

Capture-based aquaculture of cod

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SUMMARY

The concept of capture-based aquaculture (CBA) of cod is not new, in fact Norwegian fishers delivered their first live cod for marketing in Grimsby (United Kingdom) in the early 1880s. Currently, there are concerns as the Norwegian quota for the wild capture of cod is at an all time low and the seasonal differences in catch quantity are large. In addition, consumers prefer fresh high quality products. To meet these challenges, capture-based aquaculture of cod has received increased attention.

Capture-based aquaculture of cod differs from the CBA of most other species in that it is not based on juvenile catches. Instead cod from traditional fisheries, i.e. cod which is more than 4 years old is kept alive for approximately 6–8 months prior to being slaughtered and marketed as a variety of fresh cod products. Cod CBA is marginal and accounts for only one percent of the total Norwegian cod production. However, its importance is expected to increase as the methods for catching and keeping the fish alive improve. Additionally, increased quality *per se* and biomass growth through fattening in aquaculture is expected to contribute to increased attention. In many respects, cod CBA is similar to that of the bluefin tuna, but is at present smaller and with less socio-economic effects.

The biology and migratory patterns of cod imply that it is only available for short periods of time in different areas along the coast; during spawning (February to April) and when it feeds on capelin (April to June). The traditional harvesting of wild cod is carried out over a short period of time and in limited areas where the fish is easily

accessible. This coastal catch, performed by small- and medium-sized vessels, is highly dependent on favourable weather conditions.

Even though technology has made it easier to locate and catch the fish even in difficult weather conditions far from the coast, there are still seasonal differences regarding both quantity and quality. The traditional seasonal pattern of fishing for cod creates significant challenges in product development and marketing for the processing industry. These variations in supply make it difficult to plan the production and choose production capacity. Additionally, in a market that demands predictability both in volume and quality, lucrative contracts may be lost because it is difficult to commit to long-term delivery of supplies. CBA is looked upon as a promising concept for meeting the two most important challenges in a growing fresh-seafood market by reducing the uncertainty of volume, quality, delivery and documentation.

Capturing cod in periods of the year where it is easily accessible and storing it in the sea lowers the uncertainty of supply and opens the door for commitments through long-term contracts with those parts of the market that demand stability in volume and quality. In addition, new research shows that allowing the fish to restore physiologically for 12 to 24 hours after capture, reduces the capillary blood in the muscle and therefore results in a whiter fillet.

Traditional, full cycle farming of cod as a third alternative to bringing cod to the market is emerging and the production in 2006 exceeded 10 000 tonnes live weight. This is similar to the salmon farming industry, while capture-based aquaculture is rooted in the traditional industry capture and processing of wild cod. The Norwegian strategy is to apply all three concepts, i.e. traditional catch, capture-based aquaculture and farming to meet the challenge of consistently supplying the market with high quality fresh products all year round.

In order to establish and encourage CBA of cod, several challenges and regulations must be met. A new legislation was launched in January 2006 that included criteria for vessels approved for live capture. The legislation's emphasis is on improved post-harvest animal welfare as the main tool to increase survival rates. As there is a strong link between welfare and quality, this strategy is likely to be adopted by the industry. Furthermore, the use of CBA is based on the development of different weaning and feeding regimes.

DESCRIPTION OF THE SPECIES AND ITS USE IN AQUACULTURE

Cod (*Gadus morhua* L.), the most important member of the Gadidae family, was formerly abundant on both sides of the Atlantic. Due to over fishing and environmental changes there has been a substantial reduction in stocks over the past decade. A fishing moratorium was introduced for the west Atlantic stocks (George Banks, Grand Banks, New Foundland – Nova Scotia, Canada) in the early 1990s and these stocks have not yet recovered. East Atlantic stocks are in better shape – ranging from South-East Greenland, Iceland, the Faroe Islands, the North Sea, the Baltic Sea, along the Norwegian coast and in the Barents Sea. The North East Atlantic cod stock in the Barents Sea is by far the largest and is managed within the limits of sustainable harvesting. It is mainly fish from this stock that are used for CBA in Norway. In total, cod harvest in the Atlantic has been reduced from 2 500 000 tonnes to less than 1 000 000 tonnes during the last 20 years.

Spawning, eggs, larvae and juveniles

Spawning takes place along the northern part of the Norwegian coast from February to May. The main area is Lofoten and the peak spawning period is in early April. From the age of six to seven years the cod recruit into the spawning part of the population. The females ovulate eggs every second day for five to six weeks. The spawning behaviour ends with male and female swimming belly to belly shedding eggs and sperm. The amount of eggs shed by the females equals approximately 500 000 eggs per kilograms

of bodyweight. The pelagic eggs hatch two to three weeks after spawning, depending on the temperature, and the larvae are 4–5 mm in length. Within a week the larvae start eating phyto- and zooplankton. The nauplii of the *Copepode* (*Calanus finmarchicus*) are the most important prey. At 10–12 mm the larvae go through metamorphosis and become juveniles. Transported by the coastal and Atlantic current, the juveniles become demersal at 5–15 cm in length. This takes place along the coast of Finnmark County and in the Barents Sea. The juvenile cod are called the “0-group” during their first year and the varying size of each year-class is mainly decided by the conditions during the first autumn.

In the late 1980s the artificial production of cod fingerlings was limited and the number available for the aquaculture industry was unpredictable (Olsen and Soldal, 1988). In 1988, 600 000 0-group juveniles were captured for aquaculture purposes. The juveniles were caught in shallow water (10–20 m) with a small-meshed seine net. Capture mortality was low (<1 percent) and the cod were easily weaned to a moist pellet. Unfortunately, the juveniles were contaminated with a bacterial disease (*Vibrio salmonicida*) and only a small portion of the fingerlings were grown to slaughter size (Jørgensen *et al.*, 1989). The capture of wild fingerling was not repeated in Norway, but similar experiments have been conducted in Iceland (2003–2005).

Capelin cod

At the age of 3–5 years, immature cod follow the capelin (*Mallotus villosus*) on their spawning migration from the Barents Sea to the coast of Finnmark County (see Figure 6). The cod feed on capelin for several weeks and are therefore referred to, during this period, as the “capelin cod”. The capelin cod are characterised by a very low terminal post-mortem pH, resulting in a very poor processing quality. Their loose muscle structure gives low yields in mechanical operations such as filleting or splitting. It is mainly this part of the North-East Arctic cod stock that is used for CBA. Capelin cod has shown great potential for growth and quality improvement due to controlled feeding in captivity.

DESCRIPTION OF THE FISHING ACTIVITY

The capture of cod for the purpose of keeping it live is a tradition in Norway. As early as the 1880s, Norwegian sailing vessels went to Iceland to fish for cod using long-lines. On the last two weeks of each trip, they stored the cod alive in a specially designed section of the vessel’s hull. Water was exchanged through perforations in the hull, but only when the vessel was moving. The reward, however, could be substantial as live cod could achieve a price one hundred times higher than salted cod. Capture-based aquaculture on cod varied in importance during the twentieth century, but it was not until the introduction of cod as an aquaculture species in the mid-1980s that it became important. Over the last three decades, cod CBA has reflected the available quotas for coastal vessels; low quotas leading to high activity and *vice versa* (see section on “Advantages of CBA of cod”).

Gear

Seine nets (such as Danish seine and Scottish seine) are by far the most important gear for cod CBA. Since 1990 major improvements have been made, both with regards to gear construction and how the fishery is performed. The pictures in Figure 1 show modifications to the cod-end where a canvas-lining reduces pressure on the fish and hence pressure damages (left). Each bag is emptied into a shallow bin where the cod is graded and sent below to the live-fish holding tanks (right).

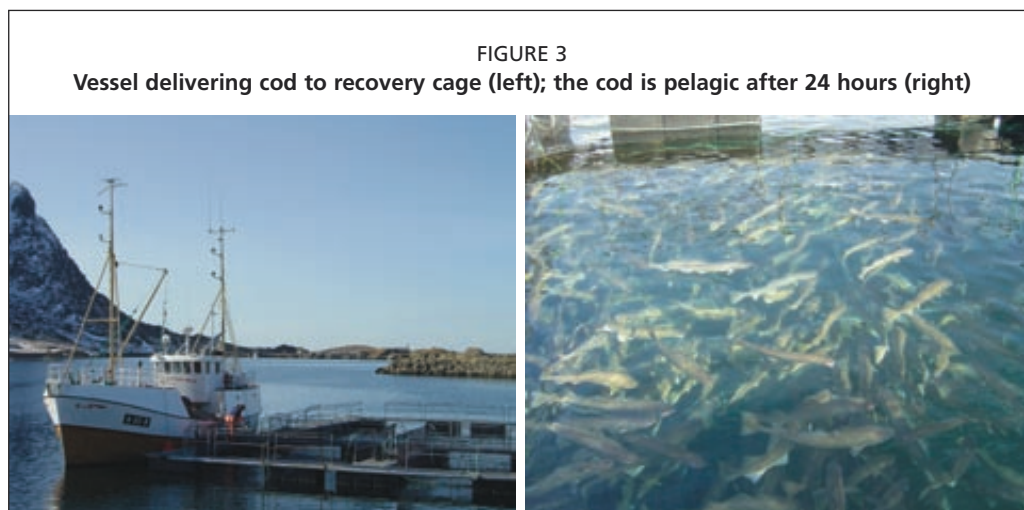
The gear is operated as in traditional fisheries, except for the final part of the haul-back where the hauling speed is reduced. This is done to reduce stress and allow for air from the gas-bladder to leave the cod. A final grading is performed following the



transfer to the holding tank, removing cod with residual gas. Normally all cod is alive when taken onboard. If the grading is done correctly, survival during transportation will be between 97 and 100 percent. Sixty percent of the cod from small coastal long-line vessels will survive capture and transport (Figure 2).

Figure 2 shows an automated line-hauler for coastal vessels which brings the fish onboard without the use of a gaffer (left). The fishers evaluate the fish and if the hook is swallowed or if the fish is damaged it is bled and gutted. If it has minor wounds it is transferred alive to the holding tank (right).





Cages and recovery

Upon delivery from the fishing vessel, the cod is lethargic and needs to restore itself physiologically as well as refill the gas bladder. Special cages with a flat and taut bottom are used for this purpose. Normally, 50 percent of the cod will move to the bottom of the cage where they will recover and the swimming bladder will heal. Within 24 hours most of the fish become pelagic and are ready for weaning (Figure 3).

Weaning, feeding and growth

As for most other wild fish species caught at an adult stage, the transition to captivity for the cod can be difficult. It is, however, a species with a wide range of behavioural assets which allow it to adapt to captivity within a few weeks. This is also reflected in the duration of the weaning time. If offered a wet-feed diet (herring, mackerel, capelin, sprat or squid) most of the fish will start eating four weeks after capture. On the other hand, if offered only a commercial dry-feed diet, practically all of the fish will refuse to eat. Recent trials to wean the cod with a semi-moist diet are encouraging and new methods are being developed, including vacuum-soaking of dry feed and the use of attractants and gustatory stimulation. There is an ongoing risk evaluation with regard to potential contamination of diseases through wet feed, in particular marine Viral Haemorrhagic Septicaemia (VHS).

Due to the fact that the cod prefer a diet based on the same food they eat in the wild and that there still are several challenges to be solved before the dry feed will suffice, CBA cod are mainly fed a diet of herring, mackerel, capelin, etc. These are wild-caught fish not suitable for human consumption, but intended for fishmeal production. All catch of these species is regulated with quotas. Depending on the state of the cod at capture, six to eight months of feeding will double the cod's weight, typically from 2.5 to 5 kilograms. The CBA and the farm-raised cod are slaughtered according to national aquaculture regulations.

LEGISLATION

According to the Norwegian authorities the term capture-based aquaculture embraces "the trade where fish are caught in the wild, stored for a certain time in a so called recovery/short-term storage phase and thereafter, as a main rule, fed to market-size under an aquaculture licence" (Fiskeridirektoratet and Mattilsynet, 2006).

The vast majority of Norwegian fish stocks, including cod, are subject to strong regulations in order to keep catch within precautionary limits. The Norwegian catch regulations are based on a core act, the salt water fisheries act, and several regulations pursuant to this, the most important being the regulations relating to marine fisheries.

Central elements of the regulations are total quotas, closed access, vessel and gear restrictions, vessel quotas and minimum fish size.

CBA has to comply with the full set of regulations, and in addition some specific regulations. Hence, the catch of juveniles for on-growing is not allowed. The minimum size for cod is presently 47 cm, so CBA has to target fish of this size or larger. After a long debate amongst CBA fishers and the authorities, the present regulations for CBA came into force on 22 December 2005. The main objectives are to ensure fish welfare and provide stable conditions for fishers.

The new CBA-specific regulations have been developed to ensure that it is clear where participants are subject to provisions, and which provisions apply for the capture process, the recovery/short-term storage phase and the aquaculture phase. Consideration of fish welfare in all phases of CBA is fixed more clearly by these laws.

Farming of fish is regulated by the aquaculture act and its accompanying regulations. The main objective is to favour profitability and competitive advantages of the aquaculture industry within the boundaries of sustainable development. Central elements are limited licenses, environmental conditions and operational requirements. Not all CBA is subject to this regulatory framework. It applies when fish are fed or fish are transferred to a licensed farm site.

The following discussion provides an overview of the specific regulations concerning CBA, covering the process from catch to short-term storage and the legal implications of the aquaculture regulations for CBA.

Catch, transport, recovery and short-term storage phase

Provisions regarding capture, transport recovery and short-term storage are covered in the new regulations regarding the requirements for vessels fishing and transporting catches. The regulations also apply to all vessels fishing and transporting live fish of all species other than herring, mackerel, sprat, eel and saithe. However they do not apply to fishing and the transportation of shellfish, e.g. lobster, crawfish or molluscs.

The new regulations are in addition to standard regulations concerning vessels that participate in fisheries. All vessels and their equipment must be approved by the Norwegian Food Safety Authority before being allowed to participate in the catch of live cod. The requirements are aimed at ensuring fish welfare, and the most important points are:

- any gear or device on board the vessel shall not inflict any harm on the fish or unnecessary stress;
- hauling the fish on board must be done by either a water filled bag or vacuum pump;
- shallow grading bins on deck that are partially filled with water must be installed;
- fish must be transferred to holding tanks without harm or being exposed to free falling. It should be possible to automatically count the fish; and
- live fish holding tanks must have a flat and perforated bottom giving an even up-welling of water. Water circulation should be at least 0.5 litres of water per kilogram fish/minute.

Provisions concerning the catch of fish, where fish are to be held alive, placed in recovery or short-term storage, are stated in the regulation regarding fishing in the sea (Chapter XVII of the regulations). Here it is defined that operations shall always be conducted with regard to fish welfare and thus training is required. Some technical requirements are placed on the design and use of Danish seine for live capture and transportation time is limited to eight hours. For the storage and recovery of fish important points are:

- cages shall be placed at least 2.5 kilometres from the nearest aquaculture farm, and health control is required before delivery to a site with an aquaculture license;

- cages for recovery must have a flat bottom-panel. During recovery, cages must be supervised daily. Cages must not hold more fish than 50 kilograms/m² bottom-panel area; and
- after recovery, short-term storage cages must be regularly supervised. The fish have to be fed daily if stored for more than four weeks.

Quota control is essential in modern fisheries management. Provisions concerning vessel registration, weighing, obligation to fill landing and sales forms and quota settlement, are specified in the regulation of cod, haddock and saithe, north of 62 °N latitude and in the regulation concerning the duty of disclosure when landing and selling fish. Before fishing commences, vessels have to register at the Directorate of Fisheries' regional offices where they are given quotas in live weight. Quota deduction is based on a conversion of the final product weight, most often headed and gutted, to live weight using standard conversion rates. In order to maintain control of the amount fished, separate provisions have been made for CBA. The main points are:

- before landing the live fish a 12-hour notice should be given to the Fisherman's sales organization to enable it to check on the quota granted to the individual vessel;
- all fish must be weighed when landed. At first time landing of live fish (not including shellfish or molluscs) from fishing vessels to the recovery cages. The weight can be set by counting all the fish and only weighing a representative selection of fish to determine an average weight/individual;
- a landing form must be completed and returned to the authorities when the fish are transferred to the recovery cages. When the fish is sold a sales form must be completed;
- deduction from the vessels quota is based on the first landing document. Adjustments can be made if the weight has changed as a result of factors which the fishers are not in control of. Examples are spawning, digestion of nutrition or escapees from the cages (not due to lack of fisher control); and
- fish which die during storage are deducted from the vessels quota.

To maintain food safety, Norwegian authorities have standards for food items for human consumption. For fish, these are stated in the regulation of quality. Adjustments have been made to this regulation to accommodate CBA. Fish caught in the wild, which die during transportation from the fishing grounds to the recovery pens, can be sold for human consumption. This is based on traditional fisheries where all fish are dead before delivery and the fact that the fisher maintains the quality of this fish on board the vessel.

Aquaculture phase

When the fish have been transferred to holding cages, the owner can decide on the storing time. The fish can be stored short-term to exploit price variations or for quality enhancement. Long-term storage implies feeding to increase the available quantity.

Enterprises are subject to a specific regulation regarding the operation of their aquaculture installations. The provisions in this regulation are founded on the aquaculture act, the food production and food safety act and the animal welfare act. The main requirements are that operations must be technically, biologically and environmentally safe, as well as epidemiologically safe, i.e. fish shall be protected against unnecessary stress, pain and suffering. This involves trained workers, health control, accurate production journals and reporting to authorities.

Live cod are covered by the CBA regulations until weaning commences. After this, the aquaculture act comes into force with its more comprehensive and resource demanding provisions and requirements, as covered in detail below. During short-term storage, the owner is required to supervise the fish regularly. There are no provisions concerning slaughter.

The maximum time fish can be kept without feeding is set by the CBA regulations at four weeks. This restriction is much debated. Some wish to store live fish for a longer period of time without feeding, or to avoid the extra considerations imposed when entering the aquaculture legal framework. This could be the case in periods when prices for fresh cod are expected to increase, while the quantity of caught cod is expected to decrease. The authorities have so far argued that a short period is important due to precautionary considerations of fish welfare. The issue has been solved by allowing the fisherman to retain and feed the fish for up to 12 weeks without entering the aquaculture legislation. However, the limit is under revision and the authorities have signalled an increase of up to 12 weeks.

When fish are fed, the aquaculture act comes into force, and several extra considerations need to be made. The aquaculture regulations require enterprises to hold a valid licence for farming marine species; the regulation concerning the licence for aquaculture for species other than Atlantic salmon, trout and rainbow trout of 22 December 2004.

Unlike short-term storage without feeding, aquaculture operations must adhere to extensive regulations concerning slaughter; i.e. proper sedation is required and slaughter has to take place at a licensed plant. New legislation and slaughtering procedures of aquaculture organisms were launched on 1 January 2007 to improve welfare and quality of farmed fish. This includes a ban on the use of carbon dioxide for sedation (effective from Summer 2009).

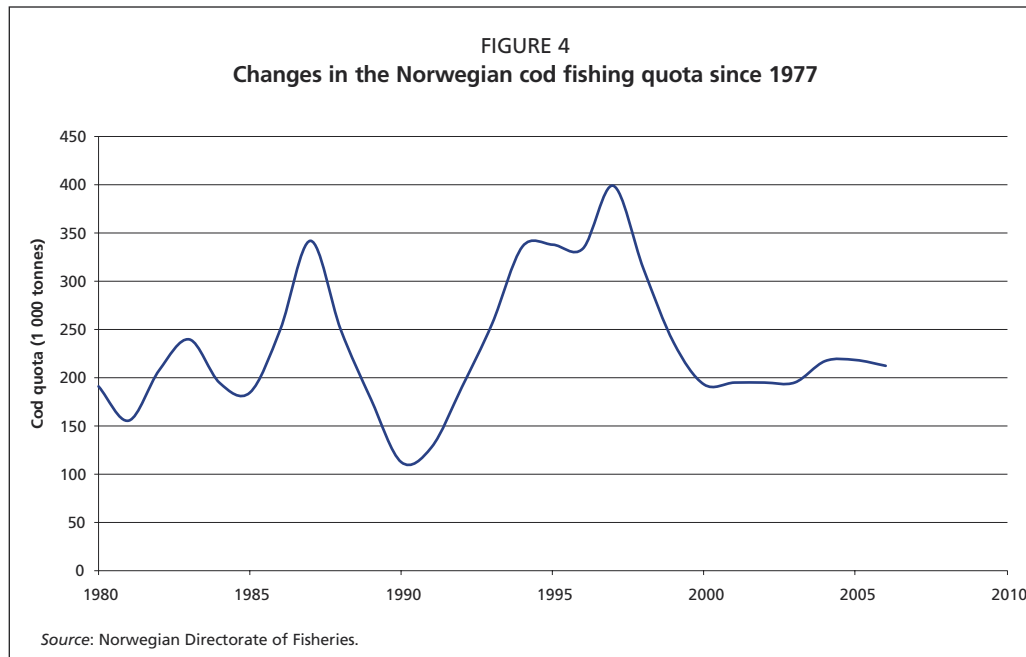
Marine aquaculture licences are given to a specific company for farming of specific species at appointed sites and life stages. Given that the application satisfies a set of conditions, licences are granted. These conditions are defined by various sector laws: the harbour act, the food production and food safety act and the pollution control act. In addition to the regular fish farming licences, a special licence for CBA has been designed. This allows a smaller quantity of live cod to be stored; it requires less information to be collected for the application, is less costly and involves less bureaucracy.

ADVANTAGES OF CBA OF COD

Harvesting of cod has always been important for people inhabiting the Norwegian coast. It is the most valuable species for the industry in terms of both revenues and employment. The traditional way of organizing the industry has been through fishing licences for professional fishermen that catch the cod in winter close to the coastal areas in the northern part of the country. Due to the seasonal migration pattern of cod, i.e. mature fish migrating to their spawning areas or immature cod hunting capelin, harvesting in winter is an efficient fishery, with high catch per unit effort (CPUE) and low costs. Improvements in technology related to finding and catching cod have made it necessary to implement management regimes to ensure sustainable harvest levels. This process has led to fewer vessels and fishers. In order to cope, fishers have had to devise ways to increase the volume of catch or to add value to a fixed quota. In the search for this, CBA has received attention particularly in recent years.

Capture-based aquaculture of cod is based on competitive advantages in relation to traditional capture harvesting. These advantages rest on major weaknesses in the traditional way of harvesting cod. First, the cod quota has recently been set at a historically low level, meaning there is a lack of supply on several markets. Second, the short fishing season opens the possibility of receiving a price premium if sellers are able to supply the markets with cod out of season. Third, if you are able to grow wild fish in cages, the volume increases accordingly to a sustainable level of catch. Last, consumers prefer fresh and high quality cod and CBA is well suited to serve such market preferences.

A closer look at how the traditional catch of cod has developed reveals several aspects that point in the direction of increased cod CBA. As stated earlier, the interest

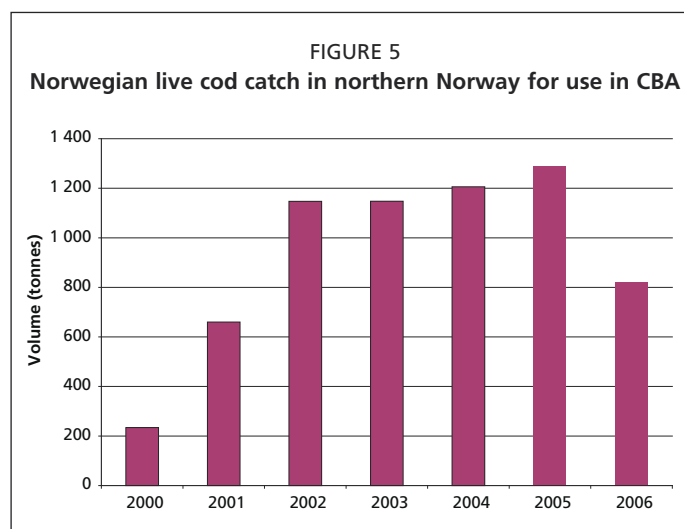


for catching live cod is closely related to the size of the cod quota. In periods with low quotas the interest is high and *vice versa*. Figure 4 presents the Norwegian cod quota for the last three decades. Not surprisingly, major technological breakthroughs related to CBA were achieved during the period 1988 to 1995. However, fishers lost their interest in CBA in the mid-1990s when the quota increased again. As shown in Figure 4 the quota fell to a low level in 1998, opening new boundaries for cod CBA.

During the period 1990 to 1994 the annual catch of cod for farming was around 1 000 tonnes. The development of knowledge and technology in the 1990s laid a good foundation for the new interest (Midling, 1994; Midling, Beltestad and Isaksen, 1996; Akse and Midling, 1997; Midling, Beltestad and Isaksen, 1997; Midling *et al.*, 2005). Figure 5 shows the annual catch for farming since 2000 in the northern part of Norway which is the most important region for cod CBA. In 2005 the quantity of cod delivered live at the national level reached a peak of approximately 1 500 tonnes.

As can be seen from Figure 5 there was a considerable drop in live catches from 2005 to 2006. This is not explained by a drop in catch quota, but mainly by market price changes. The price for cod caught live was in 2004 and 2005 almost 45 percent higher than the price for ordinary wild-caught cod. Although the fishers experienced a rise in cod prices in 2006, the price premium for live-caught cod dropped to only 30 percent. The price premium fishers receive for catching live cod thus also impacts on the development of cod CBA and fishers use CBA as an alternative market outlet, as volumes to this outlet are sensitive to price changes in the traditional value system.

The Norwegian Government expects that the CBA industry will contribute to considerable added value from the cod. They are planning a production level of 30 000 tonnes of live cod in the



near future, although the current catch level is far below this goal. In the summer of 2007 the Government announced that it will provide a quota premium for each kilogram of live caught cod. This was put into force for 2008, and only 80 percent of the live fish weight was deducted from vessel quota. A marked rise in landings indicate that this is an effective instrument. Furthermore, it will financially support investments needed to improve vessels and to establish infrastructure for storing live cod.

Seasonal pattern

Live cod is mainly caught by Danish seiners along the coast of Finnmark, Lofoten and Vesteraalen off the Norwegian coast from April to June, with the largest volumes caught in May. These areas are important fishing grounds in northern Norway and yield substantial catch of cod and other species throughout the year, with Finnmark dominating the catch levels.

Figure 6 marks the main cod fishing grounds and spawning areas in Norway along with the five CBA farms that buy live cod (regular full cycle cod farms are not marked).

Another interesting dimension of the live capture of cod is the seasonal pattern as shown in Figure 7. It seems obvious that the fishers find the period from April to July the most desirable month to carry out fishing for live cod. The traditional fisheries for cod have, as shown in Figure 7, a rather different pattern. One reason for this might be that vessels give priority to the traditional cod fishing season which runs from January to April. They then participate in the live catch when there is more time available for this activity.

The fishing grounds close to Finnmark have a dominant position in the fishery. This is due to the time of year live when the catch of cod is carried out, the migratory pattern of cod and its accessibility. The cod caught are mainly capelin cod, some smaller cod from the coastal stock of the *Gadus morhua* species or spent cod on its way back to the Barents Sea. The catch of live cod is carried out in a region and at a time of year

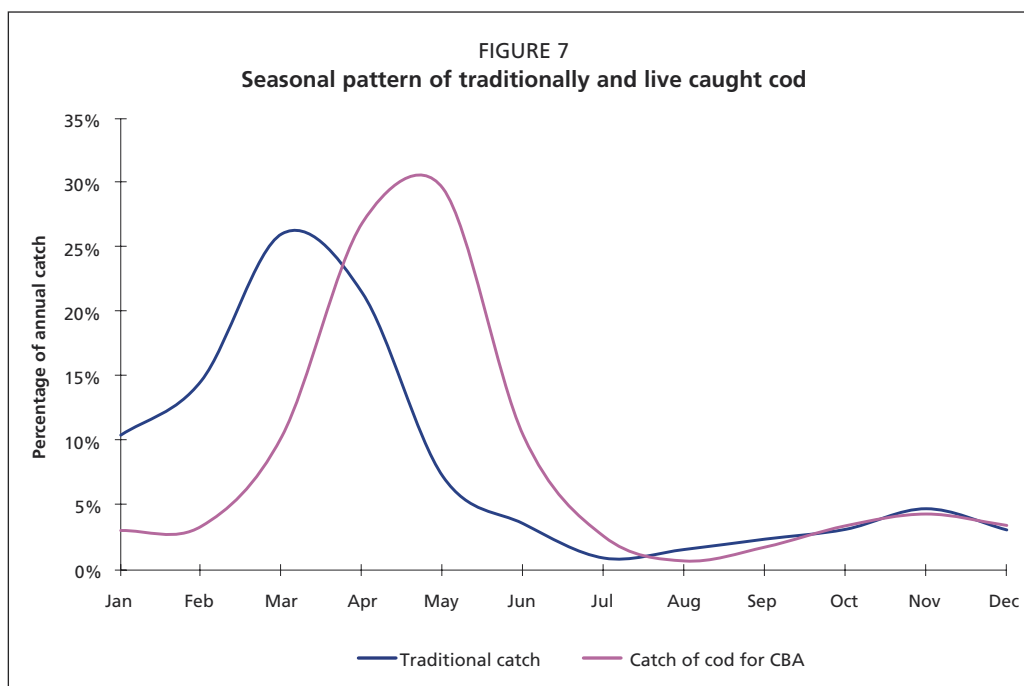
when the cod is close to shore. This time of year coincides with calmer weather and better conditions for both harvest activities and live transport.



Adding value or minimizing costs?

Detailed studies of the industry structure related to CBA reveal that over the years there has been substantial structural change in the wild cod fleet. During the period 2000 to 2006, there have been nearly 200 different vessels delivering live cod. Of these, 140 vessels delivered less than 5 tonnes during the 6 year period, and only 14 delivered more than 100 tonnes of cod. Only 15 vessels delivered cod every year in the same period. Even among these vessels, only a marginal volume of their total cod quota is caught live.

Of the 7 000 tonnes live caught cod during the period from 2000 to 2006 almost 6 000 tonnes were caught by Danish seine. The number of years each vessel delivered live cod, combined with



the distribution of catch between the vessels, indicates that there are almost 20 Danish seine vessels that maintain continuity in the cod fisheries. These vessels have several similarities; they are very flexible regarding their fishing gear; they switch easily between purse seine and Danish seine; and many are set up to transport the live fish from the fishing ground to the recovery cages in bulk. Furthermore, these vessels do not have licences for fishing other species such as herring and mackerel thus allowing them to concentrate on cod fishing. Another important characteristic for these vessels is that they only catch part of their cod quota live. In other words, they take advantage of the possibility to add value to their cod quota by delivering it live because they have the time and are properly equipped.

The reasons that so many vessels find it interesting to keep up with the live cod fishery, but not make a permanent commitment are many and complex. Empirical findings indicate that the size of the cod quota, quota portfolio, price premium, risk and legislation are important factors that influence the decision of whether or not to continue with live catch. Another problem is logistics. High fuel prices and long transport to the acclimatization cage sites are reasons for not engaging in live catch. The development of transportable storage cages or other infrastructure solutions, such as acclimatization cages close to the fishing grounds, are necessary. Additionally, CPUE and costs are important factors to consider when choosing a harvesting strategy that optimizes the profit of a fixed cod quota.

The initial cost to equip the vessel for live catch is estimated by the Foundation for Scientific and Industrial Research at the Norwegian Institute of Technology (SINTEF) to be from €67 000 to €100 000 depending on the size of the vessel (Aasjord and Hanssen, 2006). If it becomes necessary to upgrade to a more powerful engine the cost increases by €40 000. In any event, the issue of lower capacity for catch, loading and transportation of live fish will always have to be considered when planning the future use strategy of the vessel.

The fishers carrying out the live cod fishery for the CBA industry are also important contributors to traditional fisheries. As a result, there will always be a trade off between how, when and what will receive priority. Over the years, the average price of live cod has been 30–40 percent higher than the price of traditionally caught cod. However, due to the fact that the live cod fishery is more time consuming and vulnerable to weather conditions, each year fishers have a difficult choice as to whether or not they should

engage in the CBA fisheries. As the peak season for traditional cod fisheries is earlier than the optimal period for catching and storing live cod fishers must decide at the beginning of the year whether they should leave some of their cod quota in the hope that the increased price of live cod will outweigh the extra time and effort spent on catching them.

Optimizing profit includes a complex evaluation of how these factors will develop. Empirical studies indicate that they change rapidly and in directions difficult to predict. Mapping of important factors – with impacts on what strategy to choose – reveal that the vessels chose different variations of volumes of wild-caught cod, as shown in Figure 5.

Market positioning

Although there is minimal research on the organizational structures of the CBA industry its organizational pattern is built on the same basis as the traditional cod fisheries. The ownership of the fish changes the moment it transfers physically from the vessel to the buyer. The start up cost of participating in the CBA seems to be shared between the participants. The owner of the vessel invests in the equipment necessary to carry out the fisheries, the transport of live fish and the handling of the fish on board the vessel. The buyer, i.e. the shore-based industry, invests in the necessary fattening cages and equipment for slaughtering and production.

The industrial buyer

The competitive situation in the Norwegian industry calls for an increased interest in CBA from an industrial point of view. Recent years have brought about an increase in consumption of fresh seafood products and a higher demand for stability in supply. Supermarket chains want to be able to offer the same product portfolio all year round. It is impossible for the Norwegian industry to meet such obligations by depending only on the supply of wild cod due to the migratory pattern of this fish species.

The processing industry buying live cod is mainly located in Finnmark, even though many of the vessels deliver to the Lofoten and Vesteraalen areas. This is no surprise considering that the main fisheries are carried out off the coast of Finnmark. For these companies it is evident that the farming and production of live cod is only a supplement for their traditional production. The companies commonly have a portfolio of products which changes by season and with access to raw material. This access can be better controlled by the company when they store the cod live, compared to depending only on traditionally caught wild cod. Some cod fish farmers use CBA cod in addition to farming cod seed supplied from hatcheries.

Studies by Dreyer *et al.* (2006) indicate that the interest in buying live cod fluctuates from year to year. In the period from 2000 to 2006, there have been 33 different buyers involved. Of these, 27 tried out the concept for one or two years before deciding not to continue. Four companies purchased more than 500 tonnes (cumulative) of live cod throughout the aforementioned period, and only 2 companies continued to buy the fish on a regular basis. Occasionally, as much as half the total catch of live cod is bought by one company, however never the same company every year. This has caused a problem for the stable part of the industry due to the numerous companies testing the live cod market. This causes instability in access to live cod and also forces prices to rise. The decision to withdraw from this supply market is, however, not only due to negative experiences from the capture-based concept. There has also been a great deal of turbulence in general in the industry during this period.

Marketing strategy

Marketing strategies have been developed for live-caught and farm-raised cod. One of the main competitive advantages of live cod is its freshness and constant quality. To

thoroughly take advantage of this benefit it is important to know if farm-raised cod maintains the quality level expected by a highly demanding fresh fish market.

A quality study carried out in 2001 showed significant variation between wild, CBA and full-cycle farmed cod (Johansen and Johnsen, 2002). In the same study a test was carried out amongst Norwegian chefs. Compared to farmed cod the CBA cod was given a low score on quality. Of 13 chefs, ten said that they would not consider buying CBA cod for their restaurant due to the soft texture and high degree of gaping. A second and more extensive study was carried out in 2002 by Heide *et al.* (2003). This time both the farmed and the CBA scored good results in terms of quality and, in contrast to the earlier study, the chefs were satisfied with the consistency of the CBA fish. The conclusion of this exercise indicates that CBA cod shows a substantial variation in quality, thus further research is needed to ensure that CBA cod maintains the quality level demanded by the market.

The development of CBA knowledge and marketing know-how are critical issues. It is necessary to find out *if* CBA cod have any competitive advantages and *how* these advantages can be fully exploited to improve profitability and add value to the available cod quota. Two marketing strategies can be considered: a) using the same channels as wild cod for distribution, sales and marketing of CBA cod; and b) differentiating CBA cod from the wild cod.

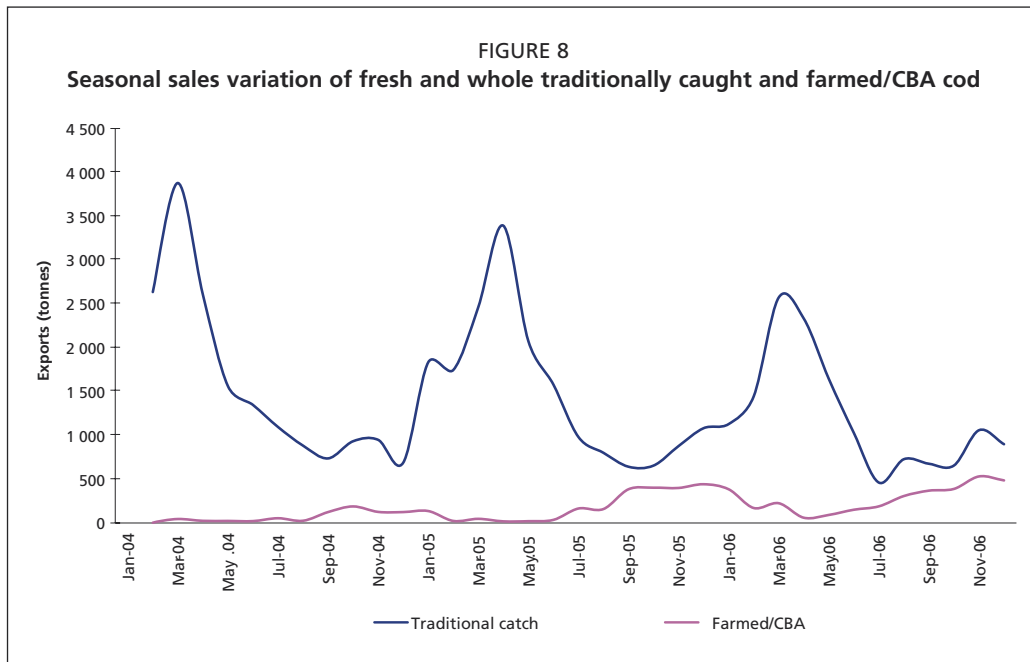
Branding regulations within the EU (Council Regulation [EC] 104/2000 of December 1999 on the common organization of the markets in fishery and aquaculture products) require that all fresh-farmed fish that are sold to consumers be branded as “farmed” and marketed as farmed fish. Furthermore, the Norwegian legislation (Aquaculture Act) specifies that wild-caught marine fish that are artificially fed shall be regarded as farmed fish and thus should follow the aquaculture legislation. Today, farmed cod is distributed and sold using the same channels as wild cod. In many ways this is a natural strategy considering the small amount of farmed cod that is available. The volume is far too small to be able to take advantage of the potential competitive advantages, such as supply stability to producers and consumers. However, the traditional full-cycle aquaculture of cod must be branded as “farmed”, and can be perceived as being different to wild cod. Furthermore, the CBA cod should be marketed as a separate product.

It has not yet been studied whether or not CBA cod has characteristics that make it possible to differentiate it from wild caught cod in other ways than by name only. However, research carried out on CBA Icelandic cod has shown that this cod has qualities which made consumers from different countries perceive that it was different from the Icelandic wild cod (Sveinsdóttir, 2006). In this study, CBA cod was perceived to be “meatier” than the wild cod and as much as 23 percent of the invited consumers preferred CBA cod. If further research of the Norwegian CBA cod reveals similar differences, there would be the potential to propose the CBA cod to consumers who prefer such qualities.

Tracing the cod in the market

Cod is mainly caught near the coast of Finnmark during spring time. It is difficult to trace CBA cod once it leaves the Norwegian producer. Interviews with participants in the CBA sector reveal how and where the cod ends up and eventually positioned in the market compared to traditional wild-caught cod. The main impression is that CBA cod is used as a supplement to the traditional production of fresh filets or exported as fresh whole fish.

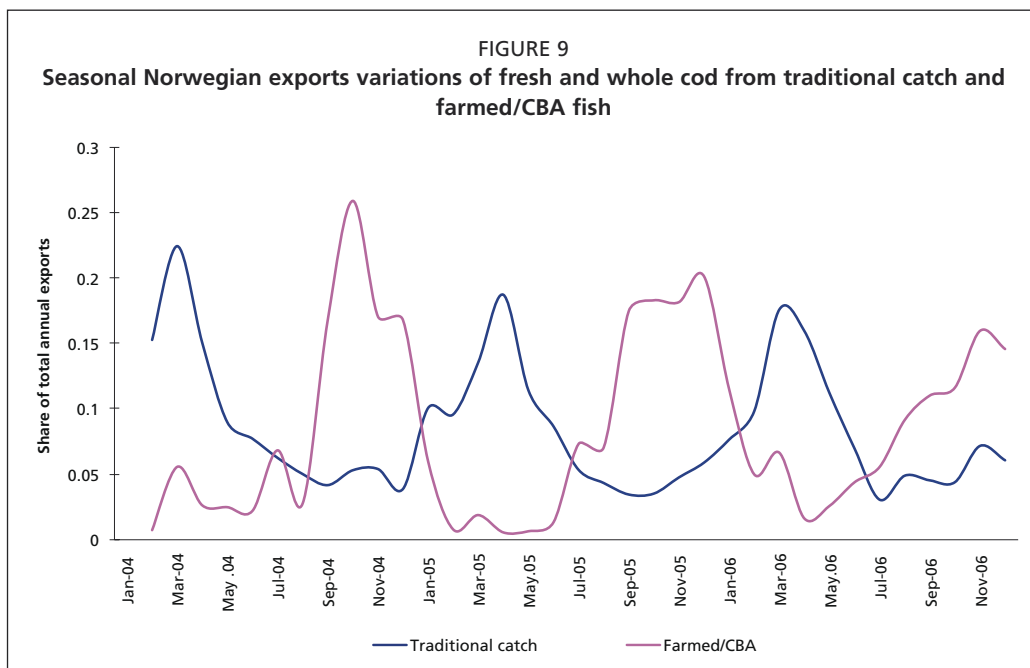
Figure 8 shows how the export of fresh whole cod evolved, on a monthly basis, from February 2004 to December 2006. The export is divided into traditionally caught cod and cod that are CBA or farmed. The figure shows that Norwegian export is dominated by traditionally caught cod. The quantity of traditionally caught cod, which is exported, coincides with the seasonal pattern of the traditional cod fisheries. The main quantity of cod is caught during the winter months.

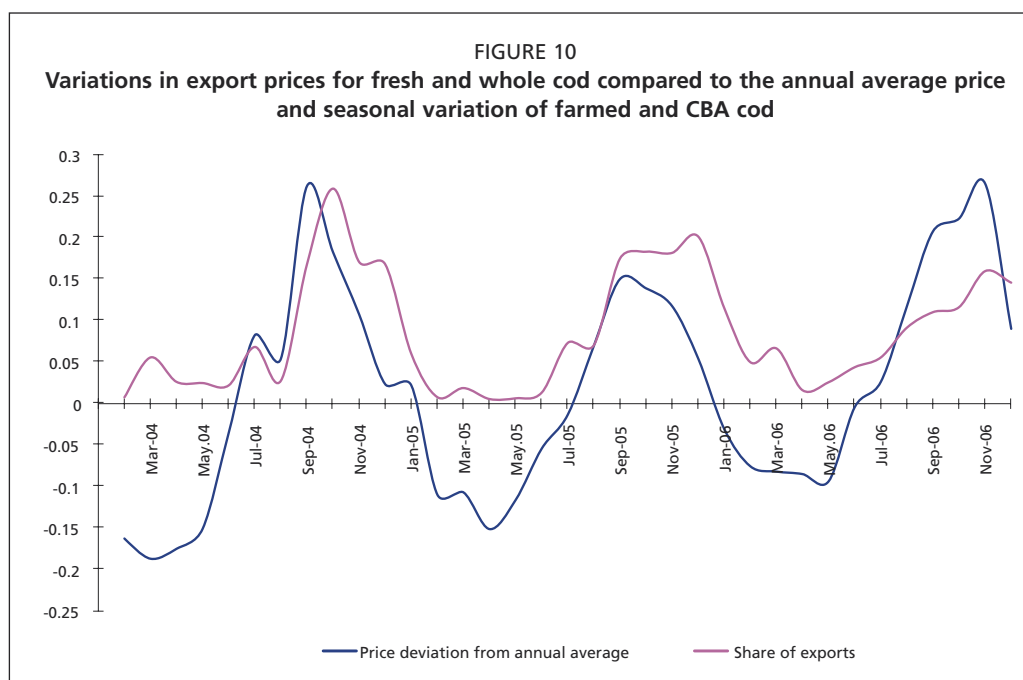


The industry based on CBA or farmed cod is expected to take advantage of the demand in the market for fresh cod in the months of the year when traditionally caught cod are scarce. Figure 9 shows the seasonal export of wild-caught cod and farmed/CBA cod.

The figure shows that farmed or CBA cod are placed on the market at a time of year when traditional cod fisheries are slow. As opposed to traditionally caught cod, the farmed or CBA cod are placed on the fresh fish market from September to December, supplementing the wild fisheries cod market, even though the quantity is less.

If the annual demand for fresh cod remains high as during the main exporting months, there is still room for a substantial increase in the quantity of farmed and CBA cod. How big an increase the market will accept is difficult to predict. The monthly amount of cod exported during the critical months lies between 3 000 and 4 000 tonnes of whole cod. If the market demand for fresh cod remains stable the whole year, the





total possible export of fresh cod would be around 40 000 tonnes. In 2004 and 2005 the total export of fresh cod was around 18 000 tonnes.

Figure 10 shows that the price for fresh cod varied substantially over the years. During the two years presented the price was above average in the autumn period and at its lowest during the first months of the year. Exported farmed or farm-raised cod are sold in the period of the year when the price premium is highest. The industry adjusts production so that it can place the product on the market at the best possible time to supplement the traditional fisheries. One of the main challenges the traditional industry is facing is supplying the market all year round.

SOCIAL AND ECONOMIC IMPACTS

Norway is a country with many small villages with 150–2 000 inhabitants. In the north and west of Norway, fisheries is often the main activity of the villages and a common social structure is the father working as a fisher, the mother working in the factory and the children taught to participate in these activities on weekends and school vacations – although this is changing. Due to smaller quotas for fish and technological improvements, there are fewer villages of these size and less recruits to most positions within fisheries. Fisheries have a reputation of being unpredictable and a low status occupation. A major challenge has been to adapt capacity to the sustainable management of crucial fish resources upon which many communities rely.

New technological breakthroughs related to CBA have opened new possibilities to add value to a sustainable cod fishery that can secure vulnerable jobs and improve profitability in an industry located in rural areas. In order to develop these possibilities several challenges have to be met. The extra costs related to this way of organising the value system have to be reduced and compared to the traditional harvesting model. Second, the consumers have to be willing to pay a higher price for the products produced by the capture-based industry.

Data indicates that the traditional wild harvesting cod outperforms cod CBA. However, statistics indicate that the two fisheries do not compete with each other – rather they complement each other. As the actors in the two fisheries are the same, CBA has become a new option for people earning their livelihood from traditional cod harvesting. Exploiting the competitive advantages of CBA will improve profitability and secure vulnerable workplaces in this rural-based industry.

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