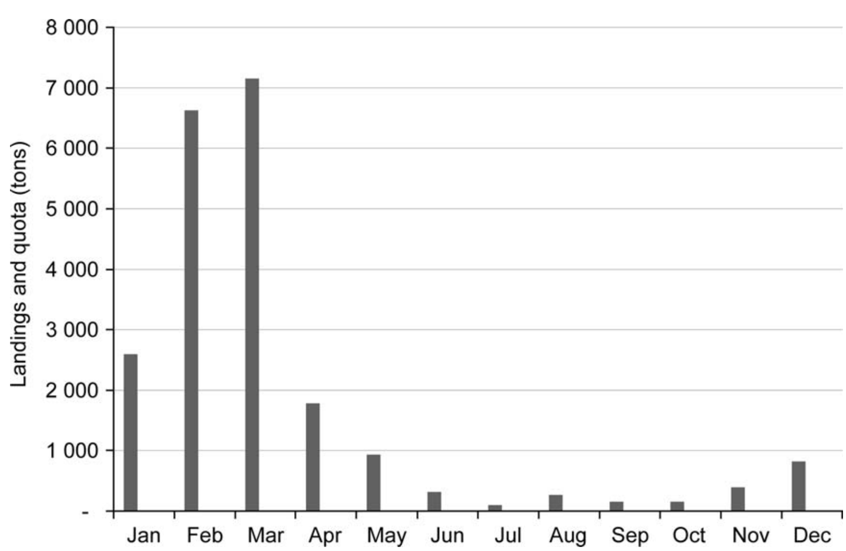

Fig. 1. Landings of cod (round weight) from vessels 15–21 m in length in 2007.

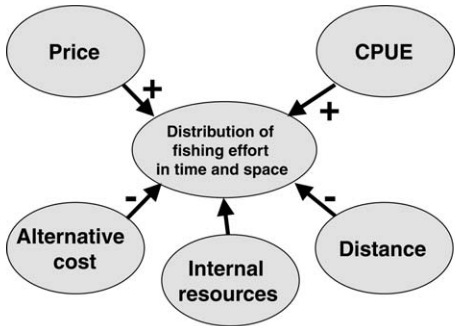

Fig. 2. Factors impacting spatial and temporal allocation of fishing effort.

directly affect fuel and time consumption. More steaming time also means less time for fishing, which directly affects profits. In addition, being further out from shore means the vessel is more vulnerable to weather conditions and requires larger investments in the vessel. Large distances thus reduce the value of a particular season, whereas proximity to shore increases attractiveness.

Based on our approach, as illustrated in Fig. 2, the adaptation of fishermen to the migration patterns of fish can be predicted. However, this requires that the variation in each item is stable and predictable, thus making uncertainty an important moderator for the harvesting pattern. Also, fisheries management may influence the harvesting pattern by limiting the options fishermen have. The attractiveness of a highly concentrated, seasonal fishery is moderated by the predictability of the migration pattern, weather conditions, and the management regime.

According to Barney's resource-based view of firms (RBV), firms are heterogeneous, i.e. they control different portfolios of resources [6]. Based on this observation, Barney concludes that firms have different strategic options and will adapt differently, even in the same competitive context. In a fishing context, this implies that we may observe different harvesting patterns among vessels in the same fishery. For instance, the portfolio of licences each vessel controls, the home port of the vessel, and knowledge of fishing areas will impact which harvesting strategy the vessel adopts. The reasons for this variation in firm resources are complex. It may often be related to historical paths in investments in vessel and gear, or it may be related to competence and where fishermen live. And, of course, it may also be a result of how the authorities manage the fisheries.

3. Norwegian RCQ implementation

Most fisheries are subject to regulation by central authorities, and the primary objective of regulations is to protect stocks from being overexploited. This is achieved by limiting the degree of freedom fishermen have to adapt to predictable migration patterns. In fact, some management regimes are established in order to avoid a concentration of fishing effort in time and space. For instance, the RCQs studied here were implemented in order to reduce catches of cod in the high season, i.e. the winter.

The seasonality of cod landings results in a lack of continuity in employment and the supply of fish to the market. It also poses challenges in terms of capacity planning for both vessels and fish processing plants. In 2006, the Norwegian government introduced a special quota system to change the distribution of cod in both time and space—so-called rural community quotas (RCQs). The expressed objective was to secure employment in particularly vulnerable communities by improving the supply of raw fish during the low season [5]. This strategy was in line with the general rural policy of maintaining the geographic population distribution structure [7,8].

Table 1
Distribution of rural community quotas in 2006 and 2007 (tons).

Vessel group	County			Total
	Nordland	Troms	Finnmark	
Trawler	948	395	553	1896
Coastal 15–21 m	482	201	281	964
Coastal 21–28 m	312	130	182	624
Total	1742	726	1.016	3484

The scheme reserved a small part of the cod quota for fishing in the low season towards the end of the year. County authorities distributed the quotas among the local communities, as they supposedly had better knowledge of the individual communities' dependency on and the vulnerability of the fish supply. Quotas were allocated to different regional zones within the counties included. Vessels applied for vessel quotas, and selected vessels were required to land the fish in specified zones during the end of the year.

Three vessel groups were included in the RCQ system implemented in 2006. The system was continued in 2007 with only marginal changes. The quota was obtained by subtracting 3% of the respective vessel group quotas. The quota for each vessel group was distributed among the three northernmost counties by the Ministry of Fisheries and Coastal Affairs. In 2006, guaranteed quotas of 10, 15, and 40 tons were set for coastal vessels between 15 and 21 m in length, coastal vessels between 21 and 28 m in length, and trawler groups, respectively. In 2007, trawler quotas were increased to 80 tons. The RCQs were made available as of late October in 2006 and late August in 2007.

The RCQs were distributed geographically according to a model that employed "ruralness" and "fisheries dependency" indices at municipality level. The distribution according to county and vessel type is outlined in Table 1. RCQs represented approx. 1.6% of the total Norwegian cod quota, hence a quite limited amount.

To make the RCQs attractive, they were given to a limited number of vessels. Vessels were asked to apply for quotas, and a lottery determined the vessels that were allowed to participate. The vessels had significant influence on their preferred county, but not on which zone they were allocated. In addition to the restriction on where to land, another important restriction was that the fish had to be landed fresh. This was a major issue, as most of the trawlers were equipped to freeze their catch.

3.1. Vessel owner behaviour and RCQs—hypotheses

The success of this management system was to a large extent dependent on vessel owner behaviour—were the quotas considered attractive? According to our approach, the attractiveness of these types of quotas depends on several factors. First and foremost, fishing the quotas must be considered profitable.

In addition to profitability, we propose five hypotheses concerning vessel owner behaviour in relation to the RCQs. These are based on the model introduced in Fig. 2, and the resource-based view that firms differ. These will be empirically tested by applying data on individual vessel catches and landings during the RCQ period.

The attractiveness of the RCQs depends on how well the high season fishery performs. If the high season fishery is generally poor, a relatively large share of the total quota will remain after the season ends. This will be redistributed among all vessels for an autumn season. In this case, fishermen will prioritize such redistributed quotas rather than the RCQs, as the latter are more restrictive.

H_1. RCQ attractiveness varies with the degree of success in the high-season fishery.

Fishermen, as most other people, are generally risk-averse. Acquiring options is a way of reducing risk, and an RCQ may be perceived as such. We thus predict that many fishermen will apply for RCQs, even if the likelihood of utilizing them is small. In our study and context, this, in turn, induces the following hypothesis:

H_2. A considerable number of vessel owners will apply for RCQs even if utilizing them is unlikely.

The RCQs are restrictive in terms of where and when the cod may be landed. As indicated in our model on seasonality in fisheries, catchability is an important decision parameter. We predict that regions close to fishing grounds where cod is accessible in the low season, i.e. in the autumn, will be more attractive than regions further away from such grounds. According to statistics on where cod is caught in the autumn, and knowledge of the migration patterns of cod, RCQs will be most attractive far north, i.e. in Finnmark, and least attractive far south, i.e. in Nordland. In other words, it is more likely that RCQs will be a success in rural areas in Finnmark than in Nordland. We thus propose the following hypothesis:

H_3. RCQ success will be higher in the north than in the south.

The internal resource position for each vessel will influence the ability of that vessel to utilize allocated RCQs. For example, large vessels are less sensitive to weather conditions and have greater mobility. Some types of fishing gear are better suited for catching cod during this period than others. Crew knowledge and experience may limit the vessel's ability to utilize RCQs. Technological position and knowledge will thus impact both the perceived risk and the profitability associated with the utilization of RCQs. This induces the following empirical hypothesis:

H_4. Internal resources such as vessel size, gear type and skipper knowledge are important factors in RCQ attractiveness.

In addition, other internal firm resources could also have significant impact on strategic choices. According to our model, the alternative costs associated with utilizing RCQs increase when vessels have a portfolio of quotas that includes quotas for other species of fish, whose season overlaps in time with the RCQ period. Consequently, we propose the following hypothesis:

H_5. Vessels with other quotas that overlap in time with the RCQ period will find RCQs less attractive than vessels that only have quotas for cod.

4. Findings

The following sections present and discuss the findings of our study. First, the actual fishery is described. Next, the effects on spatial and temporal distribution are evaluated. Finally, the five hypotheses are tested with empirical data.

4.1. Actual fishery

In 2006, although RCQs were opened in late October, there was very little activity until December, the last month of the period. To increase attractiveness, the authorities increased vessel quotas

Table 2
Rural community quotas and landings (tons) in 2006 and 2007.

Vessel group	Quota	Landings	
		2006	2007
15–20.99 m	964	94	1024
21–27.99 m	624	133	504
Trawler	1896	2487	2027
Total	3484	2714	3555

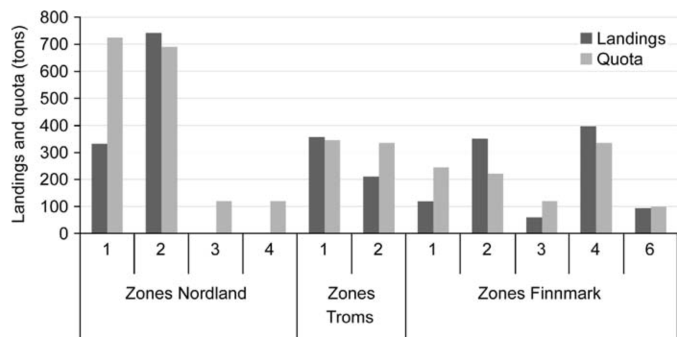

Fig. 3. Landing and allocation of RCQs per zone in 2007.

and lifted the restrictions on onboard freezing and where to land. These changes had little effect on the coastal fleet segments, but clearly stimulated the trawlers, which landed 63% of the total quantity during the last two weeks of the period. They were also allowed to overfish their allocated quota by 31%. In contrast, the coastal vessels utilized only 14% of their quota.

The following year saw a different situation. Like in 2006, however, there was little activity early on in all counties and vessel groups. Vessel quotas were therefore increased substantially, and onboard freezing was again permitted. Activity increased in December in both the coastal and the trawler groups, landing 68% and 69%, respectively, of their RCQ catch during December. In total, the quota was slightly overfished. The distribution between vessel groups was close to the intended one. A summary of quotas and landings for each vessel group is presented in Table 2.

The spatial distribution of landings differed considerably from the political intention. In 2006, Finnmark filled its share, whereas the two other counties fell considerably short. In 2007, Finnmark exceeded its share by 50%, Troms filled its allocation, whereas Nordland fell short by approximately 23%.

Investigating the distribution between individual zones reveals considerable variation from the initially allocated quotas, as shown in Fig. 1. In Finnmark, especially, landings in some of the zones were substantially larger than the allocation, whereas others got significantly less. We find the same pattern in 2006, but the low level of utilization in the coastal fleet that year makes comparisons difficult (Fig. 3).

4.2. Spatial and temporal distribution

First and foremost, the total Norwegian quota limits the landing of cod. In order for some communities to get more, other communities must get less. The rural community quotas can only alter the spatial and temporal distribution of the total quota.

Estimating the spatial impact of landings is difficult, as we have to make assumptions about the distribution without RCQs. Landings in previous years could have served as proxy, but the large natural and government variations weakens the validity of such comparisons. We have instead employed a method that deconstructs the effect of RCQs into a positive and a negative component. The negative effect stems from all vessels in the included groups having 3% subtracted from their regular cod quota. Some of this fish would have been landed in the three RCQ counties. The spatial distribution is estimated using each vessel group's RCQ allocation and the distribution of their landings during the non-RCQ period.

In 2007, the rural community quotas were fully utilized, and the actual landings thus represent the positive effect. As previously mentioned, the RCQ quota was significantly underutilized in 2006. Despite this, the total quota was filled, implying that the remainder was caught through ordinary quotas. Consequently, including only actual RCQ landings would underestimate the positive component. We have employed the coastal vessel group's RCQ allocation less the overfishing of trawlers as the positive component. This is assumed to have the spatial distribution of the regular quota landings in the RCQ period.

The results for 2006 and 2007 are presented in Table 3. As the coastal groups land their cod almost exclusively in the three counties, the net effect for the area as a whole is negligible. In 2006, the distribution between the counties yields a small positive effect for Finnmark and small negative effects for the two others. The trawlers usually land a considerable amount of their quotas in other counties, resulting in a net positive effect for all three counties. The same trend was found in 2007, with the exception that Troms and Nordland also saw positive effects.

Compared to the total landing of cod in the three counties, the impact of RCQs is rather small. In Finnmark, the total landing of cod in 2005 and 2006 was 63,000 and 60,000 tons, respectively, which implies an increase in landing of approx. 1%. In the two other counties the effect is close to zero.

RCQ changes the temporal distribution of landings. Without RCQs, it is clear that a considerable part of the quota would have been caught during the prime season. It is difficult to estimate this effect, as it, among other factors, relies on individual vessel decisions about how much of the vessel's quota will be caught during the prime season and how much will be saved for fishing towards the end of the year. To estimate the change in temporal distribution, we assume that the groups, on average, would not change their utilization rate. The average utilization rate during the high season would then reflect how much of the RCQ that would otherwise have been caught under the regular quota.

Utilization rates, RCQs and quantities that are transferred to the low season are presented in Table 4. Coastal vessels land most of their quotas during the high season; restricting these quotas thus yields significant transfer effects. The trawlers employed a more linear landing pattern during the years studied, and therefore lower effects are obtained. Still, we estimate a transfer efficiency of approximately 75%–85% for the allocated RCQs.

Table 3
Impact on spatial distribution of landings (tons).

	Negative 2006		Positive 2006		Net	Net
	Coastal	Trawler	Coastal	Trawler	2006	2007
Other counties	16	587			−603	−853
Finnmark	402	469	668	867	+664	+632
Troms	265	440	134	551	−19	+163
Nordland	905	401	195	1.069	−42	+129

4.3. Impact on employment

A simple model was constructed to evaluate the impact of RCQ on employment in the counties. The model was based on average figures for employment per kilogramme of raw materials, obtained from background data from an annual profitability survey of the processing industry [9]. Due to the relatively minor effects on landed quantities, it was clear that any employment effects would also be small. For 2006, the effect was estimated at about 11 man-years in Finnmark, i.e. 2% of the total employment of 526 man-years.

Naturally, the effect on employment during the RCQ period is larger, as landings during this period normally are relatively low. Some of the processing firms rely extensively on temporary and foreign labour during the prime season. Shifting some of the landing to the low season can thus create a more stable work situation for local workers.

4.4. Vessel owner decision hypotheses

Our first hypothesis was that vessel owners would find RCQs more attractive when the high season fishery was successful. We have tested this by comparing the degree to which the RCQs were filled in 2006 and 2007. The rationale behind this approach is based on the difference in performance in high season of the two years in question. In 2006, bad weather, combined with the migration pattern of cod, resulted in relatively low catchability throughout the high season. Consequently, many vessels did not manage to fill their regular quotas during the winter, and the remaining quotas were redistributed during the RCQ period. In 2007, however, the situation was the exact opposite. The weather conditions were favourable in the critical period, the cod migrated close to the shore, and the CPUE was extremely high. This resulted in a situation where the only cod quotas left after the winter were the RCQs.

In Table 5, the ratio of RCQ landings to granted RCQ quotas is presented for each vessel group and county. In 2006, the coastal fleet utilized only a small share of their quotas, whereas the trawlers slightly overfished their quotas as a consequence of quotas being transferred from the coastal groups. In 2007, the situation was quite different; almost all the coastal groups filled their allocated quotas. Again, the trawlers showed high utilization rates.

Table 4
Transfer of landings to rural community quota period.

	2006			2007		
	Utilization week 44	RCQ	Transferred quota	Utilization week 44	RCQ	Transferred quota
15–21 m	89%	964	858	>100%	964	964
21–28 m	95%	624	593	>100%	624	624
Trawler	68%	1896	1289	75%	1896	1422
Total		3484	2740		3484	3010

Table 5
Ratio of cod landings from RCQs to quotas per vessel group and county.

	2006			2007		
	15–21	21–28	Trawler	15–21	21–28	Trawler
Finnmark	0.3	0.7	1.6	1.5	1.0	1.7
Troms	0.1	0.0	1.4	1.0	1.1	0.9
Nordland	0.0	0.0	1.1	0.9	0.6	0.8

Table 6
Ratio of active vessels to granted RCQs per vessel group and county.

	2006			2007		
	15–21	21–28	Trawler	15–21	21–28	Trawler
Finnmark	0.8	0.5		0.8	0.8	
Troms	0.6	0.3		0.7	0.7	
Nordland	0.6	0.3		0.6	0.6	

Findings from the small vessel groups strongly support the hypothesis that the attractiveness of RCQ is highly dependent on the results achieved during the high season, i.e. H_1. Among the trawler group vessels, the findings do not confirm this relationship. This vessel group is, however, more robust and less vulnerable to weather conditions and unpredictable difficulties during the high season.

Most vessels normally catch their cod quota during the high season in winter. Being granted a RCQ would therefore represent an opportunity to fish in the autumn as well. This entails increased flexibility, which is valuable, particularly in fisheries where uncertainty is high. On this basis, we hypothesised that vessels unlikely to utilize the RCQ would also apply. No variable measures likeliness to fish directly, so we had to resort to some proxies. To test the hypothesis, we investigated the fishing activity of the individual grantee vessels during the RCQ period. In order to be categorized as "active", a vessel had to land more than 1 ton of cod. If a large percentage of applicants were inactive, it would lend support to our hypothesis.

The results are presented in Table 6. In 2006, a relatively large share of vessels did not utilize their option to fish during the autumn RCQ period. This was true for all vessel groups and counties, with the exception of the smaller vessel group in Finnmark. In 2007, however, the share of active vessels increased, particularly in the 21–28-m group. There is great variation among the vessels in terms of quota utilization. Among the 15–21-m vessels in Nordland, approximately half landed less than half their initially allocated quota. The results thus lend some support to the hypothesis that some vessels that are unlikely to fish will apply for RCQs.

The third hypothesis to be tested is whether there is a geographical component to the attractiveness of the RCQs and whether such an instrument more likely to be successful in the northern regions than in the southern regions. To test this, we investigated the ratio of applicants to available quotas in each vessel group and county. In addition, we collected information from fishermen in interviews.

Table 7 presents the ratio of applicants to available RCQs per vessel group and county. The results from 2006 are relatively inconclusive, and are likely influenced by the ordinary quota situation as described for H_1 above. However, the results from

Table 7
Ratio of applicants to available RCQs per vessel group and county.

	2006			2007		
	15–21	21–28	Trawler	15–21	21–28	Trawler
Finnmark	1.1	1.3	1.0	2.0	2.5	2.0
Troms	0.9	0.7	1.6	1.1	1.3	2.8
Nordland	0.9	1.0	0.8	1.0	1.2	1.4

Table 8
Ratio of "active" to granted RCQs and standard deviation of individual vessel quota utilization per vessel group and county in 2007.

	Ratio active to granted			Std. dev. quota utilization		
	15–21	21–28	Trawler	15–21	21–28	Trawler
Finnmark	0.8	0.8	0.7	1.3	1.0	0.7
Troms	0.7	0.7	1.0	1.3	1.1	0.2
Nordland	0.6	0.6	0.8	1.2	1.0	0.2

2007 lend strong support to the hypothesis that RCQ are considerably more attractive to the coastal groups in Finnmark than in the more southern regions, as the ratio of applicants to quotas was about twice as high here as in the other two counties. The difference between the other two counties is negligible.

This deduction was further supported by the fishermen, who stated that catchability was higher in Finnmark during this period. In addition, they claimed it is generally very difficult to catch cod during the restricted time of the year in Nordland, especially in the southern areas. These statements are further supported by knowledge about the migrating patterns of cod and historical data on landings.

To investigate H_4 we need variables measuring how well different vessels are adapted to harvest during the RCQ period. During this time, the migration pattern is such that the cod is dispersed in the open ocean, thus making the size and mobility of the vessel important. Differences due to vessel size can be analysed through the three vessel groups included in the RCQ regime; coastal vessels of between 15 and 21 m, coastal vessels of between 21 and 28 m, and large ocean-going trawlers. On this basis, we employed vessel size as a proxy to measure vessel suitability. We calculated the ratio of active vessels to granted RCQs in the three vessel groups, and the results are presented in Table 8. Due to the quota situation in 2006, we focused solely on 2007. The results show similar ratios for the two coastal vessel groups and only a moderate advantage for the trawlers. The utilization rate of each vessel group's total quota was also comparable, as presented in Table 7 above. However, the variation in utilization rates is substantially higher among the coastal vessels, indicating that some are better positioned for this type of fishing than others within the same group. The results thus lend some support to the hypothesis.

Finding variables that capture gear type and especially crew knowledge and other decision-making parameters is more difficult. The behaviour of individual vessels during the RCQ period in previous years will give an indication of how well they are adapted to fishing during this period. We therefore investigated the probability of utilizing the granted RCQs in the coastal vessel groups. We focus on the year 2007, due to the situation in 2006, when very few vessels utilized their RCQs. The probability of utilization is compared to the conditional probability of fishing, given that the vessel fished during the RCQ period the previous year.

The results are presented in Table 9. For the 15–21-m coastal group, the conditional probability of utilizing the quota was

Table 9
Probabilities of fishing in 2007 (percent).

	15–21 m	21–28 m
Vessels granted RCQ	57	47
Vessels granted RCQ and fished during RCQ-period 2006	85	54

Table 10
Licenses and RCQ utilization among vessels granted RCQs.

Quota portfolio	2006			2007		
	No.	Active	%	No.	Active	%
Cod	11	8	73	17	11	65
Cod and herring	26	5	19	25	9	36

substantially higher for vessels that fished during the same period the previous year compared to vessels that did not fish during this period. This indicates that certain aspects make some vessels more adapted to low-season fishing. The differences in the 21–28-m group are relatively small. These vessels, however, often have quotas to fish other species of fish that may disturb this conclusion.

In summary, the results lend some support to the hypothesis that some vessels are better adapted to low-season fishing. Trawlers, as a group, seem better suited for this type of fishing than coastal vessels, most likely because of technical parameters such as size and mobility. Among the coastal vessels, there seems to be great differences between individual vessels. We have not been able to identify the causes of these differences, but they are likely to be related to gear, knowledge, and quota portfolio. The latter will be further investigated in the following section.

To test the fifth hypothesis, i.e. how quota portfolios affect RCQ attractiveness, we investigated the quota portfolio of the vessels granted RCQs and to the degree to which they actually filled the allocated RCQ. This was carried out for both 2006 and 2007. The hypothesis is related to the alternative cost of exploiting RCQs. If the vessel has quotas for other species that may be profitably fished in the period during which RCQ have to be fished, the alternative costs will increase. The autumn herring season, especially, may pose a problem for the RCQ grantees. Combining the harvest of cod late winter and herring in the autumn and early winter is a popular strategy among fishermen, as it utilizes the seasonal migration patterns of both stocks well. This strategy, however, may be challenged by the introduction of RCQs on cod, as the herring season is at its peak in the period during which the RCQ fishery has to take place.

Based on this knowledge, we categorized vessels in two different groups according to their licence portfolios; one group with cod quotas only, and another group with both cod and herring quotas. Due to increased alternative costs, we predicted that RCQs would be less attractive for vessels in the latter group.

The utilization of RCQs by vessel group and quota portfolio is presented in Table 10. Vessels that have licences for both herring and cod have the lowest degree of RCQ utilization of all groups. This holds true for both 2006 and 2007, lending strong support to our hypothesis. This also contributes to explaining the variation between vessel groups in Table 3, where we reported that vessels between 21 and 28 m in length utilized less of their allocated RCQs. Most of the vessels that are licensed to fish both cod and herring can be found in this group.

This also illustrates that vessels respond differently to the RCQ system when they are differently positioned as far as quota portfolio is concerned. This corresponds well with the RBV, emphasizing that internal firm resources are important when firms respond to external changes, as described in our case introduction of a new management regime for cod.

5. Conclusions and management implications

This section summarises our findings and discusses the implications for fisheries management, in particular schemes to offset the strong seasonal profile and facilitate for a better geographic distribution of cod landings from the coastal fleet. In addition to RCQs, several measures have been employed to achieve this goal. Trawler licenses were originally granted to provide fresh fish to processing plants year-round [10]. Many of these licenses contained obligations to land their catch at specified processing plants [11]. A share of the total quota has often been reserved for fishing after the prime season.

Our findings clearly show that the attractiveness of RCQs is dependent on how well the fleet does during the high season. If the high season is unsuccessful, large quotas will be carried over to the low season, yielding relatively large quotas. Being less restrictive than RCQs, vessel owners will prefer to fish such quotas, resulting in RCQ failure. The management advice that can be extracted from our results is to implement a dynamic approach, where RCQs are not needed when high-season fishery fails.

Another finding reported is that many fishermen apply for RCQs, although they are not positioned or planning to utilize them. This emphasizes the importance of putting effort into finding vessels that are most likely to make use of the RCQs. This effort may be guided by other findings in our study—such as where, when and how cod is likely to be caught in the restricted period. This has proven to be a valuable approach. For example, in the setting studied we found that the RCQs were more successful in the north than in the south. This also shows that the success of RCQs is limited by the migration pattern of the cod. Although the need for RCQs may be high in one region—i.e. few landings and a high level of unemployment—the RCQs will fail to solve this problem if the cod is unlikely to be caught in this region in the restricted period. This applies to the coastal fleet in particular, as well as to trawlers if there are restrictions on onboard freezing. Accordingly, our results indicate that the RCQs are more successful in regions where the cod is present in the restricted period, i.e. far north.

Our findings confirm that catching cod in other areas and periods than in the high season is difficult and it is not necessarily based on same skills and technology that vessels apply in high-season fishery. This is also an important factor to keep in mind when searching for vessels that are likely to utilize RCQs in the restricted space and time. This is also important when implementing restrictions on technology and fishing activities.

Another variable proven to be important when it comes to utilization of RCQs is the quota portfolio of the vessel. Our results confirm that vessels that are in a position where they can choose between different activities will choose the most profitable. Vessels that had the opportunity to catch herring did so and disregarded the RCQ they were granted. Given the high profitability in the herring fishery, it is unlikely that increasing vessel RCQs and lifting restrictions on time and space can induce changes in behaviour. In a management perspective, this implies that vessels with quotas in highly profitable time-overlapping fisheries should be avoided in the vessel selection process.

The empirical findings reported in this paper indicate that applying RCQs as a managerial tool to change harvesting patterns in terms of space and time is difficult. The laws of biology and profit impact how fishermen act. Our findings indicate that in order to improve the RCQ regime for cod knowledge regarding the migrating patterns of cod has to be taken into account when deciding which regions and what time period to include. It is also important to improve the effort to choose the vessels most likely to utilize granted RCQs. Our findings indicate that these vessels are to be found among those who are best equipped to and experienced in catching cod in the area and time period chosen. Furthermore, they are not found among those who have access to a more profitable alternative activity during the restricted time period. The selection of vessels is, in other words, too important for the success of RCQs to be decided by lottery.

In addition, the paper evaluates whether RCQs had the intended impact on the allocation of quotas, harvesting strategies, and employment. In 2006, the RCQs ere not fully utilized due to the carryover of large, regular quotas from the prime season. In 2007, however, most of the vessels had filled their regular quotas during the prime season. This stimulated more vessels to participate, and the RCQ quotas were fully utilized.

Several restrictions were imposed on the RCQs implemented. Individual vessel quotas were relatively small, and they were initially to be delivered as fresh fish to pre-defined areas. The number of vessels actually participating was relatively low. The restrictions were thus lifted; onboard freezing was permitted, vessel quotas were substantially increased, and restrictions on where to land were eliminated.

The lifted restrictions and low interest among vessels led to spatial distribution of RCQs different than the one intended. Finnmark and the trawler group got a larger share than initially allocated. The distribution between zones was also different; some zones fell far short of their allocation, whereas others significantly exceeded theirs. At firm level, the majority of the quotas went to large, vertically integrated firms.

The effects on quantities landed were relatively small, both for counties and individual zones. The largest effect reported was an increase of about 2% in the landing of cod. This is due to the inclusion of almost all processing firms, relatively small quotas, and the fact that most of the fish would have been landed in the areas included anyway, but during winter. Minor impact on quantities also means small effects on employment and economic results. However, the shift in the temporal distribution of landings was more effective, and this effect may contribute to the creation of more stable employment opportunities in the processing firms. This effect may be achieved with substantially less complicated means.

Distributing quotas between communities was delegated to the regional governments. These governments prioritized between processing plants only to a small extent and included large parts of the processing capacity in the participating counties. Based on figures from the 2005 cod landing, the counties of Finnmark, Troms, and Nordland in 2006 included communities where 88%, 75%, and 99%, respectively, of the cod previously had been landed. In 2007, the Ministry of Fisheries and Coastal Affairs asked the regional governments to prioritize more strongly. Still, however, only minor changes were made, and Finnmark actually included more firms. The intention behind introducing RCQs was to help vulnerable communities, and although the impact on the county as a whole is low, a more stringent prioritization between communities could yield greater results for individual communities.

Other quota schemes have been employed in Norway to secure landings to specific communities and to increase landings during the second half of the year—all of them providing incentives to compensate for lower CPUE out of season. However, as for the implementation of RCQs, the harvesting strategies chosen seem to follow the maximization of the catch per unit seasonal curve. This strategy corresponds well with both the knowledge developed over generations and the migration patterns of the cod. In addition, this strategy carries strong economical incentives for the participating vessel. This is also the experience gained from the implementation of RCQs into the Norwegian cod fishery. The result, as far as spatial and temporal distribution is concerned, was far from the intended. Paradoxically, the cod landing out of season from the coastal fleet in RCQ-regions were at its highest in 2006. Not as a result of the introduction of RCQs—but because of bad weather and low catch per unit figures during the prime season. Based on these findings, the Norwegian government decided not to continue the RCQ experiment in the coastal fleet in 2008.

Another important factor that must be considered in all management efforts to modify the seasonal harvesting patterns is the recent surge in oil prices. Several of the prime seasons for harvesting from important species in the Norwegian fishing industry are based on these species migrating from the open ocean to coastal areas. Increased fuel costs will strengthen incentives to harvest seasonally, and changing this pattern will require strong means.

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