Marine Fish Nutrition in the Americas

Jorge A. Suarez, Carlos Tudela, Matthew Taynor and Daniel D. Benetti.

September 19, 2014

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In aquaculture, feed represents the most expensive component of the production costs

The FCR of Atlantic salmon was improved by 20% during five generations of selection (Gjedrem et al., 2012).

Salmon Farming

Atlantic Salmon

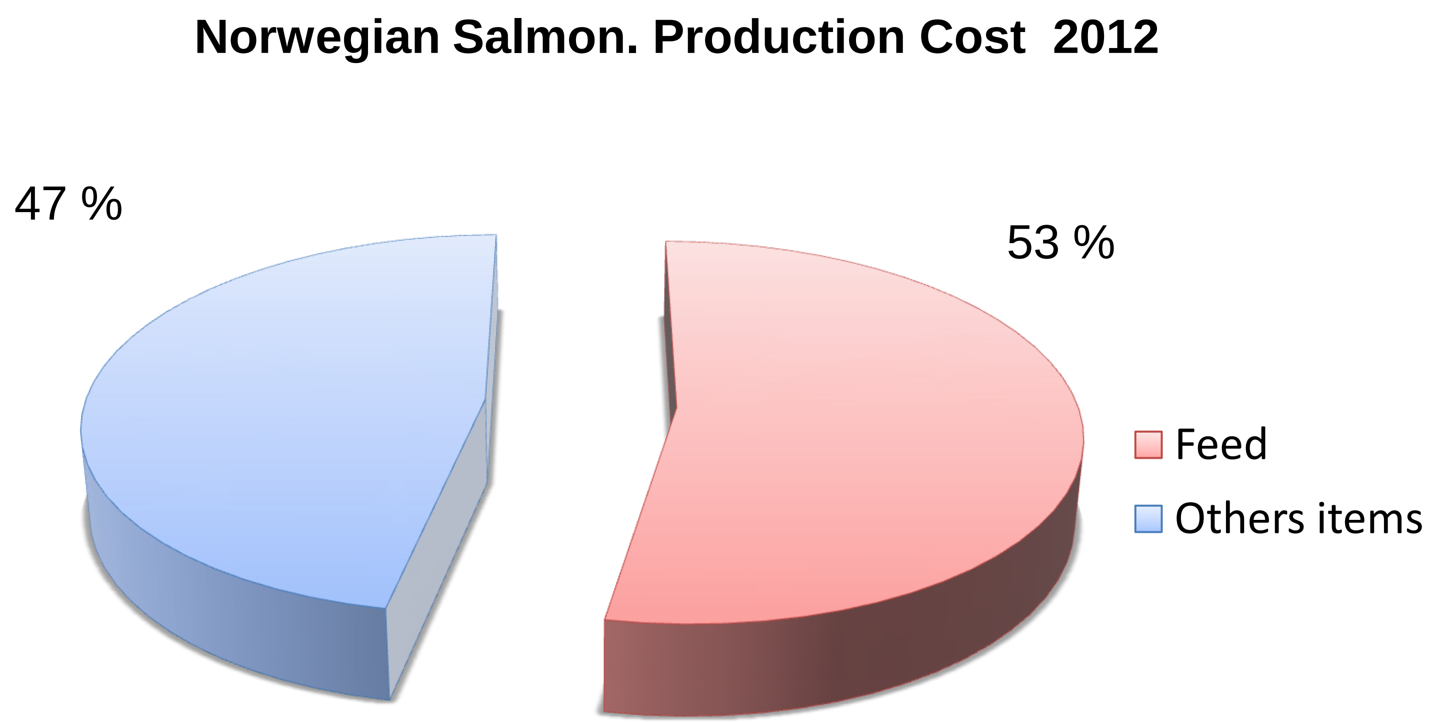
Norway 1970

Nutrition

Genetics

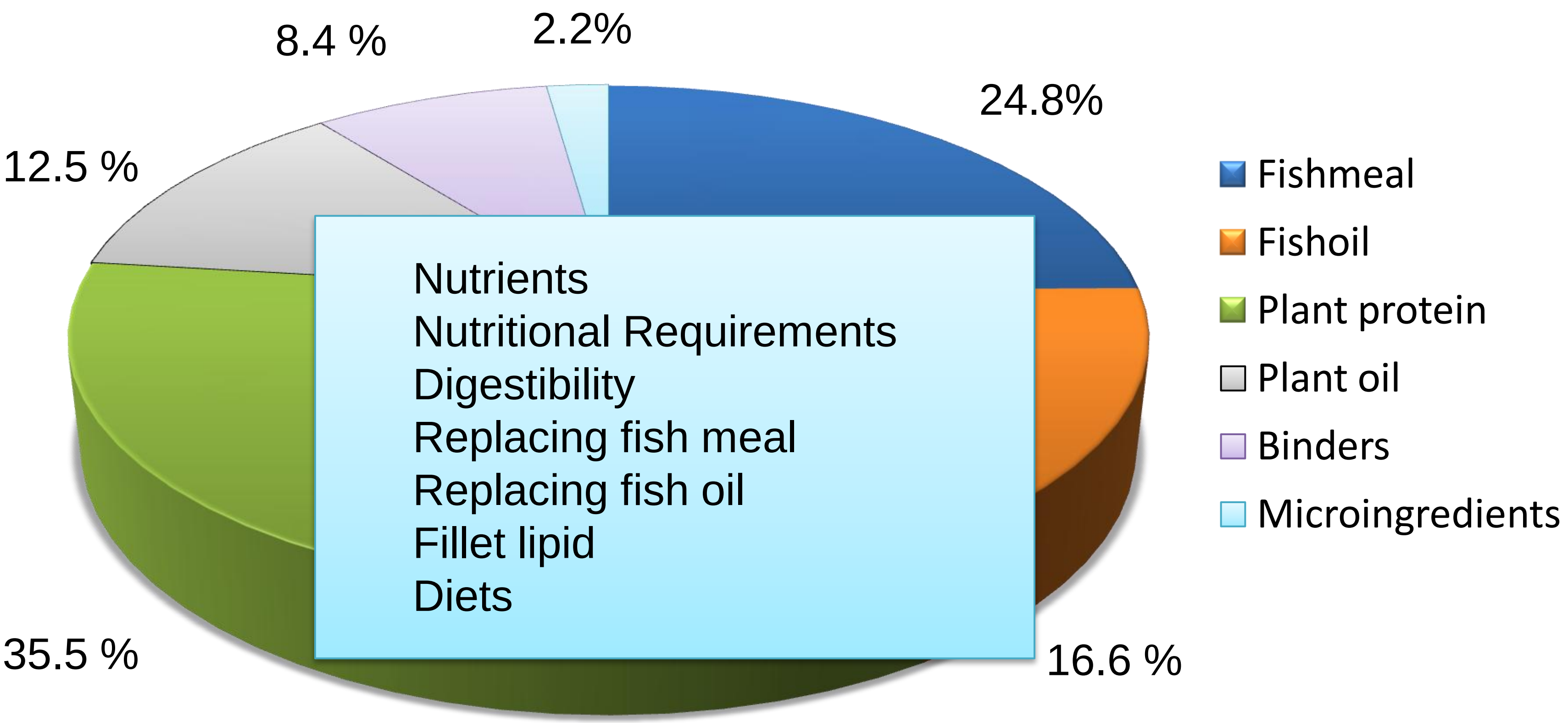
Handling

FCR: 1.3



The estimated feed loss from commercial sites is 5-7 percent (Gjosaeter et al 2008)

Norwegian Salmon. Diet Composition 2010



- Nutrients
- Nutritional Requirements
- Digestibility
- Replacing fish meal
- Replacing fish oil
- Fillet lipid
- Diets

Nofima Report, 2011

Tropical Marine Fish Farming

Feed: >70% Production Costs

FCR: > 2.0

Nutrition

Genetics

Handling

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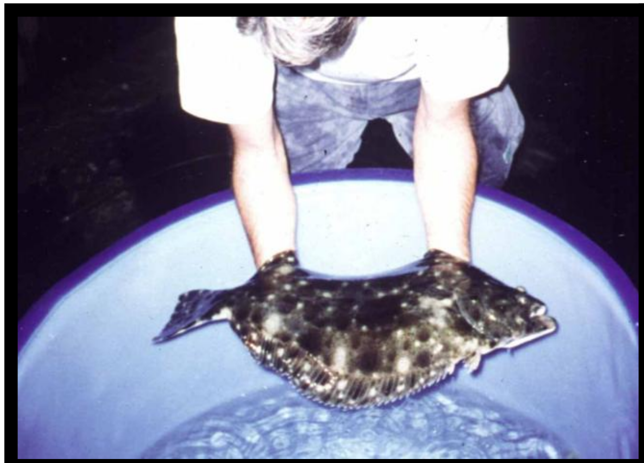

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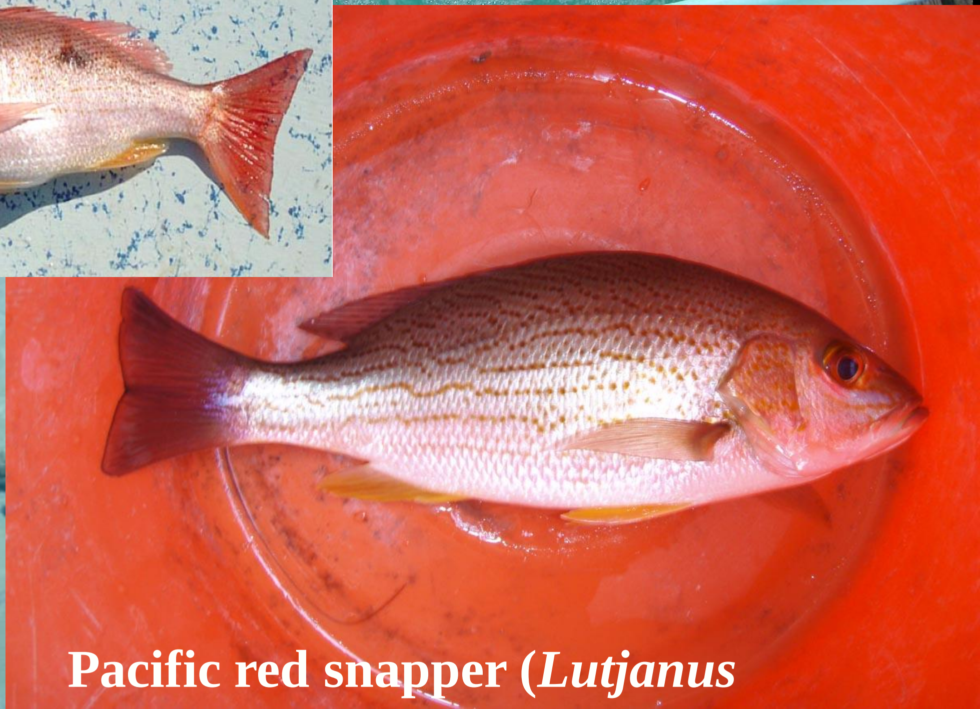
Almaco/yellowtail jack, huayaipe, kahala, kona kampachi® (*Seriola rivoliana*)

Mutton Snapper, *Lutjanus analis*

Pacific red snapper (*Lutjanus peru*)



Pacific red snapper (*Lutjanus*

Nutritional Requirements
Cobia, *Rachycentron canadum*

ELSEVIER
Aquaculture 193 (2001) 81–89
Aquaculture
www.elsevier.nl/locate/aqua-online

Optimal dietary protein and lipid levels for juvenile cobia (*Rachycentron canadum*)

Ruey-Liang Chou [a], Mao-Sen Su [a], Houng-Yung Chen [b,*]
[a] *Tungkang Marine Laboratory, Taiwan Fisheries Research Institute, Tungkang, Pingtung, 928 Taiwan*
[b] *Institute of Marine Biology, National Sun Yat-sen University, Kaohsiung, 804 Taiwan*

IW: 41 g
FW: 116 g

ELSEVIER
Available online at www.sciencedirect.com
ScienceDirect
Aquaculture 261 (2006) 384–391
Aquaculture
www.elsevier.com/locate/aqua-online

Juvenile cobia (*Rachycentron canadum*) can utilize a wide range of protein and lipid levels without impacts on production characteristics

Steven R. Craig [a,*], Michael H. Schwarz [b], Ewen McLean [c]
[a] *Department of Large Animal Clinical Sciences, VA/MD Regional College of Veterinary Medicine, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061, USA*
[b] *Virginia Seafood Agricultural Research and Extension Center, 102 S. King Street, Hampton, VA 26543, USA*
[c] *Department of Fisheries and Wildlife Sciences, 100 Cheatham Hall, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061, USA*

Received 12 April 2006; received in revised form 4 August 2006; accepted 8 August 2006

IW: 49 g
FW: 185 g

Aquaculture Nutrition
Aquaculture Nutrition 2009
doi: 10.1111/j.1365-2095.2009.00672.x

Effects of dietary starches and the protein to energy ratio on growth and feed efficiency of juvenile cobia, *Rachycentron canadum*

K.A. WEBB JR, L.T. RAWLINSON & G.J. HOLT
University of Texas Marine Science Institute, Port Aransas, TX, USA

IW: 5.6 g
FW: 92 g

Nutritional Requirements
Florida Pompano

ELSEVIER
Aquaculture 169 (1998) 225–232
Aquaculture

The effects of dietary protein level on growth, feed efficiency and survival of juvenile Florida pompano (*Trachinotus carolinus*)

Juan P. Lazo *, D. Allen Davis, Connie R. Arnold
The University of Texas at Austin, Marine Science Institute, 750 Channel View Dr., Port Aransas, TX 78373,

IW: 4.6 g
FW: 31.5 g

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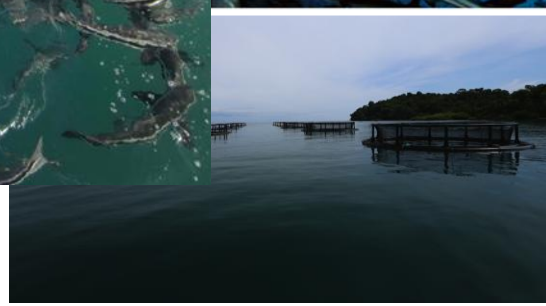
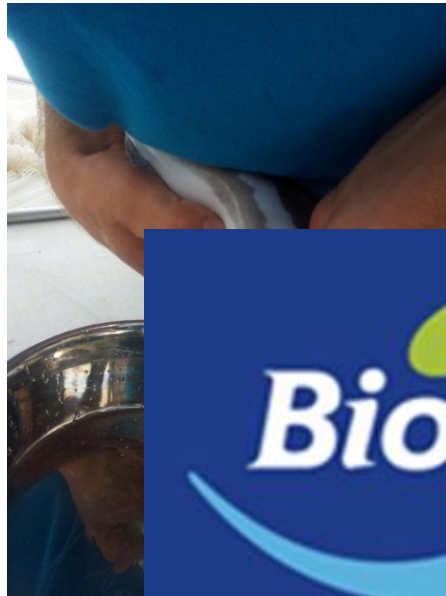
Consumption (intake) Nutritional Requirements





BioMar

In vivo digestibility
Nutritional Requirements

MARTEC

Open Formulation
Ingredients
In vivo digestibility
In vitro digestibility
Nutritional Requirements
Taurine
Replacing Dietary Fishmeal

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ATMOSPHERIC SCIENCE

Dietary Protein/Energy Ratios for Adult Florida Pompano, *Trachinotus carolinus*: Growth, Feed and Nitrogen Utilization

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Objetive of Study

- Increase the body of knowledge about the nutritional requirements of Florida pompano at a commercial size
  - Test various DP/DE ratios
  - Test digestibility of ratios for dry matter, crude protein, gross energy and amino acids
- To use these results in future studies to create a more economical and environmentally friendly diet

Feed Formulation

Experimental diets	Protein/Energy (DP/DE) ratios (*g/100 g* of dry diet)				
	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
Anchovy meal [1]	31.82	25.14	32.53	41.00	39.95
Soybean meal [2]	22.00	15.00	19.00	28.00	24.00
Corn gluten meal [3]	10.00	10.00	10.00	6.19	10.00
Wheat flour [4]	22.92	40.28	29.21	12.68	14.87
Anchovy oil [5]	10.27	6.46	6.29	9.92	6.27
Mineral-vitamin premix [6]	0.50	0.50	0.50	0.50	0.50
Luctamold	0.20	0.20	0.20	0.20	0.20
Antox	0.05	0.05	0.05	0.05	0.05
Others	2.24	2.37	2.22	1.46	4.16
Analyzed Composition (n=3)					
Crude protein (g/100 g DM)	51.6	47.4	48.7	46.3	42.9
Crude lipid (g/100 g DM)	18.4	14.4	19.0	19.5	20.2
Energy (MJ/kg DM)	19.5	19.17	20.0	20.0	20.0
DP/DE (mg/kJ)	26.2	25.4	24.3	23.3	21.7

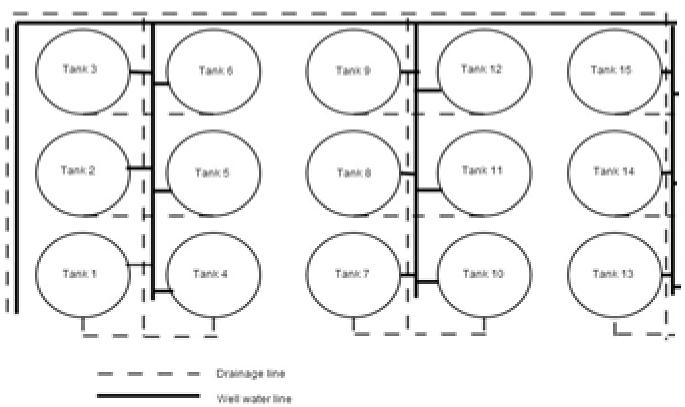
Amino Acid Profile

	Experimental diets				
	1	2	3	4	5
Essential	g/kg (dry weight basis)				
Arginine	26.3	24.3	28.2	26.2	26.4
Histidine	13.5	11.1	12.5	13.2	12.9
Isoleucine	21.9	21.7	23.7	21.6	22.2
Leucine	43.7	42.8	45.7	44.5	45.4
Lysine	29.2	25.9	32.2	28.9	27.4
Methionine	12.1	9.50	11.0	10.8	11.1
Phenylalanine	24.6	23.3	25.0	24.6	25.3
Threonine	19.7	17.6	20.7	19.7	19.6
Valine	25.3	24.8	27.0	25.1	25.6
Nonessential					
Alanine	30.4	29.2	32.5	30.5	30.7
Aspartic Acid[a]	27.6	26.2	30.7	27.5	27.3
Cysteine	1.40	1.10	1.40	1.50	1.40
Glutamic Acid[b]	45.9	47.1	50.1	47.1	49.1
Glycine	27.9	25.9	28.9	27.2	27.7
Proline	27.2	27.8	28.3	28.2	29.6
Serine	20.6	18.1	21.1	20.9	21.3

Experimental conditions

- 15 - 1000 L tanks
- Center standpipe, external tree
- Backwashed on alternating days
- Siphoned as needed
- Diets were randomly assigned
- Feeding- at 0900 h for 88 days for 10 min or apparent satiation

- Flow through on well water
- 1000% daily water exchange
  - 24.3±0.5°C
  - 33.1±0.05 ppt
  - 8.6±1.7 mg/L
  - 7.2-8.0 pH



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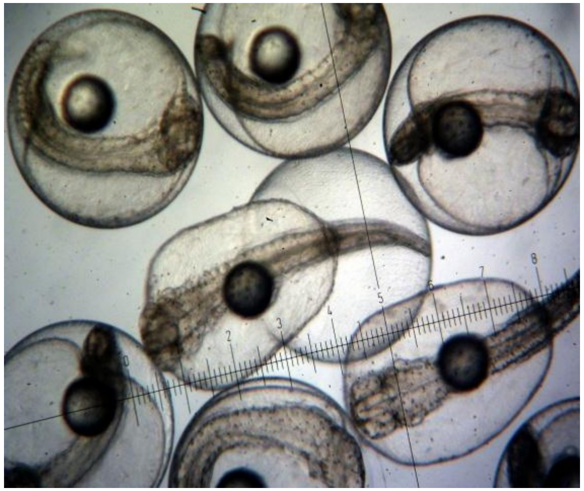
Experimental Fish

- Spawned, reared, and raised at UMEH
- Initial stocking density ~ 3 kg/m^3
- Initial mean weight ~255.5 g



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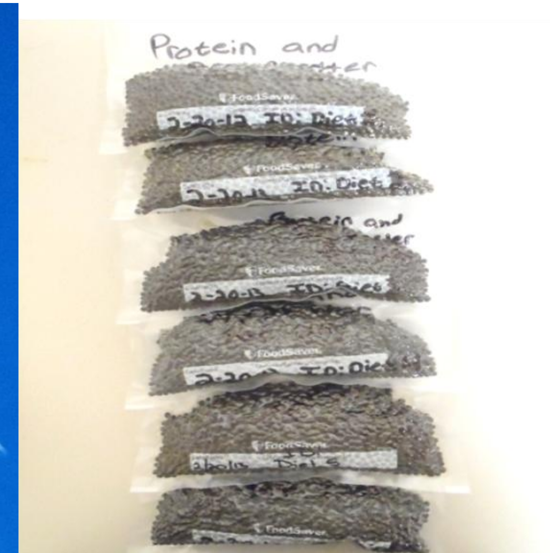
Aquaculture Performances

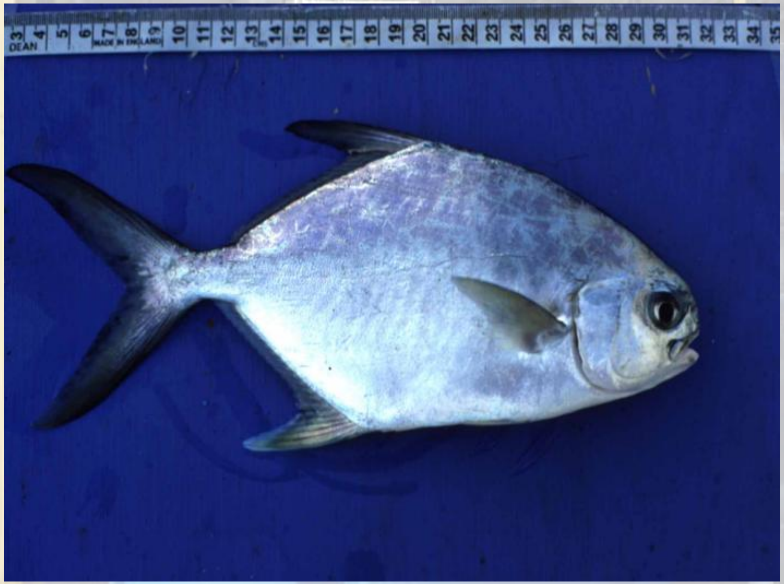


Growth Study

Diet Growth after 88 days	Diet 1: 26.2 mg kJ^{-1}	Diet 2: 25.4 mg kJ^{-1}	Diet 3: 24.3 mg kJ^{-1}	Diet 4: 23.3 mg kJ^{-1}	Diet 5: 21.7 mg kJ^{-1}
Final biomass (g fish tank -1)	6877±275 [a]	6746±605[a]	6774±158 [a]	6719±276 [a]	6226±463 [a]
Initial mean wt (g)	269±21	288±38	255±10	247±1	247±22
Final mean wt (g)	607±96	634±98	580±96	560±95	519±81
Weight gain wt (g)	338.2±10 [a]	347.2±26 [a]	325.7±10 [a]	312±23.5 [ab]	272.2±32 [b]
SGR[1]	0.92±0.05 [a]	0.90±0.04 [a]	0.93±0.01 [a]	0.92±0.05 [a]	0.84±0.09 [a]
MDI[2]	10.4±0.4 [a]	10.3±1.4 [a]	9.8±0.5 [a]	9.8±0.6[a]	9.6±0.7[a]
FE[3]	0.37±0.005 [a]	0.38±0.02[a]	0.38±0.02 [a]	0.36±0.02[ab]	0.32±0.03 [b]
PER[4]	0.68±0.01 [a]	0.76±0.05[a]	0.74±0.04 [a]	0.72±0.04[a]	0.71±0.07 [a]
FCR[5]	2.7±0.03 [a]	2.6±0.17 [a]	2.6±0.15[a]	2.7±0.16[a]	3.14±0.33 [b]
NRE[6]	29.17±1.03[a]	33.48±6.60[a]	26.03±4.28[a]	23.42±5.99[a]	23.45±0.78[a]
Survival (%)	100	100	100	100	100

Growth Study

- **Diets 1-4 (23.3-26.2 mg kJ^{-1}) were optimal for growth, FCR, and FE**



Digestibility

Proximate composition (% as-fed basis)

	Ingredients			
	RSBM	SPC (Solae)	SPC (Selecta)	Hamlet Protein
Dry matter	88.1	90.7	95.1	92.6
Crude protein	44.6	61.9	63.6	53.8
Crude lipid	3.6	1.5	2.6	3.4
Ash	5.3	5.1	4.9	5.6
Fiber	3.1	2.5	4.4	2.8
Energy (cal/g)	4,077	4,377	4,296	4,433
Arginine	3.6	5.0	5.2	3.7
Histidine	1.3	1.8	1.8	1.4
Isoleucine	2.3	3.1	3.4	2.5
Leucine	4.1	5.4	5.9	4.2
Lysine	3.1	3.7	4.1	3.1
Methionine	0.4	0.7	0.7	0.6
Phenylalanine	2.7	4.0	4.1	2.9
Threonine	2.1	2.7	2.9	2.2
Valine	2.5	3.3	3.6	2.7

	ADC of Test Ingredients	
	ADC Protein	**ADC Energy**
RSBM a	74.2±2.38 c	59.1±1.57 b
SPC (Solae)	80.6 ± 0.02 a	68.6 ± 0.29 a
SPC (Selecta)	72.5 ± 1.79 c	68.2 ± 0.17 a
Hamlet Protein	77.1 ± 1.90 b	58.4 ± 1.38 b

a Defatted soybean meal (roasted, solvent-extracted)

Effect of Replacing Dietary Fishmeal with Soy-Based Products on Growth Performance on Near Commercial Size Cobia, *Rachycentron canadum*

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ILLINOIS SOYBEAN ASSOCIATION

Picture taken by: Drew Davis

Systems

12 Tanks

4.5 Tons Each

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Digestibility

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Novel Soy Breeding Programs

- Not genetically modified soy varieties (Non-GM)
  - 25% more protein density
  - Reduced anti-nutritional factors
    - 85% less protease inhibitors

SG - 3010

Navita
Premium Feed
Ingredients

Experimental diets

Ingredient (g/kg dry diet)	Reference Diet	Test Diet
Pollock FM	612.6	
Dextrin	120.0	
Menhaden Oil	69.4	
Mineral Premix	50.0	
Vitamin Premix	40.0	700.0
Carboxylmethyl cellulose	30.0	
Celufill	73.0	
Yttrium oxide	5.0	
Test Ingredient	---	300.0
total	1,000	1,000

Test ingredients: SG-3010 and regular (commodity) soybean meal

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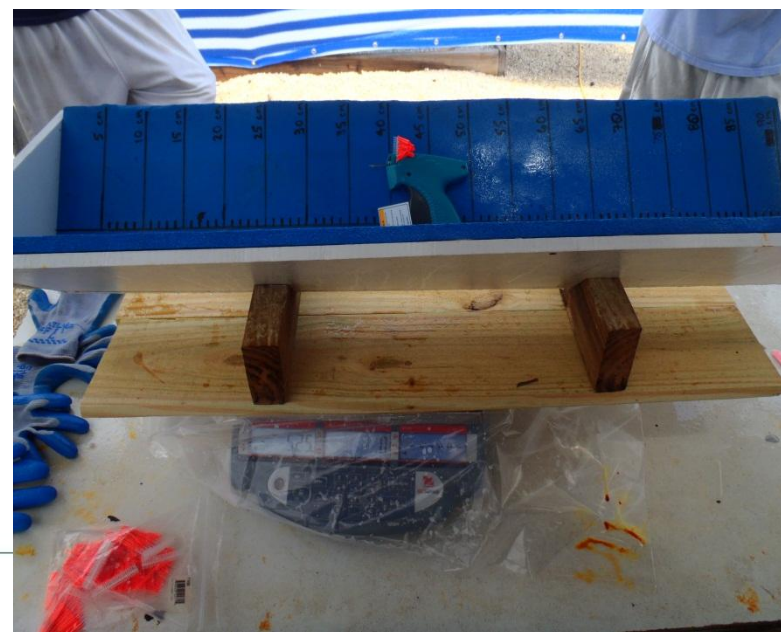
Diets made by the Oceanic Institute, Hawaii

	ADC of Test Ingredients	
	Navita® - 3010	**Regular SBM**
Protein	81.83 ± 3.79 a	68.51 ± 9.80 b
Essential Amino Acids		
Arginine	102.61 ± 0.64 a	97.85 ± 1.56 b
Histidine	86.01 ± 4.21 a	79.16 ± 3.80 b
Isoleucine	76.24 ± 7.00 a	58.09 ± 2.32 b
Leucine	76.29 ± 5.87 a	64.78 ± 2.63 b
Lysine	68.32 ± 2.13 a	64.98 ± 1.77 b
Methionine	76.64 ± 5.02 a	82.02 ± 1.49 b
Phenylalanine	74.51 ± 3.55 a	73.12 ± 5.08 a
Threonine	74.19 ± 1.76 a	41.48 ± 3.68 b
Valine	74.53 ± 6.68 a	53.39 ± 1.82 b

Aquaculture Performances



Diet Formulation

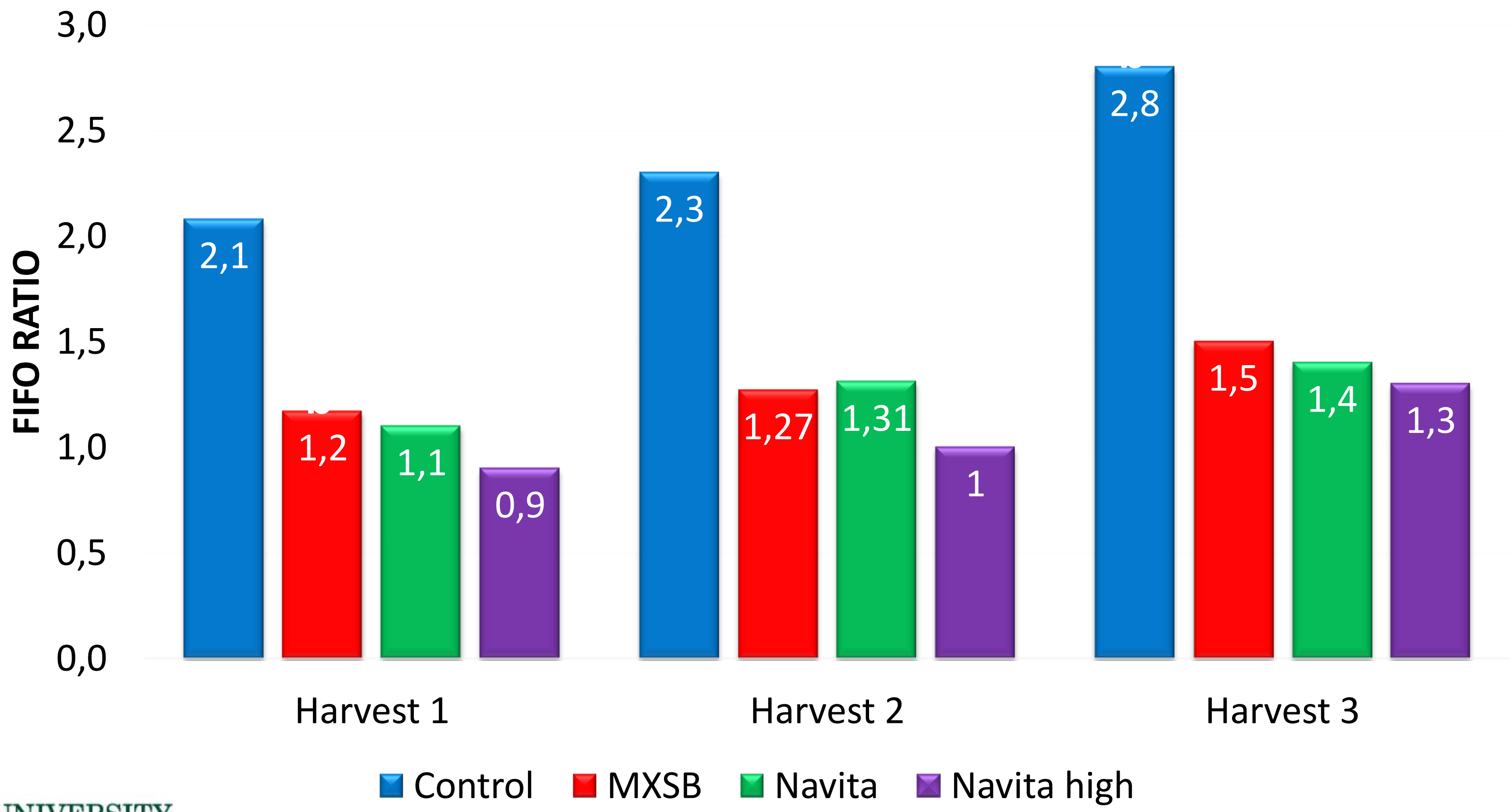
	Menhaden meal	SPC	Soybean meal	Navita™	Wheat flour	Menhaden oil	Mineral-vitamin premix	Glycine	Taurine	Lysine HCl	DL-Methionine	Cellufil
Control diet	26.0	10.3	32.0	0.0	16.0	6.0	6.0	1.0	0.5	0.0	0.1	2.4
MXSB diet	8.4	30.0	28.0	0.0	16.0	8.1	6.0	1.6	1.2	0.2	0.2	3.0
Navita™ diet	8.4	19.0	0.0	37.7	15.9	8.3	6.0	1.6	1.2	0.1	0.5	1.4
Navita™ high diet	6.0	15.0	0.0	45.4	15.0	8.6	6.0	1.8	1.5	0.1	0.6	0.2

Formulation of the experimental diets (g/100 g of dry diet) fed to adults, cobia *Rachycentron canadum*.
MXSB= soybean-based diet in which the incorporation of soybean meal has been maximized (Salze et al. 2010)
Navita™ high= Navita™-based diet in which the incorporation of Navita™ meal has been maximized.

	Final mean wt (kg)	% Weight Gain	Specific Growth Ratio	Mean Daily Intake	Gross Protein Intake	Protein Efficiency Ratio	Feed Conversion Ratio	FIFO
Control diet	3.2±0.6	78.5	0.6±0.2	35.9±1.5	16.9±0.7	0.9±0.05	2.4±0.15	2.8±0.18[b]
MXSB diet	3.3±0.7	64.1	0.5±0.14	34.4±2.4	17.0±1.2	0.8±0.05	2.5±0.16	1.5±0.09[a]
Navita™ diet	3.3±1.0	75.3	0.6±0.21	36.1±0.3	17.5±0.1	0.9±0.02	2.3±0.07	1.4±0.04[a]
Navita™ high diet	3.1±0.6	73.1	0.6±0.15	35.9±5.5	18.0±2.7	0.8±0.03	2.5±0.09	1.3±0.04[a]

Initial Average Weight/Fish=1.86±0.3 kg
Initial Average Biomass=5.16 ±0.13 kg/m^3
Final Average Biomass=8.70 ±0.54 kg/m^3

FIFO = Fish in: Fish out (level of fishmeal in the diet + level of fish oil in the diet) / (yield of fishmeal from wild fish + yield of fish oil from wild fish) X FCR



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Replacement of fish meal by a novel non-GM variety of soybean meal in cobia, *Rachycentron canadum*: Ingredient nutrient digestibility and growth performance

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ABSTRACT

A constraint for the expansion of cobia aquaculture is the availability of high quality formulated diets which reduce or eliminate fish meal (FM) protein. Therefore, the nutritive value of a novel soybean cultivar, Navita™ (Navita, non-genetically modified and selectively bred soy), and regular, commodity soybean meal (SBM, de-hulled, defatted, roasted and solvent-extracted) was evaluated for cobia, *Rachycentron canadum* via separate digestibility and growth trials. In the first experiment Navita's apparent digestibility coefficients (ADC) were higher than those of SBM for nearly every nutrient evaluated. Crude protein ADCs were 82 and 69% for Navita and SBM, respectively. Apparent DC for amino acids ranged from 68 to 109% for Navita whereas, amino acid ADCs for SBM varied from 42 to 98%. The feeding trial utilized fish of a size that more closely resembles commercial cobia stocking (1.8 kg), and was conducted over a 91-day period. Experimental diets (iso-nitrogenous and iso-energetic) were formulated such that 67% of the FM protein in the reference diet was replaced by either a combination of SBM + soy protein concentrate (SPC, Solae Profine®) labeled MXSB-diet, or by a combination of SPC + Navita; Navita-diet, hereafter. A fourth experimental diet had 80% of the FM protein replaced by a combination of Navita + SPC and was identified as Navita-high. No significant differences ($P > 0.05$) were observed in

- First time study done on near harvestable, commercial size cobia
- 80% FM replacement, with soy-based products is possible
  - With amino acid mix of (0.5% DL-Methionine, 1.6% Glycine, and 1.5% Taurine)
- Non-GM Navita has significant potential to serve as a fishmeal replacement

Acknowledgements

CIAB

Muchas Gracias-Thank You !