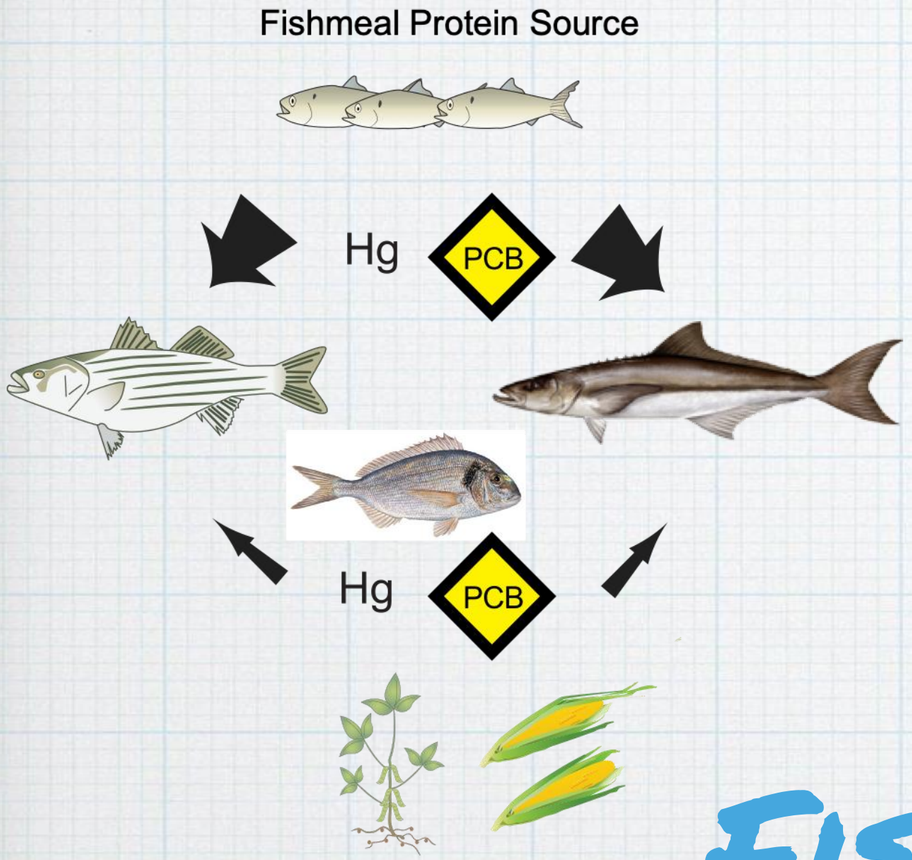
38
Years

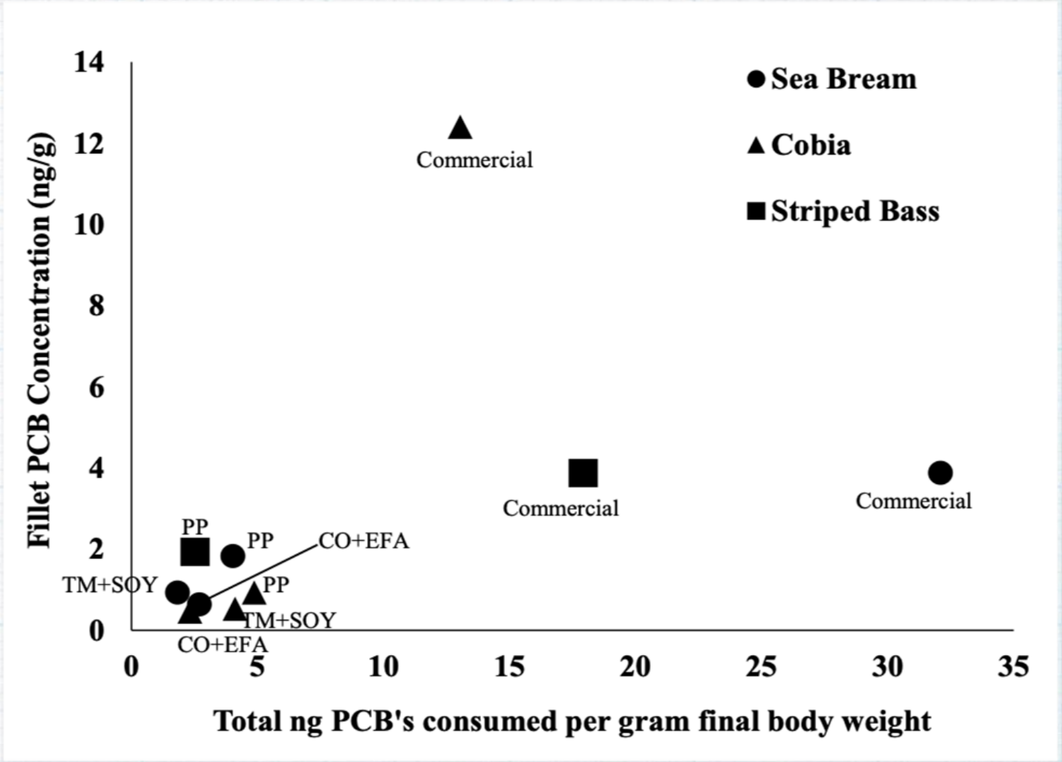
RAS-N
Recirculating
Aquaculture
Salmon Network
Sustainable • Innovative

SAS2
Sustainable
Aquaculture Systems
Supporting
Atlantic Salmon

Alternative and RAS Feeds

SAS2 Sustainable Aquaculture Systems Supporting Atlantic Salmon





Fishmeal Free Diets

Removing Contaminants from Fillets

Diet Switch from Fishmeal to Soy

YMM

FCR:
2.03 ± 0.28
Weight Gain (g/day):
4.43 ± 2.15

Soy

FCR:
1.44 ± 0.42
Weight Gain (g/day):
3.2 ± 1.33

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Replacing Soy with Black Soldier Fly Larvae (*H. illucens*)

Stratium

The Problem:

Plant protein falls short when replacing higher amounts of FM because of the presence of anti-nutritional factors, high content of crude fiber, and imbalance amino acid profile (Francis, 2001)

BSF Aquafeed

54838300	UMCES Salmon Diet Insect Meal	10/4/2023	
Code	Ingredient Name		Pct
4463000	WHEAT FLOUR BAGGED		28.00
9008600	U of MD INSECT MEAL-CO		25.00
5584000	WHEAT GLUTEN		12.41
5522010	EMPYREAL CN Protein Conc		12.00
5507000	BLOOD FLOUR		7.50
3449000	ALGAL OIL		4.50
3446001	CANOLA OIL Topdress		4.49
6620000	MONOSOD PO4 XP4		3.25
8877000	L LYSINE 98.5%		1.20
8880000	DL METHIONINE 99		0.65
8302000	TAURINE 98.5% FG		0.50
8305000	L-Threonine (FG)		0.16
9076620	PREMIX AQUA-VIT		0.15
9098000	PREMIX AQUA-MIN FISH		0.15
8827410	GUAR GUM		0.03
8874600	ASTAXANTHIN 10%		0.01
No.	Nutrient Name	Units	Actual
28	PROTEIN	%	45.2610
48	FAT, TOTAL	%	12.0603
60	CRUDE FIBER	%	3.4645
67	ASH	%	5.9196
69	PHOS TOTAL	%	1.2078
84	MOISTURE	%	6.9440
85	NFE	%	20.9578
108	STARCH	%	20.9760
133	Starch BF TD	%	20.9760

Soy Protein Aquafeed

54838200	UMCES Salmon Diet Control	10/4/2023	
Code	Ingredient Name		Pct
4463000	WHEAT FLOUR BAGGED		25.42
5592600	HP 300 SOYA PROTEIN		25.00
5584000	WHEAT GLUTEN		12.98
5507000	BLOOD FLOUR		10.00
5522010	EMPYREAL CN Protein Conc		10.00
3446001	CANOLA OIL Topdress		6.00
3449000	ALGAL OIL		4.50
6620000	MONOSOD PO4 XP4		3.25
8877000	L LYSINE 98.5%		1.20
8880000	DL METHIONINE 99		0.65
8302000	TAURINE 98.5% FG		0.50
8305000	L-Threonine (FG)		0.16
9076620	PREMIX AQUA-VIT		0.15
9098000	PREMIX AQUA-MIN FISH		0.15
8827410	GUAR GUM		0.03
8874600	ASTAXANTHIN 10%		0.01
No.	Nutrient Name	Units	Actual
28	PROTEIN	%	45.0373
48	FAT, TOTAL	%	12.3918
60	CRUDE FIBER	%	1.6402
67	ASH	%	5.6770
69	PHOS TOTAL	%	1.1769
84	MOISTURE	%	7.4734
85	NFE	%	19.0832
108	STARCH	%	19.9900
133	Starch BF TD	%	19.9900

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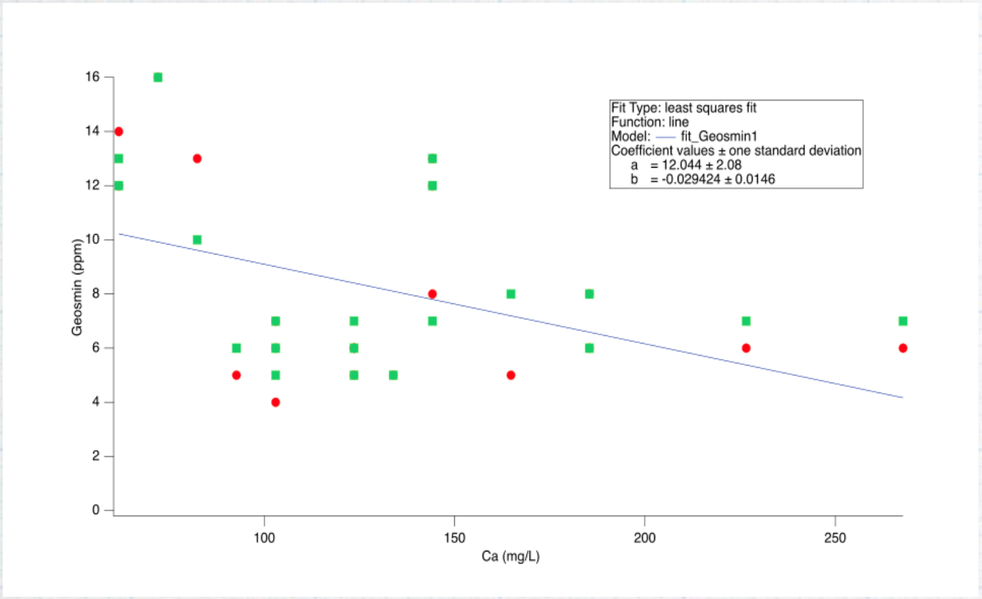
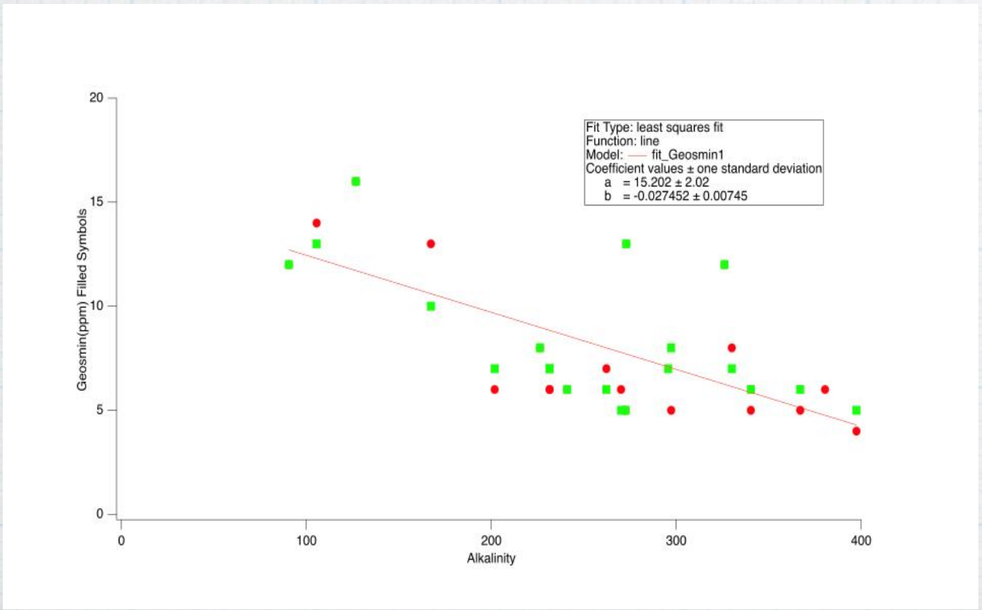
Final Takeaways

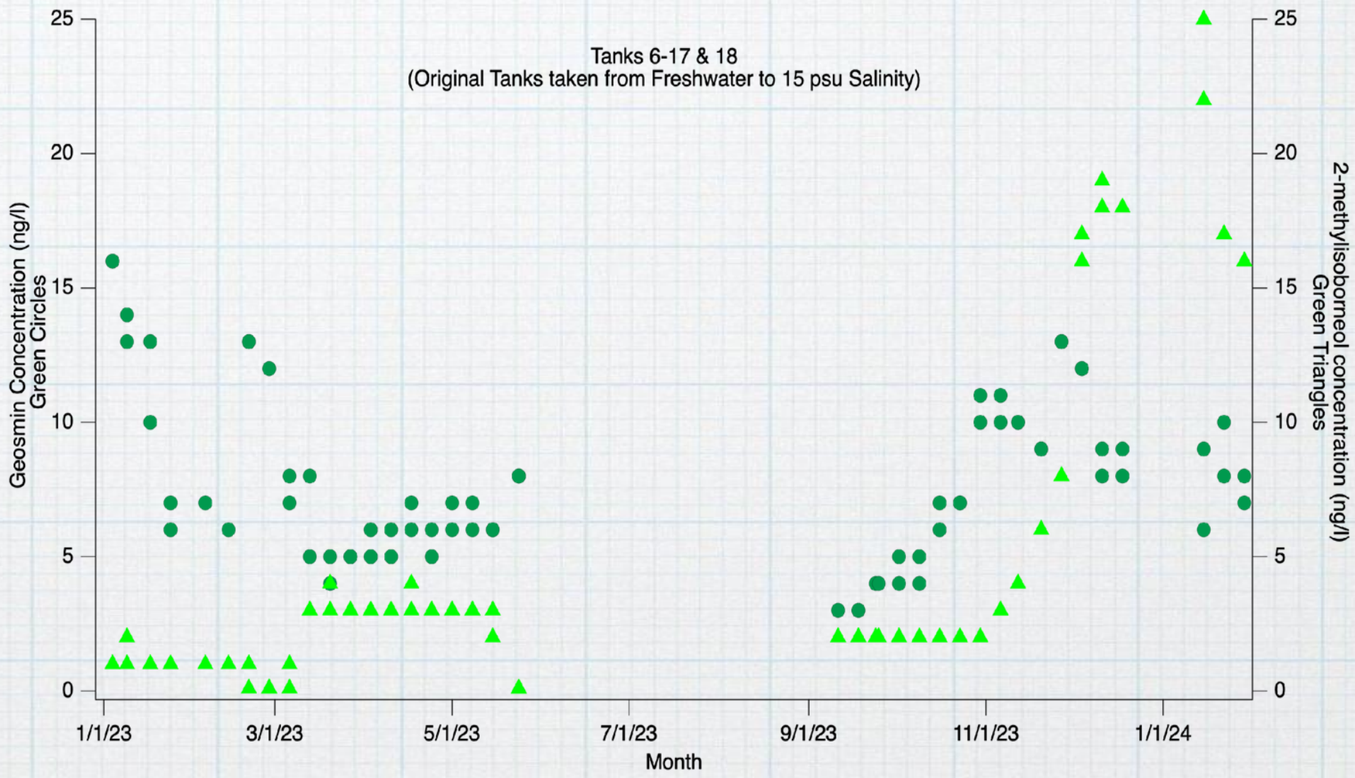
		Pros	Cons
Yellow Mealworm		• Excellent digestibility • High purity chitin as secondary product	• Long grow-out times (2-3 months) • Unable to enhance PUFA
Superworm		• Can enhance lipid profile • Allow for controlled pupation	• Longest grow-out time (3-5 months)
Black Soldier Fly Larvae		• Diet versatility • Shortest grow-out time (21 days) • Contains some omega-3 fatty acid*	• Highest chitin content • Potential for causing hepatic steatosis

*Still requires algal oil supplementation for Atlantic salmon diet

Alkalinity vs Off Flavor







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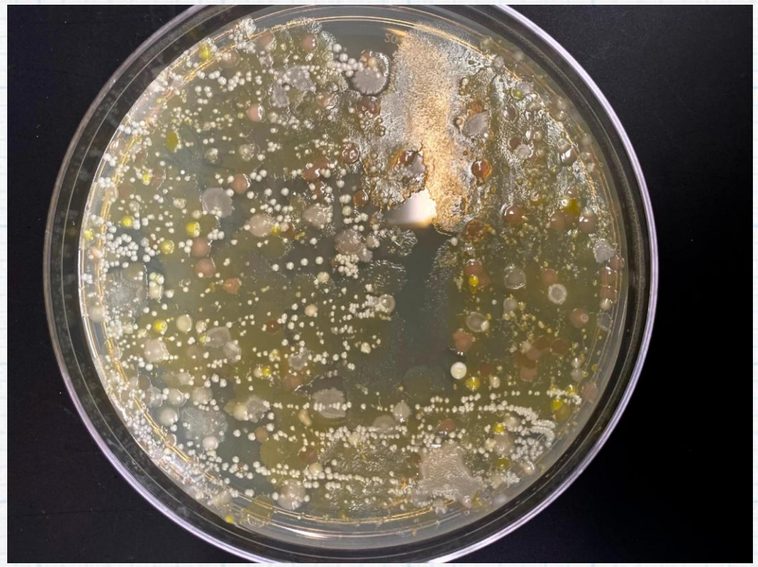
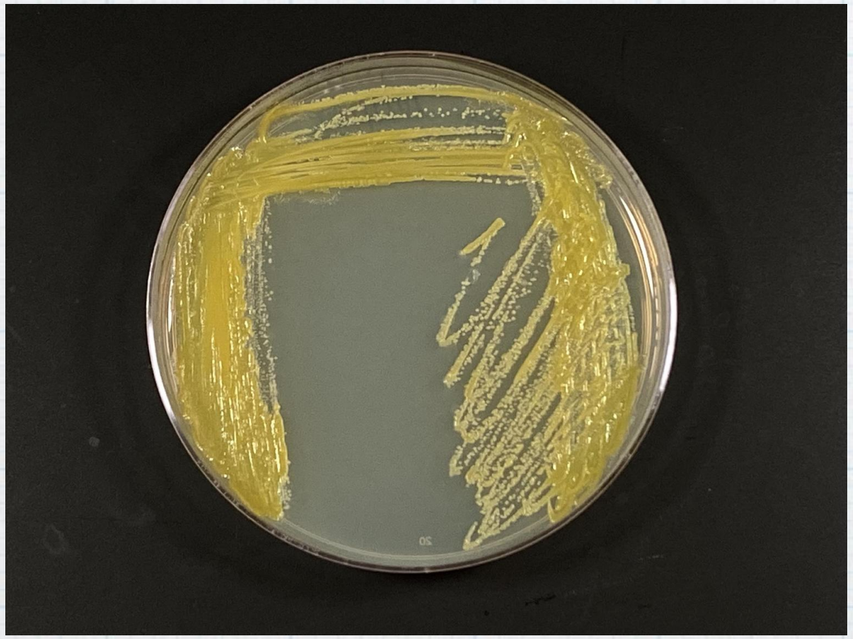
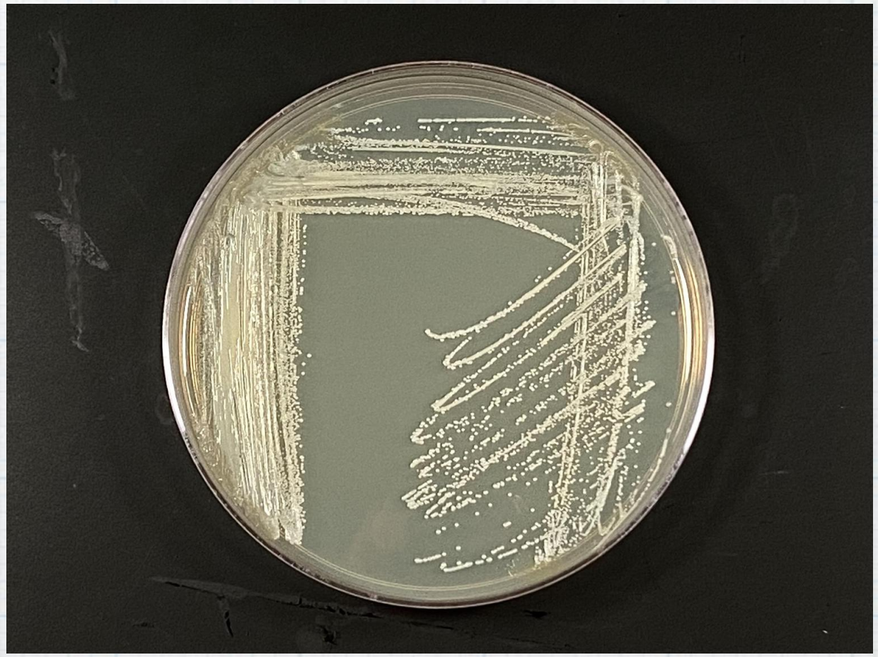
Isolation of Freshwater RAS bacteria







Freshwater RAS Microbiome

IMET ID	Organism	Upload	Geosmin Synthase	2MIB	
035A	Streptomyces papulosus	+	+	+	
036A	Nocardia asteroides	+	+	+	
038A3	Pantoea septica	+	-	-	
039A	Vibrio plantisponsor	+	-	-	
047A	Rhodococcus_b sp002259485	+	-	-	
055A1	Pseudomonas ytbd	+	-	-	
057C1	Pseudomonas ytbd	+	-	-	
061A	Pseudomonas ytbd	+	-	-	
062A1	Moraxella_a cinereus	+	-	-	
063A	Moraxella_a cinereus	+	-	-	
066A	Gordonia sp000143885	+	-	-	
067A1	Gordonia sp000143885	+	-	-	
068A	Mycobacterium ytbd	+	-	-	
071A	Microbacterium sp000800925	+	-	-	
073A	Mycobacterium ytbd	-	N/A	N/A	
077A	Micrococcus luteus	+	-	-	
078B	Micrococcus luteus	+	-	-	
081A	Mycobacterium ytbd	+	-	-	
082A	Rhodococcus_b sp001647195	+	-	-	
082B	Rhodococcus_b sp001647195	+	-	-	
083A	Rhodococcus_b sp001647195	+	-	-	
084A	Gordonia sp002009645	+	-	-	
086C1	Pseudomonas_e reinekei	+	-	-	
088C1	Shewanella baltica	+	-	-	
088D1	Rhodococcus_b sp001647195	+	-	-	
088F1	Rhodococcus erythropolis	+	-	-	
089A1	Mycobacterium ytbd	+	-	-	
098A1	Mycobacterium chelonae	+	-	-	
099A1	Micromonospora aurantiaca	+	+	-	
100A1	Pseudomonas ytbd	+	-	-	
100B1	Pseudomonas_e borbori	+	-	-	
101A1	Ensifer sp000799055	-	N/A	N/A	
101B1	Pseudomonas_e hunanensis	-	N/A	N/A	
102B1	Paenarthrobacter histidinolovoran	+	-	-	
001	Stenotrophomonas sp	+	-	-	
002	Shewanella sp002838165	+	-	-	
003	Staphylococcus caprae	+	-	-	
004	Lelliottia amnigena	+	-	-	
005	Micrococcus luteus	+	-	-	
006	Pseudomonas_e lurida	+	-	-	
007	Micrococcus luteus	+	-	-	
008	Bacillus_ab infantis	+	-	-	
009	Pseudomonas_e lurida	+	-	-	
010	Pseudomonas_e lurida	+	-	-	
011	Streptomyces cellulosae	+	+	-	
012	Nocardia asteroides	+	+	+	
014	Hafnia alvei	+	-	-	
015	Hafnia alvei	+	-	-	
022	Shewanella baltica	+	-	-	
023	Brevibacterium sp018137945	+	-	-	
024	Nocardia asteroides	+	+	+	
025	Rhodoglobus sp	+	-	-	
026	Lelliottia amnigena	+	-	-	
027	Lelliottia amnigena	+	-	-	
029	Mycobacterium chelonae	+	-	-	
031	Shewanella baltica	+	-	-	
032	Flavobacterium tructae	+	-	-	

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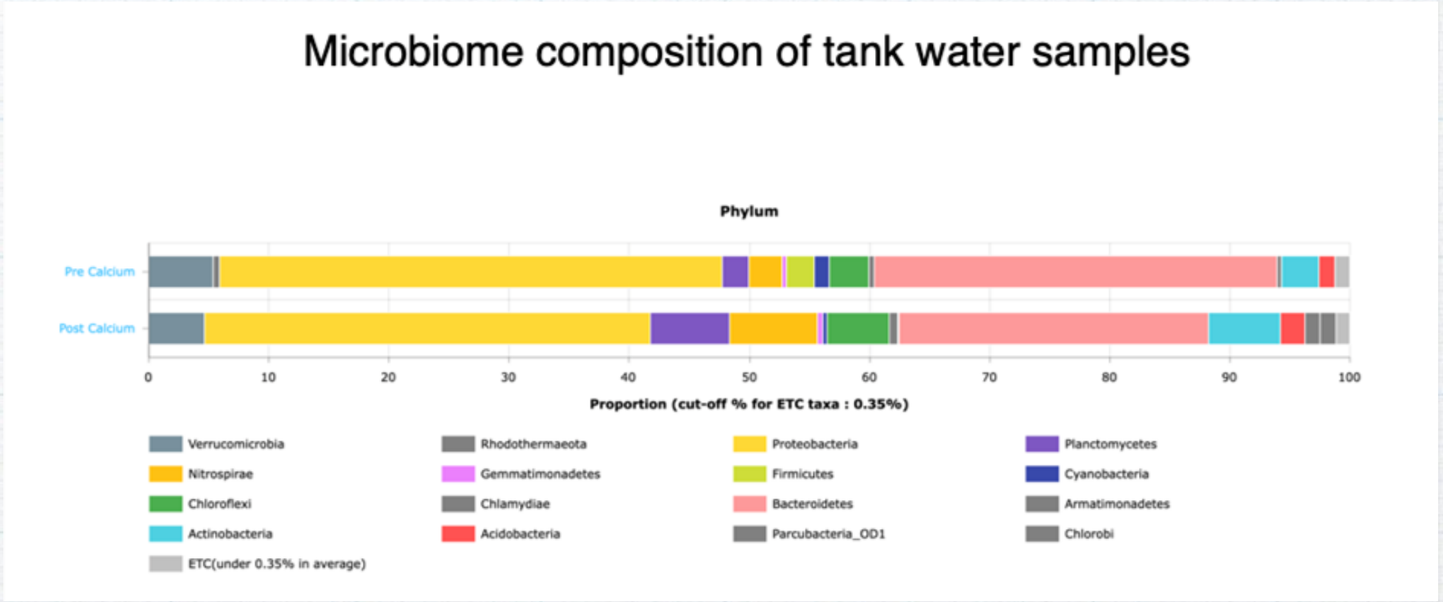
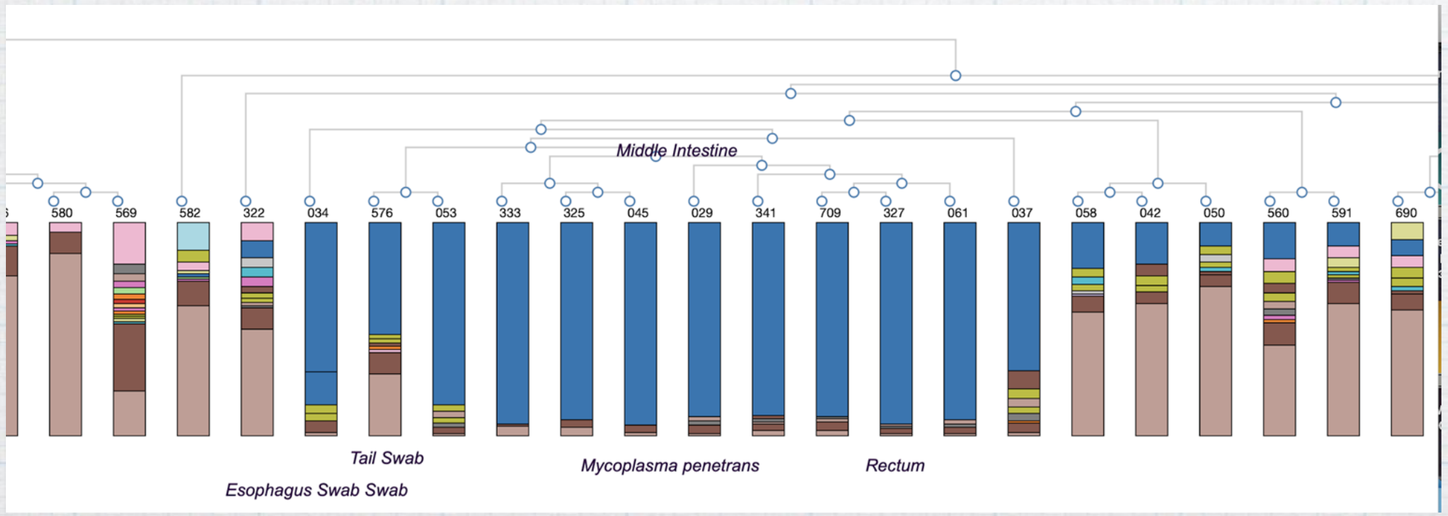
Unique Gut Microbiome





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Supporting Atlantic Salmon

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Genome erosion and evidence for an intracellular niche – exploring the biology of mycoplasmas in Atlantic salmon

B. Cheaib [a,b,*], P. Yang [c], R. Kazlauskaite [a], E. Lindsay [a], C. Heys [a], T. Dwyer [a], M. De Noia [a], Patrick Schaal [a], W. Sloan [b], U.Z. Ijaz [b], M.S. Llewellyn [a]

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m/ismej

ISME

ARTICLE OPEN

Co-diversification of an intestinal *Mycoplasma* and its salmonid host

Jacob A. Rasmussen [1,2]✉, Pia Kiilerich[3], Abdullah S. Madhun[4], Rune Waagbø[4,7], Erik-Jan R. Lock[4], Lise Madsen[4], M. Thomas P. Gilbert [2,5], Karsten Kristiansen [1,6] and Morten T. Limborg[2]✉

Nucleic Acids Research, 2002, Vol. 30, No. 23 5293–5300

The complete genomic sequence of *Mycoplasma penetrans*, an intracellular bacterial pathogen in humans

Yuko Sasaki*, Jun Ishikawa[1], Atsushi Yamashita[2], Kenshiro Oshima[2,3], Tsuyoshi Kenri, Keiko Furuya[2], Chie Yoshino[2], Atsuko Horino, Tadayoshi Shiba[2], Tsuguo Sasaki and Masahira Hattori[2,4]

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Received June 25, 2002; Revised September 18, 2002; Accepted October 11, 2002 DDBJ/EMBL/GenBank accession nos+

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A.4 Accomplishments

- IMET finished a diet study comparing black soldier fly meal diet to a fishmeal-free soy meal diet using an all-female strain of Atlantic salmon designed by Benchmark Genetics for RAS environments; a single-sex strain allows us to standardize experimental conditions. We are now pulling to publication the two diets studies.

- Results of diet trials with black soldier fly indicate that the feed formulation does not enlarge the spleen, a stark contrast to what had been observed in previous studies using yellow mealworm (reported in Year 2). Feeds were tested for mycotoxins (compounds produced by certain molds) as a possible source of spleen enlargement, but no significant levels were found in yellow mealworm feeds.

- The University of Maryland School of Medicine (UMD-SM) collected and analyzed 150+ microbial samples from RAS at IMET using metagenomic analysis, a comprehensive method to study all genetic material in a sample. This revealed a diverse microbial ecosystem in the RAS, including notable bacteria like Stenotrophomonas (94-96% similarity), Shewanella (94% similarity), and Staphylococcus (93-97% similarity). Analysis of bacterial isolates will continue into 2025 and will be shared in the Year 4 report.

- Additionally, 16S rRNA gene sequencing (a method to identify bacteria by their genetic 'fingerprint') revealed a dominance of Mycoplasma penetrans bacteria in the salmon's mid intestine, providing crucial insight into how different feeds may influence the fish's gut microbiome – a key factor in fish health and growth in aquaculture systems.