

REPLACEMENT OF MENHADEN FISHMEAL BY SOYBEAN MEAL IN THE DIET OF JUVENILE BLACK SEA BASS *Centropristis striata*

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Background

Black Sea Bass

- *Black sea bass are found in waters along the Atlantic coast from the Gulf of Maine to Northern Florida.**
- *Excellent food fish and high market value has led to over-harvesting of wild stocks in many areas.**

Research on Black Sea Bass Culture:

- Captive spawning (Watanabe et al. 2003)**
- Larviculture (Berlinsky et al. 2000)**
- Growout of sub-adult captive wild (Copeland et al. 2002)**
- Economic evaluation of captive wild (Copeland et al. 2005)**
- Protein requirement of hatchery-reared fingerlings (Alam et al. 2007)**

Background

Alternative Protein Sources in Organic Aquaculture Diets

- *Primary protein source is fishmeal, a limited and expensive resource.

- *Mid-80's: less than 10% of fishmeal production was used in aquafeeds. Today it is more than 46% (Hardy, 2006).

- *Alternative plant protein sources are less expensive, sustainable and have lower nitrogen and phosphorus levels, reducing the nutrient level in effluent waste.

- *Alternative proteins can be deficient in certain amino acids.

Target

To determine the maximum percentage of fishmeal that can be successfully replaced by solvent extracted soybean meal in black sea bass diets

Experimental Groups

Fish: Black sea bass



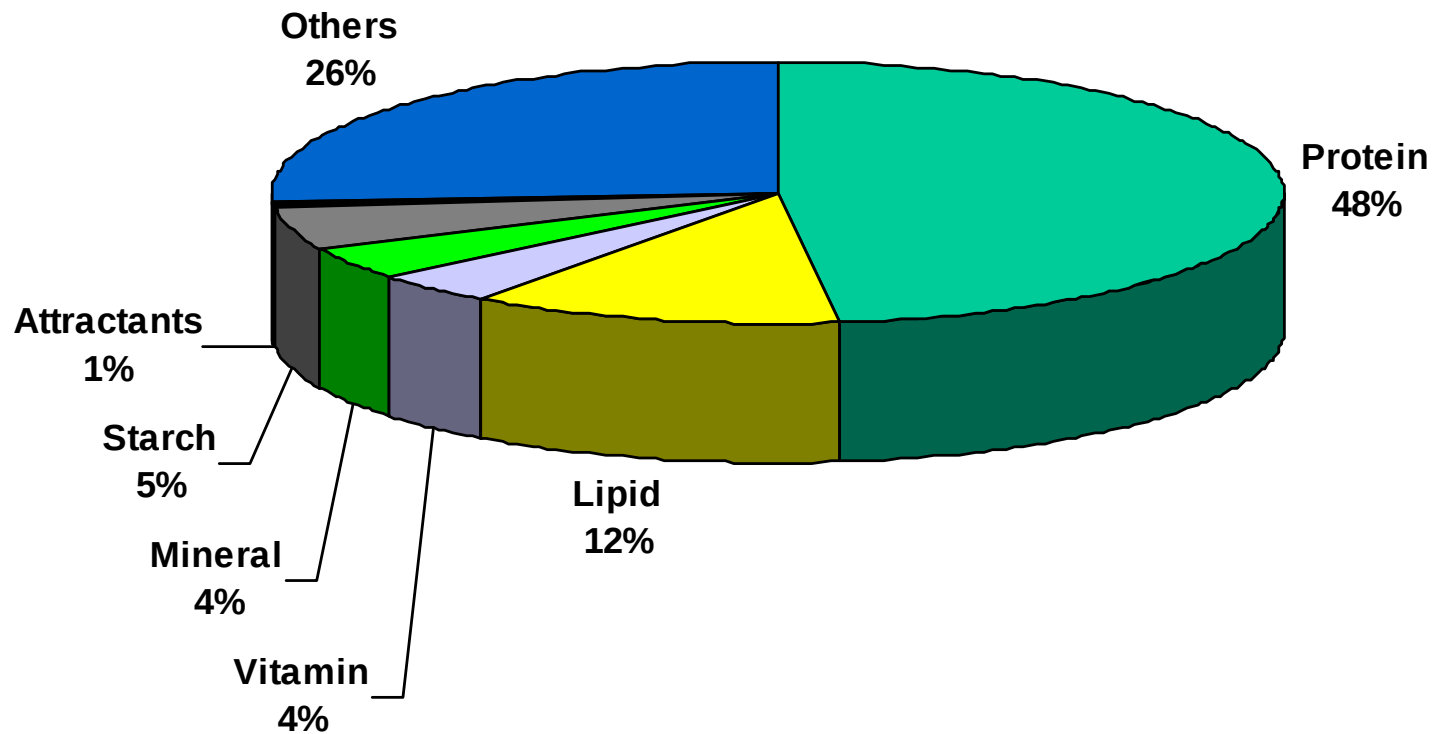
Experiment 1: Partial replacement of fishmeal protein by soybean meal protein

(0%, 10%, 20%, 30%, 40%, 50%, 60%)

Experiment 2: Partial and full replacement of fishmeal protein by soybean meal protein

(0%, 60%, 70%, 80%, 90%, 100%)

Composition of Diets



Replacement	Composition of diets					Experiment 1	
	0%	10%	20%	30%	40%	50%	60%
Menhaden meal*50		45	40	35	30	25	20
Soybean meal** 0		6.7	13.4	20.0	26.7	33.4	40.1
Squid meal	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Krill meal	5	5	5	5	5	5	5
Fish oil	4	4	4.5	5	5.5	6	6
Soybean lecithin	1	1	1	1	1	1	1
Wheat gluten	5	5	5	5	5	5	5
Wheat starch	5	5	5	5	5	5	5
Vitamin mix	4	4	4	4	4	4	4
Mineral mix	4	4	4	4	4	4	4
Attractants	1	1	1	1	1	1	1
Cellulose	13.5	11.8	9.7	7.5	5.3	3.1	0.4
Total	100	100	100	100	100	100	100

Analyzed proximate composition (%)

Protein	48.2	48.1	48.5	47.9	48.1	48.1	48.7
Lipid	12.8	12.6	12.1	11.4	13.0	13.2	12.5
Methionine***	1.04	1.01	0.97	0.93	0.89	0.85	0.81
Lysine***	3.08	3.02	2.97	2.92	2.86	2.81	2.76

***Fishmeal:** 63% protein

****Soybean meal:** 47.0% protein; *******calculated value.

Feed Preparation

**Aquaculture
Facility**



**UNCW,
Center for
Marine
Science**



Rearing Conditions

Experiment 1

Body wt.:	6.7 g
Tanks:	75 L
Stocking density:	15/tank
Replication:	3
Water temp.:	22°C
pH:	7.7-8.0
Salinity:	33-34 g/l
Dissolved oxygen:	6.5-7.8 mg/l
Feeding ration:	apparent satiation
Feed size:	1.5 mm
Feeding frequency:	2 x /d
Sampling:	every two weeks
Duration:	42 d



Biochemical Analysis

**Proximate Composition:
AOAC (1990) at UNCW
and New Jersey Feed Labs.**



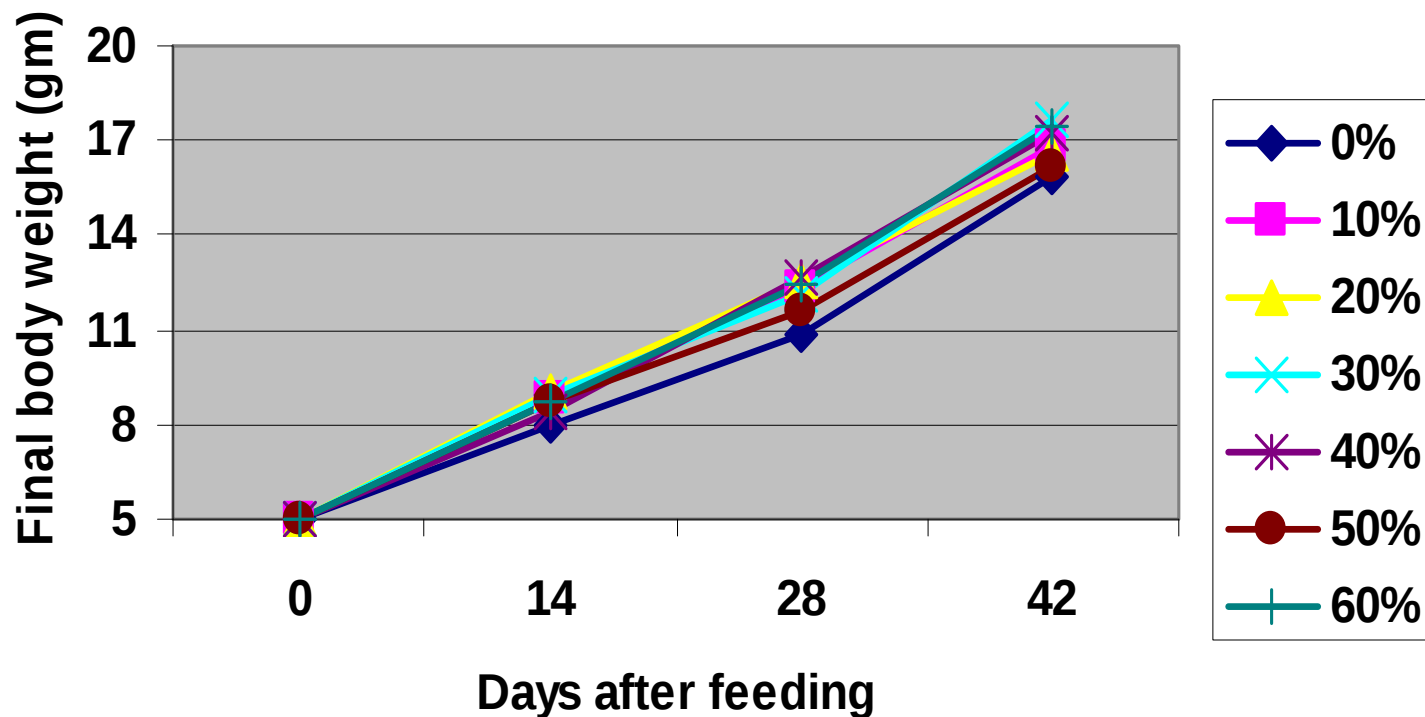
Statistical Analysis

Package: JMP ver. 6.1, SAS, USA.



Effects on Final Weight (g)

Experiment 1

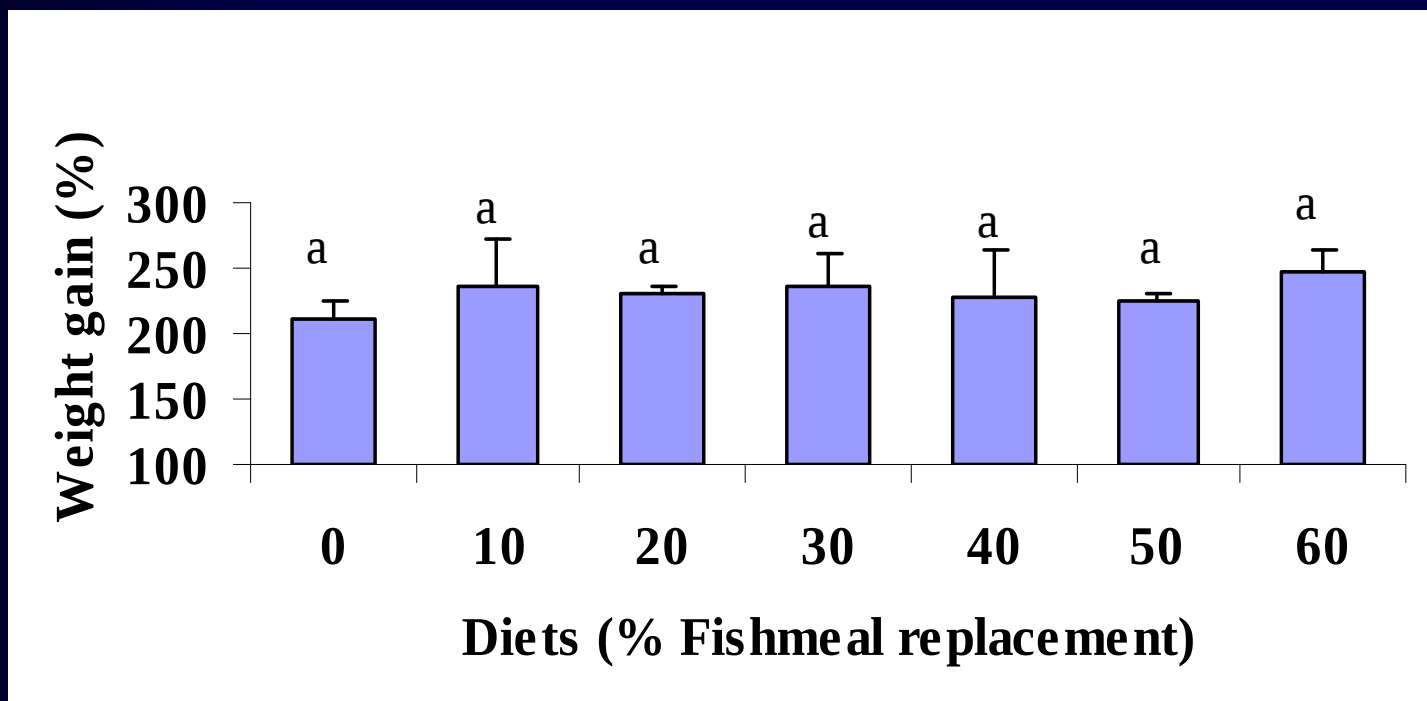


Results: no significant differences among treatments.



Effects on % Weight Gain

Experiment 1



Weight gain (%) = $(\text{final weight} - \text{initial weight}) / \text{initial weight} \times 100$

Results: no significant differences among treatments.

Growth Performance

Experiment 1

Diets	SGR	Feed intake	FCR	PER	Survival (%)
0%	2.80 ± 0.02a	0.30 ± 0.01a	1.29 ± 0.08a	3.41 ± 0.24a	93.3
10%	2.85 ± 0.27a	0.36 ± 0.02a	1.33 ± 0.12a	3.42 ± 0.21a	91.1
20%	2.83 ± 0.04a	0.36 ± 0.02a	1.33 ± 0.05a	3.47 ± 0.53ab	91.1
30%	2.87 ± 0.16a	0.37 ± 0.02a	1.29 ± 0.11a	3.46 ± 0.49ab	97.7
40%	2.79 ± 0.26a	0.37 ± 0.01a	1.36 ± 0.14a	3.72 ± 0.03b	95.5
50%	2.79 ± 0.04a	0.35 ± 0.02a	1.33 ± 0.04a	3.65 ± 0.48b	95.5
60%	2.73 ± 0.27a	0.36 ± 0.01a	1.24 ± 0.05a	3.50 ± 0.28ab	93.3

Values are means ± SEM (N=3). Means with different letters in the same column differ significantly (P< 0.05).

SGR: Specific growth rate (%/d), **FI:** Feed intake (g/d/fish),

FCR: Feed conversion ratio (feed intake (g) / wet weight gain (g),

PER: protein efficiency ratio: weight gain (g) / protein intake (g).

Effects on Body Proximate Comp

% wet weight

Diets	Moisture	Protein	Lipid	Ash
0%	66.9a	17.5a	9.6a	4.77a
10%	67.1a	17.3a	10.2a	4.48ab
20%	66.7a	17.4a	9.2a	4.29ab
30%	67.1a	17.0a	9.9a	4.17ab
40%	67.9a	16.5a	9.6a	4.43ab
50%	67.9a	16.6 a	9.2a	4.45ab
60%	67.9a	16.7a	9.4a	4.10b

Values are means (N = 3).

In progress: Whole body total amino acid and fatty acid composition.

Findings

Experiment 1

- *No significant differences in growth performance, survival and feed efficiency.**
- *No significant differences in body crude protein, lipid and moisture content.**
- *Replacement of fishmeal protein by soybean meal protein could be **more than 60%** for black sea bass diet.**



Experiment 2:

**Partial and full replacement of fishmeal protein
by soybean meal protein**

(0%, 60%, 70%, 80%, 90%, 100%)

Composition of Diets (g/100g)

Experiment 2

% Replacement	0%	60%	70%	80%	90%	100%
Menhaden meal*	50	20	15	10	5	0
Soybean meal**	0	40.1	46.8	53.5	60.2	66.9
Squid meal	7.5	7.5	7.5	7.5	7.5	7.5
Krill meal	5	5	5	5	5	5
Menhaden fish oil	3	6	6.5	7	7.5	7.6
Soybean lecithin	1	1	1	1	1	1
Wheat gluten (binder)	5	5	5	5	5	5
Wheat starch	15	8	6.2	4	1.8	0
Vitamin mix	3	3	3	3	3	3
Mineral mix	3	3	3	3	3	3
Attractants	1	1	1	1	1	1
Cellulose	6.5	0.4	0	0	0	0
Total	100	100	100	100	100	100

Analyzed proximate composition (%)

Crude Protein	47.1	47.9	47.6	46.5	46.7	46.3
Crude lipid	10.9	11.8	9.3	9.4	9.8	10.1
Methionine***	1.04	0.81	0.77	0.73	0.69	0.65
Lysine***	3.08	2.76	2.71	2.65	2.60	2.55

*63% crude protein; **47% crude protein; ***calculated value.

Diet Preparation

Rearing Conditions

Biochemical Analysis

Statistical Analysis

As Experiment 1

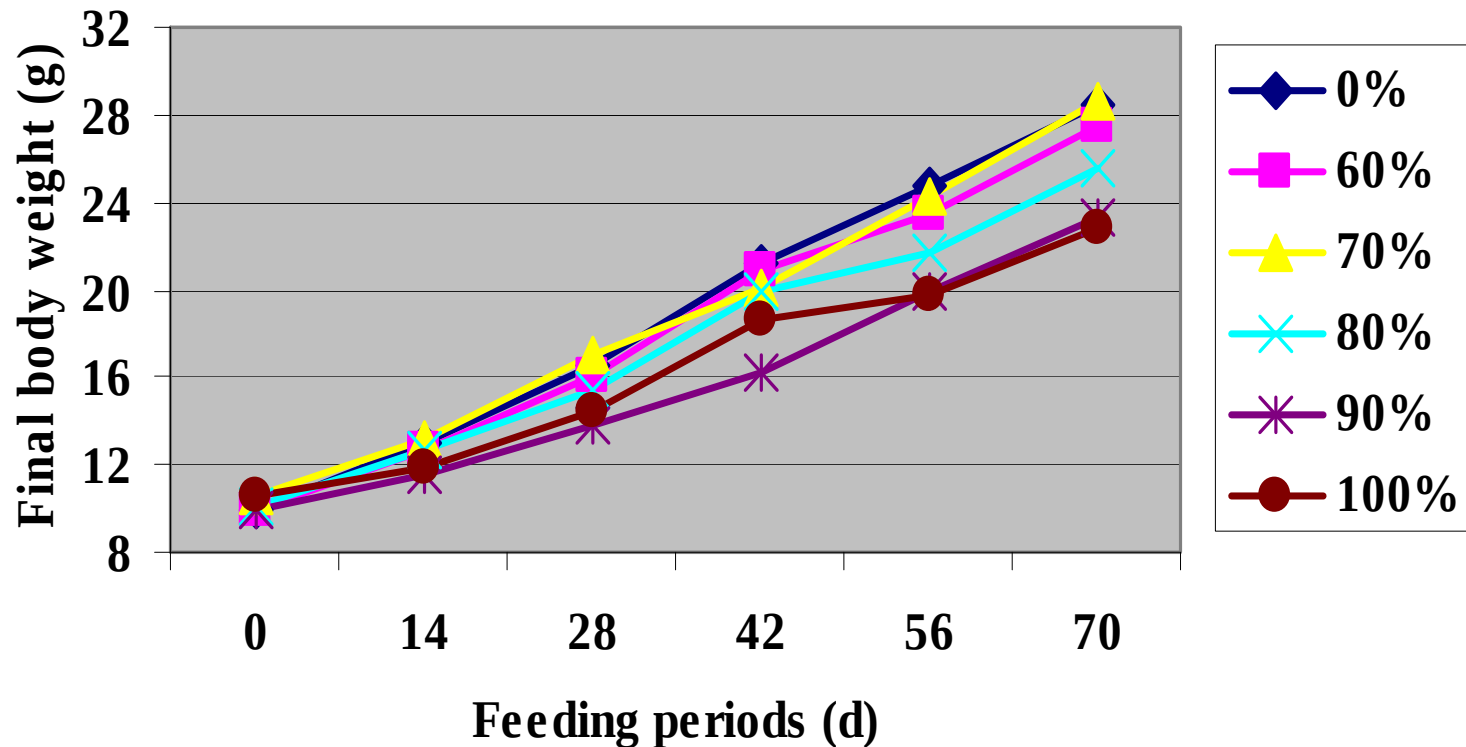




Effects on Final Body Weight

Initial Weight: 9 g

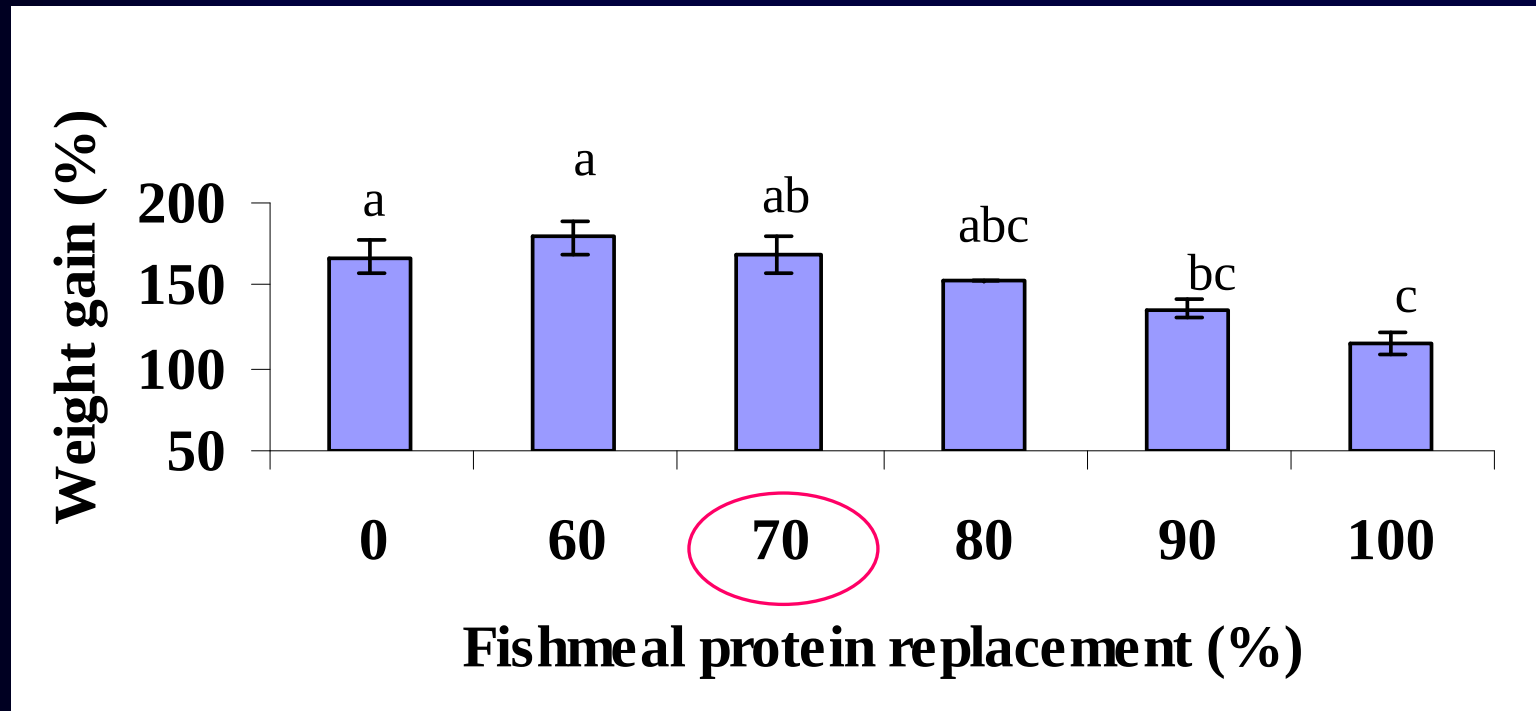
Experiment 2



Result: On d56 and d70, growth was significantly decreased for groups fed more than 70% replacement of fishmeal.

Effects on % Weight Gain

Experiment 2



Values are means $\pm$ SEM (N = 3).

Weight gain (%) = [(final weight - initial weight)/initial weight] x 100

Growth Performance

Experiment 2

Diets	SGR	Feed Intake	FCR	PER	Survival
0%	1.49 ± 0.04ab	0.47 ± 0.03a	1.54 ± 0.16abc	1.40 ± 0.14ab	87
60%	1.59 ± 0.07a	0.39 ± 0.01a	1.34 ± 0.04bc	1.54 ± 0.05ab	95
70%	1.44 ± 0.08ab	0.38 ± 0.02a	1.24 ± 0.04c	1.68 ± 0.06a	100
80%	1.36 ± 0.02abc	0.42 ± 0.04a	1.62 ± 0.23abc	1.38 ± 0.21ab	91
90%	1.23 ± 0.03bc	0.42 ± 0.01a	1.97 ± 0.15ab	1.09 ± 0.07b	93
100%	1.10 ± 0.03c	0.43 ± 0.02a	2.17 ± 0.10a	0.99 ± 0.04b	88

Values are means ± SEM (N=3). Means with different letters in the same column differ significantly.

SGR: Specific growth rate (%/d), FI: Feed intake (g/d/fish),
FCR: Feed conversion ratio (feed intake (g) / wet weight gain (g),
PER: wet weight gain (g) / protein intake (g).

Effects on Body Proximate Comp.

Wet basis (%)

Experiment 2

Diet	Moisture	Protein	Lipid	Ash
0%	66.8	17.7a	12.8a	4.57a
60%	66.7	16.6bc	12.0b	4.22ab
70%	66.8	17.0b	11.5bc	4.28ab
80%	67.5	16.5cd	10.9c	4.26ab
90%	68.6	16.1de	11.2bc	4.13ab
100%	69.0	15.9e	10.9c	3.77b

Values are means (N = 3).

In progress: Whole body total amino acid and fatty acid composition.

Findings

Experiment 2

- *More than 70% replacement of fishmeal protein decreased growth, feed conversion and protein efficiency.**
- *More than 70% replacement of fishmeal protein caused whole body protein and lipid to decrease.**
- * Recommended replacement of fishmeal protein for BSB diet: not more than 70% with attractants like glycine, alanine, taurine and betane.**

Black Sea Bass Juvenile (BSB)

Experiment 3:

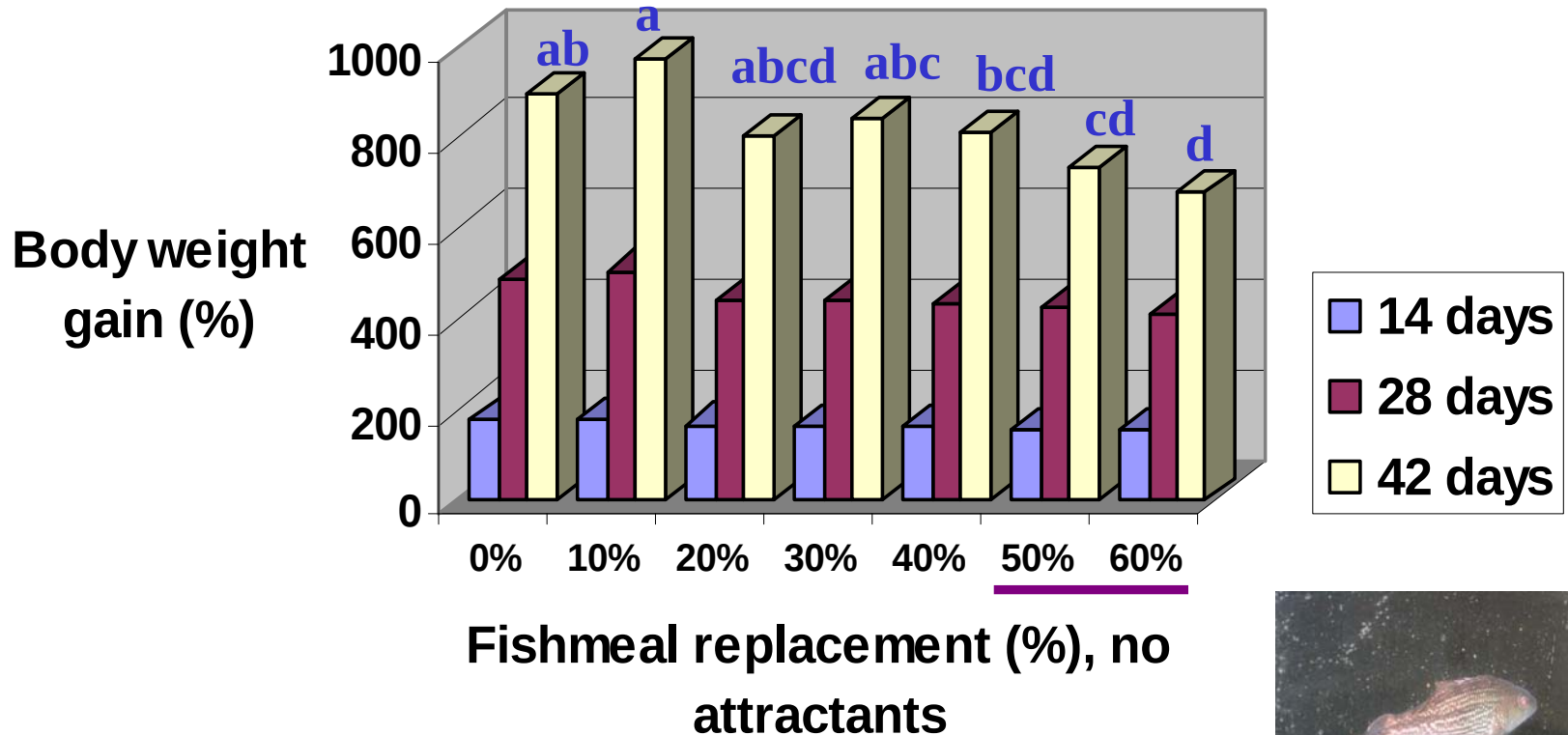
Partial replacement of fishmeal protein by soybean meal protein **without supplementing attractants (alanine, glycine, taurine and betane).**

(0%, 10%, 20%, 30%, 40%, 50%, 60%)



Experiment 3: 0-60% Fishmeal Protein Replacement (Without Attractants)

Initial Weight: 1 g



Findings: Replacement of 50 and 60% fishmeal protein (without attractants) reduced growth significantly.

Experiment 4:

Partial and full replacement of fishmeal protein
by soybean meal protein **without**
supplementing attractants

(0%, 50% 60%, 70%, 80%, 90%, 100%)

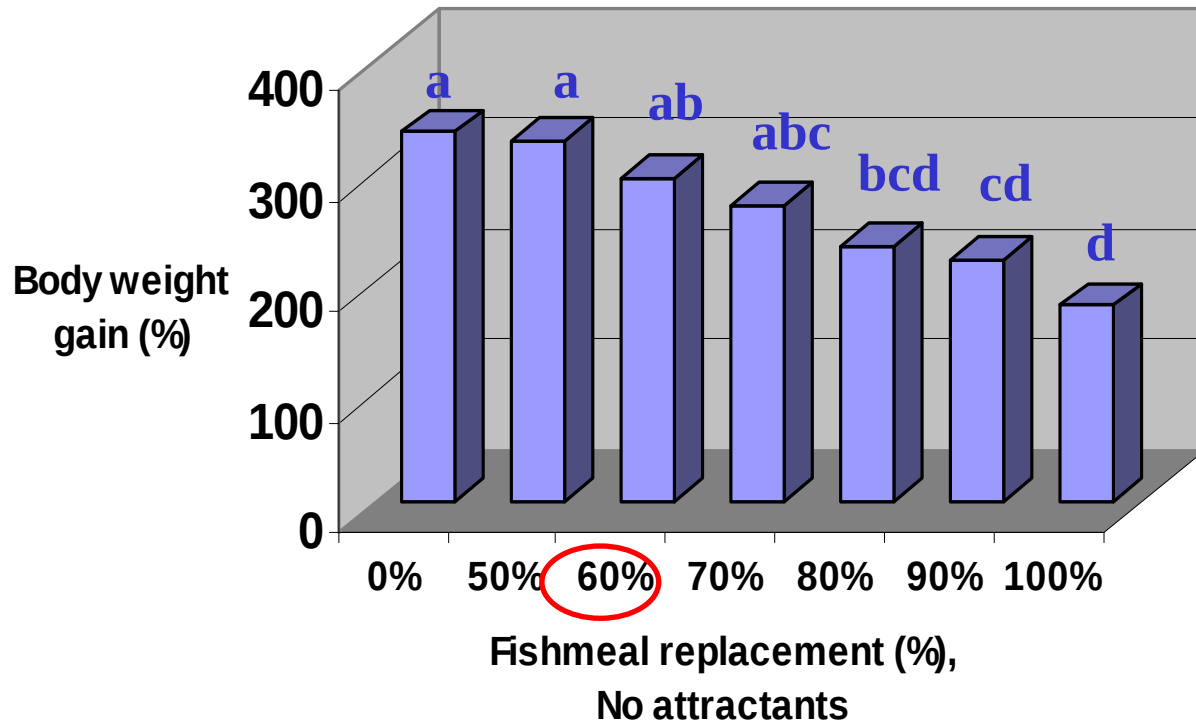


Experiment 4: 50-100% Replacement Without Attractants (BSB)

Initial weight: 2.7 g



42 d study



Findings: Maximum replacement of fishmeal protein is not more than 60% without supplementing attractants.

Fish: Southern Flounder Juvenile



Experiment 5:

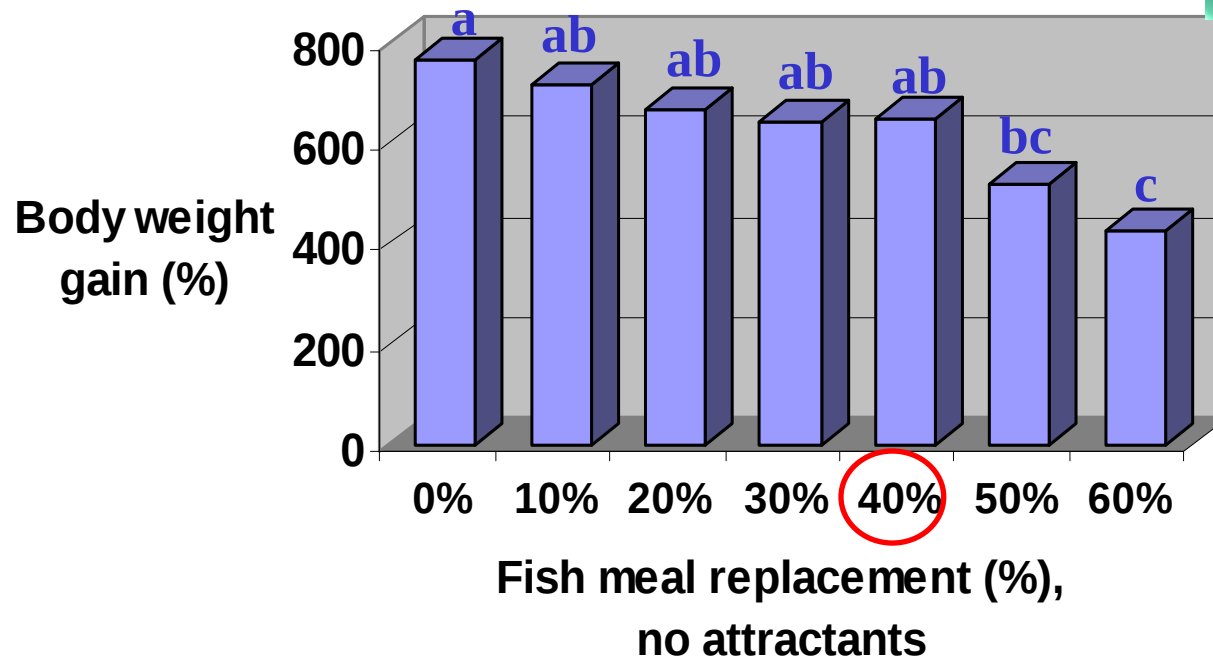
Partial replacement of fishmeal protein by soybean meal protein **without supplementing attractants**

(0%, 10%, 20%, 30%, 40%, 50% and 60%)

Experiment 5: 0-60% Replacement of Fishmeal Protein for Flounder Without Attractants

Initial weight: 0.6 g,

42 d study



Findings: Maximum replacement of fishmeal protein is not more than **40%** in southern flounder diet (without attractants, methionine and lysine).

Final Remarks

Black Sea Bass Diet:

Organic fish feed,
12% Fishmeal + 12 %
Fish oil?? (NOSB)

*Assuming no reduction in growth, about **70%** of menhaden fishmeal protein could be replaced by soybean meal protein with **1% attractants** (glycine, taurine, betane and alanine, but no methionine and lysine)

(**15% fish meal + 47% soybean meal** + 7.5% squid meal + 5% krill meal + 10% lipid = **50% fish meal + 0% soybean meal** + 7.5% squid meal + 5% krill meal + 10% lipid).

Without Attractants:

*Assuming no reduction in growth, about **60%** of menhaden fishmeal protein could be replaced by soybean meal protein.

(**20% fish meal + 40% soybean meal** + 7.5% squid meal + 5% krill meal + 10% lipid = **50% fishmeal + 0% soybean meal** + 7.5% squid meal + 5% krill meal + 10% lipid).

Southern Flounder Diet:

**Organic fish feed,
12% Fishmeal + 12 %
Fish oil?? (NOSB)**

- Assuming no reduction in growth, about **40%** of menhaden fishmeal protein could be replaced by soybean meal protein without attractants and without methionine and lysine)
- (**30% fish meal** + 27% soybean meal + 7.5% squid meal + 5% krill meal = **50% fish meal** + 0% soybean meal + 7.5% squid meal + 5% krill meal).

Considerations for Organic Feed for Aquaculture (NOSB Target: 12% fishmeal and 12% fish oil)

- Diet containing 10-15% fishmeal (in combination with other protein sources such as soybean meal, squid meal, krill meal), produced growth slightly lower than the 50% fishmeal based diet for black sea bass, but in southern flounder, growth was about half compare to the control diet.**
- need future study using non-solvent extracted soybean meal.**
- Consideration of culture system (extensive, semi-intensive and intensive, recirculating) and culture environment (freshwater or mariculture),**
- Consideration of feeding behavior such as omnivorous, herbivorous and carnivorous and dietary protein requirements.**

Acknowledgements

Marine Biotechnology in North

Carolina (CMS, UNCW)



**NOAA: National Marine Aquaculture Initiative,
Staff of UNCW Aquaculture Program**

Thank You Very Much