Matching Science and Practice to Improve Nutrition, Efficiency and Sustainability in Aquaculture Production

Dominique P. Bureau

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Fish Nutrition Research Lab

Dept. Animal and Poultry Science
University of Guelph

Ontario Ministry of
Natural Resources

Bio-Data

Laval University (Quebec City)

B.Sc.Agr. Bio-Agronomy

M.Sc. Animal Science
Thesis: Use of Crop Residues as Fish Feed Ingredients in northeastern Thailand.
Advisors: Joel de la Noue and Pornchai Jaruratjanamorn

University of Guelph

Ph.D. Nutritional Sciences
Thesis: Fate of Dietary Carbohydrates in Trout
Advisors: C.Y. Cho and J.B. Kirkland

Leading an independent research program on basic and applied fish nutrition at University of Guelph since Sept. 1994

Supervisor of UG/OMNR Fish Nutrition Research Lab since 2001

Many students, post-docs, and international collaborators

Inundated Rice Paddy, Prov. Nakhon Ratchasima, Thailand (1988)

Integrated Fish Farming in Asia

Rice fish integrated system

Horticulture fish integrated system

Duck-fish integrated system

Source: http://agritech.tnau.ac.in/fishery/fish_ifs.html

The fish species I worked with during my MSc project in 1991!

Integrated Poultry – Catfish Farm, Northeastern Thailand (1991)

MSc Research Facilities – Northeast Thailand (1991)

Steam-Pelleted Feed

RESEARCHER AND FEED SPECIALIST WINS SECOND ANNUAL *HERB DHALIWAL SUSTAINABLE AQUACULTURE* AWARD

Research Contributions C.Y. Cho and S.J. Slinger 1969-2001

- Feed formulations
  - open feed formulae concept
  - Low fish meal, economical, low pollution
- Research Equipment / infrastructure
  - Guelph fecal collection system
  - Self-cleaning fish tanks (CYAQ-5)
  - Flow-through respirometer
- Research Protocols
  - Digestibility – indirect protocol (70:30)
  - Bioenergetics protocols
  - Feed requirements and wastes outputs models

Fish Nutrition Research Lab

Dept. Animal and Poultry Science, University of Guelph | Ontario Ministry of Natural Resources

- Founded in 1969 by Prof. S.J. Slinger & C.Y. Cho

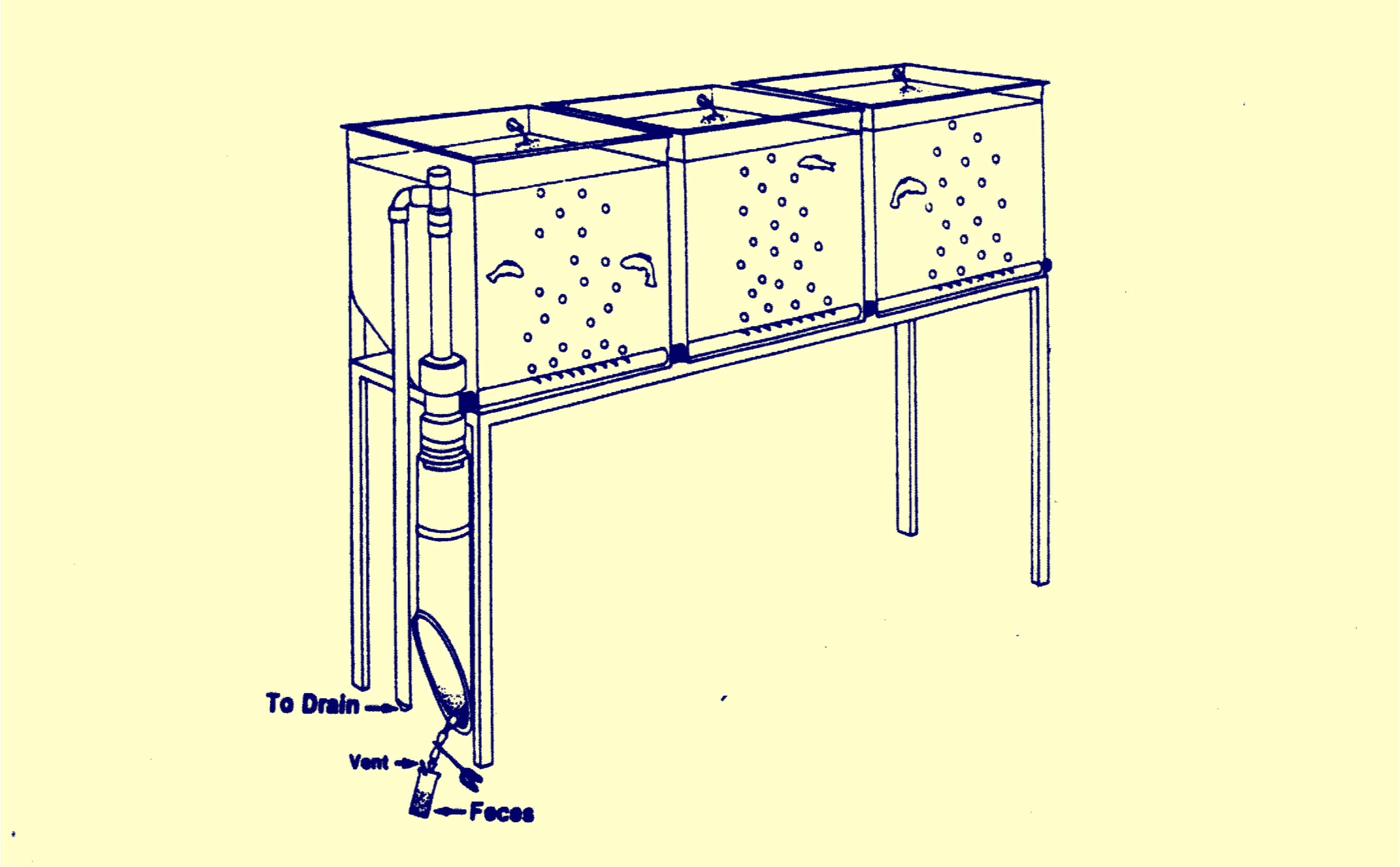
Joint venture with the University of Guelph and the Ontario Ministry of Natural Resources (OMNR)

- OMNR operates 10 fish culture stations producing fish for stocking in lakes and rivers
- Back in late 1960's, needed good quality feeds to replace beef liver and poor quality dry feeds imported from USA

UG/OMNR FNRL historically regarded as a key fish nutrition lab

- First animal nutritionists to work on fish nutrition
- Focused on developing research equipment and methodology
- Feed formulation and ingredient quality
- Modeling feed requirement and waste outputs (early 1990's)

Guelph System (Cho and Slinger, 1979)






Fish Nutrition Research Lab

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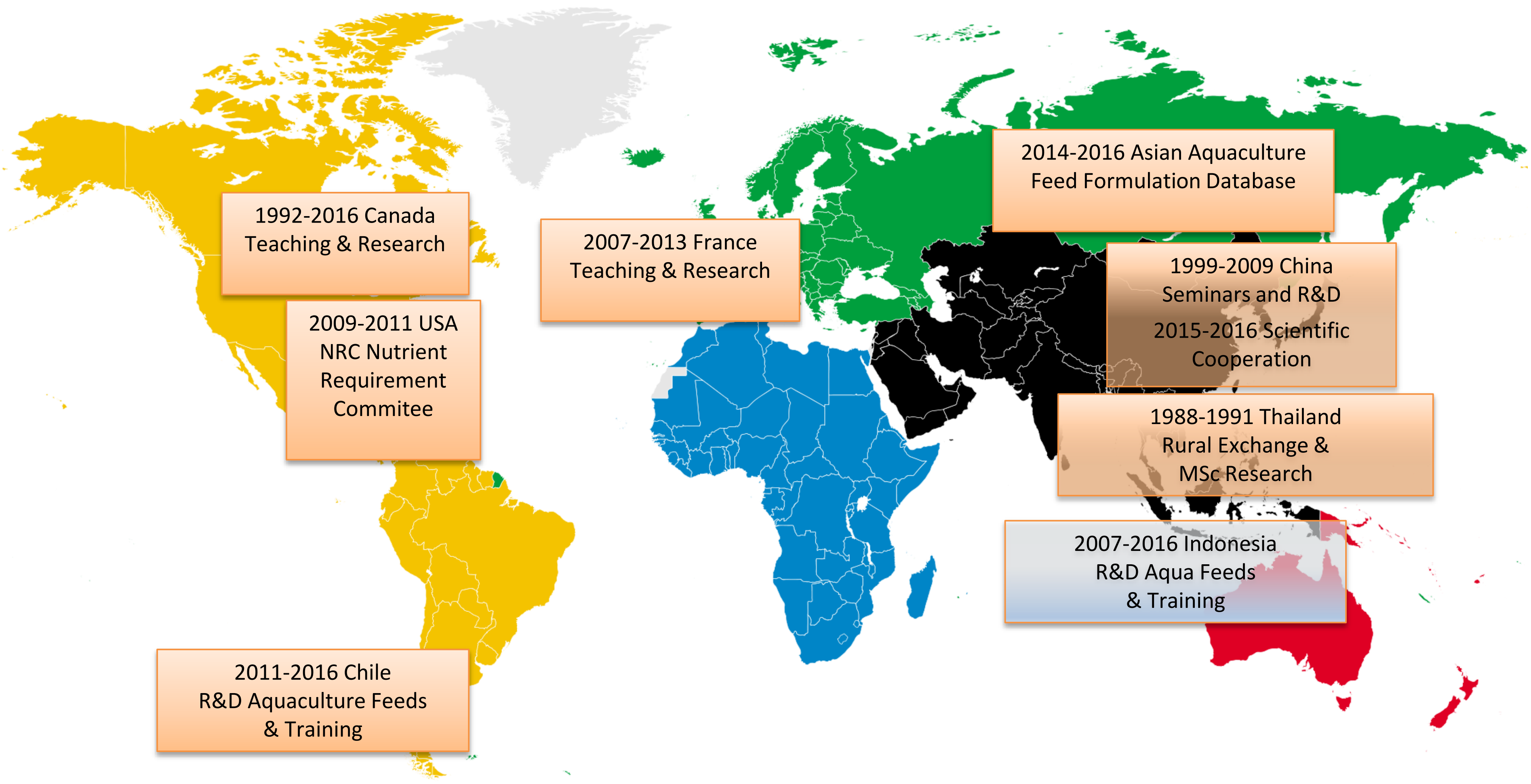
University of Guelph | Natural Resources

UNIVERSITY of GUELPH

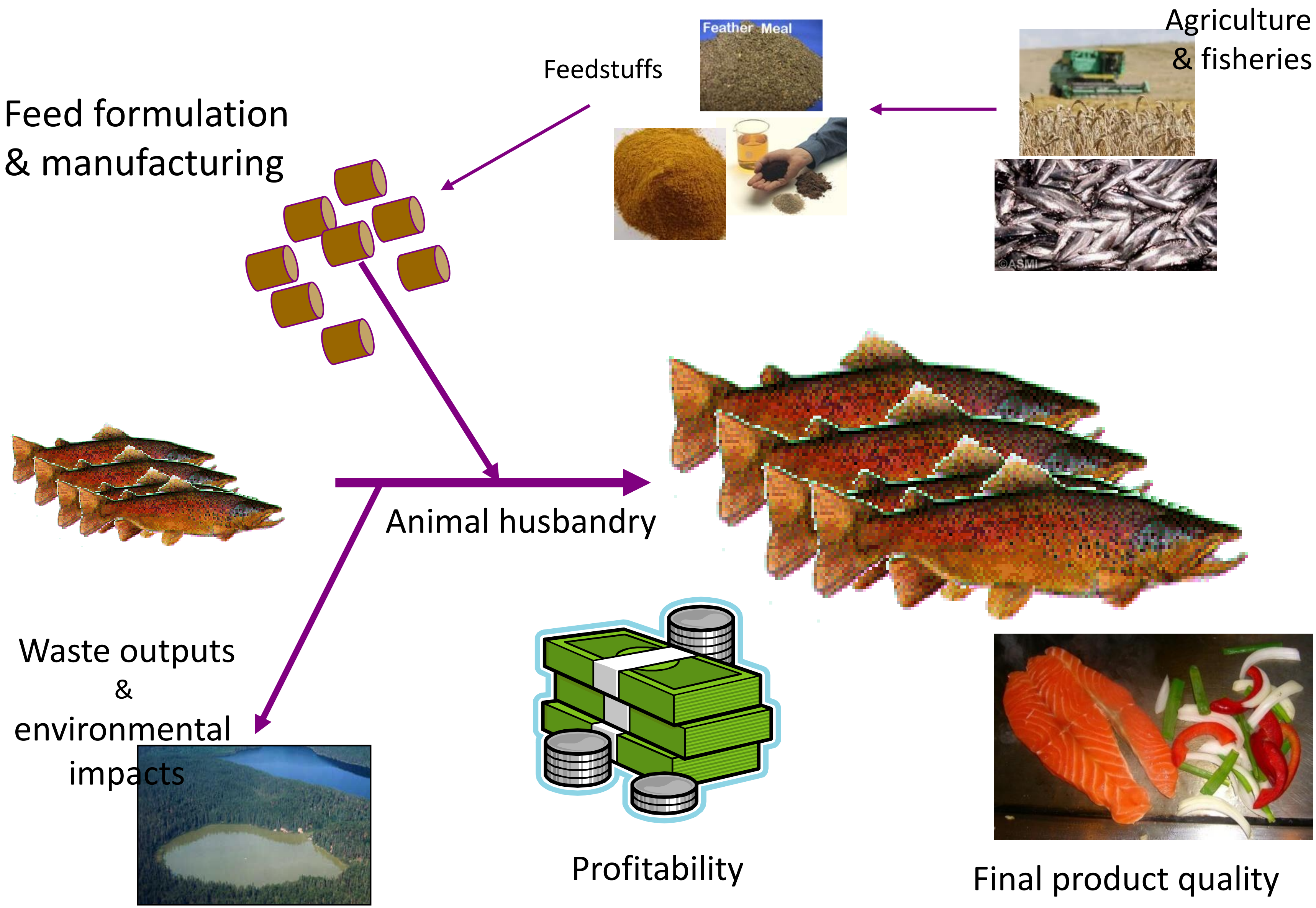
Major International Activities since 1988



Marine Fish Cage Farm on Nanao Island, Guangdong, China

Agro Super, Chile

Intensive Aquaculture:
Converting Exogenous Feed Resources into Products
(for a Profit with Minimal Negative Impacts)



Wanted: Effective Production Management Tools

Aquaculture producers require tools to:

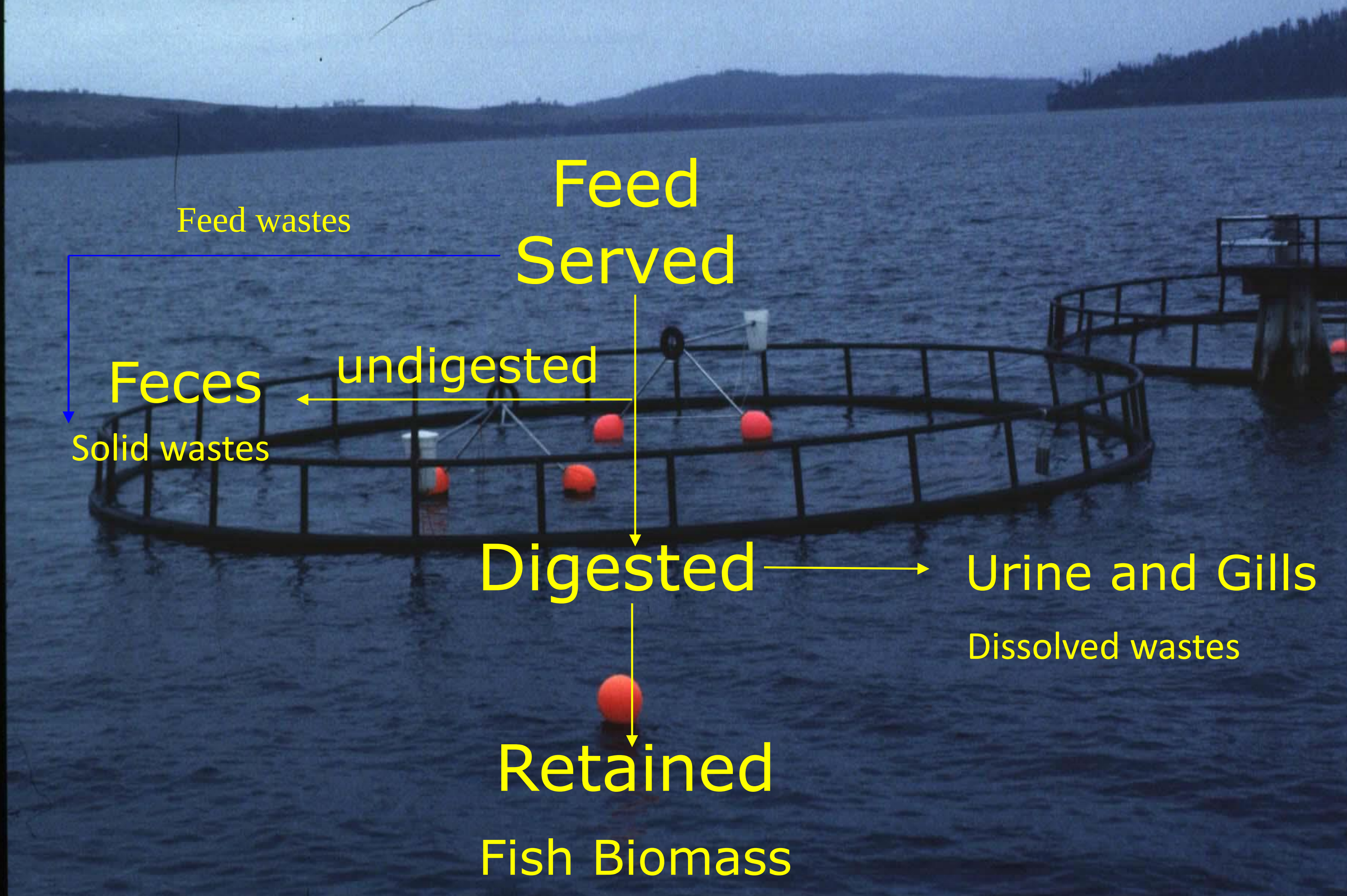
Manage and/or forecast production

Estimate feed requirements

Audit feed conversion ratio (feed:gain) achieved

Estimate the amount of waste outputs from their facilities

The Nutritional Origins of Wastes



Making Better Use of Information

A lot of information is collected every day/week/month by aquaculture operations.

Much of the information is collected and analyzed in a “piece-meal” fashion (i.e. not very systematically or meaningfully)

How can we make best use of this information?

Systematic Data and Knowledge Integration Efforts Conducted by UG Fish Nutrition Research Laboratory

Models (bioenergetics, nutrient-flow, mechanistic) for estimating feed requirements, FCR, and waste outputs of fish culture operations

(e.g. Cho, 1992, Cho & Bureau, 1998, Bureau et al., 2003; Hua et al, 2010; Chowdhury et al., 2012)

Models of phosphorus, lipids and starch digestibility for different fish species

(e.g. Hua and Bureau, 2006, 2009a&b, 2010)

Modeling growth trajectory, body composition and nutrient deposition

(e.g. Dumas et al., 2007a&b)

Meta-analysis of studies on fish meal replacement by plant protein ingredients

(e.g. Hua and Bureau, 2012)

Meta-analysis of essential amino acids requirements of teleost fish

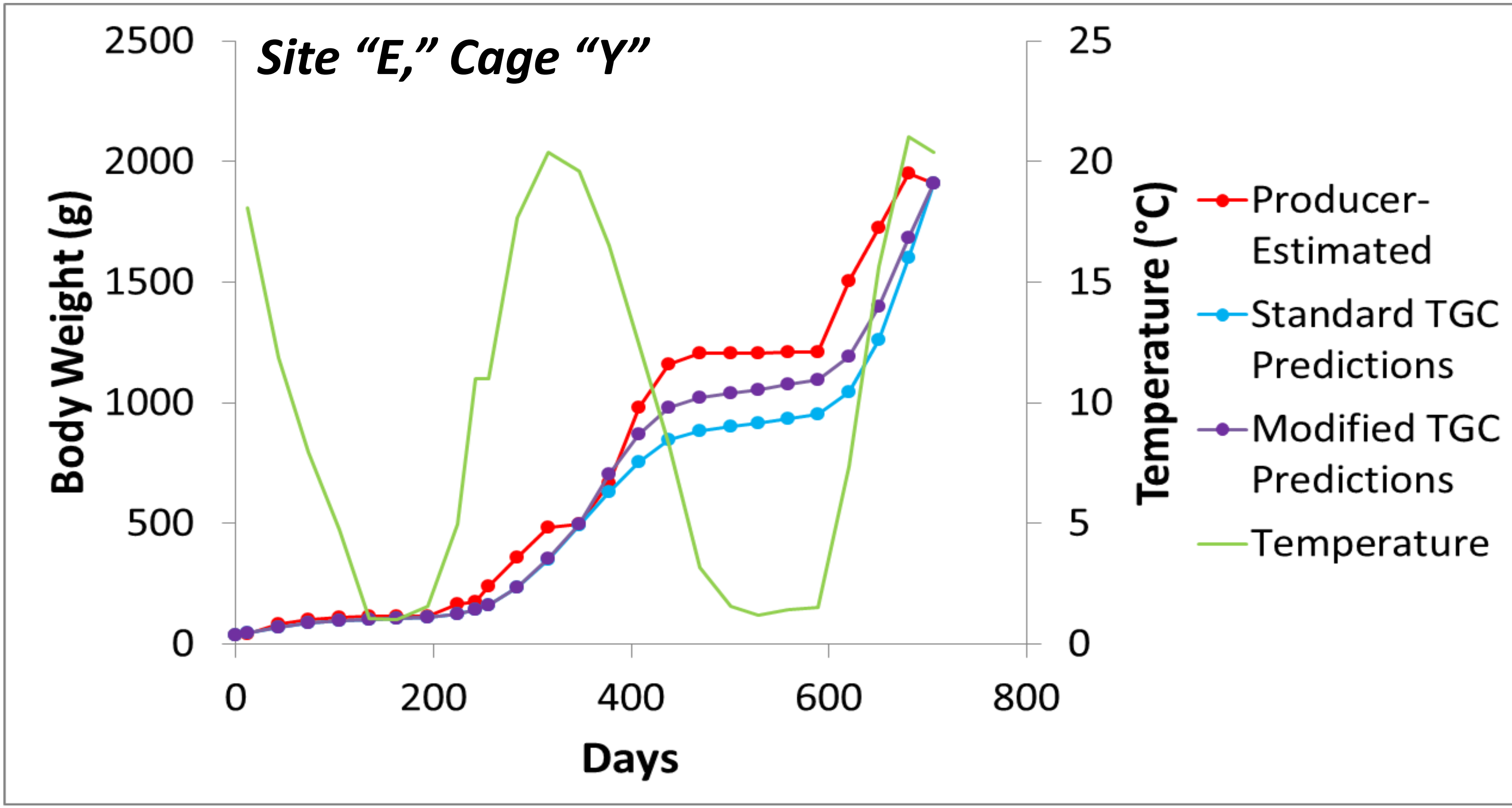
(e.g. Salze et al., 2011)

Factorial models of nutrient requirements

(e.g. Tables 5-20 & 5-21 in NRC (2011) Nutrient Requirements of Fish and Shrimp)

FNRL

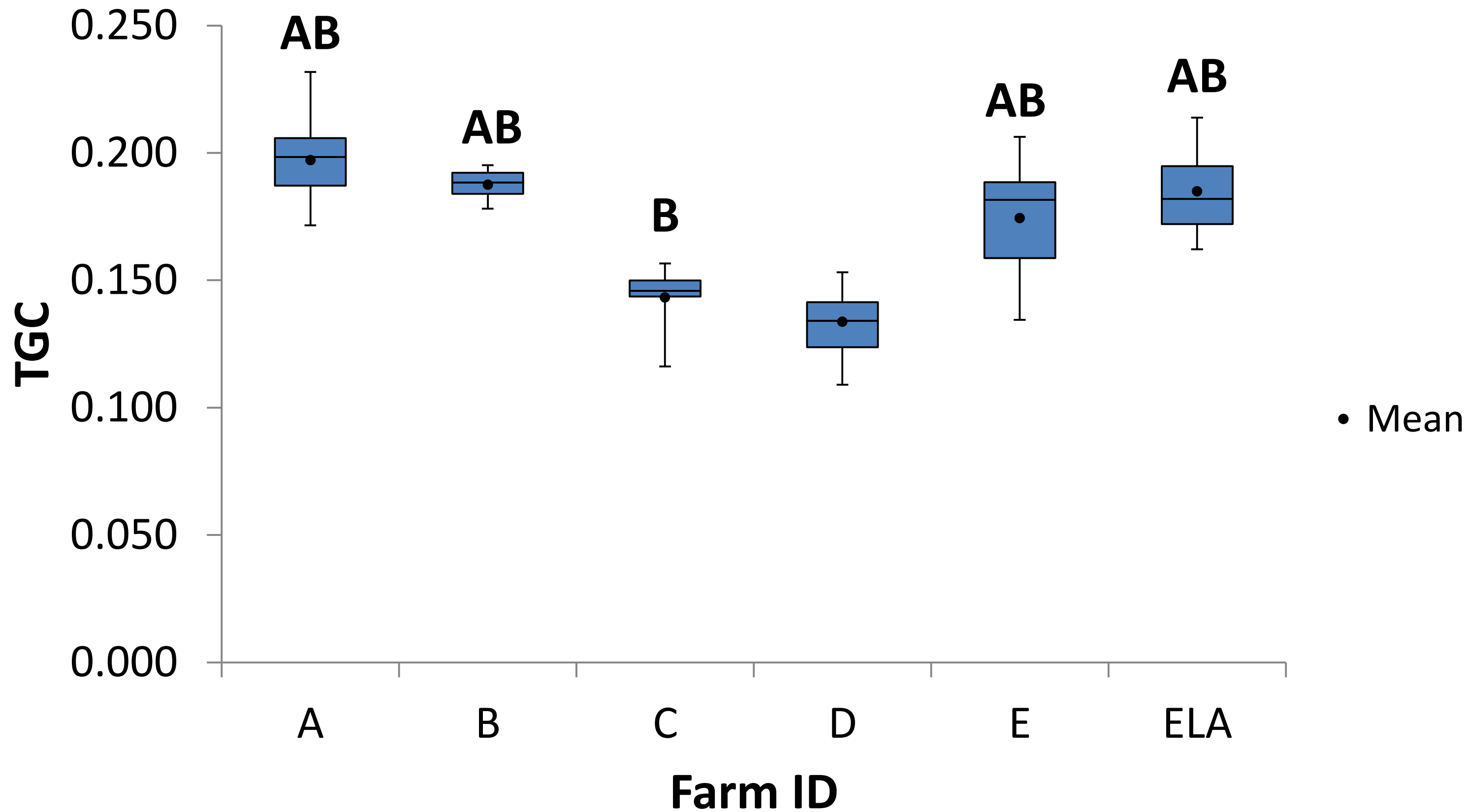
Farm Body Weight Estimates Relative to Model Predictions



- Benchmarking Farm Performances -

Thermal Unit Growth Coefficients (TGC*)

TGC = ($FBW^{1/3}$- $IBW^{1/3}$) / Σ (temp days)



The Fish-PrFEQ Bioenergetics Approach (Cho, 1991)

1- Predict or describe growth

Need an appropriate growth model

2- Determine energy gains (RE)

Need information on carcass composition
Carcass gross energy (GE) x Weight gain

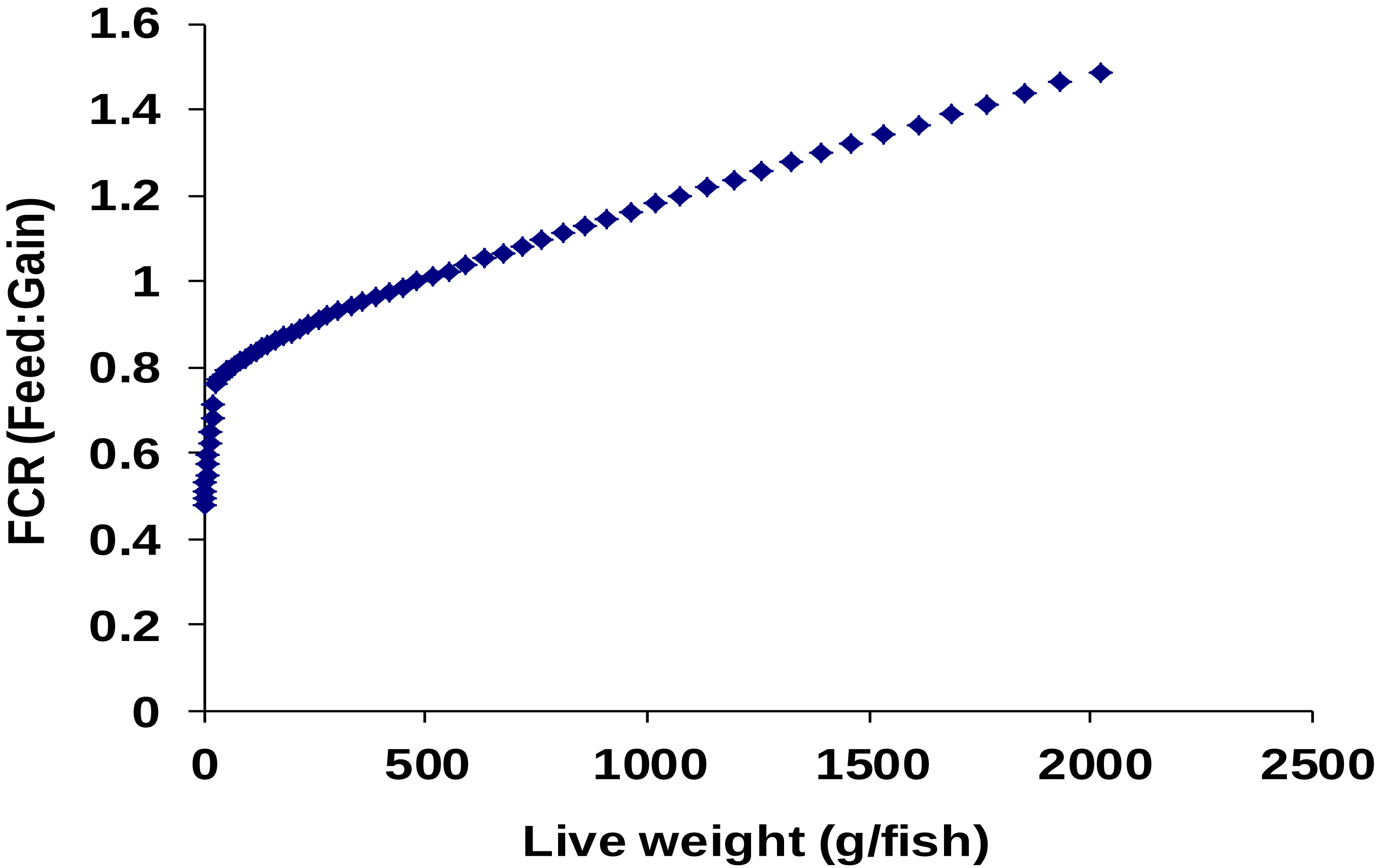
3- Estimate heat and metabolic losses

Maintenance (HeE) + Heat increment (HiE) + Non-fecal losses (UE+ZE)

4- Digestible energy requirement = sum

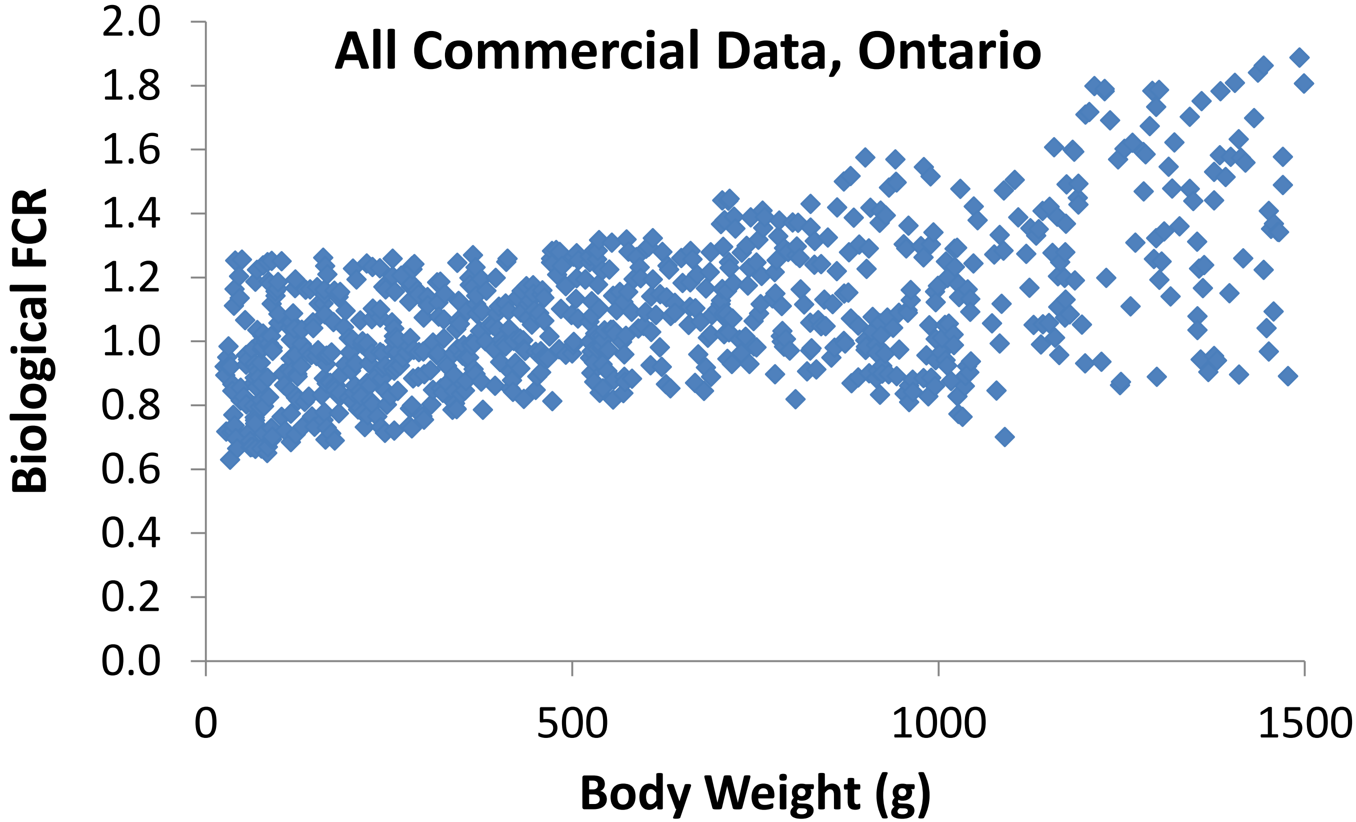
DE = RE + HeE + HiE + (UE+ZE)

Prediction of FCR of rainbow trout of increasing weight using a model developed by the UG/OMNR Fish Nutrition Research Laboratory



– Results –

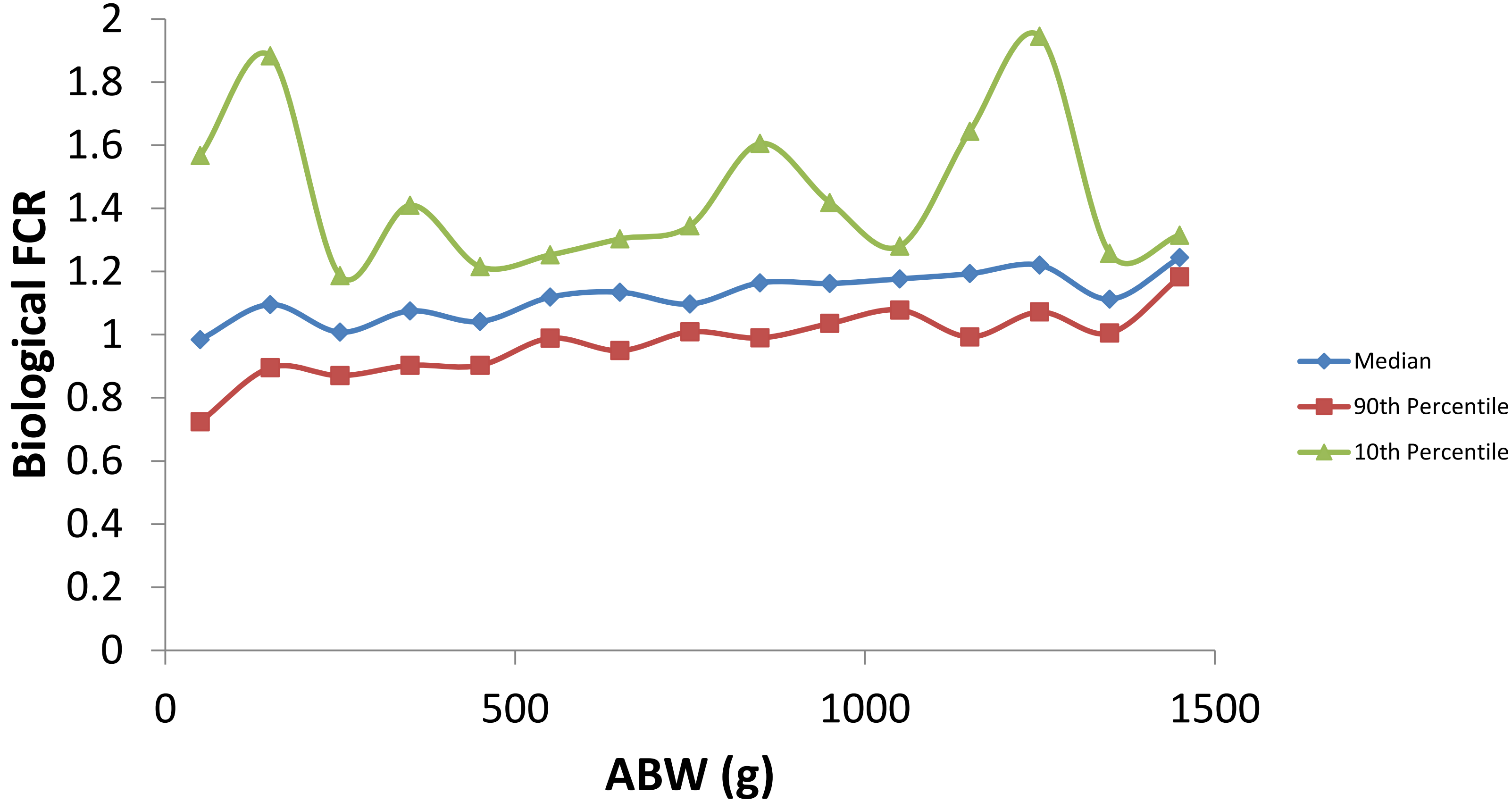
FCR vs. BW



- Data suggests increase in feed conversion ratio as fish weight increases
- Consistent with results from controlled research trials and model predictions

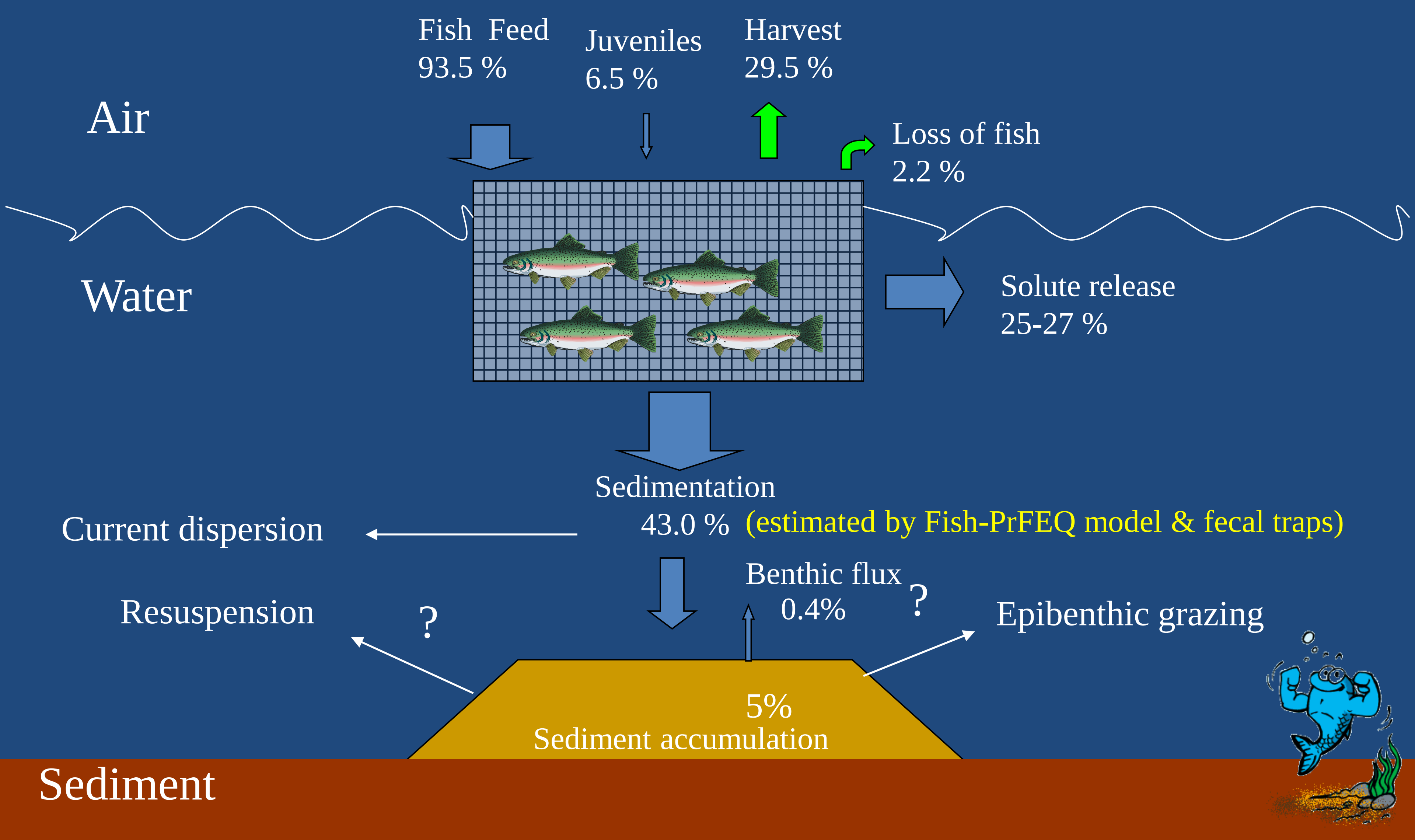
The Power of Combining Real Production Data and Model Simulations

Ex: FCR vs. Average Body Weight (ABW)



- Data suggests increase in feed conversion ratio as fish weight increases
- Consistent with results from controlled research trials and model predictions

Phosphorus mass balance for 2005



Azevedo and Podemski (2007)

Aquaculture 410-411 (2013) 138–147

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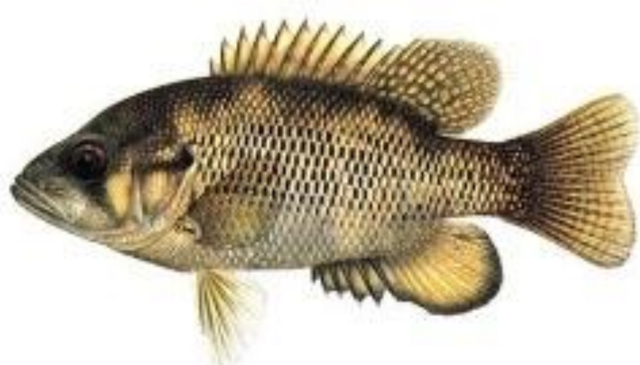
Aquaculture

journal homepage: www.elsevier.com/locate/aqua-online

Bioenergetics-Based Factorial Model to Determine Feed Requirement and Waste Output of Tilapia Produced under Commercial Conditions

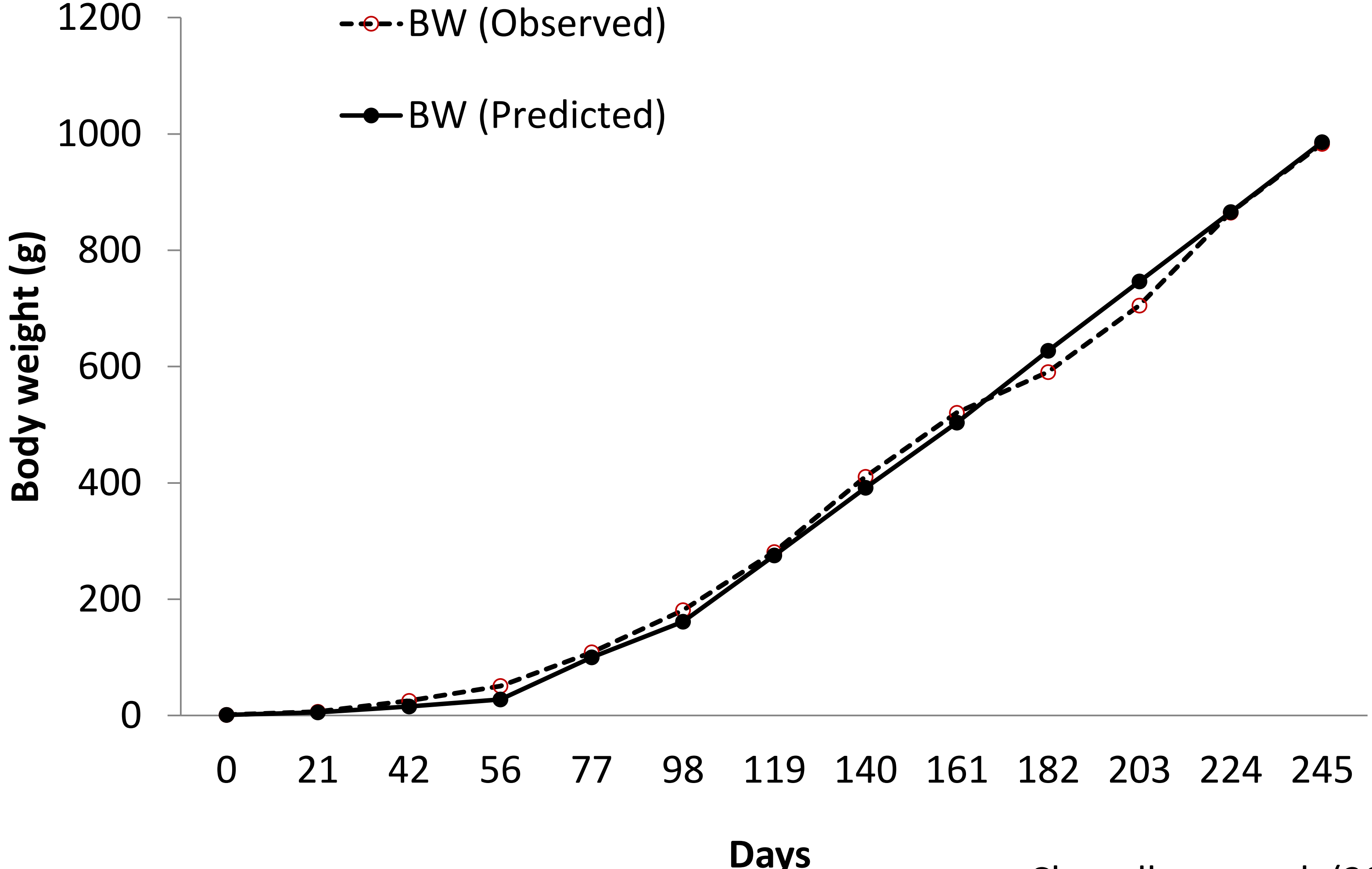
M.A. Kabir Chowdhury [a,*], Sohail Siddiqui [b], Katheline Hua [c], Dominique P. Bureau [a]

[a] Fish Nutrition Research Laboratory, Dept. of Animal and Poultry Science, University of Guelph, Guelph, Ontario, N1G 2W1, Canada
[b] Dorion Fish Culture Station, Ministry of Natural Resources, Dorion, Ontario, Canada
[c] Faculty of Agriculture and Horticulture, Humboldt-Universität zu Berlin, Invalidenstraße 42, 10115 Berlin, Germany



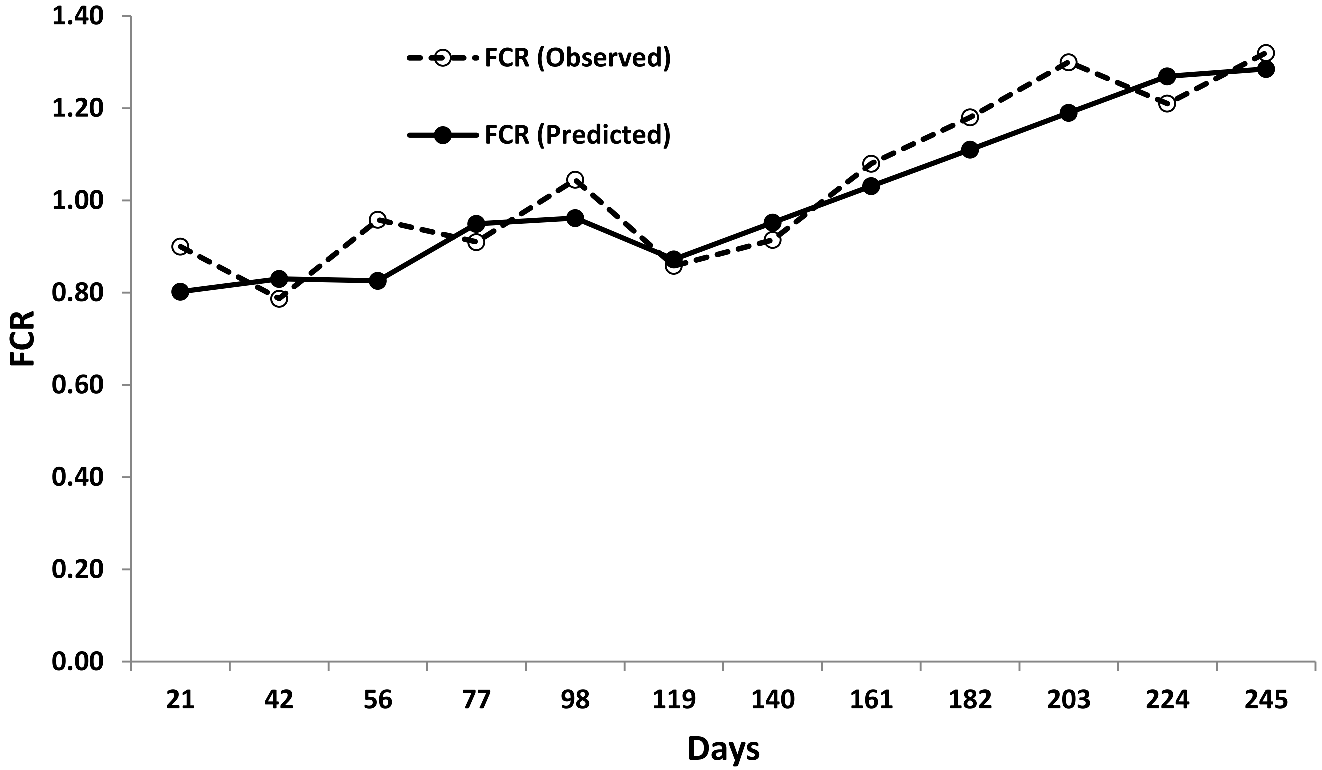
Observed and predicted growth trajectory of Nile tilapia using a modified TGC model

(data from a pilot-scale trial at the Alma Aquaculture Research Station)



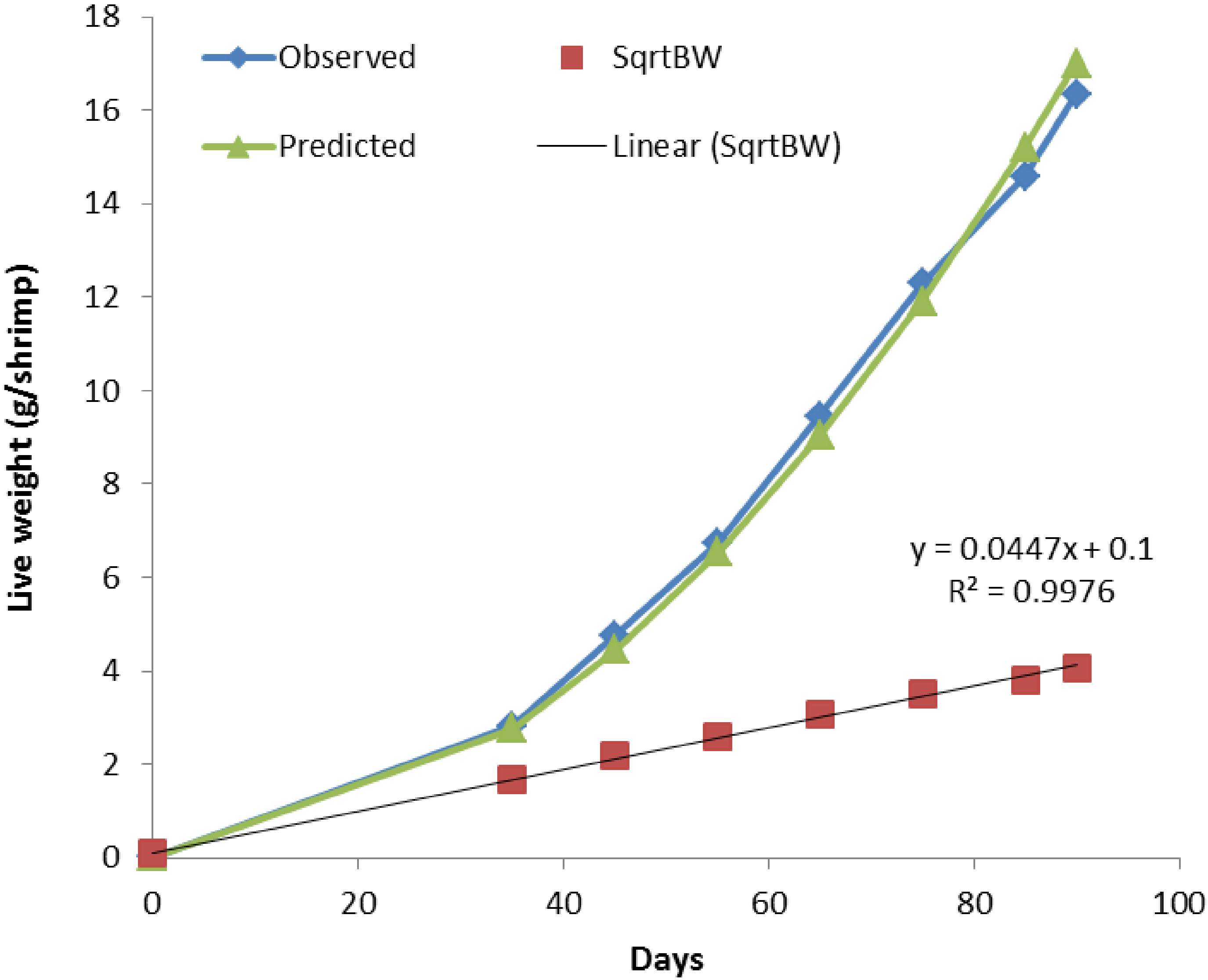
Chowdhury et al. (2013)

Observed and predicted evolution of feed conversion ratio (feed:gain) of Nile tilapia during a pilot-scale trial



What about Shrimp Models?

Modeling the growth trajectory of *P. vannamei* reared in ponds in East Java (Indonesia)



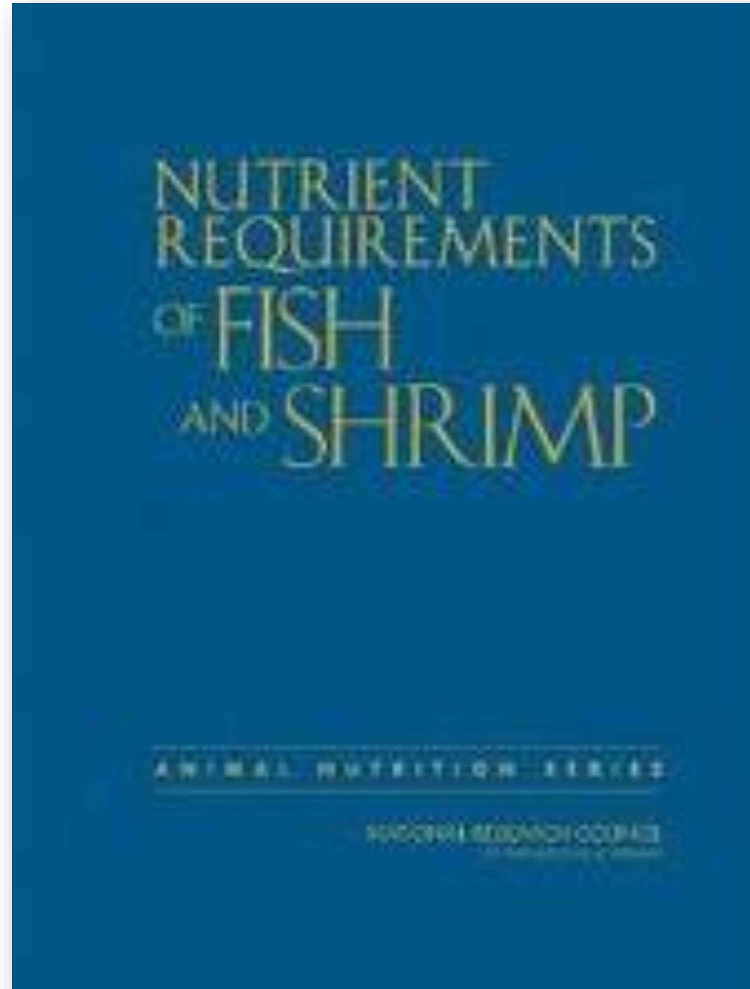
NRC Committee of Nutrient Requirements of Fish and Shrimp (2009-2011)

NRC 2011

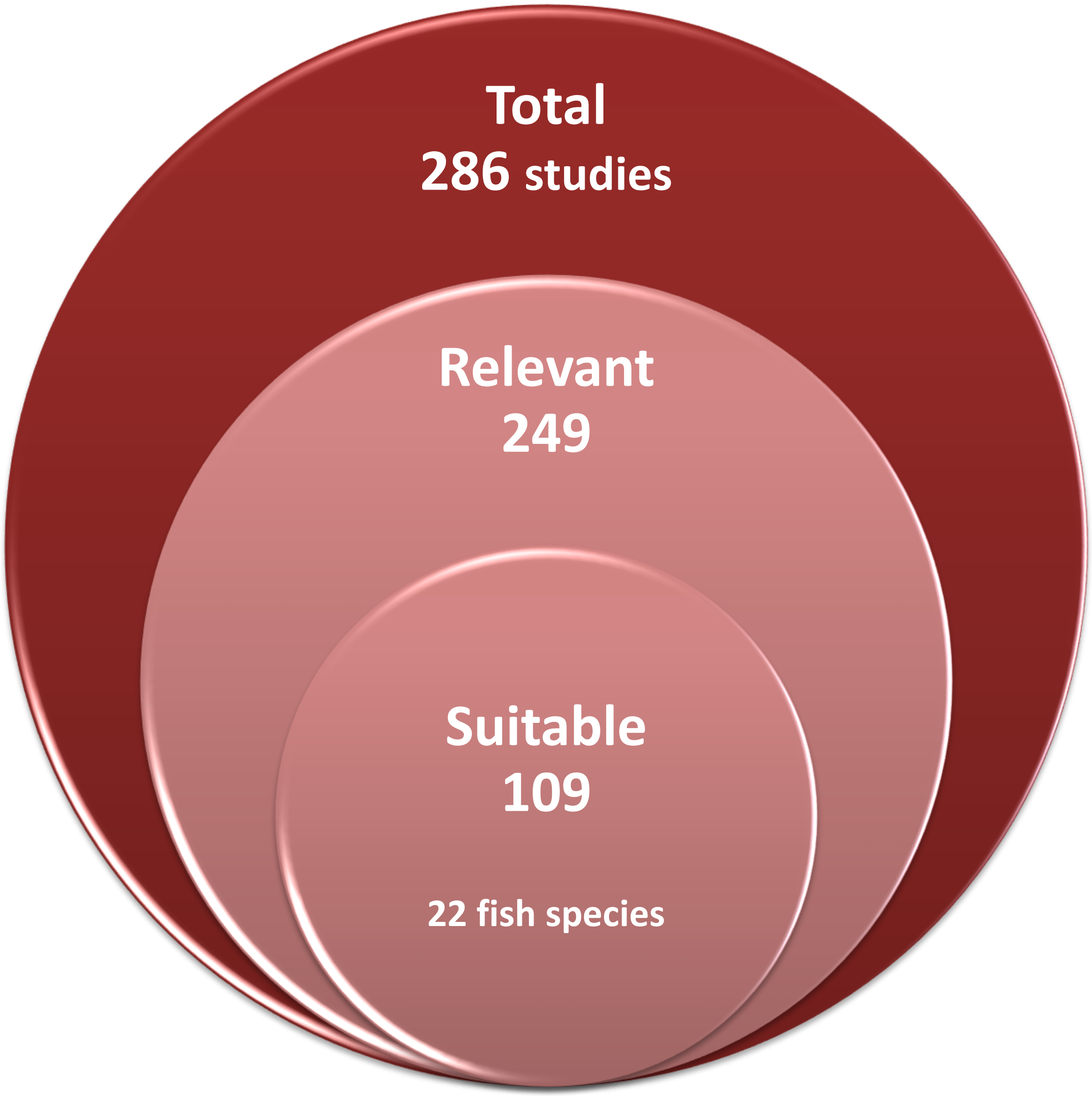
Review of state-of-the-art

Committee reviewed 1000s of papers

Imperfect document and recommendations represent best effort



Meta-Analysis of Essential Amino Acid Requirements of Fish



Main causes of rejection:

1) Key piece(s) of information missing in paper and preventing calculation of parameter(s) deemed important

2) Insufficient graded EAA levels (or inappropriate design for goal of meta-analysis)

3) Poor growth or feed efficiency achieved in study

FNRL

AQUACULTURE = Diversity of Species

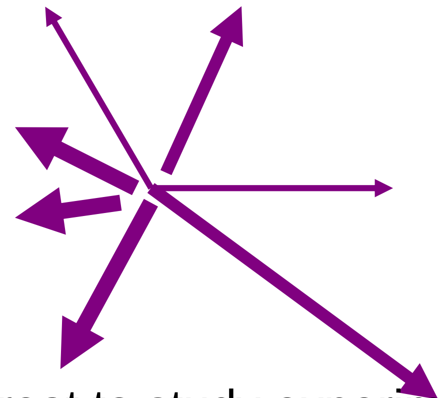
Slide courtesy of Dr. A.J. Tacon

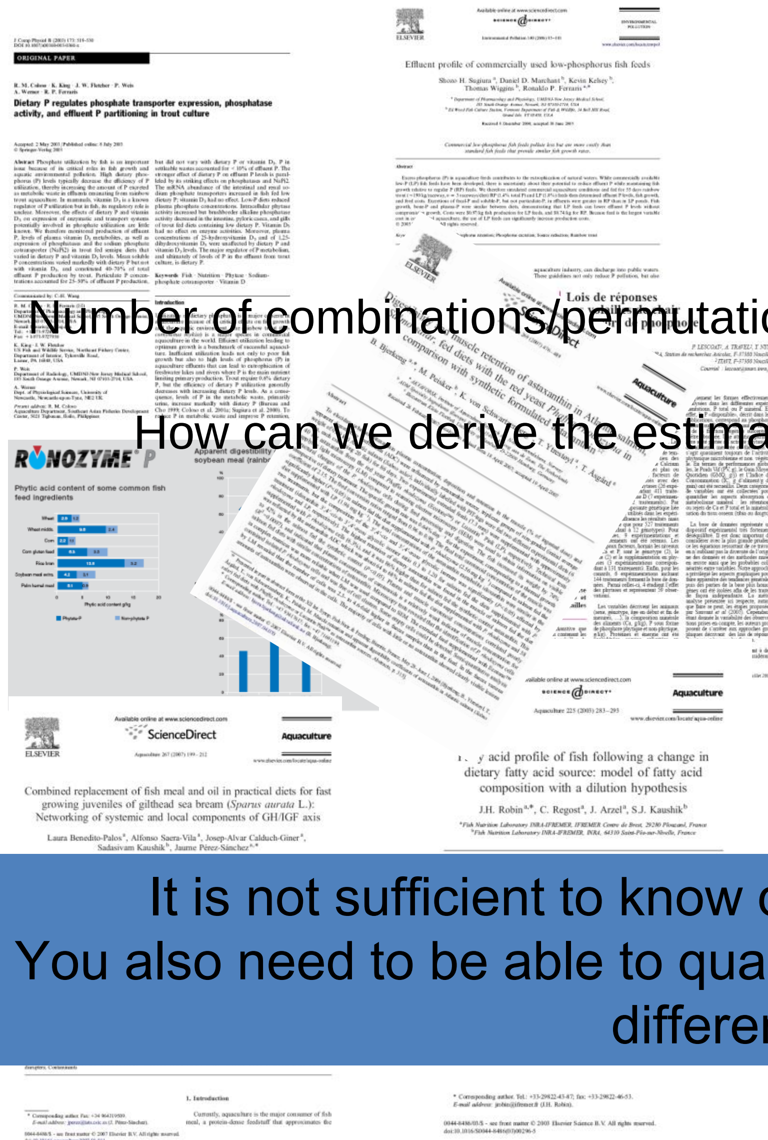
Current Challenges:

Developing Nutritional Specifications for Different Species, Life Stages, Weight Ranges and Feed Types

Predicting the content in bio-available nutrients in diets composed of an increasing wide variety of feed ingredients

Challenge: Meeting the nutrient requirements of a diversity of species ranging greatly in weight, fed diets formulated with a wide variety of feed ingredients.



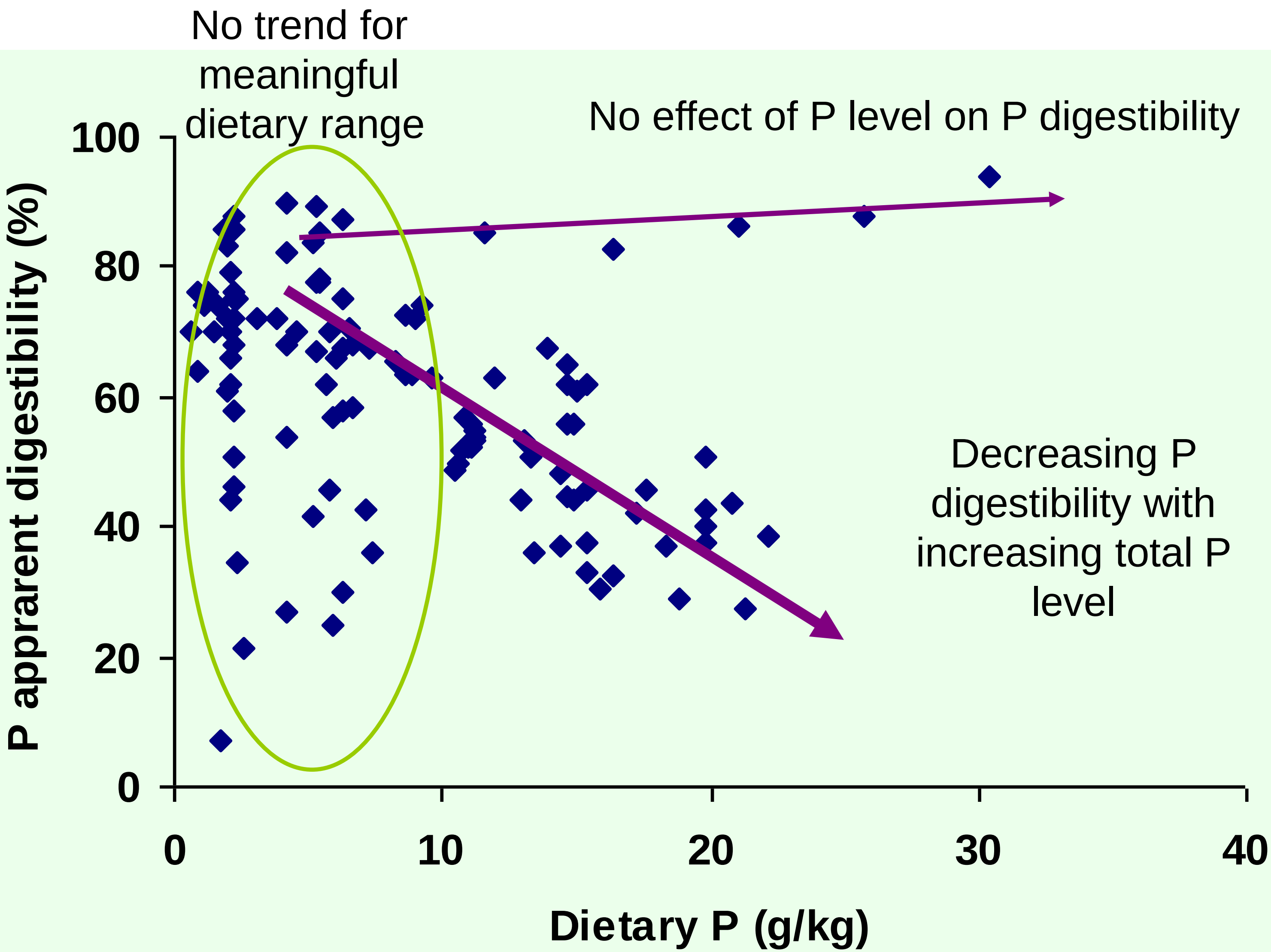


Number of combinations/permutations too great to study experimentally.

How can we derive the estimates we need from the literature?

It is not sufficient to know different factors have effects.
You also need to be able to quantify the combined effects of these different factors

Example: Dietary Phosphorus Digestibility



Dataset: 137 treatments from 22 studies with rainbow trout

We often have everything we need – the issue is finding it!

No need to reinvent the wheel

The answer is organizing the information at hand in a sensible way!

Systematic integration of data and mathematical modelling to analyze this information can be a very effective way of achieving this.

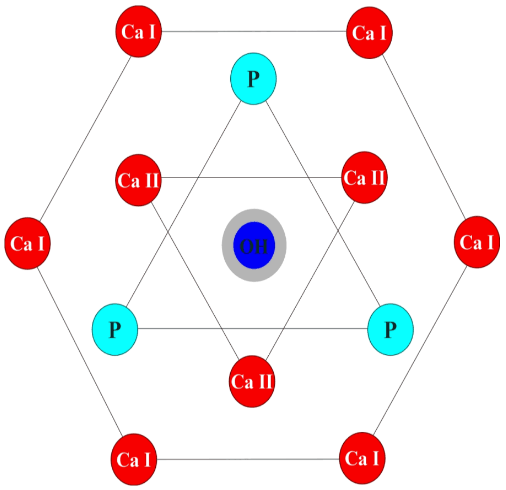
Before

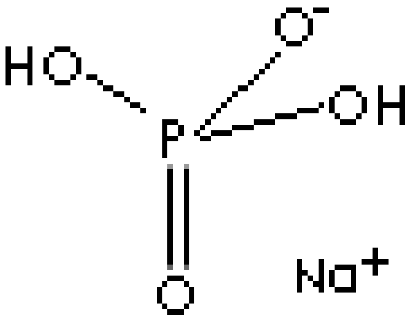
After

P Forms Present in Feed

1. Inorganic P

- Bone P: hydroxyapatite $Ca_{10}(OH)_2(PO_4)_6$
- Pi supplement:
  - Monobasic: NaH_2PO_4, $Ca(H_2PO_4)_2$
  - Dibasic: $CaHPO_4$

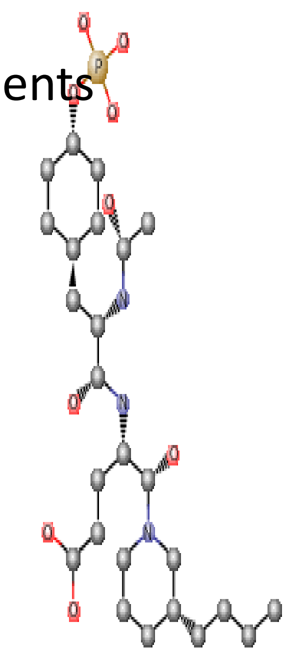




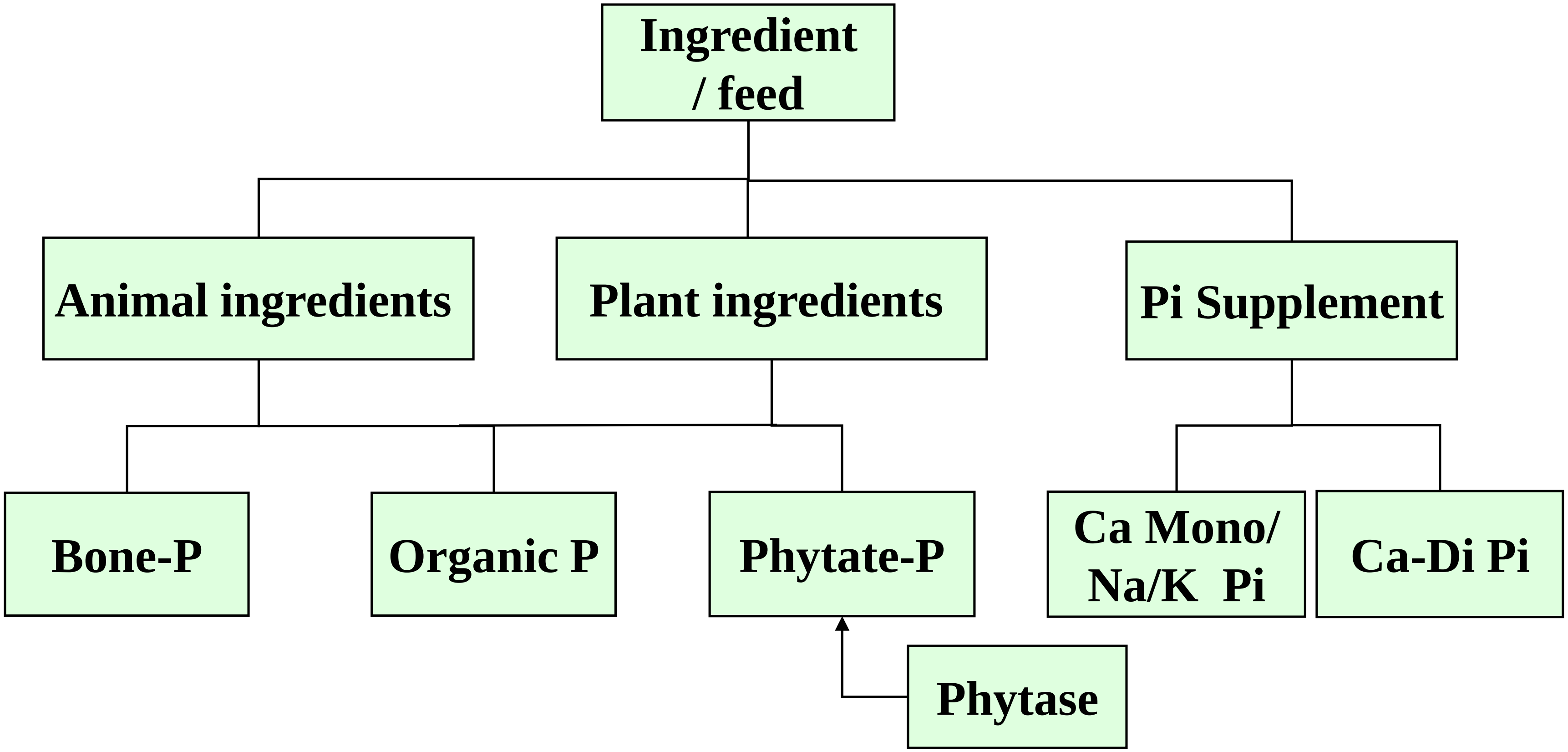
P Forms Present in Feed

2. Organic P

- Phospholipids, e.g. phosphatidyl choline
- Phosphoproteins, e.g. casein
- Phosphosugars, e.g. Glucose-6-P
- Phytate: account for 60 – 80% of total P in plant ingredients



Classification According to Type of P Compounds



Hua and Bureau (2006)

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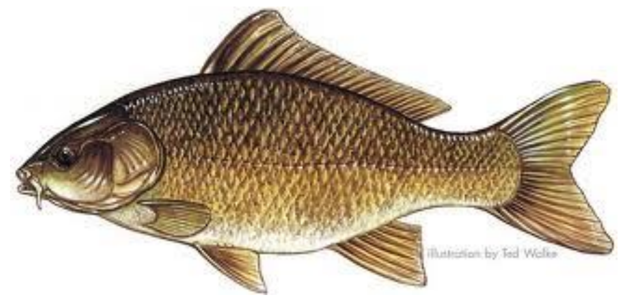
Quantification of differences in digestibility of phosphorus among cyprinids, cichlids, and salmonids through a mathematical modelling approach

K. Hua *, D.P. Bureau

UG/OMNR Fish Nutrition Research Laboratory, Department of Animal and Poultry Science, University of Guelph, Guelph, Ontario, Canada N1G 2W1



$$\begin{aligned}\text{Digestible P} = {} & 0.75\ \text{bone-P} \\ & + 0.27\ \text{phytate-P} \\ & + 0.95\ \text{organic P} \\ & + 0.93\ \text{Ca monobasic /Na/ K Pi supplement} \\ & + 0.62\ \text{Ca dibasic Pi supplement} \\ & + 0.25\ \text{phytase/phytate} \\ & - 0.02\ (\text{phytase/phytate})^2 \\ & - 0.03\ (\text{bone-P})^2 \\ & - 0.09\ \text{bone-P} \\ & \times {}^{*}\text{Ca monobasic /Na/ K Pi supplement}\end{aligned}$$

$$\begin{aligned}\text{Digestible P} = {} & 0\ \text{bone} - \text{P} + 0\ \text{phytate} - \text{P} + 0.72\ \text{organic P} \\ & + 0.86\ \text{Ca monobasic /Na/ K Pi supplement} \\ & + 0.30\ \text{Ca dibasic Pi supplement} \\ & + 0.48\ \text{phytase/phytate} - 0.04\ (\text{phytase/phytate})^2\end{aligned}$$

Proposed Approach

1-) Read and understand the literature

2-) Find or devise a rational classification for independent variables
- Based on sound nutritional principles
- Don't always think of reinventing the wheel!
- More complicated is not always better

3-) Compile independent and dependent variable from studies
- Weed out poor studies - the studies that don't add up!

4-) Identify and use robust statistical / mathematical approaches

5-) Validate / compare model predictions
- Initial observations (database modeled)
- Independent observations
  - Carry out validation trial or find independent data

6-) Identify discrepancies and limits of the model

7-) Design studies or go back to drawing board to improve models
- Deal with discrepancies or expand limits of model
- Study the effect of specific factors

FISH MEAL REPLACEMENT BY PLANT PROTEIN INGREDIENTS IN SALMONID FEEDS:

TOWARD A META-ANALYSIS OF PUBLISHED STUDIES TAKING INTO ACCOUNT NUTRITIONAL ADEQUACY, GROWTH PERFORMANCE, AND NUTRIENT UTILIZATION

Katheline Hua and Dominique P Bureau

Fish Nutrition Research Lab

Dept. Animal and Poultry Science
University of Guelph

Ontario Ministry of Natural Resources

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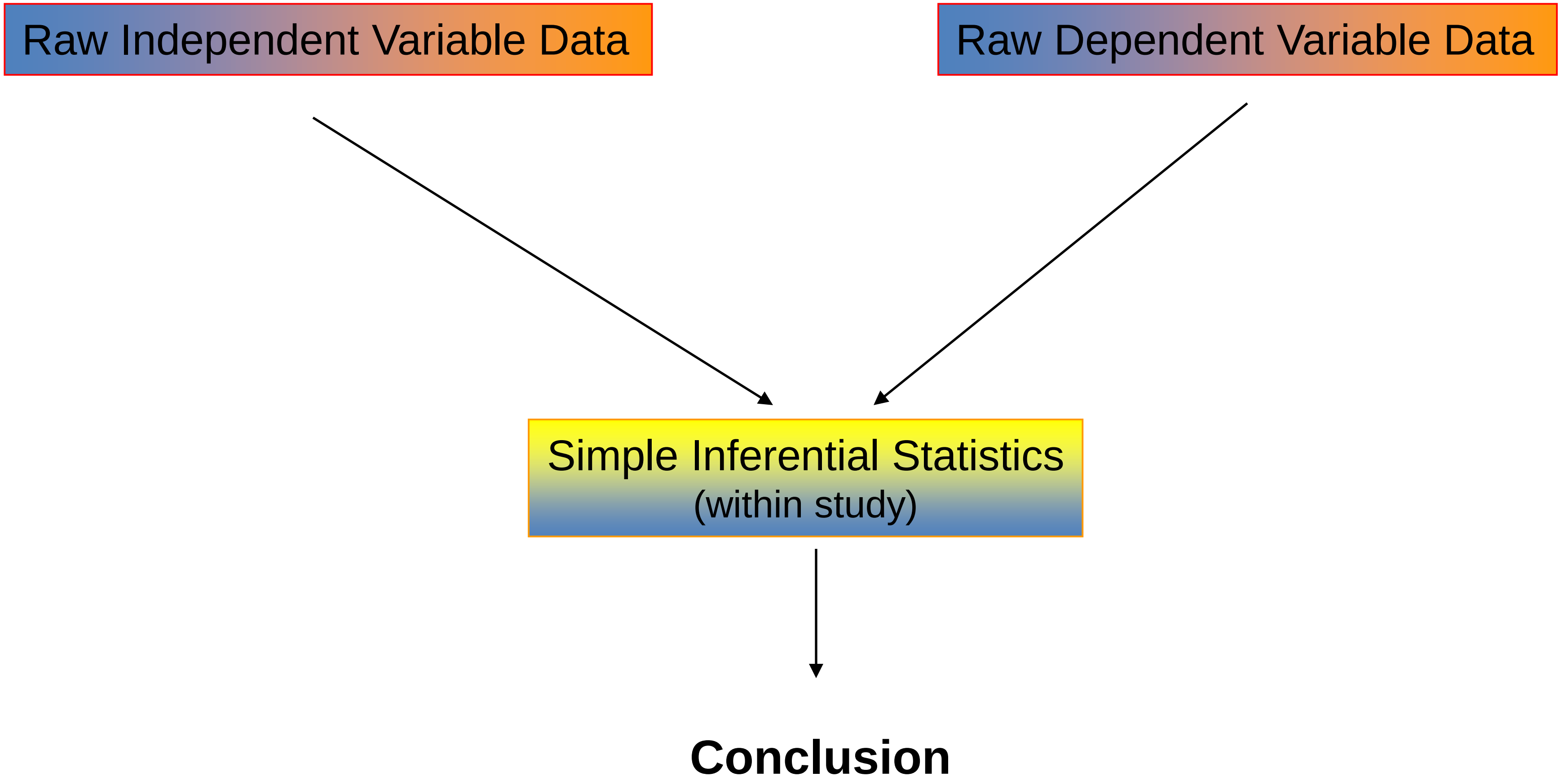
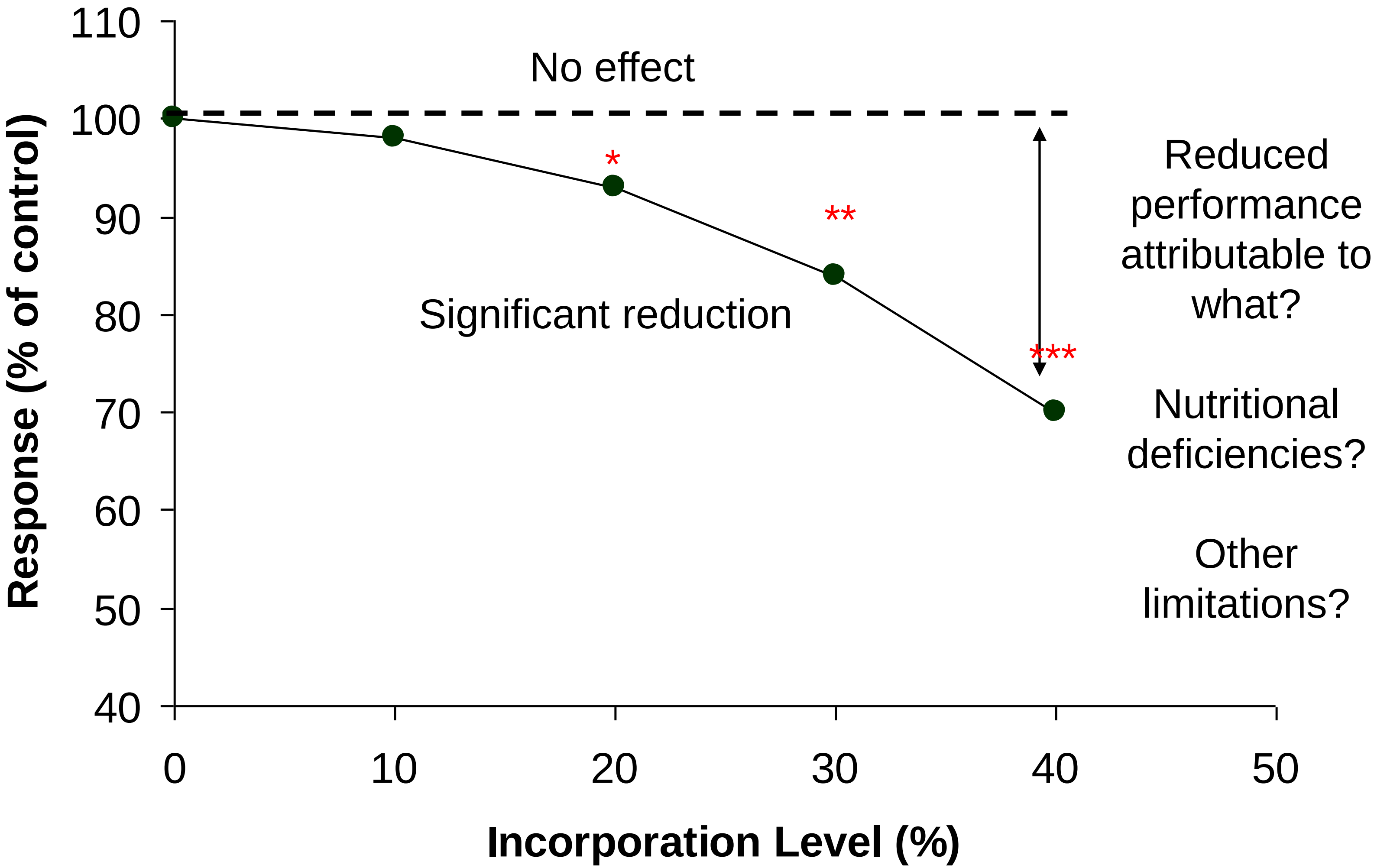
Traditional Approach for Analysis of Data from Trials



Example: Response of Fish to Increasing Levels of a Plant Protein Ingredient (e.g. SBM) Replacing Fish Meal in the Diet of Rainbow Trout



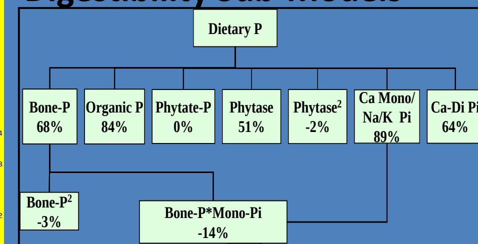
Upgrade – Standardization of Independent Parameters

Feed Evaluation Model (Digestible Nutrients – Nutritional Adequacy)

Feed Formulation

Name	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6	Diet 7	Diet 8	Diet 9	Diet 10	Diet 11	Diet 12
Fish meal	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Fish meal, LT												
Fish meal, anchovy												
Fish meal, herring												
Fish meal, menhaden												
Fish meal, mackerel												
Fish meal, sardine												
Fish meal, white												
Fish protein concentrate(CPSP)												
Fish solubes, condensed												
Fish solubes, dehydated												
Meat-bone meal 61% CP												
Meat-bone meal 56% CP												
Meat-bone meal 45% CP												
Poultry by-product meal (low ash)												
Poultry by-product meal(regular)												
Feather meal												
Blood meal, whole, spray-dry	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Blood cell meal, flash dried												
Casein												
Gelatin	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Skim milk powder												
Whey												
Brewer's dried yeast	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Brewer's grains, dehydated												
Canola meal, solvent extracted												
Canola protein concentrate												
Corn												
Corn gluten meal											0.05	0.1
Peanut meal, solvent extracted												
Rye												

Digestibility Sub-Models



Ingredient Database

Proximate Composition

Category	Name	IF#	D.M.	Protein	Fat	Fibre	Ash	NFE calc.	G.E.	GE (sum) calc.	D.P. calc.	D.E. calc.	D.L Calc	CAN $/kg	DM
Fishery by products	Fish meal		94.17	67.25	11.00	0.00	12.97	2.95	20.10	20.72	60.53	18.09	10.45		0.85
	Fish meal, LT		92.00	70.00	10.00	0.00	12.00	0.00	20.55	20.47	65.80	18.50	9.00		0.90
	Fish meal, anchovy		91.00	65.00	10.00	1.00	15.00	0.00		19.46	58.37	0.00	0.00		0.79
	Fish meal, herring	39	91.00	68.25	10.00	0.00	12.00	0.75	20.70	20.19	62.79	19.00	9.00		0.85
	Fish meal, menhaden		91.00	63.61	9.60	0.70	16.66	0.00	19.50	18.92	55.28	17.88	8.56		0.74
	Fish meal, mackerel		92.00	66.40	10.30	0.00	16.30	0.00		19.74	0.00	0.00	0.00		
	Fish meal, sardine		92.00	65.00	5.50	1.00	16.00	4.50		18.46	0.00	0.00	0.00		
	Fish meal, white	5-02-025	91.00	62.30	5.00	0.50	21.30	1.90		17.09	55.07	0.00	0.00		0.74
	Fish protein concentrate(CPSP)		97.00	84.00	7.00	0.00	6.00	0.00		22.59	0.00	0.00	0.00		
	Fish solubes, condensed	5-01-969	50.00	31.50	6.10	0.50	9.60	2.30		10.33	0.00	0.00	0.00		
	Fish solubes, dehydated	5-010971	93.00	64.30	8.20	1.30	2.50	16.70		21.51	0.00	0.00	0.00		
Animal By-products	Meat-bone meal 61% CP		96.86	60.13	2.70	2.3	22.72	9.01	18.50	17.20	48.10	13.88	2.30		0.70
	Meat-bone meal 56% CP		96.86	55.87	18.00	0.00	22.59	0.40	18.59	20.36	44.70	13.94	15.30		0.70
	Meat-bone meal 45% CP		95.39	46.70	15.00	0.00	34.28	-0.59	14.99	16.84	37.36	11.24	12.75		0.70
	Poultry by-product meal (low ash)		94.00	64.00	13.50	2.50	14.00	0.00	20.53	20.87	54.40	16.83	10.80		0.80
	Poultry by-product meal(regular)		96.28	60.25	11.00	2.50	19.72	3.50	20.02	19.60	51.21	16.42	8.80		0.80
	Feather meal	38	92.68	81.84	4.90	1.50	2.36	2.08	22.78	21.87	61.38	17.09	3.92		0.75
	Blood meal, whole, spray-dry	10	91.40	82.00	1.80	0.00	6.40	1.20	21.80	20.27	77.90	19.40	1.62		0.91
	Blood cell meal, flash dried		88.11	87.76	1.00	0.00	1.37	-2.02	21.69	20.76	74.60	18.44	0.85		0.91
	Casein		90	80.00	0.5	0.2	3.5	5.8	18.9	20.11	78.40	18.40	0.45		0.98
	Gelatin		95	95.00	0	0	0	0	22.42	22.42	93.10	19.70	0		0.98
	Skim milk powder	89	91.60	33.00	0.50	0.00	8.00	50.10	16.6	16.60	31.35	15.27	0.45		0.90
	Whey	111	94.00	12.00	0.70	0.00	9.70	71.60	14.30	15.42	11.52	13.40	0.63		0.97
Plant ingredients	Brewer's dried yeast	12	97.00	49.00	17.00	0.20	1.60	29.20	23.00	23.34	44.10	17.66	15.30		0.76
	Brewer's grains, dehydated	5-02-141	92.00	23.10	6.40	13.70	3.70	45.10		18.09	0.00	0.00	0.00		
	Canola meal, solvent extracted	5-06-145	93	38.00	3.8	11.1	6.8	33.30		18.11	30.02	0.00	0		
	Canola protein concentrate		88	63.96	8	4.7	5.9	5.44		20.00	56.92	0.00	0		
	Corn	4-02-935	88	8.50	3.6	2.3	1.3	72.30		16.26	0.00	0.00	0		0.64
	Corn gluten meal	27	88.00	60.43	3.00	2.50	1.60	20.47	20.29	19.40	58.01	16.84	2.70		0.80
	Peanut meal, solvent extracted	5-03-650	92	49.00	1.3	9.9	5.9	25.90		18.24	0.00	0.00	0		
	Rye	4-04-047	89.00	12.6	1.85	2.8	1.45	70.3		16.28	0.00	0.00	0.00		
	Sorghum	4-04-444	89.00	9.90	2.8	2.3	1.8	72.2		16.26	8.81	0.00	0.00		
	Soy protein concentrate 300		92.36	55.35	0.50	4.00	6.37	26.14	18.77	18.44	49.26	16.86	0.45		0.74
	Soy protein concentrate 340		88.00	55.73	0.50	4.00	5.91	21.86	18.48	17.80	49.60	16.60	0.45		0.60
	soybean meal, dehulled	96	87.70	48.00	1.00	3.00	6.00	29.70	18.00	17.35	42.24	13.50	0.90		0.74
	Soybean meal, 52%CP		92.00	52.00	1.50	3.50	6.50	28.50	18.4	18.37	49.92	14.00	1.35		0.75
	soybean meal, solvent		90.00	44.00	0.50	7.00	6.00	32.50		17.38	39.16	0.00	0.00		
	soybean, full fat	5-04-597	90.00	38.00	18.00	5.00	4.50	28.50		21.84	33.82	0.00	0.00		
	Starch, raw	124	90.00	0.00	0.00	1.00	0.00	89.00	17.60	15.48	0.00	6.10	0.00		0.37
	Starch, gel.		90.00	0.00	0.00	1.00	0.00	89.00	17.60	15.48	0.00	15.07	0.00		0.86
	Sunflower meal, solvent extrac	5-04-739	93.00	45.50	2.9	11.7	7.5	25.4		18.26	40.50	0.00	0.00		
	Wheat, grain	294	86.00	10.80	1.70	2.80	2.00	68.70	16.00	15.52	9.94	7.00	1.53		0.60
	Wheat flour	4-05-199	88.00	11.70	1.20	1.30	0.40	73.40		16.08	11.70	0.00	0.00		0.43
	Lentil, green Canada		88.00	26.00	1.00	18.00	3.00	40.00	17.4	16.51	22.88	12.00	0.88		0.60
	Wheat gluten		88.00	76.86	5.00	0.50	0.60	5.04	21.89	21.07	70.71	18.96	4.50		0.86
	Wheat middlings		88.57	15.66	3.60	7.00	2.61	59.70	16.94	16.59	14.41	10.16	3.24		0.35

Digestible Nutrients Content
Upgraded Independent Variables

Nutrient Requirements

Vitamin	NRC req./kg		Ingredient name	Conc./g in
Vitamin A	2500	IU	Retinyl acetate	50000
Vit. D3	2000	IU	Cholescalciferol	50000
Vit.E	50	IU	dl-a-tocopherol-acetate	250
Vit.K	1	mg	Menadione Na-bisulfate	1000
Vit. B12	0.02	mg	Cyanocobalamine	1
Ascorbic acid	200		Ascorbic acid	
Ascorbic acid	50	mg	Ascorbic acid monophos.	250
d-Biotin	0.14	mg	Biotin	1
Choline	-		(-dihydrogen citrate)	435
Choline	1000	mg	(-chloride, 50%)	435
Folic acid	1	mg		1000
Inositol	0			1000
Niacin	10			1000
Pant.acid	20		(Calcium-)	920
Pyridoxine	5		(-HCl, B6)	1000
Riboflavin	6		(B2)	1000
Thiamin	1	mg	(HCl, B1)	1000

Digestible Nutrient Content / Nutritional Requirements
Standardized / Relative Independent Variables

Upgrade – Standardization of Dependent Parameters:

To Improve Compatibility of Observations from Various Studies and Extract more Objective and Relevant Information

Parameters (examples):

Initial weight: 20 g/fish
Final weight: 86 g/fish
Water temperature: 14.5°C (12.5-16.5°C)
Duration: 120 days

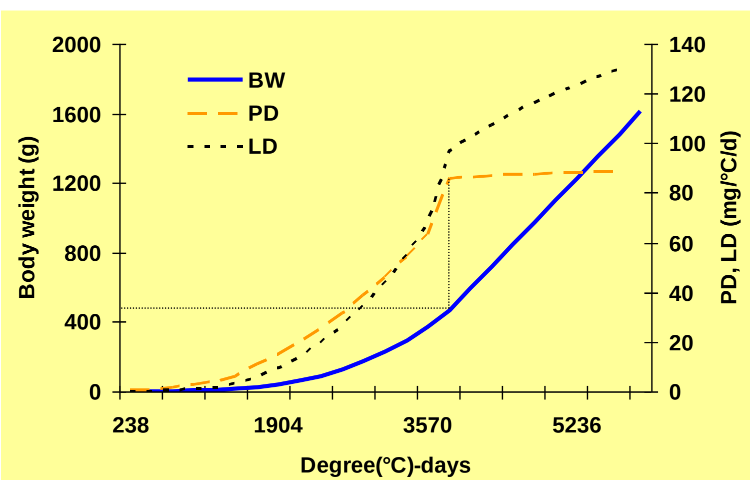
Reliable Growth Model(s)

The TGC model now becomes:

$$W_n^{1/3} = W_0^{1/3} + \frac{c_{n-1}}{1000} \sum_{i=1}^{n} T_i$$

A more general statement of which is:

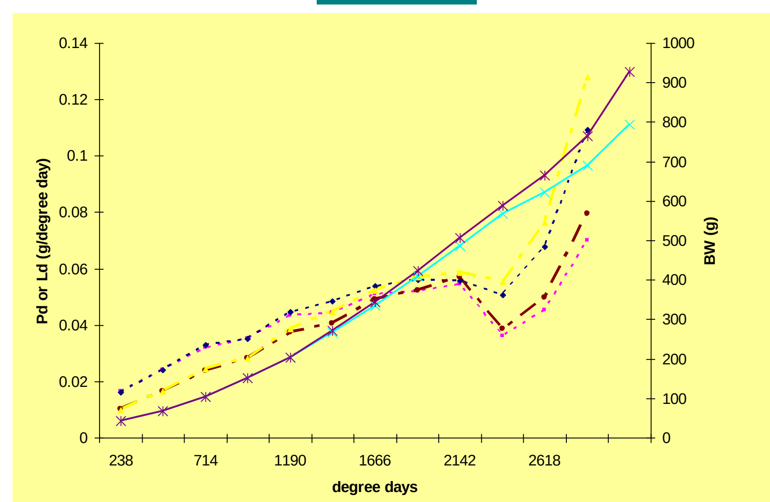
$$W_n^{1-b} = W_0^{1-b} + \frac{c_{n-1}}{1000} \sum_{i=1}^{n} T_i$$



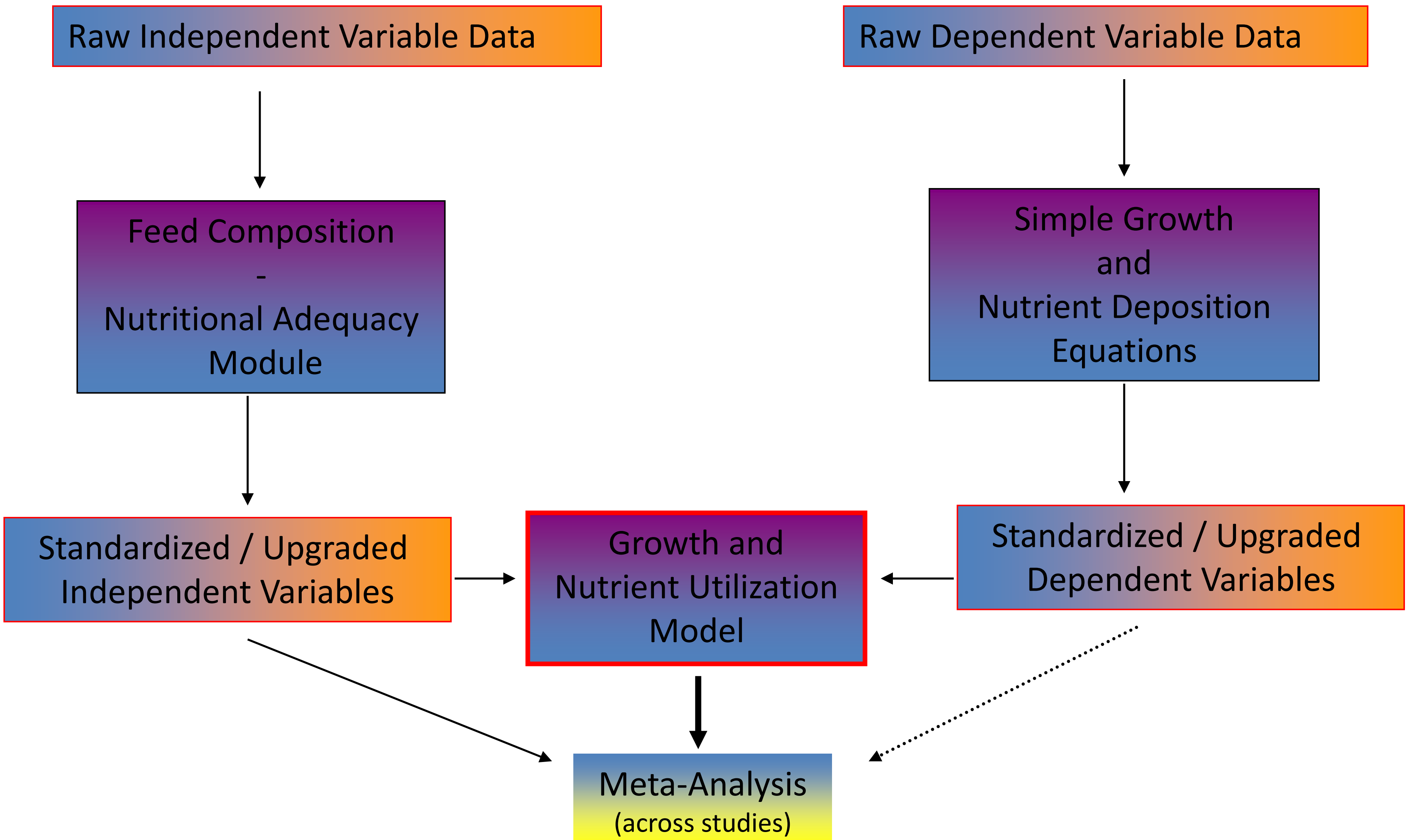
Nutrient Depositions Dynamic

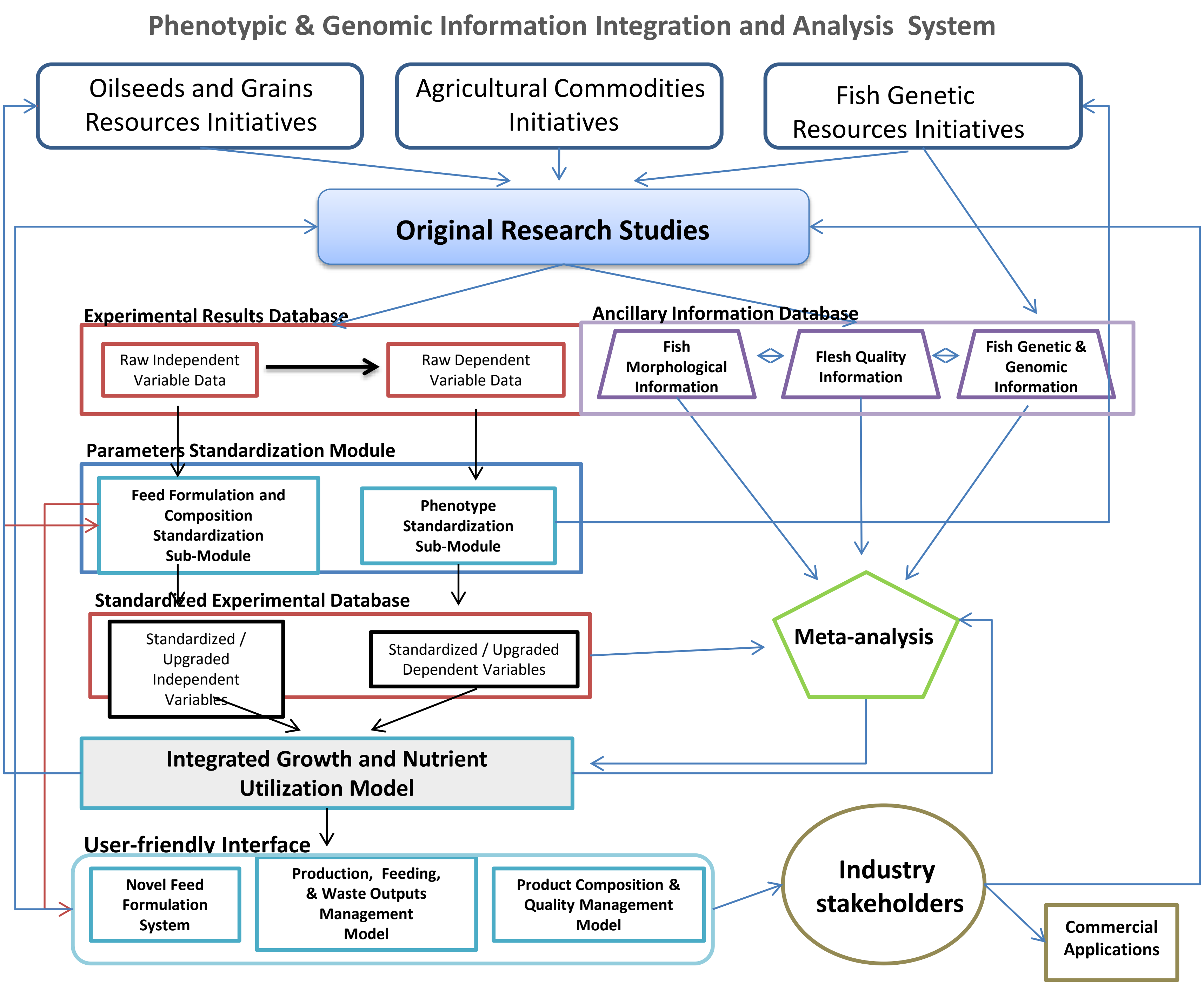
$$D_j = \frac{\text{Final content}_j - \text{Initial content}_j}{\sum_{i=1}^{n} (\text{Temperature}_i \times \text{time}_i)}$$

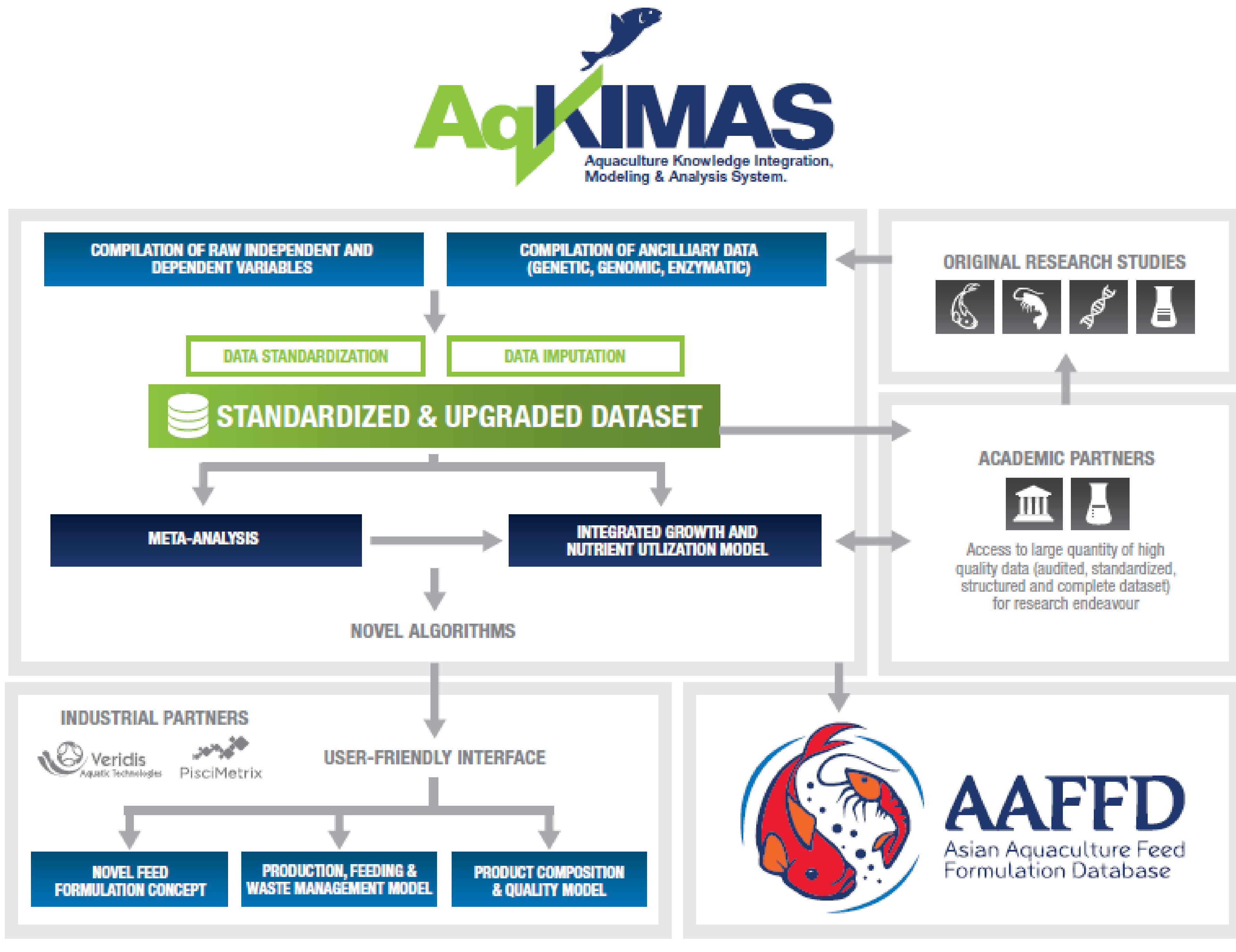
$$= \frac{\text{mg}}{°\text{C} \cdot \text{day}}$$



Data Analysis Based on Simulation using Growth and Nutrient Utilization Model




Phenotypic & Genomic Information Integration and Analysis System
Oilseeds and Grains Resources Initiatives
Agricultural Commodities Initiatives
Fish Genetic Resources Initiatives
Original Research Studies
Experimental Results Database
Raw Independent Variable Data
Raw Dependent Variable Data
Ancillary Information Database
Fish Morphological Information
Flesh Quality Information
Fish Genetic & Genomic Information
Parameters Standardization Module
Feed Formulation and Composition Standardization Sub-Module
Phenotype Standardization Sub-Module
Standardized Experimental Database
Standardized / Upgraded Independent Variables
Standardized / Upgraded Dependent Variables
Meta-analysis
Integrated Growth and Nutrient Utilization Model
User-friendly Interface
Novel Feed Formulation System
Production, Feeding, & Waste Outputs Management Model
Product Composition & Quality Management Model
Industry stakeholders
Commercial Applications


AqKIMAS
Aquaculture Knowledge Integration, Modeling & Analysis System.
COMPILATION OF RAW INDEPENDENT AND DEPENDENT VARIABLES
COMPILATION OF ANCILLIARY DATA (GENETIC, GENOMIC, ENZYMATIC)
ORIGINAL RESEARCH STUDIES
DATA STANDARDIZATION
DATA IMPUTATION
STANDARDIZED & UPGRADED DATASET
ACADEMIC PARTNERS
META-ANALYSIS
INTEGRATED GROWTH AND NUTRIENT UTLIZATION MODEL
Access to large quantity of high quality data (audited, standardized, structured and complete dataset) for research endeavour
NOVEL ALGORITHMS
INDUSTRIAL PARTNERS
Veridis Aquatic Technologies
PisciMetrix
USER-FRIENDLY INTERFACE
NOVEL FEED FORMULATION CONCEPT
PRODUCTION, FEEDING & WASTE MANAGEMENT MODEL
PRODUCT COMPOSITION & QUALITY MODEL
AAFFD
Asian Aquaculture Feed Formulation Database

AAFFD

Asian Aquaculture Feed Formulation Database

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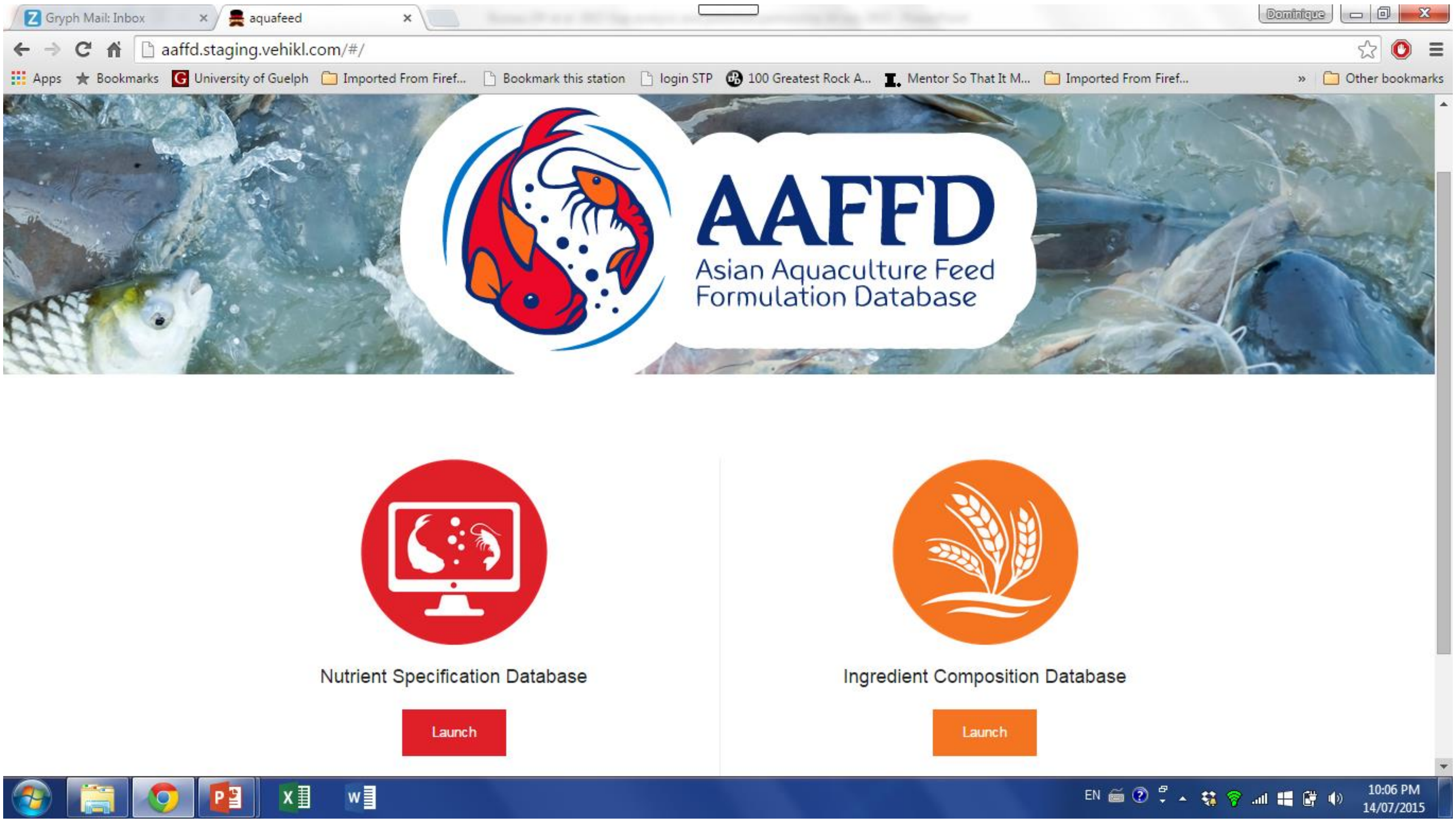
http://asianaquafeeddatabase.com/ = True home. Hosted on secure server

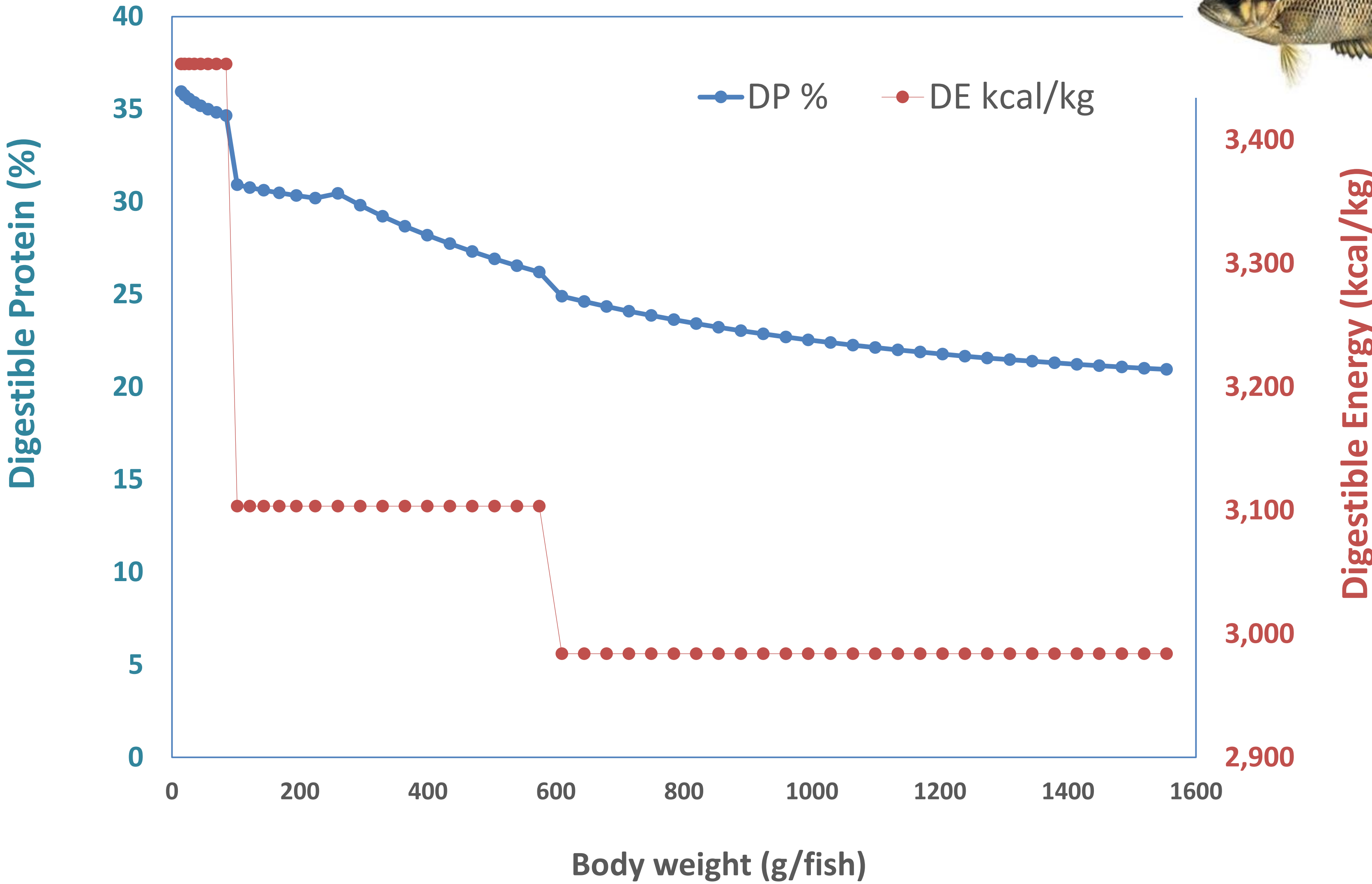


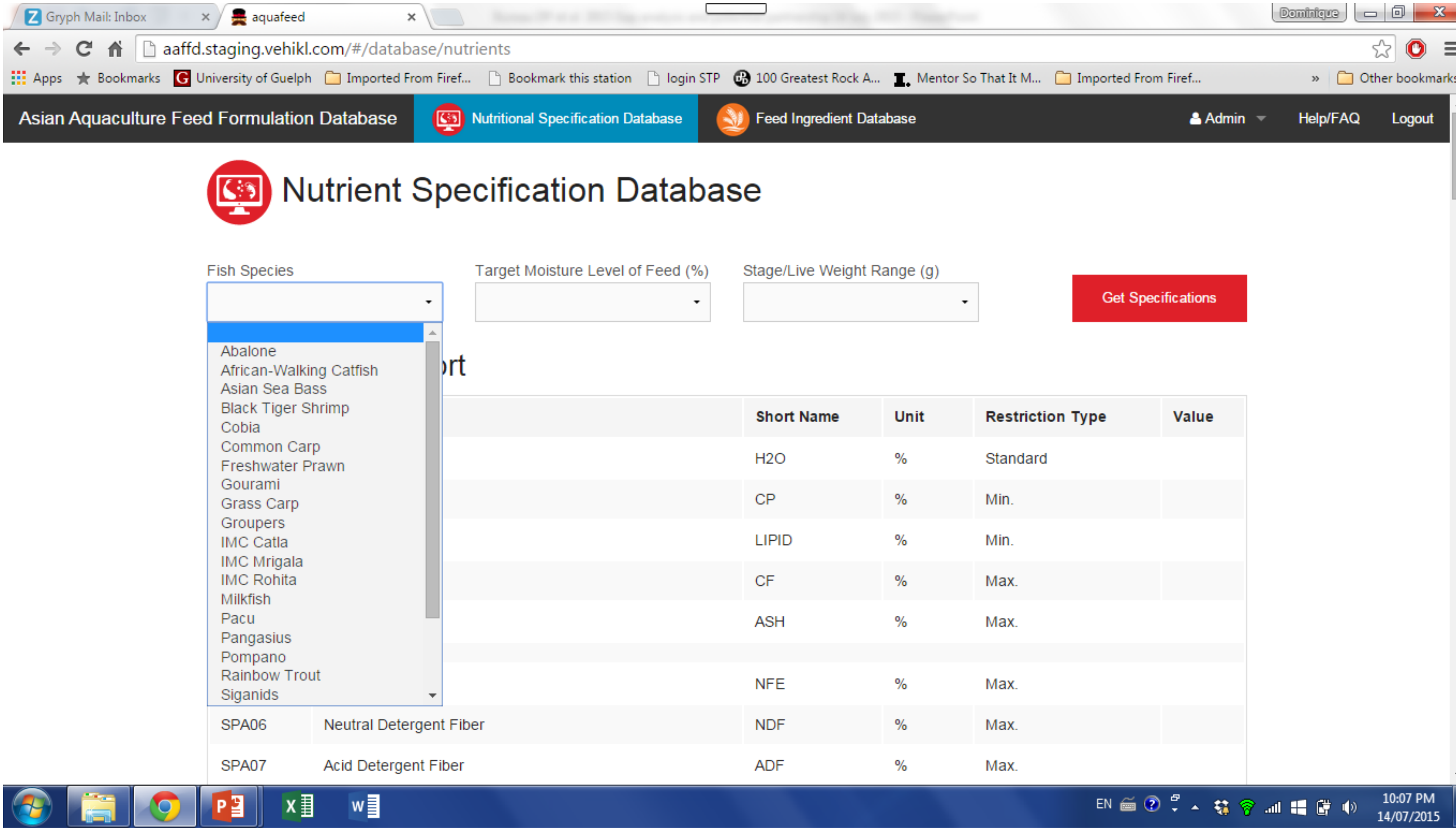
AAFFD
Asian Aquaculture Feed Formulation Database

Scope : Species

- > 1. Tilapia
- > 2. Pangasius
- > 3. Milkfish
- > 4. Asian sea bass
- > 5. Grass Carp
- > 6. Common Carp
- > 7. Indian major carps (IMCs, 3 species)
- > 8. Clarias spp.
- > 9. Gourami
- > 10. Pompano
- > 11. Cobia
- > 12. Snappers
- > 13. Groupers
- > 14. Siganids - rabbitfish
- > 15. Snakehead
- > 16. L.vannamei
- > 17. P.monodon
- > 18. Macrobrachium
- ➢ 19. Abalone
- ➢ 20. Rainbow trout
- ➢ 21. Sturgeon
- ➢ 22. Pacu

Predicted Optimal Digestible Protein and Digestible Energy Content of Nile Tilapia Feeds





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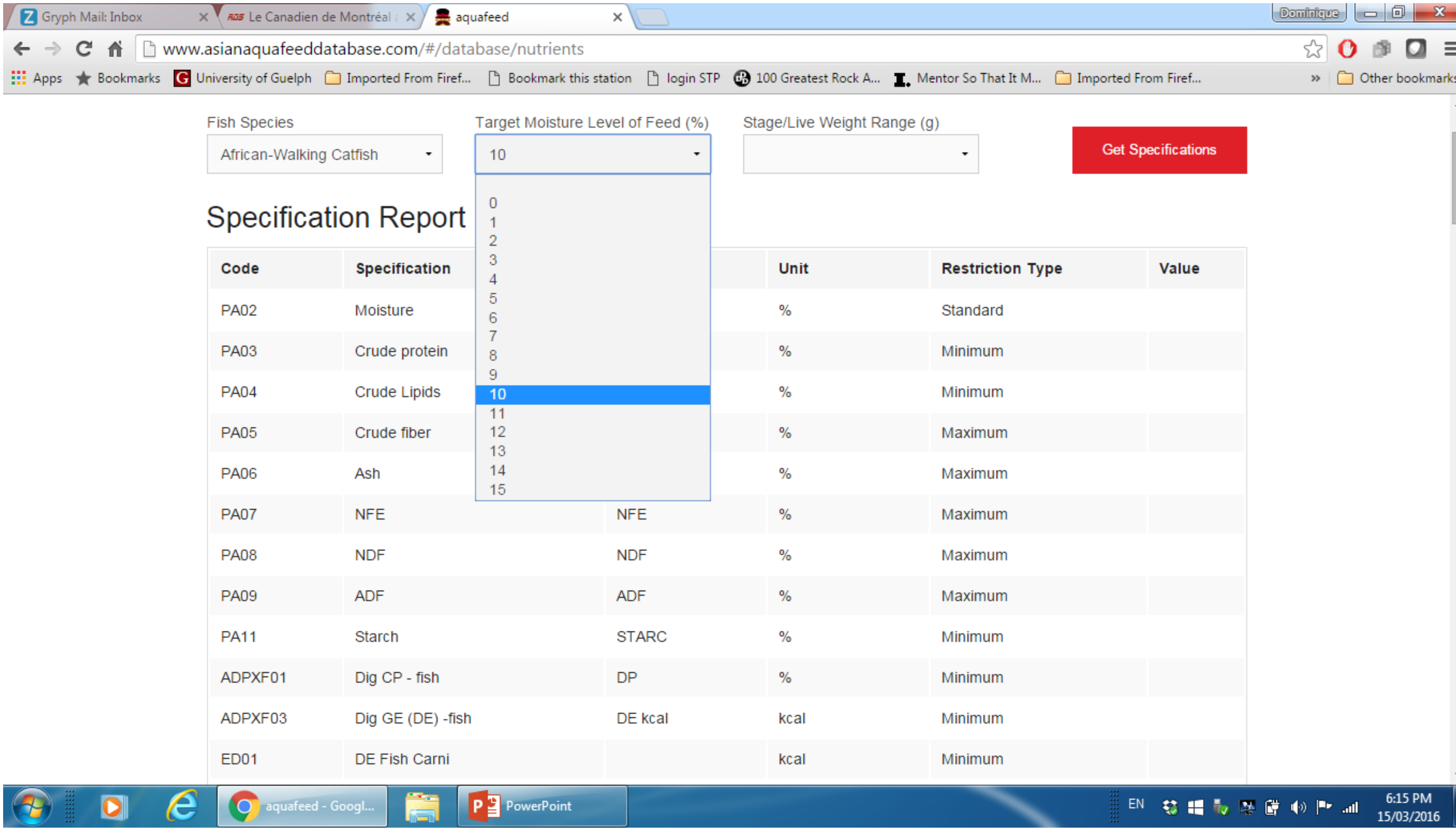
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Other bookmarks
Fish Species
African-Walking Catfish
Target Moisture Level of Feed (%)
10
Stage/Live Weight Range (g)
Get Specifications
Specification Report
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4
5
6
7
8
9
10
11
12
13
14
15
Code
Specification
Unit
Restriction Type
Value
PA02 Moisture % Standard
PA03 Crude protein % Minimum
PA04 Crude Lipids % Minimum
PA05 Crude fiber % Maximum
PA06 Ash % Maximum
PA07 NFE NFE % Maximum
PA08 NDF NDF % Maximum
PA09 ADF ADF % Maximum
PA11 Starch STARC % Minimum
ADPXF01 Dig CP - fish DP % Minimum
ADPXF03 Dig GE (DE) -fish DE kcal kcal Minimum
ED01 DE Fish Carni kcal Minimum
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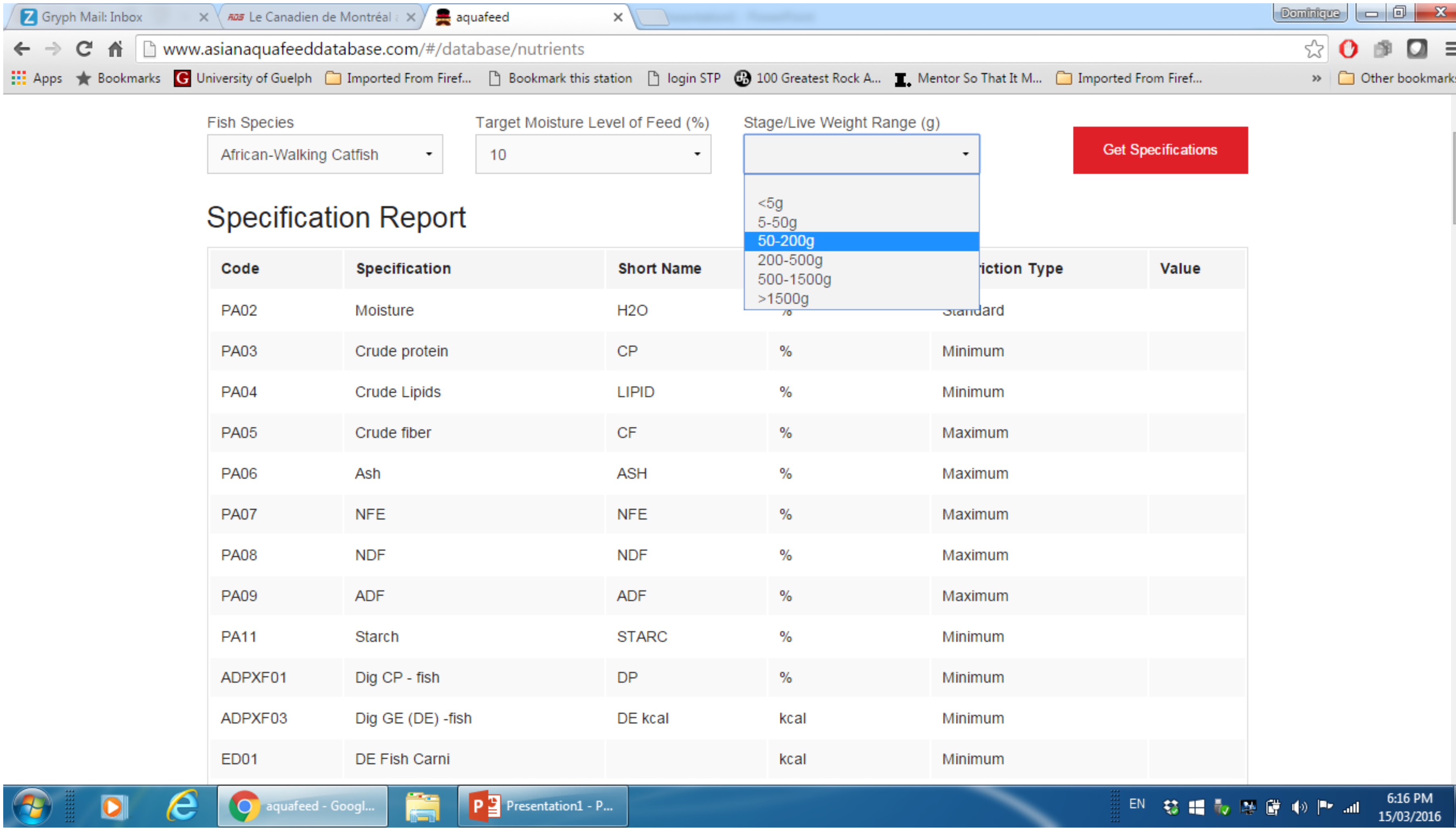

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Other bookmarks
Fish Species
African-Walking Catfish
Target Moisture Level of Feed (%)
10
Stage/Live Weight Range (g)
<5g
5-50g
50-200g
200-500g
500-1500g
>1500g
Get Specifications
Specification Report
Code
Specification
Short Name
iction Type
Value
PA02 Moisture H2O
PA03 Crude protein CP % Minimum
PA04 Crude Lipids LIPID % Minimum
PA05 Crude fiber CF % Maximum
PA06 Ash ASH % Maximum
PA07 NFE NFE % Maximum
PA08 NDF NDF % Maximum
PA09 ADF ADF % Maximum
PA11 Starch STARC % Minimum
ADPXF01 Dig CP - fish DP % Minimum
ADPXF03 Dig GE (DE) -fish DE kcal kcal Minimum
ED01 DE Fish Carni kcal Minimum
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www.asianaquafeeddatabase.com/#/database/nutrients

Fish Species: African-Walking Catfish

Target Moisture Level of Feed (%): 10

Stage/Live Weight Range (g): 50-200g

Get Specifications

Export to CSV

Specification Report

Code	Specification	Short Name	Unit	Restriction Type	Value
PA02	Moisture	H2O	%	Standard	4.74
PA03	Crude protein	CP	%	Minimum	33.35
PA04	Crude Lipids	LIPID	%	Minimum	6.73
PA05	Crude fiber	CF	%	Maximum	
PA06	Ash	ASH	%	Maximum	
PA07	NFE	NFE	%	Maximum	41.40
PA08	NDF	NDF	%	Maximum	
PA09	ADF	ADF	%	Maximum	
PA11	Starch	STARC	%	Minimum	18.19
ADPXF01	Dig CP - fish	DP	%	Minimum	29.37

FA05	Linolenic 18:3 n-3	ALA	%	Minimum	
FA07	EPA 20:5 n-3	EPA	%	Minimum	
FA08	DHA 22:6 n-3	DHA	%	Minimum	0.09
FA12	Sum n-3	N3FA	%	Minimum	0.09
FA04	Linoleic acid 18:2 n-6	LA	%	Minimum	
FA06	Arachidonic 20:4 n-6	ARA	%	Minimum	
FA13	Sum n-6	N6FA	%	Minimum	
FA14	Phospholipids	PLS	%	Minimum	0.90
FA15	Cholesterol	CHOL	mg	Minimum	
M01	Calcium	Ca	%	Minimum	0.47
M02	Phosphorus	P	%	Minimum	1.00
M0281	Digestible P Carni	DPHCARNI	%	Minimum	0.55
M0282	Digestible P Omni	DPHOMNI	%	Minimum	
M0283	Digestible P Carp	DPHCARP	%	Minimum	
M0284	Digestible P Shrimp	DPHCRU	%	Minimum	
M03	Sodium	Na	%	Minimum	0.14
M04	Chlorine	Cl	%	Minimum	0.14