Briefing Paper

CO_2 emissions

Case studies in selected seafood product chains

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CO_2 and other greenhouse gas emissions

Carbon Dioxide (CO_2) emissions, food miles and greenhouse gases (GHG) are issues that are currently at the centre of world agendas and are generally perceived to be contributing to global warming. Over the past year, in partnership with industry, Seafish has undertaken several case study evaluations of GHG emissions associated with seafood, from point of capture to output as seafood products from processing factories.

This briefing note summarises those research findings and looks specifically at levels of GHG emissions associated with the seafood commodities traded. It examines some of the key risks and opportunities facing the seafood industry with regards to GHG emissions as a preliminary step in helping UK seafood processors measure, reduce and/or offset GHG emissions throughout their supply chains.

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The wider picture

• Moving beyond 'food miles'

There is currently confusion over the difference between transport GHG emissions and 'food miles'. 'Food miles' are a simple measure of the distance food travels but ignore *how* food travels. However, estimating transport GHG emissions takes into consideration both distance and mode of transport.

• Measuring GHG emissions

Measurement involves expressing different GHG emissions in a common unit of CO_2 equivalent units. Generally, measurements associated with GHG emissions are poorly defined and a new industry is emerging that aims to measure them, undertake activities to reduce or offset comparable emissions elsewhere or produce basic CO_2 labelling schemes. GHG emissions have even entered the world of taxation in the form of vehicle emissions and energy usage schemes. To be effective, the protocols that govern these schemes need to be clearly defined. Currently this is not the case.

• Economic considerations of sea freight transportation

The current practice of processing seafood in low wage economies such as China, is a major consideration. Chinese factories can utilise their lower cost to concentrate on yield rather than speed. For seafood, modest yield improvements can compensate for the GHG added by transporting it to China and back. This, of course, only relates to seafood transported by container ship, which, because of their high utilisation rates, are extremely effective at moving freight around the world for little energy cost.

- **Economic considerations of air freight transportation**

The use of air freight adds significant levels of GHG emissions, however, again the issues are not as straightforward as they first appear. The air freight of material is primarily driven by the characteristics of the flesh, the technology available for freezing and customer choice. Customers are prepared to pay the premium for the choice of having fresh, never-frozen seafood available as required. Commonly, this material is moved in the passenger holds and contributes to the payload utilisation of the aircraft. It is interesting to note that countries exporting fresh material by air freight are often also those countries that enjoy the benefits of tourism. Ceasing movements of freight by air could increase journey costs. This could potentially impact tourism and degrade the local economy in sensitive economic regions, where this trade has become significant to the local economy. It could also affect local fishing activity which provides livelihoods for local economies; this is especially important in developing countries.

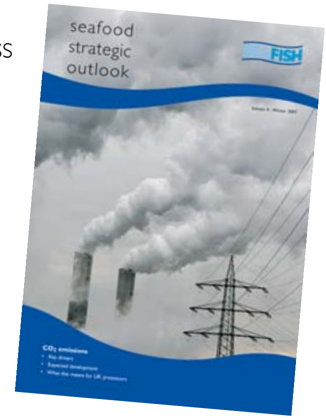
GHG emissions and consequences for the seafood industry

There appears to be very limited assessment of GHG emissions in seafood or other protein industries. Levels of GHG emissions will be closely tied to the nature of individual product supply chains.

The food and drink industry may be vulnerable on several fronts: adhering to regulations for greenhouse gas emissions may prove costly, and companies with high emissions could experience consumer backlash. Alternatively, proactive efforts to reduce emissions could create major opportunities for the industry. Lower emissions may reduce costs and/or protect sales (through improved products/company image, etc), while reducing the likelihood of severe negative environmental change.

The consequences of this for seafood companies include:

- potentially reduced access to primary resources;
- increased regulation of emitting behaviors; and
- negative perceptions amongst consumers.



Key research findings

Some early research into the GHG emissions of typical seafood product chains has recently been undertaken by Seafish and researchers at Dalhousie University, Canada, in collaboration with selected UK seafood processors[1].

Research limitations

- Supply chains were defined as being from point of origin (fishery or farm) to UK processor and, in most instances, to distribution or retail. We did not include emissions associated with the retailer or the consumer in our estimates.
- In the case of some product chains, key data were not available through processors.

Our findings from this work suggest the following:

- As with published emissions research in seafood, primary production (ie fishing or farming) is typically the dominant contributor to greenhouse gas emissions associated with seafood products.
- The direct fuel intensity and resulting emissions of various fisheries for human consumption may differ by orders of magnitude, depending on the abundance of the targeted stocks, the fishing technology employed, and the distance to fishing grounds.
- GHG emissions associated with fresh product forms sourced from abroad and consequently requiring air freighting far exceeded emissions for non air-freighted products, regardless of the

energy inputs and resulting emissions associated with primary production. This situation is made worse when multiple air freight legs are involved.

- Processing and packaging generally make very small contributions to overall emissions (often under 10% of total) except in instances in which emission-intensive materials are used (eg metals), or where cooking is involved, etc.
- For intensively cultured products (eg salmon), emissions associated with feed provision, and consequently with primary resource production generally, often dominate full supply chain GHG emissions.
- Reducing the GHG intensity of many important seafood products consumed in the UK will depend heavily on identifying and preferentially sourcing seafood from fuel-efficient fisheries or low input culture systems or alternatively, undertaking measures to reduce the emission intensity of existing systems.
- Some simple strategies, including moving from fresh air-freighted material to high quality frozen product forms and low carbon intensity ocean freight transport, would significantly reduce supply chain GHG emissions. Container ships are a highly efficient mode of transport, and although often result in higher food miles, the additional GHG emissions may be offset by yield gains (see box 1). Freezing and shipping products via ocean container transport may be an alternative to air freight, but not in every case. In some instances, fish meat characteristics, technology and customer requirements may mean that this is not a viable proposition.

Conclusions and next steps

The research conducted to date is a good starting point; however, it is important to consider the research limitations when looking at results, when comparing different species or undertaking further research. Industry needs to come up with suitable solutions to reduce emissions whilst still supporting economies, especially in developing countries. It will be important to develop a common method for measuring emissions, and for businesses to review their products and business activities against that.

- **Develop a common method for measuring GHG emissions**

A common system for measuring GHG emissions in food needs to be developed along with a widely agreed basis for comparison. This could reflect the weight of GHG emissions related to the food actually consumed or converted back to a standard live weight equivalent. The protocol needs to set out and clearly define the boundaries that a GHG assessment covers. It needs to clarify whether it covers the whole of the chain or from what point it starts. For example:

  - Does it cover the embodied energy of the vessel construction through to end product packaging, consumer purchase and use?

- Should it be confined primarily to the energy consumed during the production, wholesale and distribution process such as transport, fuel and energy costs?
- It should take account of the fact that foods are sold in different forms, eg a whole dressed chicken or fish would have a lower emissions footprint than a fillet of the same material. But a GHG assessment should also consider that generally, their carcasses would be sent to landfill and generate greenhouse gases such as methane.

- **Seafood businesses should review their GHG emissions**

Seafish recommends that businesses review their GHG emissions to gain an understanding of some of the issues they face. Before undertaking a full formal analysis, a broad overview of your product supply chain should be gained to identify key emission hotspots. They should clearly define the boundaries that they are going to assess (eg types and quantities of energy consumed, non-energy related emissions, point of capture/production to point of delivery to customer depot) and express the measurements as a quantity of CO_2 equivalent per unit weight of food consumed[2]. Generally, any effort that can reduce GHG emissions by improving utilisation, yields or reducing energy usage will translate into improved efficiency and profit.

Case study research findings

1. Estimating transport GHG emissions

Estimating transport GHG emissions takes into consideration both distance and mode of transport.

- Using GHG emissions to compare modes of transport, emissions from transporting one tonne of fish by marine transport to China can be compared with transporting the same tonne of fish from Iceland to the UK by air.
- For example, transporting one tonne of cod:
  - to the UK from China by marine transport (10,900 miles) emits around 190kg CO_2 equivalent[3] per tonne;
  - from Aberdeen to London by truck (536 miles) emits around 250kg CO_2 equivalent per tonne; and
  - to the UK from Iceland by air freight (1,042 miles) emits around 3,250kg CO_2 equivalent/per tonne.
- Around 60% of what we consume in the UK is imported and large distances are involved.
- A large quantity of frozen seafood is transported efficiently on container ships around the world.
- Fresh product forms sourced from abroad can have significant transport-related GHG emissions to ensure timely delivery.
- The principle driver of GHG emissions is the actual fishing or farming activity (60-80%) – unless products are air freighted.

- Higher yields from processing material by hand in developing countries could in some instances offset the emissions of additional transportation (see box 1).

Box 1. What do yield improvements mean in terms of GHG emissions?

With an abundance of labour, raw material processing in China typically generates a superior yield. Here we will look at shipping frozen cod (headed and gutted at 61% yield from live weight) to China for processing into skinless cod fillets. We are estimating GHG emissions to the point of leaving the Chinese production facility, and comparing emissions in two scenarios. The first where the Chinese processor generates a yield of 60% (as is the norm), the second where the processor has a yield equivalent to that in the UK - around 55%. In both scenarios, no credit is given for the potential utilisation of processing co-products (eg wastes):

- Scenario 1 Chinese processor with a yield of 60% gives around 6,840kg CO_2 eq/per tonne.
- Scenario 2 Chinese processor with a yield of 55% gives around 7,450kg CO_2 eq/per tonne.

The difference in yield accounts for around 600kg CO_2 eq/per tonne final product. For comparison, transporting back to the UK by marine transport generates emissions of under 200kg CO_2 eq/per tonne.

2. Case study approach

All product supply chains are complex, and the seafood industry is no exception. Quantifying and understanding the impacts of GHG emissions in any industry require boundaries around estimates.

Our research took a case study approach. This focused on several supply chains considered to be sufficiently important and representative of the diverse character of the UK seafood industry activity. The energy consumption associated with activities (acquiring raw materials, mode of transport, etc) along each of the supply chains was estimated; this allowed us to estimate GHG emissions. We defined the supply chain as being from point of origin (fishery or farm) to UK processor and in most instances to distribution or retail. We did not include activity of the retailer or the consumer in our estimates. We included UK chicken as a specific product chain to allow comparison with another major protein.

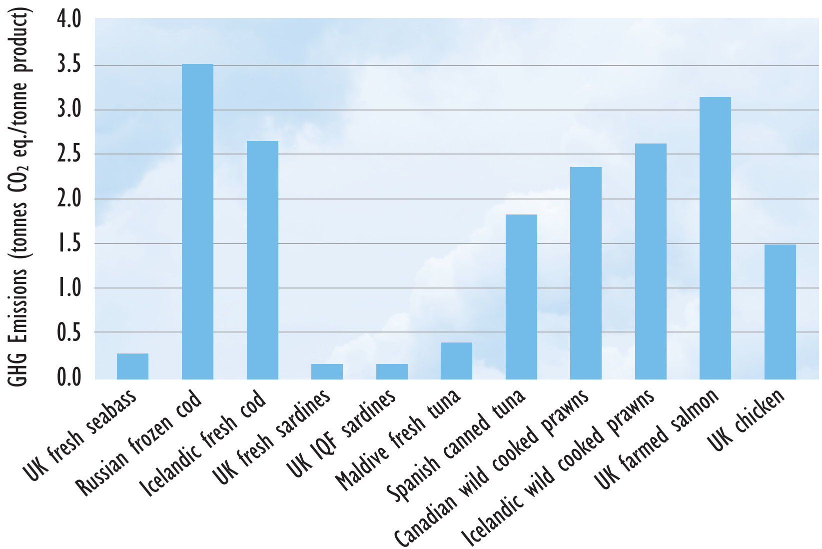
In each case, a life-cycle approach was adopted to estimate the associated GHG emissions. Further details of the methodology can be found in the annex at the end of this document. The following provides an overview of our research findings.

The following four figures show the GHG emissions associated with primary production, transport and refrigeration in the case study supply chains. In order to show the differences between the chains under each emission source, we have not used a consistent scale for the GHG emission axis across all three figures. *This must be remembered when comparing emission source.*

- **Primary production**

Figure 1 shows GHG emissions associated with primary production. The majority of emissions result from the primary resource production phase of the chain, either from direct fuel inputs to fisheries, or from the provision of feed in the case of farmed salmon production.

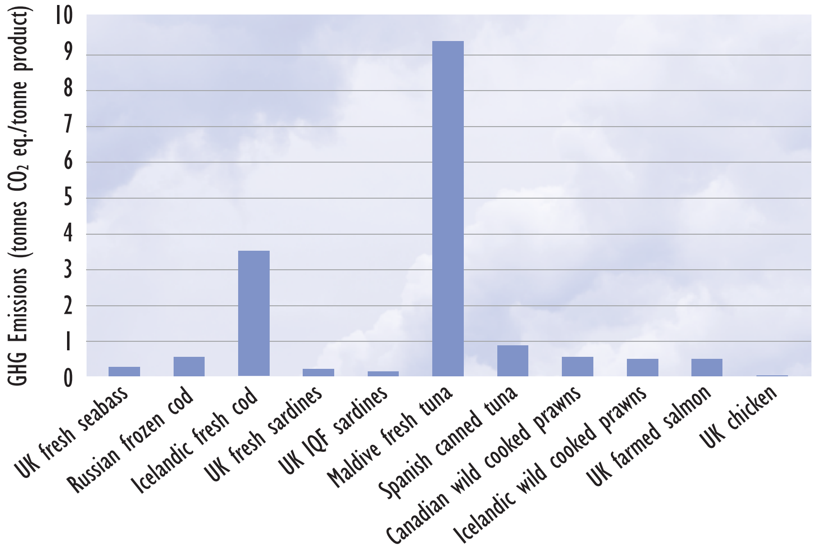
Figure 1. GHG emissions associated with primary production



- **Transport in the supply chain**

Figure 2 shows the GHG emissions associated with transport in the supply chain. In the two supply chains reliant on air freight (fresh tuna fillets from the Maldives and fresh Icelandic cod fillets), transportation-related GHG emissions dominate total supply chain emissions.

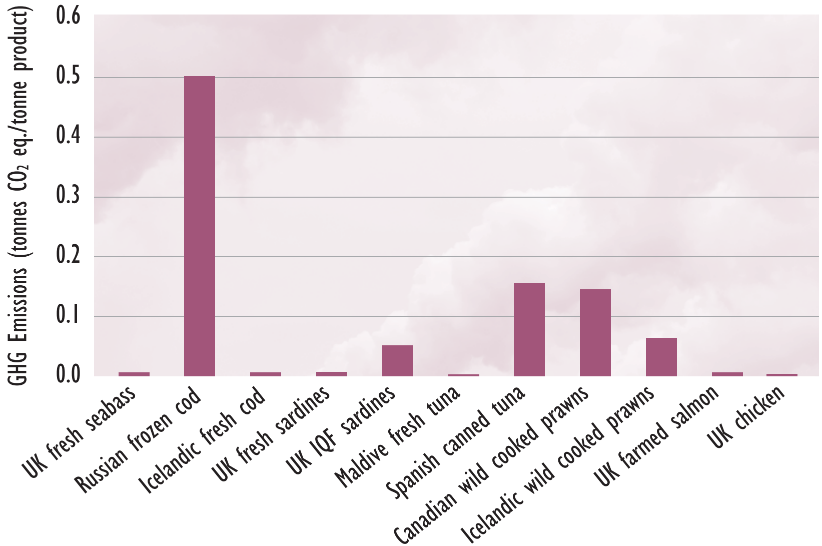
Figure 2. GHG emissions associated with transport



- **Refrigeration in the supply chain**

Figure 3 shows GHG emissions associated with refrigeration in the supply chain. We can see that the frozen cod chain has the highest levels of refrigeration-related GHG emissions, as would be expected. Those chains with fresh fish have very minimal refrigeration-related GHG emissions, however, these may be offset by higher transport-related emissions to ensure the product is delivered to the consumer fresh.

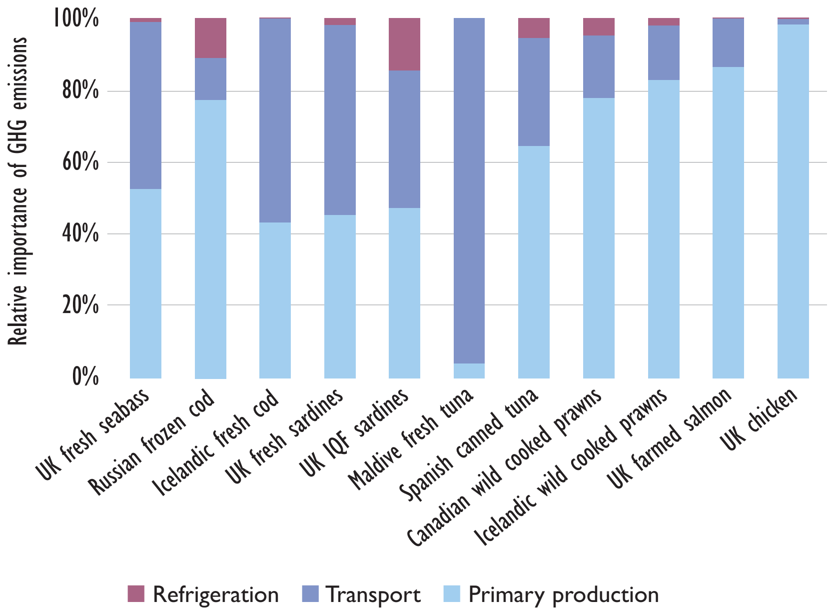
Figure 3. GHG emissions associated with refrigeration



- **Catching, transport and refrigeration**

Figure 4 shows the relative importance of catching, transport and refrigeration for each case study supply chain. Interestingly, and rather unexpectedly, transport-related emissions were also important in three products (fresh sea bass and fresh and frozen sardines) derived from local UK fisheries, not just for those chains involving air freight. The relative importance of these transportation emissions in these chains, however, is more a function of the unusually small emissions that result from the associated fisheries than of inherently large transport emissions.

Figure 4. Relative importance of catching, transport and refrigeration emissions



Annex

Study methods

1. Product supply chains

Table 1 provides an overview of the product supply chains covered by this research. Emissions associated with other product chains not considered in this report may be addressed in future studies (either by processing companies or by Seafish).

Table 1. Overview of all case study

Main species	Source waters	Capture method/process/form
Whitefish – sea bass	Local (UK)	Handline caught, fresh whole fish.
Whitefish – cod	Barents Sea (Russia)	Freezer trawler caught, frozen fillets processed in China.
Whitefish – cod	Icelandic	Longline caught, fresh fillets air freighted from Iceland.
Pelagic – sardine	Local (UK)	Ring net caught, fresh.
Pelagic – sardine	Local (UK)	Ring net caught, IQF.
Exotic – tuna	Indian Ocean	Line caught, fresh loins air freighted from Maldives.
Exotic – tuna	Various	Purse seine caught, canned in Spain.
Coldwater prawn	Atlantic Canadian	Trawl caught, cooked, double frozen, processed in Iceland.
Coldwater prawn	Icelandic	Trawl caught, cooked, single frozen, processed in Iceland.
Salmon	Local (UK)	Farmed, fresh fillets.

Seafood processing companies were approached as the main industry contacts because of their ability to leverage data along product supply chains.

A simple flow chart was designed to assist processors in providing a broad overview of the product supply chains.

For most product chains of interest, companies were asked, either by telephone interview or email, to provide data regarding their product supply chains using the simple flow charts as a starting point. These data were used to populate product chain-specific GHG emission calculators. Companies were then re-contacted for additional information or clarification where gaps or contradictions were identified.

In the case of some product chains, key data were not available through processors.

2. Production chain calculator

An Excel spreadsheet-based 'calculator' was developed to organise data and facilitate the estimation of GHG emissions associated with various steps in each product chain.

Elements common to all product chain calculators included:

- fields describing basic product characteristics including:
    - sources;
    - modes of production and transport;
    - yield rates of intermediate and final products, and destinations of associated processing co-products; and
    - intermediate and final product forms.
- fields for quantifying GHG emissions associated with key steps in the production chain, including those associated with:
    - capture or culture of raw materials;
    - pre and post processing transport of materials by various modes (eg truck, ship, air freight);
    - refrigeration throughout the product chain; and
    - non-refrigeration related processing and packaging activities.

3. 'Life-cycle GHG' emissions

In order to best reflect total 'life-cycle' GHG emissions and standardise activity-specific emissions throughout the product calculators, emission intensities for various generic activities including:

- production and combustion of diesel, gasoline, natural gas, etc;
- transport via three sizes of truck (3.6 tonne delivery vans, 16 tonne lorries and tractor trailers), ocean freighter, and air freight (both short haul and long haul);
- freezing (via both plate and blast freezing technologies); and
- refrigeration in storage/buildings, on trucks and in containers.

were derived from various sources and applied, as appropriate, in each calculator. Where possible/appropriate, data reflecting contemporary European conditions were used.

4. Boats and gear

Due to the challenges inherent in acquiring real-world data regarding material and energy inputs and resulting emissions associated with building and maintaining fishing boats and providing fishing gear, etc, a simplifying assumption was employed in each product chain calculator that models a fishery derived product. In these cases, it was assumed that energy inputs to provide boats and gear would amount to 10% of the direct fuel energy inputs to the fishery. Furthermore, resulting emissions were conservatively estimated to be based entirely on the combustion of natural gas.

5. Calculating total GHG emissions associated with each product chain

To facilitate the calculation and comparison of total GHG emissions associated with each product chain, all emissions were quantified in terms of their CO_2 equivalents on the basis of their relative radiative forcing potential over a 100-year time horizon. Similarly, all inputs and resulting GHG emissions were quantified based on an output of one metric tonne of consumer-ready product, excluding the mass of any associated packaging materials, ice, etc. Consequently, for each product chain, results were expressed as kilograms of CO_2-equivalent GHG emissions per tonne of finished seafood product.

Currently, there is no set procedure for how we should report the final CO_2 equivalent emissions figures. The possible expressions are:

- per tonne of final product;
- per tonne liveweight;
- allocating emissions to all utilised co-products; and
- allocating emissions entirely to primary seafood products.

Here, we have expressed CO_2 equivalent emissions per tonne of final products excluding the emissions that can be attributed to utilised co-products.

6. Emission burdens assigned to co-products

The method by which emissions are assigned to co-products of processing activities (eg fillets vs. processing trimmings rendered for fishmeal and oil) can, in some cases, have an important impact on the results. The method we used was to consistently assign emission burdens up to the point of processing, to utilised co-products in proportion to the relative mass of the co-products involved. Emission burdens, however, were not assigned to true wastes destined for disposal, incineration, etc. This mass-based allocation rule is consistent with the carbon accounting practice recommended by the Carbon Trust in their preliminary assessment of emission accounting methods to use.

7. Carbon Footprint Measurement Methodology (CFMM)

Our methodology is largely consistent with the Carbon Footprint Measurement Methodology (CFMM) Version 1.3 recently published by the Carbon Trust (2007), including initial process mapping with key stakeholders, data collection and validation, and carbon footprint calculation per process stage. All CO_2 equivalents are calculated according to 100-year GWP using IPCC assessment methods. Our mass-based allocation approach adheres to ISO 14041 guidelines, as well as CFMM recommendations. Two departures from CFMM methodology that should be noted are:

1. We did not account for GHG emissions associated with packaging for all product forms, nor disposal-related emissions.
2. We included GHG emission estimates associated with the provision and maintenance of fishing vessels and gear.

References

[1] *Greenhouse gas emissions for selected seafood species supplied to UK processors.* Dr. P. Tyedmers, N. Pelletier, Dalhousie University and A. Garrett, S. Anton Seafish (2007).

[2] The Carbon Trust (www.carbontrust.co.uk) and the British Standards Institute (www.bsi-global.com/en) are currently working on a standard methodology, PAS 2050, for calculating CO_2-equivalent GHG emissions in products and services.

[3] Results are expressed as kilograms of CO_2-equivalent GHG emissions per tonne of finished seafood product. The data are not based on an assumption of full loads, half loads, etc but reflect typical or average activities for all of modes of transport over a year.

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