Towards Product Carbon Footprinting For Aquaculture Products

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- **Little is also involved in a consortium promoting decentralized fish seed strategies in Asia, research on the co-culture of sea cucumbers with shrimp in Thailand and *Pangasius* production in Vietnam and Bangladesh. He continues a long association with the Asian Institute of Technology through training and networking activities**

Overview

- Ethical food……ethical food from the water
- Relationships between product carbon footprinting (PCF) and Life Cycle Analysis (LCA)
- Assessing the environmental impact from “cradle to grave”
- Not just about climate change but many other factors too
- Factors that LCA cannot address
- Limitations of LCA for aquatic systems and food production
- Examples of LCA in aquaculture

Greener Living

- "With big brands such as Tesco taking action to reduce the carbon footprint of many of the products we buy every day, there's been a quiet kitchen revolution over the last three years"
  - Murray, 13th October 2010

‘A quiet kitchen revolution’

- average household spends >$100 a year on items bearing the footprint logo
- Manufacturers working with Carbon trust to measure the carbon footprint of products over last 3 years

Ethical Aquatic Products

- Is it ‘good’ for us?
- Is it ‘good’ for others?
- Is it ‘good’ for the fish or shrimp?

- Is it ‘good’ for the environment?

ETHICAL LIVING < FOCUS 21

Food is the new fur for the celebrity with a conscience

Actors, designers, pop stars have all got behind the hot new ethical campaign: food. From saving species to investigating conditions for pigs, star quality is pushing it to the foreground. **Jay Rayner** reports

Rayner, 2009

Environmental Concerns

- Pollution from the production system itself
- ‘point sources’ – nutrients leading to eutrophication-local impacts
  - Water quality..and other uses
  - Biodiversity..and other species

Photo Flavio Corsin

Going Global - The Last Decade

- Over the last decade climate change associated with Greenhouse Gas (GHG) emissions or Global warming Potential-$C0_2$ e
- Interconnectedness-e.g. PCBs in polar food chains
- Step-wise change in global trade in foods products
- Need for assessing global impacts

Ecological Footprint

- Impact of Man's activities on the broader environment
- Intensive food production utilises large areas for 'ecosystem support'
- e.g .intensive tilapia cage farming utilises 10,000 area for feed production (Kautsky et al, 1997)

Food Miles - Fair Miles Debate

- The rise of the ‘local’-‘importing food harms the environment ?
- Mainly affecting fresh rather than frozen product
- Engagement with LDCs through food-growing development impacts
- Per capita carbon emissions-’ecological space’
- Not buying fresh vegetables and flowers in UK would reduce emissions by <0.1%
- Is it *really* ‘local’ - feeds from afar…….
- Most emissions associated with *production* rather than *transportation*

Food Production and GHG Emissions

- Increased GHG linked to climate change
- 18% of global GHG (Steinfeldt et al (2006)
- 29% of all GHG emissions in EU are 'food related' (EIPRO, 2006)-based on food consumed in EU
- Product carbon foot-prints (PCFs) for food can reduce impacts?

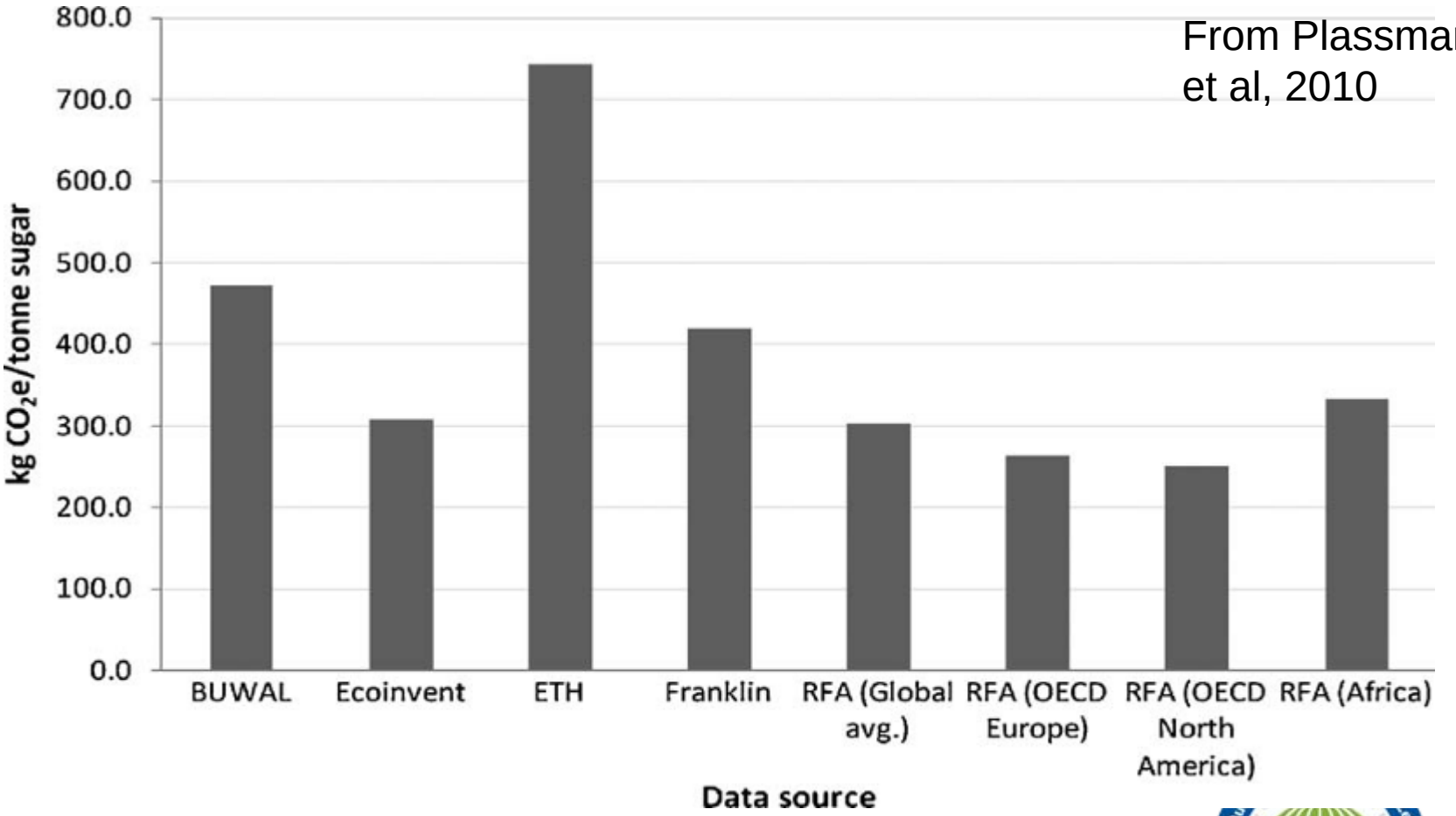
Concerns

- Development of PCFs faster than knowledge about measurement and interpretation of GHG
- Especially the case for a*griculture* and for *developing countries*
- Fears of trade restrictions
- Accounting for *other* types of environmental impacts-Life Cycle Analysis (LCA)

Constraints

- Needs of PCFS not fully met by LCA standards (ISO, 2006) or those of WRI
- Currently little comparability as too flexible- need international standards
- But already 13 different accounting systems driven by 'green' businesses have emerged (Plassman et al, 2010)
- Driven by dominant supermarket chains

Variation in different datasets for GHG emissions in kg $C0_2e$ per tonne of sugar transported 2000km by road in 16MT truck



From Plassman et al, 2010

Key Issues for Aquaculture

- Land use change; cleared natural vegetation or converted from agricultural use
- Soil carbon
- Incomplete data sets, especially smallholder farms

Moving to Life Cycle Analysis

- Assessment of GHG alone presents only a partial picture
- Reducing GHG may increase other environmental problems

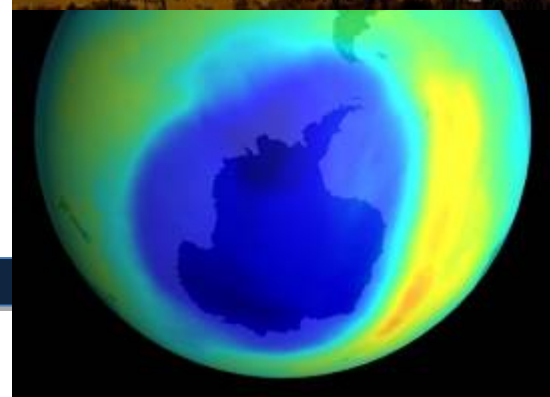
Basics of LCA

- LCA - developed for assessing the environmental impact of producing industrial goods or services over the **entire life cycle**
- Impacts from:
  - extraction of raw materials,
  - the manufacturing process,
  - consumption
  - and final disposal of the waste
  - “cradle to grave”
- Standardised by ISO 14000 and subsequent amendments
- Standards outline boundary setting and allocation of burdens to processes
- Analyses are performed using specialist LCA software

LCA Criteria

- LCA compares the impacts over several criteria but does not have to include them all:
  - Global warming potential
  - Acidification potential
  - Eutrophication potential
  - Photochemical oxidant formation
  - Aquatic/terrestrial ecotoxicity
  - Human toxicity potential
  - Energy use
  - Abiotic resource use
  - Biotic resource use
  - Ozone depletion
- These criteria are cited by Pelletier *et al* (2007) as being the most relevant for seafood production but others have been used.



Factors That LCA Cannot Assess

- Does not easily measure changes in biodiversity
- Destruction of sensitive habitats-e.g. seabed
- Various sensitivities of natural resources
- No socio-economic or other demographic factors
- Working environment-occupational health issues for fisheries and aquaculture
- Social and economic impacts on surrounding communities
- Water –use and consumption
- Contaminants e.g. anti-foulants
- Aquatic animal welfare issues

Other LCA Limitations

- LCA must be used in conjunction with other tools to get the full picture of sustainability
- Should be subject to sensitivity analysis which measures changes to the scenario e.g. if electricity is from renewable sources compared to fossil fuels
- However, LCAs should be generalisable and comparable, wherever their location, to be of true value
- Some LCA impacts are taken from databases which may be context specific and/or may have changed over time

Comparing Products Using LCA

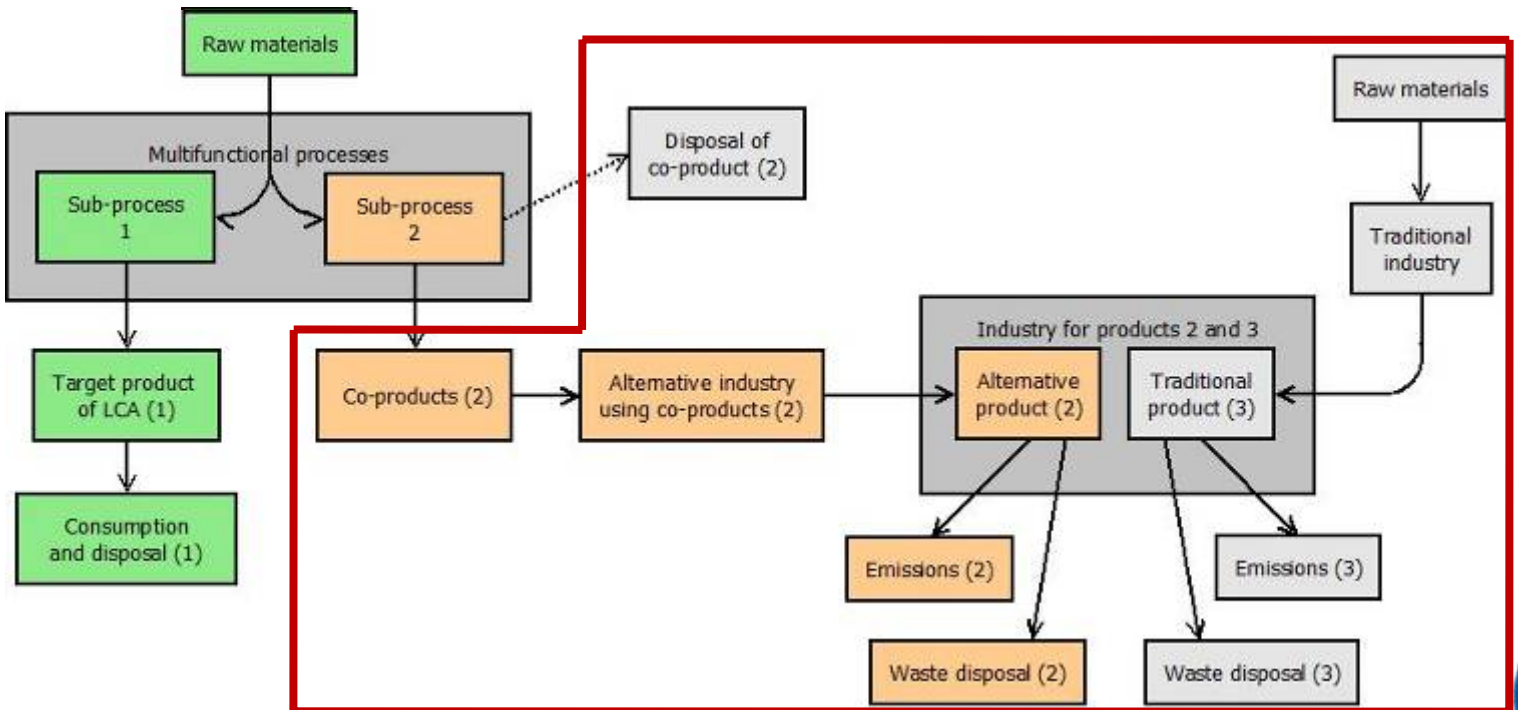
- Centres around the impact of producing a certain amount of a product, the functional unit, FU.
- For food production, the FU may be:
  - A fillet of certain weight. e.g. Compare 500g of chicken or 500g of fish fillets
  - A certain amount of protein, energy or other nutrient (uncommon). e.g. compare producing 100g of protein from a vegetarian diet compared to one containing meat
- **Choices made for comparability**

LCA And Recycling Or By-product Use

- FU for recycling industries?
- “Cradle or grave” when recycling?
- Boundary setting in LCA
- Co-product allocation of impact
- Can measure the alternative uses of all products and co-products (system expansion) but is very unwieldy
- Significant disagreements in approaches despite ISO standards
- Need clear methodology and transparency

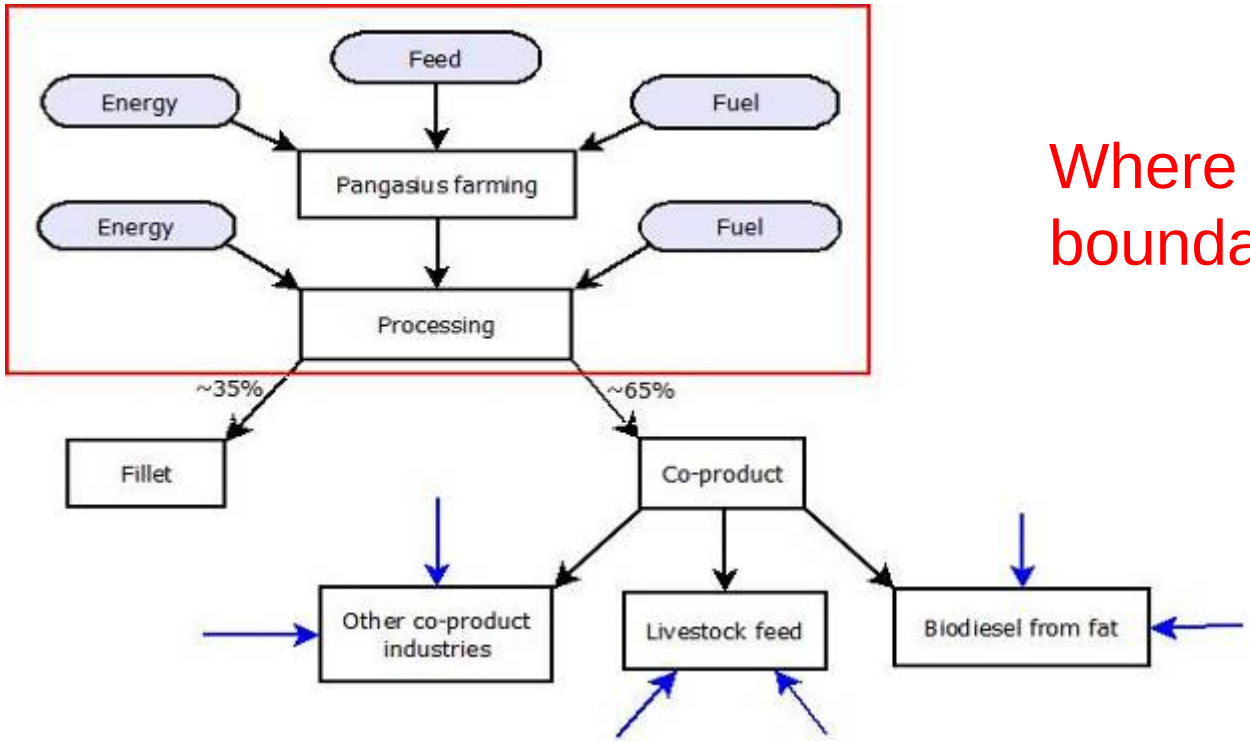
Allocation And System Expansion

- Many LCAs are simple processes
- Some LCAs compare using co-product in other industries vs. traditional production, e.g. feeds
- Allocation assesses the impact that can be attributed to the co-product from the original production process based on mass, energy or economic value



Adapted from Ekvall *et a* 2001

Allocation and Boundary Setting



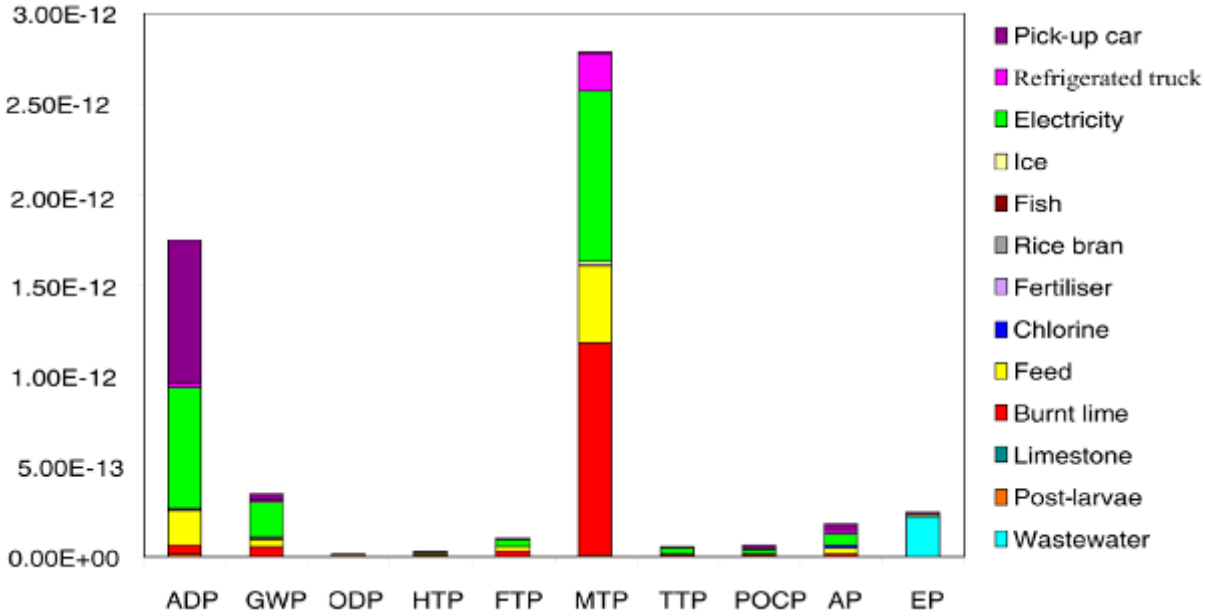
Where should the boundary be set?

- Allocation can imply that the co-product is the purpose of the original process and neglects the target product
- Allocation often fails to include that the alternative to using co-products is their disposal
- The way in which boundaries are set and allocation choices are made can affect the LCA outcome enormously

Hot Spots Of Shrimp Aquaculture

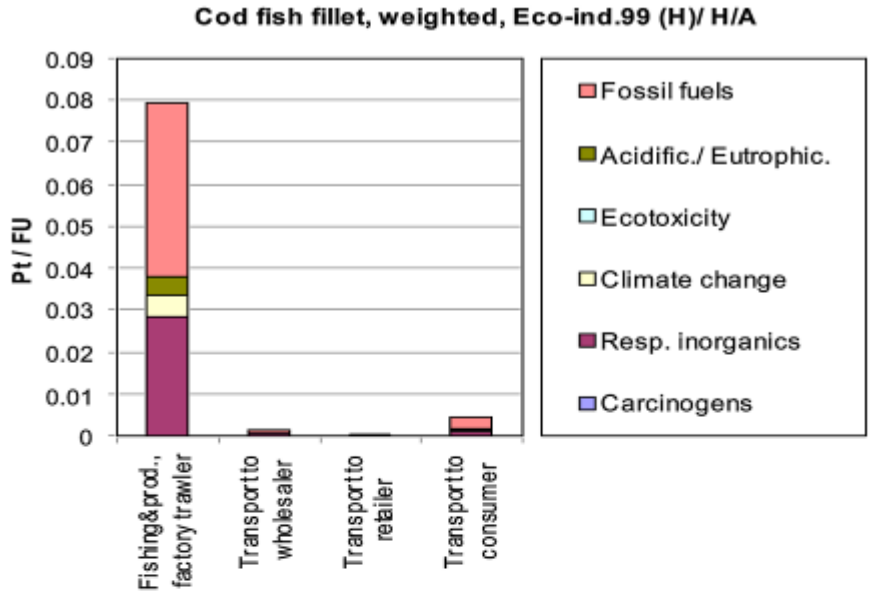
Taken from Mungkung *et al*, 2006; Potentials and Limitations of Life Cycle Assessment in Setting Ecolabelling Criteria: A Case Study of Thai Shrimp Aquaculture Product

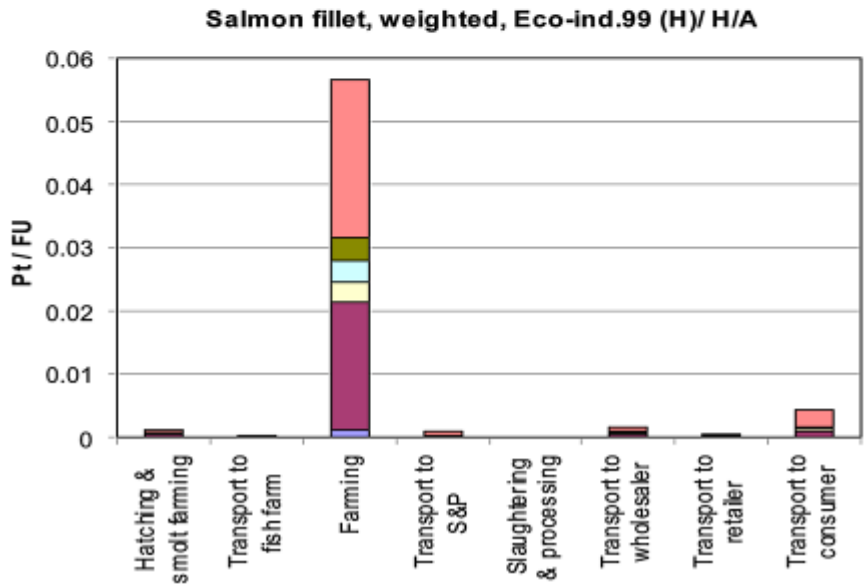
1.8 kg frozen shrimp block



- Impacts assessed for major stages and inputs in the production
- Allows simple snapshot LCA of "hot spots" with no comparisons or sensitivity analysis
- **Global warming potential (GWP)** and **eutrophication potential (EP)** are small compared to **Abiotic Depletion Potential (ADP)** and **Marine Toxicity Potential (MTP)**
- To significantly reduce impact, should use electricity more efficiently and find alternatives for burnt lime.

Comparing aquaculture systems with fishing and terrestrial livestock





Ellingsen and Aanondsen 2006

Comparing Aquaculture Systems With Livestock

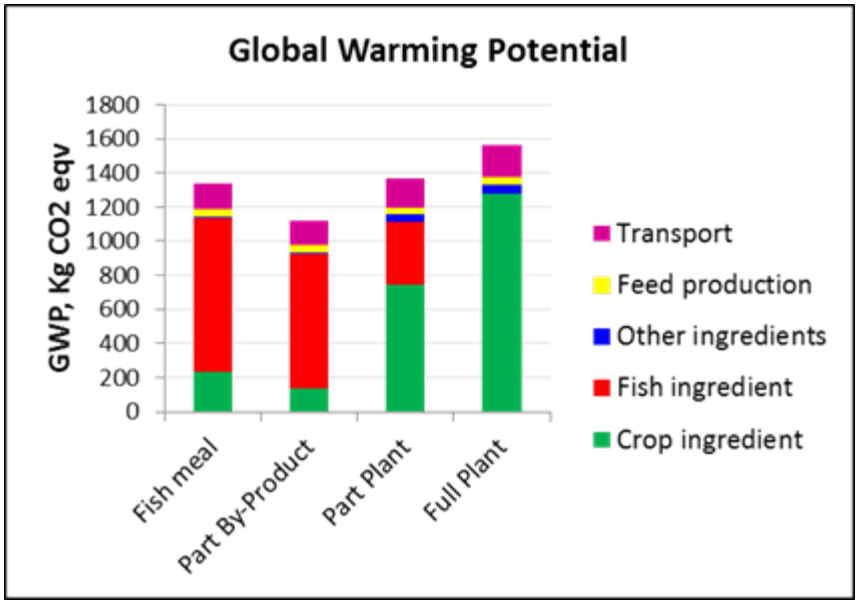
Type	Kg CO_2 e kg edible product^{-1}
Beef	16-40[a]
Milk	0.8-1.4[a]
Pork	3-6 [a]
Chicken	1.5-7[a]
Salmon	2.7-5.2 [b]
Tilapia	2-2.5 [c]

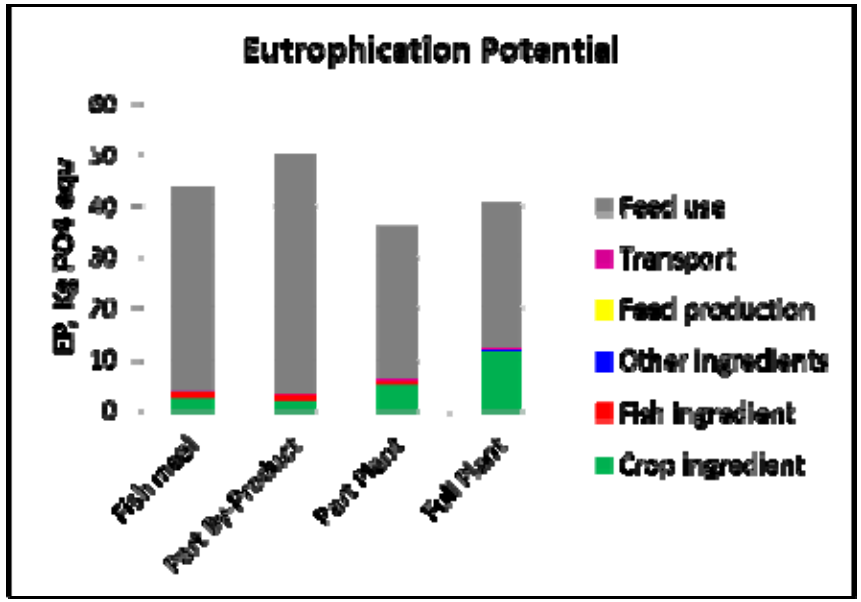
[a]Sonesson eta l, 2009
[b]Pelletier et al, 2009; Ellingsen and Aanondesen,2006
[c]Pelletier and Tydemyers, 2010

A Common Problem:
Reducing Feed Related GHGs

- Mainly related to agricultural rather than transportation or processing phases
- Field-level nitrous oxides and nitrates dominate GHG, acidifying and eutrophying emissions
- Production of fertilisers, especially nitrogen important in GHG, energy use and ozone depleting emissions
- Organic feed ingredients? Or more efficient use fertilisers

Impacts of salmonid herbivorous diets





- LCA is useful for showing trade-offs, e.g. GWP vs EP
- Changing diets may not effect global warming in some circumstances but other factors?
- Results may be very different if other boundary and allocation choices were made.

Diets: **1)** Commercial 100% FM **2)** 50% FM, 50% fishery BP **3)** 25% FM, 75% Plant **4)** 100% plant protein and oil

Papatryphon *et al* 2004

Reducing Animal Derived Ingredients?

- Increasing range of animal source ingredients
- Some analyses indicate they impact disproportionately despite low inclusion rates…but
- Impacts on expansion and intensification of arable crops

The Way Forward

- Improving feed efficiency without increasing animal source products (amino acid supplementation)
- Integration into broader food production systems-integrated use of water and nutrients – allows co-allocation of impacts
- Local feeds
- Improving productivity and % edible product

Pangasius - Intrinsic Advantages

- Omnivorous
- Air breathing, so very high stocking densities possible without aeration
- Potentially able to reuse nutrients locally - locate to reuse effluent for crops
- Processing co-products reused locally (net producer of ‘fishmeal’?)
- Need for selective breeding for higher % fillet

Summary

- Environment related ethical concerns are driving rapid adoption of Product Carbon Foot-Printing without sufficient concern for comparability and interpretation
- Carbon footprints illustrate life cycle emissions of greenhouse gases and potential climate change, but give an incomplete and often misleading picture of overall environmental impacts

Lcas Give A More Complete Picture But….

- Boundary setting and allocation choices need to be well thought out and argued
- Impacts may vary according to location because of various underlying local conditions and differences in supply of resources and services
- Are often not comparable or generalisable
- Are unable to contextualise impacts in some circumstances
- Need to be complimented with other sustainability assessment tools

Sustaining Ethical Aquaculture Trade (SEAT)

- **The EU-FP7 funded SEAT Project will perform LCAs on tilapia, pangasius, shrimp and prawn in 4 countries and their EU trade**
- **We will also try to address some of the other issues raised here concerning different approaches to LCA and better procedures for aquaculture production and by-product use.**