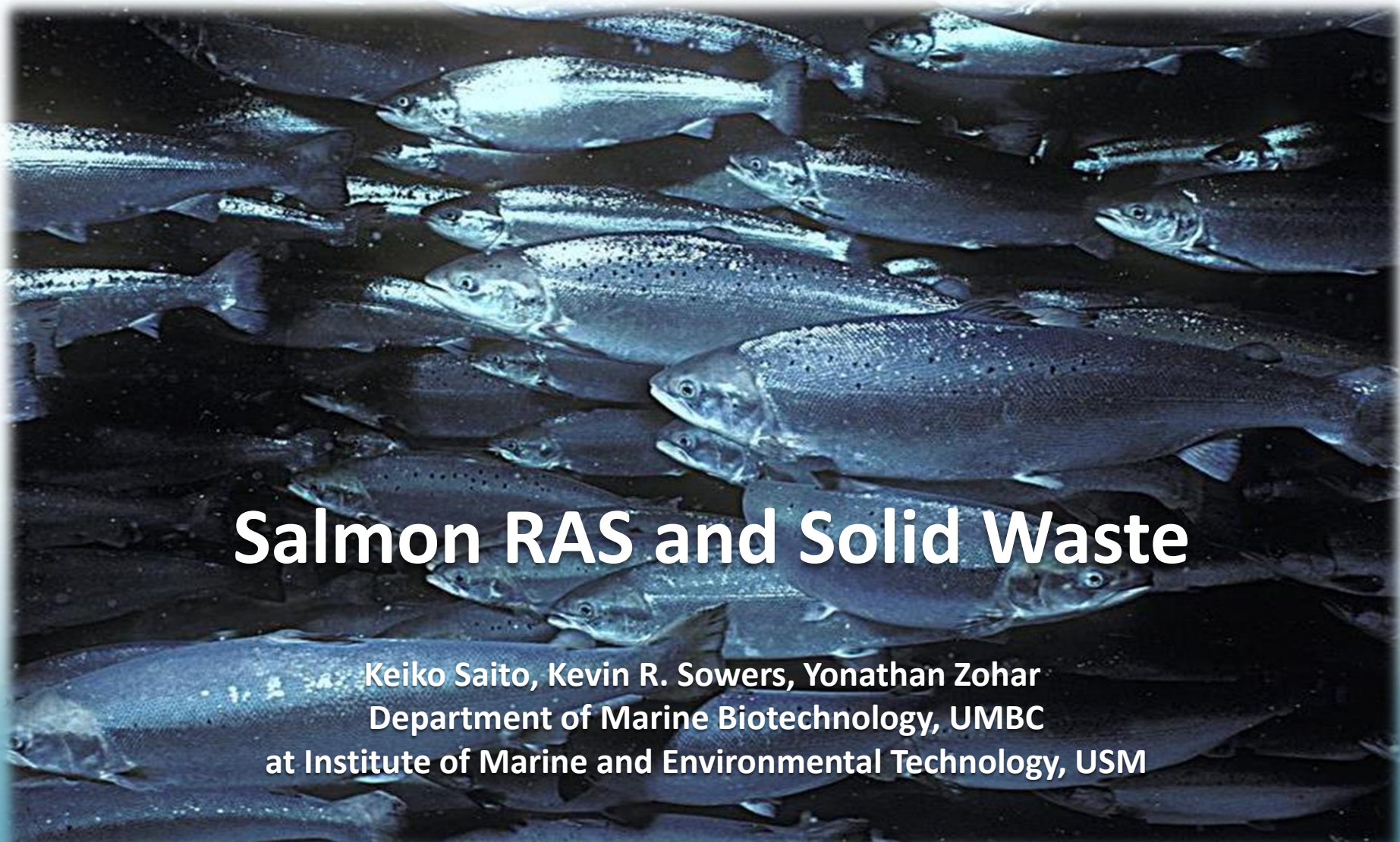


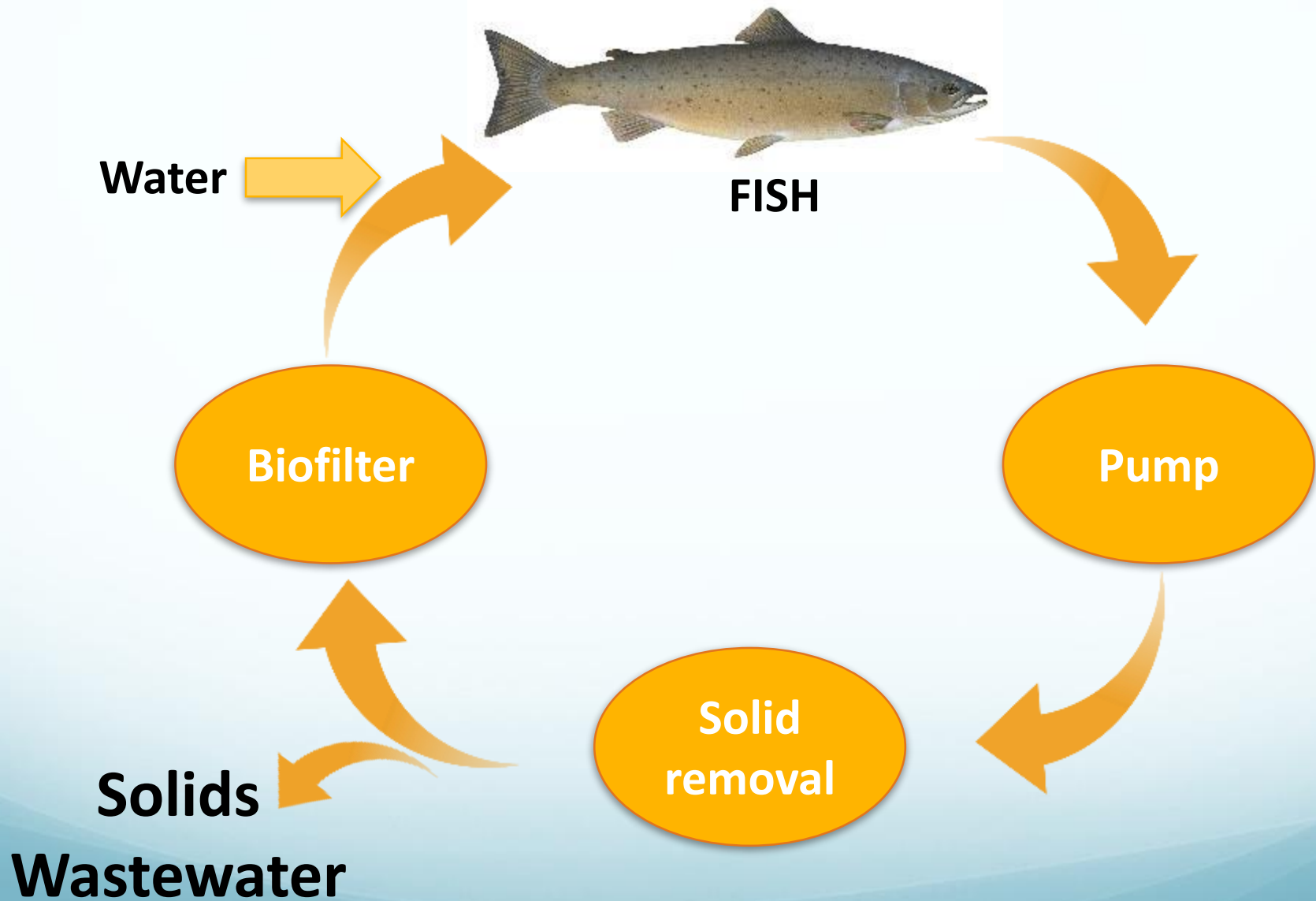
A large, dense group of salmon swimming in water, filling the background of the slide.

Salmon RAS and Solid Waste

Keiko Saito, Kevin R. Sowers, Yonathan Zohar
Department of Marine Biotechnology, UMBC
at Institute of Marine and Environmental Technology, USM



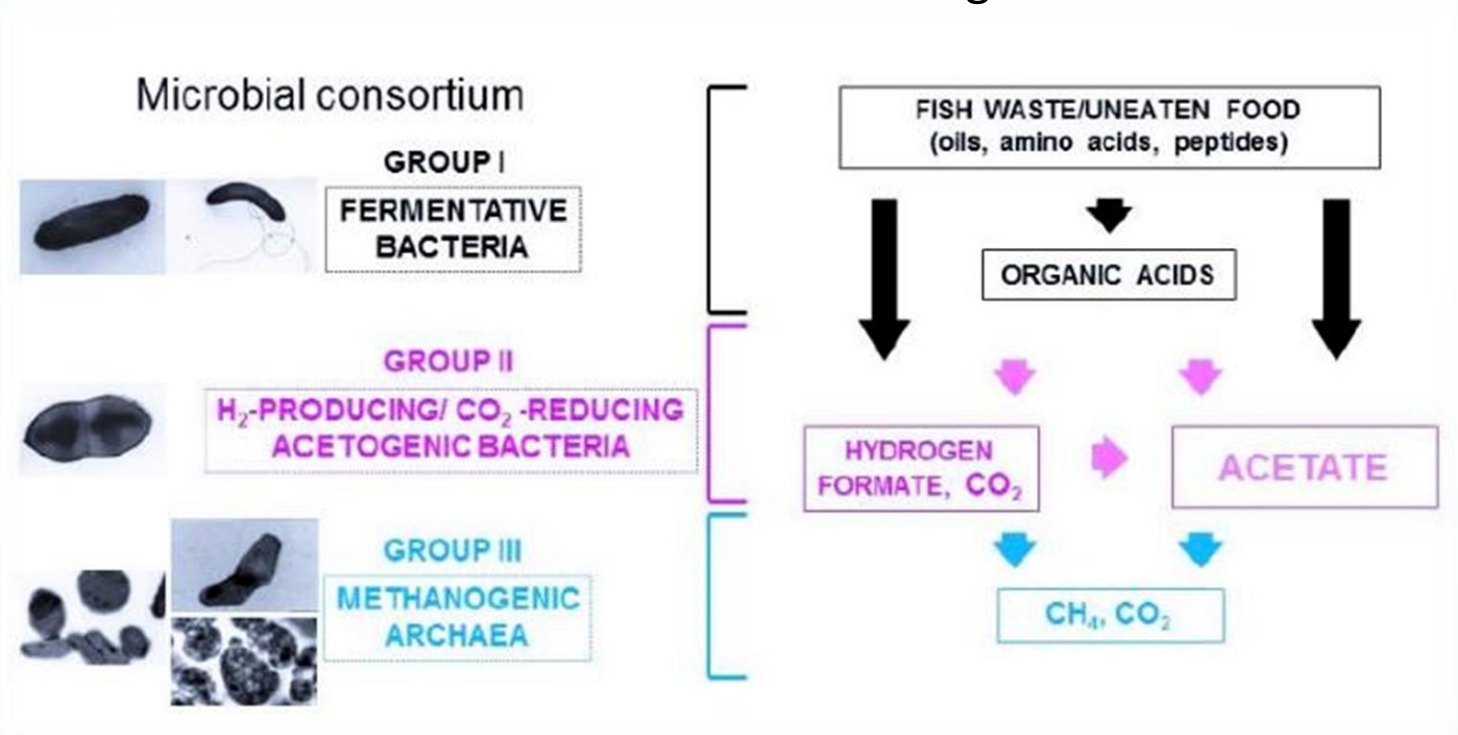
Typical RAS and Challenges





Anaerobic Digestion:

How it works and advantages



- High reduction of BOD and sludge volume (up to 90%)
- Effective with high organic and hydraulic loading rates
- Effective at temperatures as low as 25°C
- Can be optimized for fish waste requiring no additional nutrients/supplements
- Low energy input (compared to aerobic digestion)
- Process generates fuel-quality biomethane



Fish Sludge for Anaerobic Digestion

Characteristics of aquaculture and domestic sludge*

Parameter	Aquaculture	Domestic
Total solids (%)	1.4-2.6	2.0-8.0
TVS (%TS)	75-87	50-80
BOD ₅ (mg/L)	1,600-3,900	2,000-30,000
TAN (mg/L)	7-26	100-800
TP (%TS)	0.6-2.6	0.4-1.2
pH	6.0-7.2	5.0-8.0
Alkalinity	280-420	500-1,500

Aquaculture vs. commercial agriculture animal production*

Animal	Solids	BOD ₅	TKN	Sludge Volume
Sea bass RAS**	2.2		0.40 (TAN)	44-184
Catfish RAS	4.2	0.8-1.3	0.20	70-420
Beef cattle	9.5	1.6	0.32	30
Daily cow	7.9	1.4	0.51	51
Poultry	14.0	3.4	0.74	37
Swine	8.9	3.1	0.51	76

*Chen *et al.* (1993) American Society of Aquacultural Engineers, pp. 16-25.

**Saito *et al.* in preparation.

Waste generation (kg/day/1,000 kg live weight production)



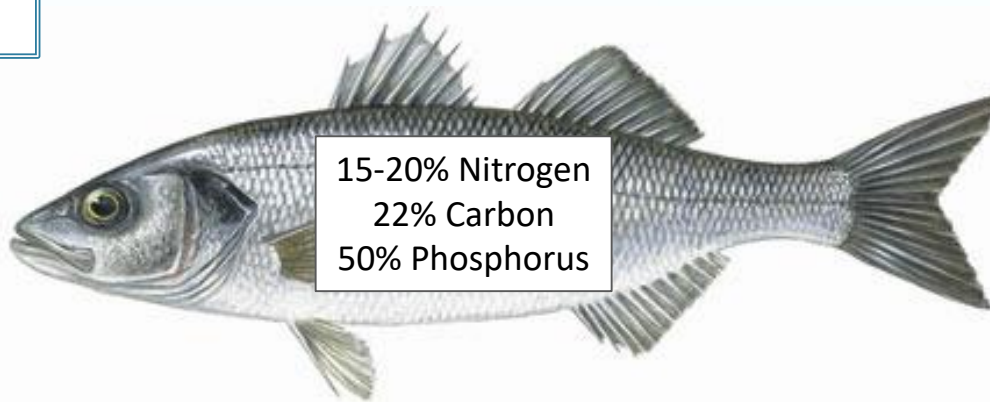
Organic and Inorganic Wastes in RAS

Characteristic of fish farming sludge

Feed:

Organic N = 60-80 g/kg
Organic C = 400-450 g/kg
Organic P = 12-15 g/kg

Low C/N ratio of fish farming sludge



15-20% Nitrogen
22% Carbon
50% Phosphorus

Wastes produced by fish

Respiration:

52% C as CO₂

Dissolved:

60-86% Nitrogen (TAN)

0.7-3% Organic C

30% Phosphorus

Feces:

6-15% Organic N

25% Organic C

20% Phosphorus

+ Uneaten feed



Dissolved in water:

C/N $\cong$ 1/5

Solid waste:

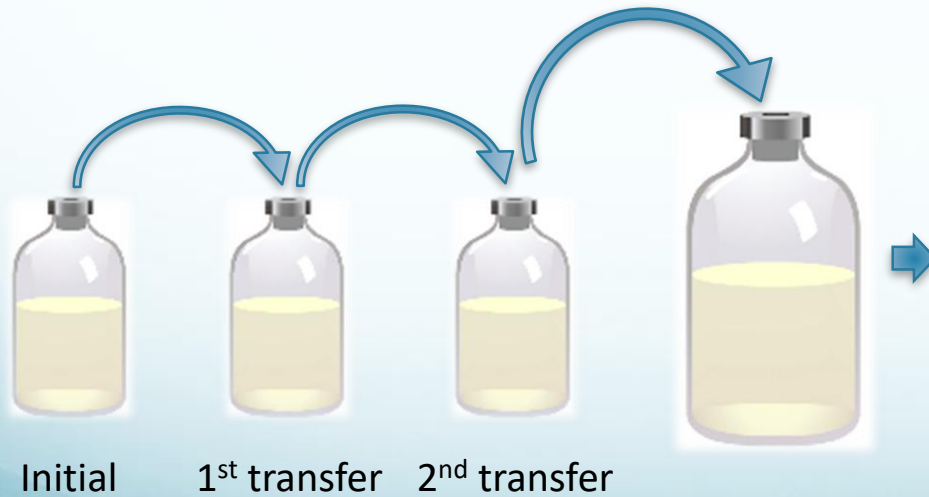
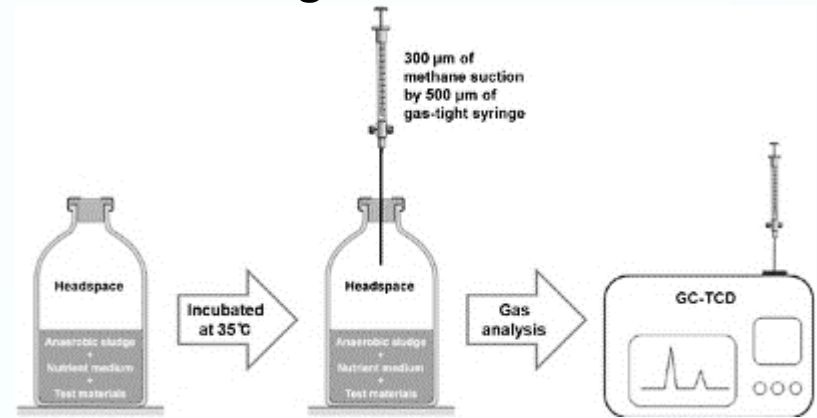
Feces: C/N $\cong$ 10/1

Feed: C/N $\cong$ 5/1



Development of Optimal Consortium

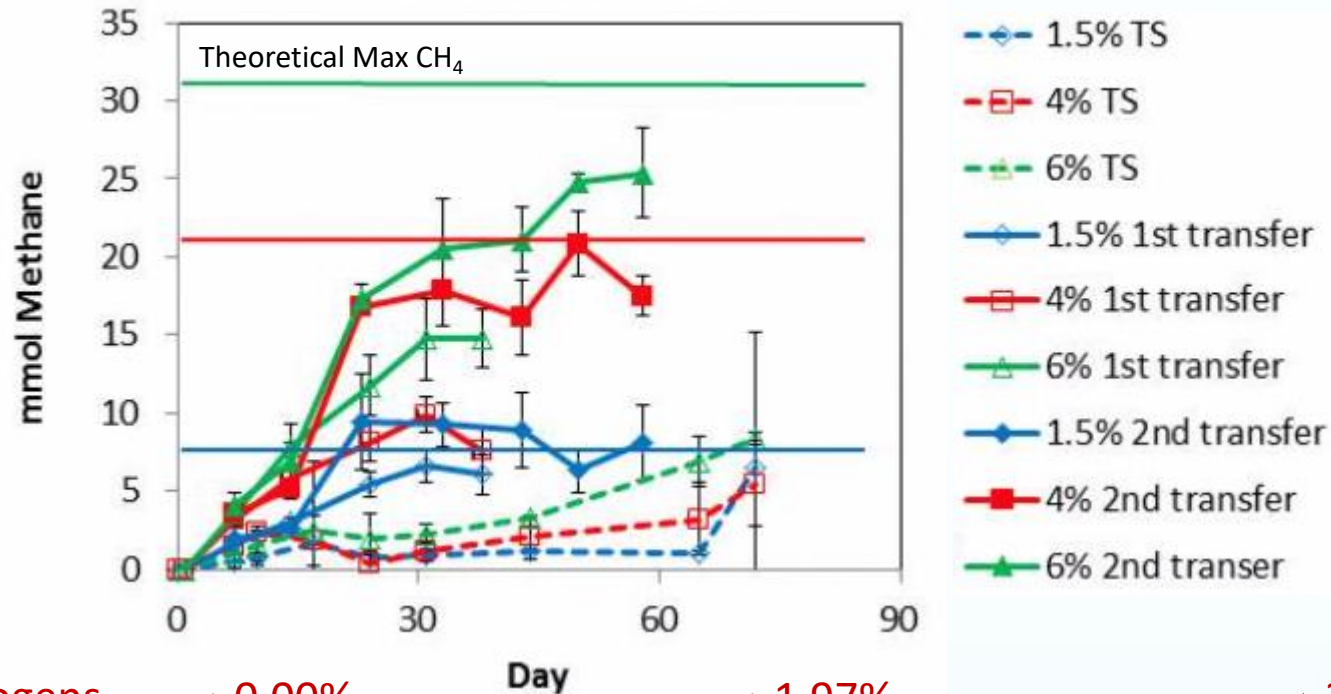
Selectively enrichment of methanogens





Enrichment of Methanogen Consortium

Optimal for fish farming sludge digestion



%Methanogens 0.00%



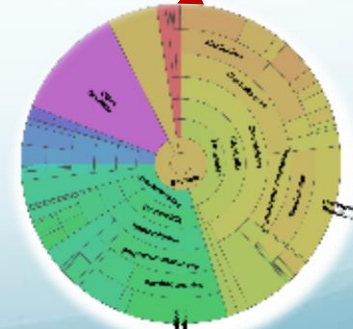
Raw sludge

1.97%



Initial

2.67%



BHI media

* Estimated BMP for sewage is 0.395 mols methane per gram COD



Atlantic Salmon Smolt Farm

Forsan, Norway

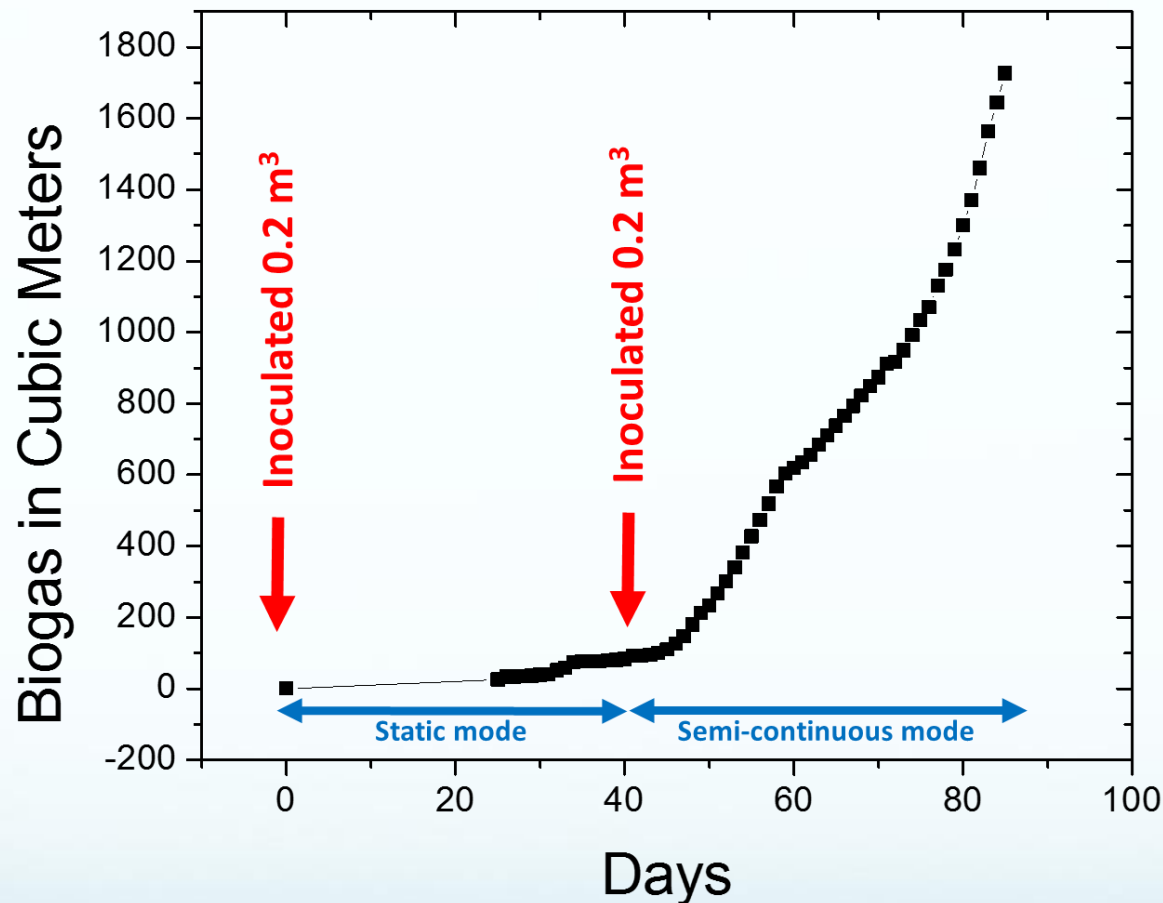


- 2.5 million lbs smolts annually
- Daily: 60,000 lbs sludge (5%solid)





Anaerobic Digestion of Salmon Sludge



- Rate of biogas production up to 175 m³/day (46,000 gallons)
- Methane content: 60-65%
- Biogas used to heat water; ~10% offset of facility energy costs



Anaerobic Digestion for Salmon RAS

- Available for freshwater and saltwater salmon sludge treatment
- Tailored consortia increase bioconversion efficiency and accelerate start-up phase (must to be specific)
- Able to develop monitoring and maintenance molecular tools
- Increase water reuse and decrease the discharge
- Potential for integrating anaerobic digester inline and/or offline
- Able to use for any systems (flow-through to recirc)
- Simple and easy to apply
- Offset operational energy requirement



Sustainable Aquaculture: Environmentally-Friendly Clean Seafood Production

