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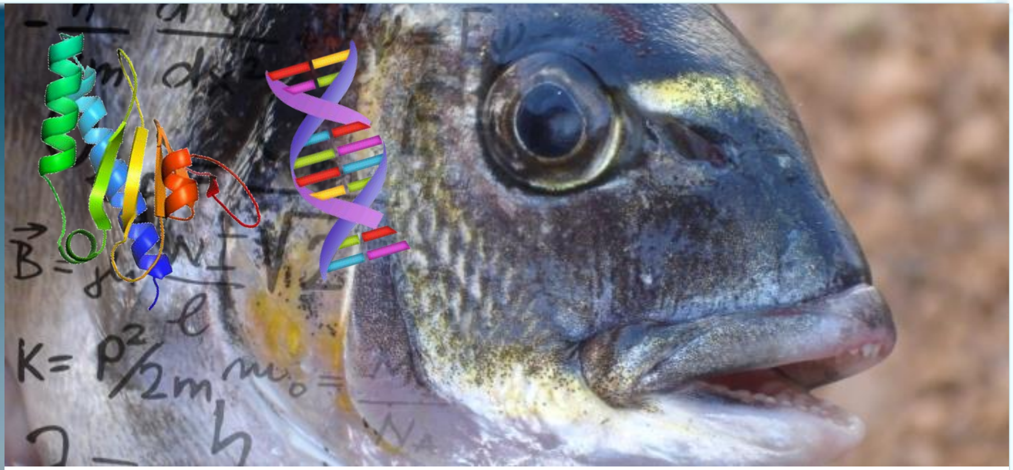

Models and tools for measuring environmental impacts

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Jorge Dias

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www.sparos.pt

Training course on
"Fish nutrition research: recent advances and perspectives"
13-16 June 2017, Benicassim, Spain

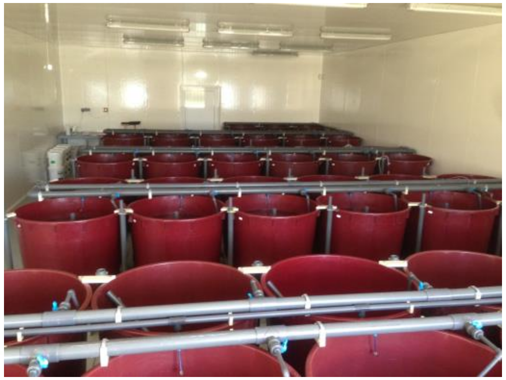
Tailoring your feeds

SPAROS location & markets

SPAROS Pilot-plant - Olhão

Olhão, Algarve

RIASEARCH - SPAROS trial facility



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Tailoring your feeds

SPAROS Activities

CAE 72190 - Outra investigação e desenvolvimento das ciências físicas e naturais

Industrial R&D Services

- Custom feeds for R&D
- Fish nutrition trials
- Pellet quality tests
- Stability tests through extrusion

Own Products & Services

- **Hatchery feeds** range
- Custom feeds for fish farms
- **Zebrafeed** – zebrafish (biomedicine)
- **Aquatica** range – ornamental fish
- Feed evaluation tools

Customers

Feed Additives

Feed Ingredients

AquaFeeds

Fish Farmers

R&D Institutes

National & European Projects

CAE 10913 - Fabricação de alimentos para aquicultura

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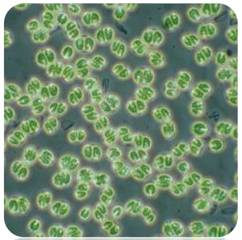
Tailoring your feeds

Collaborative R&D projects

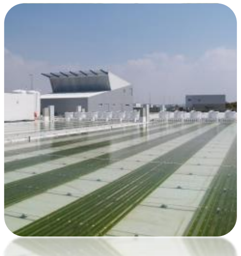
- **FP7 ARRAINA -**

ARRAINA
Advanced Research Initiatives for Nutrition & Aquaculture

- **FP7 MIRACLES - biorefinery of bioactives from microalgae for food, aquafeeds, and non-food products**



MIRACLES
SPECIALTIES FROM ALGAE



- **H2020 WISEFEED - Improving sustainability and performance of aquafeeds**

Wisefeed

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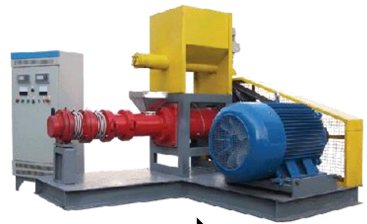
I&D nutrition in aquaculture

Tailoring your feeds

Context


Ingredients
Micronutrients
Pigments
Other additives
Technological processes



Feed quality and performance

Digestibility
Environmental impact
Growth performance
Economic performance

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Tailoring your feeds

Modeling - Context

Effect of changing feed formulation on

- Growth and economic performance
- Environmental impact

- not straightforward to predict /assess

- Assess: digestibility trials (results after 2 months)
  growth performance trials (results in 3-4 months)
  Extrapolation to longer periods !?

- Predict: experience & common sense ??
  bioenergetic models
  mechanistic models

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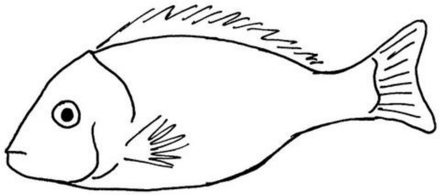
Tailoring your feeds

Mathematical modeling

Feed
Oxygen
Temperature



Biomass
Waste

Inputs → Process → Outputs

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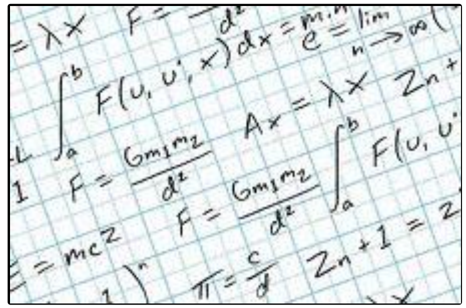
What is a model?

Feed
Oxygen
Temperature



Biomass
Waste

Inputs (ind. var.) → Model → Outputs (dep. var.)

Mathematical description of process, provides an **estimate of the outputs, given the inputs.**

Dynamic fish models

- Bioenergetic models

Based on explicit solutions of simple growth models

Example: Mayer 2012

Explicit solution to differential equation assuming allometric growth and a dependence of growth on accumulated temperature

Dynamic fish models

1. Simple equation models:

e.g., Mayer 2012

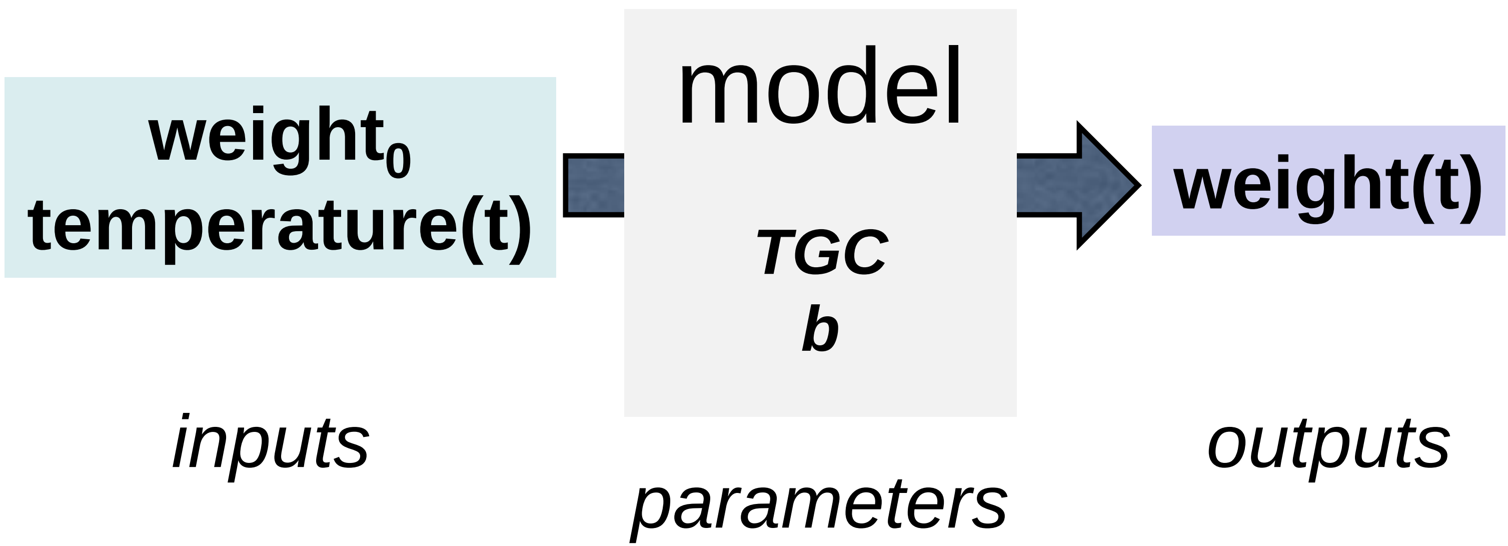
$$weight(t) = (weight_0^{b} + TGC_b \times ST)^{1/b}$$

$ST(t, temperature(t))$
$weight^0$
} inputs

TGC_b
b
} model parameters

Dynamic fish models

- Mayer 2012 (in practice...)



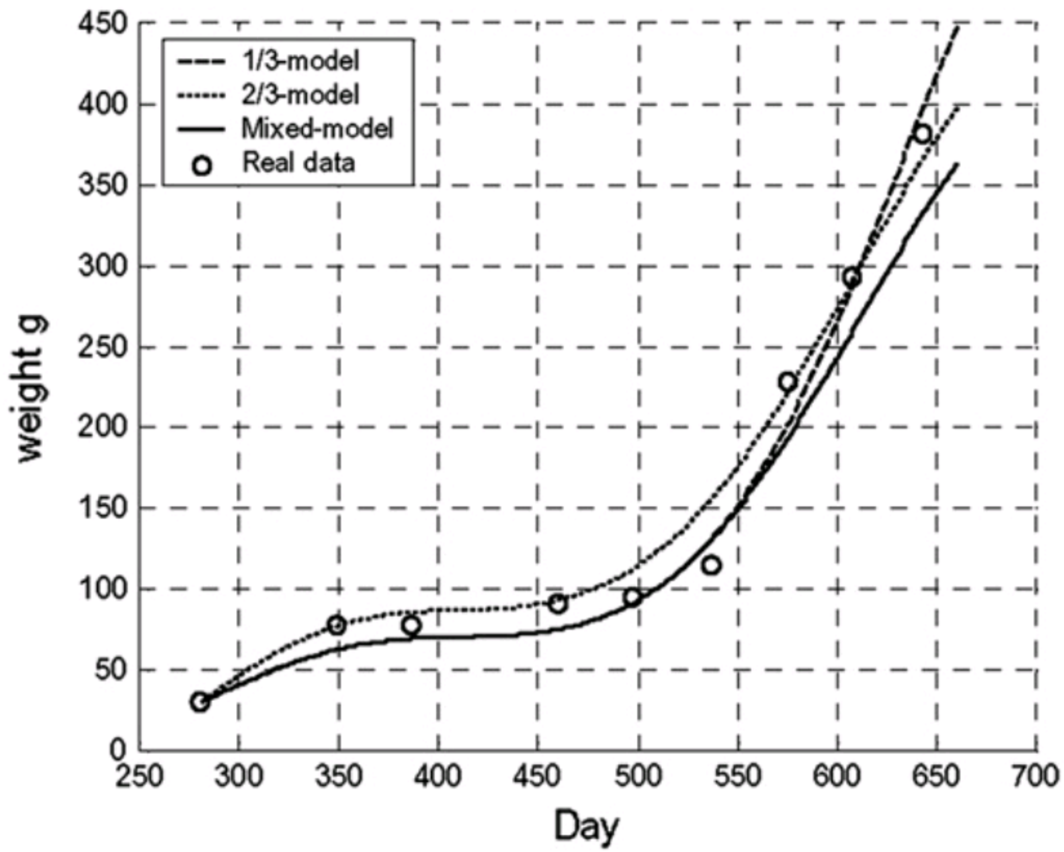
Tailoring your feeds

Dynamic fish models

- **Mayer 2012 (in practice...)**

initial weight + temperature profile

weight(t)



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Dynamic fish models

2. Bioenergetic models:
e.g., Cho & Bureau (1998) - FISH-PRFEQ

weight_0
feed quantity(t)
feed P,N,E

inputs

Model

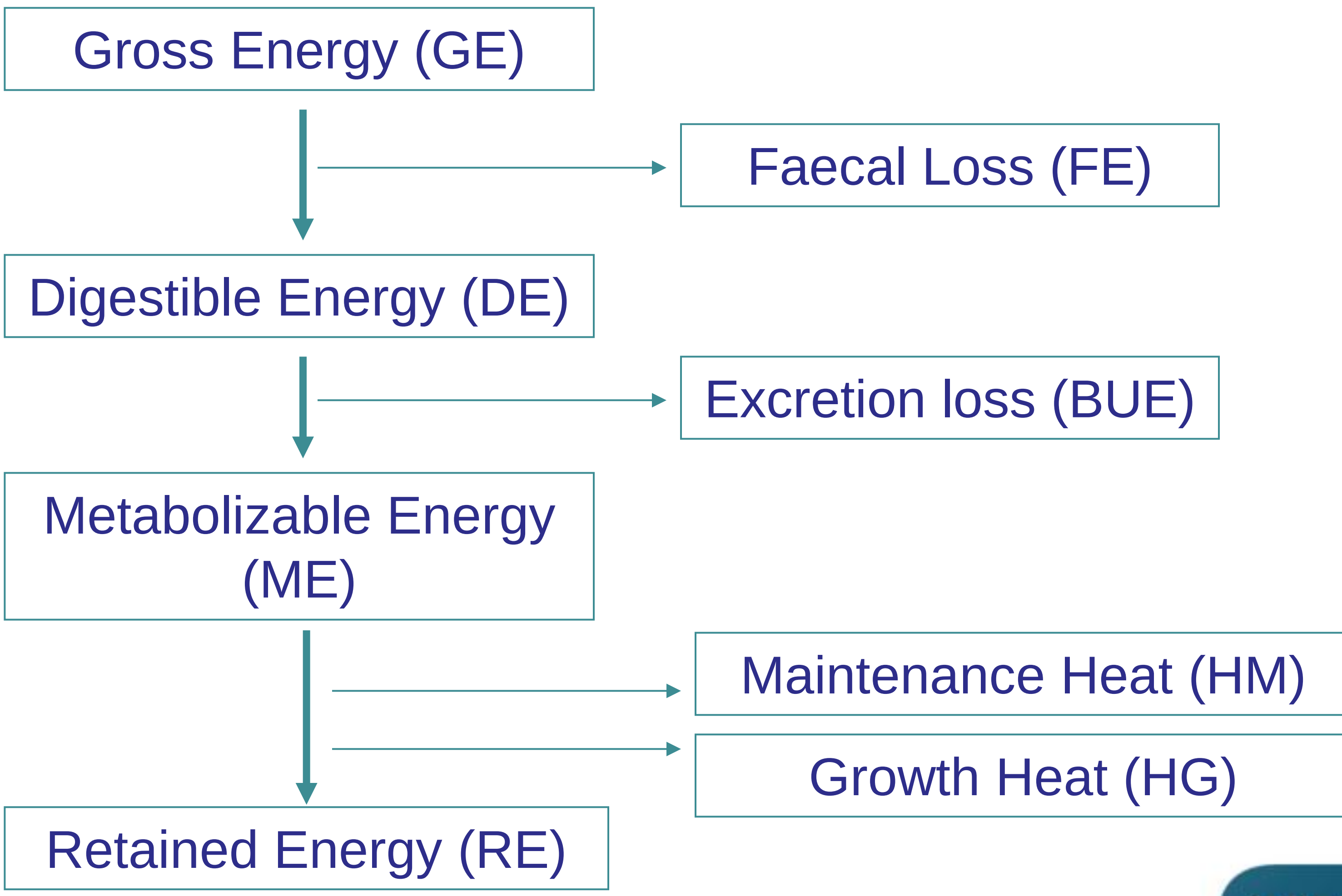
parameters

weight(t)
retention P,N,E
waste (t)

outputs

Tailoring your feeds

Bioenergetic models



adapted from Cho & Kaushik (1990)

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WASTEst - Objective

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Develop a practical tool to compare the impact of different fish feed formulations on seabream, seabass, carp and salmon waste outputs, based on bioenergetic principles.

Web tool which allows the estimation of P, N and total waste output uncertainties based on (input) performance variability, combined with statistical models that provide plausible confidence intervals in the case of unavailable (optional) inputs

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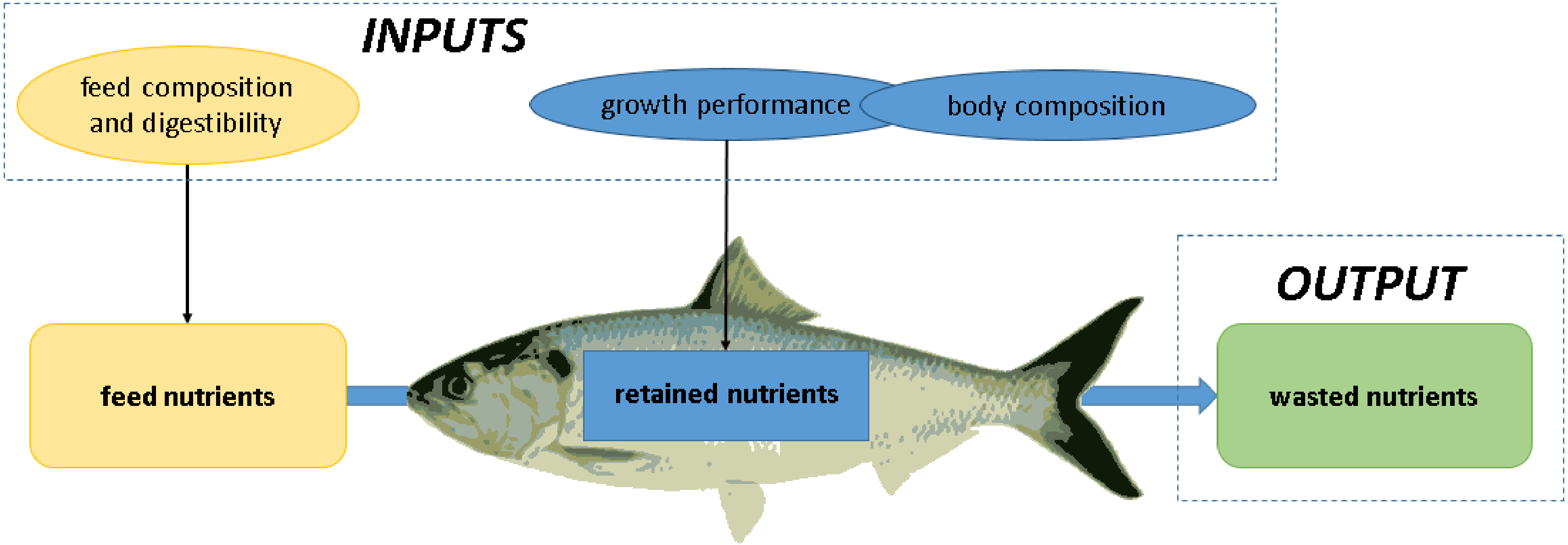
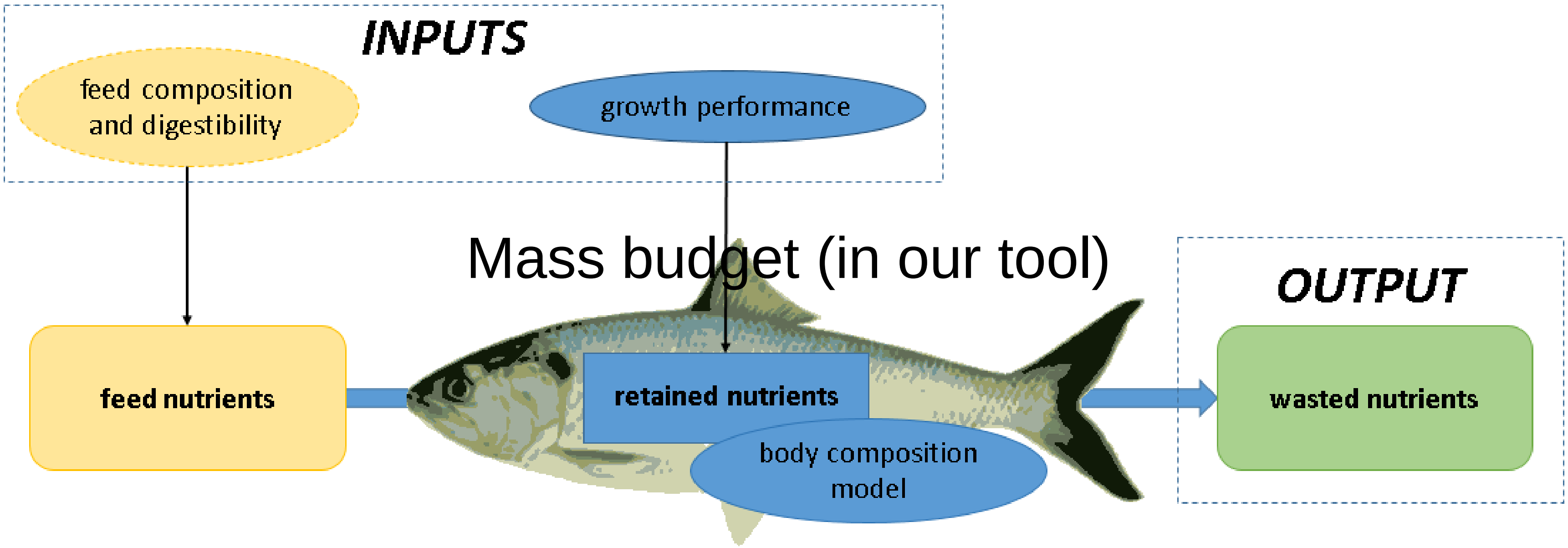
WASTEst - Concept

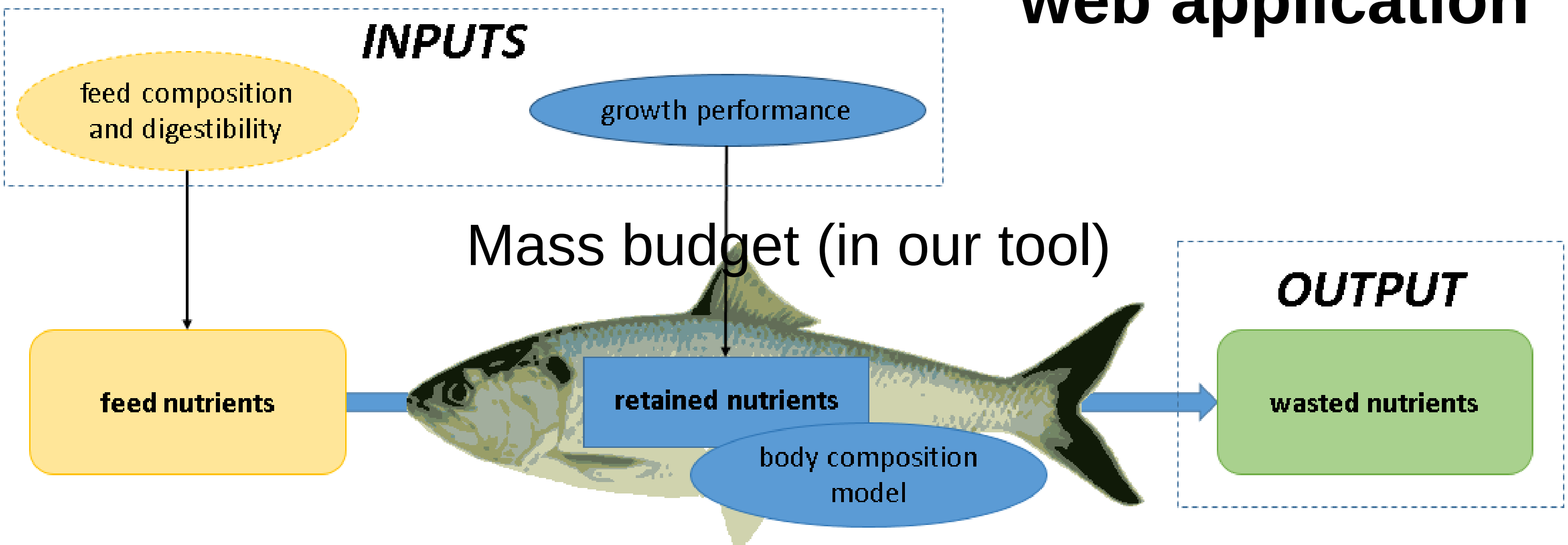


WASTEst - Concept



WASTEst - Implementation

web application



http://www.sparos.pt/wastest/

WASTEst - Example

Feed A

45% CP
6% Ash
1,5% P

Feed B

WASTEst - Example

Feed A

45% CP
6% Ash
1,5% P

Feed B

IBW ≈ 100 g

growth trial

FBW ≈ 250 g

WASTEst - Example

ARRAINA
Advanced Research Initiatives for Nutrition & Aquaculture

Feed A

45% CP
6% Ash
1,5% P

Feed B

growth trial

IBW ≈ 100 g

FBW ≈ 250 g

FCR =
1.34, 1.55, 1.45
in 3 replicate tanks

FCR =
1.15, 1.19, 1.13
in 3 replicates

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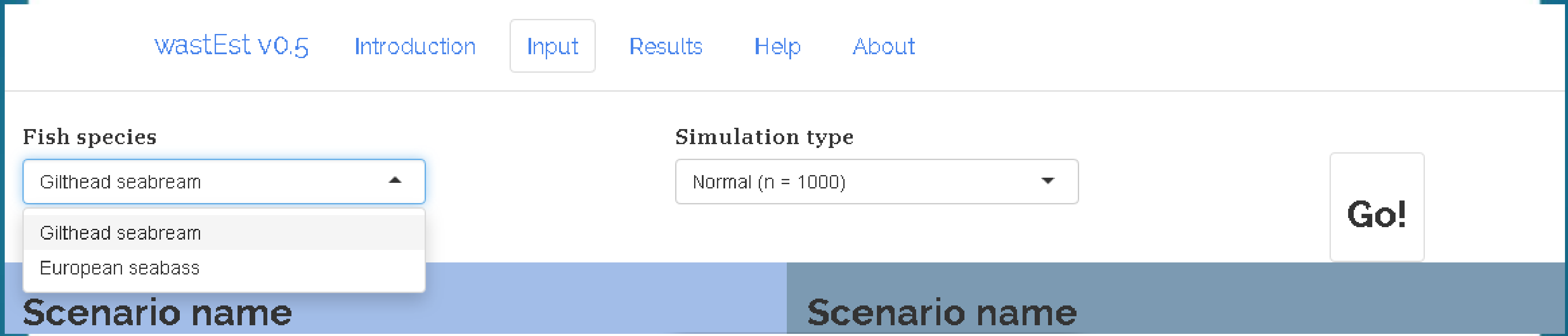
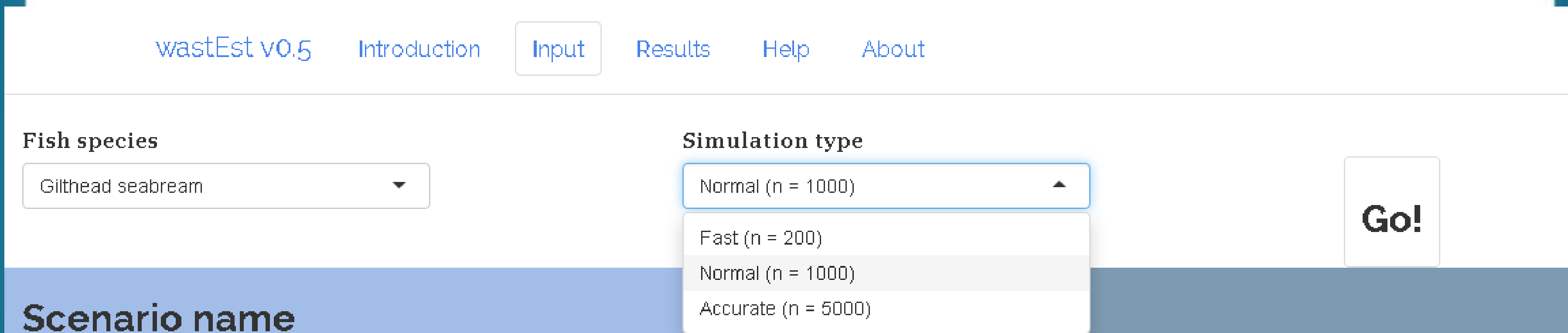
I&D nutrition in aquaculture

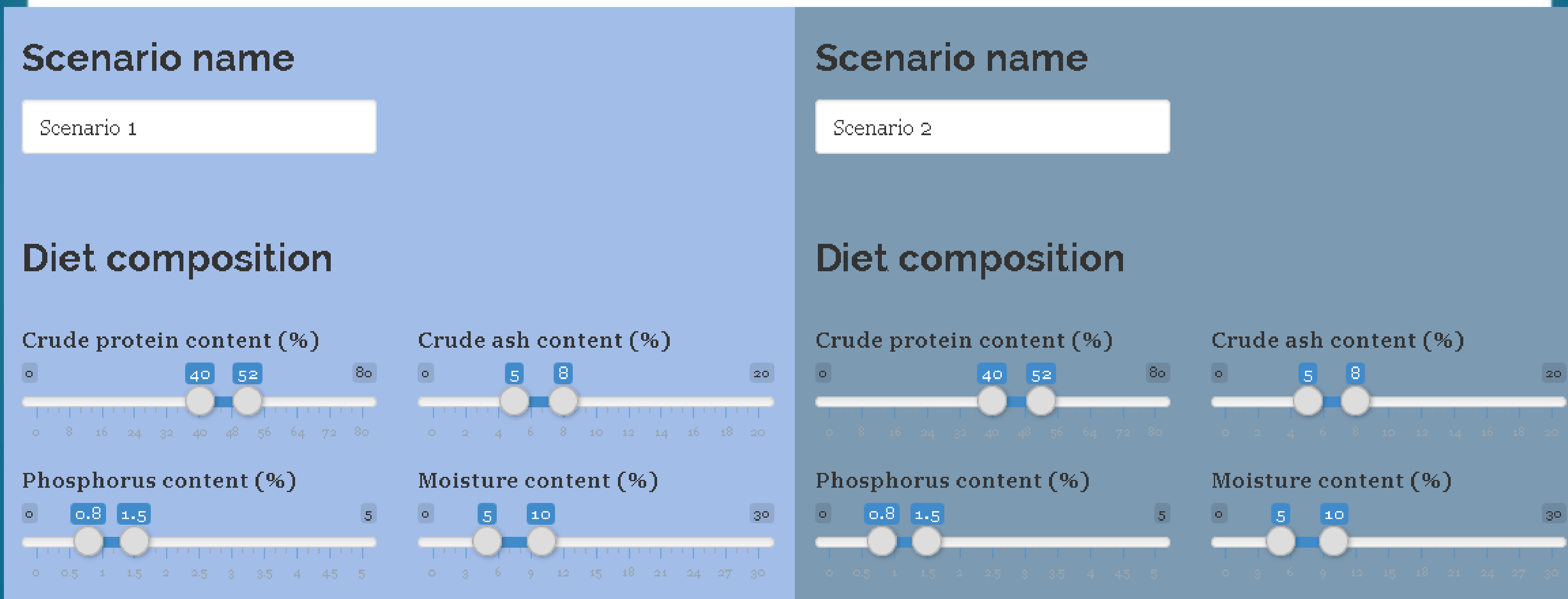
WASTEst - Example



WASTEst - Example



WASTEst - Example



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WASTEst - Example

Diet digestibility

Diet type

ADC crude protein (%): 65 – 93

ADC phosphorus (%): 40 – 65

Performance

Provide rearing performance in Excel (.xlsx) or text (.txt) format.
Example files: Excel format / text format
If data is imported correctly, it should appear in the table below.

Choose file to upload

Explorar... Nenhum

	A	B	C
1	InitialWeight	FinalWeight	FCR
2	100,2	250,4	1,34
3	120,2	260,4	1,55
4	110,3	257,5	1,45
5			

Diet digestibility

Diet type

ADC crude protein (%): 65 – 93

ADC phosphorus (%): 40 – 65

Performance

Provide rearing performance in Excel (.xlsx) or text (.txt) format.
Example files: Excel format / text format
If data is imported correctly, it should appear in the table below.

Choose file to upload

Explorar... Nenhum

	A	B	C
1	InitialWeight	FinalWeight	FCR
2	98,6	249,7	1,15
3	121,3	255,6	1,19
4	115,5	261,3	1,13
5			

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WASTEst - Example

Diet digestibility

Diet type

Standard

Premium
Standard
Low-cost

ADC phosphorus (%)

45 – 60

Performance

Provide rearing performance in Excel (.xlsx) or text (.txt) format.
Example files: Excel format / text format
If data is imported correctly, it should appear in the table below.

Choose file to upload

Explorar... example.:

Upload complete

InitialWeight	FinalWeight	FCR
100.20	250.40	1.34
120.20	260.40	1.55
110.30	257.50	1.45

Diet digestibility

Diet type

Premium

ADC crude protein (%)

88 – 93

ADC phosphorus (%)

60 – 65

Performance

Provide rearing performance in Excel (.xlsx) or text (.txt) format.
Example files: Excel format / text format
If data is imported correctly, it should appear in the table below.

Choose file to upload

Explorar... example:

Upload complete

InitialWeight	FinalWeight	FCR
98.60	249.70	1.15
121.30	255.60	1.19
115.50	261.30	1.13

Tailoring your feeds

WASTEst - Example

wastEst v0.5 | Introduction | Input | Results | Help | About

Done. 100.0%

Fish species

Gilthead seabream

Simulation type

Normal (n = 1000)

Go!

Scenario name

Feed A

Diet composition

Crude protein content (%)

0 44.89 – 45.09 80

Crude ash content (%)

0 5.94 – 6.06 20

Phosphorus content (%)

0 1.5 5

Moisture content (%)

0 5 10 30

Scenario name

Feed B

Diet composition

Crude protein content (%)

0 44.69 – 45.06 80

Crude ash content (%)

0 5.94 – 6.06 20

Phosphorus content (%)

0 1.5 5

Moisture content (%)

0 5 10 30

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WASTEst - Example

ARRAINA
Advanced Research Initiatives for Nutrition & Aquaculture

wastEst v0.5 | Introduction | Input | Results | Help | About

Summary | Total waste | N waste | P waste | Advanced

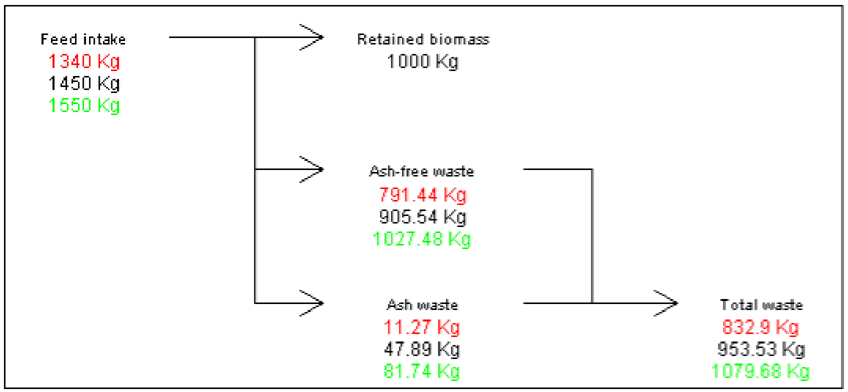
Calculations finished. A summary of the results is presented below.

	Feed A	Feed B	unit	sig.
Total waste	953.53	685.39	kg/ton biomass produced	*
Ash-free waste	905.54	654.96	kg/ton biomass produced	*
Ash waste	47.89	30.45	kg/ton biomass produced	
N waste (total)	75.14	54.32	kg/ton biomass produced	
N waste (fecal)	12.99	7.85	kg/ton biomass produced	*
N waste (metabolic)	62.00	46.50	kg/ton biomass produced	
P waste (total)	15.88	11.57	kg/ton biomass produced	
P waste (fecal)	10.32	6.52	kg/ton biomass produced	*
P waste (metabolic)	5.53	5.06	kg/ton biomass produced	

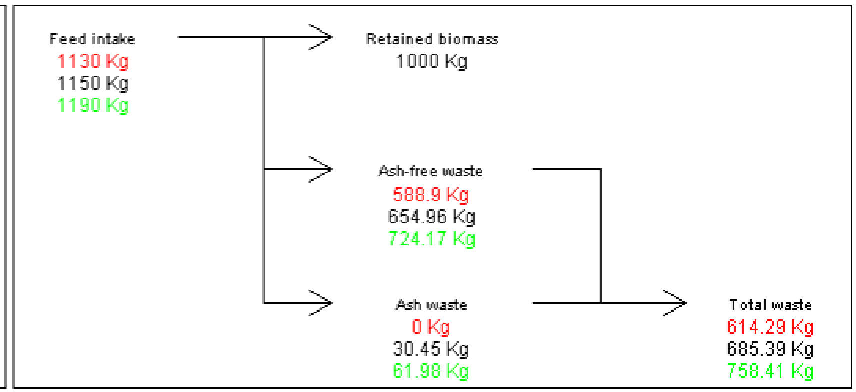
WASTEst - Example

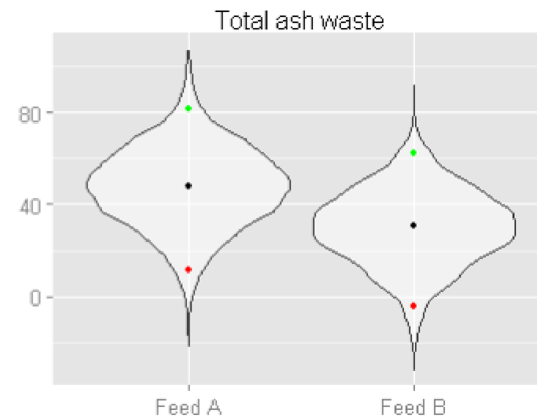
Summary | Total waste | N waste | P waste | Advanced

Feed A



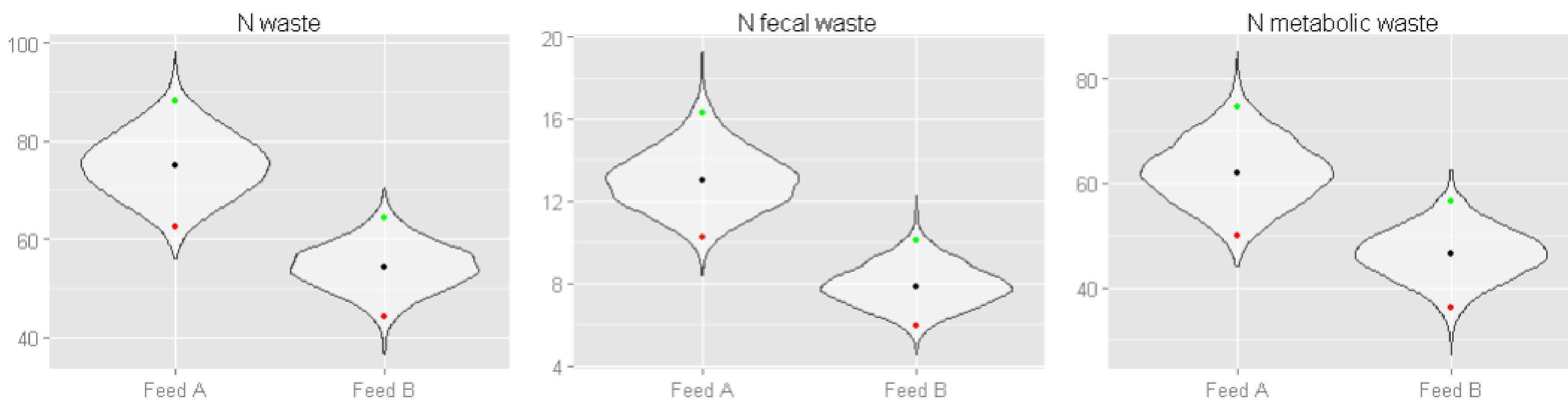
Feed B





WASTEst - Example

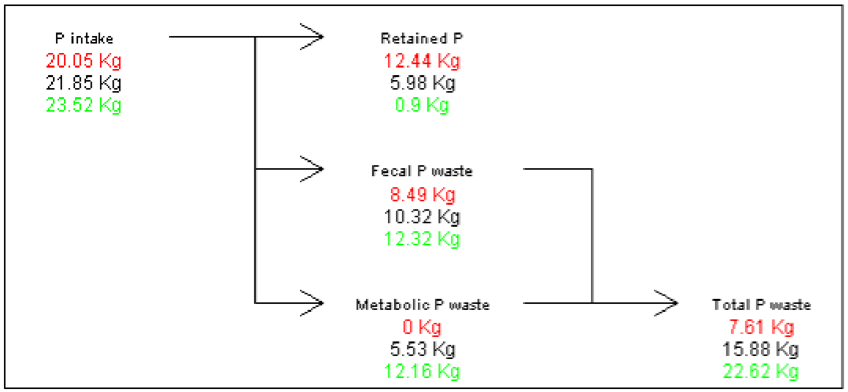
Summary | Total waste | N waste | P waste | Advanced



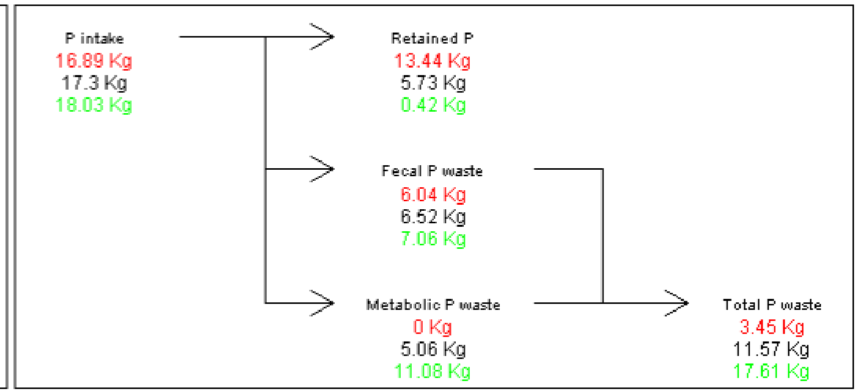
WASTEst - Example

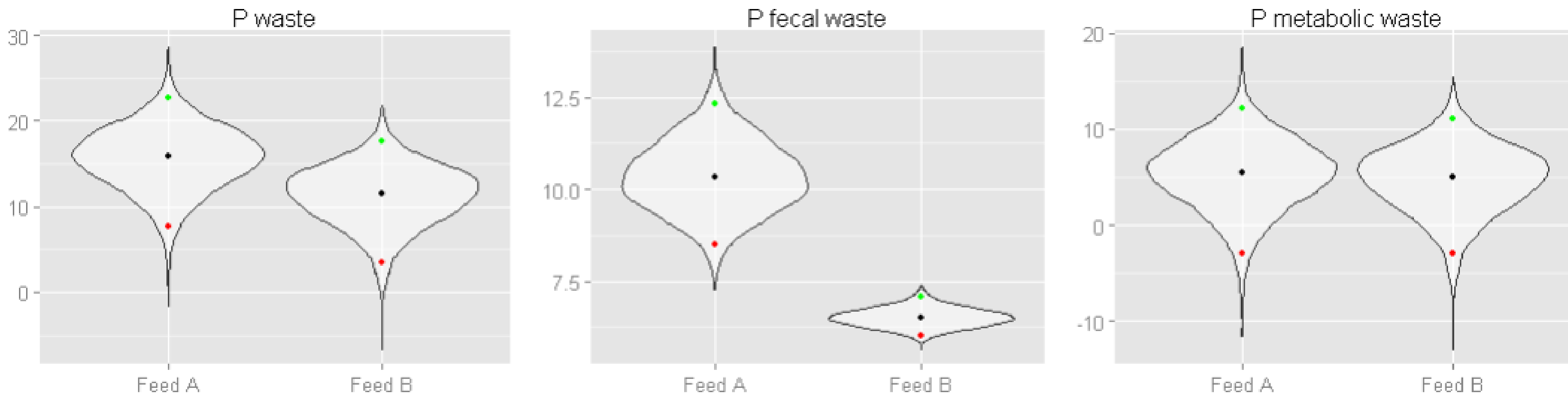
Summary | Total waste | N waste | P waste | Advanced

Feed A



Feed B

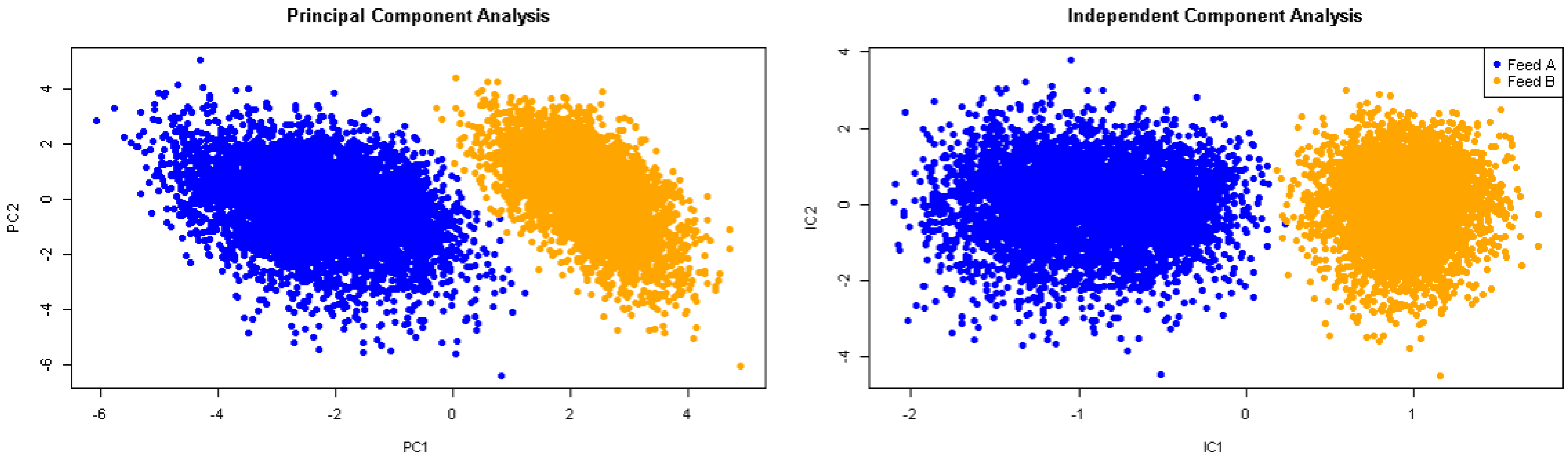




WASTEst - Example

Summary | Total waste | N waste | P waste | Advanced

Overlap between 95% confidence ellipsoids: 0%



*Is the **overall waste pattern** of Feed A different from Feed B?*

WASTEst - Example

Growth performance
Diet composition

WASTEst

Feed A and Feed B display a distinct waste pattern
Total waste
Ash-free waste
N fecal waste
P fecal waste

Dynamic fish models

3. Biochemical/metabolic models:
e.g., FEEDNETICS

Based on a “reaction” model

System of differential equations solved numerically

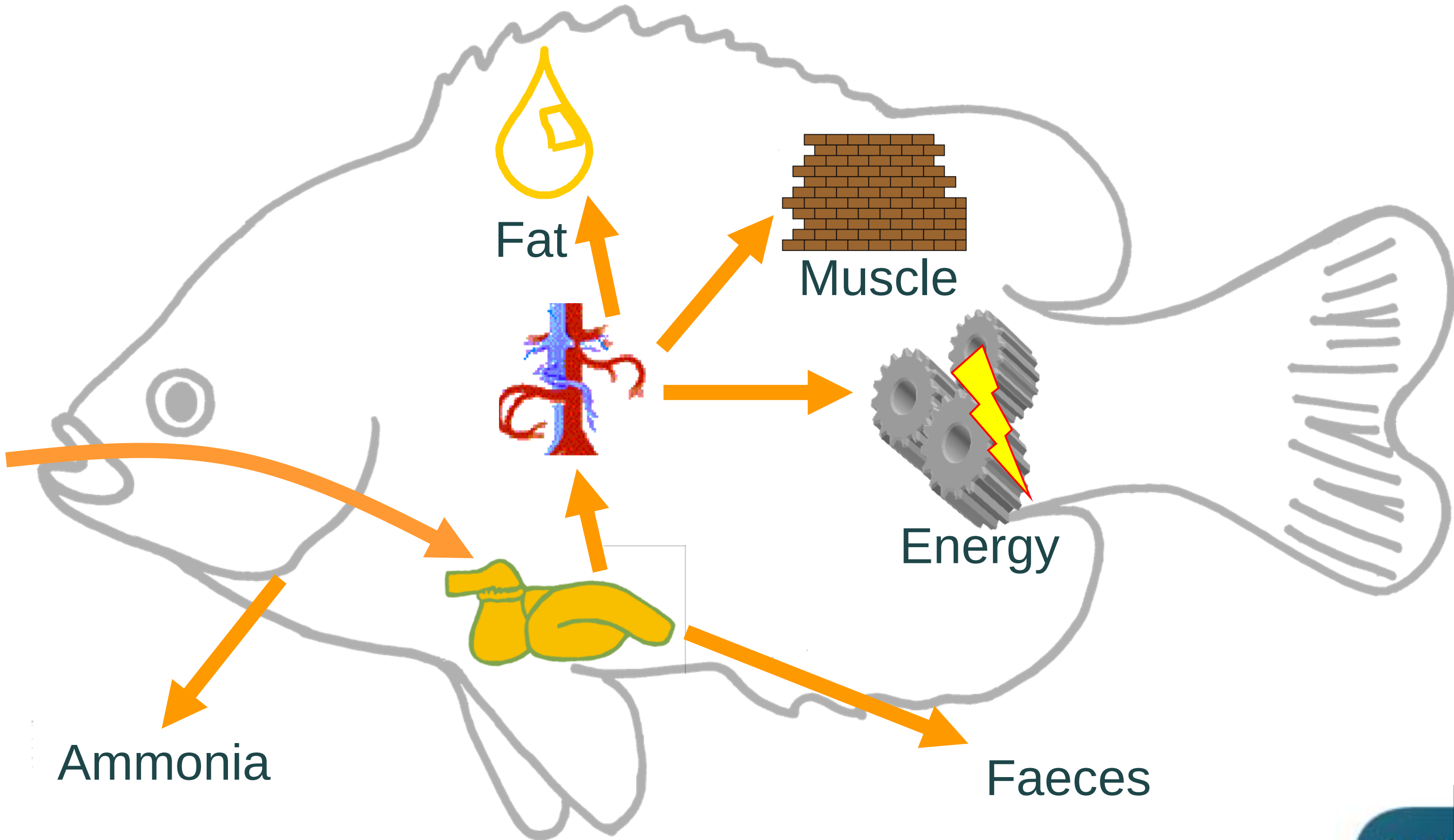
FEEDNETICS - Objective

A computer application to assess/predict nutritional and environmental effects on:

- Growth
- Carcass composition
- Environmental impacts
- Production (feed) costs

Tailoring your feeds

Dynamic fish models



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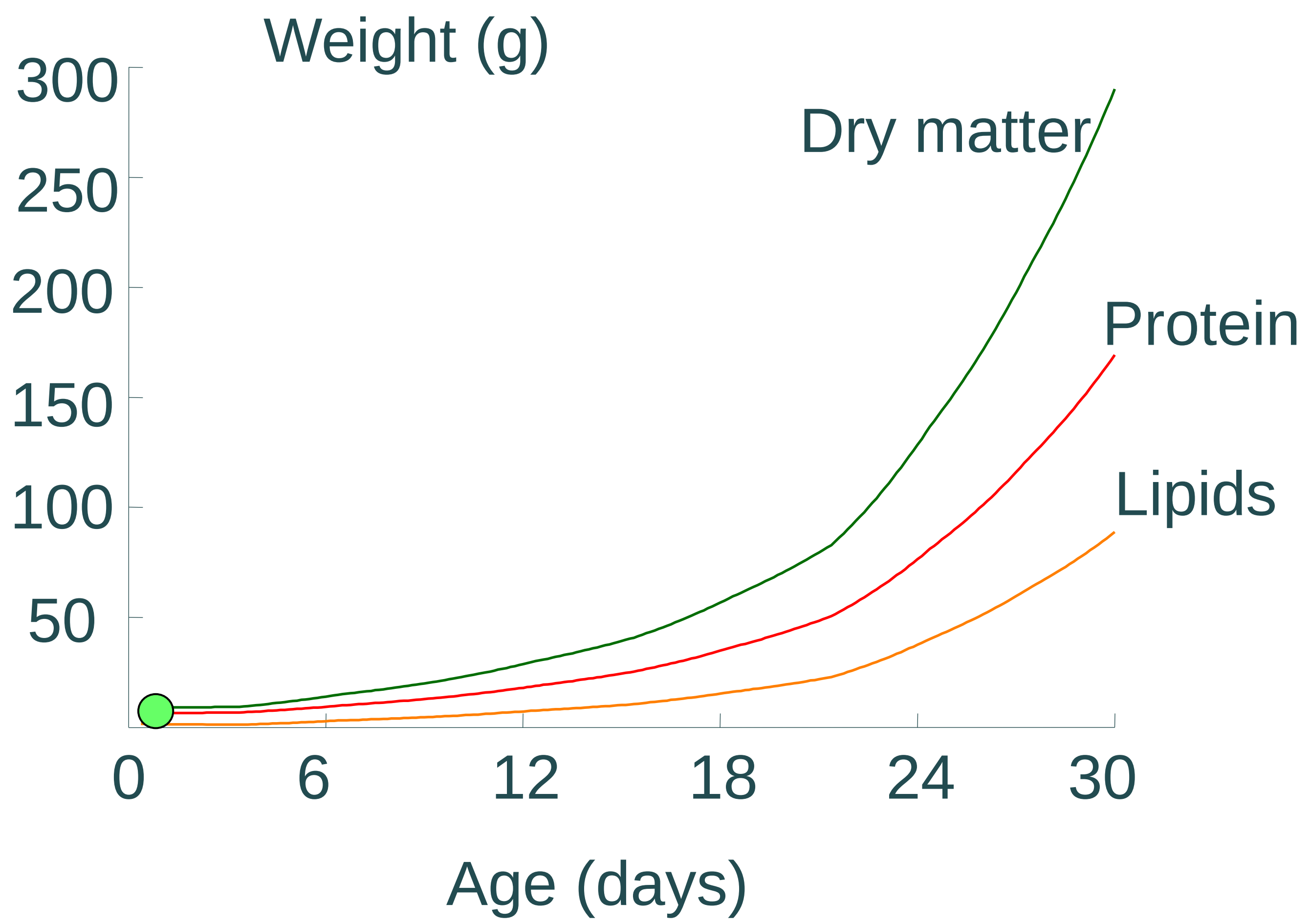
FEEDNETICS – a dynamic fish model



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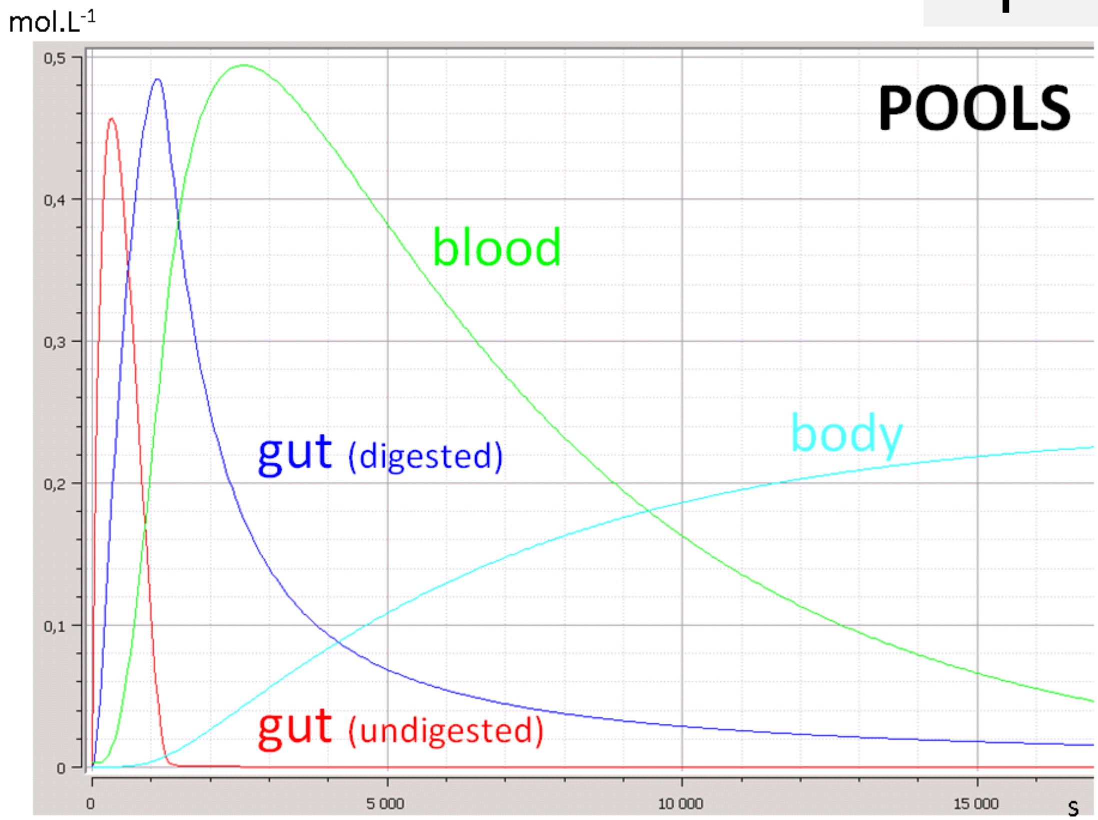
Dynamic fish models

- **FEEDNETICS (in practice...)**

pool1(t)
pool2(t)
pool3(t)

initial conditions
+
temperature profile
+
nutrient inputs



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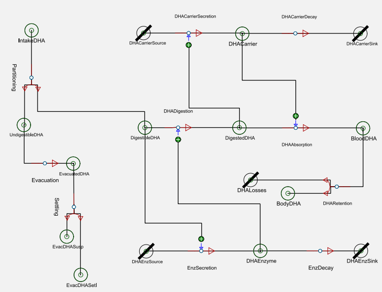
Dynamic fish models

- **FEEDNETICS (in practice...)**

t
$weight_0$
temperature(t)
feed(t)

inputs

model



...

(many) parameters

weight(t)
composition(t)
waste(t)

outputs

Model parameters

- Initial fish size
- Temperature
- Feed ration (feeding table)
- Feed composition (protein, lipid, AA, FA)
- Feed digestibility (protein, lipid, CH)
- Biochemical coefficients for protein & lipid breakdown, protein & lipid synthesis, etc
- Metabolic rate (maintenance)

Tailoring your feeds

Model simulation

- Initial body weight: 180 g
- 3 Diets: 50 CP / 20 CL
  - FM => Fish meal based (32%)
  - PP60 => 60% of FM replaced
  - PP100 => 100% of FM replaced
- Trial duration: 90 days
- Temperature: 18-24 °C
- Ration
  - FM: 0.78%BW
  - PP60: 0.72%BW
  - PP100: 0.72%BW

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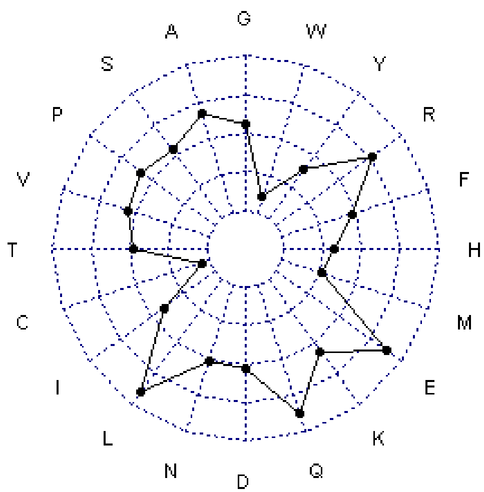
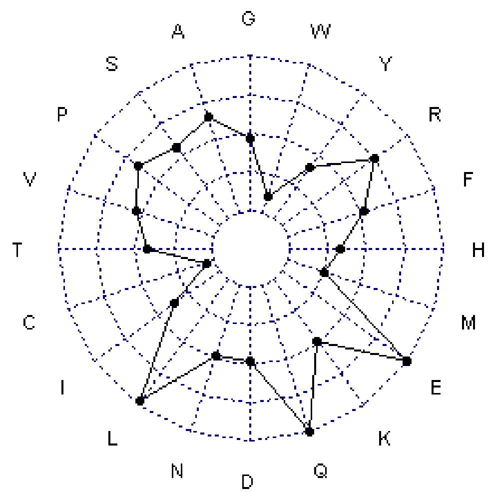
Tailoring your feeds

Diet amino acid contents

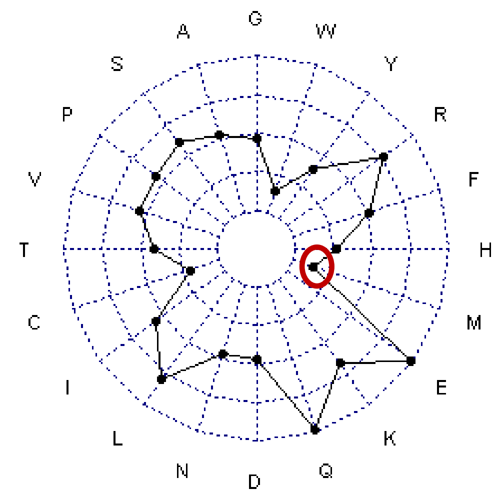
FM



PP60



PP100



- **FM and PP60 meet all estimated AA requirements for seabream**
- **PP100 slightly deficient in Met**

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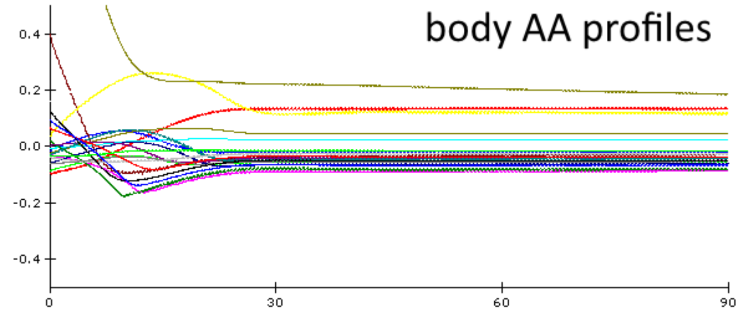
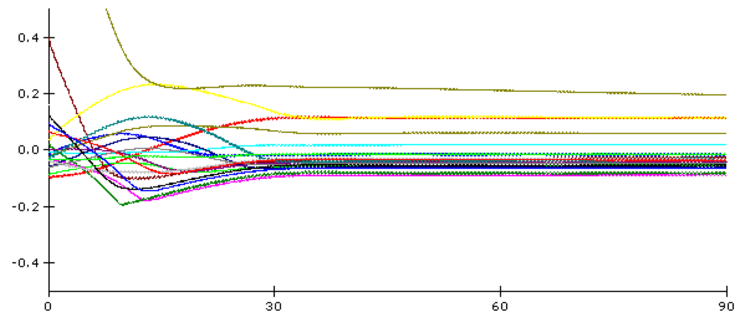
Tailoring your feeds

Model Output

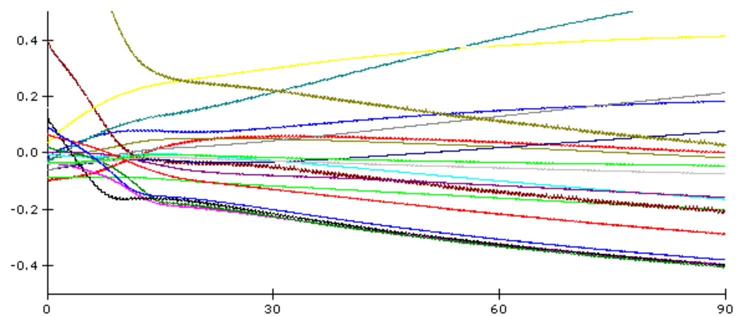
FM



PP60



PP100



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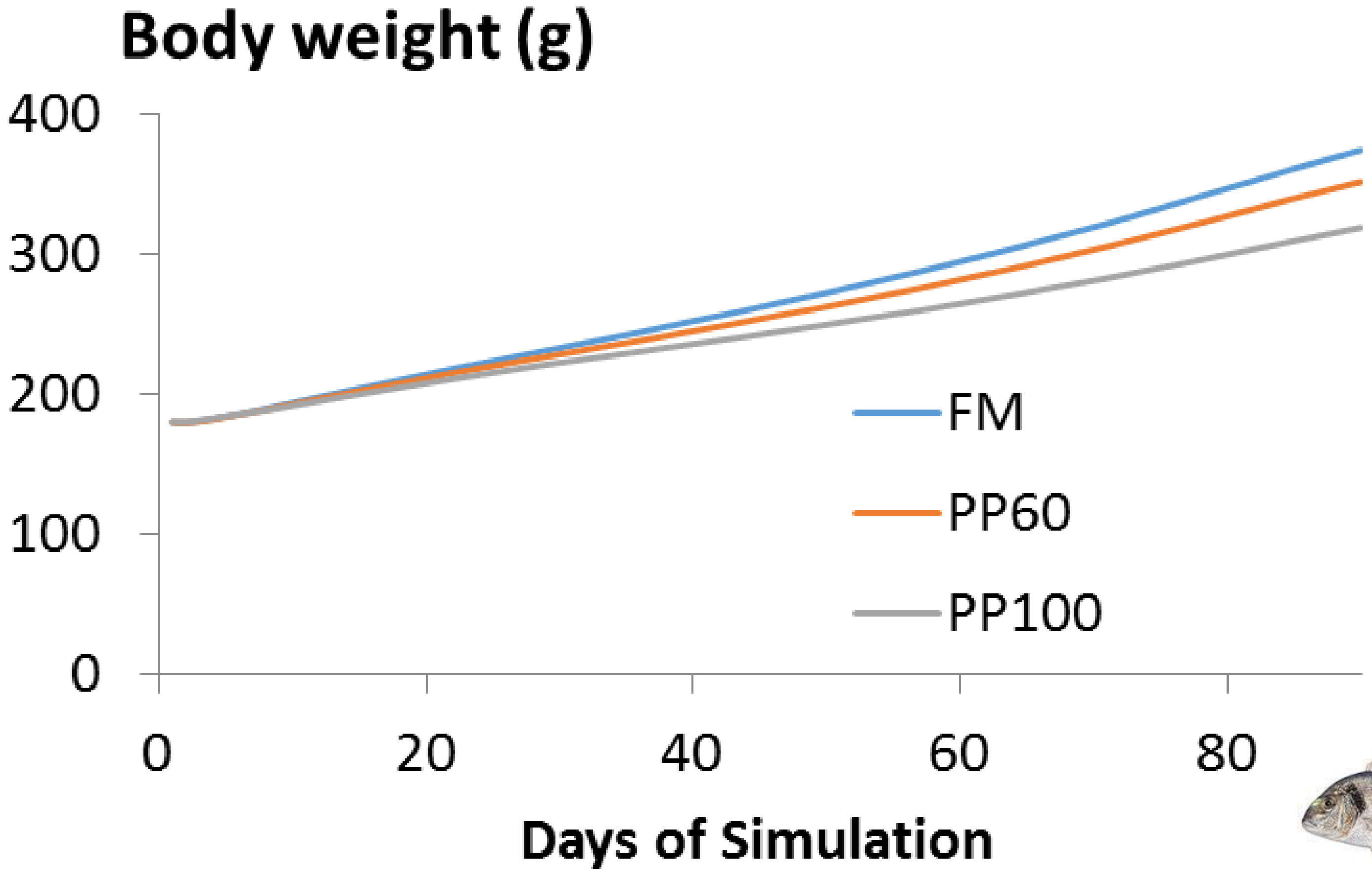
Tailoring your feeds

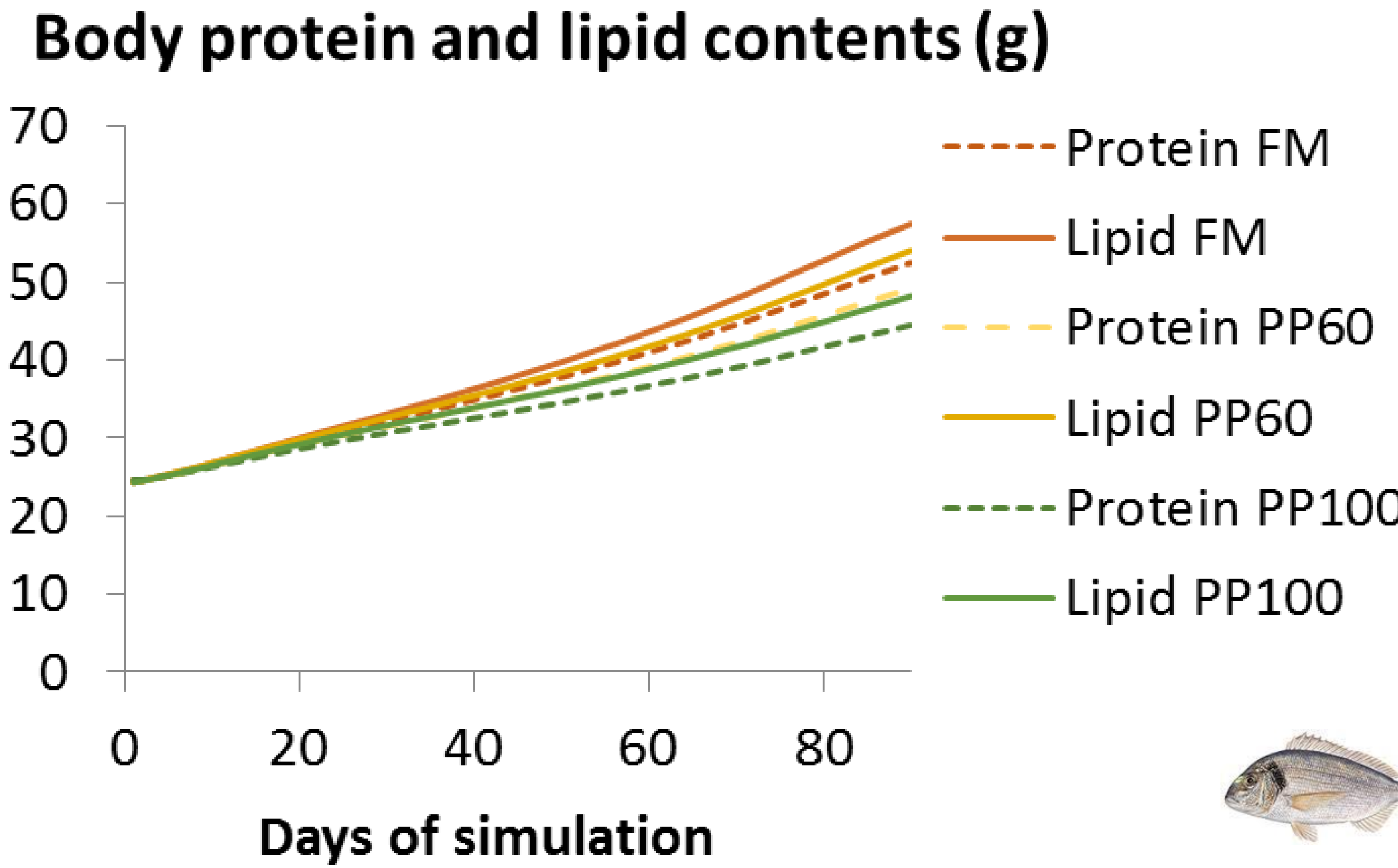
Model Output



sparos I&D nutrition in aquaculture

Tailoring your feeds

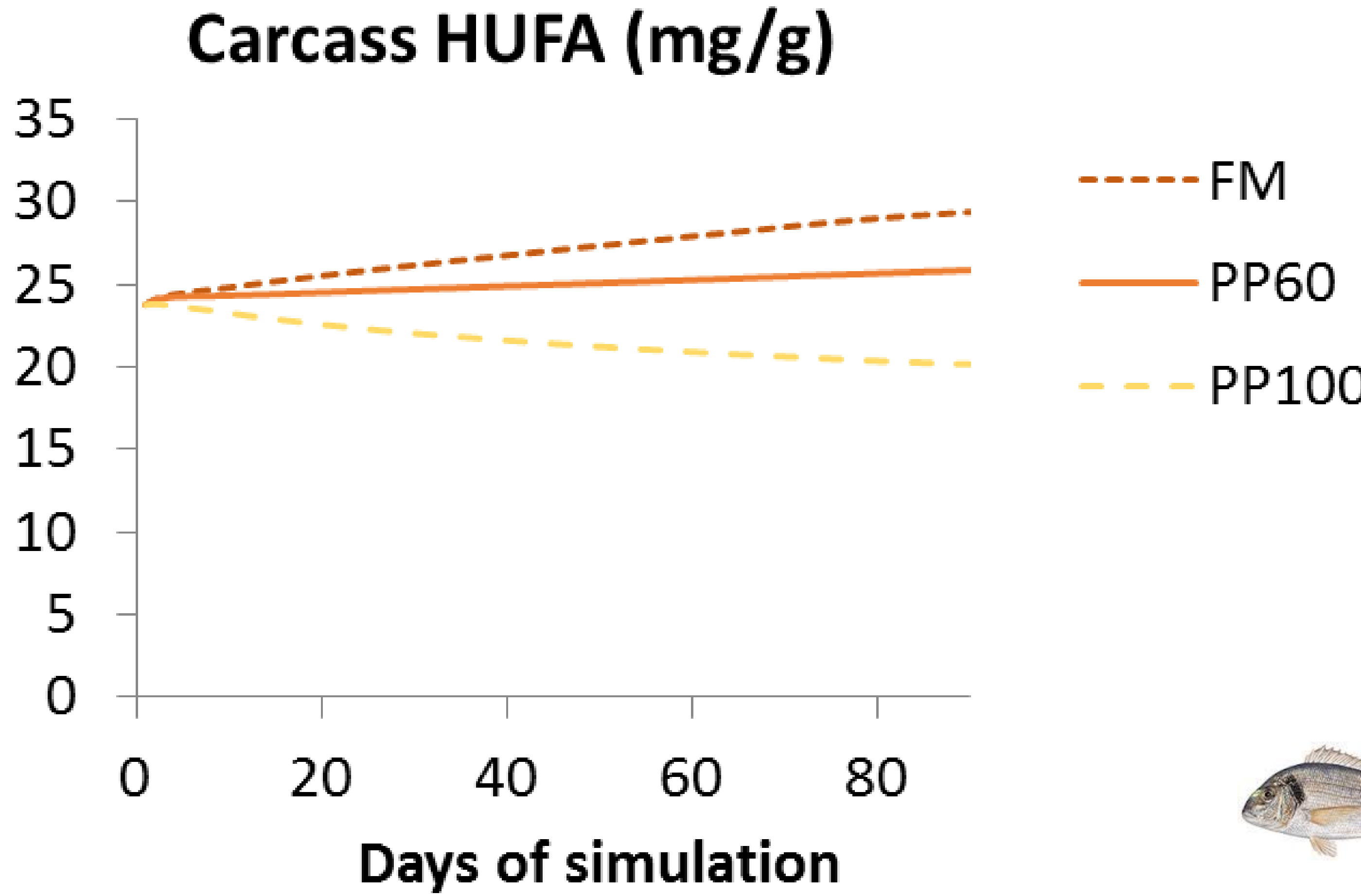
Model Output



sparos I&D nutrition in aquaculture

Tailoring your feeds

Model Output



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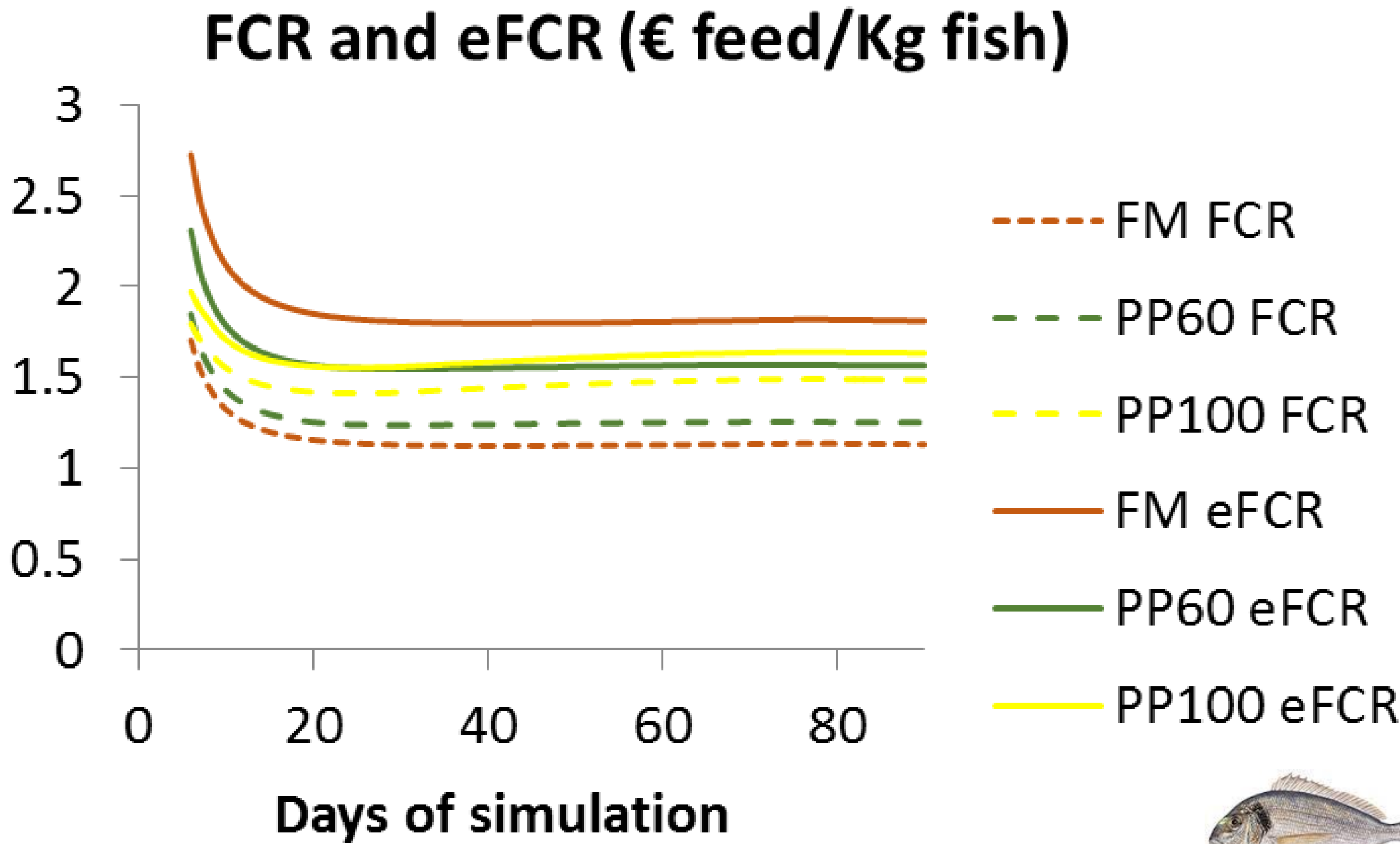
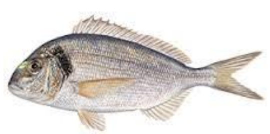
Tailoring your feeds

Model Output



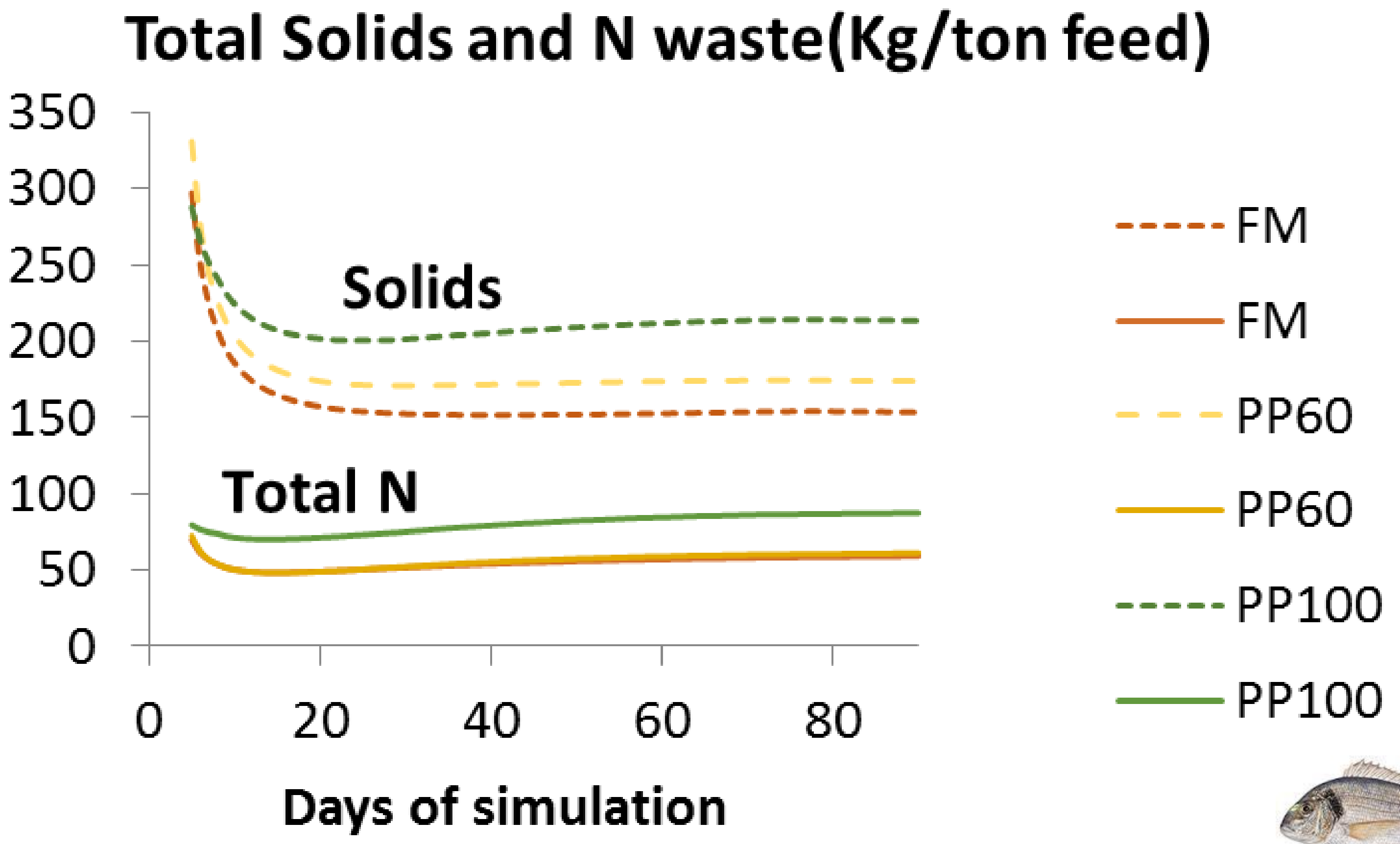


Feed costs (€/ton): FM – 1600; PP60 – 1250; PP100 – 1100

sparos I&D nutrition in aquaculture

Tailoring your feeds

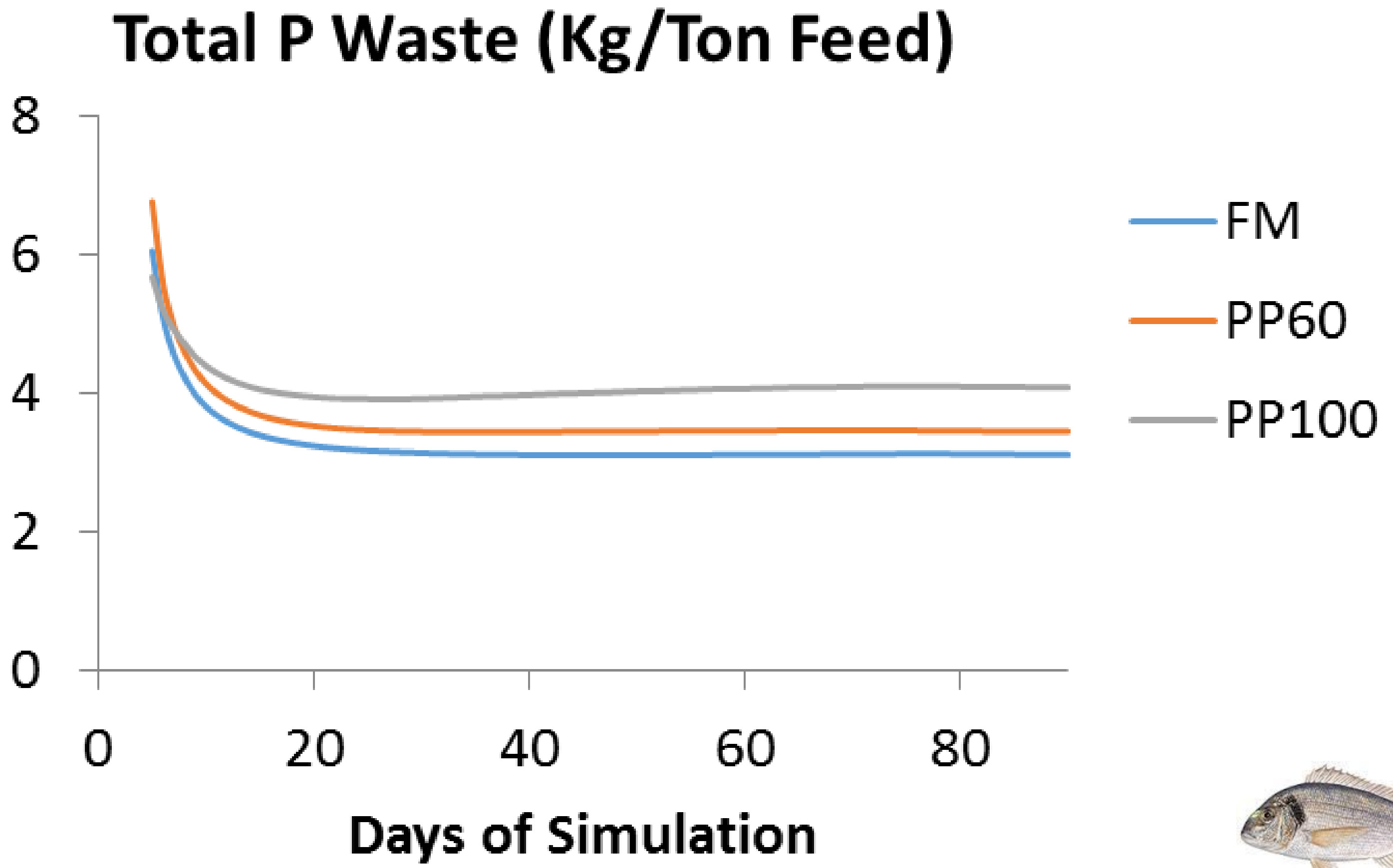
Model Output



sparos
I&D nutrition in aquaculture

Tailoring your feeds

Model Output



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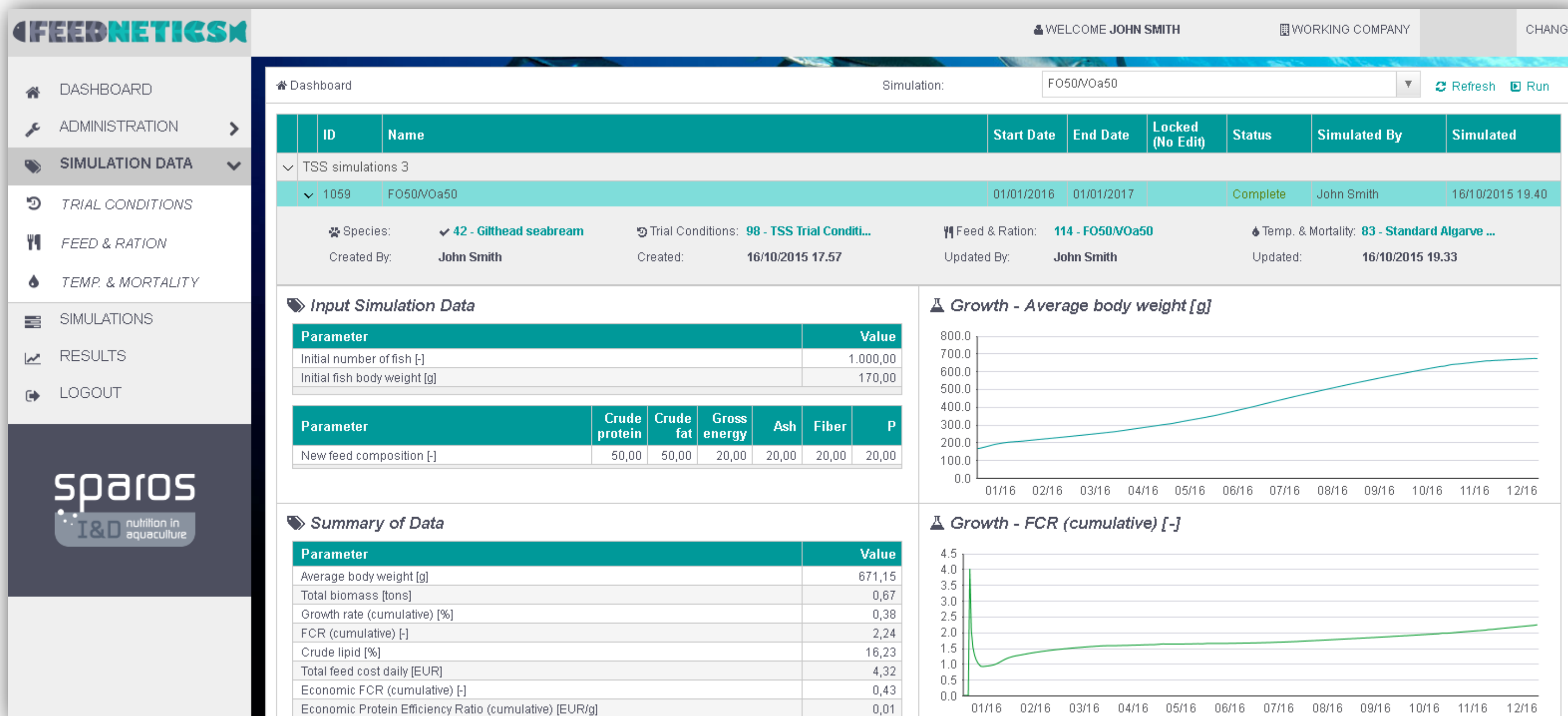
Tailoring your feeds

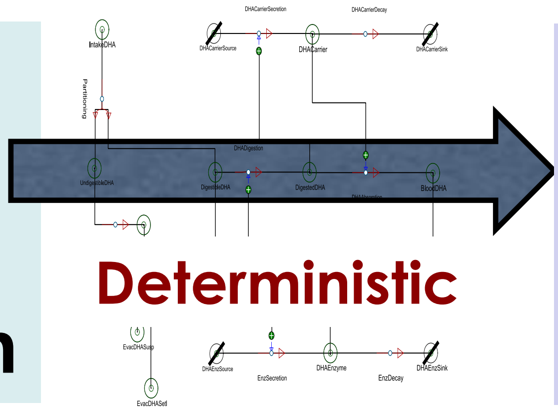
Web application



Tailoring your feeds

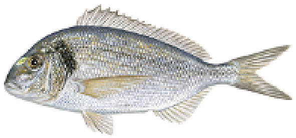
FEEDNETICS today

weight$_0$
temperature(t)
feed amount(t)
feed formulation



weight(t)
composition(t)
waste(t)
Cost

- Compare formulations to optimize feed cost and growth performance
- Compare performance of formulations in different temperature profiles
- Adjust feeding to meet growth targets
- Predict effects of restrictive feeding on growth performance and FCR



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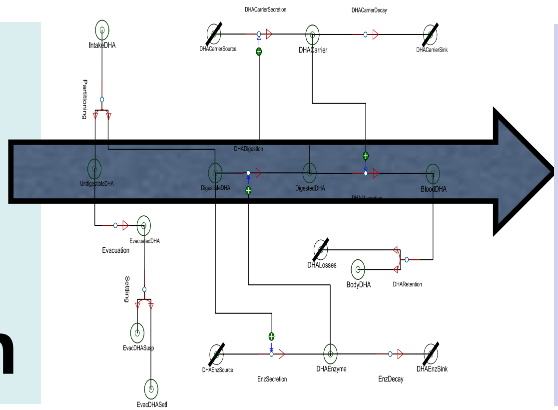
FEEDNETICS in progress

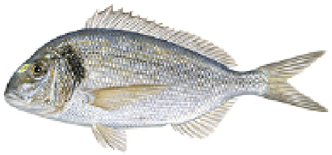
weight$_0$
temperature(t)
feed amount(t)
feed formulation



weight(t)
composition(t)
waste(t)
Cost

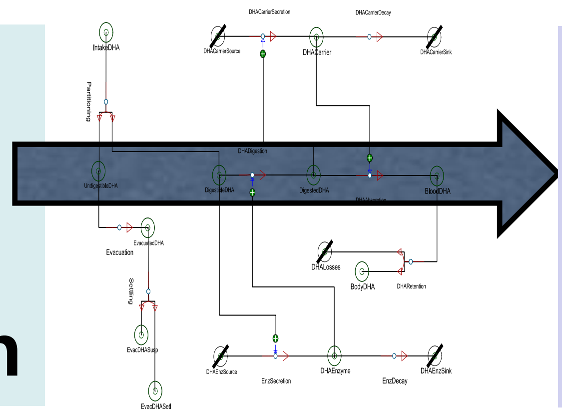
- Predict formulation and/or feeding to reach a given growth target and composition

- Expand to trout and seabass



FEEDNETICS in progress

Wisefeed

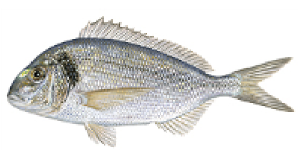
weight$_0$ temperature(t) feed amount(t) feed formulation		weight(t) composition(t) waste(t) Cost

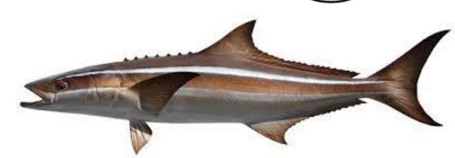
- Refine digestion & metabolism modules
- Create a new feed intake module
- Expand to Salmon and Cobia

ICMAN Instituto de Ciencias Marinas de Andalucía

CSIC Consejo Superior de Investigaciones Científicas

Universitas Bergensis



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Tailoring your feeds

Model use

- model design
- calibration
- simulations
- validation

→

- Knowledge Integration
- **Prediction**
- Sensitivity analysis

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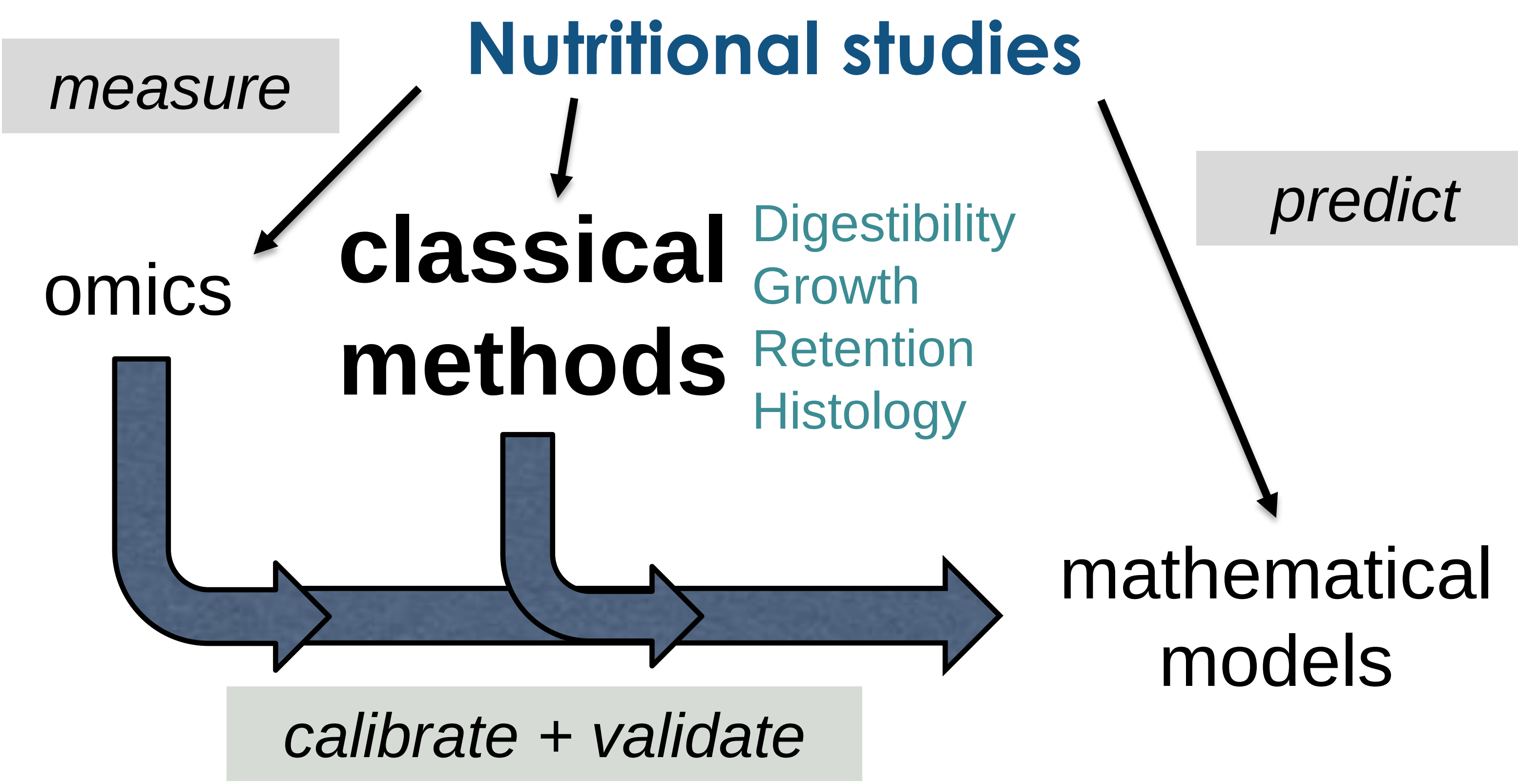
The future ?


Nutritional studies
measure
omics
classical methods
Digestibility
Growth
Retention
Histology
predict
mathematical models
calibrate + validate

Tailoring your feeds

Conclusions

- **Modelling tools** are useful to assess and quantify the effect of changes in aquafeed formulations on performance and environmental impact

- **WASTEst** provides waste output estimates based on incomplete data, but also by making the best of the data obtained from experiments
    - It also gives reliable confidence intervals on estimations when more detailed data on nutrient digestibility are available
    - It is a valuable tool to compare environmental impacts of alternative feed formulations

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Tailoring your feeds

Conclusions

- **FEEDNETICS** is able to generate a realistic prediction of concrete scenarios:
  - interactions between feeding level, feed formulation and water temperature.
  - accurately predicts performance differences due to dietary amino acid imbalances.
  - It may be used to optimize feed formulations and feeding regimes.

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Thanks for your attention!

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Wisefeed

FEEDNETICS

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