Uppsala 2010-05-28

# Climate Smart KRAV Fish

**Emissions of greenhouse gases from a 400 g pack of cod**

**A comparison of KRAV-approved cod and average cod**

# Contents

## Summary

KRAV, in partnership with SIK (Swedish Institute for Food and Biotechnology), the retail food sector and fishing companies, investigated the effects on the climate of choosing KRAV-labelled cod compared with conventional atlantic cod (*Gadus morhua)*.

From the time it is caught until it has been transported to the central warehouse of the supermarket, a 400 gram pack of KRAV cod gives rise to emissions of approximately. 0.6 kg carbon dioxide, while the average pack of cod that is not environmentally labelled emits approx. 1.3 kg. Around half of all the packs of cod sold in Sweden give rise to emissions of at least 1.7 kg carbon dioxide. Converted to kg carbon dioxide per kg product, the emissions for the KRAV cod are approx. 1.5 kg carbon dioxide per kg, for the average cod 3.3 kg carbon dioxide per kg and for the most common cod 4.3 kg carbon dioxide per kg.

Even with the worst case scenario of emissions for KRAV-labelled cod, it is still 40% more climate smart than the average cod. This means that if all Swedes only bought KRAV-labelled packs of cod, we would save almost 4 000 tons of carbon dioxide, which is equivalent to the emissions from around 1 300 cars. The additional cost to the consumer of choosing KRAV or MSC certified cod is estimated to be SEK 2 per pack or SEK 5 per kg.

In most cases, it is the actual fishing that contributes the greatest proportion of the climate impact. This can be decreased by only fishing in sustainable stocks, since this decreases the engine running time per kg caught fish. Within fishing, the refrigerant used also has a significant climate impact. Since the start of this year, KRAV has placed a limit on maximum fuel consumption and has banned the most dangerous types of refrigerants on KRAV certified vessels.

If processing is carried out in countries where electricity production has a high climate impact, it can also make a major contribution. This is the case if fish are shipped to China for filleting and packaging. Fish filleted and packaged in Norway has a low climate impact from processing.

The climate impact of transport only becomes significant where the transport distance is very long, e.g. to China and back or, in the case of hoki (*Macruronus novaezelandiae*), from the other side of the world. Transporting fish in diesel-powered freezer containers drives up the impact further.

KRAV-labelled fish is guaranteed to come from sustainable fisheries. The sustainability is assessed by an expert panel in an open process where everyone can comment. All fishery vessels are inspected by certification bodies that work under contract with KRAV. It is obvious that Swedes appreciate KRAV-labelled fish, since sales increased by around 60% in 2008 and by 126% in 2009.

# 1. Approach and sources

### Aims of the report

The overall aim of this report was to investigate whether there is any significant difference in terms of climate impact between KRAV-certified fish products and what can be assumed to be a type of average product. In other words, does the consumer reduce any of the climate impact through choosing KRAV fish and if so, how much? This is an interesting question since KRAV recently introduced changes to its standards with the aim of decreasing the climate impact of KRAV-certified fishery.

We selected the 400 g pack of frozen cod as an example, since it is a product that is fairly easily available to consumers throughout Sweden. There are also MSC-labelled options available under private brands, and the supermarket chains ICA, COOP and Axfood all have eco-labelled frozen cod packs in their eco food range. This gives the consumer a real opportunity to make a choice, which would not have been the case if we had opted to study a less common or less widespread product.

The species of cod in question is Atlantic cod, *Gadus morhua*. We also included New Zealand hoki, *Macruronus novaezelandiae*.

We decided to compare the climate impact of active selection of KRAV with the absence of such a selection. Consumers naturally have other reasons governing their choice (brand loyalty, price, the influence of advertising), but to make the study manageable we called the alternative the average cod pack. Therefore we assumed that instead of choosing KRAV, consumers selected packs of cod at random.

### Important limitations in life cycle analyses

This report is based on data and methods used when carrying out life cycle analyses (LCA). Our aim was thus to present details on the climate impact of the entire production process for a pack of cod, from fishery through cleaning, packaging, freezer storage and transport. Although LCA may appear to provide clear data, it is important to understand the boundaries set up in order to correctly interpret the information. More details on these exact boundaries are given in Appendix 1. However, we particularly want to highlight the following:

- The study was limited to climate impact. There are many other important environmental considerations. Sustainable development is a question of even more dimensions, but here we only compared the climate impact.
- The objective of the study was to give a rough estimate of emissions, not to produce detailed data. The intention was to show the results in terms of a single figure, or at most two.
- We applied mass allocation of the climate impact from the fish. This means that of the total climate impact of the whole fish caught, we attributed climate impact to waste (bones, fins, guts, etc.) in relation to its proportion by weight of the fish. For mass allocation to function, the waste must be utilised as a product, e.g. as a feed in fish farming. Another common method is economic allocation.

- The system boundaries for the study were from fishing vessel to central storage of supermarket (assumed to be situated in Helsingborg, Sweden). We calculated emissions for the entire vessel journey, all energy use in processing and transport to the central storage. However we did not calculate the effects of fish growth, transport by the consumer from the supermarket or fish cooking by the consumer. The boundaries we chose were selected because the differences between KRAV and other fish arise within them.

The results of the life cycle analyses are expressed as kg carbon dioxide equivalents ($CO_2$e) per kg product. In certain cases we give the results as kg $CO_2$e per 400 g pack of cod. Expressing the climate impact as carbon dioxide equivalents meant converting the climate impact of gases such as refrigerants, methane and nitrous oxide to carbon dioxide.

### Partnership with SIK and retail food sector

This report was produced in a partnership between KRAV, SIK (Swedish Institute for Food and Biotechnology), Domstein Sverige AB and the supermarket chains COOP, Axfood and ICA. SIK, the retail sector actors and their suppliers provided data. KRAV was solely responsible for compiling the report and for its content, including any errors. The author responsible at KRAV was Johan Cejie. The rapporteur at SIK was Friederike Ziegler.

## The climate project

KRAV is working together with a number of other actors in both Sweden and Norway within the project Climate Certification of Food. The results produced within that project form a major part of the knowledge base for climate impact of sea food. The project website, hwww.klimatmarkningen.se/in-english/, presents the scientific results and the standards used by KRAV as the starting point for our new fishery standards.

### What is KRAV?

KRAV is an organisation and a label for those wishing to make a conscious choice of food from sustainable production, from a healthy soil and a healthy planet. In brief, this means natural cultivation without chemical pesticides, artificial fertilisers and GMO. Fishing and other use of nature's resources must be carried out on nature's terms. KRAV food only contains natural additives. KRAV also stands for good animal welfare, social responsibility and a lower climate impact. The KRAV label can only be found on food products that have been checked by independent and accredited certification bodies.

Behind the KRAV label is the KRAV organisation. This organisation is non-profit making and is owned by 26 members. A list of these members can be found at www.krav.se/sv/Om-KRAV/Fakta-om-KRAV/Organisation/Medlemmar/

KRAV was founded in 1985 and its members together with producers and consumers have been working over the past 25 years to create an organic market in Sweden. Today there are 3600 KRAV farmers and almost 11% of Swedish agricultural land is managed according to KRAV standards.

Find out more about KRAV at: www.krav.se/System/Spraklankar/In-English/About-KRAV/.

KRAV can also be contacted at phone +46 18 15 89 00, e-mail info@krav.se. Postal address: Box 1037, SE-751 40  UPPSALA, Sweden.

## 2. Sales of cod packs in Sweden – origin, price, etc.

### Origins of cod in Swedish freezer cabinets

All cod sold on the retail market must bear a label showing its origin. However, the Swedish Food Administration only requires this to state the FAO fishing zone. Fishing Zone 27 is named the North-East Atlantic and comprises areas of sea that extend from the Straits of Gibraltar via Greenland to the coasts of Norway and Russia, including the Baltic Sea[1]. Within these limits, there are many stocks of cod. Some of these are rich and well-managed (e.g. most of those in the Barents Sea), while others have collapsed or are on the brink of collapse (e.g. many of those in the North Sea, and specifically Skagerrak and Kattegatt).

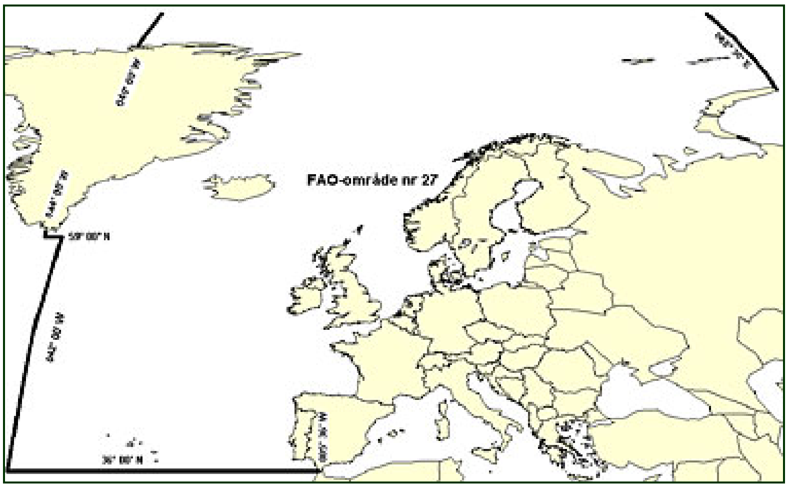


**Figure 1. FAO Fishing Zone 27.** Source; Svensk Fisk, www.svenskfisk.se/media/38622/fangst2.jpg

It is legal to catch fish within the quotas negotiated within the EU, and cod are taken even from very weak stocks. Thus the level of traceability in existing legislation does not provide consumers with any great guidance when it comes to choosing sustainable products.

In contrast, KRAV standards require considerably better traceability. Fish can be traced to within an accuracy of 10 nautical miles (approx. 19 km), and the packaging states the catch site. Modern technology also allows the consumer to obtain information about e.g. capture time and/or the boat that made the catch.

[1] www.svenskfisk.se/media/38622/fangst2.jpg

**Figure 2.** M/S Statthav, one of the KRAV-certified fishing vessels.

The vast majority of the deep-frozen cod consumed in Sweden is imported. Most (86%) originates from Norway (Table 1), where the major fisheries are in the area of the Barents Sea. In addition, much is imported from Denmark, including Greenland (14%). Other sources of imports are negligible. Total imports in 2008 amounted to 7865 tonnes of frozen cod.

**Table 1.** Imports of frozen cod to Sweden, 2008[2]

| Country of origin | ton/yr | Percentage |
|---|---|---|
| Denmark | 1114 | 14 % |
| Iceland | 4 | 0 % |
| Netherlands | 14 | 0 % |
| Norway | 6722 | 86 % |
| Portugal | 1 | 0 % |
| Great Britain & Northern Ireland | 10 | 0 % |
| **Total** | **7865** | **100.0%** |

[2] http://www.ssd.scb.se/databaser/makro/ Codes 03035210 (cod of the species *Gadus morhua*, frozen) and 03025010 (cod of the species *Gadus morhua*, fresh or chilled)

### Origins of packs of deep-frozen cod

Based on a compilation of data on sales of 400 g packs of deep-frozen cod in the three major supermarkets in Sweden, we were able to conclude that such packs make up around 2800 tons or 36% of the cod imported. Using these data, we were also able to summarise the origins of the cod and the fishery methods used (Figure 3).

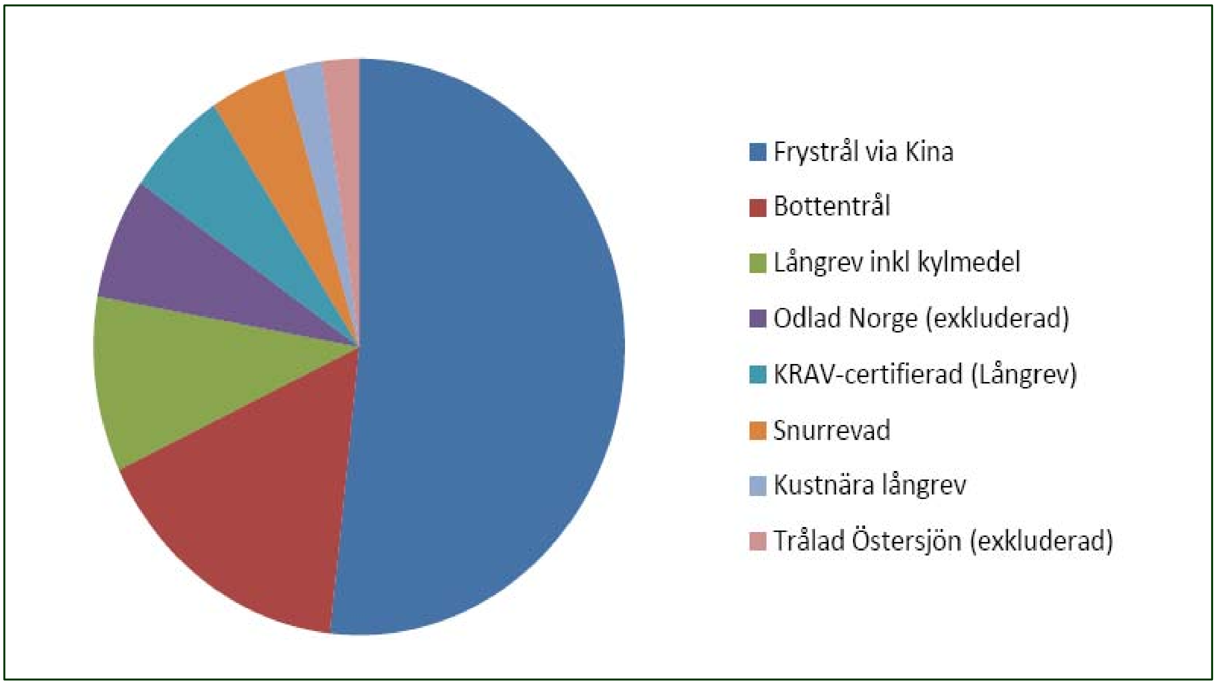


**Figure 3.** Origins and fishery methods used for packs of cod found in Swedish supermarkets. **KEY: Blue:** Freezer trawler via China, **brown:** Bottom trawler, **green:** Long line incl. refrigerants, **purple:** Farmed Norway (excluded)**, light blue-grey:** KRAV-certified (long-line), **orange:** Seine net, **light blue:** Coastal long line, **pink:** Baltic sea trawler (excluded).

As shown in the pie diagram above, we estimated that 52% of the packs of cod sold are produced by freezer trawler via China, 16% by bottom trawler, 10% by long line with refrigerants, 7% farmed in Norway, 6% KRAV-certified (long line without refrigerants), 5% by Seine net, 2% by long line close to the coast and 2% trawled in the Baltic Sea. Since relevant data for Baltic fisheries and farmed cod were not available, we opted to leave these out of the calculations. There have been a number of studies on farmed salmon in Norway, but cod farming differs with regard to composition of the diet, feed conversion, escapes and mortality, and salmon farming is a much larger scale and more optimised enterprise. This means that at present, farmed cod is in all probability more resource-demanding than farmed salmon.

'Freezer trawler via China' means that the fish are caught in one place (e.g. off the coast of Norway), frozen whole, shipped to China for hand-filleting and packaging and then re-frozen before being shipped back for sale in e.g. Sweden. This procedure has environmental advantages since hand-filleting gives greater yield, but also disadvantages since there is long freezer transport.

### Price of packs of cod

Cod, or similar fish in the form of a 400 g block, is a product found in most Swedish supermarkets. The price is generally between SEK 35 and 40 (approx € 3.50 to 4.00). The price varies depending on supermarket chain, supermarket concept, advertising campaigns and segmentation. In order to compare the KRAV pack in subsequent evaluations as regards price, we considered a leading brand, such as Findus, and the supermarkets' own private brands in the quality segment, e.g. COOP and COOP Änglamark.

We found that the price difference between a KRAV-labelled pack of cod and the Findus equivalent was zero in COOP supermarkets. However, the KRAV-labelled pack cost SEK 2 (approx € 0.20) more than the COOP's private brand.

# 3. Climate impact of cod packs with and without environmental labels

## Cod fishery

Cod are caught by different fishery methods, both passive and active. An example of a passive method is long line fishing, where baited hooks are laid out in the sea (they are kept at the correct depth in the water by weights and buoys, left there and then hauled in after around 16-18 hours). An active method is bottom trawling, where a large, funnel-shaped net is dragged along the sea bed behind a boat. The net is kept open by boards that separate the two sides of the net mouth so that the fish can enter. In terms of frozen cod, bottom trawling is the most common active fishery method used and long line fishing the most important passive method. A seine net is a piece of equipment that looks like a trawl net, but it has no boards and it is not drawn along the bottom. The boat rather moves in a circle. It was more widely used in the past than today, but is also included in fishery methods that supply cod for deep frozen cod production.

Cod fishing has traditionally been substantial in Sweden, with enormous catches in the Baltic Sea during the 1970s and 1980s. Stocks in the Baltic Sea have declined heavily, although a weak positive trend has been detected in recent years. Stocks in the Barents Sea are regarded as being sustainably fished. Several of the fisheries in this region is MSC- and KRAV-certified, which is a strong indication of this. This is mainly thanks to a joint effort by Russia and Norway to get to grips with the previous extensive illegal fishery in the area.

## Average cod pack compared with environmentally labelled

Based on the available data and the assumptions made above and those in Appendix 1, emissions of greenhouse gases for an average 400 g pack of cod bought in a supermarket in Sweden were found to be 1.3 kg $CO_2$e/400g cod, see Figure **4**.

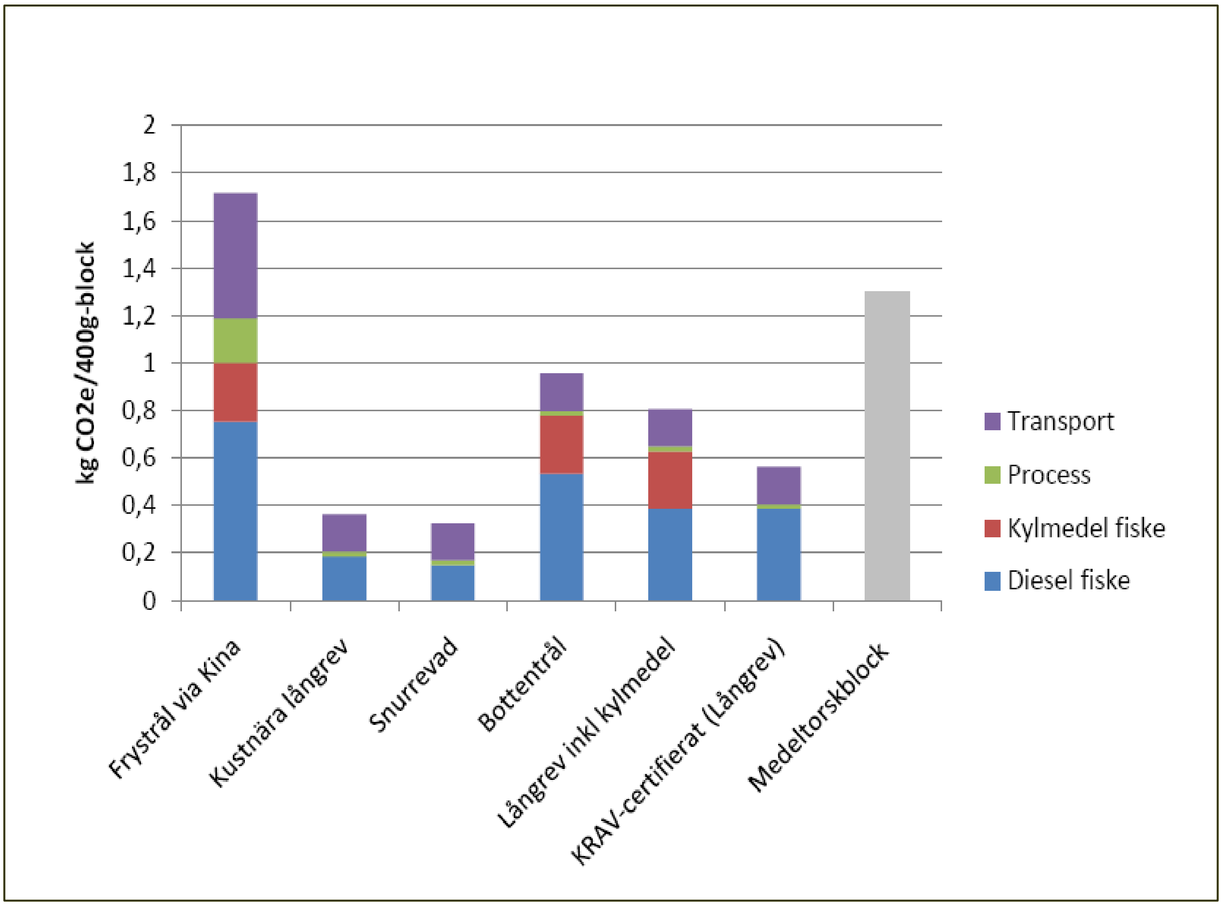


**Figure 4.** Emissions of greenhouse gases for the average pack of cod bought in a Swedish supermarket [kg $CO_2$e/400g cod pack]. KEY: Freezer trawler via China / Coastal long line / Seine net / Bottom trawler / Long line incl. refrigerants / KRAV-certified (long-line) Average cod pack. / SIDE: Transport, Processing, Refrigerant fishery, Diesel fishery

The results in Figure 4 are divided into the contribution from the different stages in the production chain. The majority of the emissions originate from the use of diesel in fishery, as has been found in most life cycle analyses of fish products based on fish caught in the wild. Diesel consumption in turn depends on how far the boat has to travel and fish to catch a certain amount of fish. In well-managed stocks the entire time is shorter, since the fish are simply closer together. KRAV standards have long required that the stocks must be well-managed and the equipment must be efficient. Since the beginning of this year, there is also a maximum limit on diesel consumption of 0.5 litre diesel per kg landed fish. However in the case of KRAV fish above, a value of only around 0.35 litre diesel per kg landed fish was used.

Fish processing makes a relatively insignificant contribution when it takes place in Norway due to the hydropower-based electricity used in Norway, which gives low climate emissions. When processing takes place in China the environmental impact is greater, mainly due to the coal-based electricity production there. The long transport to and from China in terms of distance and (transport takes around 80 days in diesel-powered freezers on board the ship) also has an effect and leads to this chain having the highest total climate impact of those included: 1.7 kg $CO_2$e/400g cod. This chain represents over half the packs of frozen cod on the Swedish market.

In cases where refrigerants are used, these also make a substantial contribution to the total climate impact. The refrigerants normally used at sea are what are known as synthetic refrigerants, which when they leak out have a greenhouse effect that can be many thousand times stronger than that of carbon dioxide – and freezer equipment at sea does leak refrigerants, mainly because the environment is aggressive and takes a heavy toll on pipes and joints, but also because the vessel is subjected to mechanical stress. Leakage of refrigerants can cause up to 30% of the climate impact from fishery and is therefore comparable to diesel consumption. Since the beginning of this year, KRAV standards require the refrigerant used to be of a natural type, usually carbon dioxide or ammonia. Ammonia has almost no climate impact, but has other disadvantages.

The fishery method used is also significant for energy consumption. Towing a trawl along the bottom to catch cod requires a lot of energy. The trawl consists of a large, funnel-shaped net fitted with weights that are dragged over and partly through the sea bed. The trawl itself weighs a considerable amount and in addition it holds the catch and a certain amount of sea bed material. KRAV does not permit bottom trawling, and nearly all the cod in KRAV-labelled packs is line-fished.

If a consumer chooses a pack of cod without considering environmental labelling and on a more or less random basis, we can thus conclude that this pack gives a climate impact of 1.3 kg $CO_2$e per 400 g pack (or 3.3 kg $CO_2$e per kg fish). However, for the average cod pack it is difficult to say exactly how much of the impact should be allocated to the different stages in production. Since we know that the most important climate impact from the actual fishery is determined by the health of the stocks and that the two dominant labelling systems, KRAV and MSC, monitor stocks in a similar way, it is interesting to compare the average pack in these two cases. In this comparison we had access to detailed data for hoki (MSC), which is marketed as an alternative to cod, and cod (KRAV). See Figure 5.

Note however that the allocation in the 'average cod pack' bar is theoretical and thus cannot be compared directly with the others. For an indication of how the 'average cod pack' should be interpreted, see Figure 4. Note too that the scale in Figure 5 is $CO_2$e per kg fish, not $CO_2$e per 400 g pack. This gives an idea of what fish is like compared with other products.

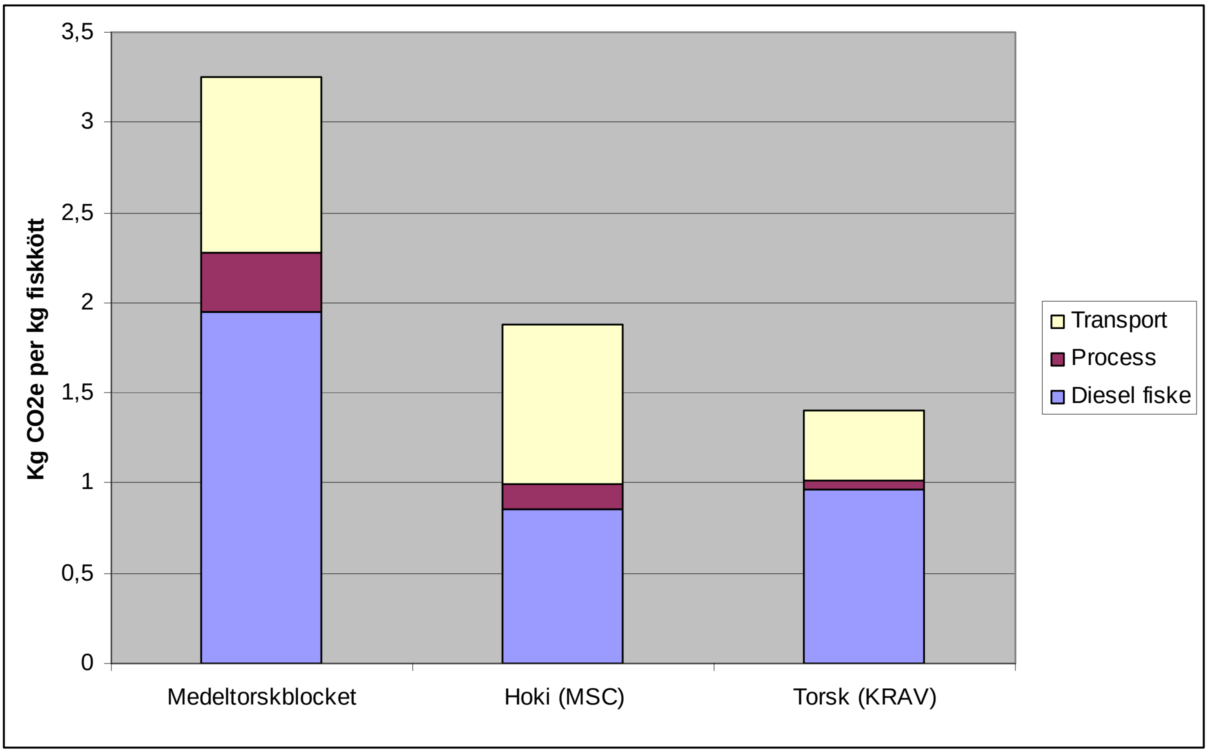


**Figure 5.** Comparison of the average cod pack and the environmentally labelled alternatives. Note 1: The subdivisions in the 'average cod pack' bar are only theoretical. Note 2: In this case the scale is $CO_2$e per kg product, not per 400g pack. KEY: ..per kg edible fish / Average cod pack / …Cod (KRAV). Transport / Processing / Diesel fishery

The data depicted in Figure 5 for the different products are expressed in figures in Table 2.

**Table 2.** Comparison of the different types of fish products

| **Origin** | **kg $CO_2$e per 400 g pack** | **kg $CO_2$e per kg product** | **Comparison with average pack, $CO_2$ savings per 400 g pack** | **Comparison with average pack, $CO_2$ savings, %** |
|---|---|---|---|---|
| Average cod pack | 1.3 | 3.3 | 0 kg | 0 % |
| Hoki (MSC) | 0.75 | 1.9 | 0.55 kg | 42 % |
| Cod (KRAV) | 0.56 | 1.4 | 074 kg | 56 % |

In rough terms it can therefore be said that the eco labelled fish emits about half as much carbon dioxide as the average fish. It can also be said that hoki and cod give similar amounts of emissions in terms of fishery and processing. It is the long transport that gives the hoki a higher final value.

### How much does money saved cost in terms of emissions?

Apparently, prioritising anything other than an environmentally labelled product has an environmental cost – emissions of at least 0.5 kg $CO_2$e per 400 g pack of cod. In many cases there is no price difference between environmentally labelled packs and competing packs, but we can see e.g. that the COOP's ordinary pack of cod is SEK 2 (€ 0.20) cheaper, and the same is generally true for the other supermarket chains. The consumer buying two packs of KRAV-labelled cod has saved at least one kg carbon dioxide, at a cost of SEK 4 (€ 4.00).

Scaling this up to Sweden's total imports of frozen cod (7,865,000 kg, see Table 1) means that we could save almost 4 000 000 kg or 4 000 ton carbon dioxide if all the packs of cod bought were KRAV-labelled.

The average car in Sweden emits approx. 200 g carbon dioxide per km and travels approx. 15,000 km per year. This means that the saving produced by everyone buying KRAV cod would be equivalent to the annual emissions from 1,300 cars.

## 4. More information on KRAV fishery standards

### How KRAV's fishery standards work

The approval process consists of two stages:

1. KRAV, with the help of its fishing committee, determines whether the stock is sustainable and whether the equipment used is sufficiently careful.
2. A certification body determines whether the individual fishery vessels fulfil the standards that apply for KRAV fishing.

The application to open a fishery is first examined by the KRAV fishing committee, which consists of experts on fishery within different areas such as toxicology, sustainable fisheries and life cycle analysis. At present its members are:

- Chair: Friederike Ziegler, SIK
- Kine Mari Karlsen, Nofima
- Jonas Nilsson, Kalmar College
- Helena Röcklingsberg, Lund University
- Inger Näslund, World Wildlife Fund, WWF
- Call in: Bengt Sjöstrand, Swedish Board of Fisheries

This fishing committee decides whether:

- The fishery is performed using sustainable methods on stocks that are within biologically safe boundaries
- The equipment is sufficiently selective
- The target species contains abnormal levels of environmental toxins, for example heavy metals and dioxins.

In order to ensure that all the supporting data are correct and that the process is transparent, a proposal on the decision by the fishing committee is sent for consultation to KRAV members, the board, selected researchers, relevant authorities, and fishing companies and organisations. The consultation process is also open to the public via the KRAV website. On the basis of the fishing committee's proposal and the results of consultation, the CEO of KRAV then makes a final decision. This decision specifies the equipment permitted for use and other conditions for approved fishing.

When a fishery has been approved, individual fishery vessels or a fishery company can apply for certification of their operations according to KRAV standards. These standards include requirements on traceability, training of fishermen and bans on certain refrigerants, oils, lubricants and paints. Since the start of this year they also include standards on maximum fuel consumption.

**Find out more about fishing according to KRAV standards** and other information on the fisheries open visit: www.krav.se/System/Spraklankar/In-English/Fishing/

**Read the KRAV fishery standards at:**
http://www.krav.se/System/Spraklankar/In-English/KRAV-standards/

**Find out more about the members of the fishing committee at:**
http://www.krav.se/sv/Om-KRAV/Fakta-om-KRAV/Organisation/Fiskekommitte

## Market for KRAV-approved fish

KRAV has had standards for approval of sustainable fisheries since 2004. In recent years, the market has developed at a rapid pace. During 2009 sales of KRAV fish in the supermarkets increased by 126%, a doubling in the rate of increase compared with 2008. The two main groups within this category are frozen fish and preserved fish. In 2009 there was active product development, with e.g. the launch of around thirty new KRAV products.

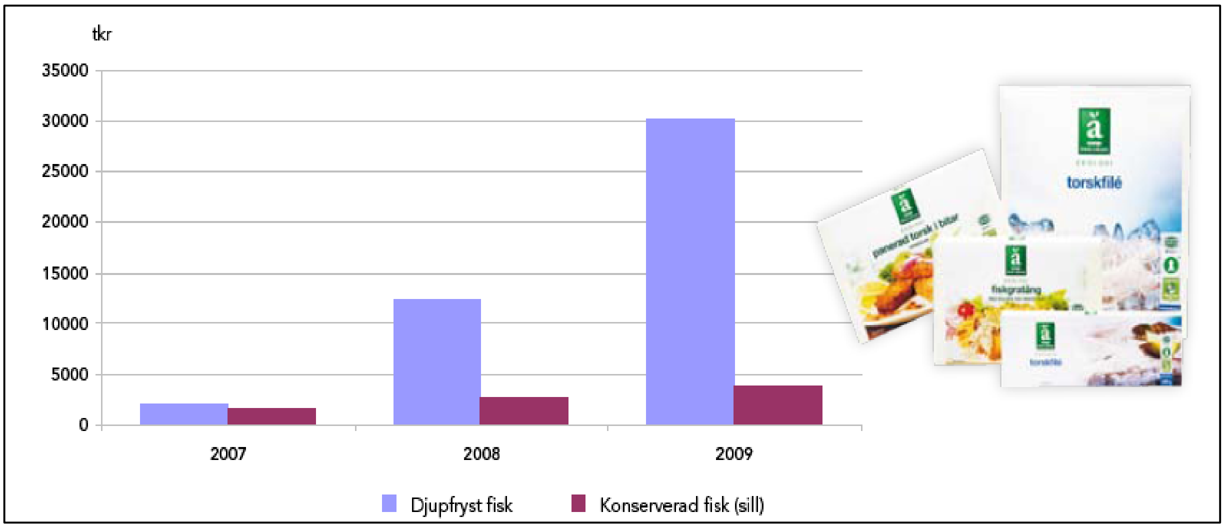


**Figure 6.** Trend in sales of KRAV-labelled fish in Sweden between 2007 and 2009. Source: KRAVs marknadsrapport 2010.

# Appendix 1: Methodology

## Methodology and sources of data

The climate impact (kg $CO_2$-eq./400 g cod pack) covers the system from fishery up to a retail outlet assumed to be located in Helsingborg, i.e. up until the packs of cod are transported to Sweden. To calculate an ‘average cod pack’, three large retail chains in the Swedish food market were contacted and provided data on total sales of packs of cod during 2009 and the breakdown into different brands and the supplier of these brands. These fish suppliers were then asked where and with what fishery methods their cod had been caught. This information was used to estimate how the average pack of cod was produced and how far the cod had been transported before it reached the retail outlet in Helsingborg. This inventory led to inclusion of the following production chains for cod caught off northern Norway:

1. **Freezer trawler** with **filleting in Qingdao, China,** including transport by ship from northern Norway to China and back to Sweden after filleting.
2. **Coastal long line fishing** with filleting in northern Norway, including transport by lorry to Helsingborg.
3. **Seine net fishing** with filleting in northern Norway, including transport by lorry to Helsingborg.
4. **Bottom trawling** with filleting in northern Norway, including transport by lorry to Helsingborg.
5. **Long line fishing** with filleting in northern Norway, including transport by lorry to Helsingborg.
6. **KRAV-certified long line fishing** with filleting in northern Norway, including transport by lorry to Helsingborg.

In addition to the above fish production chains, results are also presented for the following three environmentally labelled alternatives to the ‘average cod pack’:
**a)** A theoretical pack of KRAV cod, with fuel consumption of 0.5 l diesel/kg landed cod, i.e. exactly on the limit for KRAV certification.
**b)** An alternative to cod consisting of a pack of MSC-certified hoki fillet caught in New Zealand.
**c)** Existing KRAV fishing, which takes place by long line without the use of synthetic refrigerants (same as chain 6 above).

Allocation of the environmental load between the main product and by-products in the fishing and processing stages was based on the respective mass, which meant that e.g. fillet and by-products carried equal amounts of the environmental burden in the processing stage. It was also assumed that the by-products in fish processing were fully utilised. However, the fish guts and heads thrown overboard at sea were not allocated any of the environmental load of the fish since these are not utilised for any other purpose. The supermarket stage was not included since all packs are handled similarly at that stage, making comparisons unnecessary. It was assumed that there was no difference in wastage between the brands, so an inventory or calculation of this was deemed unnecessary. Data on resource use and emissions from production of plastic, production and consumption of various fuels and electricity production in Norway were taken from the ecoinvent database (ecoinvent, 2007). Electricity production in China and New Zeeland was simulated using data from the International Energy Agency (iea.org). The characterisation indices used in calculations are presented in Table **A1**.

**Table A1. Characterisation indices for climate change (Global Warming Potential per 100 years). Source: Forster *et al.* (2007)**

| Emission | Characterisation index ($g\ CO_2$ per gram) |
|---|---|
| Carbon dioxide ($CO_2$): | 1 |
| Methane ($CH_4$): | 25 |
| Nitrous oxide ($N_2O$): | 298 |
| Refrigerants (HCFC-22/R22): | 1810 |

## Fishing

For all Norwegian fish, average data for fishing with the respective fishing method were used (Winther *et al.*, 2009). The exception was freezer trawling, for which the supporting data used in Ziegler (2008) formed the basis. Data from that study were also used for the calculations on New Zealand hoki.

The hypothetical KRAV-labelled pack was based on an existing fish production chain with the only differences being that fuel consumption was set at 0.5 litre diesel/kg landed fish, which is the maximum permitted fuel consumption in fishing according to KRAV standards, and that it was assumed that no synthetic refrigerants were used, since these are not permitted in KRAV-certified fishing.

Fishing included production and consumption of the diesel used as fuel on the boats and in some cases to power onboard freezers, plus emissions of refrigerants in the form of freons in cases where these were used. We made the assumption that freons were used in large-scale trawler and long line fishing, but not in coastal fishing with small boats as understood in KRAV-certified fishing.

Transport was assumed to be by lorry in all cases except for hoki and for cod filleted in China, where transport to Sweden was assumed to be by freezer container on a freight vessel.

## Processing

The data used for filleting, packing and freezing in Norway for the packs of cod were taken from Ziegler (2008). Electricity was assumed to be used as the energy source and was simulated using a Norwegian production sector that mainly consisted of hydroelectric power. In the cases where processing was carried out elsewhere (China and New Zealand), this was simulated with a different cutting-out percentage, with the hoki in New Zealand having a lower fillet yield. Hand filleting in China gives a better yield of cod than machine-filleting in Norway. When processing was carried out in New Zealand and China, the electricity used was simulated using a country-specific production mix of electricity that was somewhat better from a climate perspective for New Zealand and considerably worse for China (owing to the high proportion of fossil fuels used; China has almost 100% coal-based electricity production). Energy consumption per kg fish is also slightly higher in these countries, contributing to the higher outcome for processing compared with Norway. In China, energy is required to first thaw the fish and then freeze it again after filleting.

Du får mer

#### Transport

Data of resource use and emission from transport work were taken from the FHL project (Winther *et al*., 2009), with two different containers being used: a large container ship that travels at 14 knots and a smaller ship that travels at 17 knots. These were used for transport from New Zealand and to and from China. The lorries used in other cases were based on specifically collected data on lorry traffic on hilly roads in Norway and on motorways (Winther *et al*., 2009). It was assumed that containers were completely full on both ships and lorries and return journeys were not included. Data on energy consumption and refrigerant leakages for freezer units during transport were taken from Winther *et al.* (2009).

#### Supporting data

## Freezer trawling (via China)

For freezer trawling, fuel consumption of 0.6 l/kg cod landed in cleaned and de-headed form was used (based on data from Ziegler, 2008). The refrigerants used were assumed to be freon R22, [using] a Norwegian average for demersal fishing of 0.336g/kg landed (Winther *et al*., 2009). After fishing, the freezer-trawled cod was assumed to be shipped to Qingdao, China, for filleting. Transport from Norway to China and from China to Sweden was simulated for two types of ship on each route. The shorter trips between northern Norway and Rotterdam, and Rotterdam-Helsingborg, were simulated using the smaller container vessel mentioned above. For the transport between Rotterdam and Qingdao (and the return trip Qingdao-Rotterdam), the larger container vessel was used in the calculations. Emissions from diesel and refrigerants in the freezer units were also simulated according to Winther *et al*. (2009).

## Bottom trawling

The value used for fuel consumption in bottom trawling was an average for Norwegian bottom trawling: 0.43 litre diesel per kg landed cod (Winther *et al*., 2009). Refrigerants were also assumed to be used in the form of freon R22, with a Norwegian average for refrigerant use in demersal fishing of 0.336 g R22/kg landed cod (Winther *et al*., 2009).

## Long line (not KRAV)

Long line fishing was simulated with fuel consumption of 0.31 litre diesel/kg landed cod, based on a Norwegian average value for long line fishing taken from Winther *et al*. (2009). Refrigerant use was simulated based on the Norwegian average for demersal fishing of 0.336 g R22/kg landed cod.

## Long line (KRAV)

Long line fishing was simulated using fuel consumption of 0.31 litre diesel/kg landed cod, based on a Norwegian average value for long line fishing taken from Winther *et al*. (2009). No synthetic refrigerants are allowed in KRAV-certified fishing.

## Seine netting

The fuel consumption value used for fishing by seine netting was an average for Norwegian seine net fishing of 0.12 litre diesel per kg landed cod (Winther *et al*., 2009). It was assumed that no refrigerants were used in this fishing, which takes place nearer the coast and in smaller boats than the above types of fishing.

## Coastal long line

The figure used on fuel consumption in coastal long line fishing was the average for Norwegian coastal long line fishing: 0.15 litre diesel per kg landed cod (Winther *et al*., 2009). It was also assumed that no refrigerants were used in coastal long line fishing for the same reasoning as for seine netting above.

## 'Theoretical' KRAV fishing

According to current KRAV standards on the use of fuel in fishing, fuel consumption may not exceed 0.5 litre diesel/kg landed cod. This consumption was used to simulate the theoretical KRAV pack of cod.

## Pelagic trawling of hoki in New Zealand

In hoki fishing, which is certified according to MSC, fuel consumption is 0.25 litre/kg landed hoki and the fish are landed whole. No refrigerants that have a climate impact are used in this fishing (Ziegler, 2008).

Du får mer

## Appendix 2: References

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