AqKIMAS: A Data Compilation, Integration, Standardization, Modeling and Analysis Effort for Aquaculture Nutrition Studies

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Aquaculture nutrition: a very dynamic research field

> 1000s studies on nutrient requirements of fish and crustaceans

> 300 scientific papers and technical documents on essential amino acid requirements

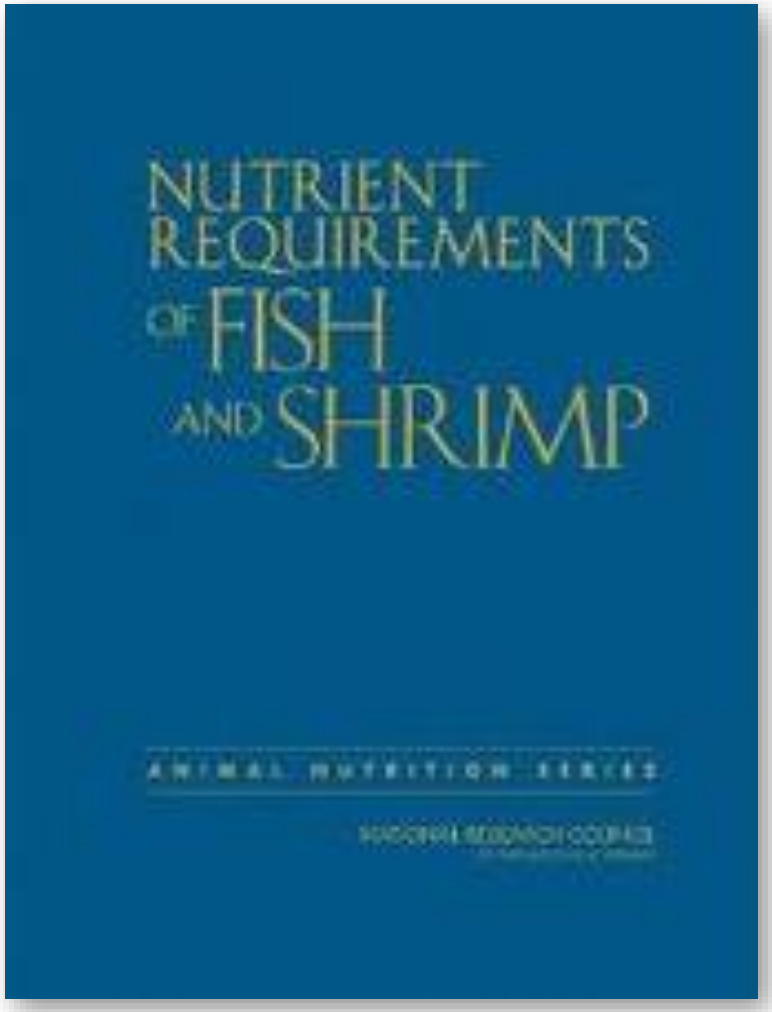
> 500 studies or papers on the nutritive value of soybean products (soybean meal, oil, protein concentrates)

> 500 papers on nutritive value of animal proteins and fats for aquatic species

> 500 documents on “fish meal and fish oil replacement" over the past two or three decades.

Interest in the field, effort invested, talent pool, and money are not lacking and these represent terrific resources/driving forces.

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



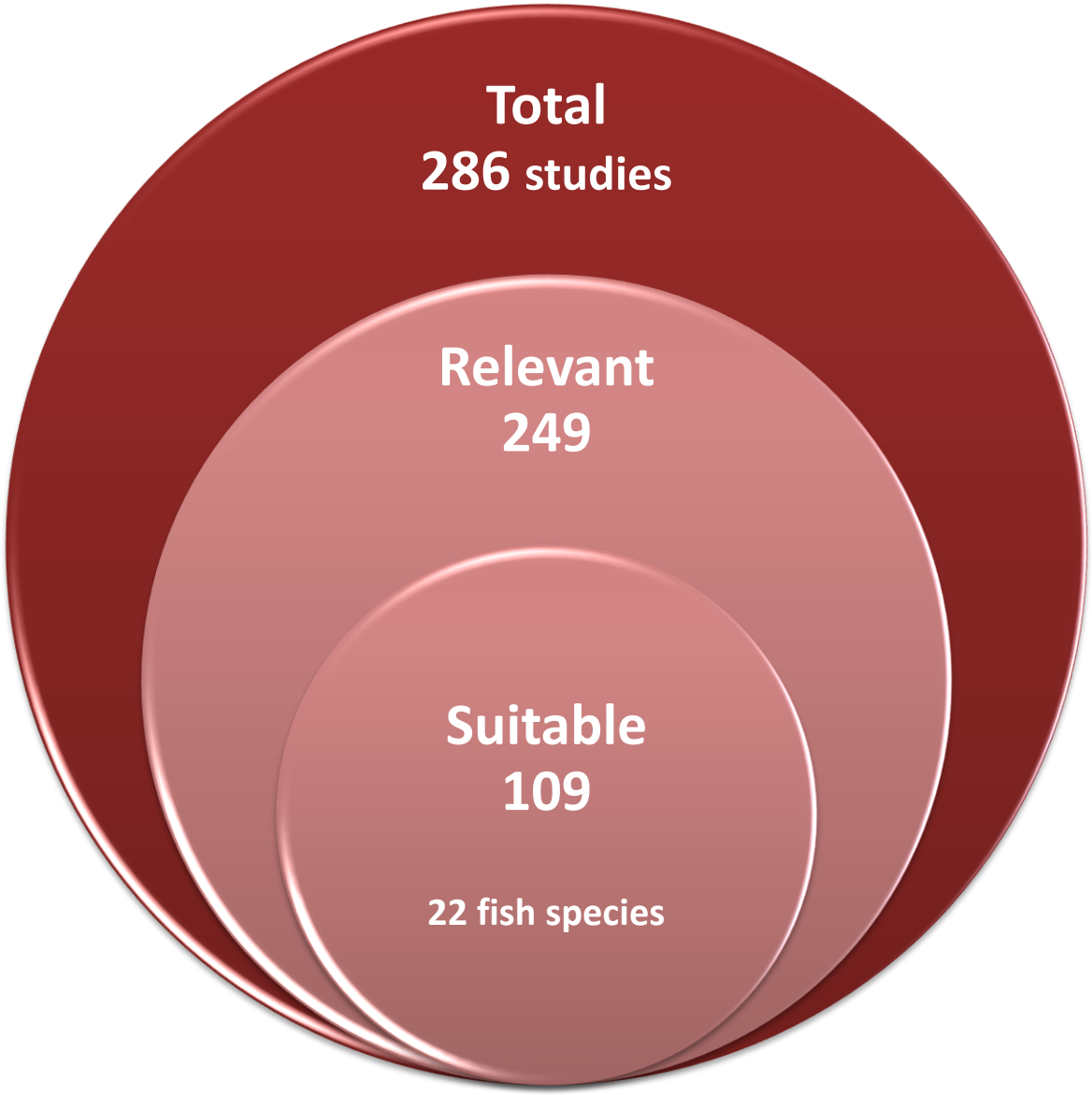
NRC 2011

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



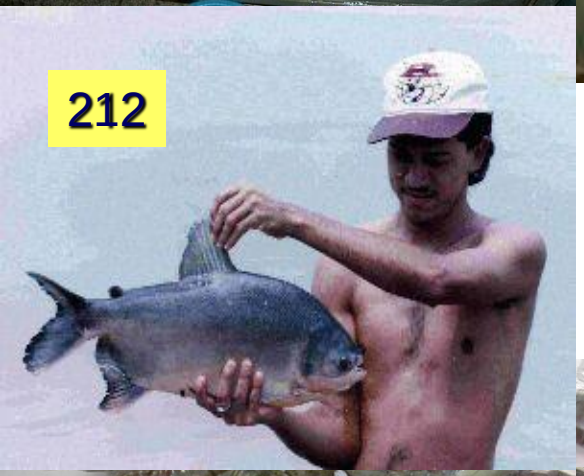
Main causes of rejection:

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

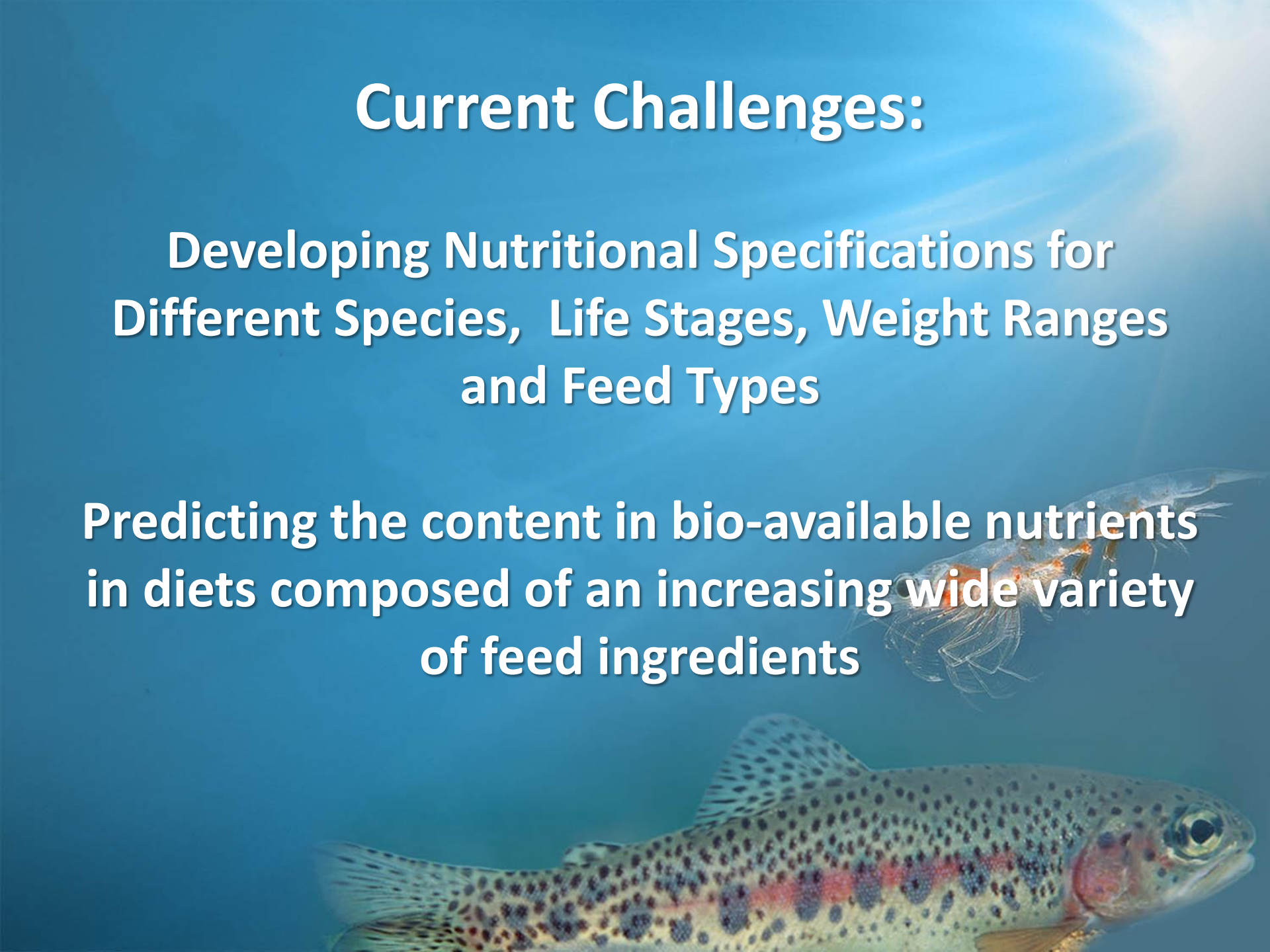
AQUACULTURE = Diversity of Species



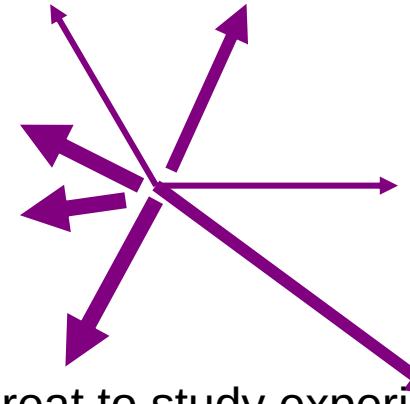
Current Challenges:

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.

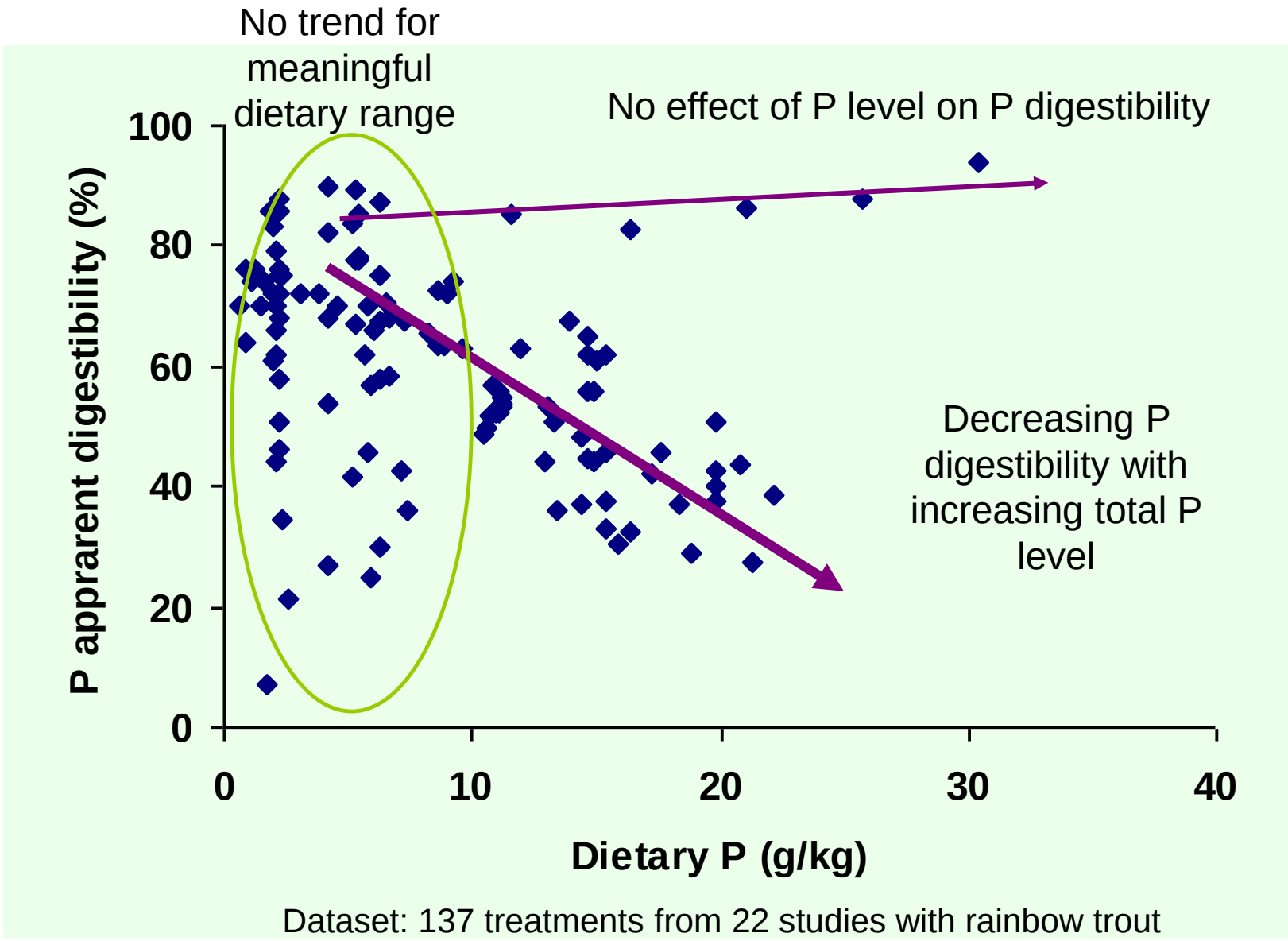


Number of combinations/permutations too great to study experimentally.

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

Contents lists available at ScienceDirect

Aquaculture

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

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

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

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

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

Knowledge Translation and Transfer (KTT) Efforts by UG/OMNR Fish Nutrition Research Laboratory

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

(e.g. Cho, 1992, Cho & Bureau, 1998, Bureau et al., 2003; Azevedo et al., 2011)

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, submitted for publication)

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)

Asian Aquaculture Feed Formulation Database

These efforts all involved gathering, compiling, auditing (verifying), integrating and analyzing data from wide variety of sources

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 | Ontario Ministry of
University of Guelph | Natural Resources

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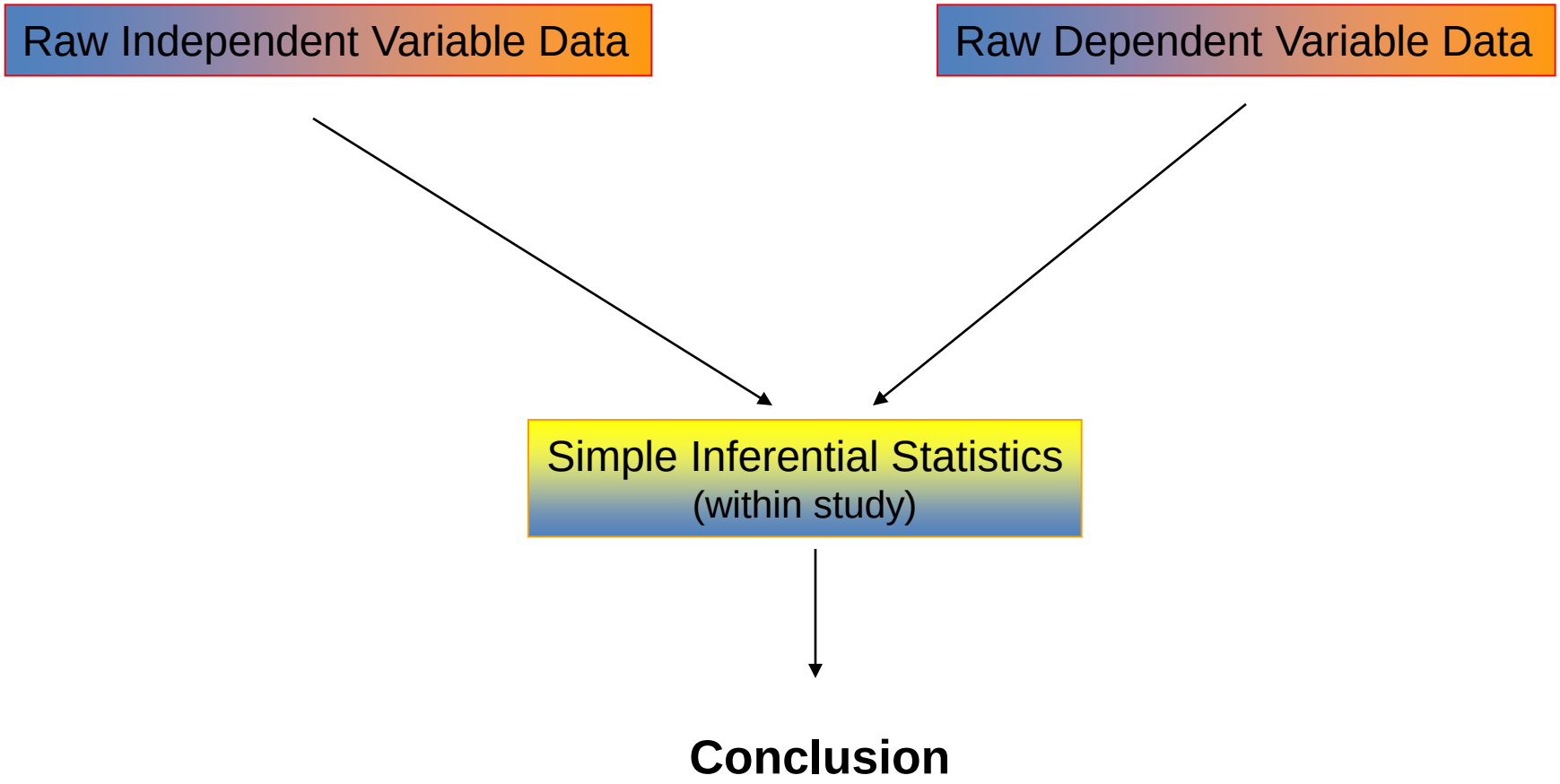
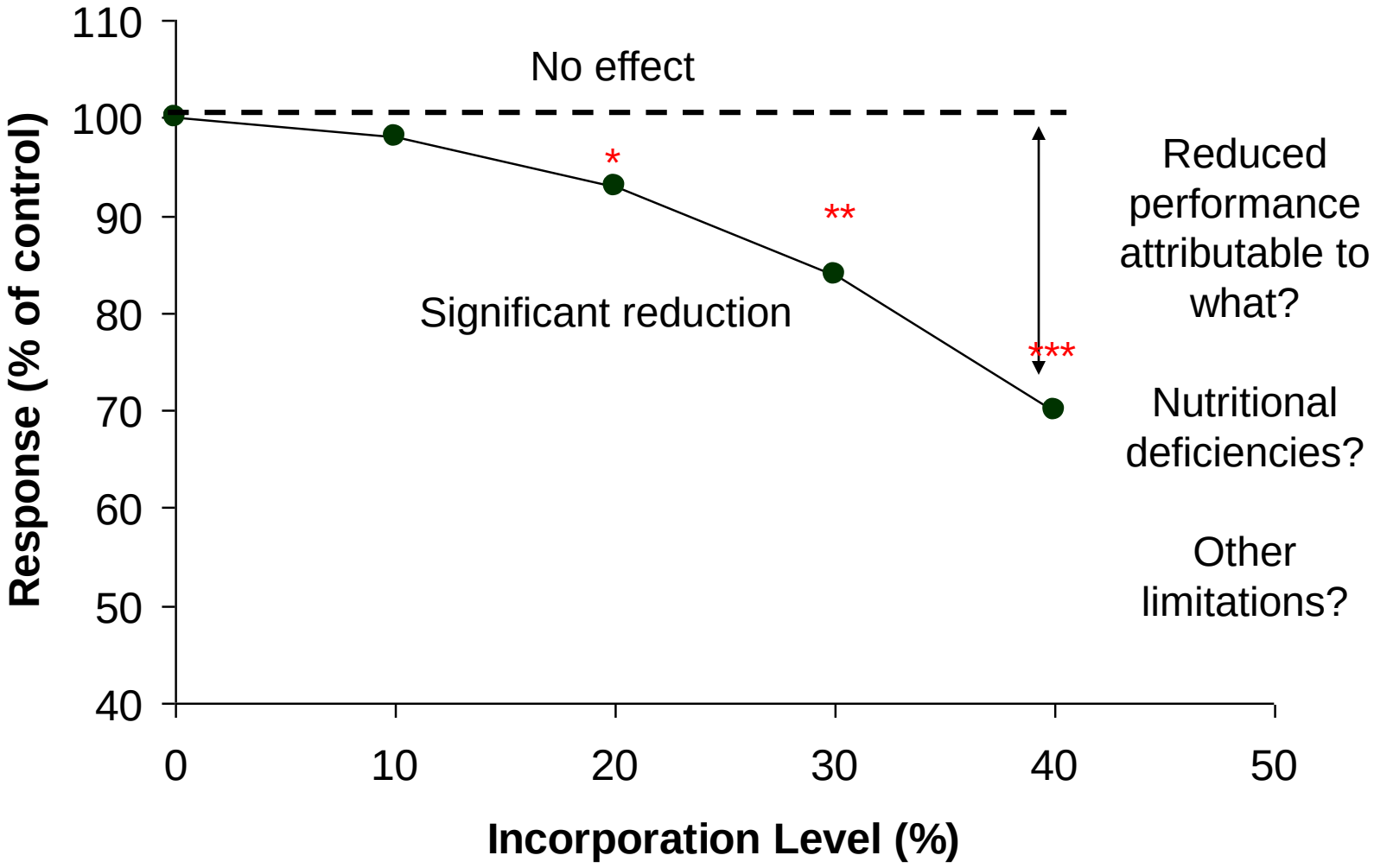
Traditional Approach for Analysis of Data from Trials



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



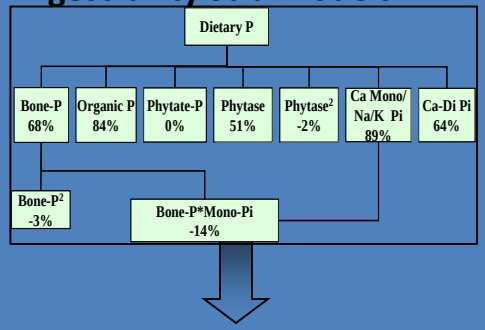
Upgrade – Standardization of Independent Parameters

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

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
			Proximate Composition												
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	5-01-069	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	18.39	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	34.02	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		0.55

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

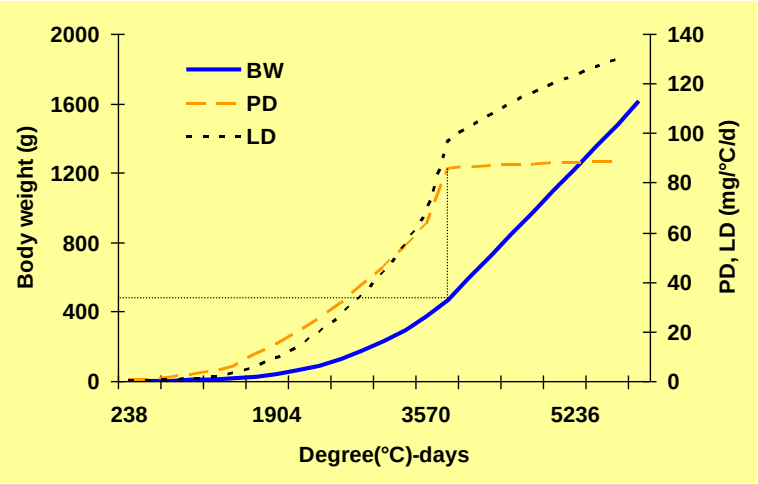
Reliable Growth Model(s)

The TGC model now becomes:

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

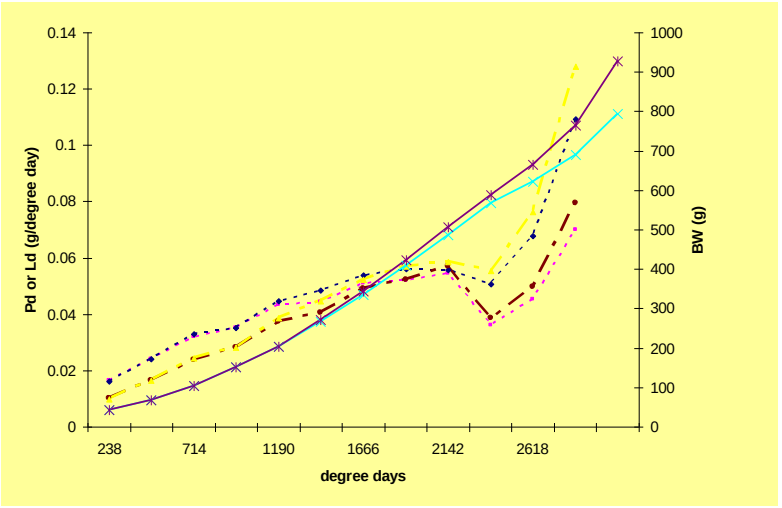
A more general statement of which is:

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

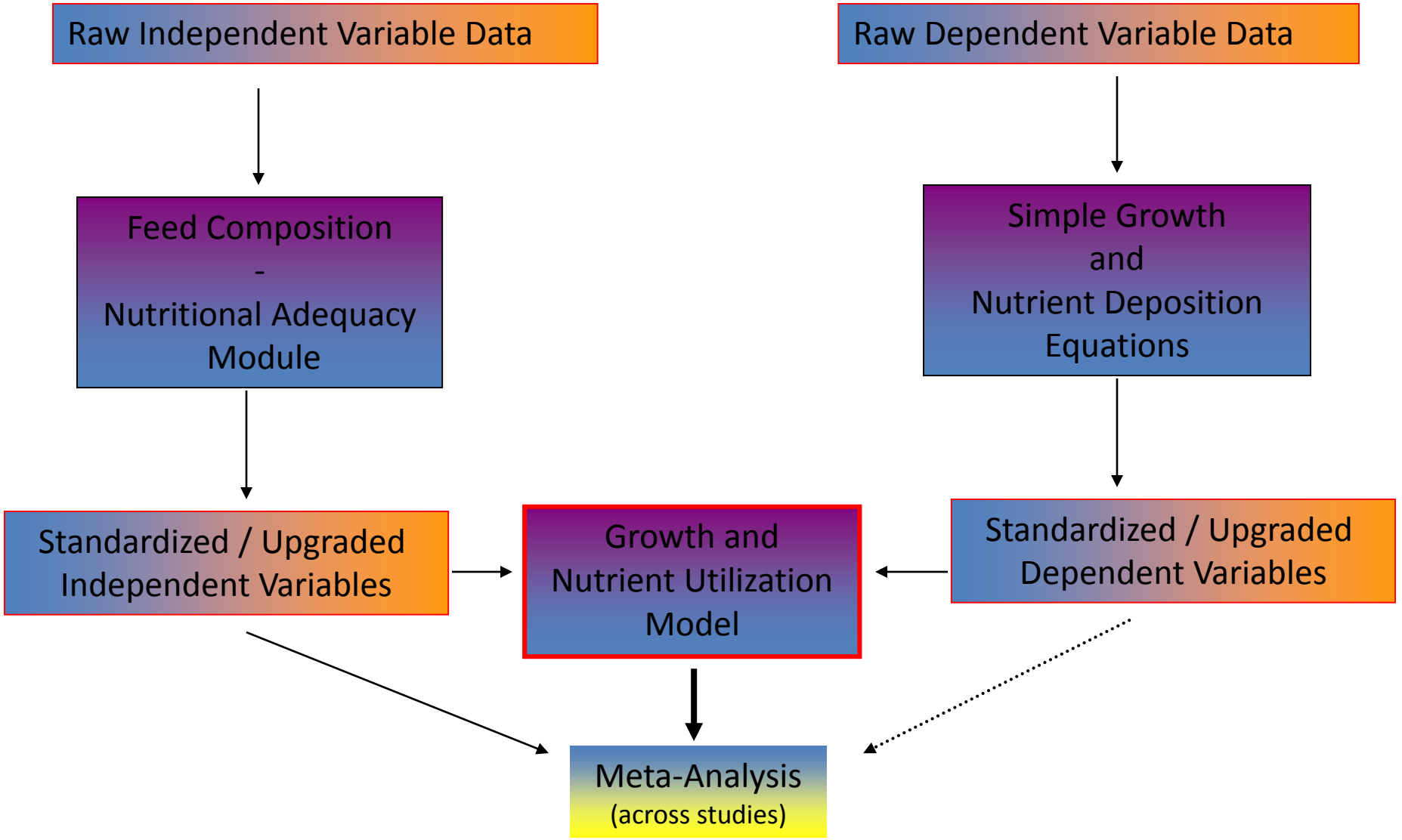


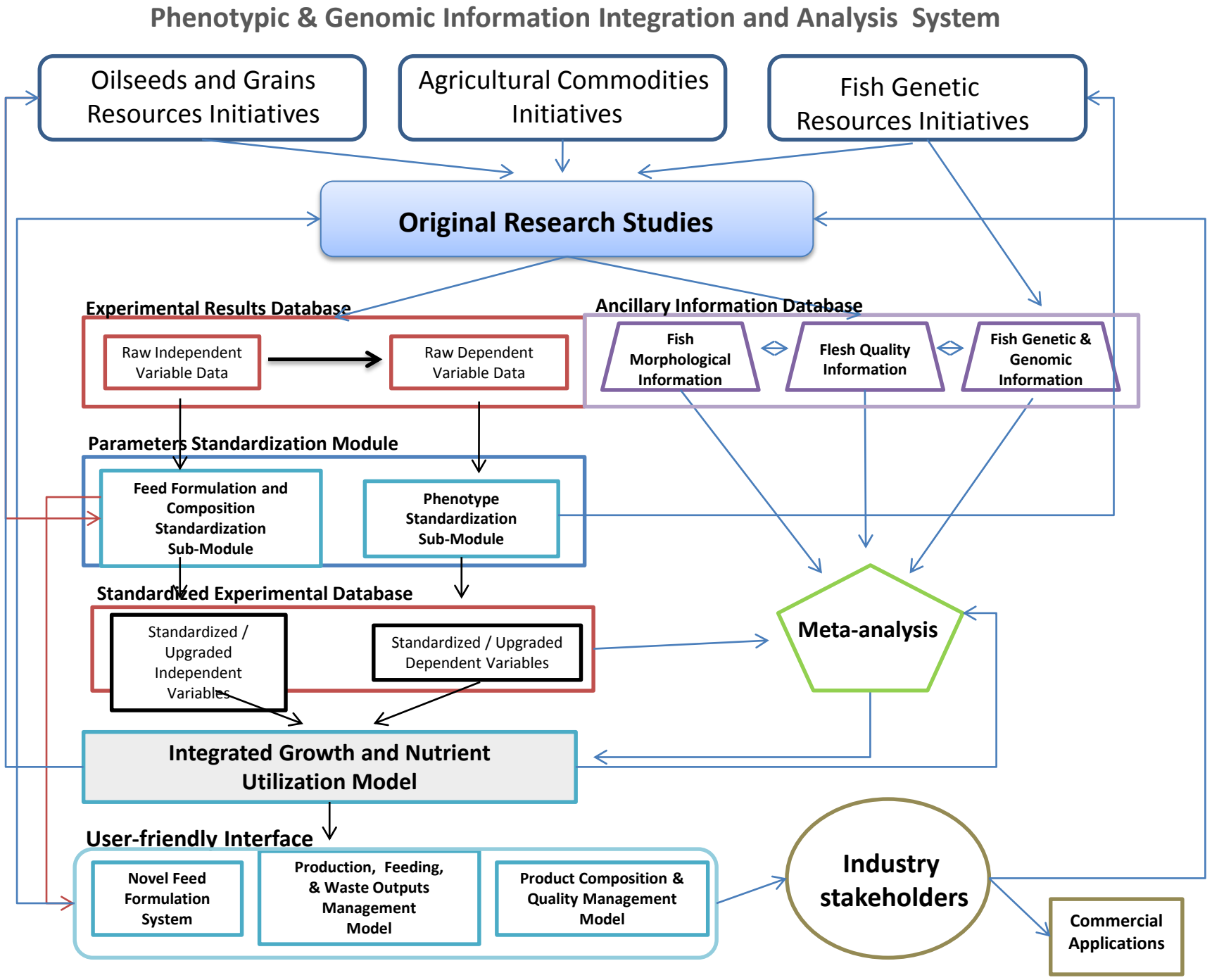
Nutrient Depositions Dynamic

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



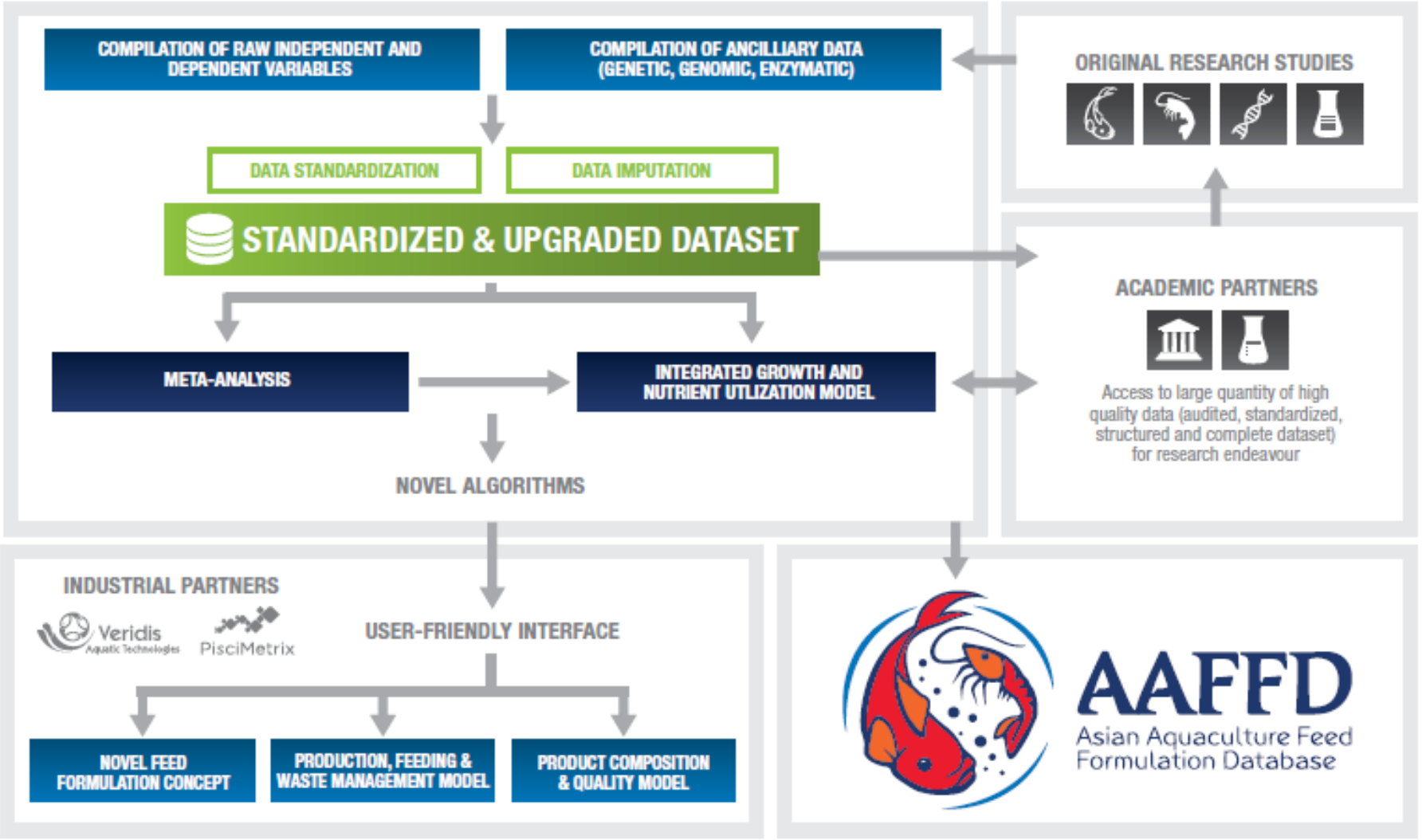
Data Analysis Based on Simulation using Growth and Nutrient Utilization Model




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.



AAFFD

Asian Aquaculture Feed Formulation Database

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FROM THE AMERICAN PEOPLE

Veridis Aquatic Technologies
Fish Nutrition Research Laboratory
GRIPHA
UNIVERSITY of GUELPH
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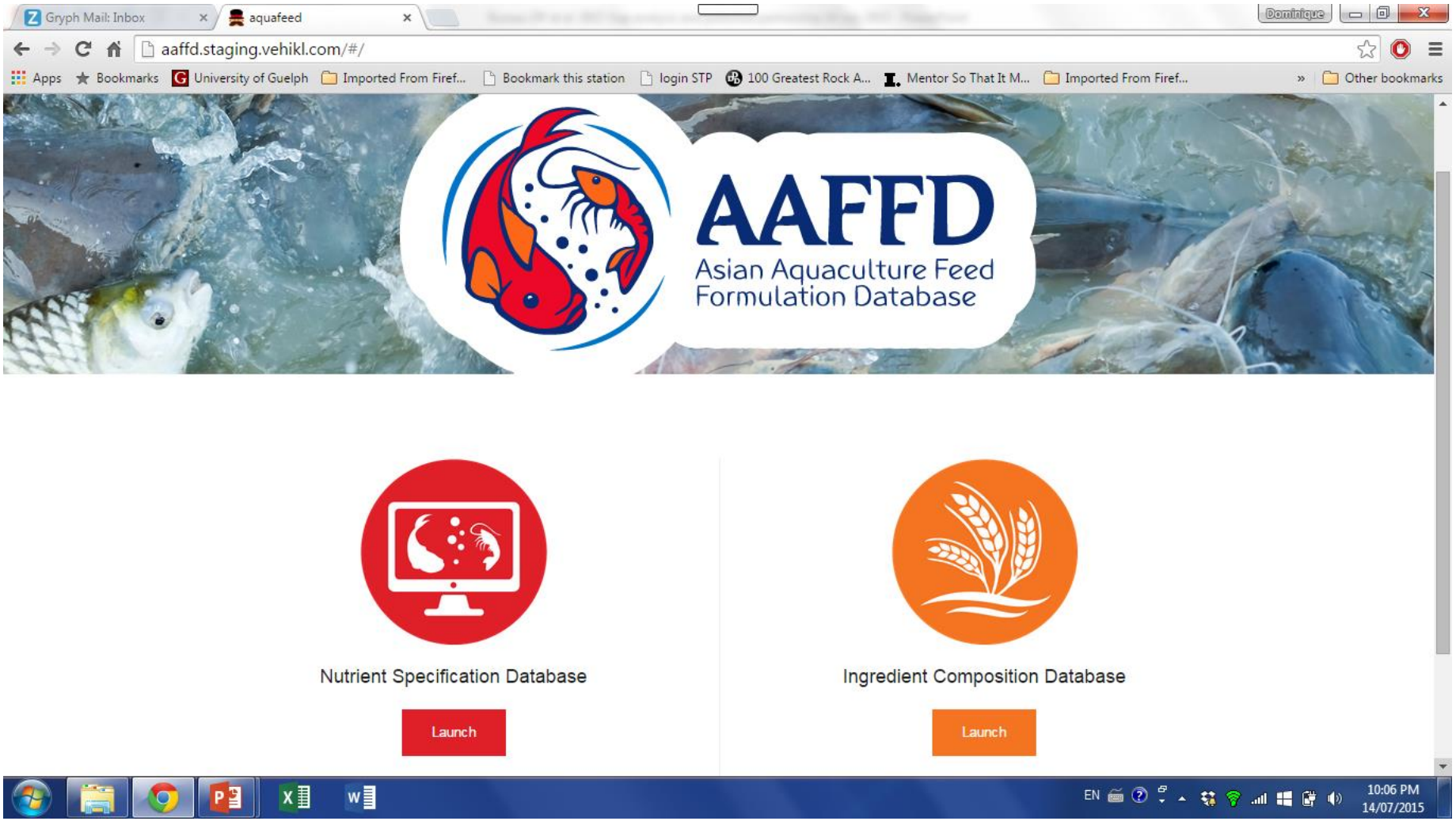
http://aaffd.staging.vehikl.com/ = http://tinyurl.com/AAFFD

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

AAFFD
Asian Aquaculture Feed Formulation Database

Nutritional Specifications

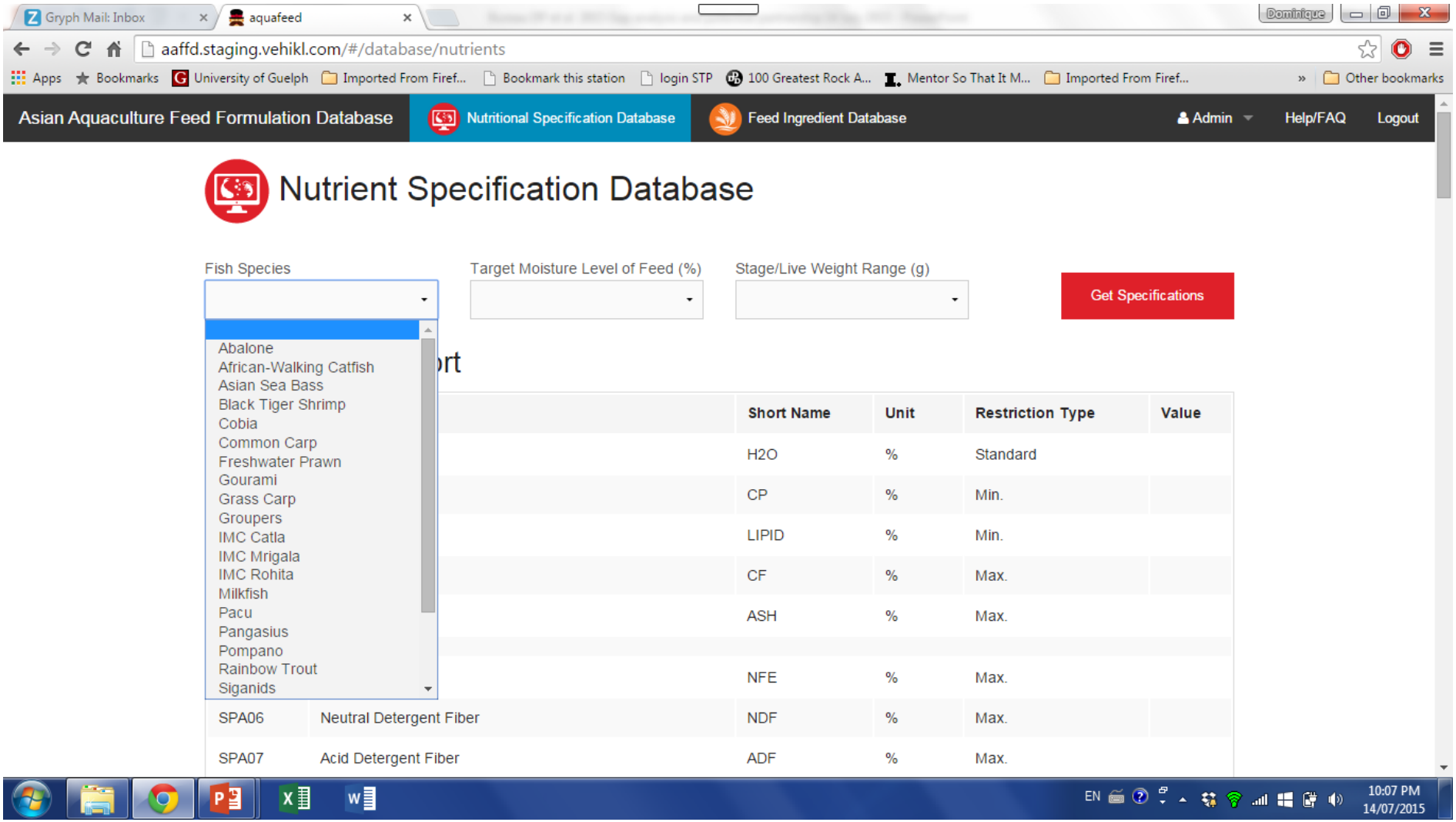
This part of the project involves compiling and generating information on nutrient requirements and recommended nutritional specifications for a large number of commercially important aquaculture species in Asia.

This was approached in three different, complementary ways:

1) Reviewing the scientific and technical literature = useful to lay ground-base but did not really work!

2) Surveying a large number of stakeholders in the Asian feed industry to define common nutritional specifications = Did not work! Sharing proprietary information = helping the competition! However, essential “reality check”

3) Advanced nutritional modeling = The only way that worked.



URL: http://www.asianaquafeeddatabase.com/