



Quality-enhancing fishing in the coastal fishery for Atlantic cod in Norway

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ARTICLE INFO

Keywords:

Fish quality
Atlantic cod
Fishing gears
Fishing tactics
Sustainability

ABSTRACT

In the important coastal fishery for Atlantic cod in Norway quality-based pricing is largely absent. Thus, driven by a focus on fish quantity, not quality, a high share of downgraded fish is landed. This study identified some encouraging exceptions with actors trying to align incentives and increase revenues in both fishing and processing. More specifically, we examine two cases involving quality-enhancing fishing and find indications of substantial improvements in fish quality and importantly, that this is rewarded with higher prices. In a revenue-sharing arrangement with a focus on high quality fish delivered outside of the main season, fishers obtain approximately 50 % higher prices than comparable vessels fishing with the same gear in the same period. In the other case, fishers' "skip" the Norwegian ex-vessel market and sell their high-quality cod catches at Danish auctions at significantly higher prices than comparable vessels fishing in the same area and delivering in South Norway. The cases may guide fishers and fish buyers in increasing revenues through quality-enhancing fishing but also involve important dilemmas for policymakers which are highlighted and discussed.

1. Introduction

Norway is an important fish harvester, the world's second largest fish exporter [1], and cod is the most valuable species in Norwegian fisheries [2]. The coastal fishery for Atlantic cod in Norway, the focus of this paper, is substantial. Approximately 150,000–200,000 tons of fresh cod are landed yearly, contributing substantially to employment and economic activity, especially in rural regions. However, a recent study indicated that quality-based pricing is largely absent in this important fishery [3]. More specifically, using an objective quality index in hedonic price modeling it was found that a 33 % increase in the share of downgraded cod in a sample of catches led to a miniscule 1.2 % reduction in price [3]. Buyer hesitancy toward penalizing fishers by lowering prices for low-quality fish has been observed in other fisheries as well [4,5]. For example, Wilson [4] showed that because of non-existent definitions and measures of product quality in the New England fresh fish market, fishers are not encouraged to land high-quality fish. And Peterson and Georgianna [6] showed that in the New Bedford fish auction, while reputation acts as a proxy for freshness, the fish is sold by the boatload and not sorted by quality, making it difficult for buyers to ascertain pricing quality.

This indicates that fishers are not incentivized to land fish of high quality. Instead, economic incentives promote the use of the most quantity-efficient fishing gear, such as gillnets and Danish seines, and

intense fishing tactics [7]. For Danish seines this can mean using large gear and targeting dense schools of fish, resulting in large hauls. Gillnetters may increase catch rates by using more nets and longer soaking times [7,8]. Almost 80 % of the landed cod in this fishery was caught with gillnets and Danish seines in 2018 [7]. About 44 % and 28 % of the cod in a sample of landings from gillnetters and Danish seiners, respectively, were downgraded [7]. This is substantially higher than the 11 % and 5 % share of downgrading found for longlines and handlines, the two other main types of fishing gear in this fishery [7]. Moreover, a high share of downgraded cod in this fishery has been documented for almost 20 years [7,9–12].

Importantly, the quality of the raw fish influences the share of high-value products in onshore processing [13–18]. A catch consisting of zero downgraded fish provides the fish buyer full freedom in terms of choosing a mix of products that maximizes the output value of the fish, depending on relative prices and market conditions [19]. However, when large quantities of low-quality fish are landed as described above, value-adding opportunities in onshore processing and downstream marketing are reduced, and consequently the share of high-value products such as fresh loins is substantially reduced [16,20,21]. In line with this, Asche et al. [22] recently documented that Norway is an important supplier of cod (and haddock) to the Chinese re-exporting industry, which is not known for demanding high quality. In addition to the lower market prices for products such as frozen mince blocks,

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<https://doi.org/10.1016/j.marpol.2022.105191>

Received 27 February 2022; Received in revised form 20 June 2022; Accepted 24 June 2022

Available online 1 July 2022

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production costs are also higher when using low-quality raw materials due to factors such as reduced fillet yield and increased labor time [15–17]. When fish buyers pay a high price for quality downgraded cod, the profitability in onshore processing is influenced negatively. According to Sogn-Grundtvåg et al. [3], average operating margins in the onshore processing sector were negative in 6 of the 11 years between 2008 and 2018.

The lack of quality-based pricing can be attributed to a poorly performing ex-vessel market [3]. The market organization with direct sales has implications for the bargaining power of fishers and fish buyers [23–25], as buyers are highly dependent on fishers for supplies due to considerable processing overcapacity [3]. Fearing a loss of supply, fish buyers are reluctant to penalize fishers by lowering prices for low-quality fish [3,25].

In addition, the quality of cod is seldom assessed by buyers during unloading [3]. Reliable and trustworthy quality assessment is costly, and during the peak season the logistics of unloading vessels is put under considerable pressure. Assessing all catches would add to this pressure by delaying onshore gutting and processing. With insufficient information about the quality of fish in individual catches, buyers may use fishing gear as a proxy for quality in their pricing. This is evident from several studies that found price differences between types of fishing gear for cod [26–29] and other species such as tuna [30,31]. At the same time, it is well known that the quality of fish may vary substantially between vessels fishing with the same gear, which may be due to variations in fishing tactics such as soaking time for gillnets and longlines [20,32,33] and haul sizes with Danish seines [34], as well as onboard handling practices and technology, including how fast the fish are bled [35,36].

The point of departure for this study is anecdotes reported in the trade press and by industry experts involving quality-based pricing, indicating that some actors in the value chain are trying to align incentives and increase revenues. We examine two cases in detail to try to understand whether fishers and fish buyers may be able to share revenues by improving the quality and value of both landed cod and end products. We also examine the specifics of quality-enhancing fishing, including any additional costs this may incur, and identify and discuss policy implications.

The study contributes to the literature in several ways. First, our study expands on the idea of “revenue-sharing” for the fishing and processing sectors by improved quality of landed fish facilitated through the information flows and control over fishing activities offered by vertical integration, as shown by Larkin and Sylvia [37] and Margeirsson and colleagues [17]. We show that improved fish quality and landing timings are also possible without majority ownership but may depend on revenue-sharing arrangements, market organization, and fishery management. Second, our study also focuses on the important trade-off between fishing efficiency and fish quality [8,27]. We show that in the coastal fishery for cod in Norway, even when using the most efficient fishing gear often associated with low-quality fish in this fishery – gillnets and Danish seines – fishers may land fish of high quality and achieve high prices. In this way, we also contribute to literature regarding the effect of fishing strategies and tactics on efficiency and fish quality [7,32,38]. Finally, by focusing on how quality-enhancing fishing – and market arrangements and organization – can improve the quality and value of fish, our study may guide fishers, fish buyers and policy-makers aiming to improve revenues from fishing and processing. We also address policy dilemmas, including increased greenhouse gas emissions due to lower catch rates associated with quality-enhancing fishing.

The remainder of the paper is organized as follows. In the next section we provide an overview of the fishery and ex-vessel market for cod in coastal Norway. In Section 3 we describe the two cases. Finally, in Section 4 the main findings are highlighted and discussed.

2. The coastal fishery and ex-vessel market for cod in Norway

The coastal cod fishery in Norway was open access until 1989, when it was closed due to the dire state of the cod stock. Individual vessel quotas were awarded based on previous fishing activity, and a complex system of vessel group quotas and vessel quotas was developed based on target species, gear type and vessel length. A Total Allowable Catch (TAC) is set for the main groundfish species such as cod, haddock, and saithe and divided between vessel groups. The vessels in the coastal fleet can target cod using any gear except trawl and purse seine, the latter of which is disallowed for lack of selectivity. From 2008, a system with individual fishing quotas was introduced to allow transfers of quotas for all vessels above 11 m, provided one vessel was scrapped, which increased the quotas of the remaining vessel [39]. This has proven successful in the sense that overcapacity has been reduced and the profitability of the remaining vessels has improved [40], but it has also led to a reduction in the number of coastal vessels and landing locations [41].

The fishing fleet involved in the coastal groundfish fishery is diverse, ranging from small vessels less than 10 m in length fishing primarily with handlines and gillnets to larger vessels over 30 m fishing mainly with gillnets and Danish seines. The smaller vessels deliver fresh catches to local fish buyers daily during the main cod season. Large coastal vessels with more storage space may stay at sea for several days before they deliver fresh catches. Fig. 1 shows the average landing pattern and ex-vessel prices for fresh cod from the coastal fleet throughout the year.

Many of the larger coastal vessels now hold relatively large quota portfolios, often combining different groundfish species such as Atlantic cod, haddock, and saithe with pelagic fish such as herring and mackerel. To catch the different species with partly overlapping seasons, incentives for intense and swift fishing may be created, with the result that

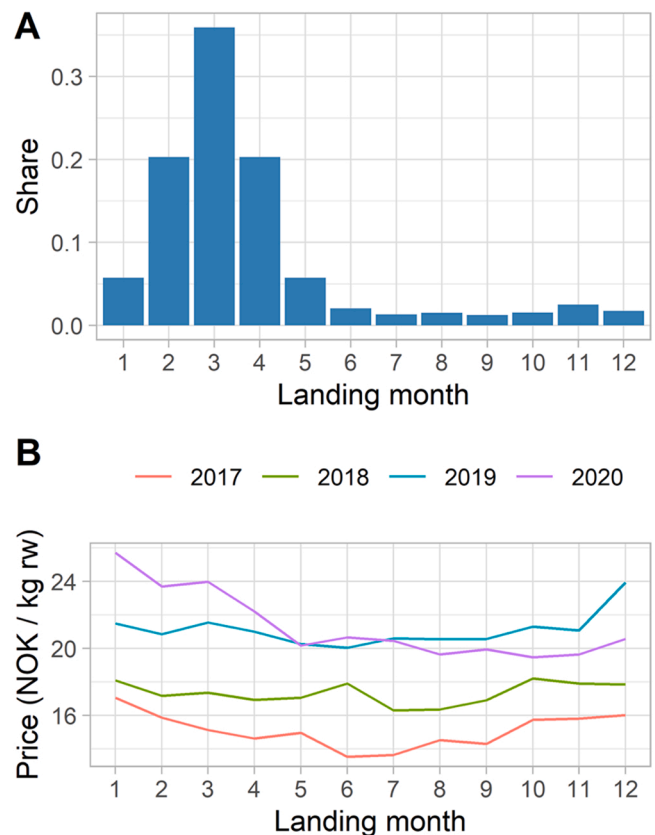


Fig. 1. Average share of landings of fresh cod per month (panel A) and average monthly prices for fresh cod (panel B).

Source: Elaborated from Directorate of Fisheries (2021).

fish quality may be compromised by the quantity of the fish landed [8]. In terms of fisher behavior, it is useful to distinguish between fisher strategies and tactics [7,32,42]. According to Christensen and Raakjær [32], fisher strategies refers to long-term decisions such as upgrading of vessels, hiring of crew, and purchasing additional quotas. Fishers' tactical decisions include short-term decisions such as how many hooks or nets to use, how long a haul should be, soaking time and responses to weather and other conditions, such as how to adapt fishing to ocean currents [32].

The landing pattern shown in Fig. 1 (panel A) is primarily driven by the seasonal changes in fish availability caused by the yearly spawning migration of the cod from its feeding grounds in the Barents Sea to the coast of Norway. During the main season in February, March, and April, about three-quarters of the yearly catch of fresh cod is landed [7]. This reduces the fishing costs for the coastal fleet [43,44], but as shown in Fig. 1, panel B, landing large quantities in a short period generally leads to lower prices during the main season compared to early and late in the year when fresh cod supply is lower and demand picks up [29]. The prices for 2020 (Fig. 1, panel B) show a strong drop between March and June 2020, most likely caused by a sudden drop in demand for fresh seafood from the hotel, restaurant and catering sectors due to the social distancing and lockdown measures taken in many countries to contain the spread of the COVID-19 pandemic [45,46].

A long-standing political goal in Norway is to maintain coastal communities, but this is challenged by the strong seasonal pattern of cod landings (see Fig. 1, panel A) causing difficulties for onshore processing [47,48]. To incentivize off-season landings of cod, a scheme by which coastal vessels get an additional cod quota based on their landings of other fresh demersal species was introduced in 2013 [43]. The quota bonuses have generally been 20–30 % and entered into force from May. For example, if the bonus is 30 %, the vessel will get an extra three tons of cod quota if it lands ten tons of fresh haddock or other demersal species. This is possible because quotas for other less valuable species such as saithe and haddock restrict vessels in the coastal fleet to a small degree, providing opportunities to increase catches of the more valuable cod. By reducing the shadow price of cod quotas, this scheme has contributed to increased landings of demersal species, including cod, in the second half of the year when the onshore processing sector generally lacks raw materials. The northernmost county Finnmark, where the catchability of cod is better in the second half of the year than in Troms and Nordland, the two other main counties for cod fishing in Norway, has benefitted the most from this policy [49].

In other fisheries such as the Icelandic groundfish fishery, vertical integration between fishing and processing is common, which may be beneficial in terms of coordinating fishing and processing in line with market demand [17]. In Norway, however, this opportunity is restricted by the Participation Act of 1999, which states that only fishers are allowed majority ownership in vessels. Thus, fish buyers are generally prohibited from adopting vertical integration strategies to control the harvesting strategies and tactics of fishing vessels. Fishers, on the other hand, are allowed majority ownership in processing plants, and although uncommon, some downstream vertical integration has taken place.

The Norwegian Food Safety Authority enforces technical regulations regarding the catching and onboard handling of fish. For example, these regulations state that fishing vessels should be equipped so that damage to fish is avoided during catching operations, onboard handling, and unloading. Importantly, it is explicitly stated that the draining of fish blood should keep pace with the catch operation. Further, fish that were dead when taken onboard should be stored separately from those that were alive during uptake. However, compliance with these regulations is low during the peak season, especially by gillnetters [50]. The high share of downgraded fish for gillnets and Danish seines as described above is also an indication of low compliance.

The ex-vessel sale of wild-caught fish in Norway is legally regulated by the Raw Fish Act and is organized by six sales organizations owned by

fishers – one for pelagic fish and five for groundfish covering different geographical regions. Fishers are free to choose where to land the fish, but they vary in terms of how far they can, within reasonable costs and time, travel to land their daily catches.

3. The cases

Based on articles from the trade press in Norway and discussions with industry experts, two cases involving quality-enhancing fishing tactics were identified. Indications are that in these cases, quality-based pricing is applied. To investigate the cases further, interviews were conducted with a sample of fishers and fish buyers that were linked to the cases. The interviews with fishers focused on how higher quality was achieved in terms of fishing strategies and tactics, as well as how the fish were handled and stored onboard the vessels. We also asked about any additional costs associated with quality-enhancing fishing and onboard handling compared with fishing the traditional way.

Furthermore, we make use of secondary data in the form of trade press articles and transaction data drawn from a database provided by the Directorate of Fisheries, which contained details about catch size, fish size, prices, and other relevant variables. These data are used to compare prices for the vessels included in the cases with average prices for other vessels of similar sizes using the same gear and fishing in the same areas. We also make use of the annual profitability survey conducted by the Directorate of Fisheries.

The two cases presented below are (1) fishers who “skip” the Norwegian ex-vessel market to sell their cod fresh at auction in Denmark, and (2) a “revenue-sharing” arrangement whereby fishers receive a post-payment depending on the market prices achieved by the buyer.

3.1. Skipping the ex-vessel market

In the south of Norway, vessels with cod quotas in the North Sea are relatively close to Danish fish auctions, and for several years about 20 Norwegian coastal vessels have landed their catches directly at these auctions. However, Fig. 2 shows that the quantities of cod landed directly at auctions in Denmark are relatively small and have been in sharp decline for the last three years, along with the number of vessels. The decline in landings is likely due to a substantial reduction in Norwegian quotas for Atlantic cod in the North Sea. These cod quotas were reduced from 6995 tons in 2018 to 1870 tons in 2021, a reduction of more than 73 % in four years. The quota situation in the western part of the Baltic Sea is even more grim with a reduction in cod quotas from 4000 tons in 2021 to 489 tons in 2022.

With the low cod quotas in both the North Sea and the Baltic Sea, the chief auctioneer, Jesper Kongsted, at the Hanstholm auction in Denmark, urges Norwegian vessels fishing in northern Norway, where stocks are in good shape, to sell their cod at the auction (Kyst og Fjord, 20.10.2021). Recently, several vessels fishing in northern Norway have started sending their catches to the auction via road transport. Some of these vessels are from the south of Norway and have experience of delivering cod catches directly to Danish fish auctions.

To sell at Danish fish auctions, fishers must pack the fish in auction-compliant cases. This is different from the traditional way of onboard storage in containers, sometimes with ice and water. To obtain good prices, the quality of the fish must be impeccable. As seems typical for fish auction markets, the reputation of the vessel is an important indicator of fish quality [6], which is also the experience of the fishers we interviewed. Thus, vessels cannot expect to be fully rewarded for the quality of their catches before they have earned a positive reputation among buyers, and the reputation is quickly lost should the quality of the fish be lower than expected. To deliver fish of high quality, fishers have had to adopt several quality-enhancing fishing strategies and tactics that differ substantially from the traditional way of fishing in coastal Norway, which places a strong focus on quantity, not quality.

For example, we interviewed the skipper of a large coastal Danish

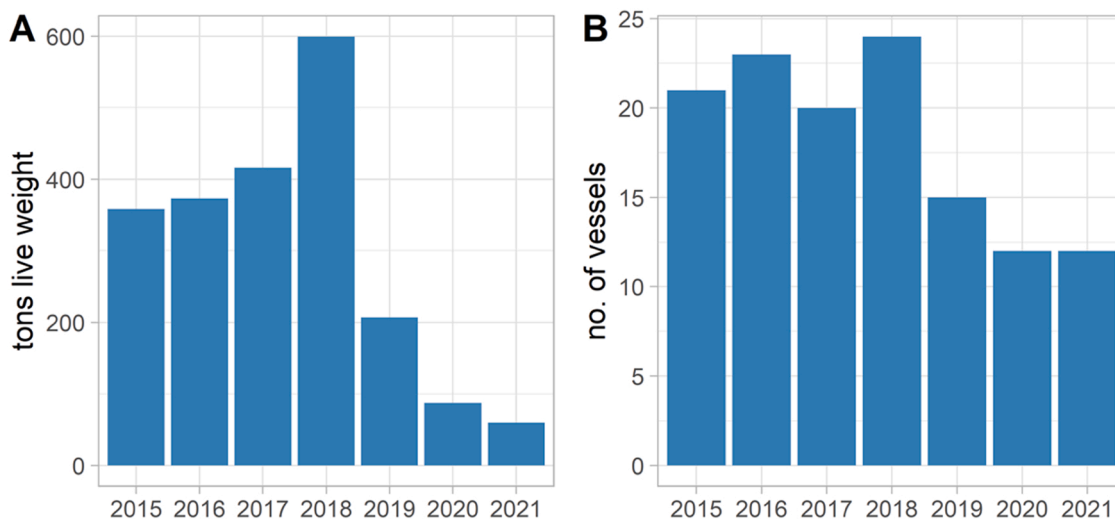


Fig. 2. Norwegian direct landings of cod in Denmark by quantity (panel A) and number of vessels (panel B) for 2015–2021. Source: Elaborated from Directorate of Fisheries (2021).

seiner using a seine net adapted to restrict cod catches to about four tons in each haul (for a description of the catch-limiting technology for demersal seines, see [34]). The seine is also retrieved slowly to reduce stress and pressure damage to the fish. The fish are then hauled onboard, about 400–500 kg at a time, where they are bled in a seawater tank and subsequently gutted. There is no pumping of the fish.¹ After bleeding and gutting, the fish are graded in different size categories and placed belly down, head to tail, on top of ice in auction-compliant cases. Compared to the common pumping and bulk storage in tanks with refrigerated seawater, this is considerably more laborious and time-consuming and thus more costly.

The cases are labeled with the catch date, the weight categories of the fish in each case, the total weight of the fish in the case, and the vessel's identity. The cases, which hold about 26 kg of fish, are stacked onboard in a refrigerated storage room, with 10–12 cases in each stack so that cold water from the melting ice in the cases at the top helps cool the fish in the lower cases. One truck takes about 720 cases, so approximately 18 tons of cod are contained in a truckload. If the vessel has more fish than the truck can take, it is sold directly to the local fish buyer together with any downgraded fish not suitable for the auction.

In accordance with the regulations of the sales organization, the fish are sold to a local fish buyer, usually at the current minimum price. The fish are loaded on the truck by the fish buyer who sells the fish back to the fisher, adding NOK 2/kg² to the paid price. An agent does all the paperwork related to the transportation, logistics, and customs.³

¹ This is in contrast to the common practice in which the large Danish seiners pump the fish using vacuum pumps from the seine to tanks onboard, then pump them from the tank to a process line where they are bled and gutted. Finally, the fish are pumped from the vessel to the onshore processing plant. Research has shown that pumping may negatively affect fish quality, particularly for large cod [59,60].

² This has increased from NOK 1/kg in just six months and the fisher is not prioritized in terms of unloading the fish. This indicates a certain unwillingness on the buyer's behalf, which is understandable given that the fish buyer's margins would probably be higher if he could buy, process, and sell the fish himself. Interestingly, according to the fisher, the fish buyer tried to send fish to the same auction in Denmark, but the quality was not sufficient and the buyer was penalized with low prices, and so he stopped. The fisher then bought the auction cases from the fish buyer.

³ Another fisher with a close relationship to the buyer sells the fish to the buyer at the current price at the Danish auction. The buyer then sells the fish to the auction, and any price difference between the ex-vessel price and the auction price is settled on the next landing note.

According to the skipper, prices at the auction vary substantially, but generally they are high and well worth the effort. This way of fishing takes more time, but because the vessel has quotas for cod, haddock, and saithe only, using extra time does not imply opportunity costs that could have been incurred had the vessel also had quotas for pelagic species. This slower way of fishing is also a way of creating year-round activity for the crew.

We also interviewed the skipper of a medium-sized gillnetter with experience of direct deliveries of North Sea cod and other demersal species to a Danish fish auction. For the last three years, almost all their landings in northern Norway have been transported by truck to auction in Denmark where they achieve good prices for high quality fish. They fish their cod quota in northern Norway in December, January, and February, when cod prices are usually at their highest, as shown in Fig. 2, panel B. In Finnmark, the catchability of cod is good during these months. The vessel does not take advantage of the off-season quota bonus for cod because, being based in the south of Norway, they find it too risky to go all the way to Finnmark where they may find that the bonus scheme has little or no cod left.

In terms of fishing strategies, this gillnetter has made substantial investments in new technology adapted to auction deliveries, including a high capacity ice machine and an onboard weighing and labeling system. Regarding fishing tactics, the skipper explains that they are careful to adapt the number of nets according to fish availability to avoid too large catches. They soak the nets for about six to seven hours before hauling. This is substantially shorter than the common method of hauling in the early morning, setting the nets, and hauling the next morning, which means a soaking time of 18–20 h. To increase catch rates, they use the ocean current to set the nets but with a mooring only at the start. They let the nets drift with the current and haul against the current. This means that the time of day for setting and hauling differs with the changing rhythm of the tides. Another main difference from the traditional method is that they gut and pack the fish in cases with ice in accordance with auction requirements, as described above.

Fishing this way demands more from the crew. This mainly relates to gutting, sorting, and packing of fish in auction-compliant cases, which is much more time consuming than the common onboard bulk storage of round fish that is gutted onshore. However, the skipper claims that this does not affect the vessel's time spent at sea; they just work harder while at sea. But due to lower catch rates, the vessel needs to do more trips compared to vessels fishing the traditional way.

3.2. Revenue-sharing arrangements

In several cases, fish buyers have made informal agreements with fishers to first buy the fish at an agreed fixed price and then adjust this depending on market prices. This is done as a post-payment because the regulations of the sales organization stipulate that the buyer and fisher must sign the landing note with the agreed price at the time and place of landing. And at this time the buyer does not know what prices the catch may fetch in the marketplace, which also means that a post-payment may not always materialize. In January to April, the best paid fresh cod is usually sold and labeled as “Skrei” in accordance with the quality standard of the Norwegian Seafood Council and as “shiny” cod⁴ later in the year.

One of the buyers has a strong focus on selling fresh, high-quality cod outside of the main season when prices are usually higher. Thus, the timing of landing is very important.⁵ This can be seen in landing patterns for three of the vessels delivering their catches to this buyer, which deviate substantially from the average landing patterns shown in Fig. 3.

Fishing outside of the main season when the catchability of cod is lower than in the high season is more costly – as is the quality-enhancing fishing strategies and tactics required. For example, one of the vessels using longlines almost doubles the number of hooks used per trip, from 9000–10,000 in December and January to 18,000 in the early autumn when catch rates are much lower. Despite twice as many hooks, they may need three days to catch the same quantity in the autumn as they do in two days in December or January.

Using more hooks incurs increased costs for bait and wear and tear on the line, including replacement of lost hooks. The annual fisheries profitability survey conducted by the Directorate of Fisheries does not distinguish between different types of gear for the coastal fleet, but costs for oceangoing longliners are given [51]. For these, the average cost of bait, ice, and packaging constituted 9.3 % of total operating costs in 2020. The cost of ice and packaging is probably small as the oceangoing longliners do not use ice for chilling the fish but instead freeze them after gutting, typically in 25- or 50-kg packs wrapped in durable paper bags. In addition, the cost of gear maintenance and new gear for oceangoing longliners was 3.6 % of total operating costs. It is reasonable to assume that the costs of bait and wear and tear on the gear are similar for a coastal longliner. Thus, doubling the number of hooks will have a big impact on costs and reduce profits. It also takes more time to set and haul a line with more hooks, which increases fuel costs and emissions. In contrast to the main season when large spawning cod congregate near the coast, off-season fishing also means that fishers need to go outside the 12 nm zone to find cod of decent sizes and catch rates, adding further to fuel costs and emissions.⁶

Interestingly, in terms of fishing tactics, the same longliner has recently changed from three-day trips with 24-h continuous fishing to trips of similar length but only setting the line in the evening and hauling early in the morning. This reduces the share of shiny cod from catches but requires fewer man-hours, reduces the cost of bait, and limits wear and tear on the line and hooks. According to the skipper, it comes down

⁴ Shiny cod refers to the flawless and shiny skin on the fish that is achieved by putting the fish belly down on top of ice in Styrofoam boxes. In this way, the ice is not in direct contact with the fish skin, avoiding ice “burns” on the skin.

⁵ Reliable and timely delivery can be considered an important quality attribute, as shown by Korneliusen and Grønhaug in their study of quality perceptions along the supply chain for salmon from Norway to Singapore [61].

⁶ In terms of fuel use, the energy efficiency of all vessel groups in Norwegian fisheries has improved in recent years [62]. Until recently, vessels in the Norwegian fishing fleet paid a substantially lower CO₂ fuel tax compared to other commercial vessels [63], but as of January 1st, 2020, fishing vessels must pay the same CO₂ fuel surcharge as other vessels, a reflection of a change in policy to try to reduce greenhouse gas emissions. However, fishing vessels are still exempt from some emissions taxes (the base tax) and although not linked to fuel use, they receive some compensation for the increase in CO₂ tax.

to a trade-off between the cost of fishing per day versus prices achieved. He further argues that the higher prices achieved from fishing outside of the main season and the off-season quota bonus for cod are the most important incentives for fishing considering the substantially higher costs incurred from off-season fishing.

In sum, this increases the value of the vessel’s cod quota and is perceived as more profitable than fishing in the main season, when fishing costs are lower but prices and cod quotas are lower as well. This also allows the vessel to fish other species during the main cod season, currently primarily gillnetting for saithe. This increases the vessel’s total revenue and contributes to year-round employment for the crew. Interestingly, there are no formal contracts or agreements with the buyer, but prior to the season they discuss the market outlook in general and when cod prices are likely to be high.

3.3. Does higher quality lead to higher prices?

A main driver behind fisher behavior is economics, and thus fishers seek to maximize profitability while adapting to regulations [32,52]. Ideally, we should have had data on both sales revenues and the costs of cod fishing for different fishing strategies and tactics, but because all vessels fish many other species during the fiscal year such data are unavailable. However, by comparing prices for cod landed by vessels in the two cases with average prices gained by all other vessels fishing with the same gear in the same areas, we gain insights into the economic performance of the case vessels.

For vessels delivering catches directly to auction in Denmark, data on landings and prices are available from the Norwegian Directorate of Fisheries. To get an idea of the counterfactual – the prices they would have achieved had they landed their catches in the south of Norway – we compared the prices achieved by all Norwegian vessels landing cod in Denmark with average prices for all Norwegian vessels landing cod in southern Norway. We compared prices for the most common product category sold by Norwegian vessels at auction in Denmark: cod, gutted with head on, 2–4 kg, iced in boxes. The price comparison is shown in Fig. 4. A Welch t-test shows that the Danish prices are significantly higher than those in the south of Norway for all years in the sample ($p < 0.01$), and the price difference increases over time.

Unfortunately, there are no data available to show prices and quantities for the vessels sending their catches by truck to auction in Denmark as these catches are, in accordance with the regulations of the Norwegian Fishermen’s Sales Organization, sold to a local fish buyer and subsequently exported to Denmark by either the fisher or the fish buyer. However, there is good reason to believe that cod sent by truck can expect prices like those presented in Fig. 4, not least because some of the same vessels are involved in direct landings to the auction and may have established a good reputation among auction buyers.

Price premiums for the three vessels participating in one of the revenue-sharing arrangements are evaluated by comparing average prices for cod landed in the same area with similar vessels not participating in the scheme. Data from the Directorate of Fisheries allow the post-payment to be added to the initial payment.

Fig. 5 shows a comparison of the average prices for cod achieved by the three selected longliners which delivered their catches to the same buyer (see also Fig. 3), with all other longliners in the same vessel size category delivering their catches in the same geographical area. Illustrated in Fig. 5, a Welch t-test shows that the revenue-sharing vessels achieve significantly ($p < 0.01$) higher prices than other comparable vessels in January, July ($p < 0.05$), September, October, November, and December. Price differences are not statistically significant for August. The case vessels have very few landings from February to June. The very large price difference for January is partly explained by the fact that the revenue-sharing vessels land their fish in the two first weeks of January, when prices are higher than later in January. The differences between median prices for September to December are on average about 10 NOK/kg, or about 50 % higher for the revenue-sharing vessels,

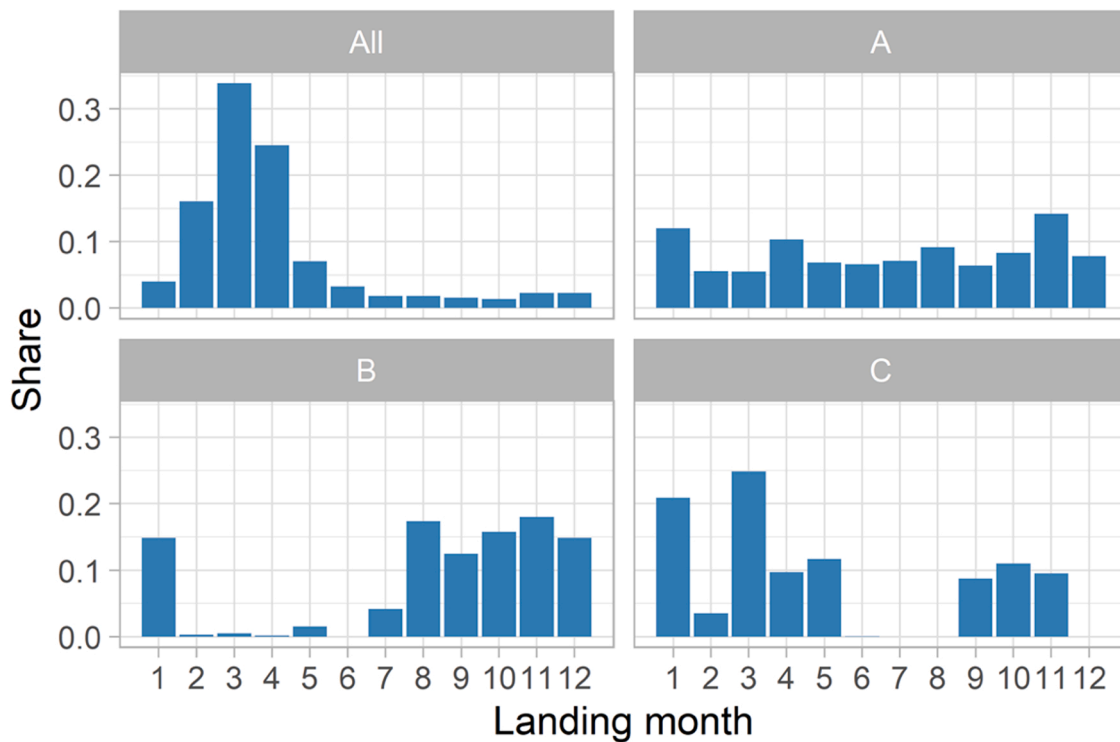


Fig. 3. Monthly share of cod landings for three vessels participating in the revenue-sharing arrangement compared to the monthly share of all fresh cod landings in 2021.

Source: Elaborated from Directorate of Fisheries (2021).

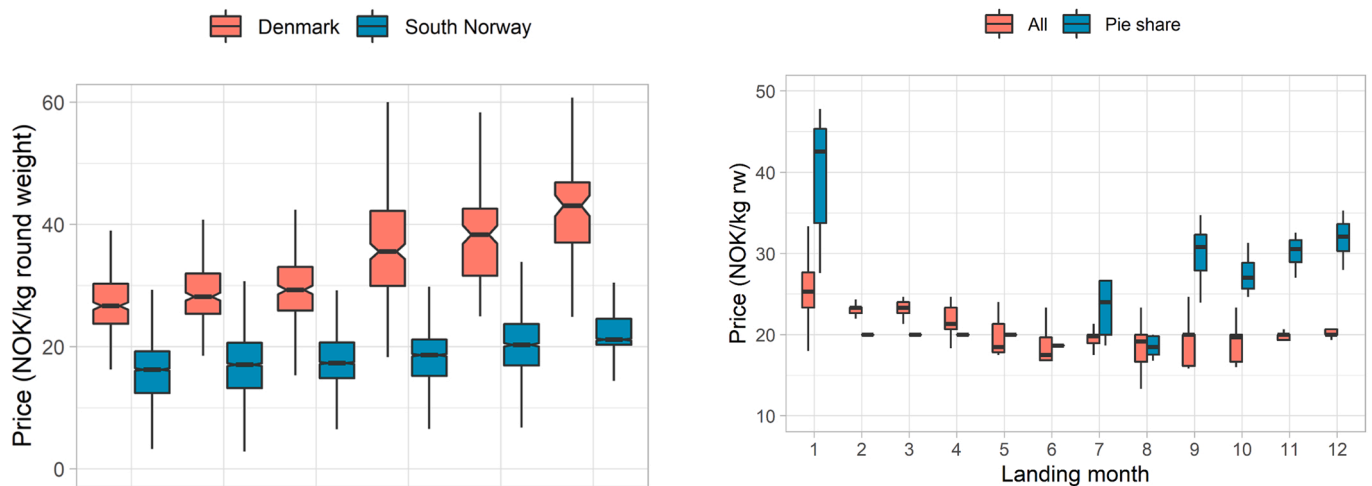


Fig. 4. Price comparison for cod (gutted, head on, 2–4 kg) between the Danish auction and direct sales in the south of Norway (sales organizations are Fiskehav SA, Rogaland Fiskesalgslag SL, Vest-Norges Fiskesalgslag). Outliers omitted.

Source: Elaborated from Directorate of Fisheries (2021).

indicating that substantial price premiums are achieved.

An important feature of the revenue-sharing arrangement is that the buyer’s income from a sale is fixed and covers the buyer’s costs and provides a margin. In a highly uncertain market environment such fresh fish, with frequent supply fluctuations and associated price variations, a stable margin is beneficial. In sum, the high prices to fishers and the stable margins earned by the buyer indicate that the revenue-sharing arrangement based on quality-enhancing fishing may be beneficial for both fishers and buyers.

Fig. 5. Boxplot of prices for cod larger than 2.5 kg caught with longlines, fresh, gutted, head off, for three vessels taking part in a revenue-sharing arrangement compared with all other vessels, 11–28 m, landing in Finnmark. Outliers not shown.

Source: Elaborated from Directorate of Fisheries (2021).

4. Discussion

Our case descriptions provide strong indications that quality-enhancing fishing leads to improved fish quality for the three main types of gear used in the coastal fishery for Atlantic cod in Norway. This is supported by the substantially higher prices achieved by those selling their fish at auction in Denmark or participating in the described revenue-sharing arrangement, reflecting a large share of high-quality products in onshore processing and downstream markets.

In both cases, additional costs and alternative costs were identified

but their magnitudes vary and are uncertain for different fishing strategies and tactics. Still, the higher prices achieved and the continuation of fishing this way indicate that these fishers find it worthwhile. It should also be noted that due to the shared remuneration system, higher revenues equate higher pay for the crews, which means that skilled labor can be attracted and kept – and motivated to engage in quality-enhancing fishing.

These findings indicate that even in an ex-vessel market with direct sales and where quality-based pricing of individual catches is largely absent [3], there are opportunities for increasing revenue through quality-enhancing fishing, which is beneficial for the fishing and processing sectors. That this can be done without the control and information flows offered by vertical integration is an important extension of past research focused on fish quality improvements in vertically integrated fishing and processing [17,37]. These strategies can also serve as guiding examples for other actors and may thus improve on an ex-vessel market currently performing poorly in terms of quality-based pricing. However, the described cases are not without caveats, some of which involve important policy implications and dilemmas.

First, due to a lack of revenue and cost information specific to cod fishing, we have not been able to demonstrate how fishers' profits are affected by quality-enhancing fishing. There is also uncertainty regarding the prices that can be achieved at Danish auctions or off-season sales through revenue-sharing arrangements should the landings of high-quality cod increase. This is in contrast to the more predictable prices when selling to local buyers. Off-season fishing may also benefit from the quota bonus scheme for cod, reducing the opportunity cost of spending the cod quota, but the scheme is not permanent, and due to the higher costs of off-season fishing it is uncertain how much the additional cod quota contributes to the profitability of quality-enhancing fishing.

Second, skipping the ex-vessel market and selling at Danish auctions is good in the sense that quality-based pricing incentivizes fishers to raise the quality of their landings, which improves revenues substantially. However, for policymakers this creates a dilemma as it also means that local fish buyers and communities miss out on much needed off-season supply of cod and other demersal species. The substantially higher revenues earned at Danish auctions – and the loss of raw material for the Norwegian processing industry – indicate that auctions for fresh demersal species should be considered in Norway, too. Display auctions where fish are weighed and graded by size and quality by a neutral auction house will minimize information asymmetry regarding fish quality and should, with a sufficient number of buyers, facilitate quality-based pricing [53]. However, display auctions introduce a new dilemma in that they may lead to centralization of fish sales, which may disadvantage small and less mobile vessels and fish buyers in rural communities located near fishing grounds that are good but which may be far from the nearest auction [3].

A final policy dilemma is that whereas off-season fishing supported by the off-season quota bonus scheme leads to increased revenues and off-season landings, emissions increase substantially due to the lower catch rates, implying conflicting policy goals. Longliners fishing off-season may need to travel far out to find cod of decent sizes, which would add to fuel costs and emissions. The gillnetters selling their catches at auction in Denmark incur additional costs related to transportation and more work at sea. But they fish while catch rates are high, which means low emissions.

Somewhat paradoxically, due to uncertainty over the sustainability of the coastal cod stock, the Marine Stewardship Council (MSC) suspended its certificate for cod caught inside the Norwegian 12 nm zone from August 15th, 2021 and from April 27th, 2021 for haddock caught inside the 12 nm zone. Thus, fishing outside the 12 nm zone – which increases emissions compared to fishing inside the 12 nm zone – means that the cod and haddock caught here is certified by the Marine Stewardship Council (MSC). Given that some of the price premiums for MSC labeled cod and haddock observed at the retail level of the value chain

[54–56] are reflected in prices at the ex-vessel level, an incentive may be created for fishing outside the 12 nm zone, which will mean increased emissions.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The authors acknowledge funding provided by the Research Council of Norway, grant no. 301951. We are also grateful to the informants that participated in the study and the two anonymous reviewers that provided useful comments improving the study.

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