INRA
Institut National de la Recherche Agronomique

The development of Life Cycle Assessment for the Evaluation of Rainbow Trout Farming in France

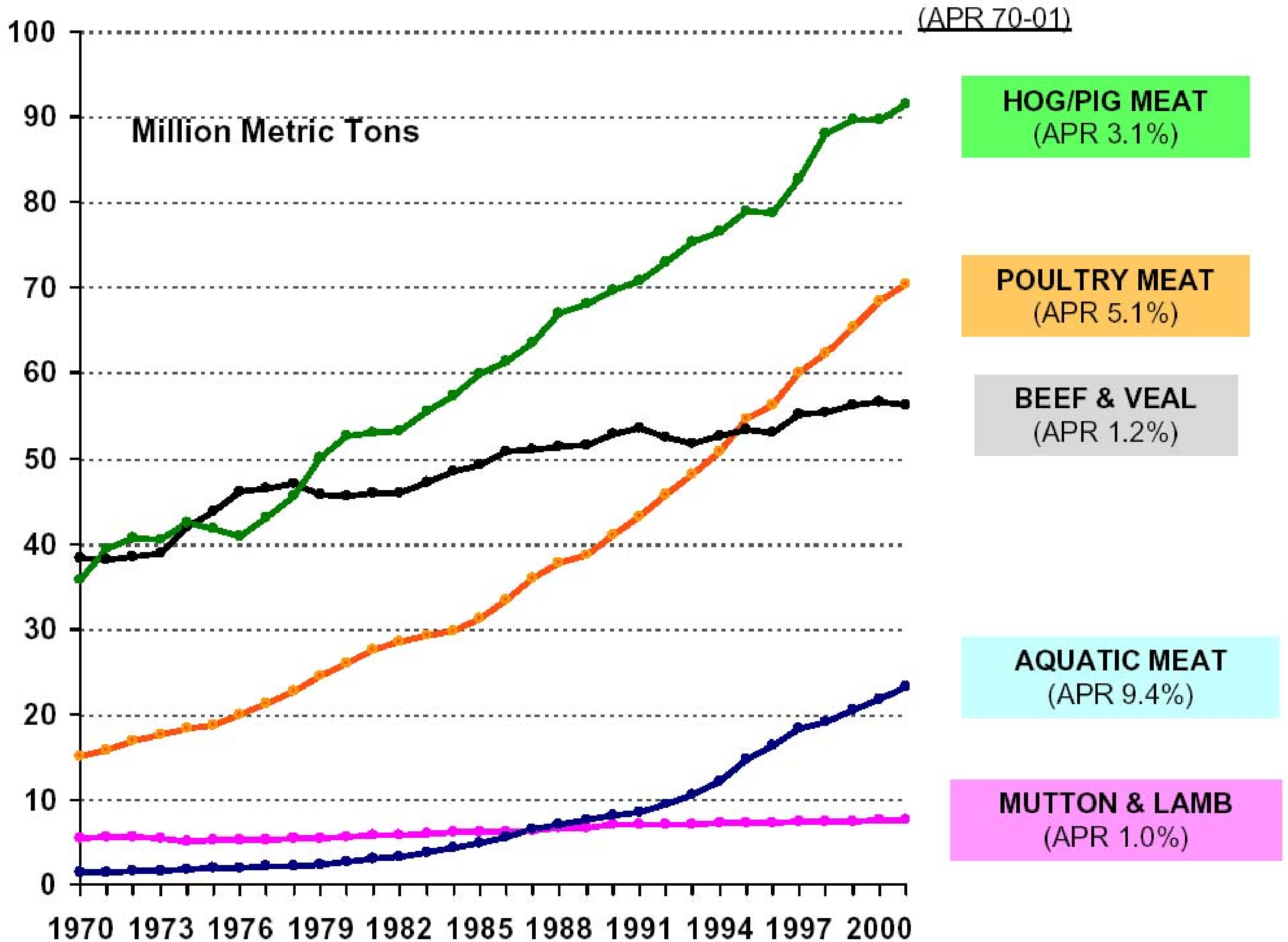
Elias Papatryphon, Jean Petit and Hayo, M. G. Van der Werf

UMR Sol Agronomie Spatialisation, Institut National de la Recherche Agronomique, 35042 Rennes cedex, France

6-8 October, 2003
Horsens, Denmark

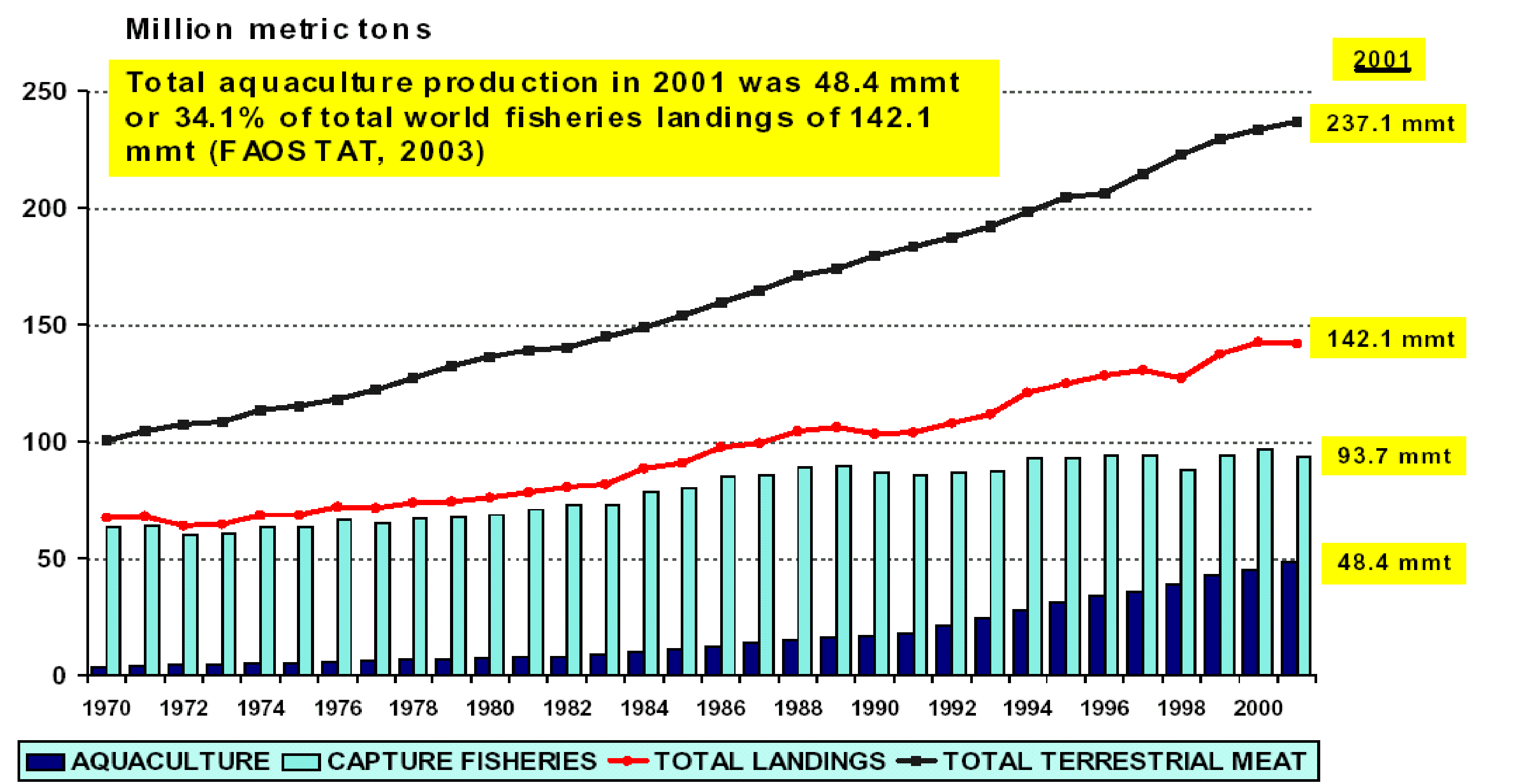
4th International Conference:
Life Cycle Assessment in the Agri-food Sector

Total global farmed terrestrial and aquatic meat production 1970-2001 (Source: FAOSTAT, 2003)

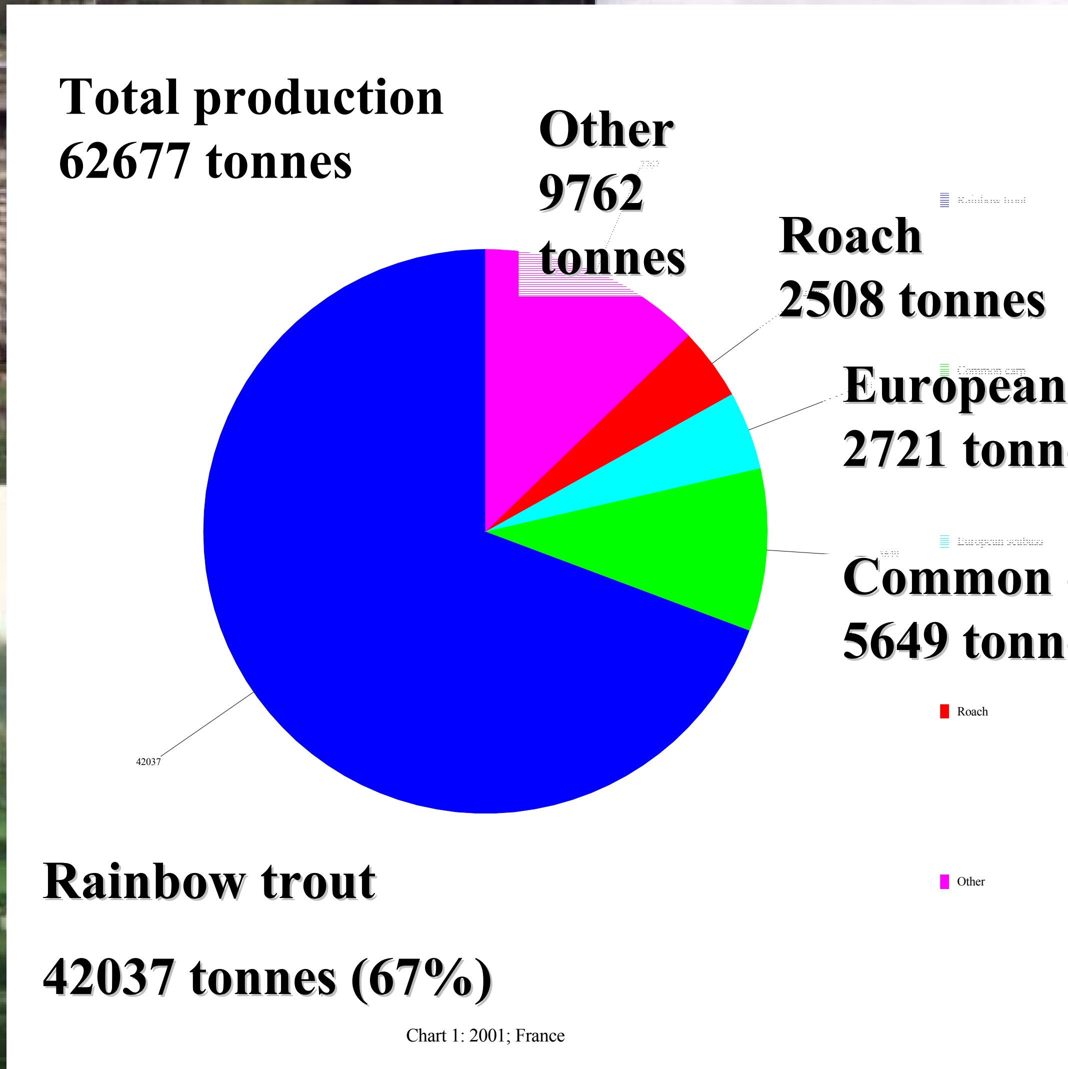


Aquaculture production is increasing at a fast pace…but so do the environmental concerns associated with it

Contribution of aquaculture to total world fisheries landings 1970-2001

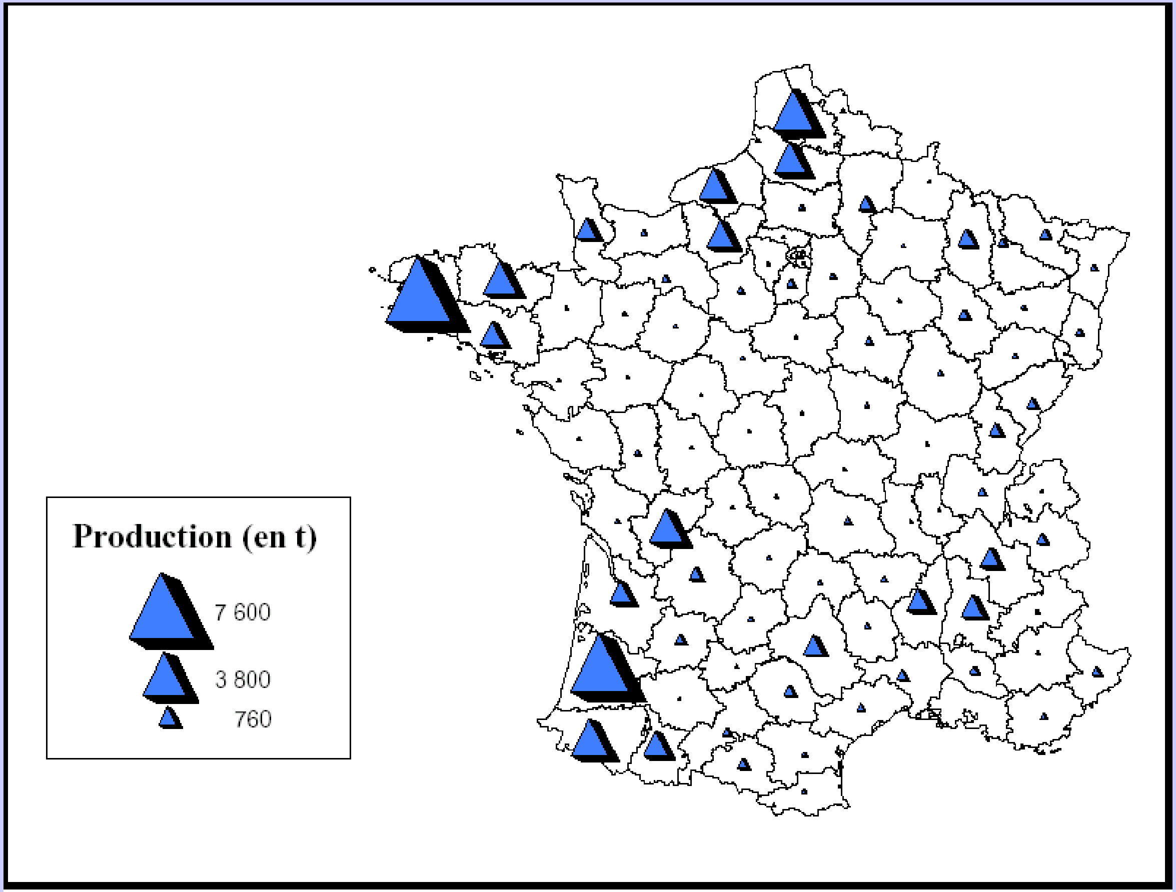


Aquaculture production in France by major species for the year 2001



FAO, 2001

There are two major trout producing regions: Aquitaine and Bretagne



© Agreste – Recensement de la salmoniculture 1998

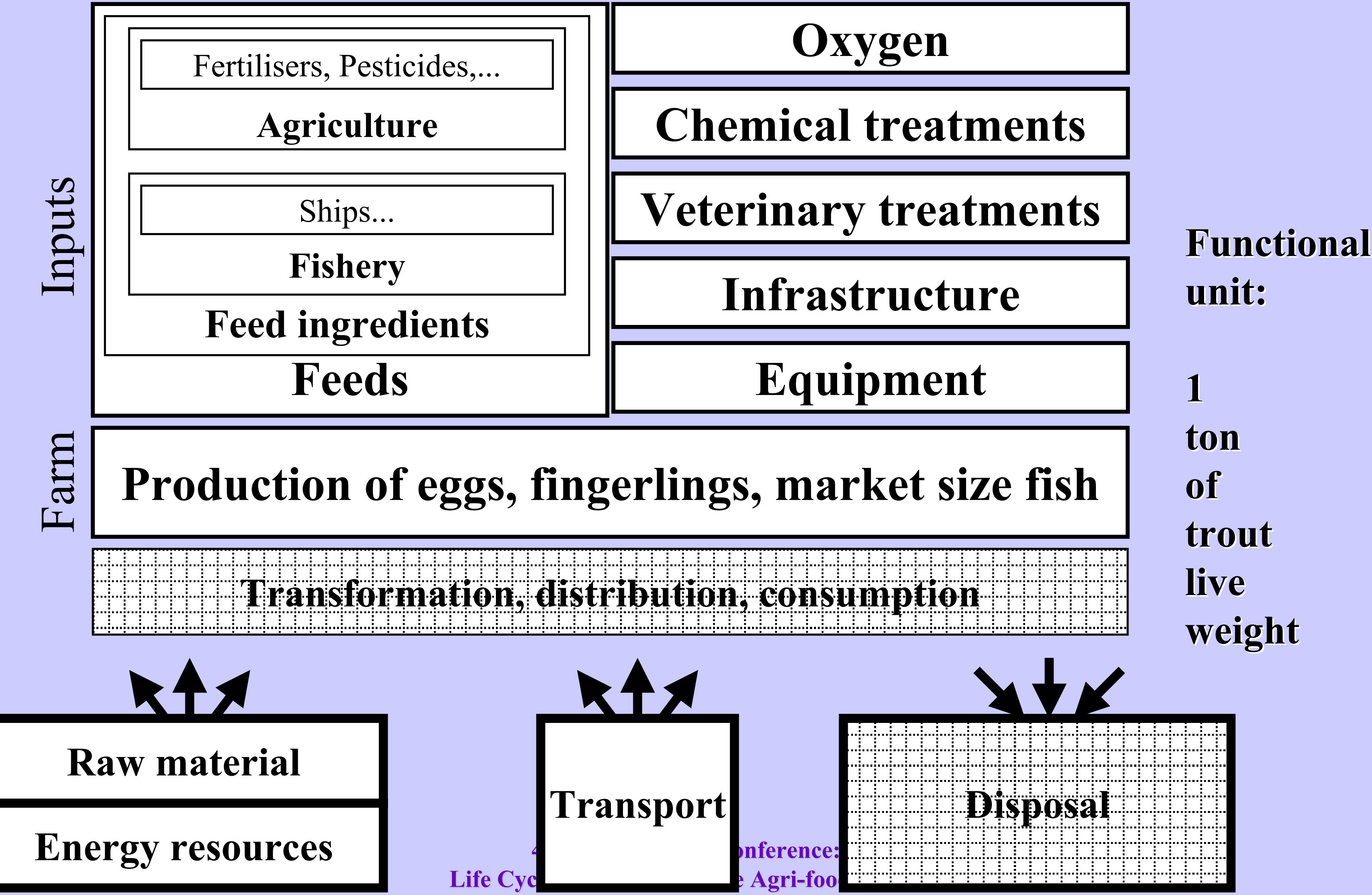
Decrease in farms: environmental and economic constraints

Goal and Scope

- **To develop and apply the LCA methodology for the evaluation of the environmental impacts of trout farming in France**

- **To assess the potential of using LCA as a tool for the identification and demonstration of the potential variability in the environmental impacts due to different choices in farm management**

LCA of trout production in France



Choice of farms
objectives

- Commercial farms - intensive freshwater raceway type system
- Main producing regions (cover >50%)
- Variation in production capacity (cover >80%)
- Variation in market sizes (cover 100%)
- Variation on technological sophistication (types of equipment use)
- Construction of production scenarios
- Availability of and willingness to share data

Production scenario construction

Production process A — Broodstock/Eggs

Production process B — Juveniles/Portion

Production process C — Large/Very large

Scenario I

Scenario II

Description of farms used for the inventory analysis stage

Farm No	Region	Starting size	Product type	Production capacity	Average weight at market size	TS
1	Aquitaine	broodstock/eggs		45 million eggs	NA	NA
2	Aquitaine	eggs	juveniles-portion	393 tonnes	220	18
3	Bretagne	eggs	juveniles-portion	38 tonnes	250	7
4	Bretagne	juveniles	portion-very large	231 tonnes	925	13
5	Aquitaine	juveniles	portion-very large	100 tonnes	984	13
6	Aquitaine	juveniles	portion-very large	230 tonnes	1410	16
7	Aquitaine	juveniles	portion-very large	330 tonnes	2062	22
8	Aquitaine	juveniles	portion-very large	192 tonnes	2189	13

Impact categories and emissions

Impact Categories	Resources and Emissions
Energy use	Coal, oil, gas, uranium, lignite
NPP use	Biotic resources (direct use)
Climate Change Potential	CO_2, N_2O, CH_4
Acidification Potential	NH_3, NO_2, NO_x, SO_2
Eutrophication Potential	N, NH_3, NO_3, NO_2, NO_x, P, PO_4, COD, ThOD

Hypotheses

- Trout Farm Inputs-Outputs: producers records
  - Eutrophying emissions, energy use and emissions related to non-renewable energy use
- Production of feed: extended assessment (Papatryphon et al., in press)
  - All emissions, energy and biotic resource use during agricultural/fishery phase
- O_2 production and transport: industry-expert data (Air Liquide)
  - Energy use and emissions related to non-renewable energy use
- Equipment production and transport: industry-expert data (Faivre)
  - Energy use and emissions related to non-renewable energy use
- Farm infrastructure: farm measurements and data
  - Energy use and emissions related to non-renewable energy use

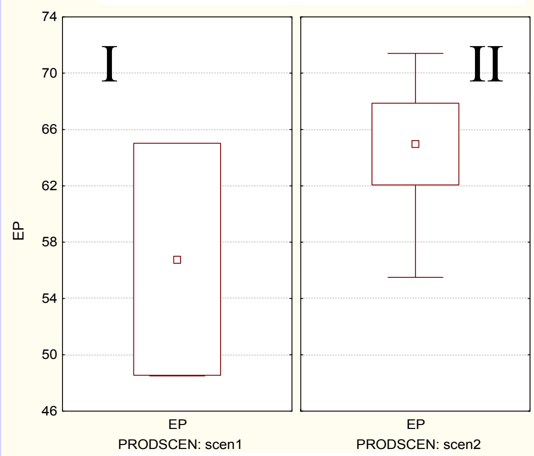
Hypotheses

- All other processes: only energy use and emissions related to non-renewable energy use is taken into account
- Allocation: economic for feed production, mass for oxygen production, none for fish production, none for manure production.
- Manure management: accounting of airborne emissions during agricultural application, no penalty for soil/water emissions as it is assumed to replace chemical fertiliser use.

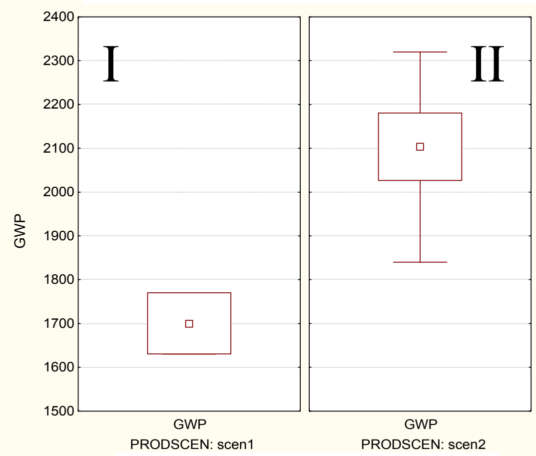
Results

Production Scenarios: total calculated impacts between 2 trout production scenarios for the production of 1 ton of rainbow trout live weight

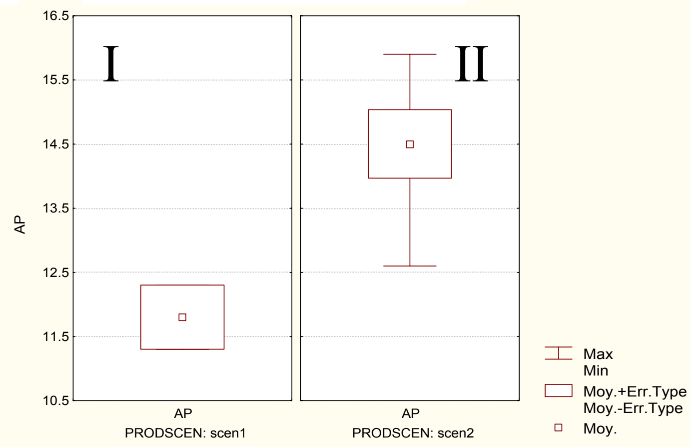
Eutrophication



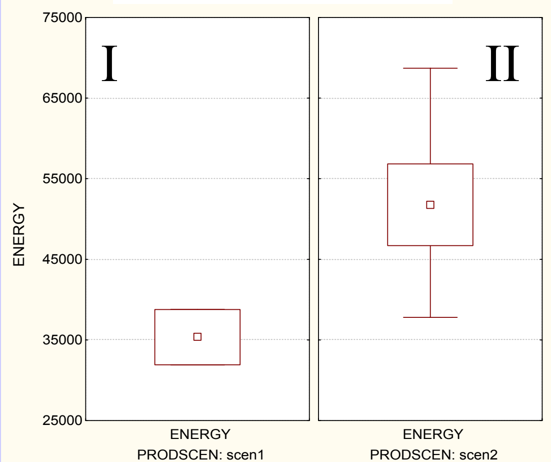
Global Warming



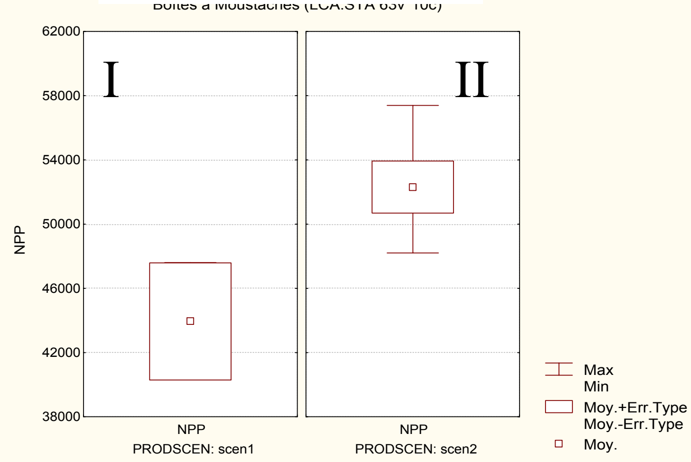
Acidification



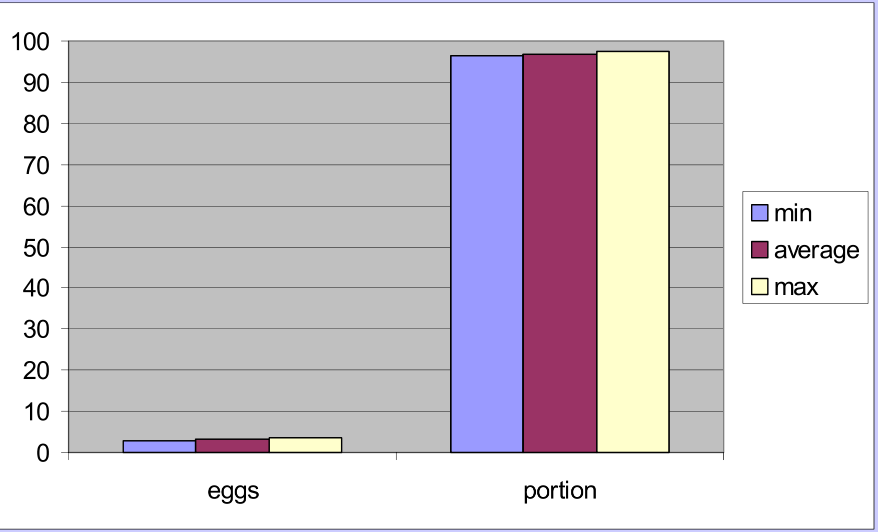
Energy Use

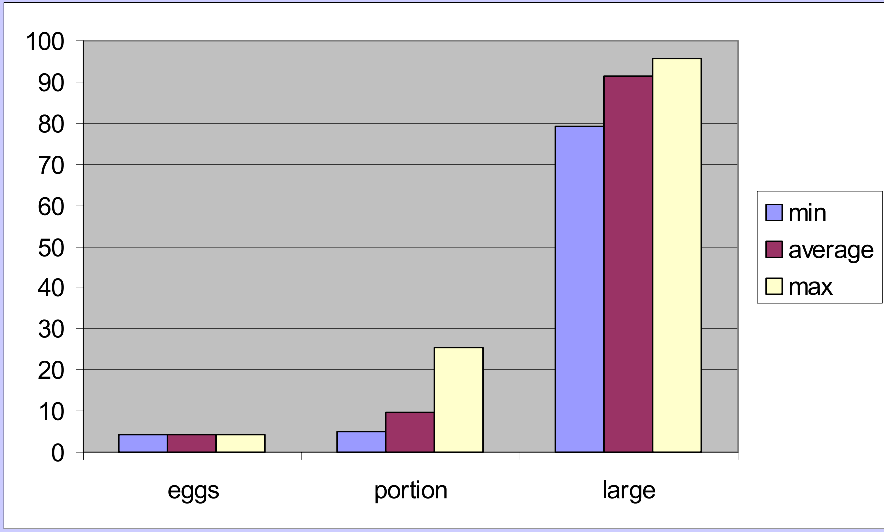


NPP Use



Production Scenarios:
process contribution analysis



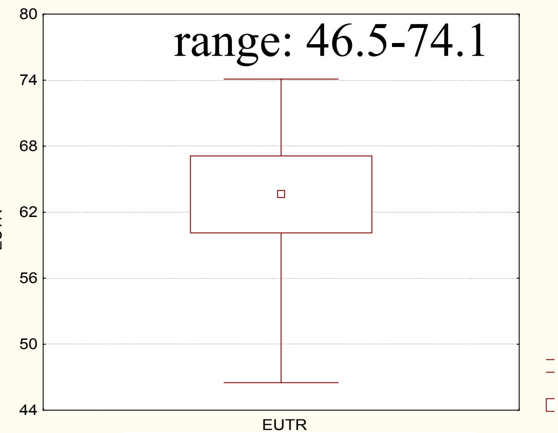


Scenario I: Portion trout

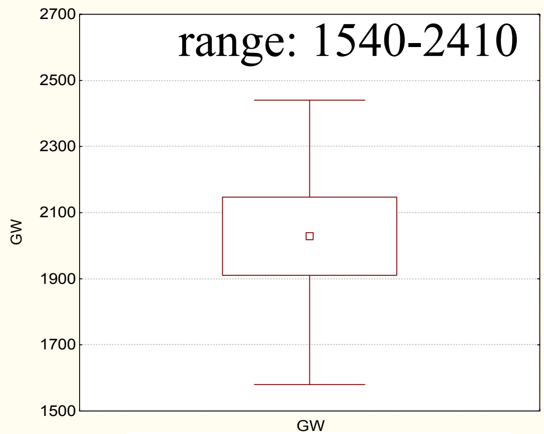
Scenario II: Larger sizes

Farm variability: Total calculated impacts among 7 trout farms for the production of 1 ton of rainbow trout live weight

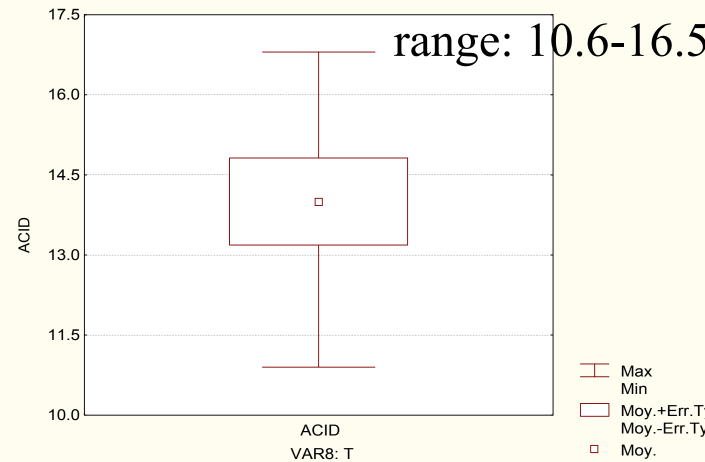
Eutrophication



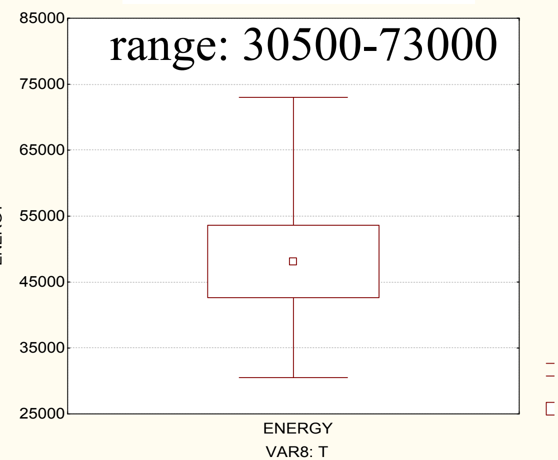
Global Warming



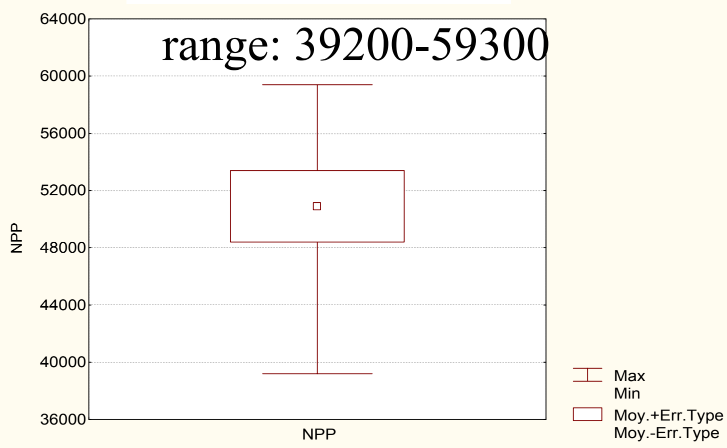
Acidification



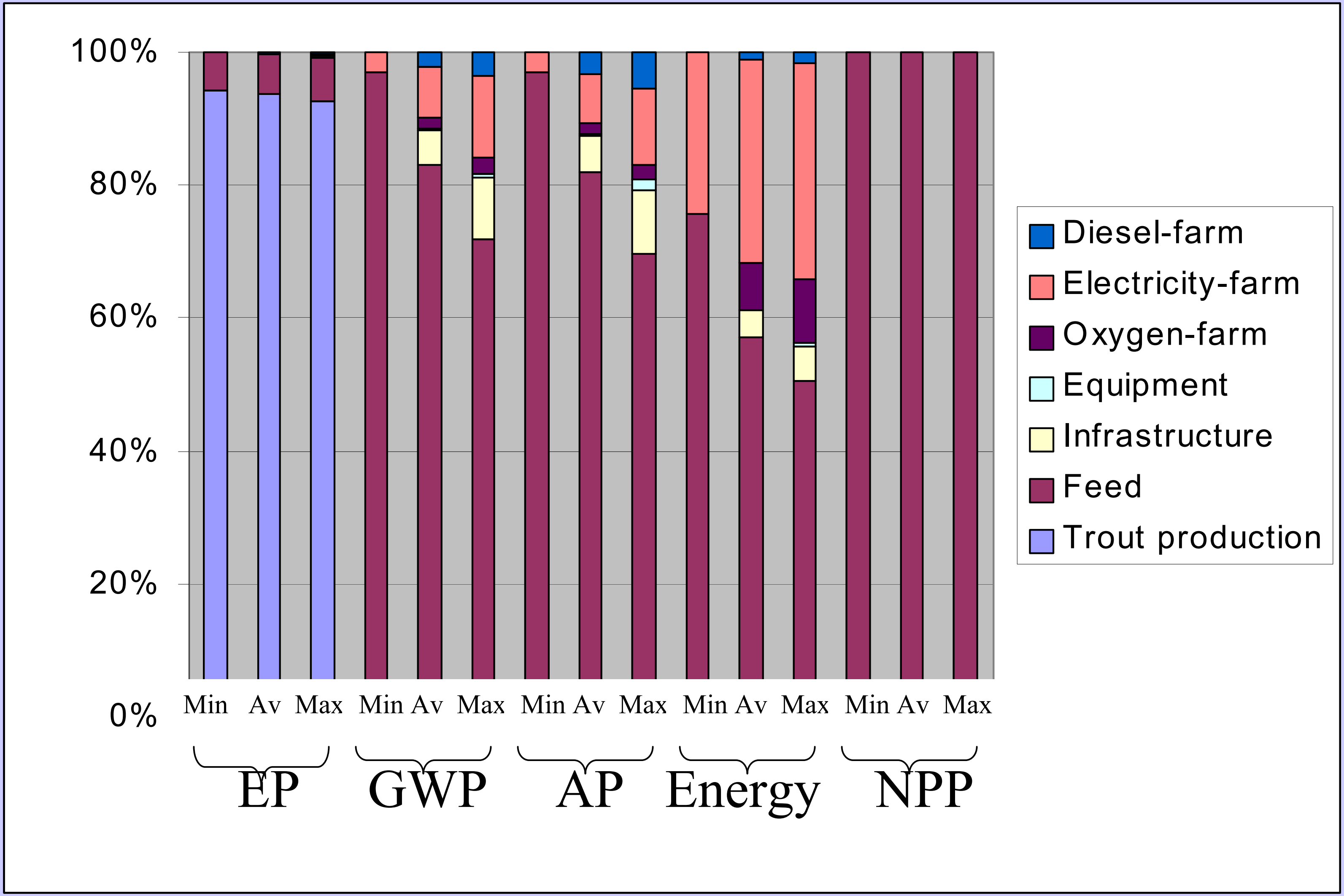
Energy Use



NPP Use

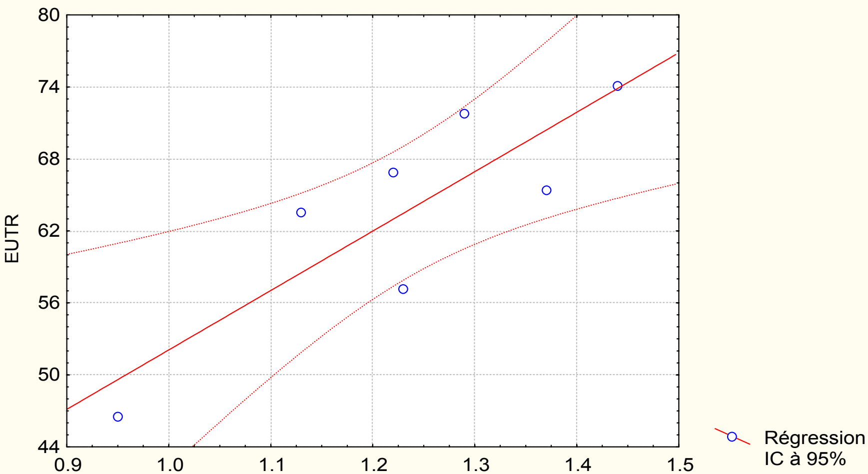


Farm variability:
process contribution analysis



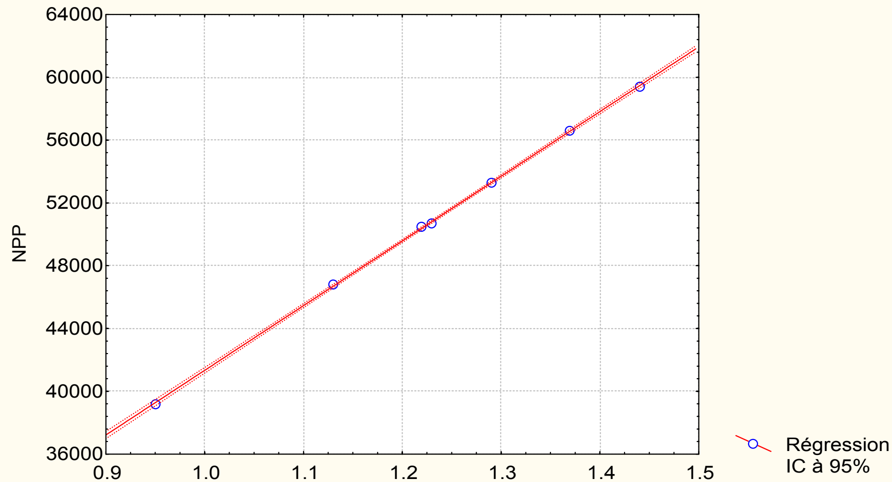
Farm variability:
Eutrophication and NPP use

Eutrophication



Feed:Gain

NPP Use



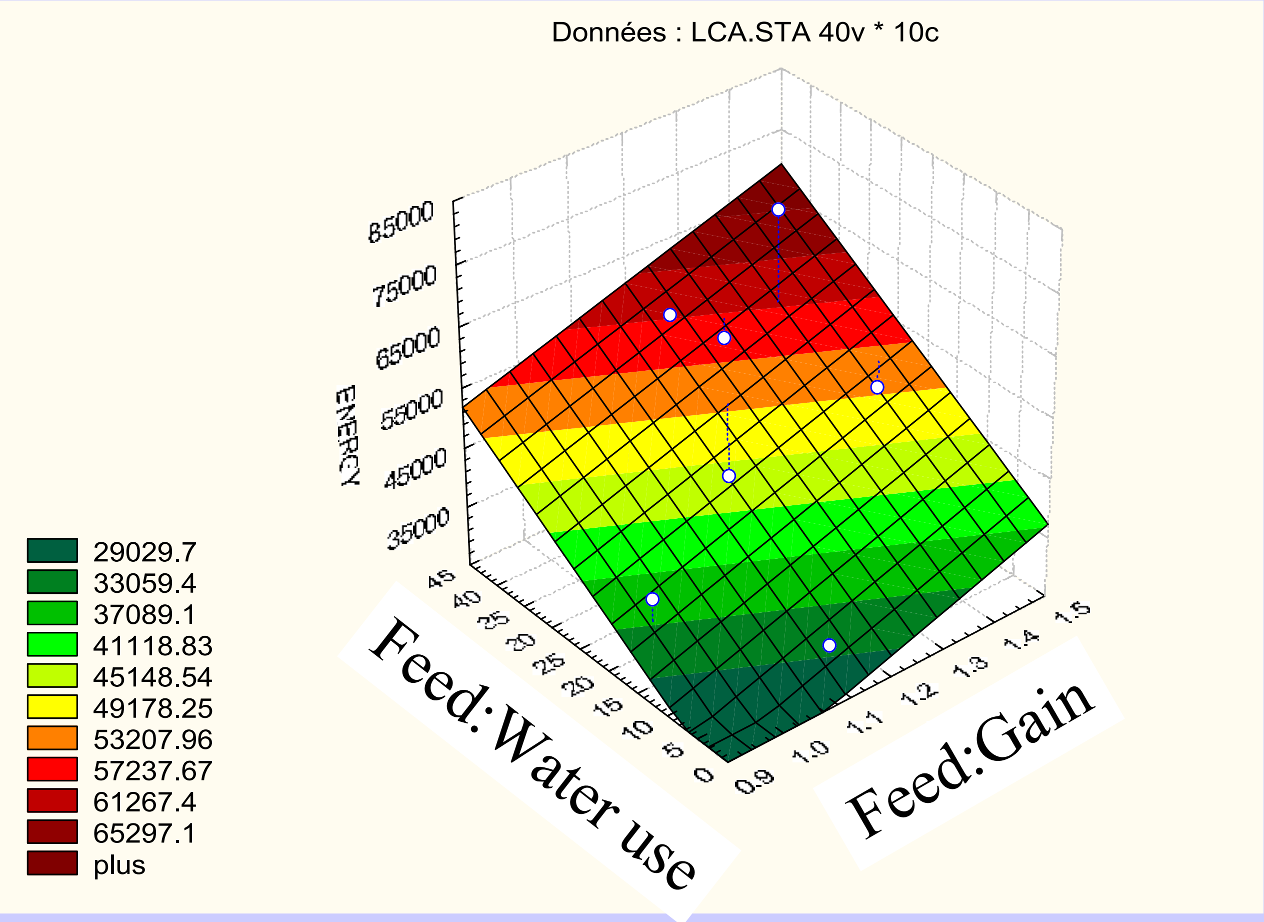
Feed:Gain

R= 0.85; R^2= 0.73; p<0.01

R= 0.99; R^2= 0.99; p<0.00

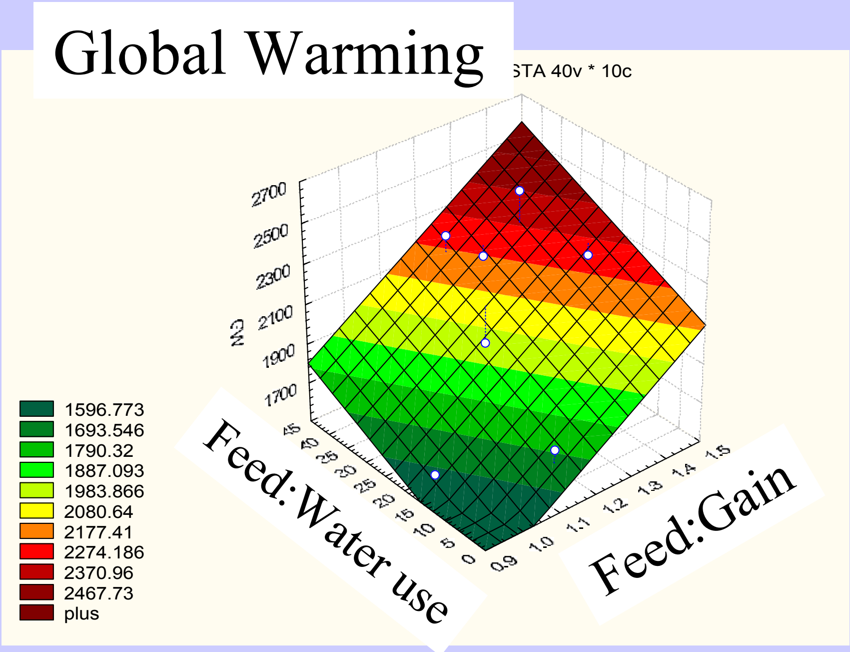
Regression equations → Predictions

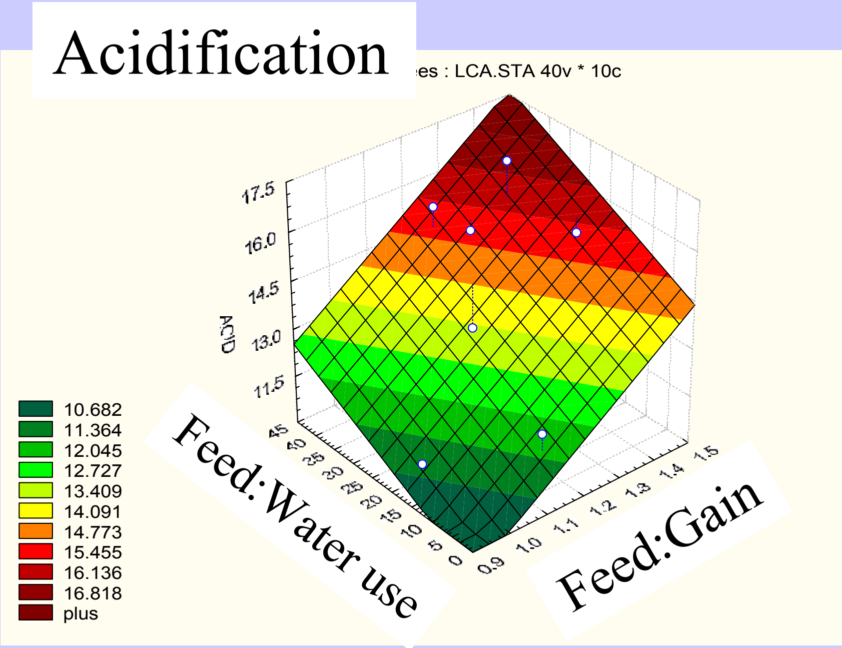
Farm variability:
Energy use



Rm= 0.82; R^2= 0.67; p<0.11

Farm variability:
Global warming and Acidification





Rm= 0.93; R^2= 0.87; $p<0.02$

R= 0.92; R^2= 0.86; $p<0.02$

Conclusions

- The present assessment is an estimate representing the **range of potential impacts** of trout farming in France
- **The last stage in the production chain** of trout farming is by far the most important in terms of environmental concern
- In general terms, the potential environmental impacts of trout production **increase with final product size**
- **Feed is the largest single contributor** to all environmental impacts associated with trout production
- The **metrics “feed : gain“ and “feed : fresh water use“** explain the majority of variation regarding the environmental impacts of trout production (as considered in this assessment)

Conclusions

Improvements in environmental impacts could be brought about by:

- *On farm improvements in*
  - **feed : gain ratio - All impacts**
    - shifting to smaller sized product
    - improving feed composition and management
    - genetic selection for better feed efficiency
  - **feed:water use - Energy use, Global warming, Acidification**
    - assuring adequacy of fresh water flow
    - using most environmentally-friendly technology for water treatment (aeration, oxygenation, recycling)
    - reducing production capacity under current feed:gain
  - **waste treatment technology - Eutrophication**
- *Improvements in agriculture/fishery stages of ingredient production*
  - **Energy use, NPP use, Global warming, Acidification**

Perspectives

- **The methodology is now in place:** inclusion of more farms, simulations for alternative systems, seek means of improvement, seek better metrics

- The results from a detailed LCA assessment may be used for the **identification of metrics** which could serve as simple indicators for the evaluation of farming systems