Comparing sustainability credentials for aquafeed ingredients using Life Cycle Assessment

Dave Little

Institute of Aquaculture
UNIVERSITY of STIRLING

BE THE DIFFERENCE

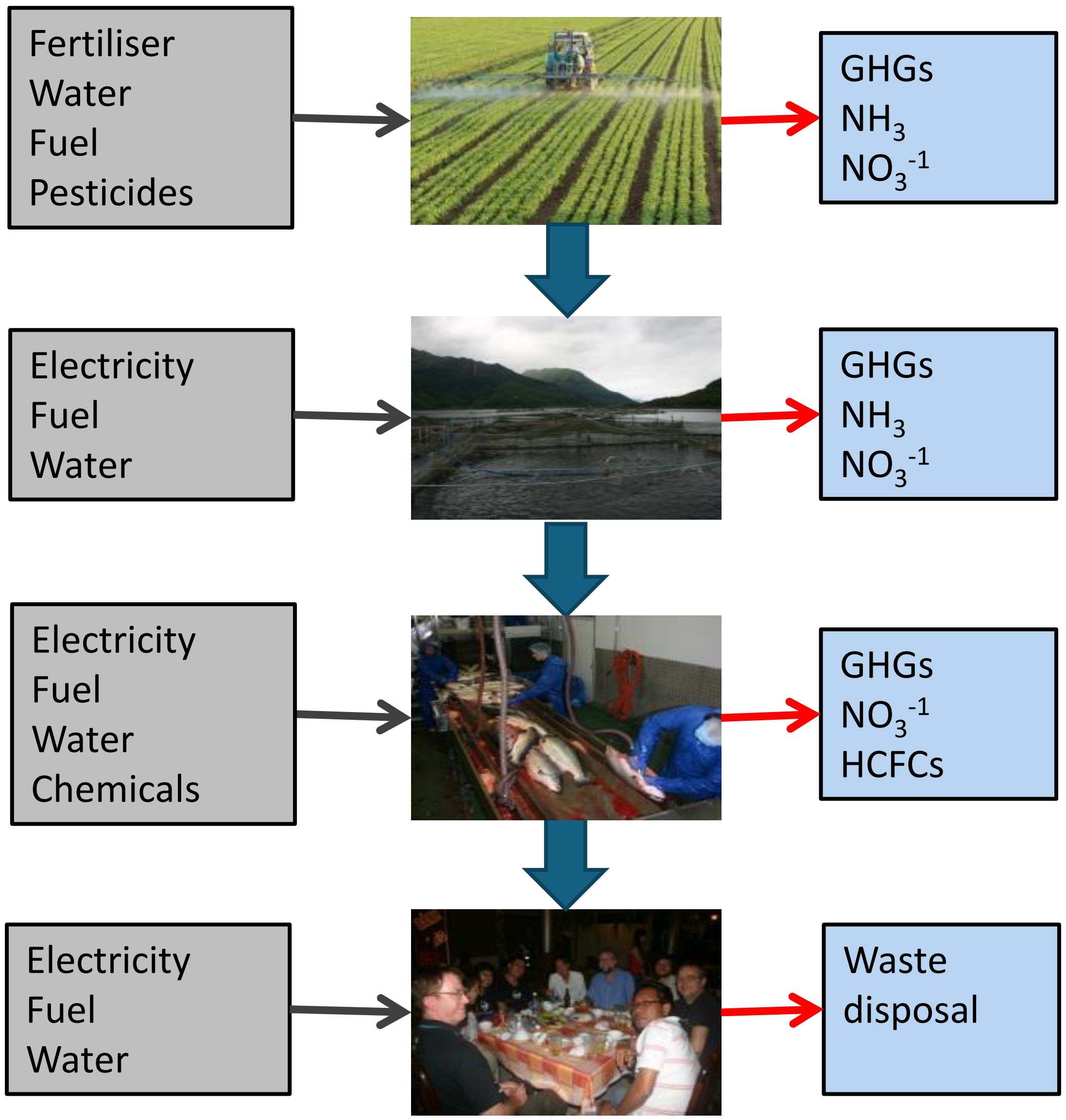
Life Cycle Assessment – why?

Label	Name	Value	Unit	Uncertainty
[E10]	NMVOC, non-methane volatile organic co	0.00012	kg	L(0.206)
[E11]	Carbon dioxide, fossil[air]	0.19	kg	L(0.0345)
[E12]	Ammonia[air]	2.61E-5	kg	L(0.108)
[E13]	Nitrogen oxides[air]	5.13E-5	kg	L(0.206)
[E14]	Particulates, < 2.5 um[air]	8.48E-6	kg	L(0.554)
[E15]	Particulates, > 10 um[air]	7.81E-5	kg	L(0.215)
[E16]	Particulates, > 2.5 um, and < 10um[air]	1.35E-5	kg	L(0.354)
[E17]	Zinc, ion[fresh water]	2.7E-7	kg	L(0.864)
[E18]	Lead[fresh water]	3.93E-9	kg	L(0.864)
[E19]	Nickel, ion[fresh water]	1.23E-9	kg	L(0.864)
[E21]	Copper, ion[fresh water]	6.39E-9	kg	L(0.633)
[E22]	Chromium, ion[fresh water]	4.55E-10	kg	L(0.633)
[E23]	Cadmium, ion[fresh water]	9.55E-11	kg	L(0.633)
[E42]	Carbon monoxide, fossil[air]	0.000984	kg	L(0.806)
[E44]	Dinitrogen monoxide[air]	2.66E-6	kg	L(0.211)
[E57]	Methane, fossil[air]	5.42E-6	kg	L(0.206)
[E64]	Sulfur dioxide[air]	6.03E-6	kg	L(0.0588)
[E67]	Toluene[air]	1.05E-5	kg	L(0.206)
[E153]	Benzene[air]	7.28E-6	kg	L(0.206)
[E206]	Cadmium[air]	1.33E-9	kg	L(0.845)
[E207]	Chromium[air]	9.57E-9	kg	L(0.845)
[E208]	Copper[air]	1.14E-7	kg	L(0.845)
[E209]	Nickel[air]	1.01E-8	kg	L(0.845)

Label	Name	Value	Unit	Uncertainty
[E10]	NMVOC, non-methane volatile organic co	0.00013	kg	L(0.206)
[E11]	Carbon dioxide, fossil[air]	0.175	kg	L(0.0345)
[E12]	Ammonia[air]	1E-6	kg	L(0.108)
[E13]	Nitrogen oxides[air]	0.000518	kg	L(0.206)
[E14]	Particulates, < 2.5 um[air]	3.71E-5	kg	L(0.554)
[E15]	Particulates, > 10 um[air]	7.93E-5	kg	L(0.215)
[E16]	Particulates, > 2.5 um, and < 10um[air]	1.59E-5	kg	L(0.354)
[E17]	Zinc, ion[fresh water]	2.7E-7	kg	L(0.864)
[E18]	Lead[fresh water]	3.93E-9	kg	L(0.864)
[E19]	Nickel, ion[fresh water]	1.23E-9	kg	L(0.864)
[E21]	Copper, ion[fresh water]	6.39E-9	kg	L(0.633)
[E22]	Chromium, ion[fresh water]	4.55E-10	kg	L(0.633)
[E23]	Cadmium, ion[fresh water]	9.55E-11	kg	L(0.633)
[E42]	Carbon monoxide, fossil[air]	0.00061	kg	L(0.806)
[E44]	Dinitrogen monoxide[air]	5.61E-6	kg	L(0.211)
[E57]	Methane, fossil[air]	3.28E-6	kg	L(0.206)
[E64]	Sulfur dioxide[air]	5.55E-6	kg	L(0.0588)
[E67]	Toluene[air]	4.38E-7	kg	L(0.206)
[E153]	Benzene[air]	1.81E-6	kg	L(0.206)
[E206]	Cadmium[air]	1.28E-9	kg	L(0.845)
[E207]	Chromium[air]	9.33E-9	kg	L(0.845)
[E208]	Copper[air]	1.05E-7	kg	L(0.845)
[E209]	Nickel[air]	9.71E-9	kg	L(0.845)

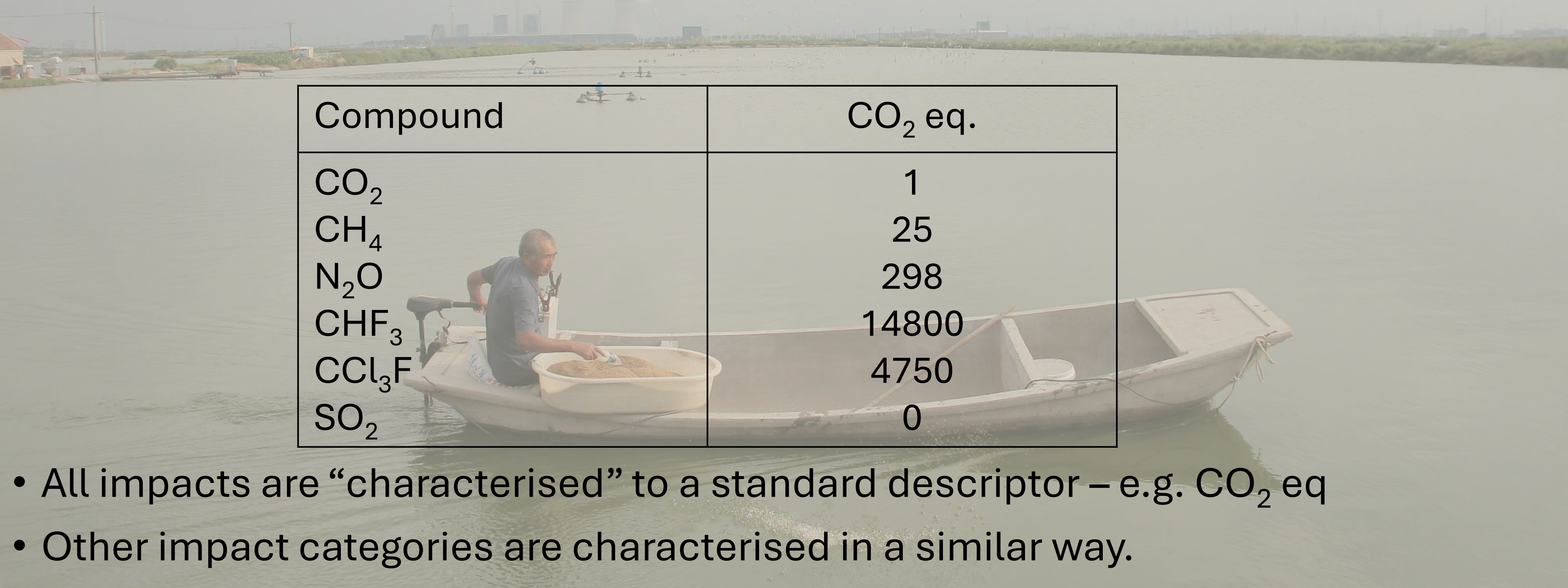
Life cycle approach to impact assessment - LCA

- Environmental impacts do not just occur on the production unit
  - Feed ingredients
  - Feed processing
  - On farm production
  - Processing
  - Distribution
  - Consumption
  - Waste disposal
- All require land, water, raw materials and energy, and can lead to harmful emissions



Characterisation

- How do we make sense of the long list of emissions?
- Characterisation to reference compound e.g. Global Warming Potential (GWP)



Compound	CO_2 eq.
CO_2	1
CH_4	25
N_2O	298
CHF_3	14800
CCl_3F	4750
SO_2	0

- All impacts are “characterised” to a standard descriptor – e.g. CO_2 eq
- Other impact categories are characterised in a similar way.

LCA impact categories – Carbon Footprint and much more!

- Global Warming Potential (carbon footprint)

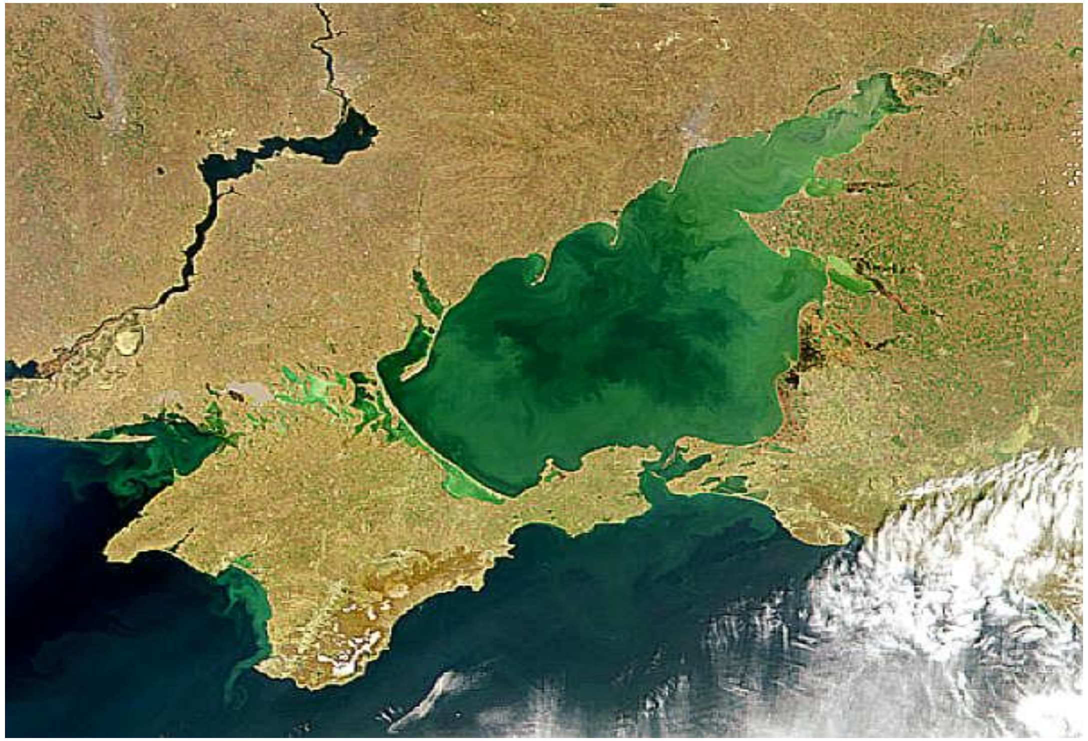
LCA impact categories

- Acidification Potential

https://commons.wikimedia.org/wiki/File:Silberwald_NationalparkHarz.jpg

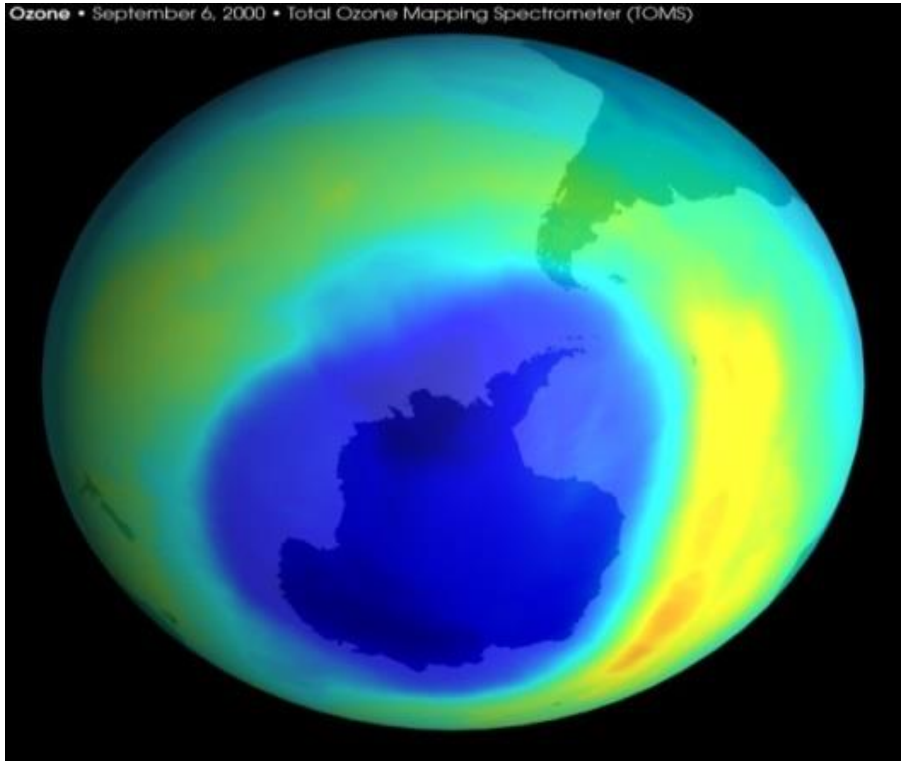
LCA impact categories

- Eutrophication Potential



LCA impact categories

- Ozone Depletion Potential



LCA impact categories

- Typically:
  - Global warming potential
  - Acidification potential
  - Eutrophication potential
  - Photochemical oxidant formation
  - Aquatic/terrestrial/human toxicity potential
  - Cumulative energy use
  - Abiotic resource use
  - Ozone depletion potential
  - Biotic resource use
  - Consumptive water use
  - Land use
  - Novel categories? E.g. Fish In Fish Out ratio
  - Socio-economic indicators too?

  - Provides comprehensive assessment of global impact and avoids trade-offs

Institute of Aquaculture

BE THE DIFFERENCE

Functional unit

- LCA measures and compares the **function** of different products and services
- The difference between a standard light bulb (SLB) and an energy saving light bulb (ESLB).

- Manufacturing impact of ESLB is higher
- Energy use is much lower
- Life time is much longer

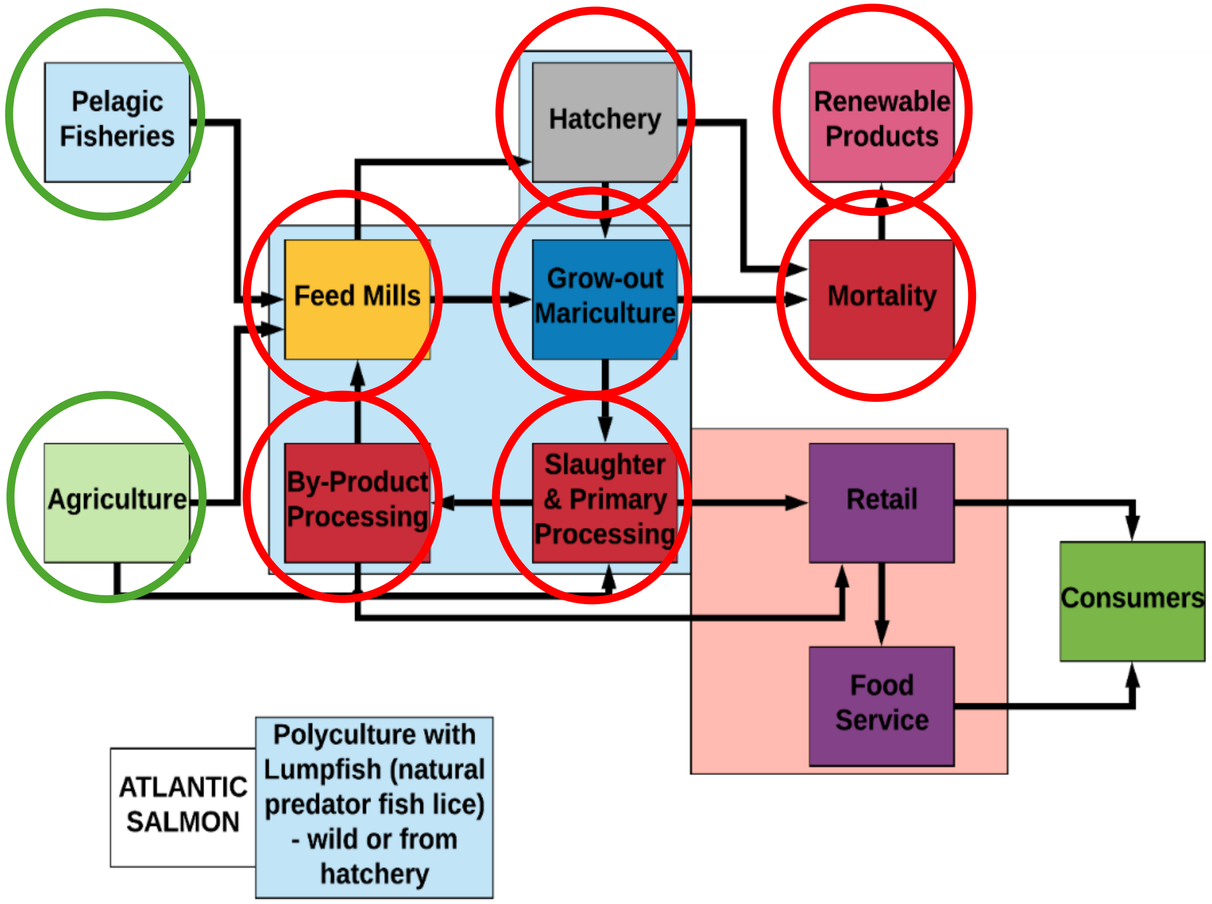
- Disposal (end-of-life) concerns around ESLB - mercury

What are we measuring? - Functional unit (FU)

- LCA measures the "function" of products
- E.g. Plastic disposable vs. ceramic mug
- Ceramic mug manufacture uses a lot more resources than a plastic cup but is used many more times
- How many uses before it breaks?
- Vessel manufacture
- Disposal/recycling of plastic…
- Washing of ceramic
    - Energy, water, detergents
- FU = 1000 cups of coffee in either ceramic or plastic cups?
- FU choice depends on goal of study

LCA – where does the data come from?? Considerations….

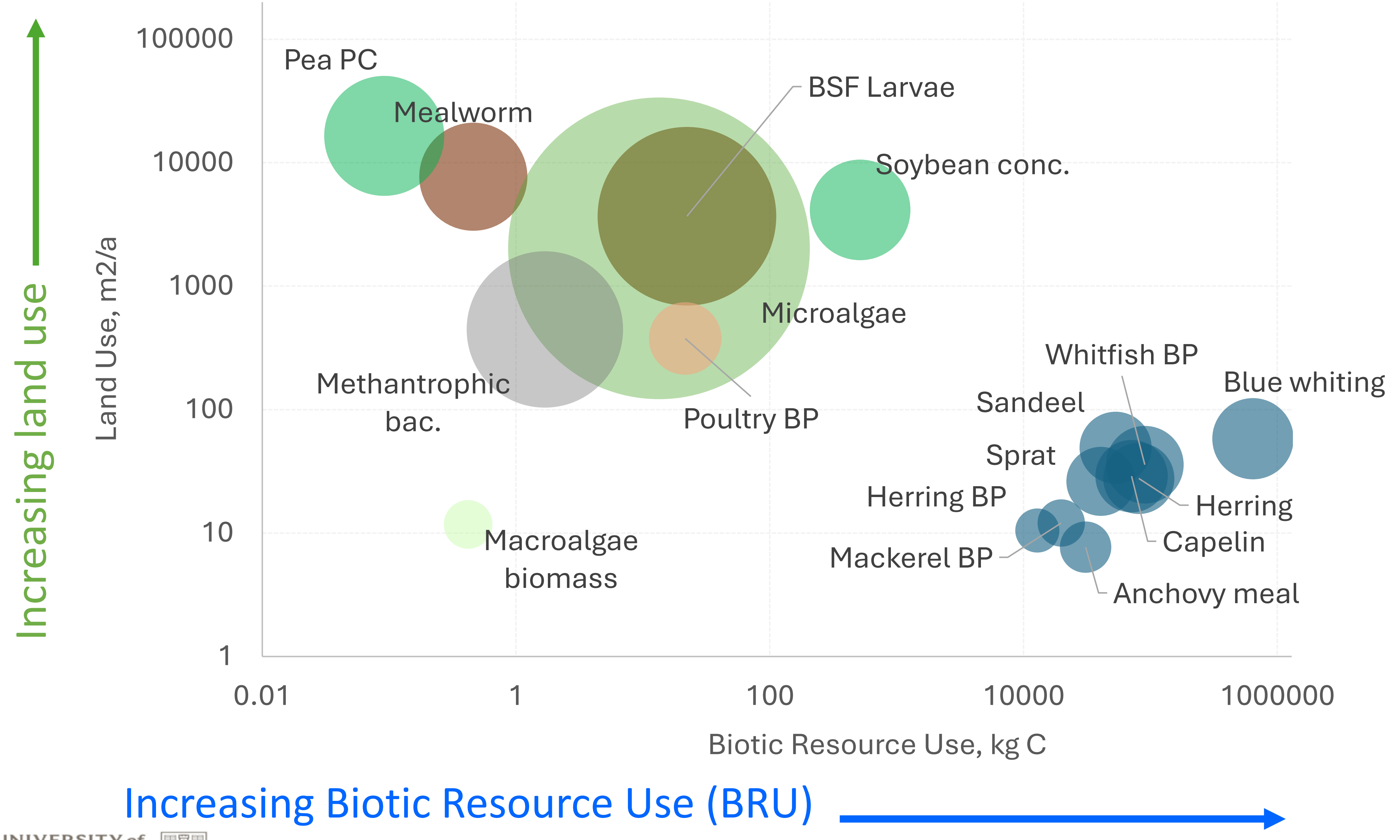
- What is the boundary of the study?
  - The value chain up to processing?
- What is the "functional unit"?
  - Processed products at the processor gate?
- Where is the data coming from at each point in the study?
  - Surveys (primary)
  - Literature (secondary)
  - Database (background)



UNIVERSITY of STIRLING

BE THE DIFFERENCE

Marine ingredients sustainability trade-offs



Land Use, Biotic Resource Use and Global Warming Potential (bubble size) major feed ingredient (1 tonne production)

Bubble size: increasing carbon footprint

BE THE DIFFERENCE

UNIVERSITY of STIRLING

Local contextualisation?

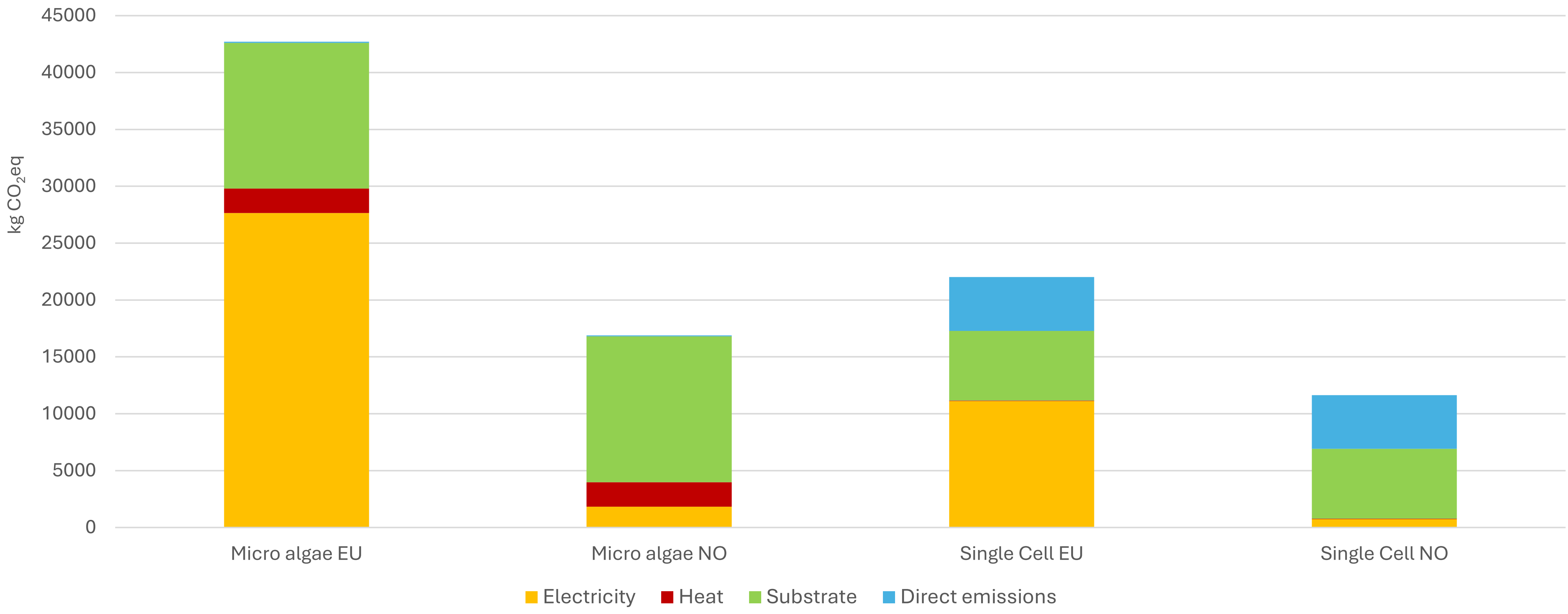
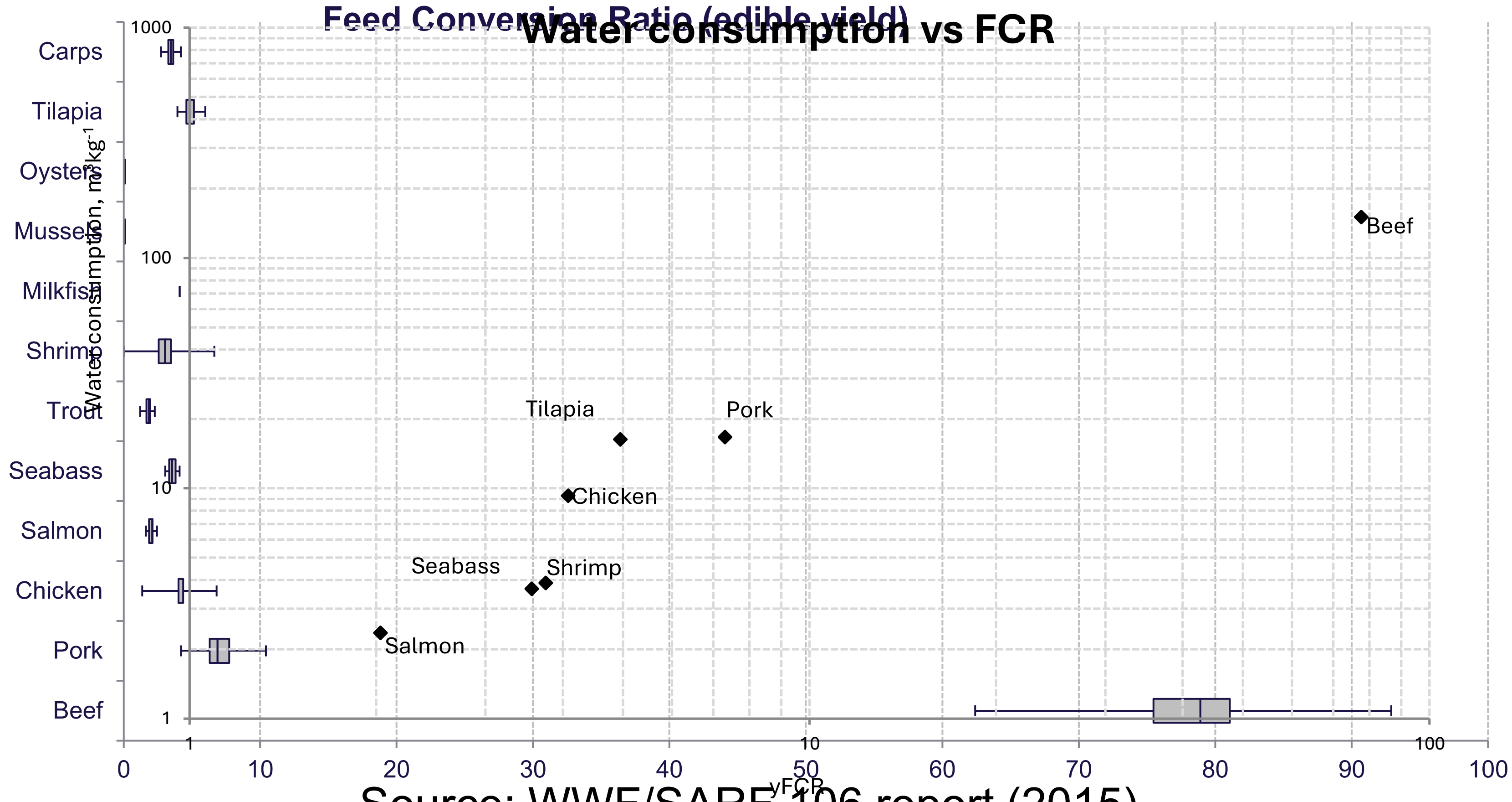


Figure 8.41 Comparative GWP impacts from single cell bacteria protein and microalgae oil produced with EU average electricity mix and Norwegian energy mix.

Livestock and feed

- Feed is the biggest operating cost to production
- Efficient use is critical to reducing overall environmental impacts
- Beef is highest but nutritional value of feeds and products differ

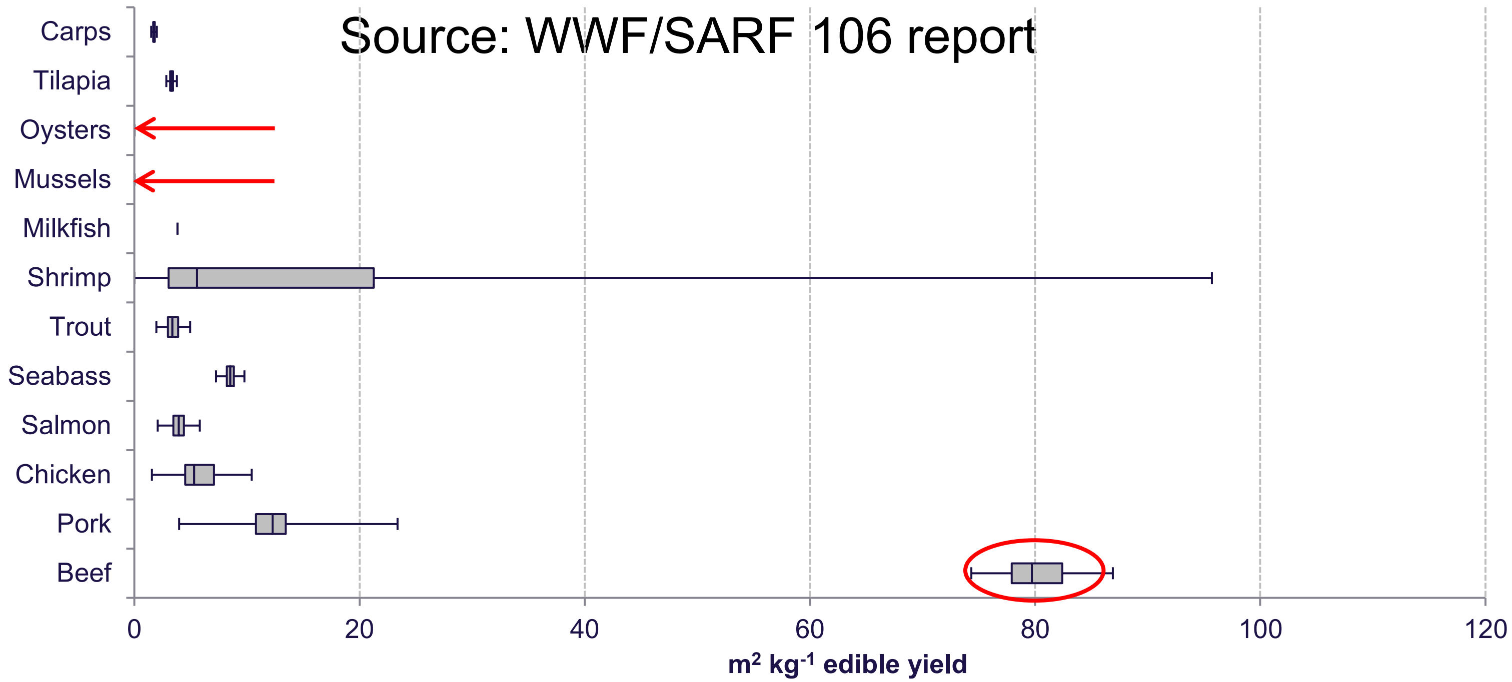


Source: WWF/SARF 106 report (2015)

Livestock and land

- Feed carries most impact
- Land use largely reflect FCRs
- Shrimp have a huge range of systems intensity

Source: WWF/SARF 106 report



Contested but increasingly mainstream……

Outdated Data Relies on lab-scale studies and overlooks recent industrial LCA updates.

No Industry Consultation UK producers weren't engaged, and as a result, key insights were missed.

Skewed Comparisons: Modelling used for conventional proteins downplayed environmental impact, whilst assumptions made for insect protein inflated it

Waste Valorisation Ignored: The LCA overlooks insect farming's role in tackling food waste and instead assumes that insects are fed a "traditional feed" of wheat.

Policy Impact at Risk: Misleading assumptions across the LCA hinder sustainable feed innovation.

ALL ABOUT FEED   Feed   The industry   Mark

Life Cycle Analysis of insect protein criticised by trade sector

09:00 | New proteins | News

- Thanks to Richard Newton, other colleagues at the Institute of Aquaculture and its start-up Blue Food Performance for support preparing this presentation