Perspectives on Aquaculture's Contribution to the United Nations Sustainable Development Goals for Human and Planetary Health

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EARTH
OCEAN FOOD SYSTEMS
ETHOS

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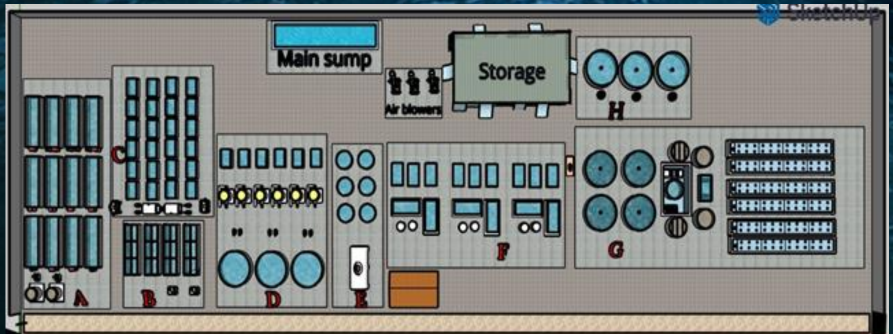
NORWEGIAN INSTITUTE OF BIOECONOMY RESEARCH

مشروع الأبحاث التطبيقية لتطوير
قطاع الاستزراع المائي الداخلي
Applied Research for Inland Aquaculture Development



EARTH
OCEAN FOOD SYSTEMS
ETHOS

- The SDGs & Aquaculture
- Future Aquaculture
- Nearshore Oceans & Land-Based Aquaculture
- Final Comments

- The SDGs & Aquaculture
- Future Aquaculture
- Nearshore Oceans & Land-Based Aquaculture
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2020

USA 51 mil

Germany 15.8 mil

Saudi Arabia 13.5 mil

Asia, Africa Dominate Global Population

Rise of China, India Consumer Classes

Global Population Concentrated in Coastal Mega-Cities

Migration – Mobility from Economic and Climate Crises, Wars and Overall Desperation

Scientists call for revamped Sustainable Development Goals

- The SDGs & Aquaculture
- Future Aquaculture
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- Final Comments

Received: 23 December 2022 | Revised: 8 February 2023 | Accepted: 8 February 2023
DOI: 10.1111/jwas.12946

Journal of the World Aquaculture Society Open Access | WORLD AQUACULTURE Society | WILEY

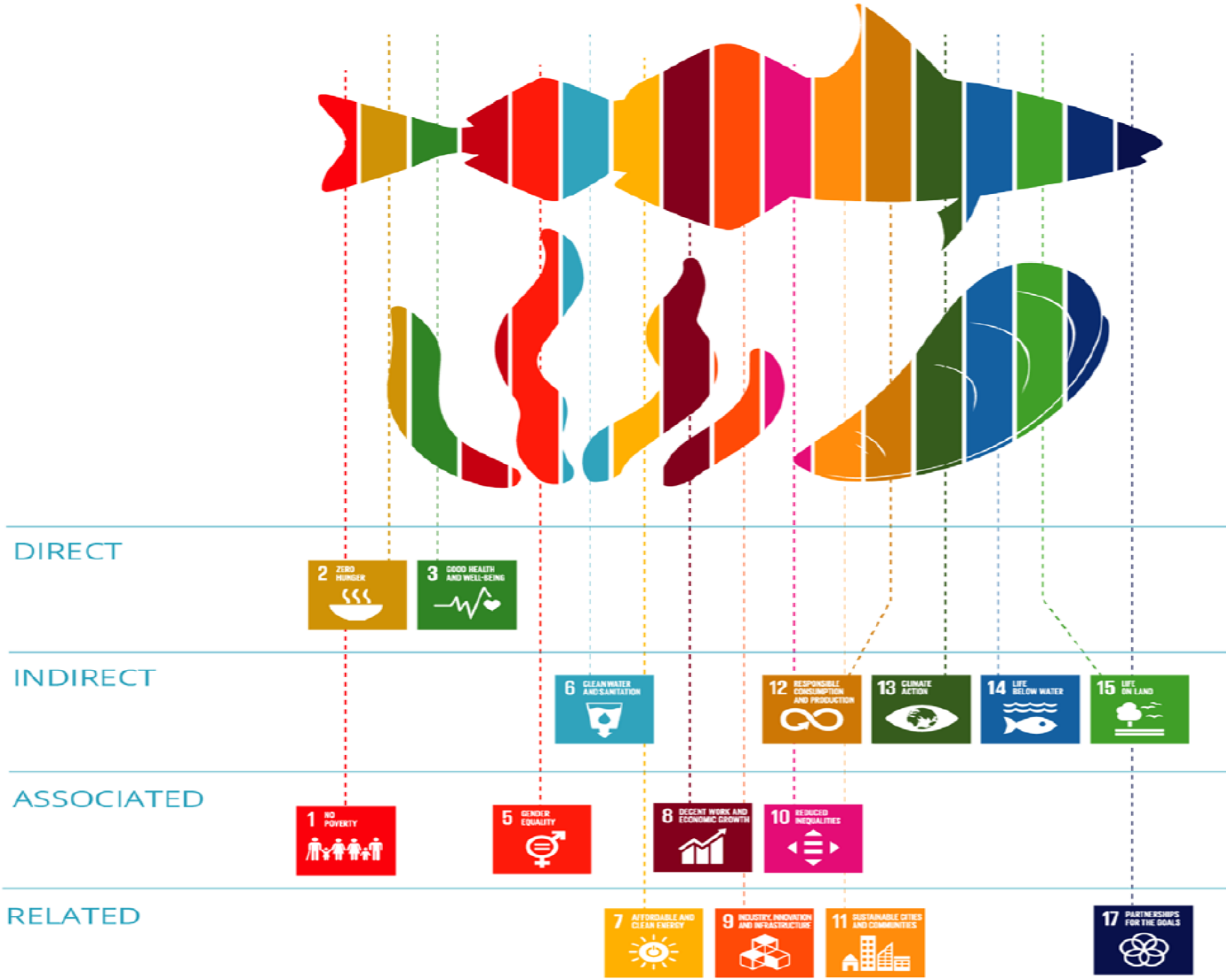
REVIEW ARTICLE

Perspectives on aquaculture's contribution to the Sustainable Development Goals for improved human and planetary health

Max Troell[1,2] | Barry Costa-Pierce[3] | Selina Stead[4] | Richard S. Cottrell[5] | Cecile Brugere[6] | Anna K. Farmery[7] | David C. Little[8] | Åsa Strand[9] | Roger Pullin[10] | Doris Soto[11,12] | Malcolm Beveridge[13] | Khalid Salie[14] | Jorge Dresdner[12] | Patricia Moraes-Valenti[15] | Julia Blanchard[16,17] | Philip James[18] | Rodrigue Yossa[19] | Edward Allison[19,20] | Christopher Devaney[8] | Uwe Barg[21]

Troell, M. *et al*. (2023). Perspectives on aquaculture's contribution to the Sustainable Development Goals for improved human and planetary health. *Journal of the World Aquaculture Society* 54(2): 251–342. https://doi.org/10.1111/jwas.12946

AQUACULTURE AND THE SDGs



SDG4: QUALITY EDUCATION

Nordic Master's Programme in Sustainable Production and Utilization of Marine Bioresources (MAR-BIO)

"the issues and problems of the people of the place that scope from local to global"

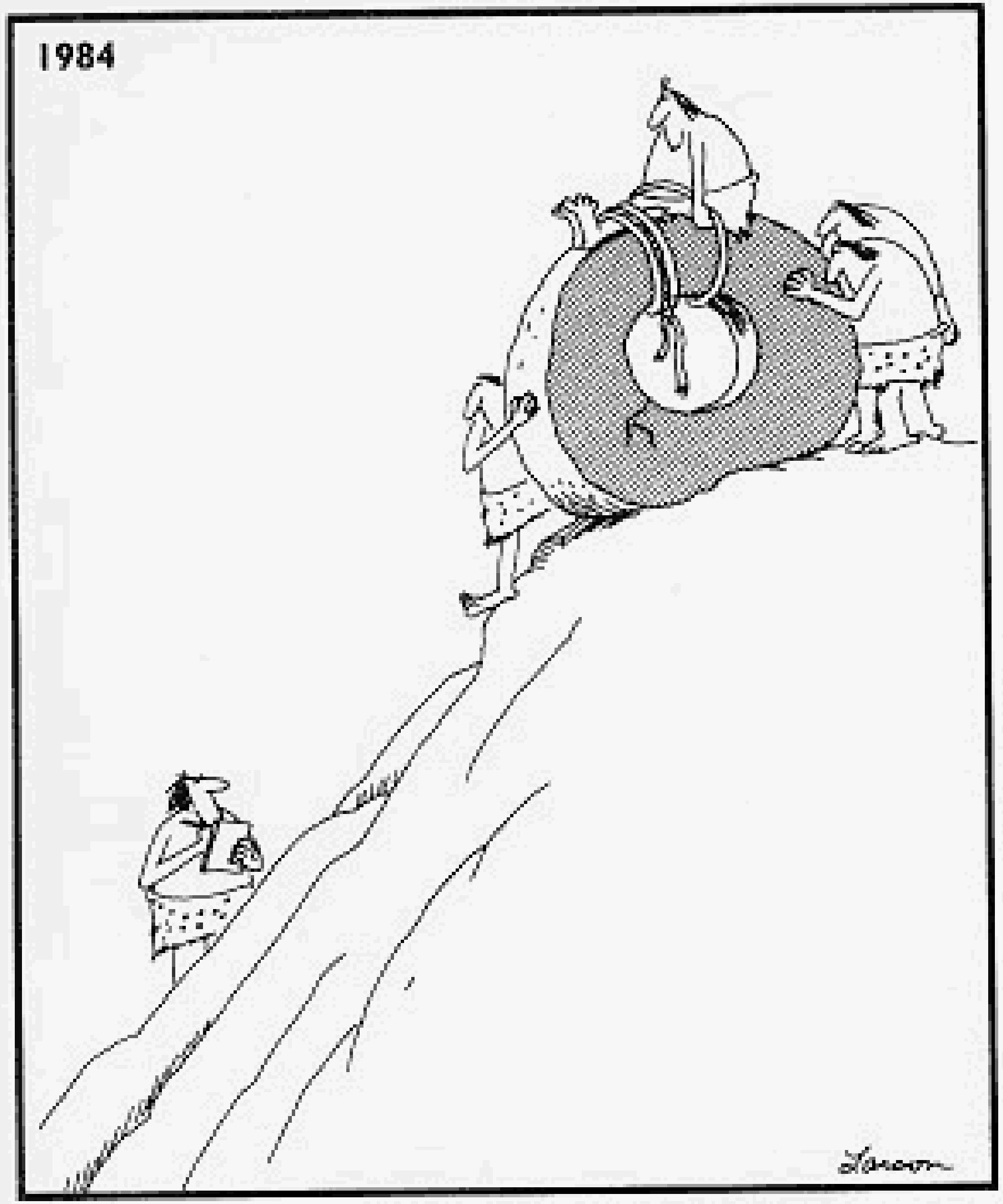
GÖTEBORGS UNIVERSITET

SWEMARC
SWEDISH MARICULTURE
RESEARCH CENTER

NORD
University

HÓLASKÓLI · HÁSKÓLINN Á HÓLUM · FRÁ 1106

- The SDGs & Aquaculture
- **Future Aquaculture – The "Big Stuff" (LARGE SCALE)**
- Nearshore Oceans & Land-Based Aquaculture
- Final Comments

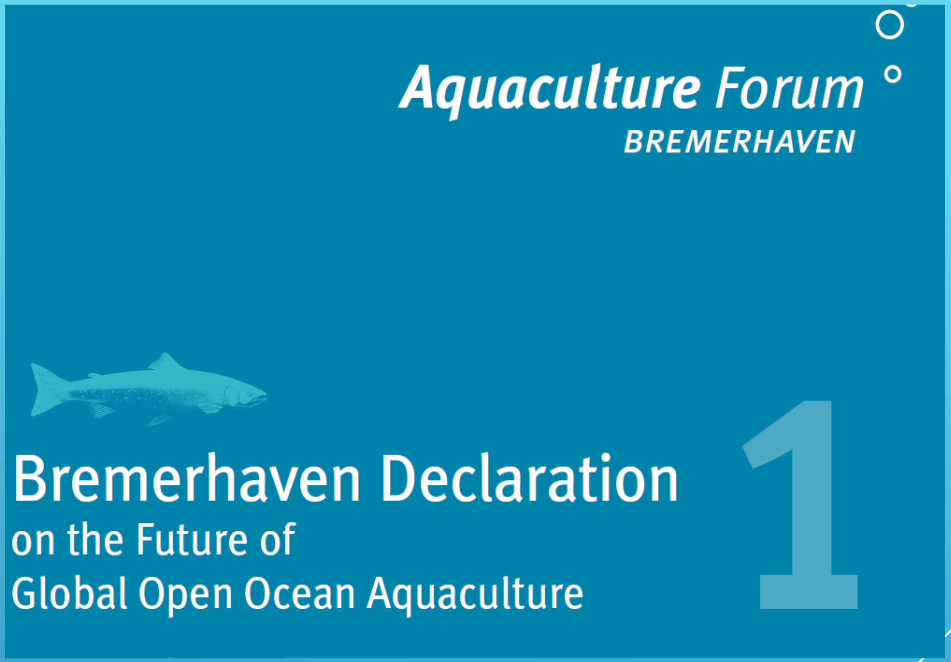


Early experiments in transportation

Large Scale Circular Blue-Green BioEconomies

Open Ocean (High Energy) Aquaculture

- **ICES WGOOA**
- **OLAMUR** (Offshore Low-trophic Aquaculture in Multi-Use scenario Realisation), Institute of Marine Research, Norway



Mixed Use Offshore Energy & Food Systems

EU/USA University of Rhode Island/KTH/UGOT
Belmont Forum MULTIFRAME initiative


HAVFARM

Marine Pollution Bulletin 195 (2023) 115556

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Detecting sediment recovery below an offshore longline mussel farm: A macrobenthic Biological Trait Analysis (BTA)

Llucia Mascorda-Cabre*, Phil Hosegood, Martin J. Attrill, Danielle Bridger, Emma V. Sheehan

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A R T I C L E I N F O

Keywords:
Aquaculture
Ecology
Functional traits
Infauna
Ecosystem assessment
Other effective conservation measures
CWM

A B S T R A C T

Expansion of bivalve aquaculture offshore reports lower environmental impacts compared to inshore farms. Taking a Before-After Control-Impact approach, this study presents the first functional diversity analysis and long-term Biological Trait Analysis (BTA) of infauna functional traits following the development of the United Kingdom's first large-scale, offshore longline mussel farm. Located in an area historically impacted by mobile fishing gear, farm sites had the greatest number of taxa and abundance compared to control sites. Functional diversity varied significantly across treatments (farm, near control, far control); while Functional Diversity, Richness, Divergence and Dispersion increased over time within the farm, Functional Evenness and Redundancy decreased. Bioturbation, body size, diet, feeding mode, life span, motility, sediment position, sensitivity and substrate type were chosen for Community-level Weighted Mean analysis, depicting the most frequently affected biological traits by shellfish farming. Farm sites developed a wider range of traits enhancing ecosystem function and habitat recovery after years of seabed damage. Outcomes support the use of functional diversity and BTA analysis to perform ecosystem assessment, supporting decision-makers implement policy and management.

offshore shellfish ltd

- The SDGs & Aquaculture
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Case #1
Development of Seaweed Aquaculture in the Crowded Nearshore Ocean

Design Charette

Community Scale

"Grant cycles live and die. Business doesn't. The world is ready for seaweed. It doesn't need to be subsidized."

Brianna Warner
CEO
Atlantic Sea Farms

The Rise of Transdisciplinary Science
(and the MANY journals)

"Transdisciplinarity today is characterized by its focus on *"wicked problems" that need creative solutions…reliance on stakeholder involvement… and engaged, socially responsible science."*

Bernstein, J. H. 2015. Transdisciplinarity: A review of its origins, development, and current issues. *Journal of Research Practice 11(1):* R1.

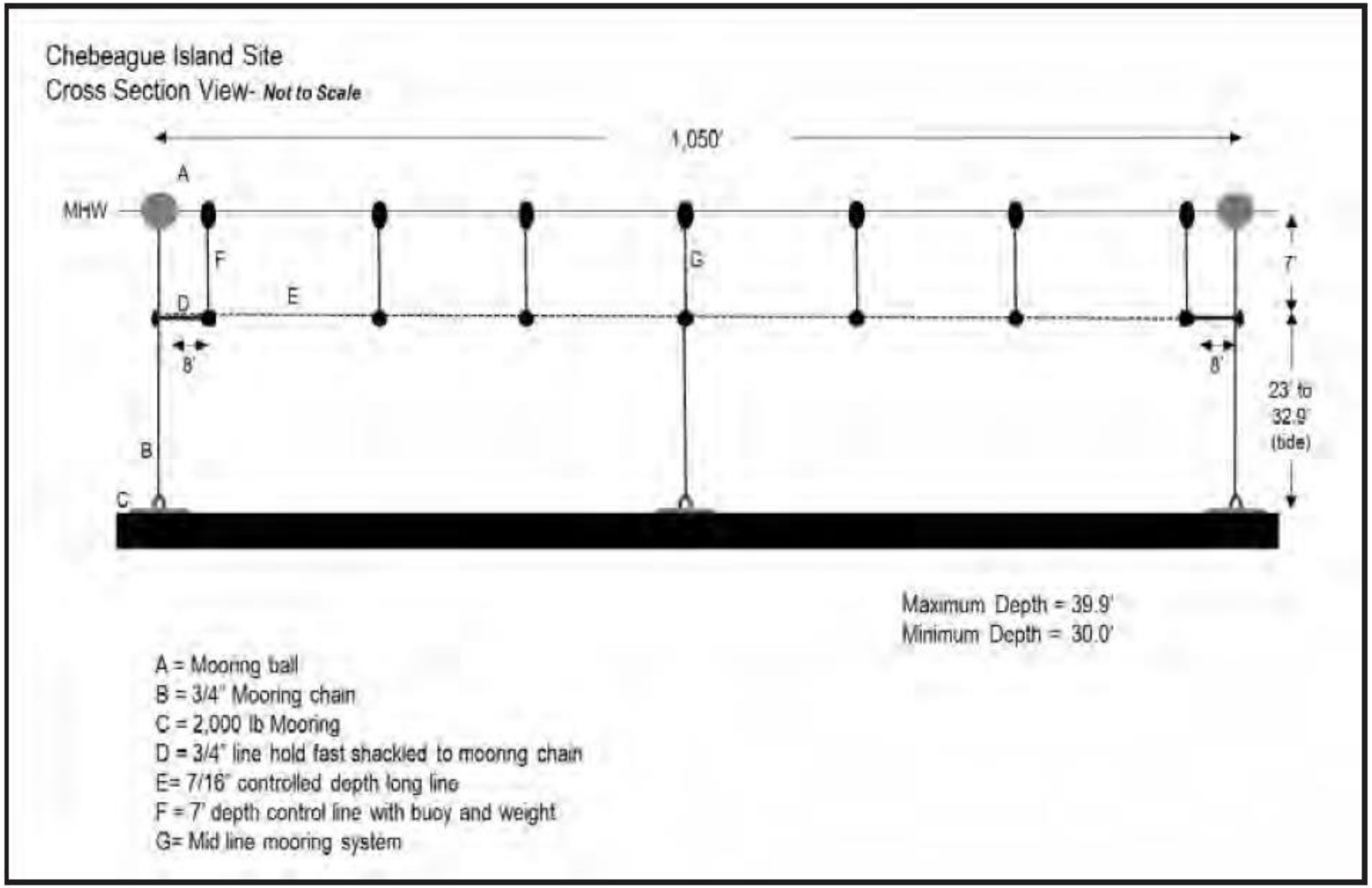
Science Based DESIGN CRITERIA

SURVIVABLE, SOPHISTICATED ENGINEERING BUT LOW COST

- Minimalist approach to gear
  - low capital…use existing fishing assets
  - highly mobile
  - easily deployed
  - easily permitted
- Submerged technology
- No conflicts with the "fishing/tourism summers"
- Cash on harvests
- High education value => easy tech transfer

RESULTS of the Design Charette

Dead Weight Moorings
Vertical Mooring Line Design



- Expensive Moorings
- Cumbersome to Deploy
- Permanent Installation
- Large Buoys
- Slack System
- Requires Large Boat

Edible Seaweed Market Analysis

ISLAND INSTITUTE

ASIA

Growing and harvesting the primary farmed edible seaweed species (sugar/skinny kelp and alaria) is a relatively low cost, easily implementable process that can deliver supplemental revenue and asset utilization. For most harvesters that lack processing capabilities, edible seaweed provides supplemental revenue rather than their primary source of revenue.

The annual revenue potential for harvesters varies significantly depending on lease acreage and processing practices. Harvesters without processing capabilities can expect to realize approximately $0.40 – $0.70 per wet pound for bulk unprocessed seaweed. For these harvesters, securing access to processing capabilities prior to initiating the growing process, either via established contracts with processors or investing in first stage processing (typically drying) capabilities, is critical to success. Maine infrastructure requirements to support continued growth include:

- Expanded processing capacity
- Value-added product development
- Distribution network expansion
- Brand building/consumer awareness

Farm in a Box

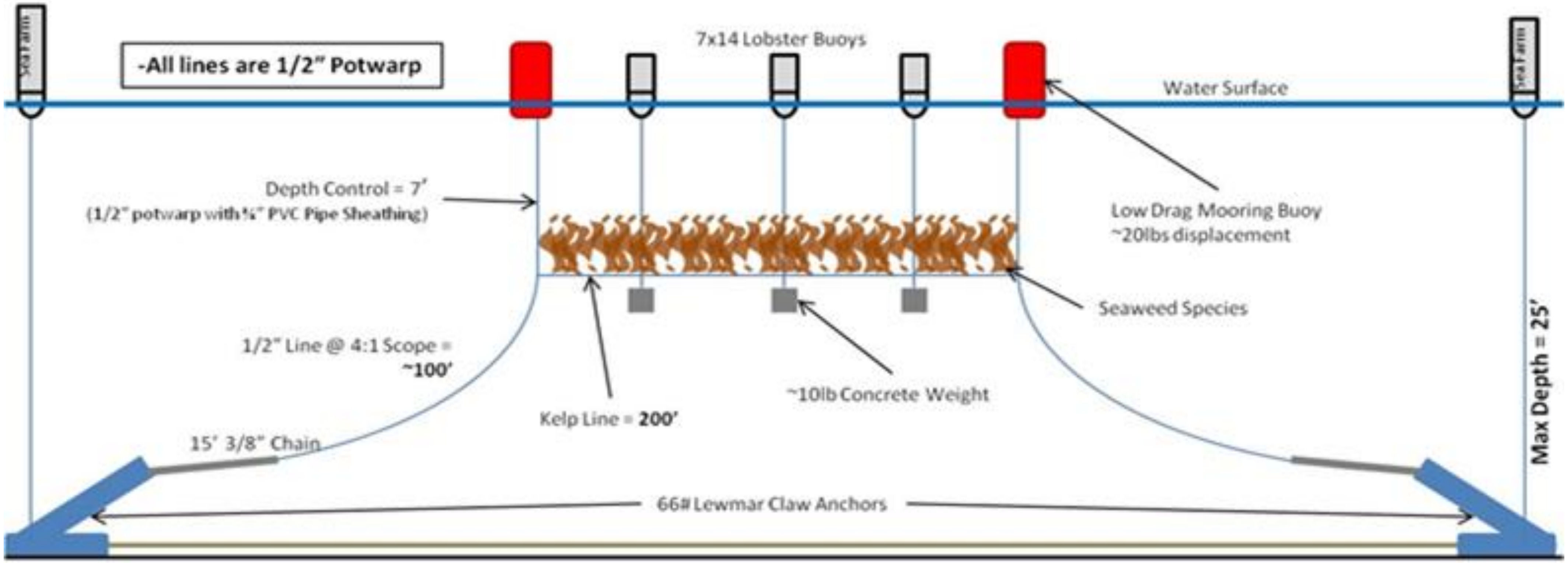
~70 m culture lines
6 m Maritime Skiff
Crew of 2...Total deployment time < 0.5 hour

*Mobile gear all removed during high fishing season
*Supplies and materials - All locally available and familiar to commercial fisheries and reuseable
*Cash on harvests
*Easy tech transfer

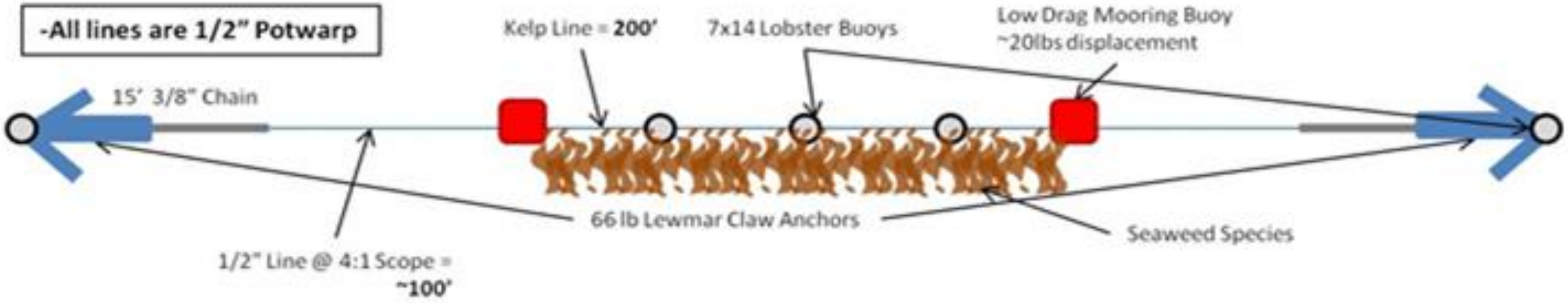
Five Years of R&D = Success
High education value

TOTAL COST ~US$ 600
Produced ~ 1000 kg WW/line
~15-16 kg/m of Sugar Kelp

Cross Section



Overhead



frontiers in Sustainable Food Systems

ORIGINAL RESEARCH
published: 23 February 2022
doi: 10.3389/fsufs.2022.848035

OPEN ACCESS

Edited by:
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Reviewed by:
Mark Flaherty, University of Victoria, Canada
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Engineering A Low-Cost Kelp Aquaculture System for Community-Scale Seaweed Farming at Nearshore Exposed Sites *via* User-Focused Design Process

Adam T. St-Gelais[1†], David W. Fredriksson[2], Tobias Dewhurst[3], Zachary S. Miller-Hope[1], Barry Antonio Costa-Pierce[1†] and Kathryn Johndrow[1†]*

Aquacultural Engineering 90 (2020) 102086

Contents lists available at ScienceDirect

Aquacultural Engineering

journal homepage: www.elsevier.com/locate/aque

Hydrodynamic characteristics of a full-scale kelp model for aquaculture applications

David W. Fredriksson[a,*], Tobias Dewhurst[b], Andrew Drach[c], William Beaver[d], Adam T. St. Gelais[e,f], Kathryn Johndrow[e], Barry A. Costa-Pierce[e,f]

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frontiers | Frontiers in Marine Science

TYPE Original Research
PUBLISHED 17 May 2023
DOI 10.3389/fmars.2023.1178548

Check for updates

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RECEIVED 02 March 2023
ACCEPTED 24 April 2023
PUBLISHED 17 May 2023

Mooring tension assessment of a single line kelp farm with quantified biomass, waves, and currents

David W. Fredriksson[1*], Adam T. St. Gelais[2], Tobias Dewhurst[3], Struan Coleman[4], Damian C. Brady[2,4] and Barry Antonio Costa-Pierce[5,6]

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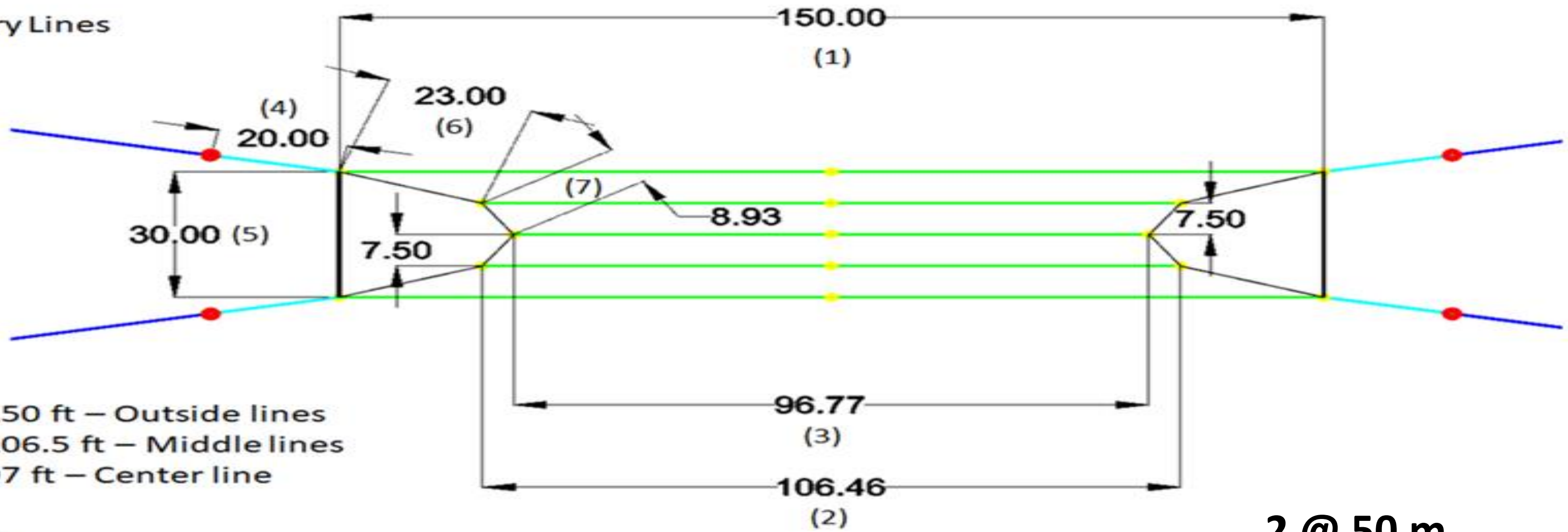
Farm in a Truck



a) Grow out and Catenary Lines



Green Grow-out Lines

1. (2) 1" nylon at 150 ft – Outside lines
2. (2) 1" nylon at 106.5 ft – Middle lines
3. (1) 1" nylon at 97 ft – Center line

Light Blue Load-cell lines

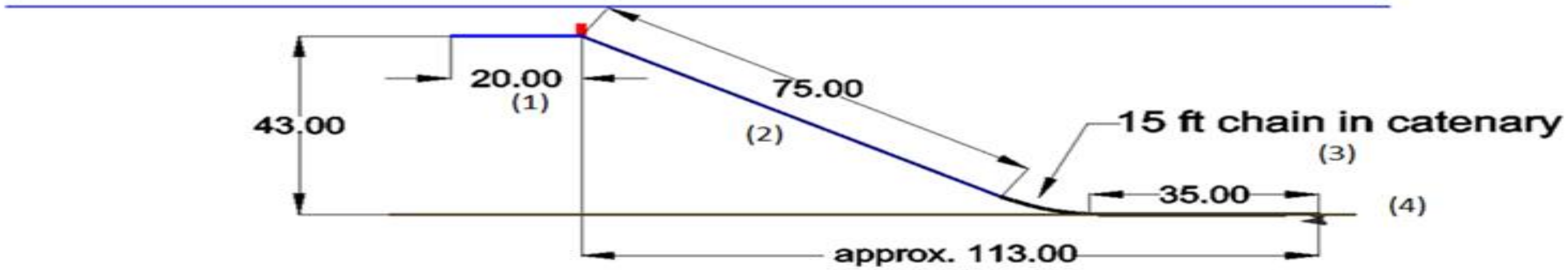
4. (4) 1" nylon at 20 ft

Black Catenary Lines

5. (2) 1" nylon at 30 ft – Open span lines
6. (4) 1" nylon at 23 ft – Outside catenary lines
7. (4) 1" nylon at 9 ft – Inside catenary lines

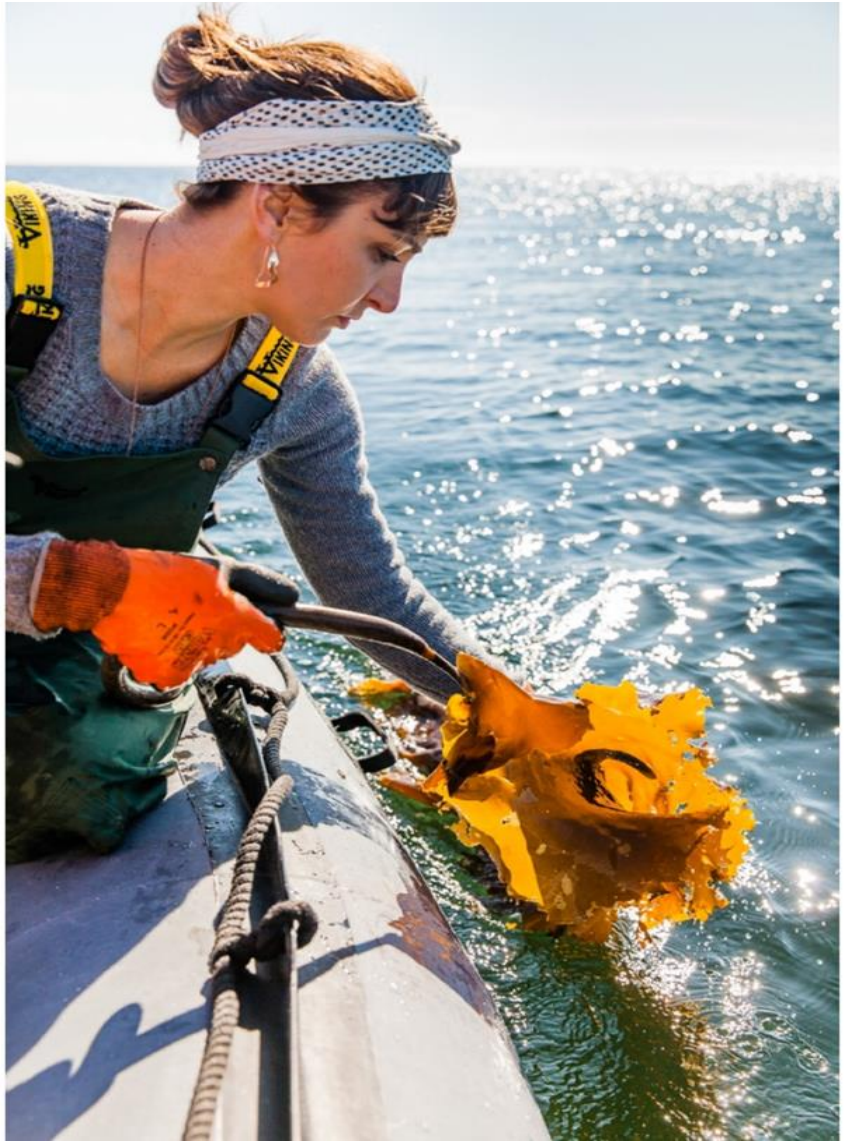
2 @ 50 m
2 @ 35 m
1 @ 33 m

b) Anchor leg components



Anchor leg components

1. (4) 1" nylon at 20 ft – Load-cell lines
2. (4) 1" nylon at 75 ft – Anchor lines
3. (4) 5/8" longlink chain at 50 ft
4. (4) 110# claw anchor



Atlantic Sea Farms

Successful "Scaling Out" Model of Seaweed Farming – most ~2 ha

*27 independent ASF partner farmers, primarily fishing families who already have boats/gear

*Trains/Provides free seed/Contracts to buy harvests

Make US$ 40,000 to $110,000/season as supplemental income

- The SDGs & Aquaculture
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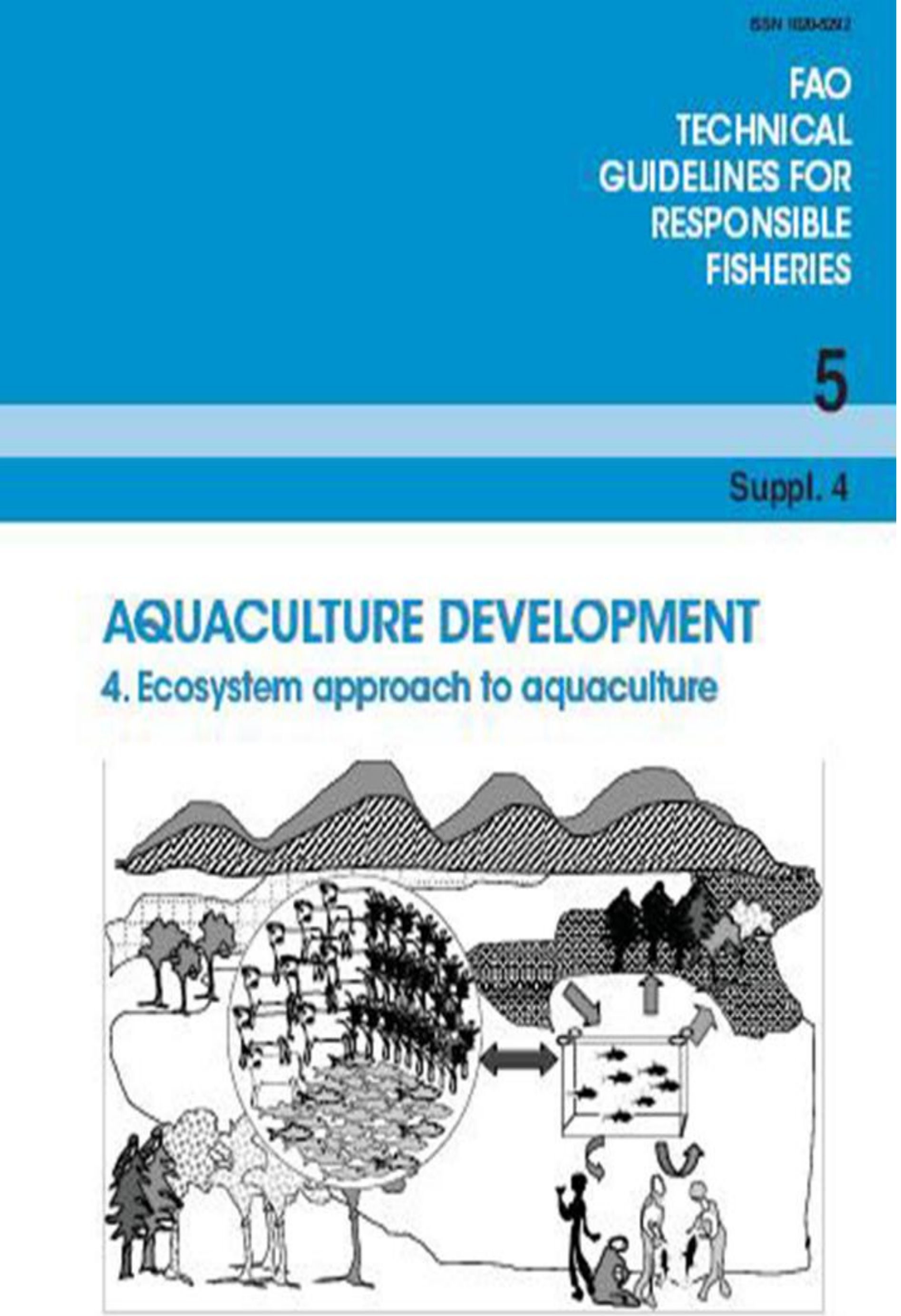
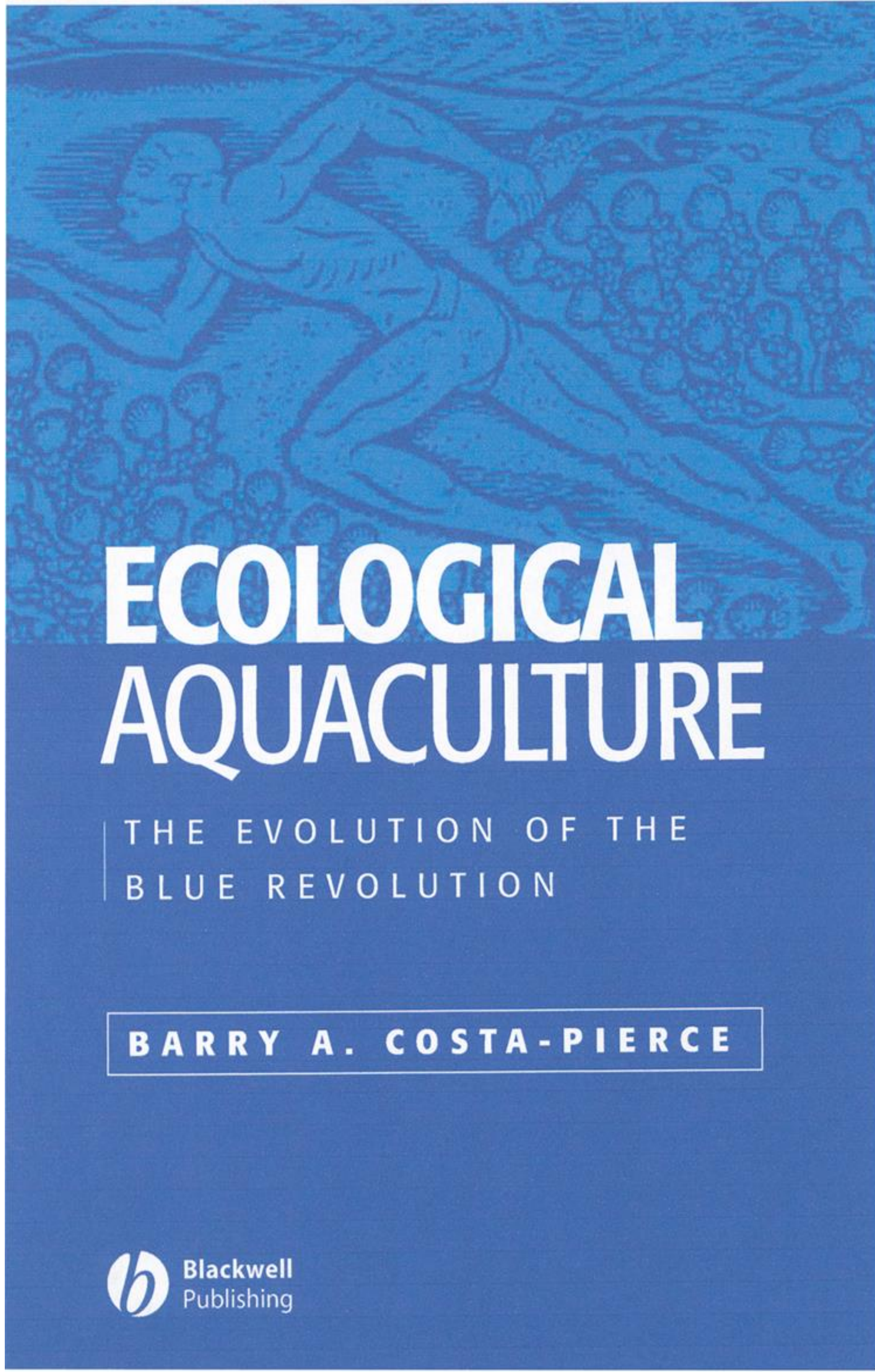
Have RAS Technologies Outpaced their Social-Ecological Approaches and Developments?

{ Design Charette –> Shared Conceptual Framework



Recirculating Aquaculture Ecosystems



Risk Analysis Findings GESAMP Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection	Win-Win Design Interventions for Risk Communications * Blue-Green Bioeconomies * Food Security/Food Justice * Watershed/Coastal-Bay Management	
Additional Nutrient Pollution "The Solution to Pollution is NOT Dilution"	**NO POLLUTION** **<u>SOLUTES</u>** Freshwater Systems Seawater Systems	**NO POLLUTION** **<u>SOLIDS</u>** Energy Fertilizer
Incompatibilities with Rural Communities "Industrial Fish Farming"	**COMPATIBLE** Scaling Out (vs. Scaling Up) Strategies Restoration Tourism & Art	
Additional Exploiting Economies "People from Away" "We can't even buy your fish"	**CONTRIBUTING** Business Integrations - Aquaponics Enhance Local Value Chains – Retail	

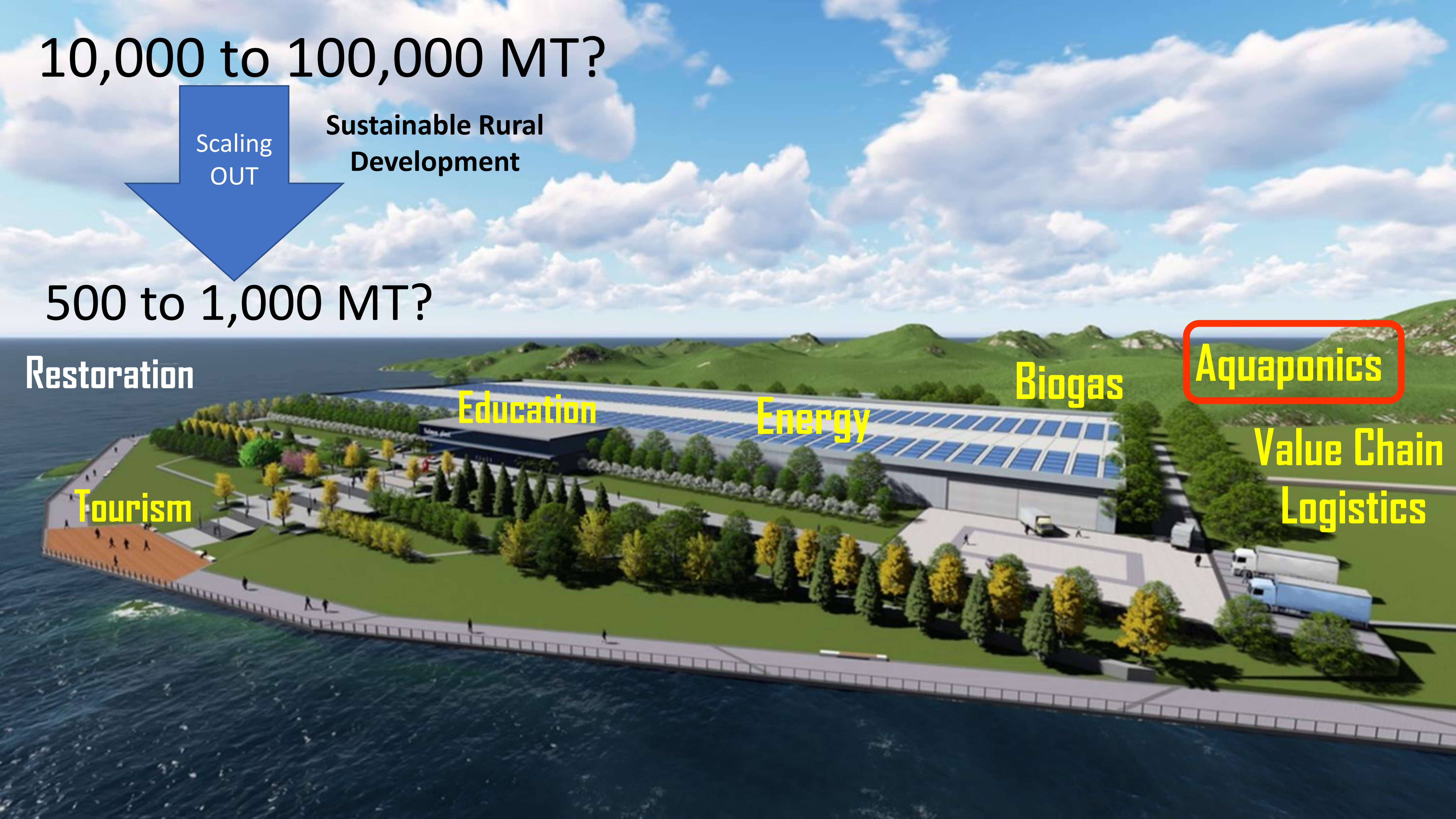

10,000 to 100,000 MT?
Scaling OUT
Sustainable Rural Development
500 to 1,000 MT?
SCALE
Restoration
Education
Energy
Biogas
Aquaponics
Value Chain
Tourism
Logistics

Sterner Group AS,
NORWAY

Anaerobic Baffle
Reactor (ABR)
Fish sludge ONLY

260 T sludge (DM)
from 1600 T feed

Expanding to 10,000 T
feed/year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	Sizes m² (ha)	Production per year (MT)
Fish Salmon in FW	3,716 (0.4)	72.6
Plants	11,427 (1.1)	816.5
TOTALS	15,143 (1.5)	889.0

@FCR 1.1 x 72.6 MT fish =

79.9 MT feed yields

889.0 MT FOOD

1 kg feed produces 11 kg food

- Climate control – No Plastic Greenhouses !!
- LED lighting
- Plant experts
- Sludge used in regenerative agriculture


10,000 to 100,000 MT?
Scaling OUT
Sustainable Rural Development
500 to 1,000 MT?
Aquaculture Ecosystem
Business Models at Scale
Restoration
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frontiers | Frontiers in Sustainable Food Systems

TYPE Editorial
PUBLISHED 08 September 2022
DOI 10.3389/fsufs.2022.1021801

Check for updates

OPEN ACCESS

EDITED AND REVIEWED BY
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SPECIALTY SECTION
This article was submitted to
Agroecology and Ecosystem Services,
a section of the journal
Frontiers in Sustainable Food Systems

RECEIVED 17 August 2022
ACCEPTED 24 August 2022
PUBLISHED 08 September 2022

Editorial: Ocean/aquatic food systems: Interactions with ecosystems, fisheries, aquaculture, and people

Barry Antonio Costa-Pierce[1,2]*, Helgi Thor Thorarensen[3] and Åsa Strand[4]

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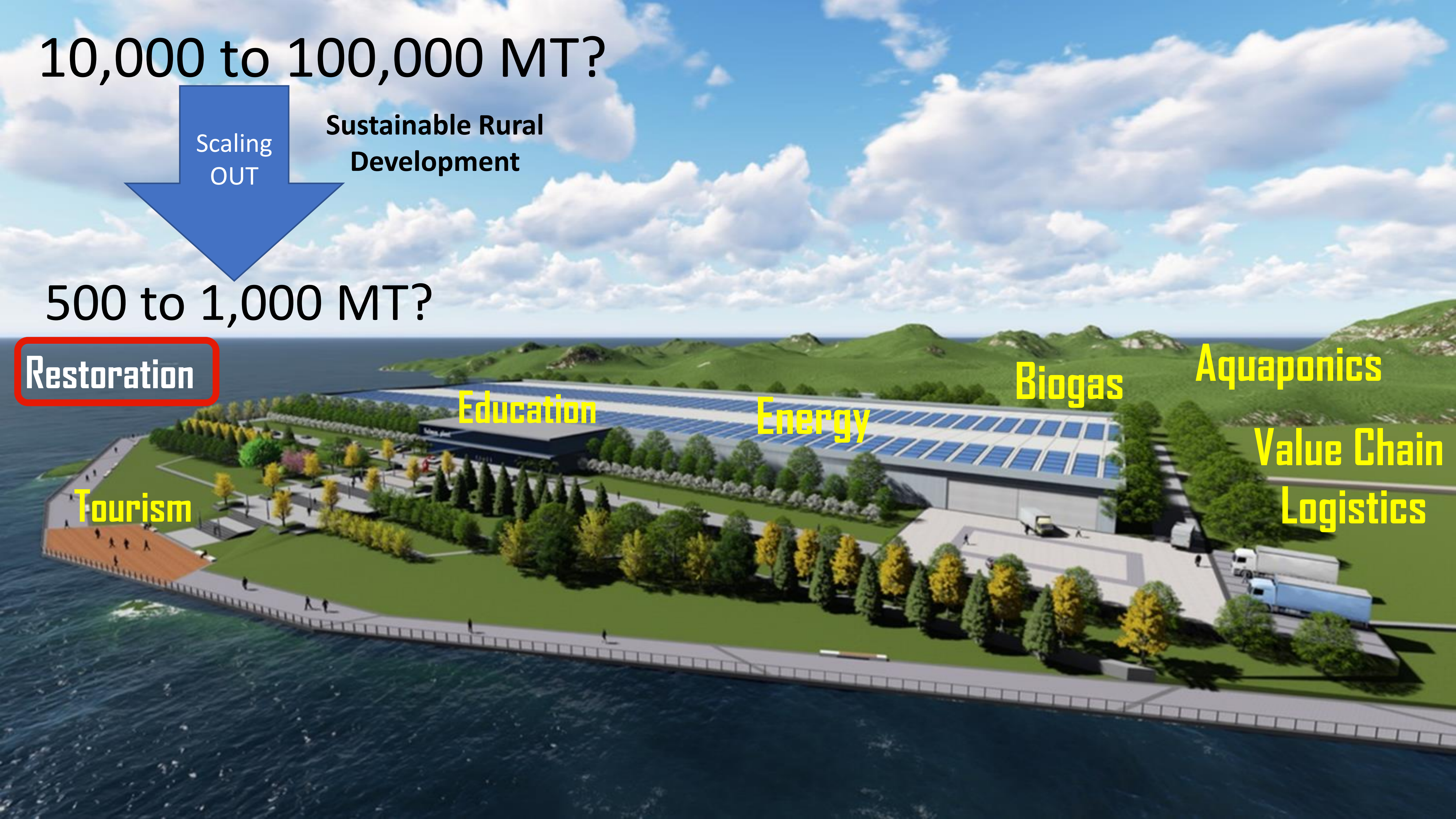
Guðrún Helgadóttir et al (2022)
"Wild and Farmed Arctic Char as a Tourism Product in an Era of Climate Change"

Integration of Tourism and Aquaculture

Tourism contributes to ~10% of global GDP
Businesses that incorporate sustainable tourism into aquaculture can be very successful

"Arctic Charr are a traditional food in the Nordic, Arctic, and Subarctic regions…researchers considered innovative connections between culinary, heritage-based, and nature-based tourism and the Arctic Char aquatic food system"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Received: 15 July 2022 | Revised: 14 May 2023 | Accepted: 22 May 2023
DOI: 10.1111/csp2.12982

Conservation Science and Practice Open Access
A journal of the Society for Conservation Biology
WILEY

RESEARCH NOTE

Global principles for restorative aquaculture to foster aquaculture practices that benefit the environment

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2023. *Conservation Science and Practice.*

The Nature Conservancy®
Saving the Last Great Places

Is a Solution to Pollution Transformation?

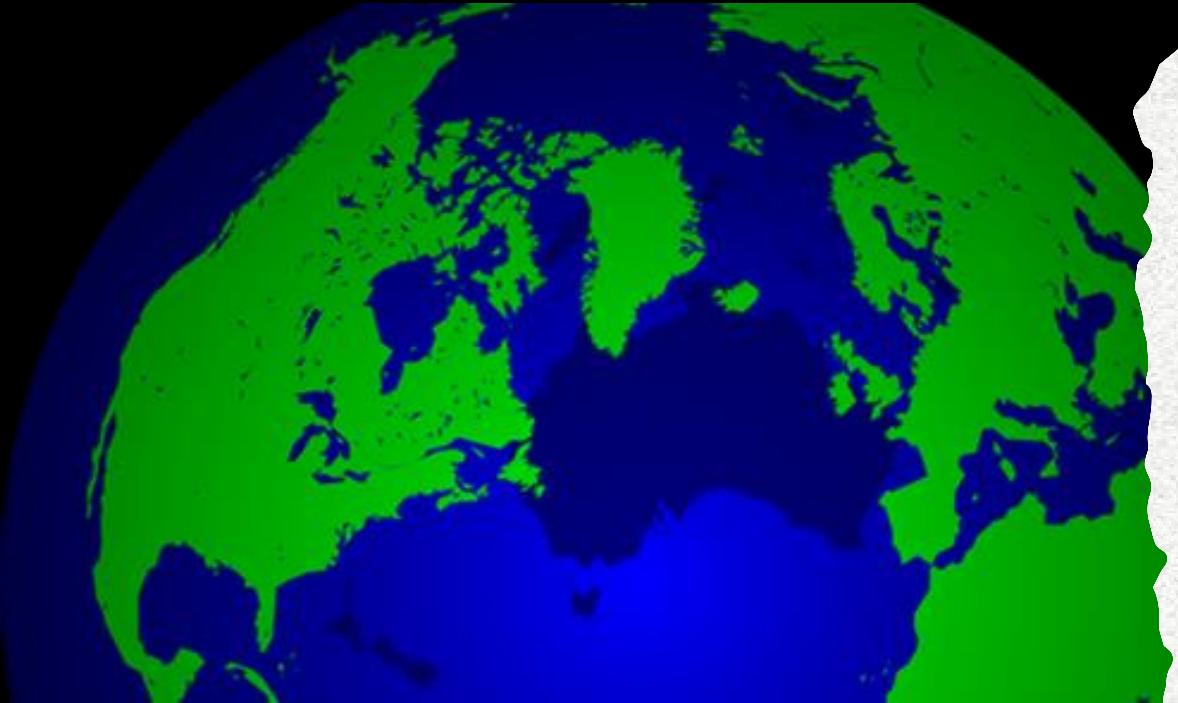
1 kg OUT = 1 kg Transformed??

12 kg N for 1 MT seaweeds

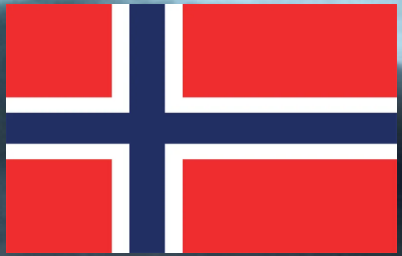
1 kg OUT =>
1 kg Transformed??

- The SDGs & Aquaculture
- Future Aquaculture – The "Big Stuff"
- Nearshore Oceans & Land-Based Aquaculture
- Final Comments – Searching/Helping New Governance to Arise??

Earth Charter



We stand at a critical moment in Earth's history, a time when humanity must choose its future. As the world becomes increasingly interdependent and fragile, the future at once holds great peril and great promise. To move forward we must recognize that in the midst of a magnificent diversity of cultures and life forms we are one human family and one Earth community with a common destiny. We must join together to bring forth a sustainable global society founded on respect for nature, universal human rights, economic justice, and a culture of peace. Towards this end, it is imperative that we, the peoples of Earth, declare our responsibility to one another, to the greater community of life, and to future generations.



Tack så mycket

Tusen takk !

Mahalo !

Muchas gracias !

Muito obrigado !

Thank you !

EARTH OCEAN FOOD SYSTEMS

ETHOS