

CONVERSION OF SOLID WASTE TO BIOGAS IN A SALTWATER RECIRCULATING AQUACULTURE SYSTEM FOR ATLANTIC SALMON

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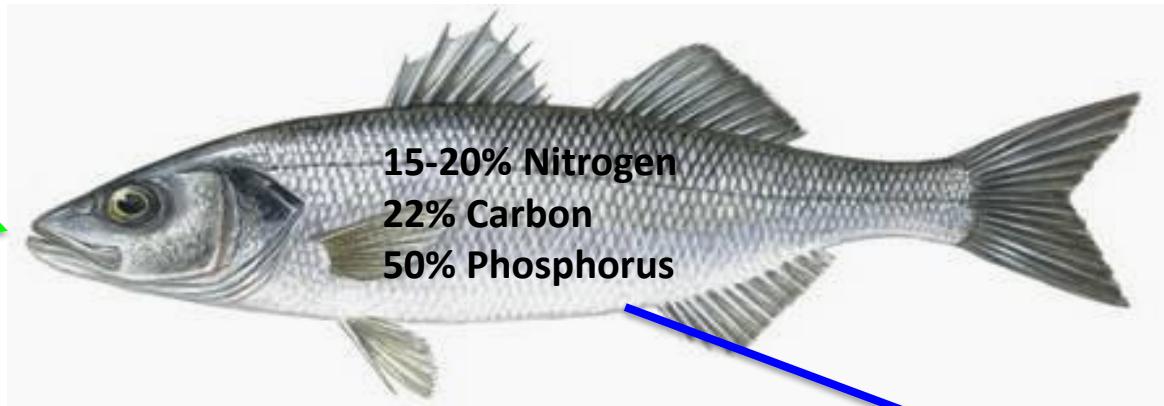
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Aquacultural Solid Waste = Feces + Uneaten Feed

Feed:

- Protein
- Lipid
- Carbohydrate
- Phosphorus

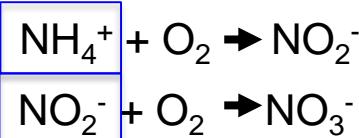
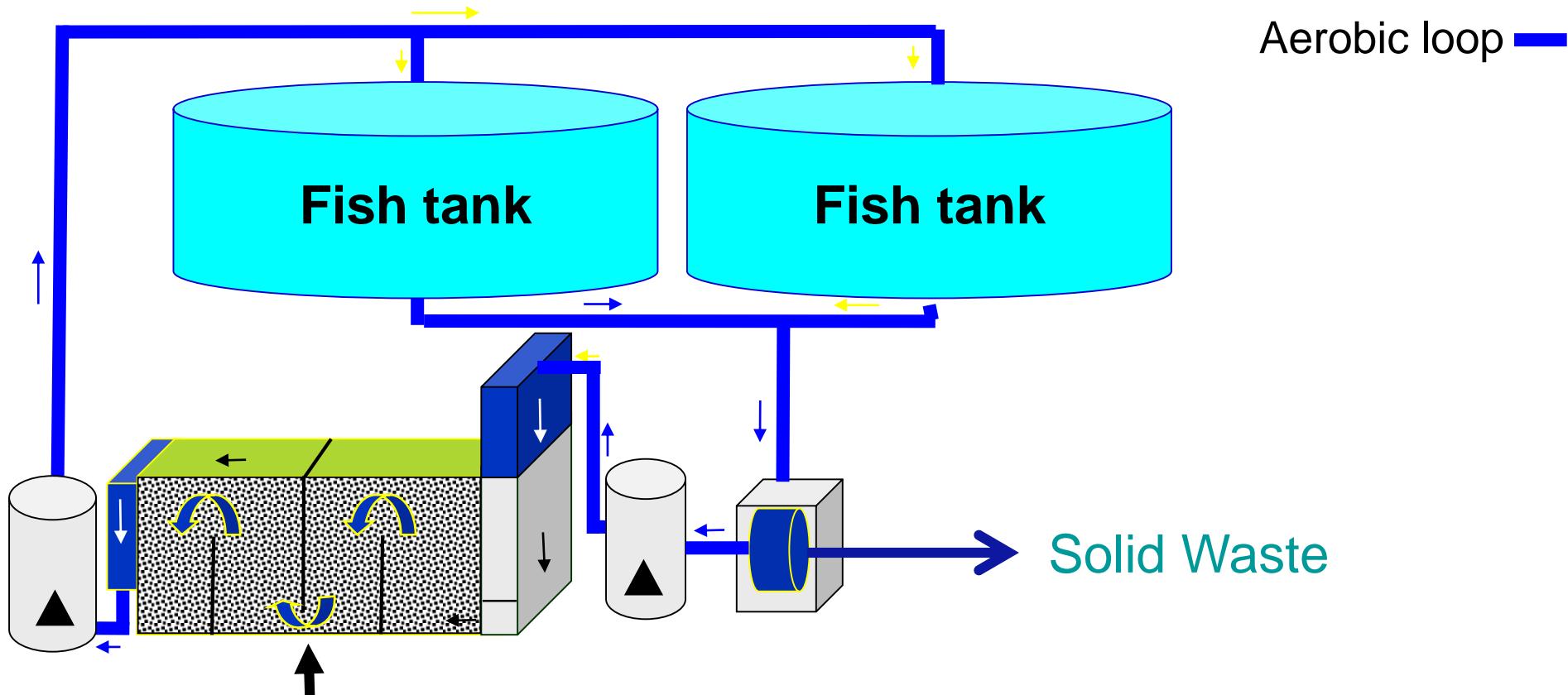


Aquaculture solid waste \approx 20-25% feed load (dry)

1 ton feed \Rightarrow 250 kg solid waste (dry weight)
 \Rightarrow 6.25 ton sludge (4%)

1000 ton farm produces \approx 20 ton sludge (4%) daily!!

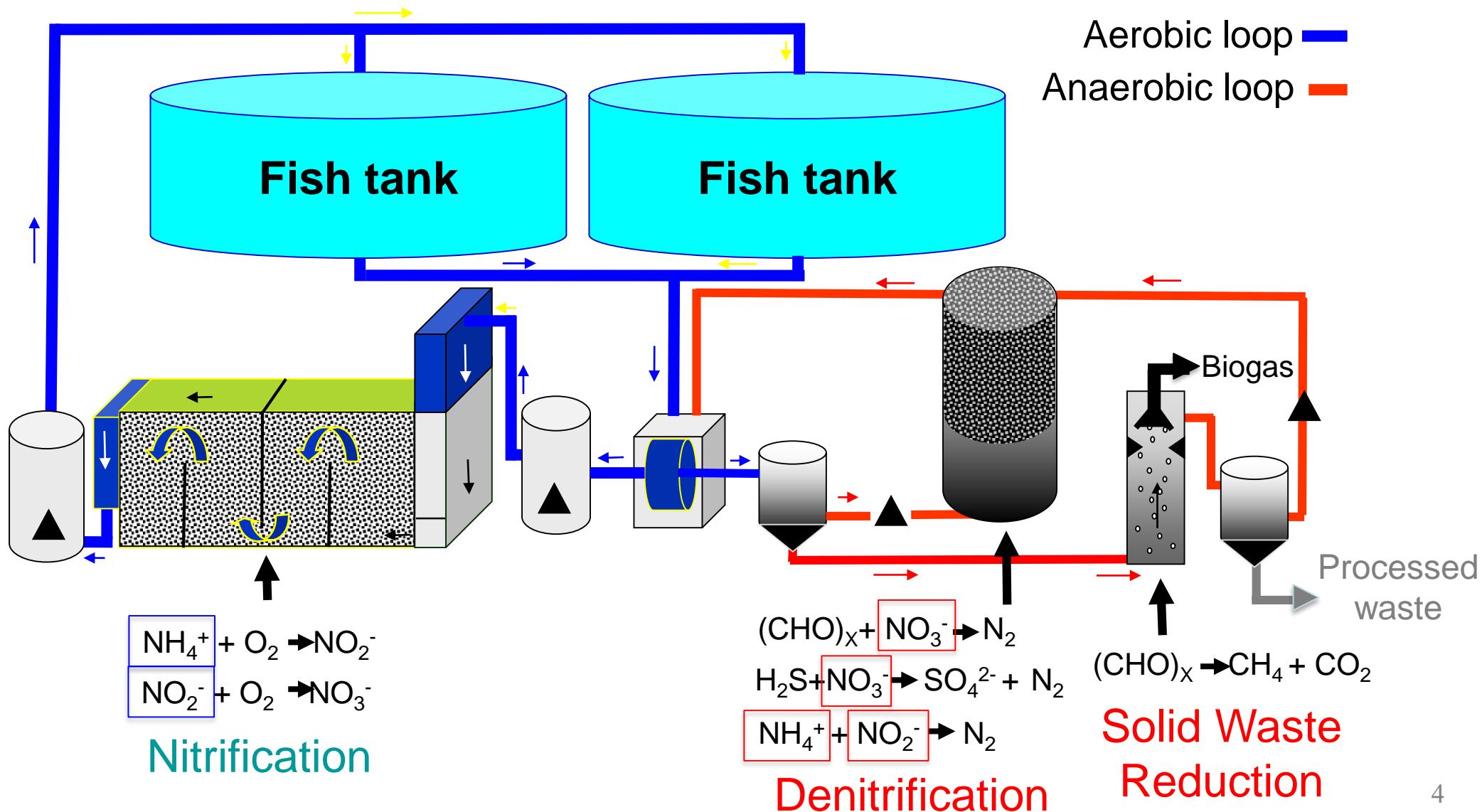
Partial Flow-Through System



Nitrification

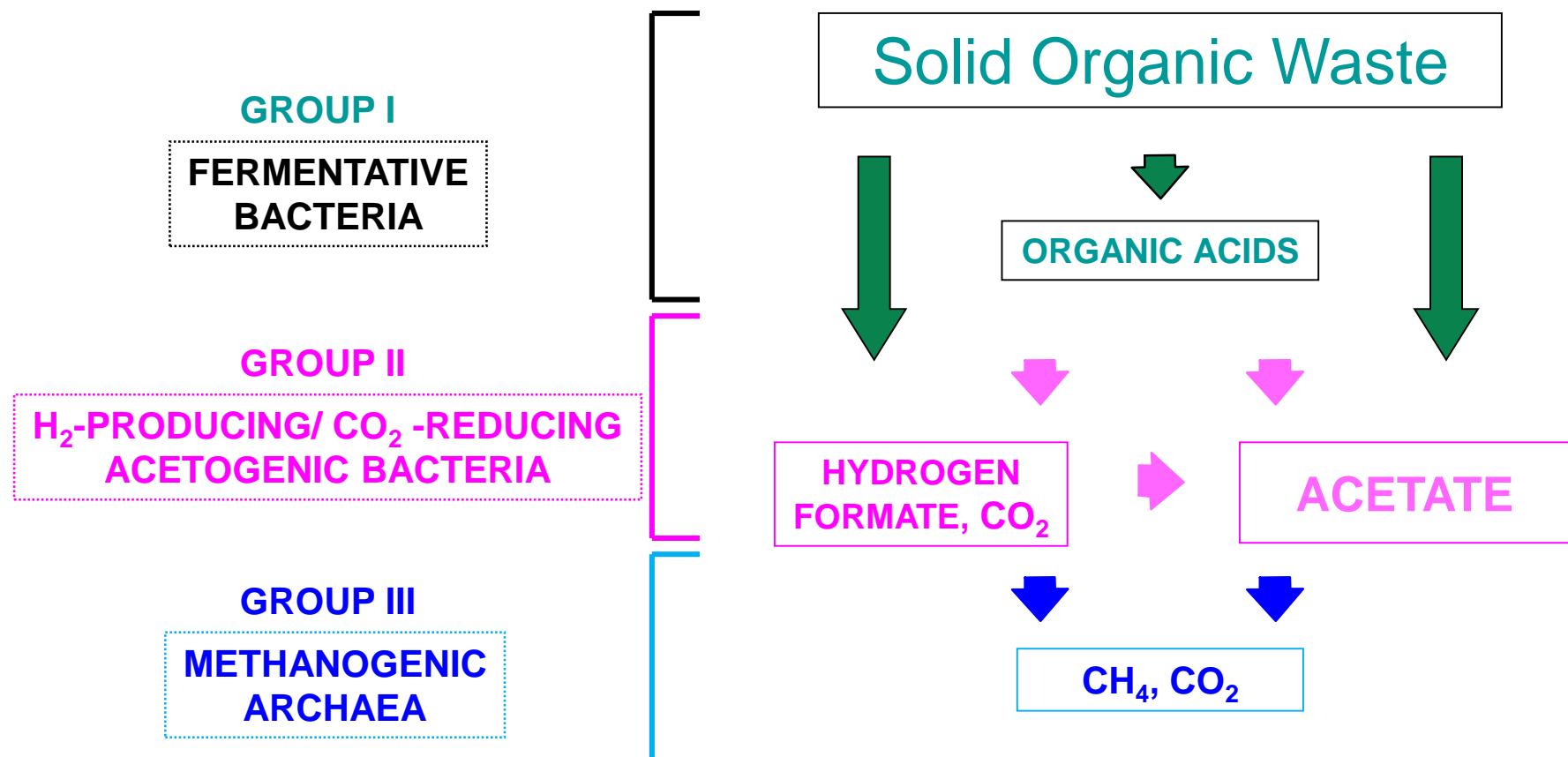
10-20% water replacement

Prototype Marine RAS





How a methanogenic consortium works



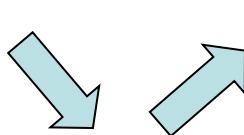
Fish Waste Sludge Characteristics

Parameter	Value
COD	$20,840 \pm 1,322 \text{ mg L}^{-1}$
TN	$1,420 \pm 309 \text{ mg L}^{-1}$
TOC	$2,470 \pm 61 \text{ mg L}^{-1}$
pH	7.4
C:N	5.2:1
COD:TN	14.7:1
Salinity	15 g L^{-1} (marine systems)
COD:SO ₄	20.5:1

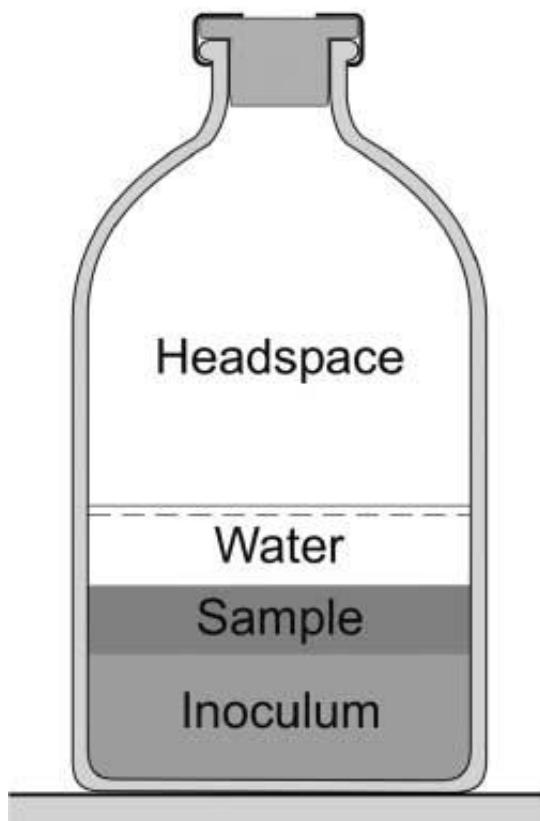
C:N ratio of manure = 30:1

Biochemical methane potential assay

COD
Chemical Oxygen Demand

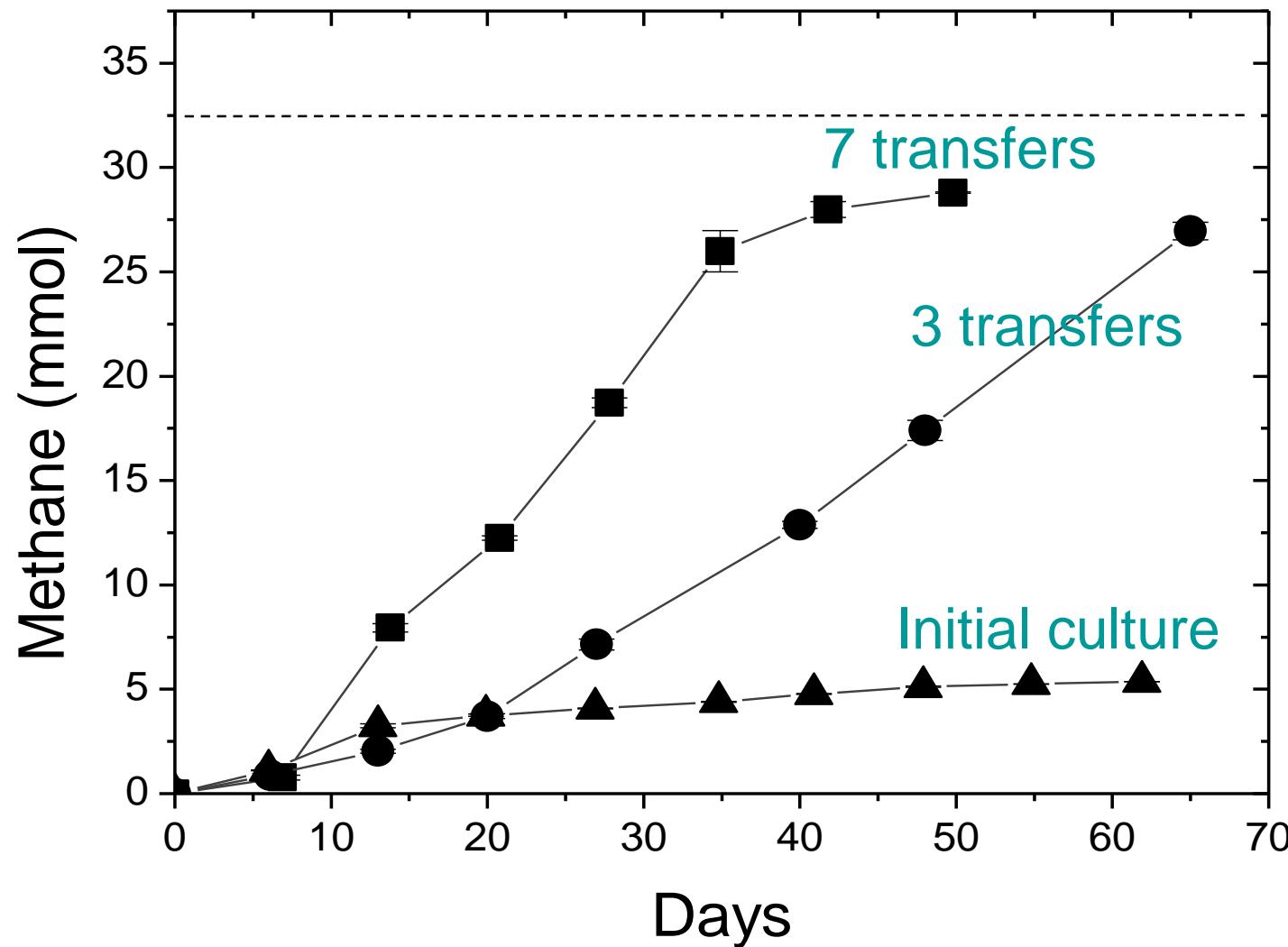


CH₄
Biomethane Gas



Estimated BMP for sewage is 0.395 mols methane per gram COD

Development of Biomethane Consortium



Development of Biomethane Consortium



Initial

- Black-brown
- Viscous



After

- Yellow, clear
- Settled material

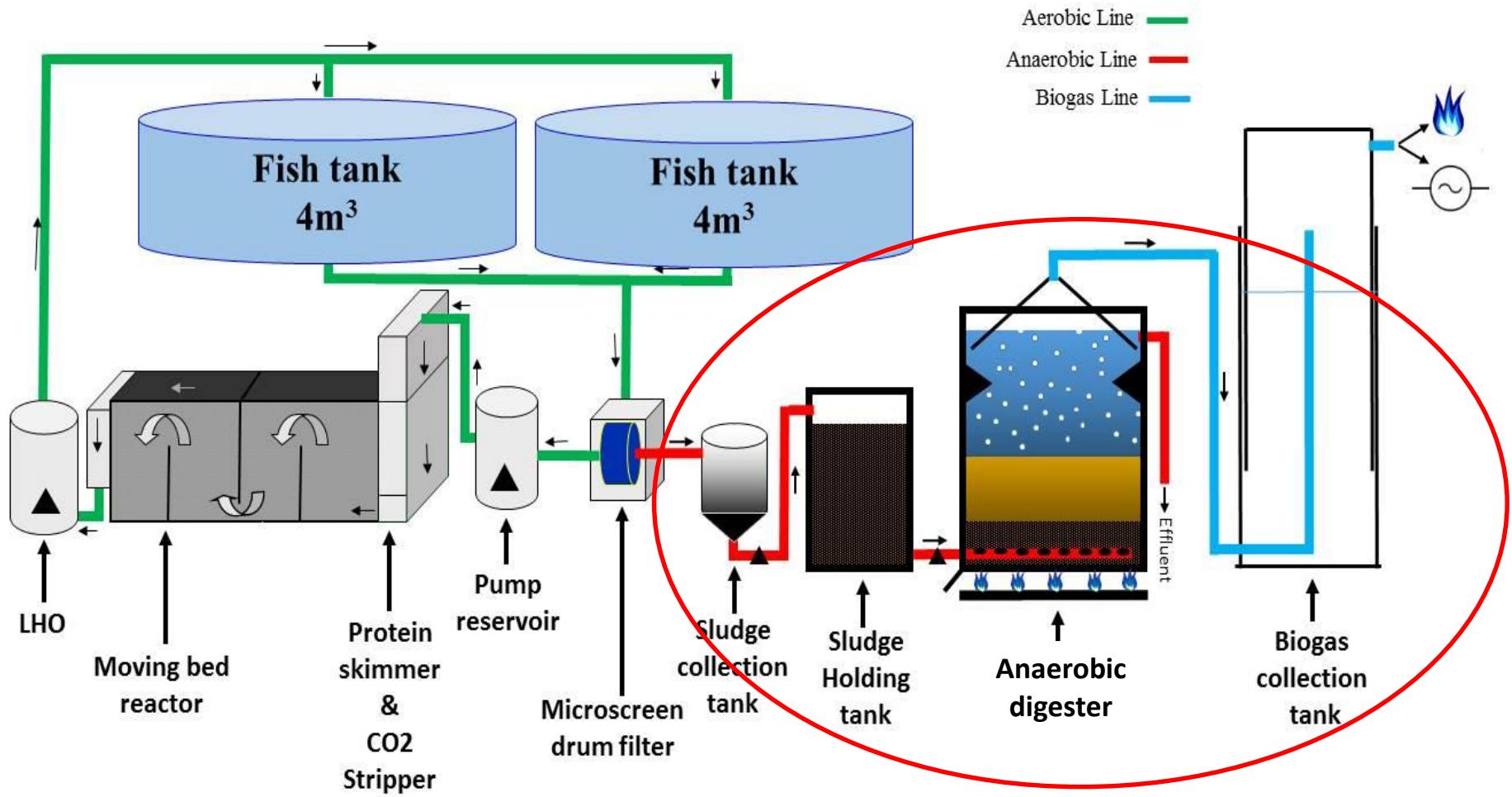
Reconstituted consortium can be mass cultured



- Culture can be maintained in artificial medium
- Can be maintained as mixed culture to maintain required ratios of species
- High volumes of concentrated cells can be generated as inoculum

IMET Atlantic Salmon Pilot System

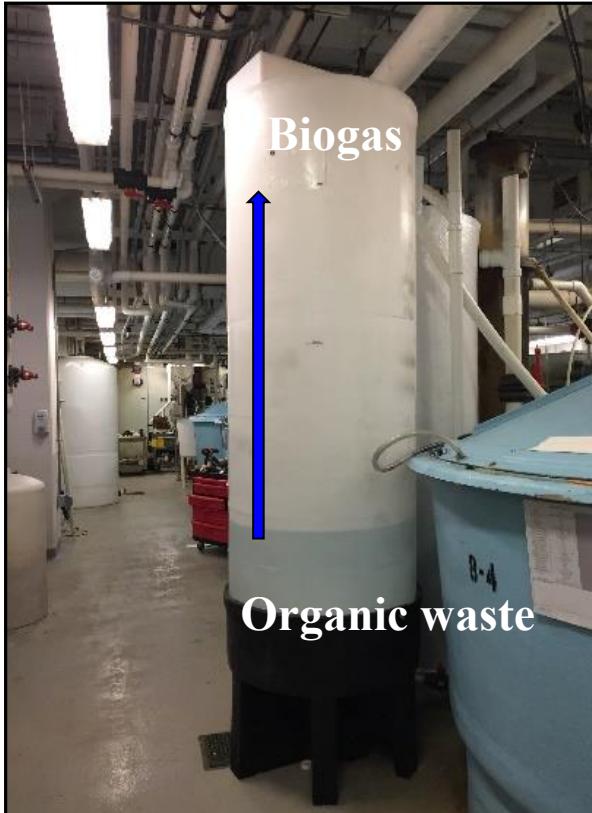
13-14 degrees C, 20 PPT



System Startup



Inoculating Consortium
in Sludge Holding Tank

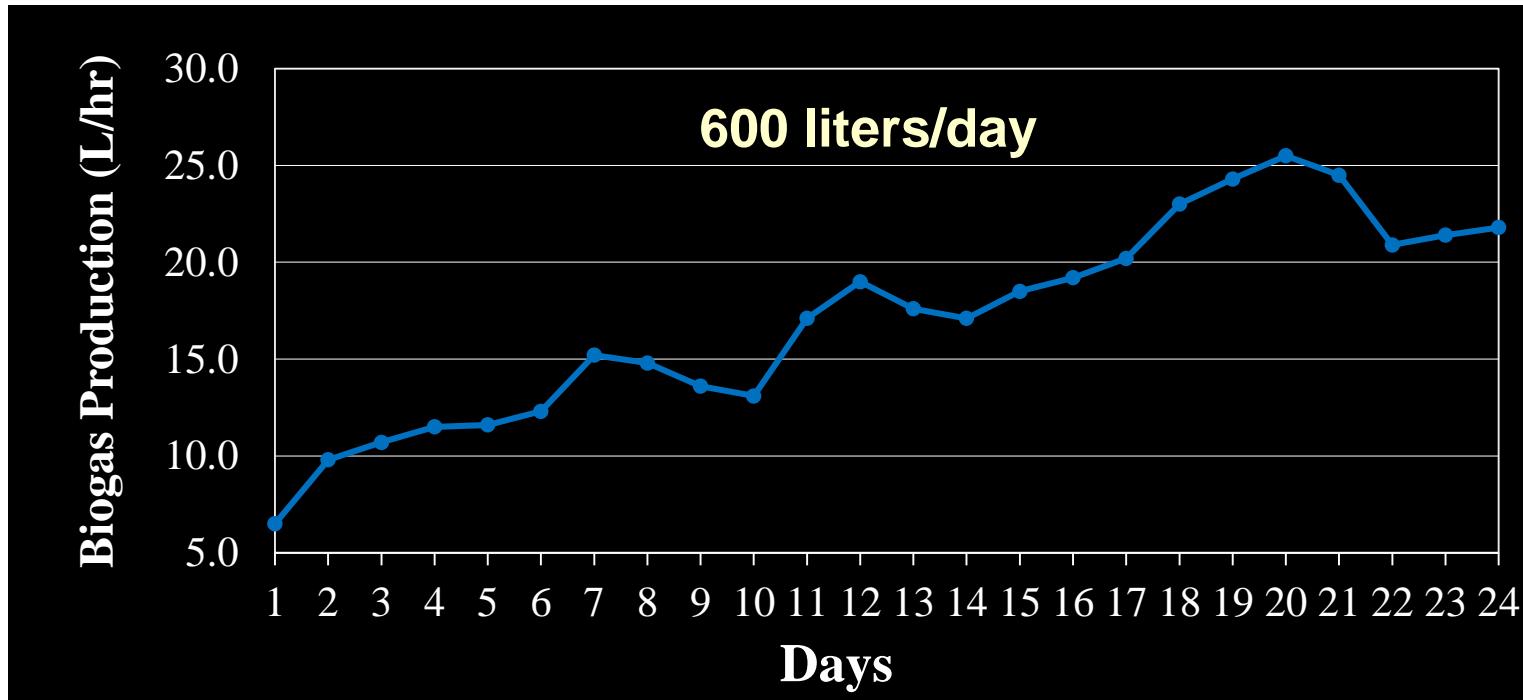


Anaerobic Digester
(1000 L)



Biogas collection

Biogas Reactor Performance



- 83% reduction in COD at 14d HRT
- Efficient production of fuel-grade methane (70% methane)
- At optimal efficiency: ~ 0.65 kWh/kg fish produced, 11.7% of operation's energy consumption

Cermaq – Forsan, Nordland Norway

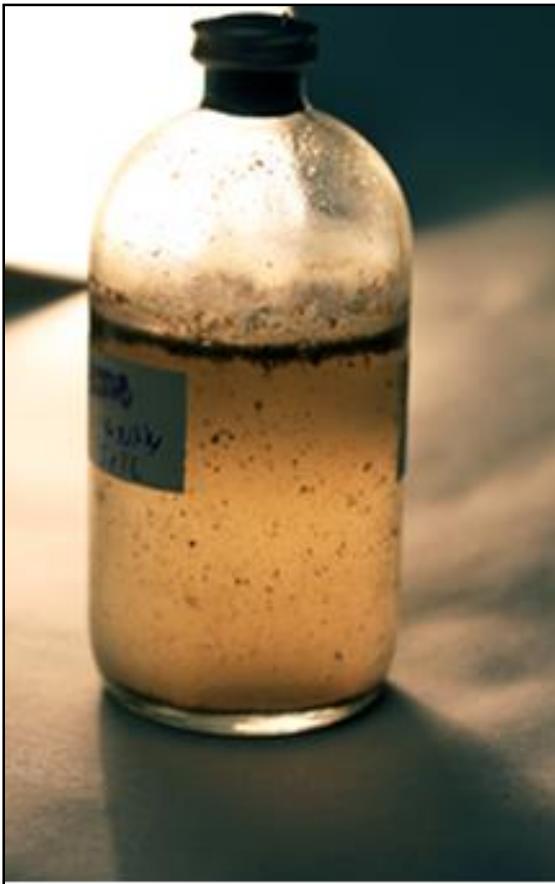


- 12.2 million smolt production capacity; ~1,200 ton
- Daily: 1 metric ton dry waste, ~22 mt sludge (4-5%)

Waste Treatment Facility Designed by Sterner AS



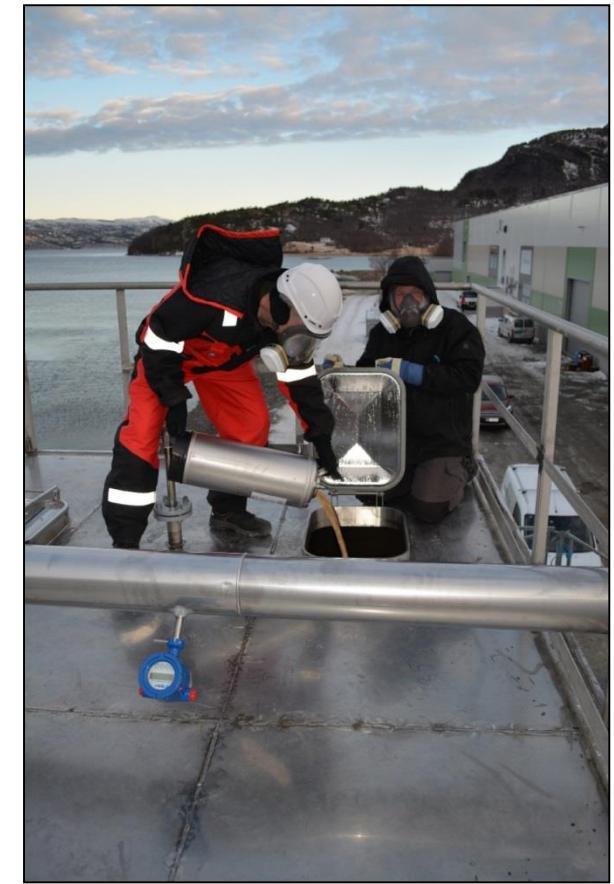
From the bench to the bioreactor



Enrichment from
hydrolyzed Forsan sludge



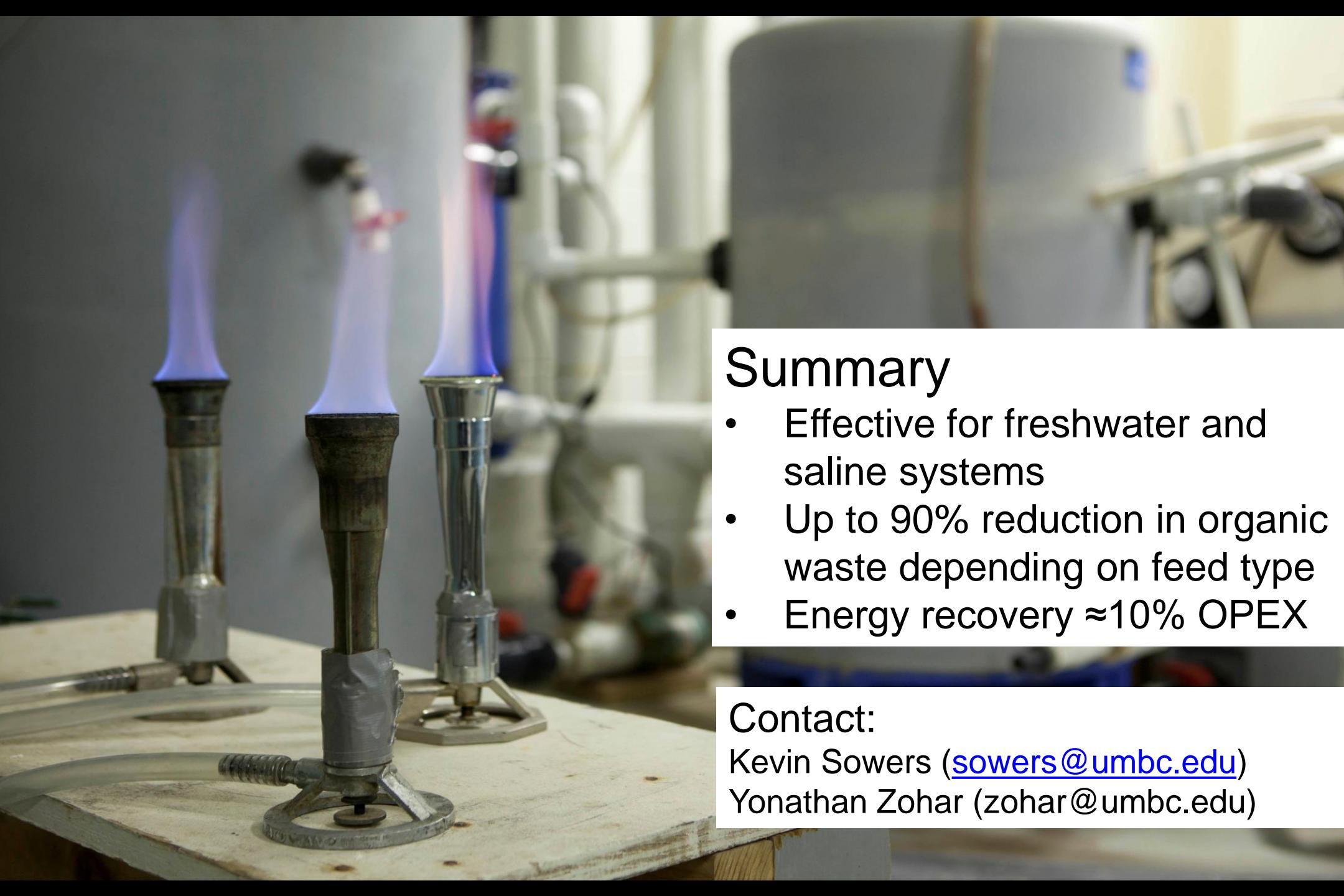
Scaleup, concentration,
shipment of inoculum



Inoculation of 100 m³
biogas reactor

Operational Performance

- Rate of biogas production up to 175 m³/day
- Methane content- 65-70%
- Stable operation for 4 years

A photograph of laboratory equipment, specifically three flame torches, sitting on a wooden bench. The torches are mounted on stands and are all lit, showing blue flames. In the background, there are various pieces of lab equipment, including what looks like a large metal drum or tank.

Summary

- Effective for freshwater and saline systems
- Up to 90% reduction in organic waste depending on feed type
- Energy recovery ≈10% OPEX

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