From Sludge to Biogas

An environmentally Sustainable Approach for Treating Aquaculture Waste

Kevin R. Sowers
Institute of Marine & Environmental Technology

Blue Economy Aquaculture Forum

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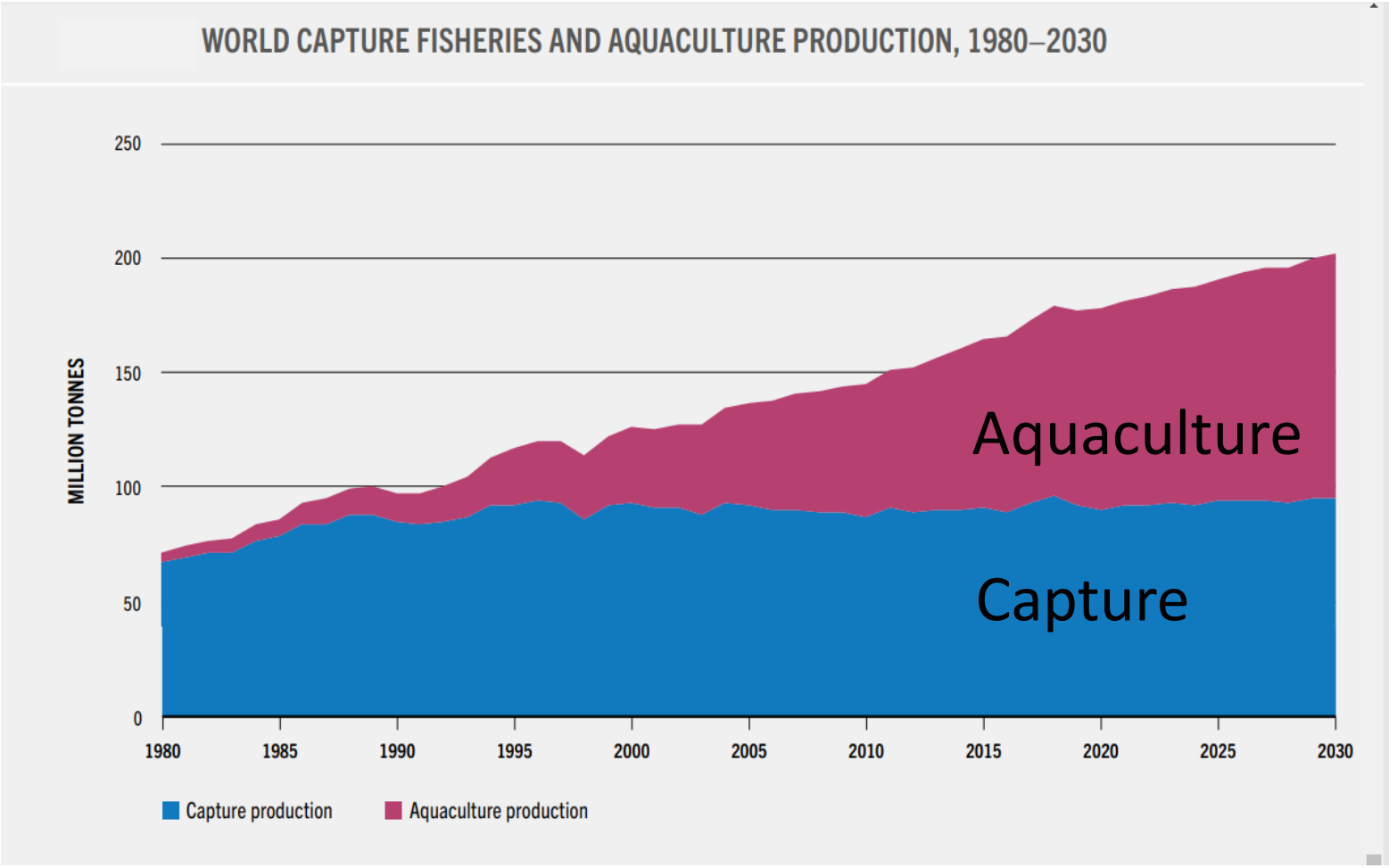
Aquaculture Production is Growing



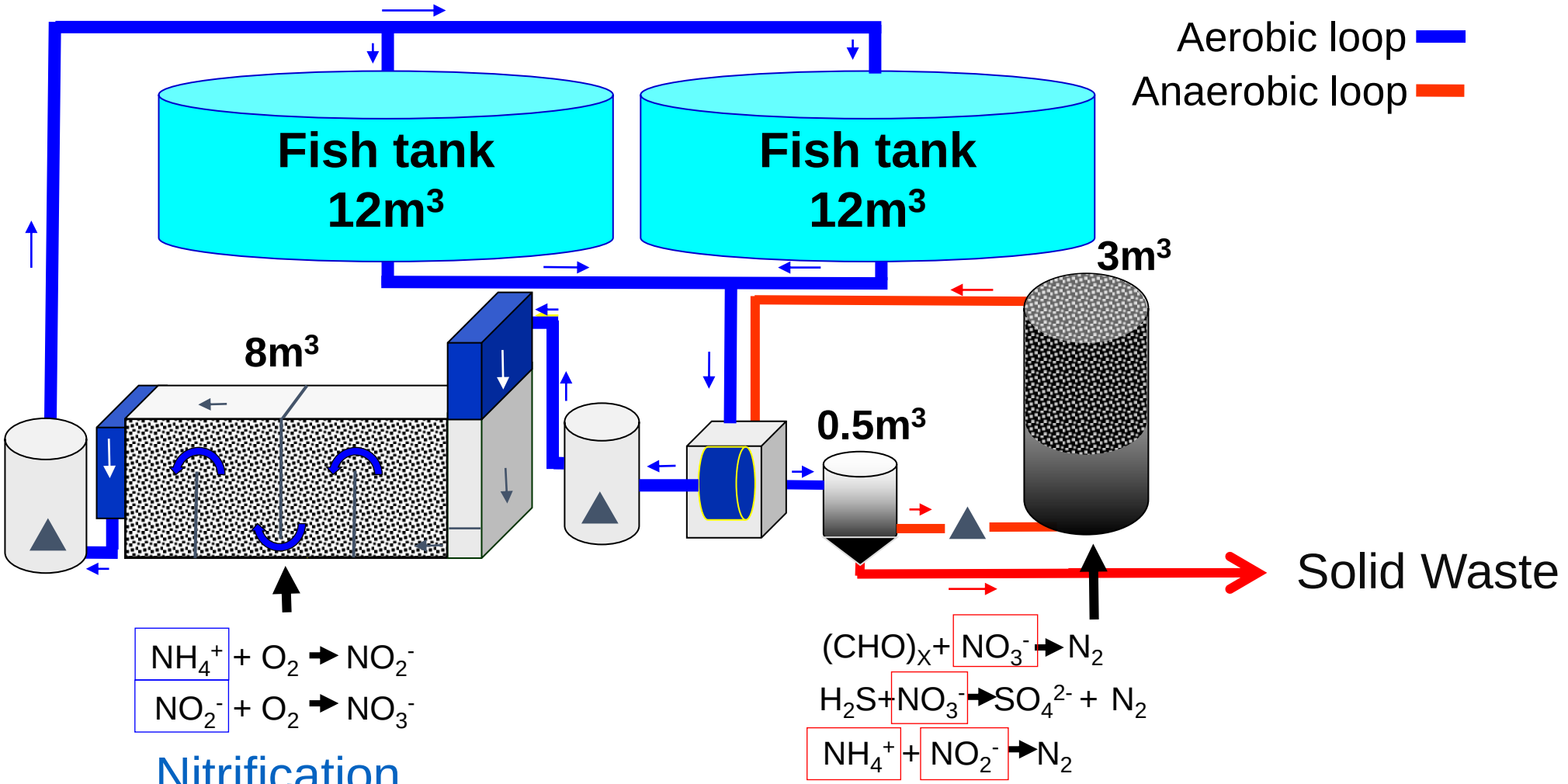
FAO 2022

Advantages of Recirculating Aquaculture Systems

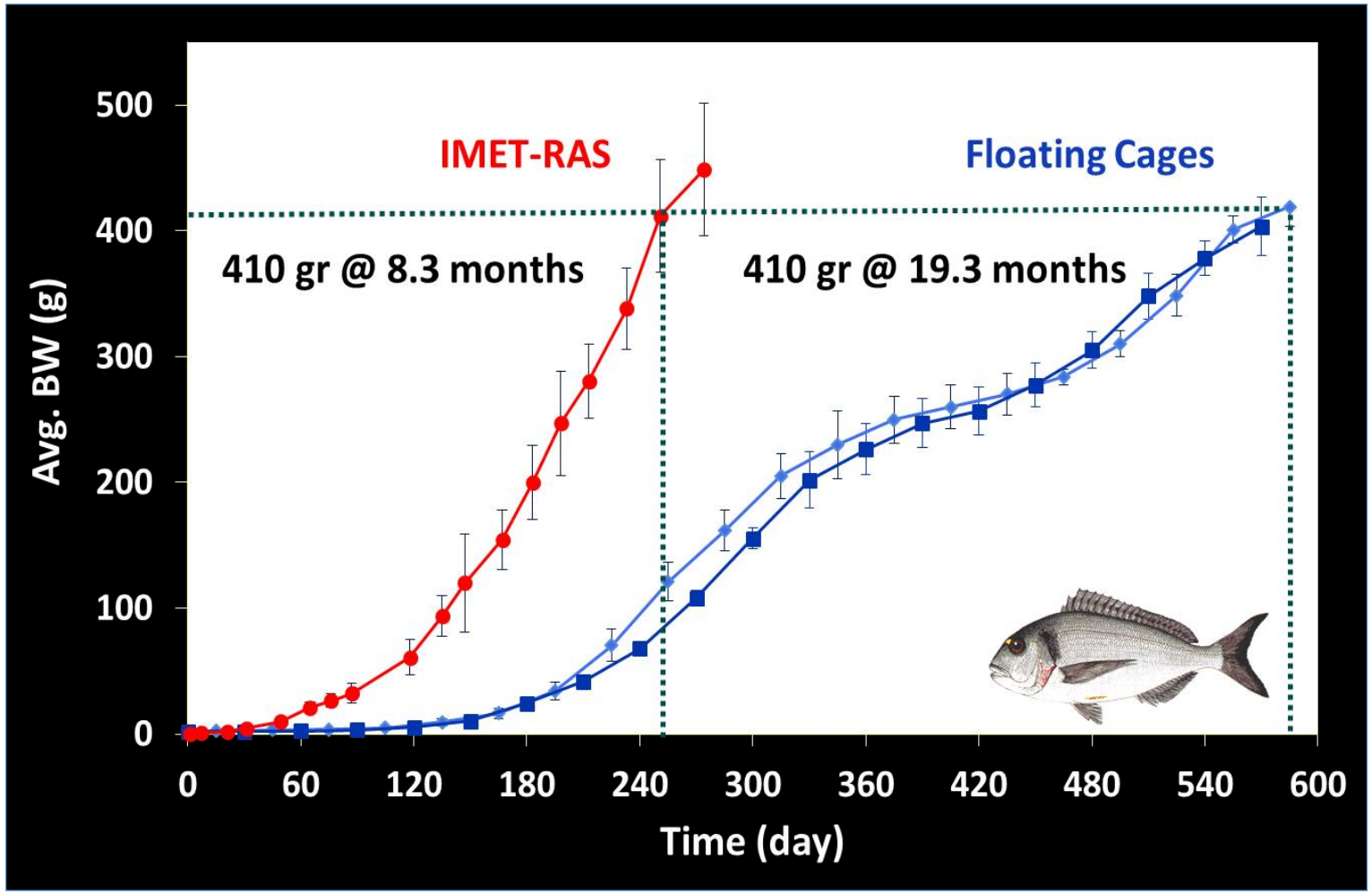
- Can be installed in nearly any location

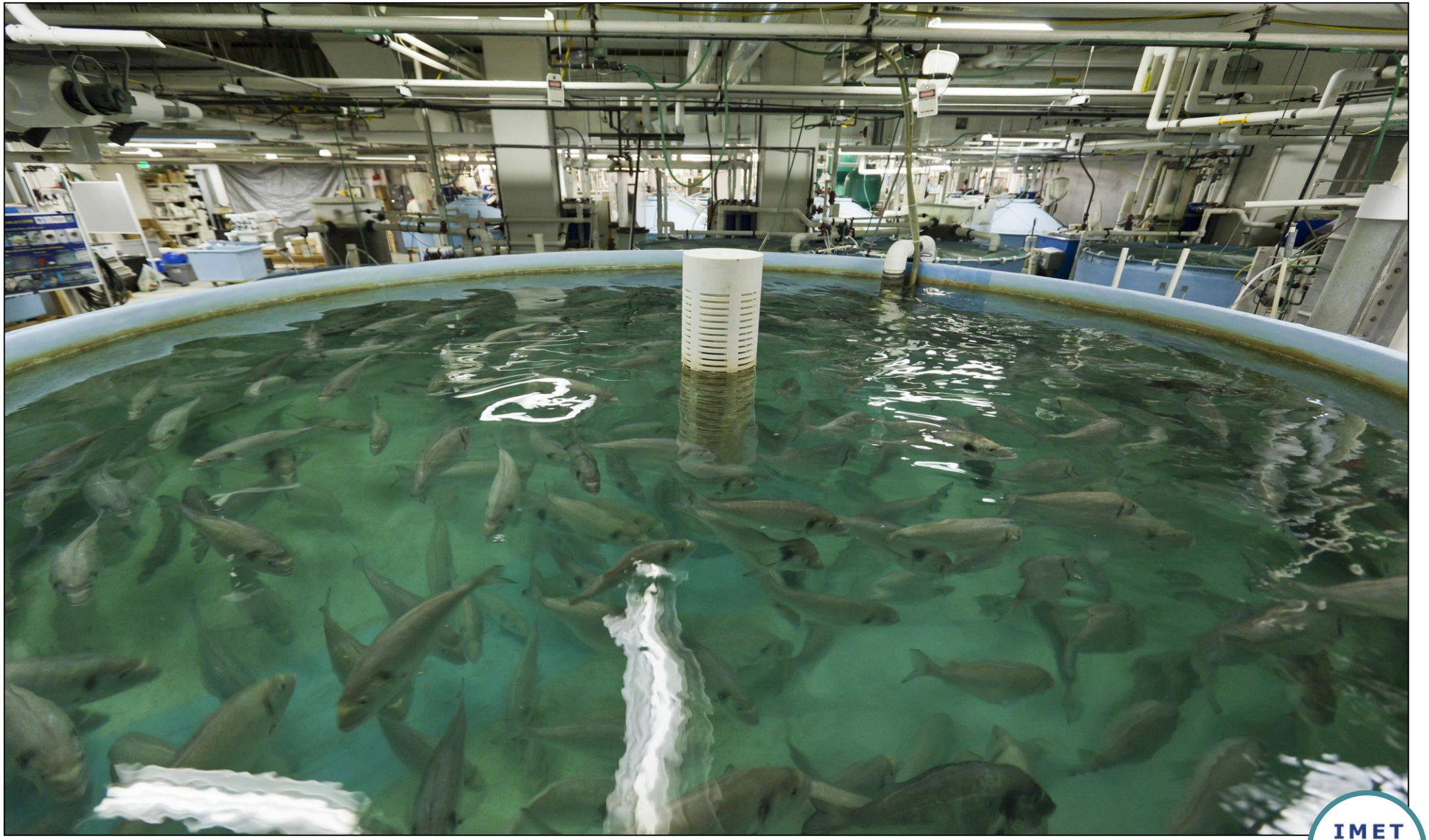
  benefiting local economy
- Biosecure: non-native species
- Near-zero discharge of organic waste material
- Total control of growth parameters-generic
- Low risk of pathogens
- Low risk of toxic compounds from environment

RAS Works by Harnessing Natural Microbial Processes



Growth Efficiency of Sea Bream in RAS





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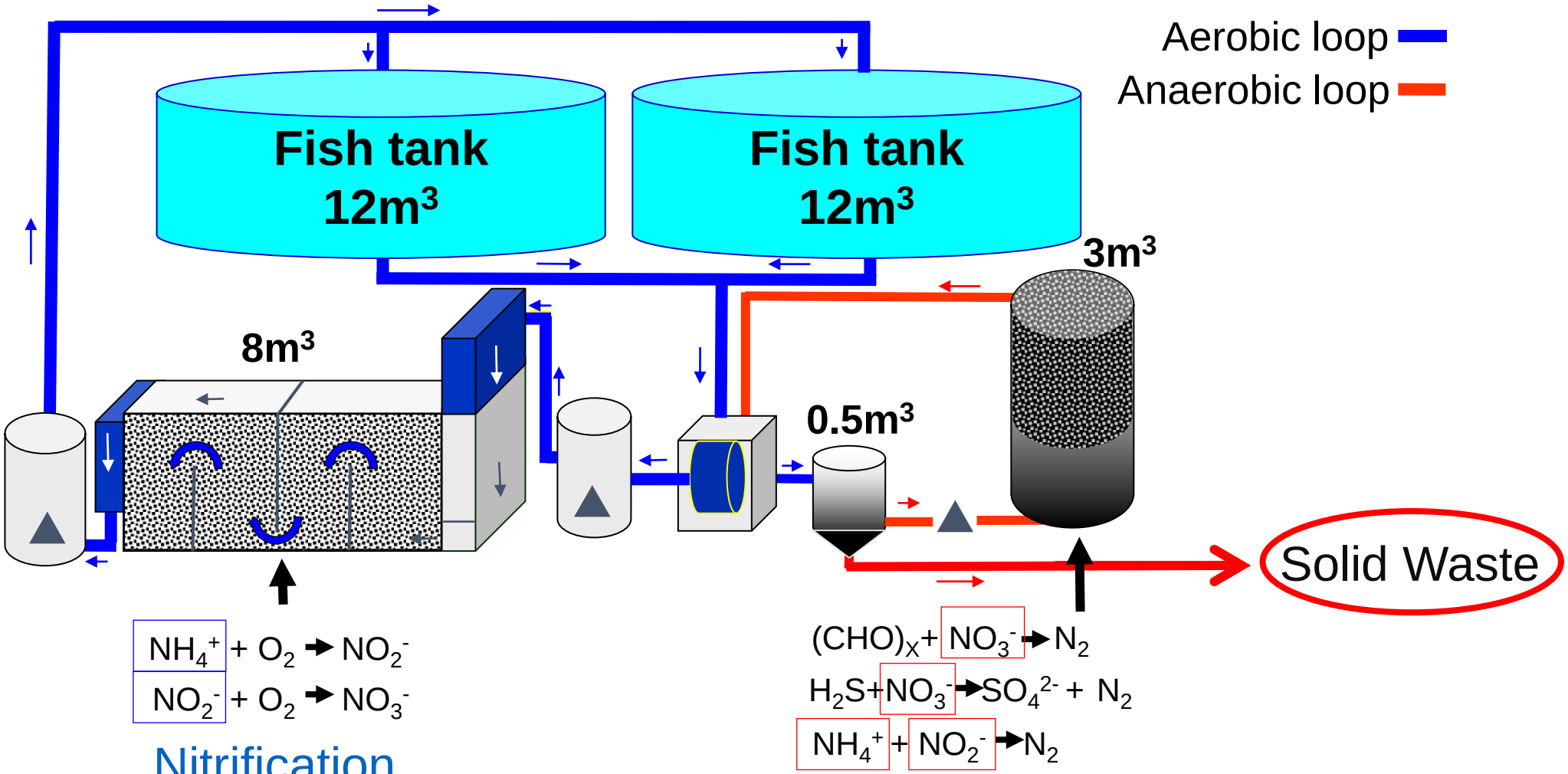
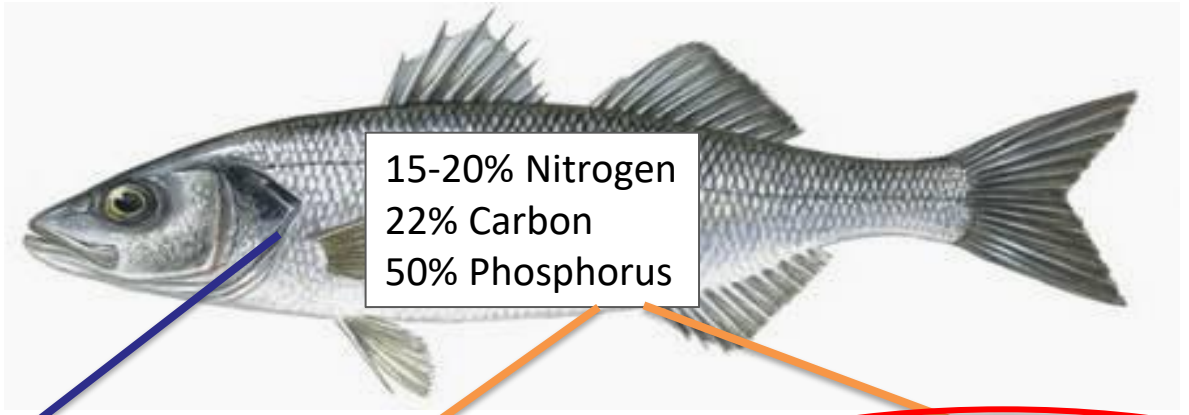


Fish Waste = Metabolic Products + Uneaten Feed

Feed:
Protein
Lipid
Carbohydrate
Phosphorus



15-20% Nitrogen
22% Carbon
50% Phosphorus

Respiration:
52% C as CO_2

Secretion:
Ammonia
Phosphorus

Feces + uneaten feed:
Organic nitrogen
Organic carbon
Phosphorus

1 kg feed ⇨ 0.25 kg solid waste (dry weight)

D'orbcastel and Blancheton (2006) World Aquaculture Society Magazine, 70: 28-35

IMET

Natural Production of Biogas

- Efficient natural process
- Anaerobic environments + organic matter
- Predominant products are CO_2+CH_4 (biogas)
- Freshwater and marine

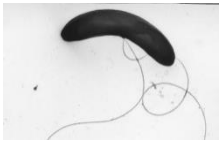
Composition of Methanogenic Consortium

GROUP I

FERMENTATIVE BACTERIA

FISH WASTE/UNEATEN FOOD (oils, proteins)

Fusobactieacea



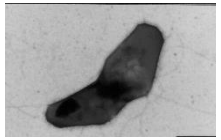
Dethiosulfovibrio sp.

HYDROGEN CO_2

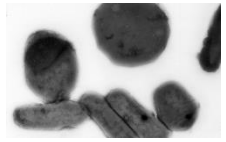
ACETATE

GROUP III

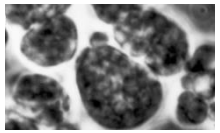
METHANOGENIC ARCHAEA



Methanogenium sp.



Methanoplanus sp.



Methanosarcina sp.

CH_4, CO_2

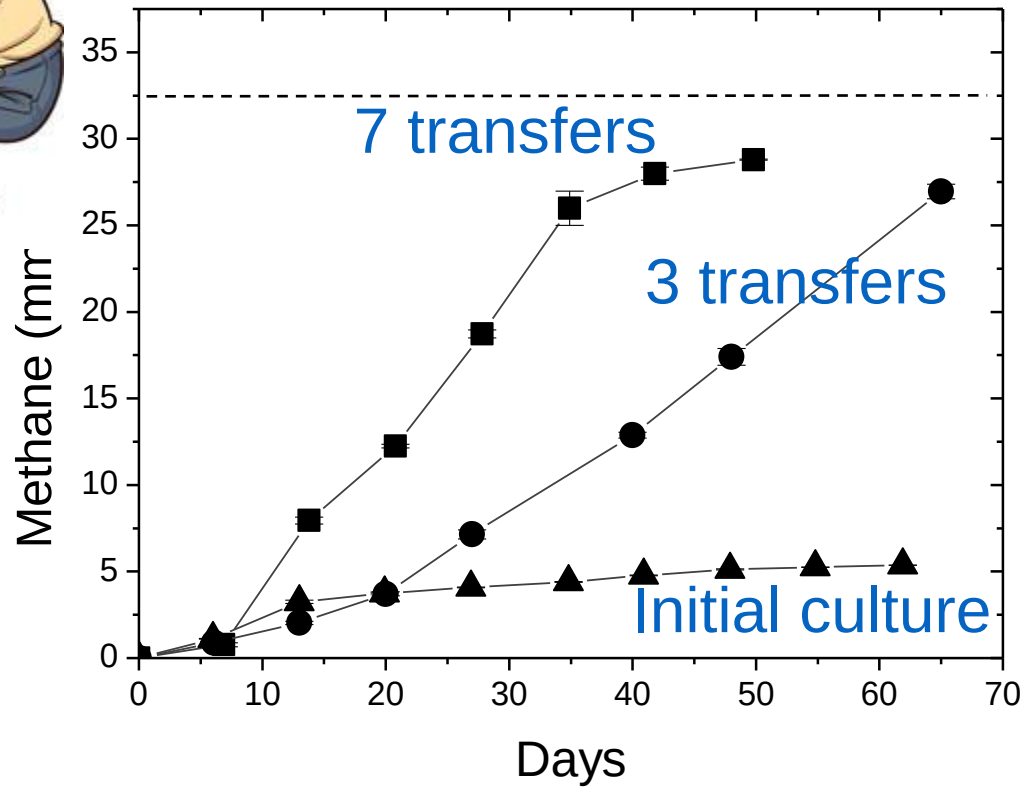
Bioprospecting for Biogas Producing Consortia

Sludge or Sediment
From different sources

CH_4

Multiple

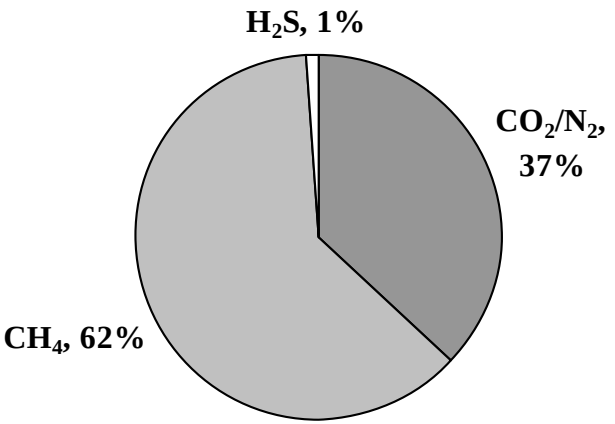
Transfers



Advantages of Enriching for Biogas Culture

- Culture developed from several sources provides robust inoculum
- Optimal growth parameters can be determined to inform bioreactor design and operation
- High volumes of concentrated cells can be generated for rapid start up or recovery

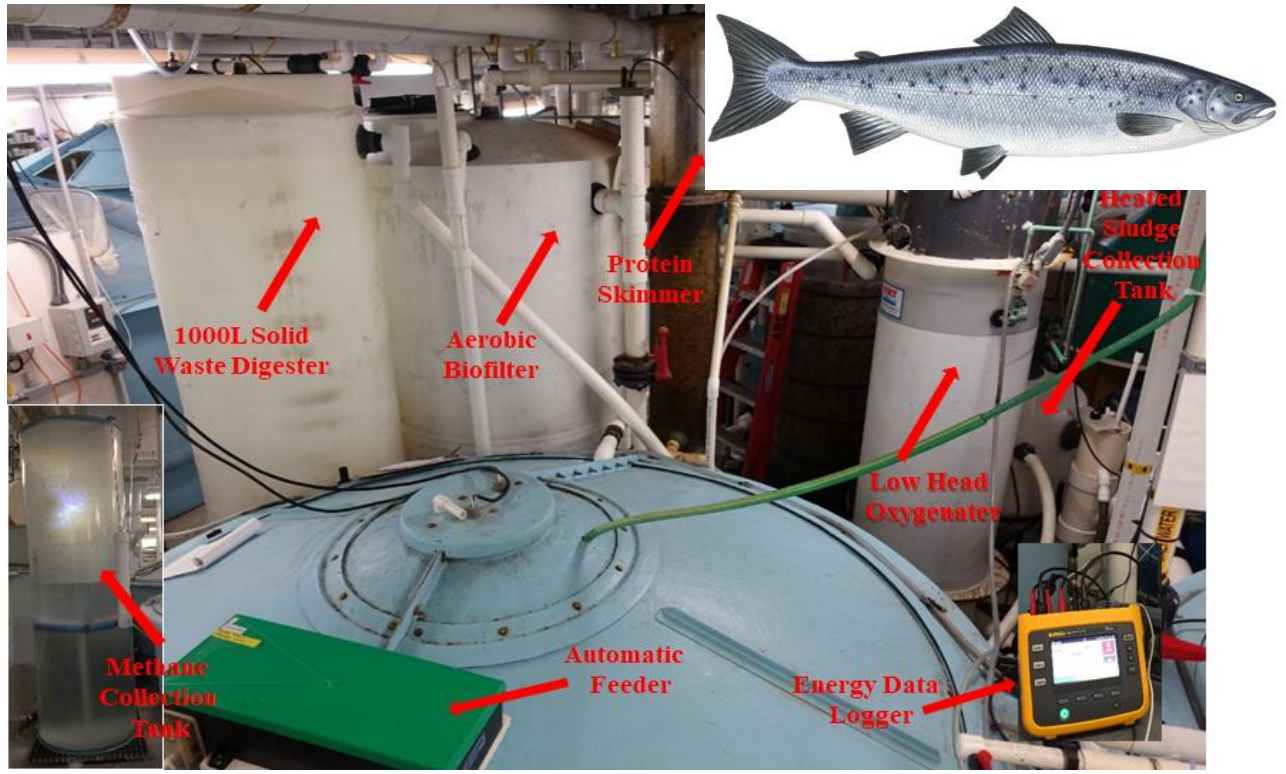
Efficient Conversion of Waste to Biogas



Up to 90% conversion depending on retention time

Fuel grade biogas

Marine RAS for Atlantic Salmon



- Stocked the system at high density (>65 kg/m^3)
- Energy input and methane yields measured to grow out
- Experimental energy yield = 10-12% OPEX

Cermaq – Forsan, Norway

- 12.2 million smolt capacity
- 160 tons of sludge annually
- 0.6 GWh annually
- 270 tons CO_2 eqv.

Waste Treatment Designed by Sterner AS

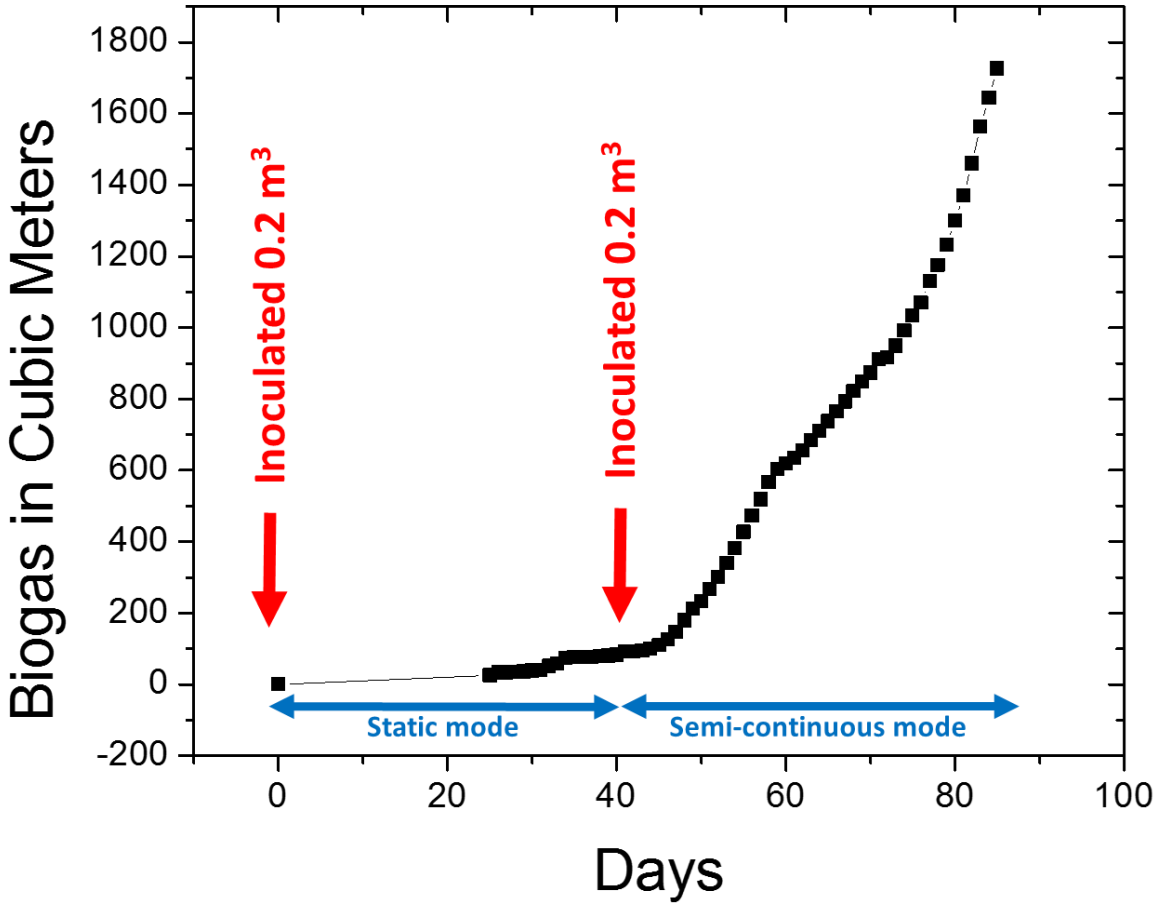
Solids separation

Concentration/hydrolysis

100 m^3 anaerobic baffled bioreactor

Enrichment – Scale Up - Inoculation

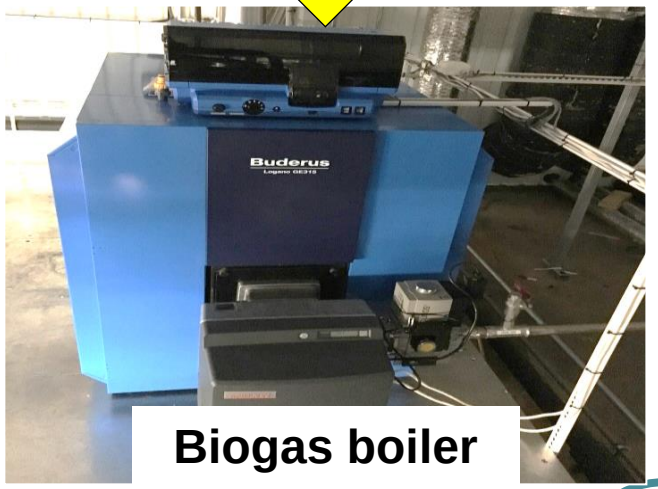
ABR Performance



- Rate of biogas production up to 175 m^3/day
- Methane content- 60-70%
- Stable operation for 5 years

Why is converting Sludge to Biogas Important for the Environment?

- Prevents release of CH_4 as a greenhouse gas
- Prevents negative impact of salt contamination in a landfill
- Possible to desalinate residual solids from biogas reactor for agricultural fertilizer



Biogas boiler

Thank you