New developments in feeds for recirculating aquaculture systems

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Aquaculture Innovation Workshop - 04 December 2018

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Skretting's history in RAS

2004

Skretting files global patent on faecal binders in fish feed

2009

Launch of first ever commercial RAS feed – Nutra RC for salmonids

2012

Launch of RecircReady concept – focus on raw materials suited for RAS feeds

2015

Development of models to predict waste output in RAS

2017

Established state-of-the-art RAS research facilities at Lerang Research Station in Norway

2018

New RecircReady concept

marineharvest

Grieg Seafood

Cooke AQUACULTURE Inc.

RIVERENCE

KUTERRA
SUSTAINABILITY HAS LANDED

New York STEELHEAD
HUDSON VALLEY Fisheries

USDA Agricultural Research Service

SUPERIOR fresh

LITTLE CEDAR FALLS

Responsibly Raised Fresh Atlantic Salmon
Cape d'Or Salmon
ORGANIC
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AquaBounty CANADA

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RAS Global Multidisciplinary Team

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RAS R&D facilities

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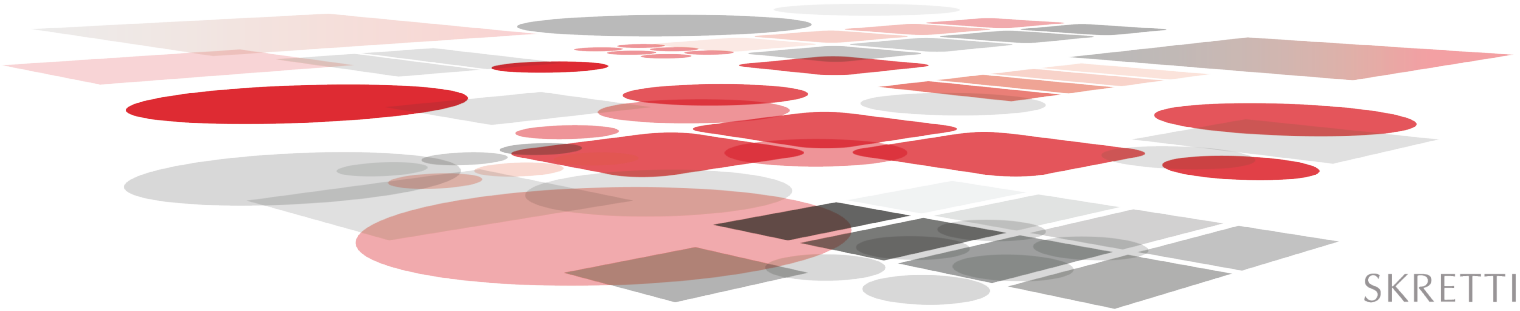
RECIRC READY



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Feed solutions

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Specific needs for RAS diets

1. Flexible choice **raw materials** and exact composition and digestibility of **nutrients**
2. Good **physical quality** optimised for the system
3. **Easy removal of faeces** to reduce load on the biofilter

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Raw materials and nutrients

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Formulating RAS diets requires exact nutritional values

- RAS diets should cover nutritional needs and excess of nutrients should be minimised
- Both the digestible and the indigestible fraction of nutrients must be considered
- Real/time analytical tools are required to monitor exact nutritional value of raw materials (NIR)

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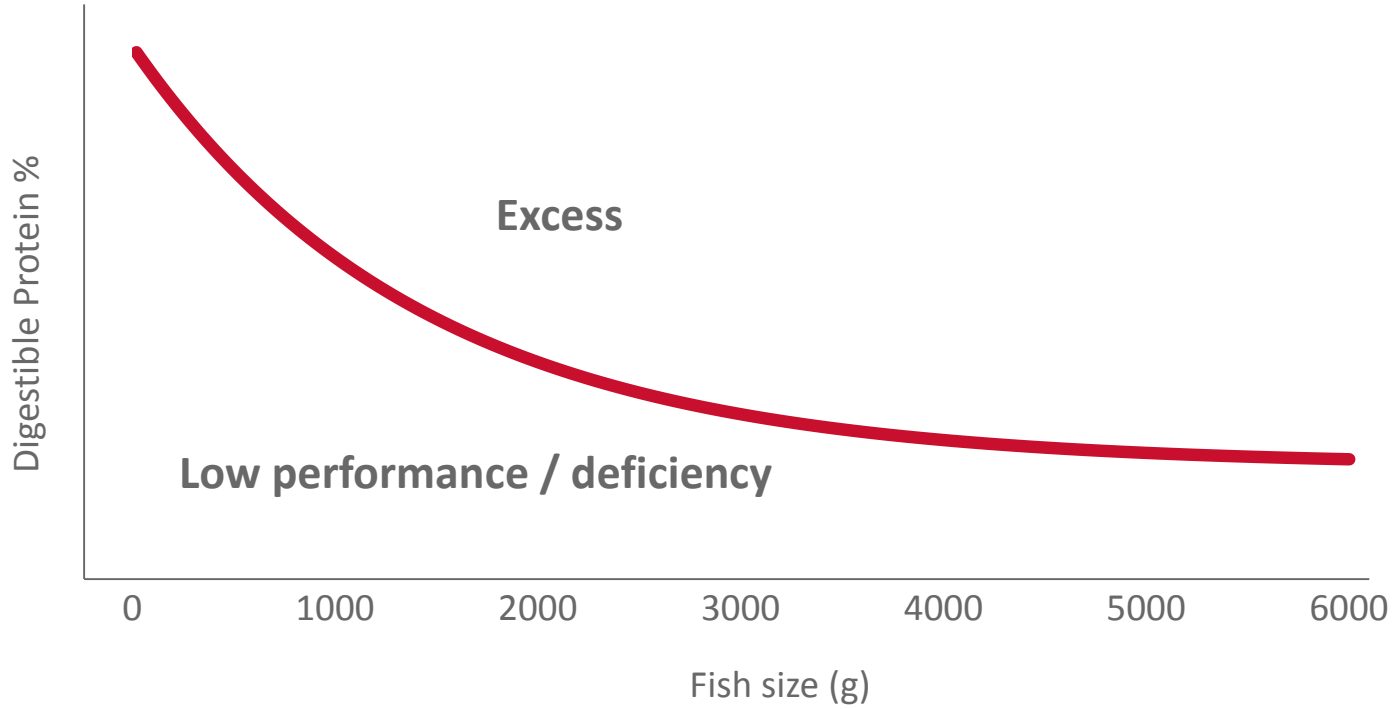
Digestible protein requirement in Atlantic salmon



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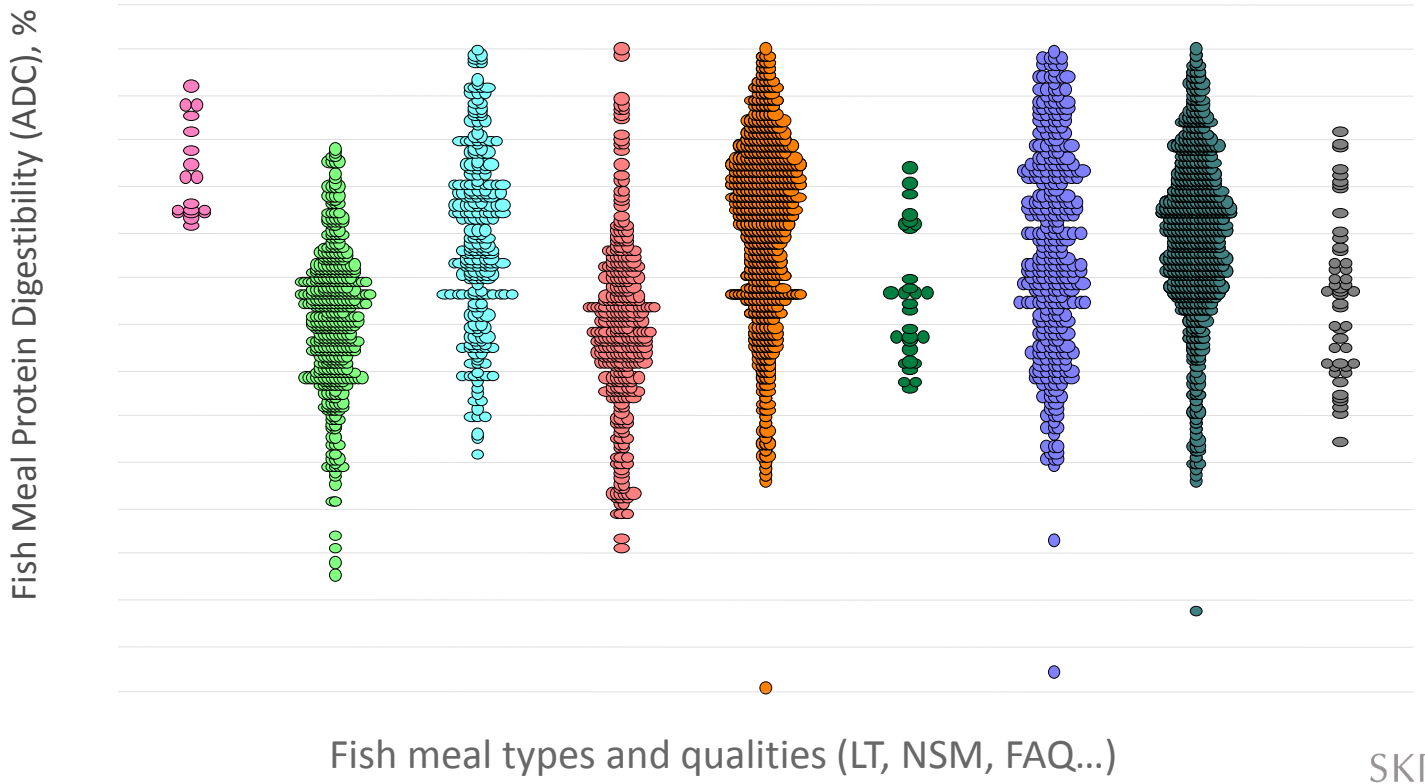
Protein Digestibility in Fish Meal - ADC (%)



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NIR - Near Infra-Red spectrometry

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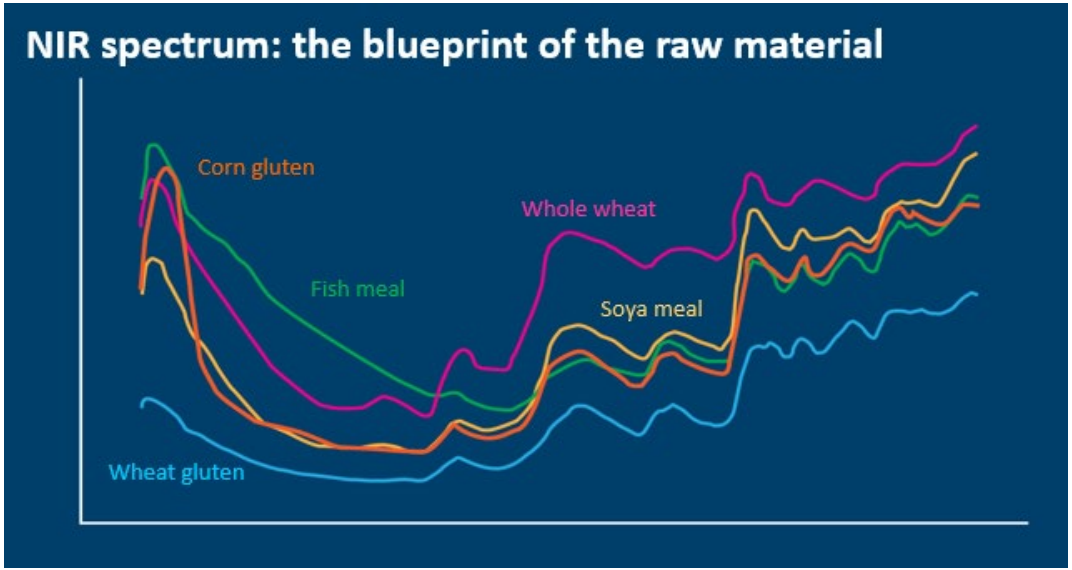
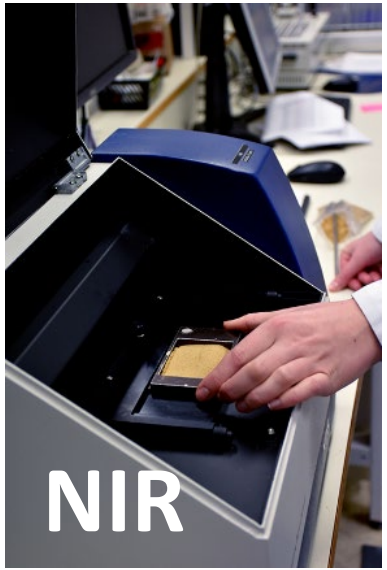
Near infrared spectrometry (NIR) is an accurate and rapid method to analyse both raw materials, feeds and fish





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NIR analyses of raw materials and complete feed

Fish meal
Tuna meal
Krill meal
Squid meal
Shrimp meal
Crustacean meal
Tilapia meal

Poultry meal
Feather meal
Blood meal
Meat meal

Fish oil
Rapeseed oil
Soybean oil
Poultry oil

Canola meal
Corn gluten
Corn DDGS
Cotton meal
Faba bean
Guar meal
Guar Korma meal
Lupine meal
Pea meal
Peanut cake
Rice bran
Rice protein concentrate
Soybean meal
Soya protein concentrate
Sunflower meal
Sunflower protein concentrate
Wheat
Wheat gluten
Wheat middlings
Wheat DDGS

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NIR analyses of raw materials and complete feed

Protein
Fat
Moisture
Ash
Starch
Crude Fibre
Water soluble protein
Protein digestibility (ADC)
Arginine
Cystin
Histidine
Isoleucine
Lysine
Methionine
Serine
Proline
Threonine
Valine

Cholesterol
FFA
Choline
Inositol
Calcium
Calcium
Phosphorus
Total Volatile Nitrogen
Particle size
Bulk Density
C14:0, C16:0, C18:0
EPA
DHA
Sum saturated FA
Sum monoenes
Sum n-6 FA
Sum n-3 FA
Free fatty acids

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Pellet Quality

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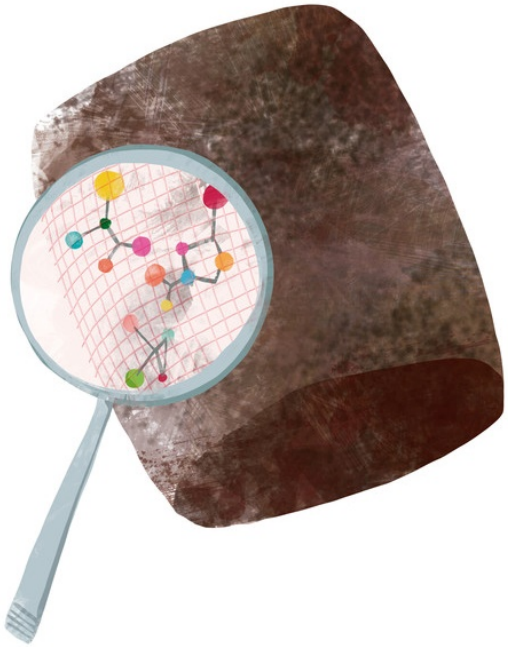
Parameters to define pellet physical quality



- Durability
- Fat leakage
- Water stability
- Sinking speed

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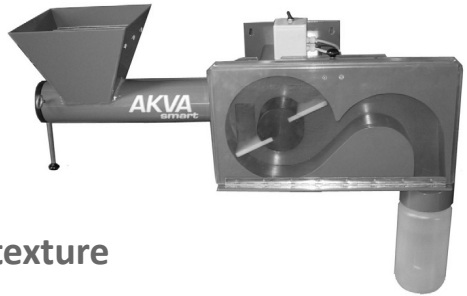
Evaluation of physical quality of feed

Durability (Doris & Holmen) and texture



Fat leakage

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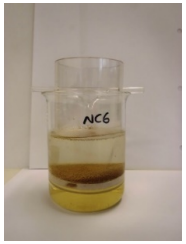
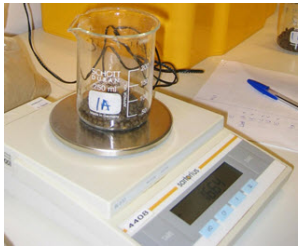
Evaluation of physical quality of feed

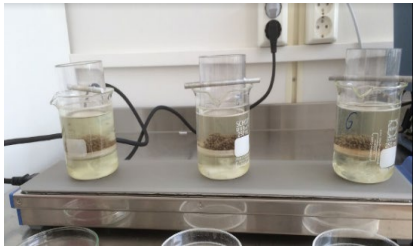
DM loss test (>24 hours)







Turbidity (< 30 min)

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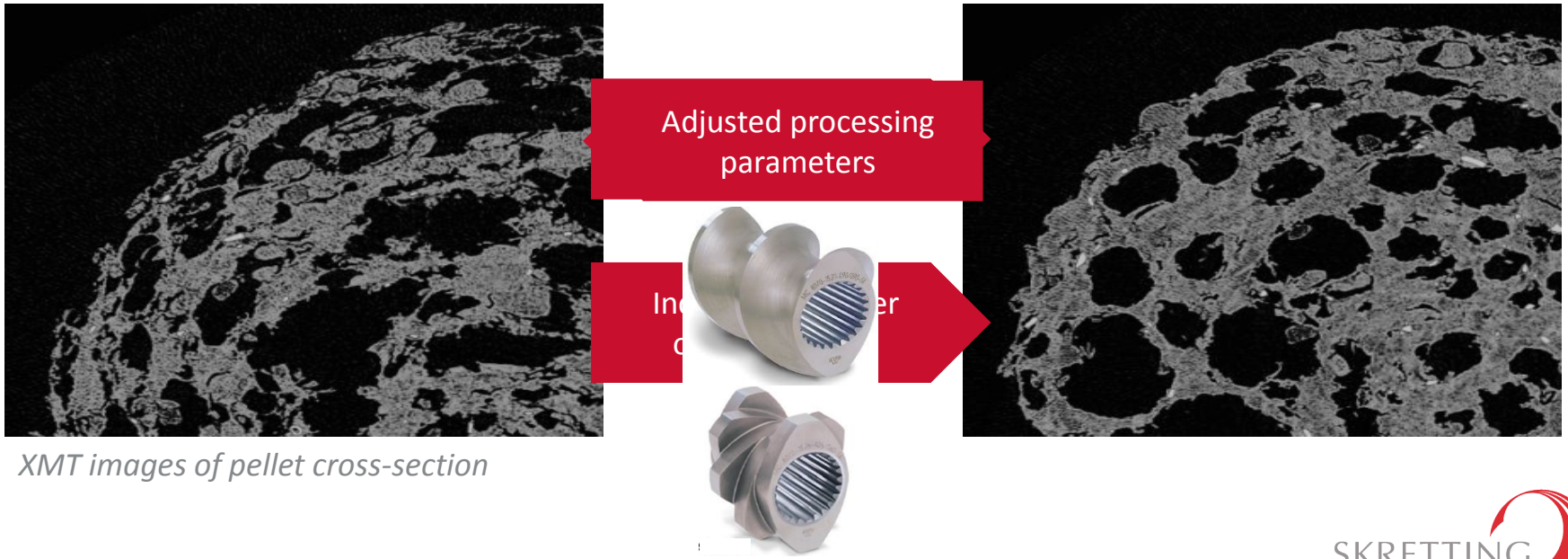
Raw materials, process and physical quality

Raw materials can change the technological properties of feed such as pellet strength and oil uptake. This can be controlled by adjusting processing parameters.



XMT images of pellet cross-section

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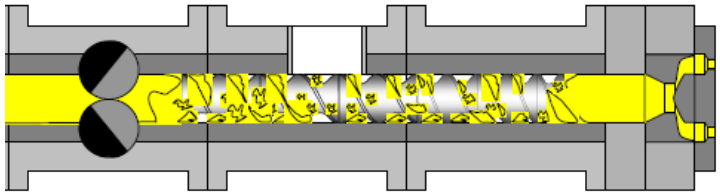
Effect of raw materials on process and durability

Raw material	Process Parameter					Physical Quality
	Moisture addition	Specific Mechanical Energy	Die pressure	Radial Expansion	Axial Expansion	Durability
RM 1	↑	↑	↑	↑	↑	—
RM 2	↑	—	—	↑	↓	↑
RM 3	↓	↓	↓	—	—	↓
RM 4	↓	↓	↓	—	—	↑
RM 5	↓	↓	↓	—	—	↑



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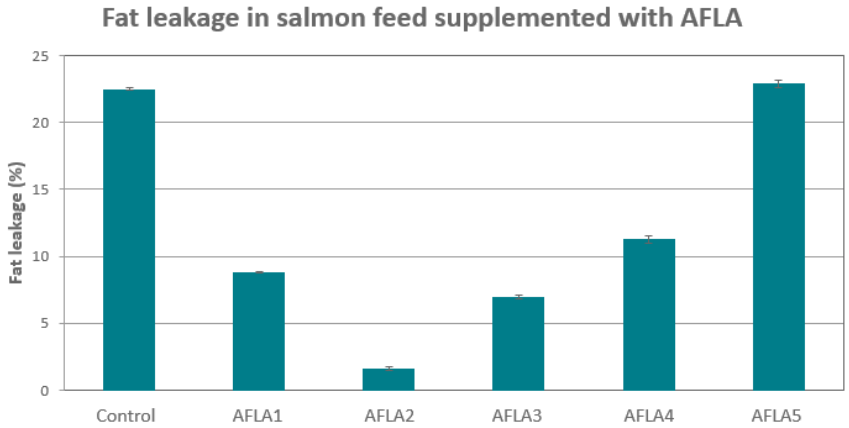
Fat leakage prevention in RAS diets

Factors that affect fat leakage:

- Amount of oil
- Fatty acid composition
- Temperature during transport of feed
- Temperature during storage of feed
- Handling of feed

Factors that prevent fat leakage:

- Amount of anti-fat leakage agent (AFLA)
- Type of AFLA
- Processing (grinding, extrusion, drying, coating, cooling)



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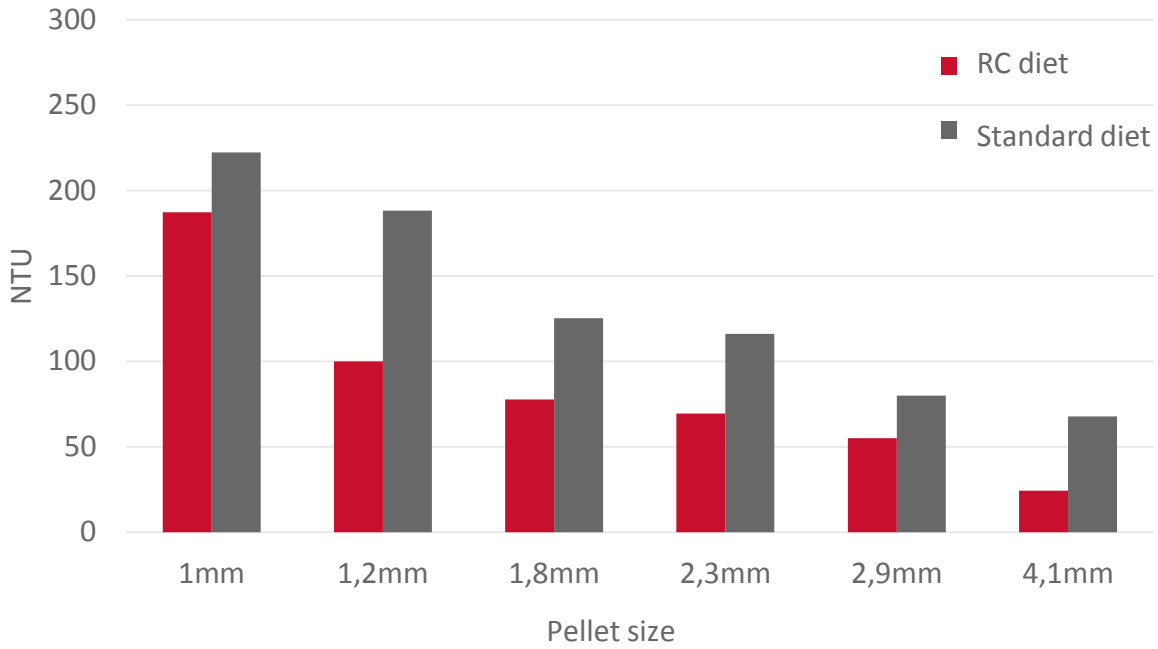
Water stability and sinking speed

Turbidity RC and standard feed



Sinking time RC and standard feed

RC feed

Standard feed

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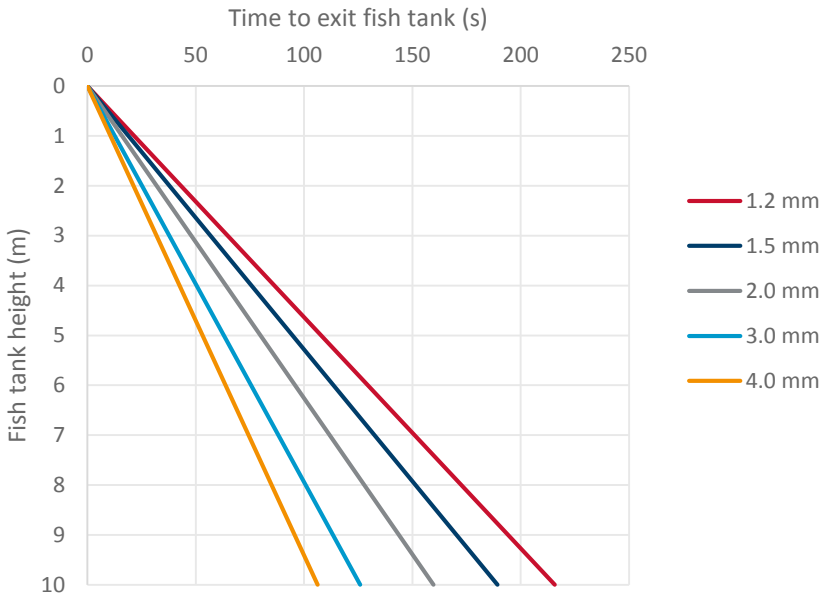
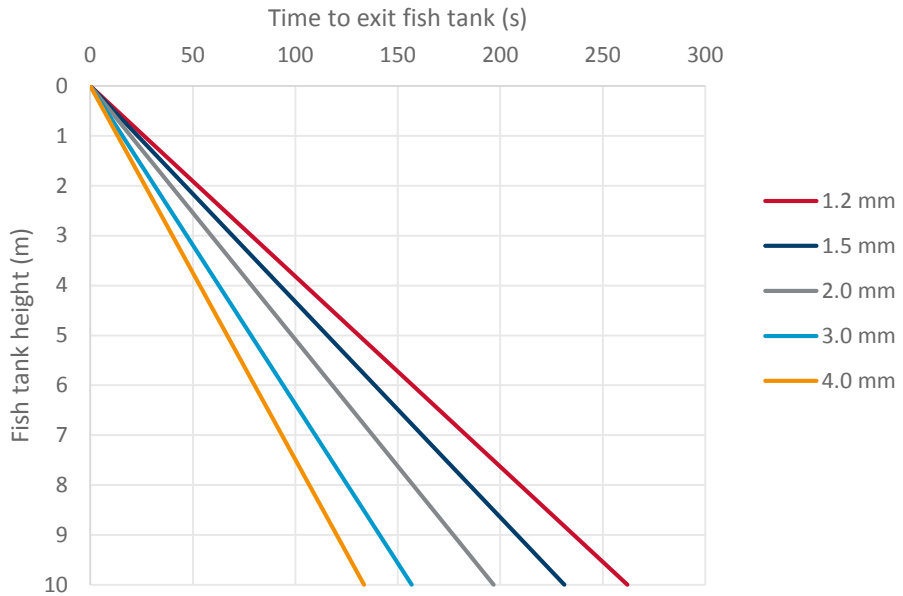
Time to exit tank

Time to exit fish tank of RC pellets of different sizes in freshwater



Time to exit fish tank of RC pellets of different sizes in seawater



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Faeces Quality

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Importance of faecal stability in RAS

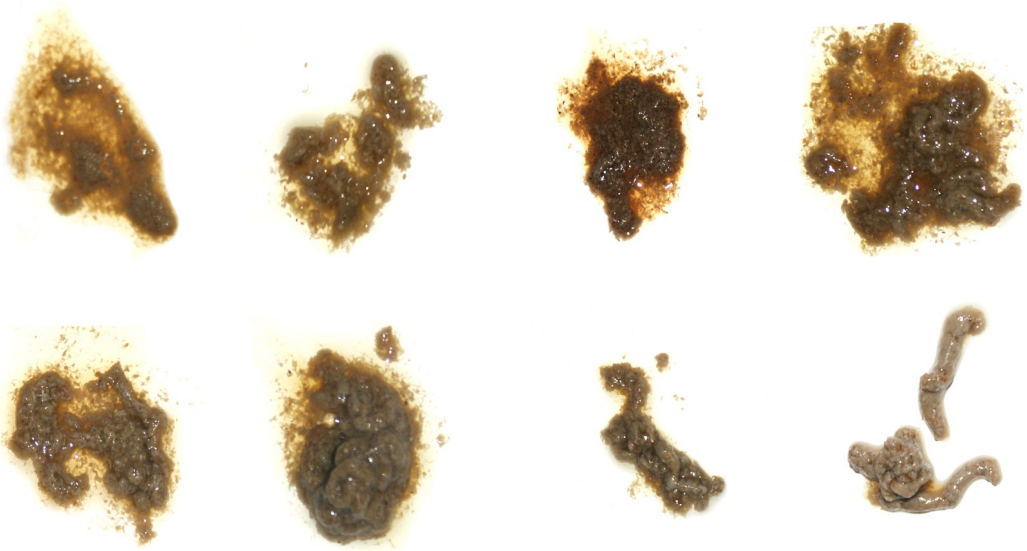
Stable faeces

less suspended solids

Less N, P and C

Cleaner tanks

Reduced turbidity



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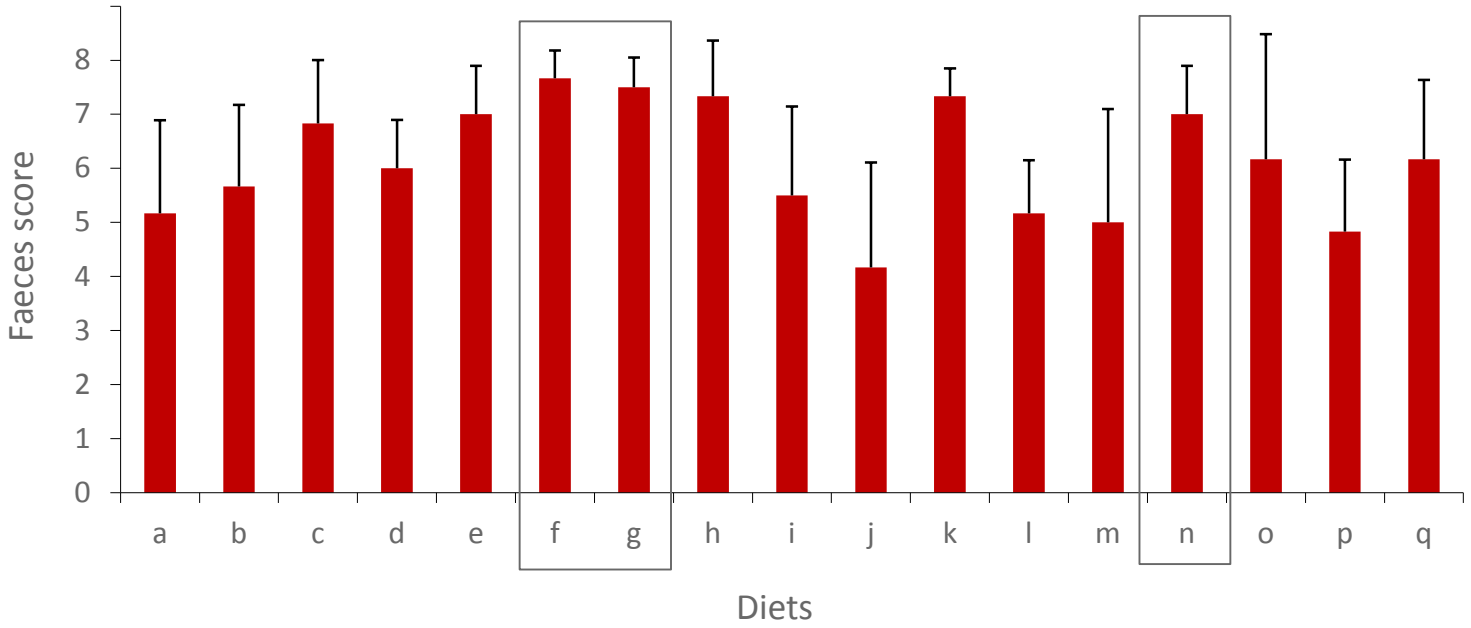
Faeces scoring of diets with different ingredients



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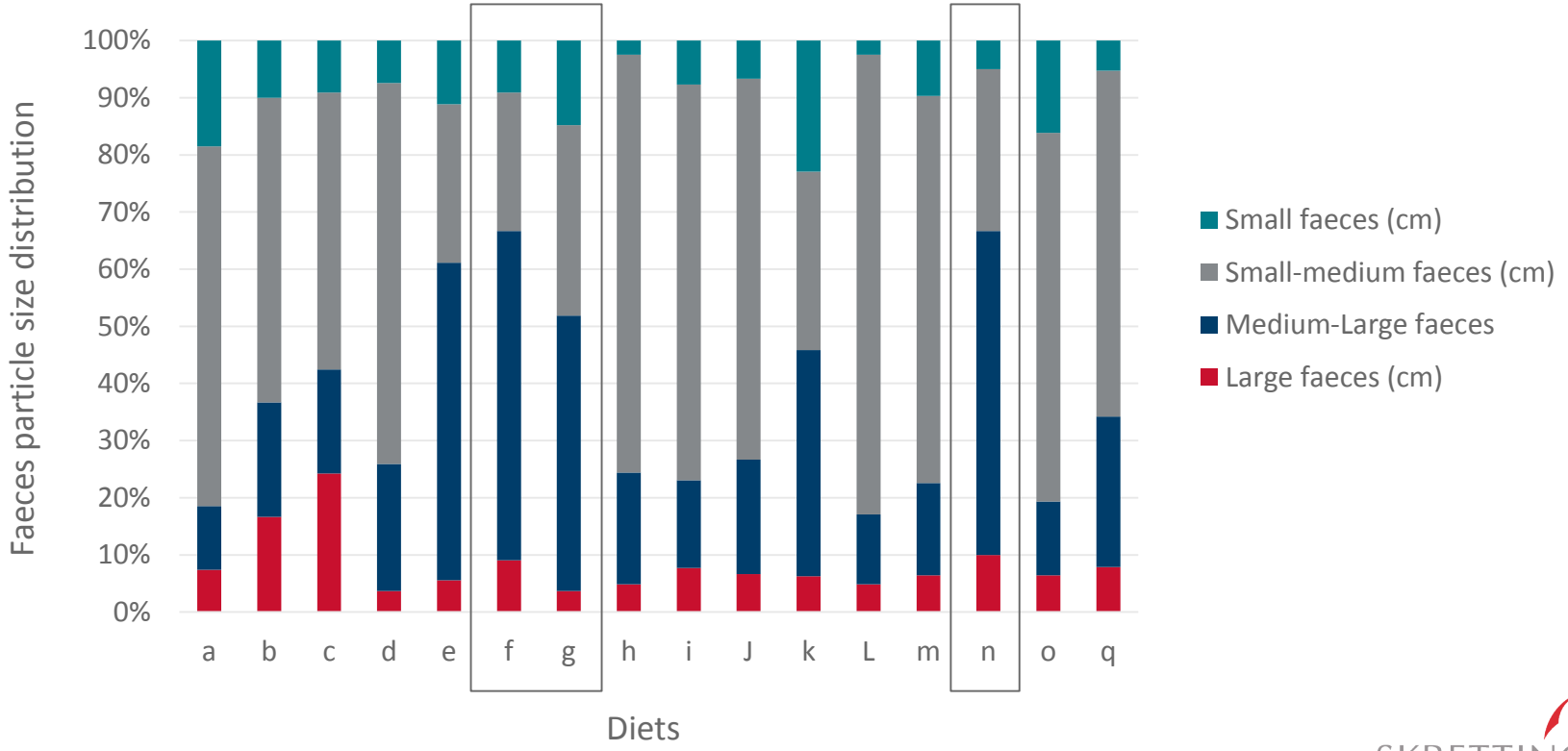
Faeces particle size distribution with different ingredients



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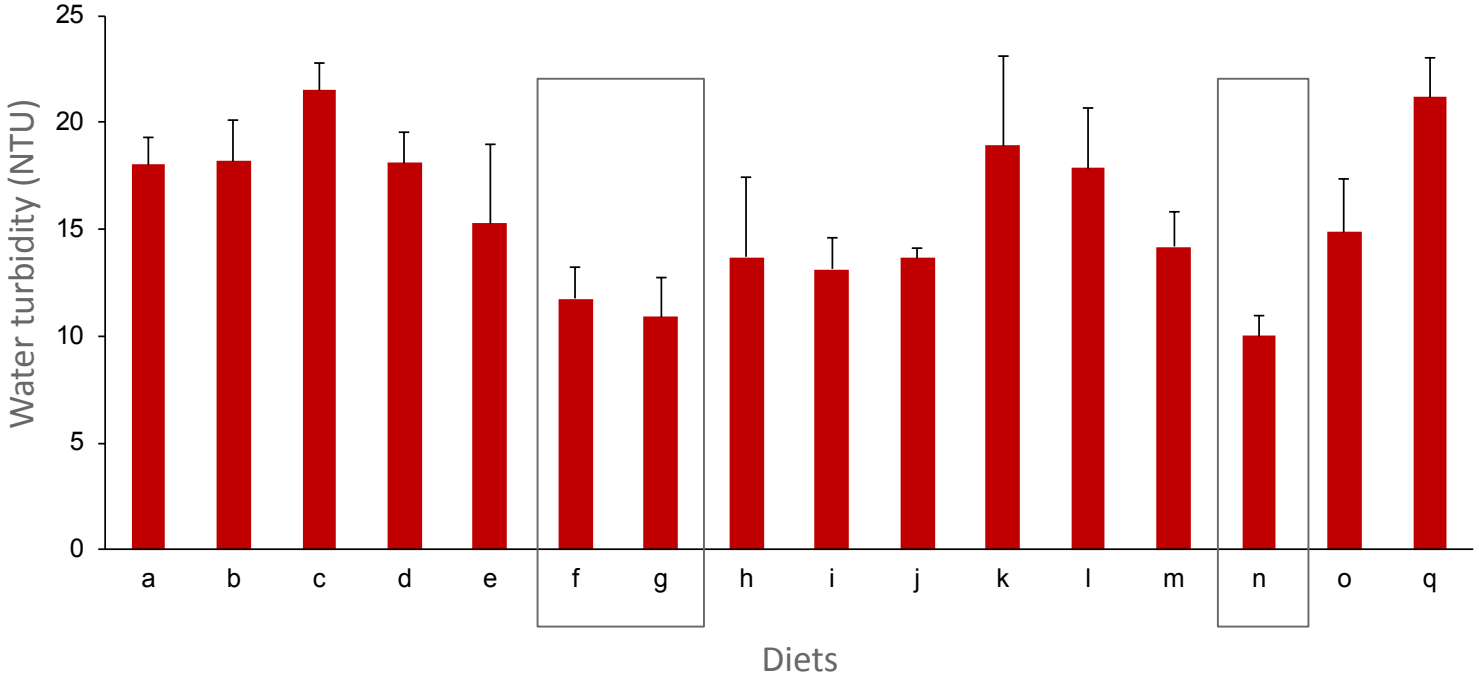
Water turbidity with different ingredients



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Growth & waste prediction models

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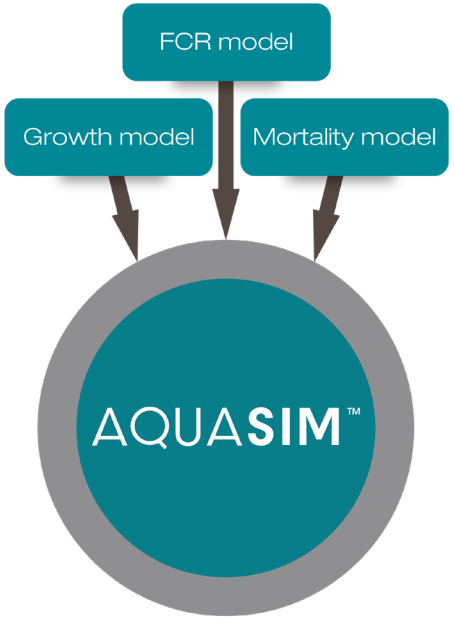
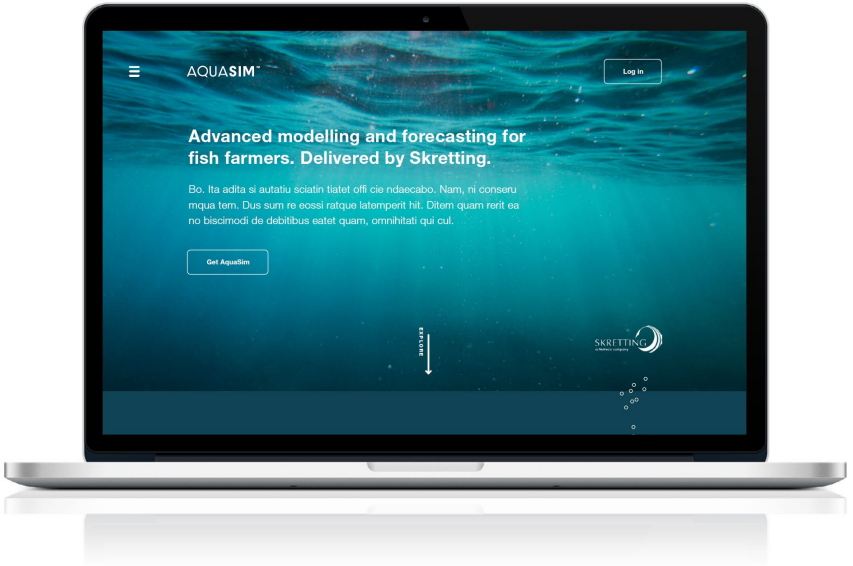
Growth and waste prediction models





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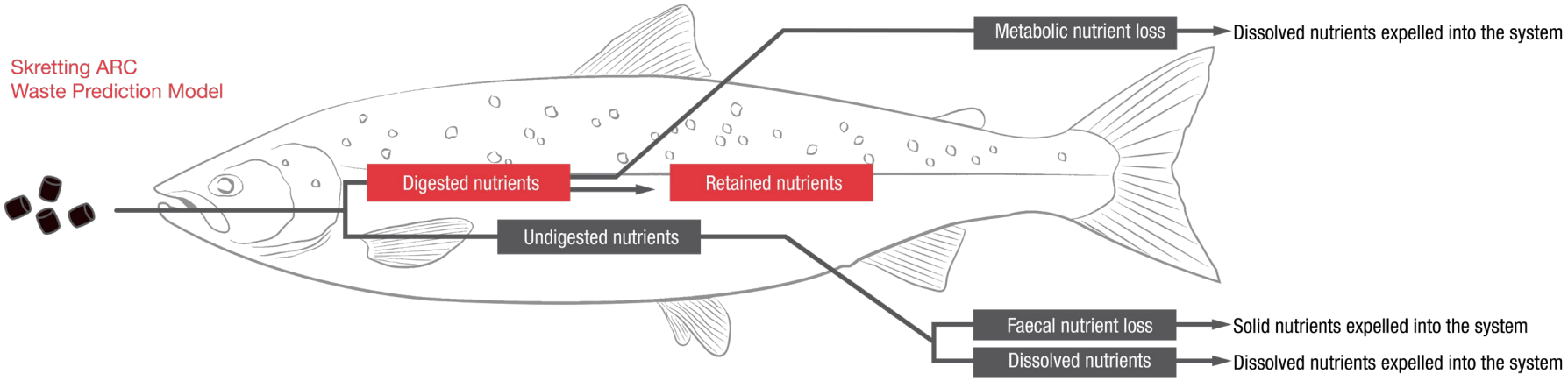
Growth and waste prediction models



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AQUASIM™

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Efficiency Model: Fresh Water

Step 1 *Enter the feeding regime*

Step 2 *Refresh*

Start weight, *g*	10	Start date	01/02/18
End weight, *g*	150	End date	05/09/18
No. of fish	10000	No of days	216
FCR, *%day*$^{-1}$	0.81	SGR, *%day*$^{-1}$	1.26
		Total feed, kg	1134

☐ **Feed composition, %**

☐ **Growth and feed consumption**

Total Discharge from production

CopyResults

	Nitrogen	Carbon	Phosphorous	
	kg	*kg*	*kg*	
Fecal	12	106	8	
Particle bound fecal matter*	8	75	6	*as % of total fecal nutrients : N -67 , C - 71 , P - 72*
Dissolved	40	162	2	
Total	53	268	11	

☐ **Discharge per diet**

Retention Efficiency, %

	Nitrogen	Carbon	Phosphorous
Overall	42	47	34

☐ **Efficiency per diet**

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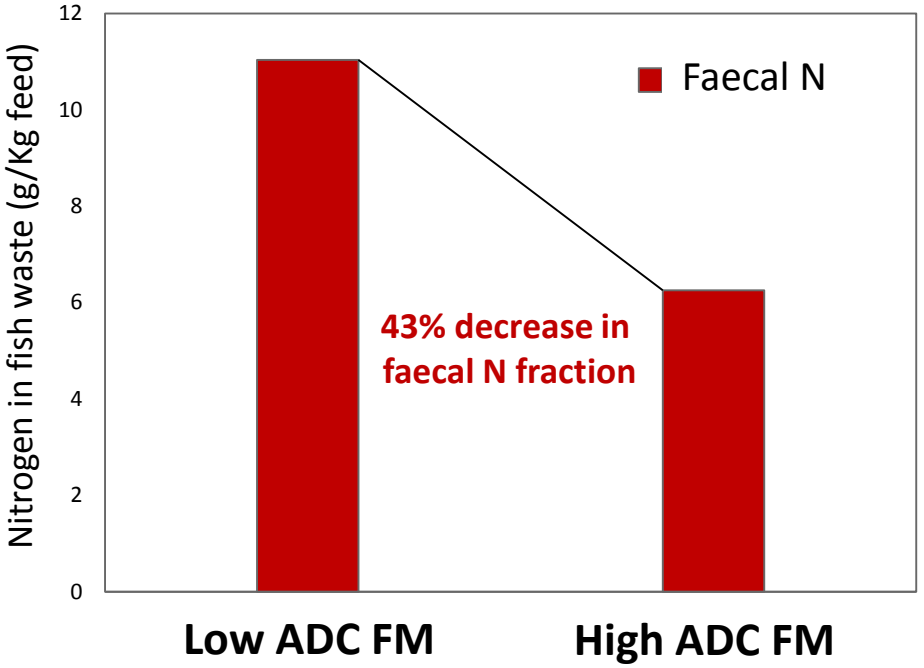
Fish meal digestibility on faecal nutrient content

With the AquaSim excretion model we can estimate the effect on faecal N excretion of two diets formulated with two different fish meals with low and high protein digestibility



SW efficiency model	Low ADC FM	High ADC FM
Initial weight (g)	150	150
Target weight (g)	500	500
No. of fish initial	10000	10000
Pellet size (mm)	4	4

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Thank you

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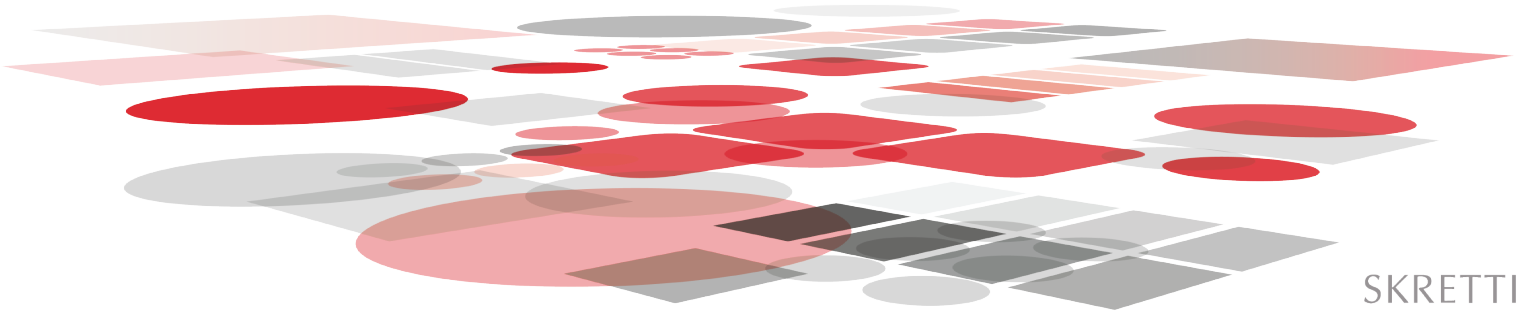
RECIRC READY

Feed solutions

Growth & waste prediction models

Fish & system health

Nutrient recycling



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