Ecological Aquaculture

Barry Antonio Costa-Pierce

Ecological Aquaculture International, LLC
bcp@oceanfoods.org

Professor II (20%)
Faculty of Biosciences & Aquaculture
Nord University
Bodø, Norway
barry.costa-pierce@nord.no

https://oceanfoods.org

Costa-Pierce, B.A. **2021**. Radical Aquaculture: Transformational social-ecological systems that advance Sustainable Development Goals (SDGs). *World Aquaculture* 52 (4): 18-32.

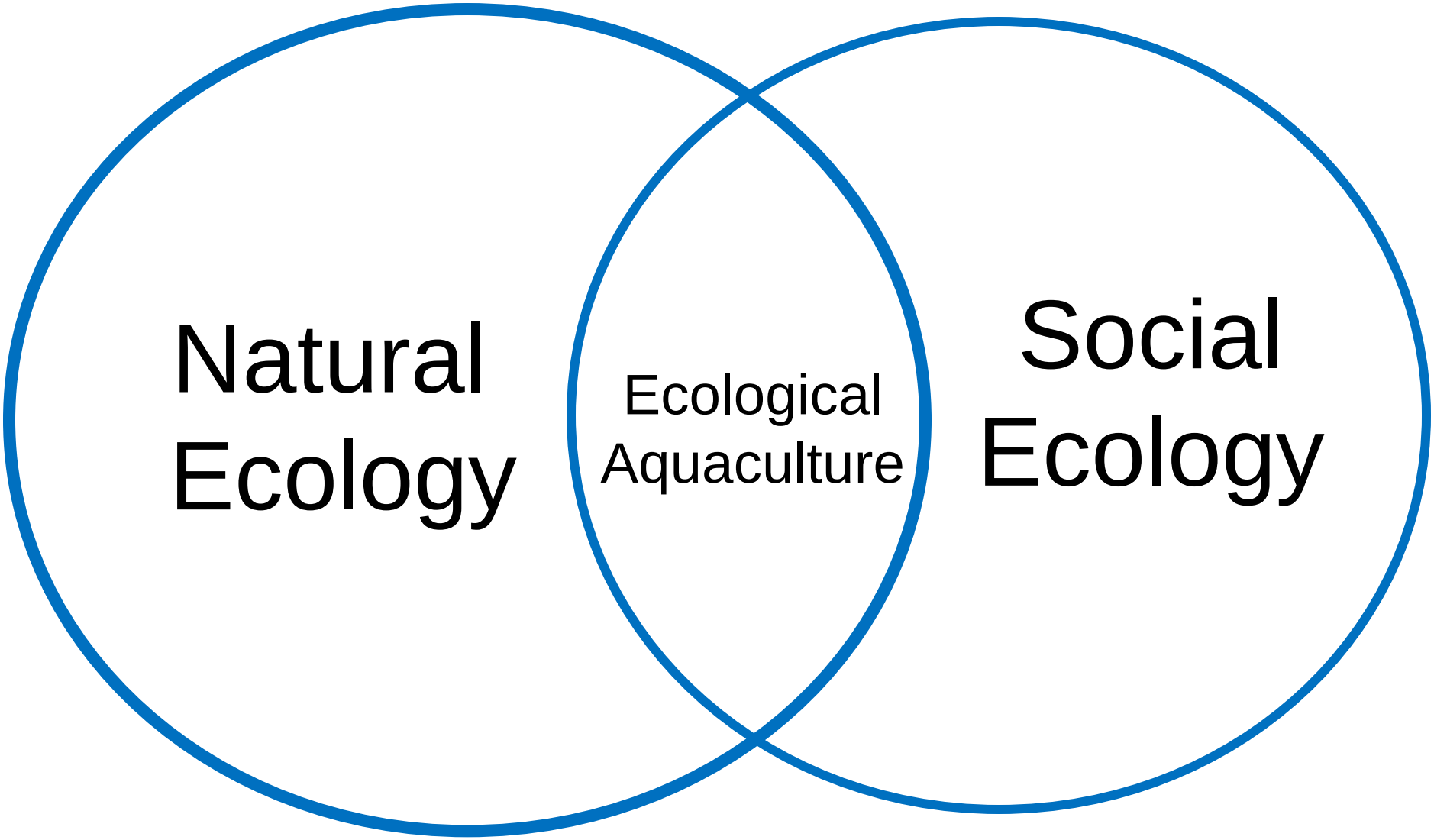
Costa-Pierce, B.A. **2013**. Ecological aquaculture, p. 174-183. In: Christou, P., R. Savin, B.A. Costa-Pierce, I. Misztal & B. Whitelaw, Editors. *Sustainable Food Production*. Springer Reference, N.Y. 1,865 p.
•

ECOLOGICAL AQUACULTURE

THE EVOLUTION OF THE BLUE REVOLUTION

BARRY A. COSTA-PIERCE

Blackwell Publishing


Natural Ecology
Ecological Aquaculture
Social Ecology

The ***overall goal*** of ecological aquaculture is the adoption by societies of an ***accelerated social license*** to develop aquaculture throughout the World, inland, and in common property resources in aquaculture's "new geographies".

Ecological aquaculture develops "***aquaculture ecosystems***" designed to deliver ***economic and social profits without irreversible environmental or social harms***. Such aquaculture ecosystems mimic the form and functions of natural ecosystems. They are sophisticated, knowledge-based farming ecosystems planned as combinations of land and water-based ocean/aquatic plant, agronomic, algae, and animal subunits that are embedded into the larger context of human social systems.

Costa-Pierce, B.A. 2021. The principles and practices of ecological aquaculture and the ecosystems approach to aquaculture: Concepts with a future in planning for the world's blue foods and bioeconomies. *World Aquaculture* 52 (1): 25-31.

Ecological aquaculture systems are *"aquaculture ecosystems"* that mimic the form and functions of natural ecosystems.

Ecological aquaculture is integrated with communities to maximize not only local but also regional economic and social multiplier effects in order to provide maximal job creation and training and create *"aquaculture communities"* that are an essential part of vibrant, working waterfronts.

Ecological aquaculture results in economic profits by practicing trophic efficiency to ensure that aquaculture is *humanity's most efficient protein producer*.

Ecological aquaculture results in *social profit* by integrating aquaculture developments into global fisheries, food, and poverty alleviation programs.

Ecological aquaculture practices *nutrient management* by using ecosystems design, reuse and recycling, and does not discharge any nutrient or chemical pollution causing irreversible damage to natural aquatic or terrestrial ecosystems.

Ecological aquaculture uses *native species/strains* and does not contribute to "biological" pollution.

Ecological aquaculture is a *global partner*, producing *information for the world,* avoiding the proprietary.

Two, overarching, ***ethical concepts*** are embedded into the foundation of ecological aquaculture as a field of knowledge and community of practice:

1) The Hippocratic Oath — do no harm to social and ecological systems

2) The Precautionary Principle — do not proceed with disruptive innovations when comprehensive scientific knowledge is lacking.

Massive Changes in Aquaculture in 20 years

Blue Foods Blue Communities Blue Economies

New Geographies → Common Property Resources

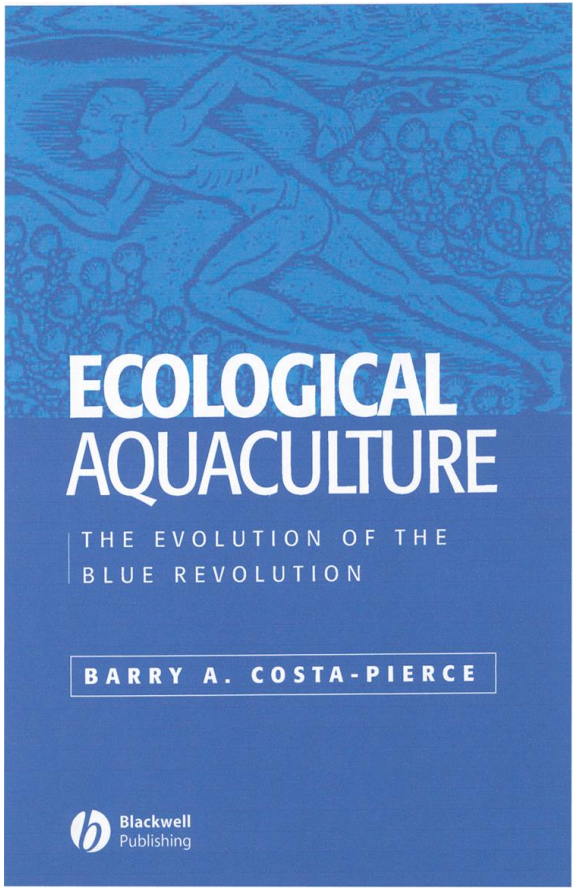
SDGs - Global to Global → Local

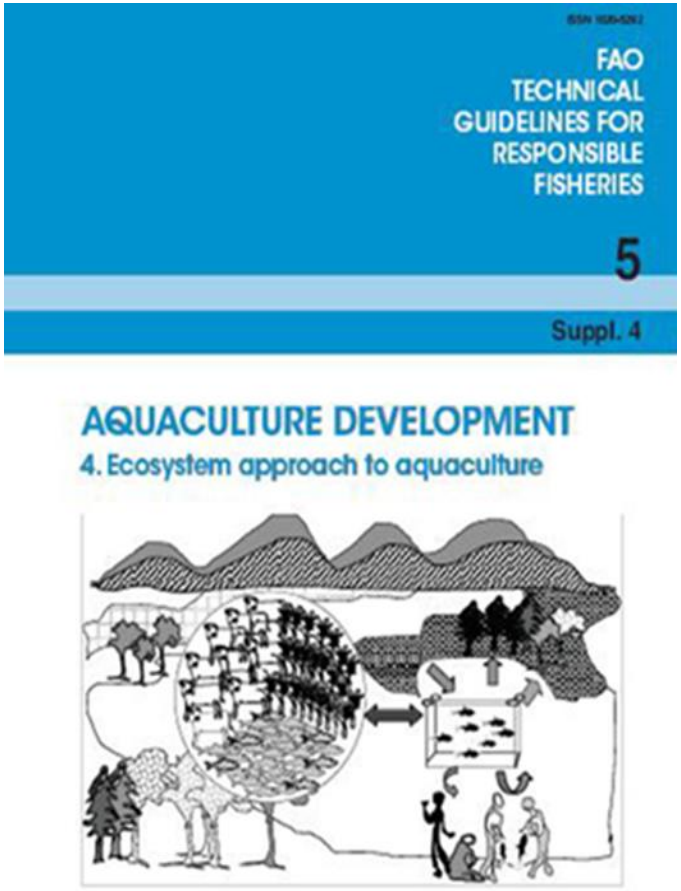
Transdisciplinary Approaches

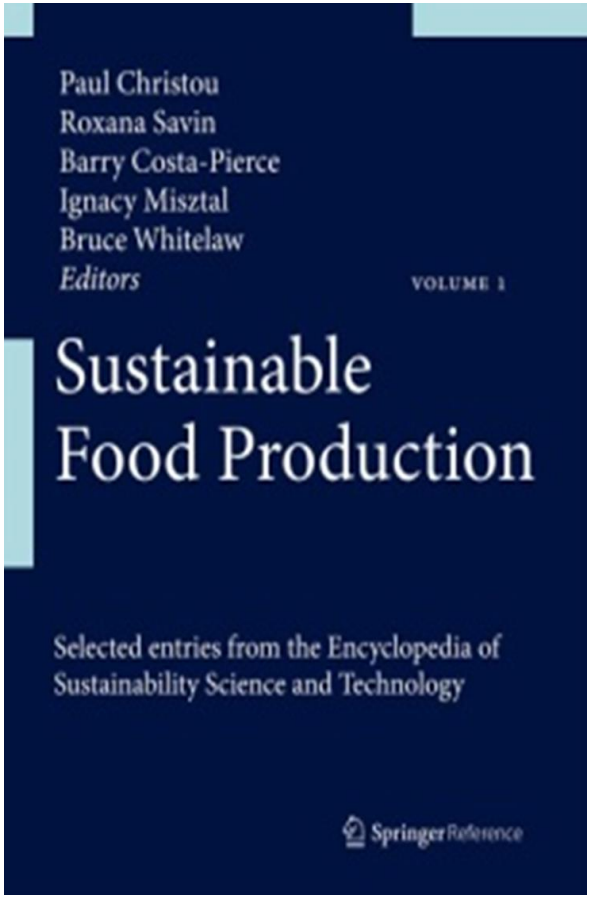
Social-Ecological Systems → Systems Thinking

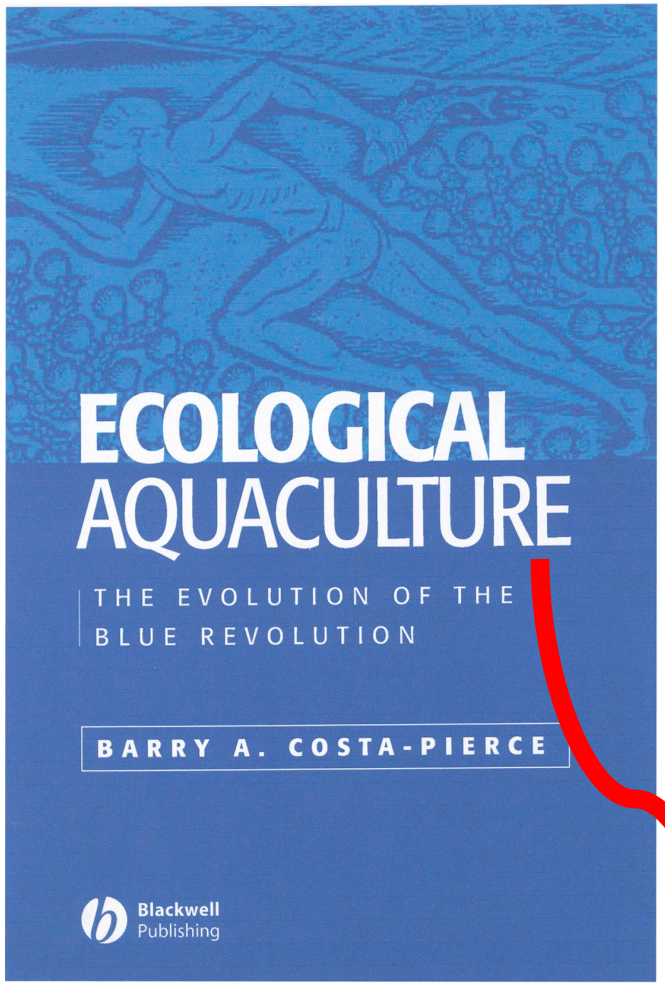
Inter-Generational Change:

YOUTH, DIVERSITY, WOMEN


ECOLOGICAL
AQUACULTURE
THE EVOLUTION OF THE
BLUE REVOLUTION
BARRY A. COSTA-PIERCE
Blackwell
Publishing


FAO
TECHNICAL
GUIDELINES FOR
RESPONSIBLE
FISHERIES
5
Suppl. 4
AQUACULTURE DEVELOPMENT
4. Ecosystem approach to aquaculture

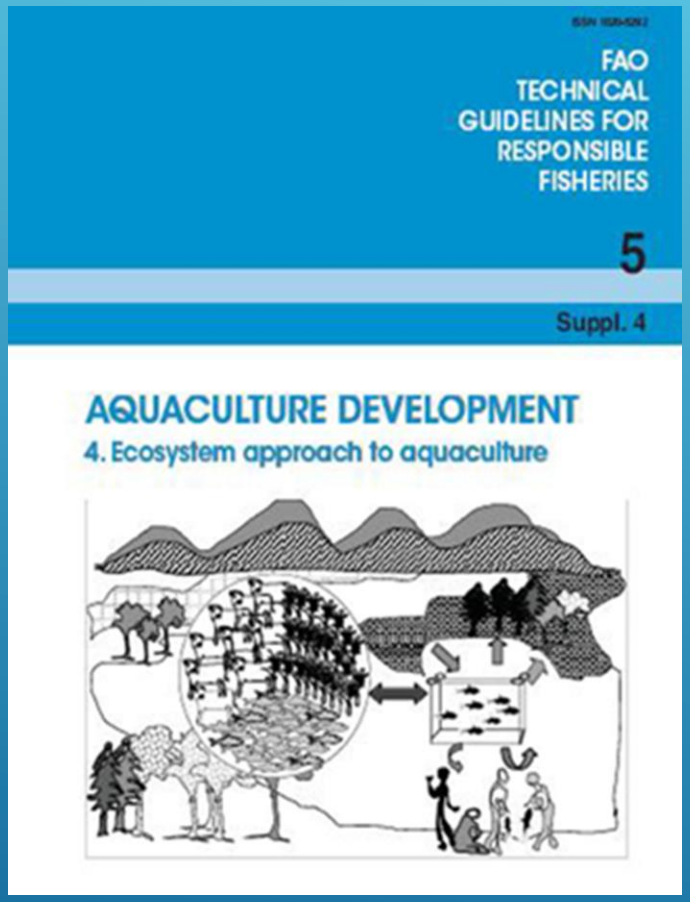

Paul Christou
Roxana Savin
Barry Costa-Pierce
Ignacy Misztal
Bruce Whitelaw
Editors
VOLUME 1
Sustainable
Food Production
Selected entries from the Encyclopedia of
Sustainability Science and Technology
SpringerReference



Radical Transformation of the Global to Local Food System

Transformative—Transdisciplinary--Transgenerational

Costa-Pierce, B.A. 2021. Radical Aquaculture: Transformational social-ecological systems that advance Sustainable Development Goals (SDGs). *World Aquaculture* 52 (4): 18-32.



Ethical and value-based guidelines have existed for 14 years

GLOBAL CONFERENCE ON AQUACULTURE

AQUACULTURE FOR FOOD AND SUSTAINABLE DEVELOPMENT

22-27 September 2021 Shanghai, China

Food and Agriculture Organization of the United Nations

SUSTAINABLE DEVELOPMENT GOALS

中华人民共和国农业农村部

Ministry of Agriculture and Rural Affairs of the People's Republic of China

Network of Aquaculture Centres in Asia-Pacific

Aquaculture systems

Developments in production technology ranging from unfed species, recirculating systems to offshore cages. Which systems will underpin growth?

Innovation and smart technology

Aquaculture is benefiting from smarter technology in data rich environments. Which technologies will be drivers of future growth?

Transforming aquaculture to achieve the SDGs

New paradigms are unfolding for the global food system. What is the future role of aquaculture and how can aquaculture contribute to delivering the SDGs?

Feed and feeding

Feed is a major component in many aquaculture production systems; great advances have already been made in sustainable use of feed resources. What is the future of aquafeeds?

Sustainable management and improvement of genetic resources

Aquaculture lags far behind terrestrial agriculture in the development of its genetic resources. How can we accelerate this development while conserving natural diversity?

Biosecurity and aquatic animal health management

Aquaculture faces important challenges from disease. How can we better protect the industry?

Policies, planning and sectoral governance

Many countries lack adequate planning and regulatory support for aquaculture development. How can governments further develop policies supportive of sustainable aquaculture development?

Social and human dimensions

Many millions of people depend on aquaculture but the benefits are not always equitably distributed. How can these inequities be successfully addressed?

Value chains and market access

The importance of value chains are increasingly better understood. What roles will value chain elements play in supporting the growth of sustainable aquaculture?

Received: 23 December 2022 | Revised: 8 February 2023 | Accepted: 8 February 2023

DOI: 10.1111/jwas.12946

REVIEW ARTICLE

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

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[11,12] | Patricia Moraes-Valenti[15] | Julia Blanchard[16,17] | Philip James[18] | Rodrigue Yossa[19] | Edward Allison[19,20] | Christopher Devaney[8] | Uwe Barg[21]

Scientists call for revamped Sustainable Development Goals

Biermann et al. (2023). Four governance reforms to strengthen the SDGs. *Science* 381: 11590-1160

"In sum, research has shown that the 17 SDGs ***have not led to the global sustainability transformation that is urgently needed***. The claim by the UN General Assembly in the 2030 Agenda for Sustainable Development that the SDGs would enable governments to take bold and transformative steps that are urgently needed to shift the world on to a substantiable and resilient path ***has not materialized***."

"Assessments of the influence of the SDGs have shown that ***they had sizeable impact beyond national governments***"

"A new post-2030 governance system must therefore recognize the valuable role of local and provincial governments ***and provide stronger institutions, within the UN and beyond, to support subnational action.***"

Biermann et al. (2023). Four governance reforms to strengthen the SDGs. *Science* 381: 11590-1160.

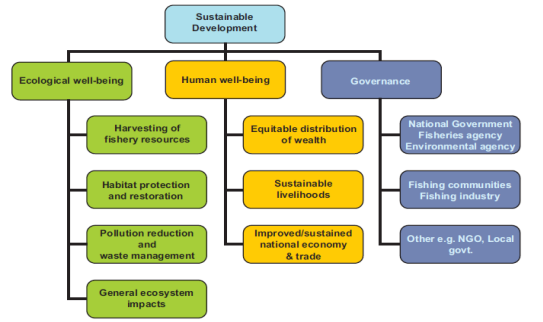

LOCAL
GLOBAL

RAP PUBLICATION 2009/10

APFIC Regional Consultative workshop

Practical implementation of the ecosystem approach to fisheries and aquaculture

18–22 May 2009, Colombo, Sri Lanka



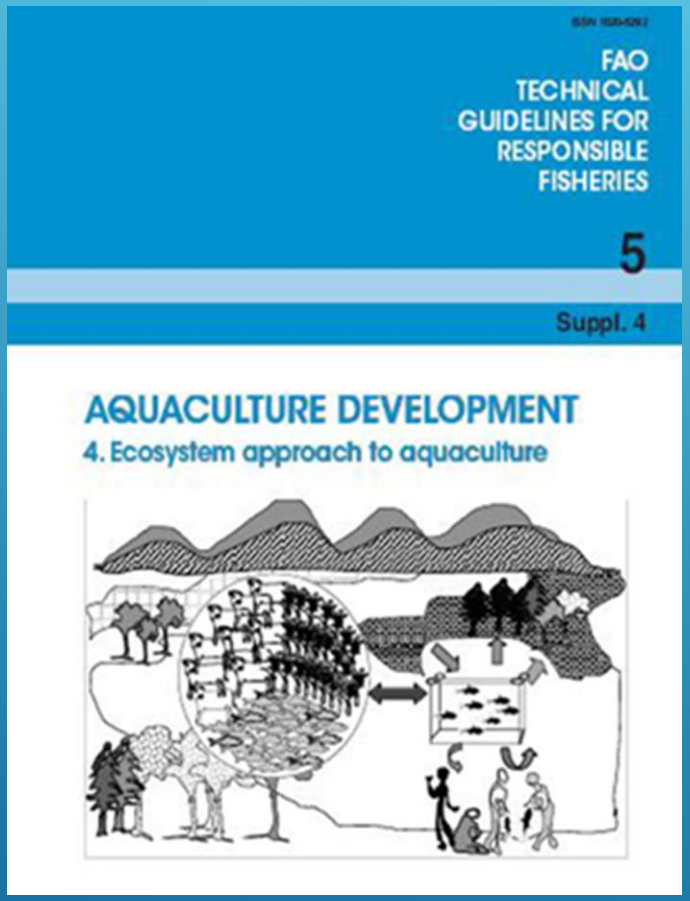
APFIC

FAO

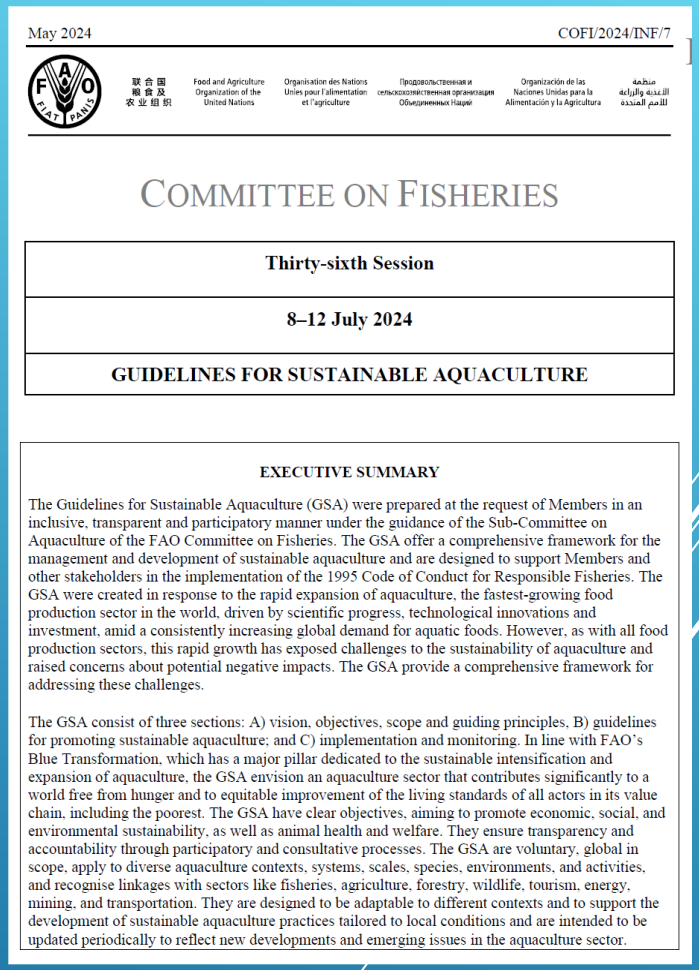
Food and Agriculture Organization of the United Nations

Ecosystem approach to aquaculture management

HANDBOOK



Detailed implementation guidelines



May 2024 COFI/2024/INF/7

Food and Agriculture Organization of the United Nations | Organisation des Nations Unies pour l'alimentation et l'agriculture | Продовольственная и сельскохозяйственная организация Объединенных Наций | Organización de las Naciones Unidas para la Alimentación y la Agricultura | منظمة الأغذية والزراعة للأمم المتحدة

COMMITTEE ON FISHERIES

Thirty-sixth Session

8–12 July 2024

GUIDELINES FOR SUSTAINABLE AQUACULTURE

EXECUTIVE SUMMARY

The Guidelines for Sustainable Aquaculture (GSA) were prepared at the request of Members in an inclusive, transparent and participatory manner under the guidance of the Sub-Committee on Aquaculture of the FAO Committee on Fisheries. The GSA offer a comprehensive framework for the management and development of sustainable aquaculture and are designed to support Members and other stakeholders in the implementation of the 1995 Code of Conduct for Responsible Fisheries. The GSA were created in response to the rapid expansion of aquaculture, the fastest-growing food production sector in the world, driven by scientific progress, technological innovations and investment, amid a consistently increasing global demand for aquatic foods. However, as with all food production sectors, this rapid growth has exposed challenges to the sustainability of aquaculture and raised concerns about potential negative impacts. The GSA provide a comprehensive framework for addressing these challenges.

The GSA consist of three sections: A) vision, objectives, scope and guiding principles, B) guidelines for promoting sustainable aquaculture; and C) implementation and monitoring. In line with FAO's Blue Transformation, which has a major pillar dedicated to the sustainable intensification and expansion of aquaculture, the GSA envision an aquaculture sector that contributes significantly to a world free from hunger and to equitable improvement of the living standards of all actors in its value chain, including the poorest. The GSA have clear objectives, aiming to promote economic, social, and environmental sustainability, as well as animal health and welfare. They ensure transparency and accountability through participatory and consultative processes. The GSA are voluntary, global in scope, apply to diverse aquaculture contexts, systems, scales, species, environments, and activities, and recognise linkages with sectors like fisheries, agriculture, forestry, wildlife, tourism, energy, mining, and transportation. They are designed to be adaptable to different contexts and to support the development of sustainable aquaculture practices tailored to local conditions and are intended to be updated periodically to reflect new developments and emerging issues in the aquaculture sector.

A transformation of food production systems is needed to meet the challenges of simultaneously adhering to the planetary dimensions, food security and food justice to advance human health and wellness...

https://www.mianpo.org/

The USA office and 2 ha research/education farm of the Ecological Aquaculture International LLC is located about 1 km inland from the North Atlantic Ocean. EAI recognizes it is located on lands of the Sokoki Wabanaki Nation whose sovereign rights were stolen, and sacred sites desecrated by colonialism, racism, and hatred. EAI recognizes the Sokoki and all other Wabanaki Nations (Passamaquoddy, Penobscot, Maliseet, Mi'kmaq) as distinct, sovereign, legal and political entities with self-governance and self-determination.

Aquaculture Ecosystems

SEAS: Sustainable Ecological Aquaculture Systems

Food Systems

SEAS: Sustainable Ecological Aquaculture Systems

* FRESHWATER Inland Aquaculture ("land-based")
  Integrated Aquaculture

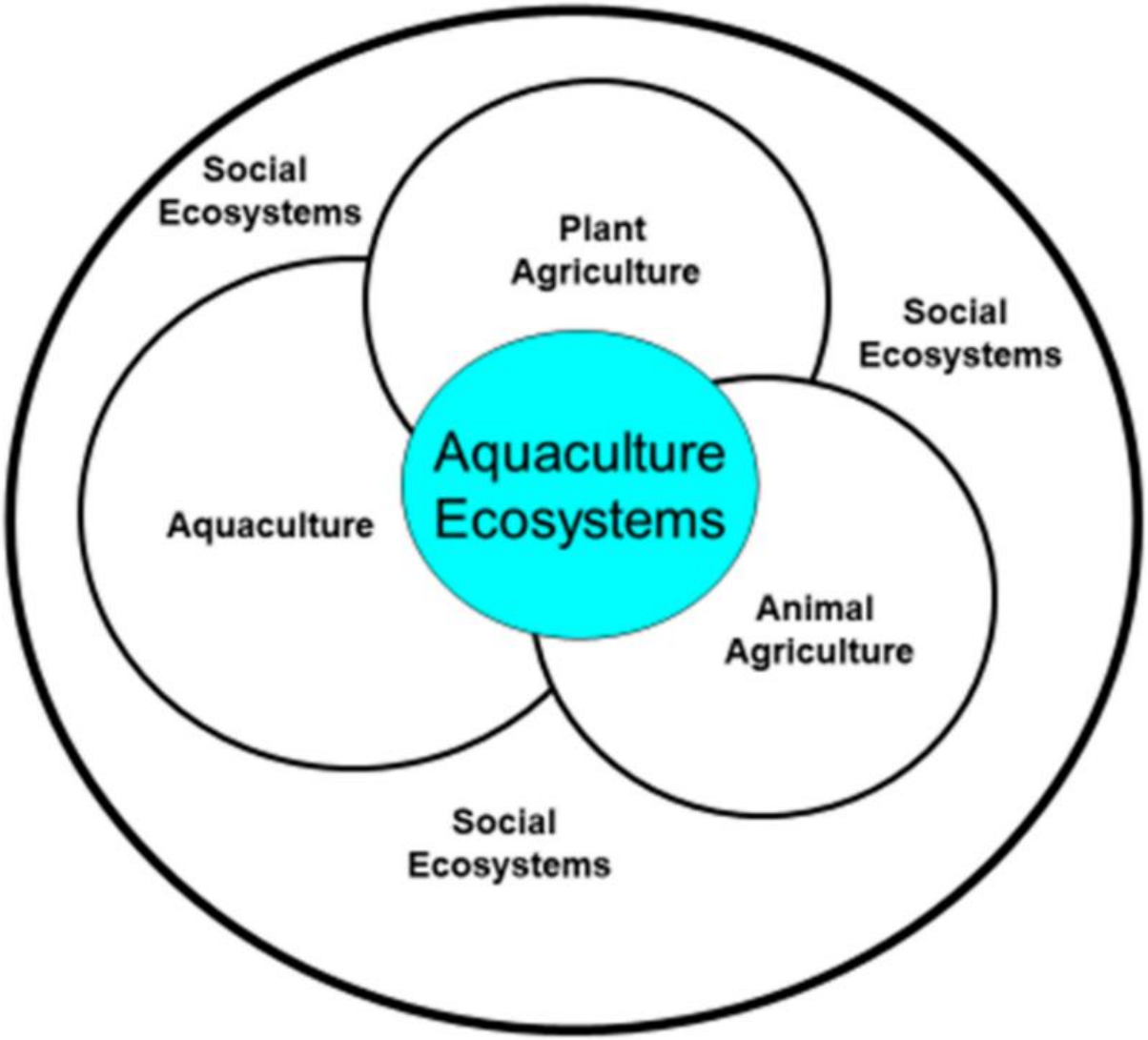
Belton B, Little DC, Zhang W, Edwards P, Skladany M, Thilsted SH. 2020. Farming fish in the sea will not nourish the world. *Nature Communications* 11(1):5804. doi:10.1038/s41467-020-19679-9

vs.???

Costa-Pierce, B.A., A.B. Bockus, B.H. Buck, S.W. K. van den Burg, T. Chopin, J.G. Ferreira, N. Goseberg, K.G. Heasman, J. Johansen, S.E. Shumway, N.A. Sims and A.G.J. Tacon. **2021**. A fishy story promoting a false dichotomy to policy-makers: it's not freshwater vs. marine aquaculture. *Reviews in Fisheries Science & Aquaculture*, 1-18 doi: 10.1080/23308249.2021.2014175

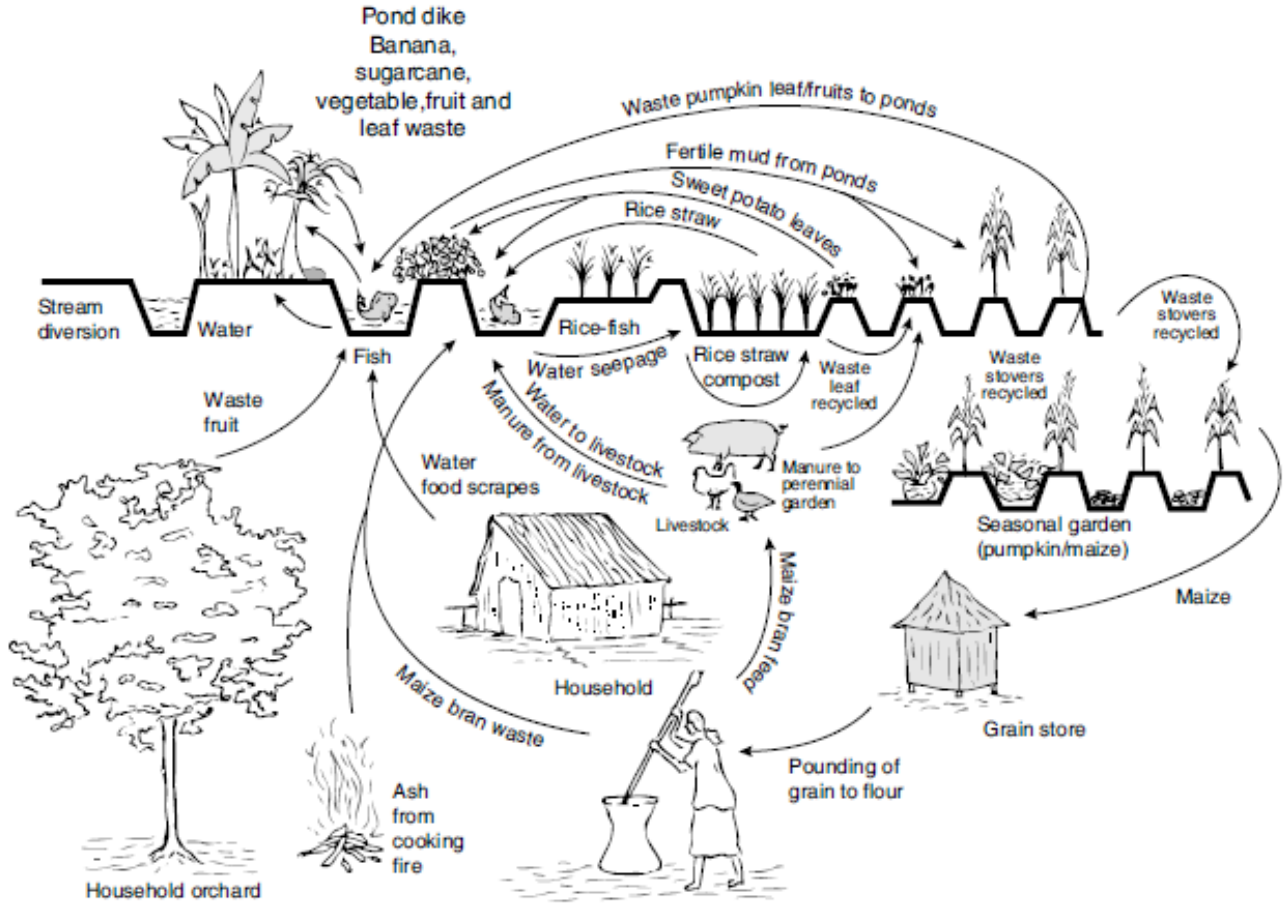
Table 3a. *Top Ten Global Aquaculture Nations and Principal Species in 2014 (FAO, 2016).*

Nations	Total (MMT)	% Inland	Primary and Secondary Species Cultured
China	58.79	44	Carps, Tilapias, Shrimp, Seaweeds (wide diversity)[1]
Indonesia	14.33	20	Marine Shrimp, Carps, Seaweeds
India	4.88	90	Carps, Marine Shrimp
Vietnam	3.41	73	Catfish, Marine Shrimp
Philippines	2.34	13	Marine Shrimp, Seaweeds,Tilapia
Bangladesh	1.96	88	Carps, Freshwater Prawns
South Korea	1.57	1	Seaweeds, Marine Fish, Molluscs
Norway	1.33	<1	Salmon
Chile	1.23	5	Salmon
Egypt	1.14	100	Tilapia
Others (in order of FAO production statistics: Japan (1.20), Myanmar (0.96), Thailand (0.93), Brazil (0.56), Malaysia (0.52), North Korea (0.51), USA (0.43))	5.11	Japan (3%), Myanmar (94%), Thailand (43%), Brazil (85%), Malaysia (21%), North Korea (<1%), USA (41%)	Costa-Pierce (2016) from FAO (2014)
World	101.09		


Social
Ecosystems
Plant
Agriculture
Social
Ecosystems
Aquaculture
Ecosystems
Aquaculture
Animal
Agriculture
Social
Ecosystems


Integrated Agriculture-Aquaculture Farming Ecosystems


Warm Water, Nutrients, Microbes
Feeds, Fertilizers

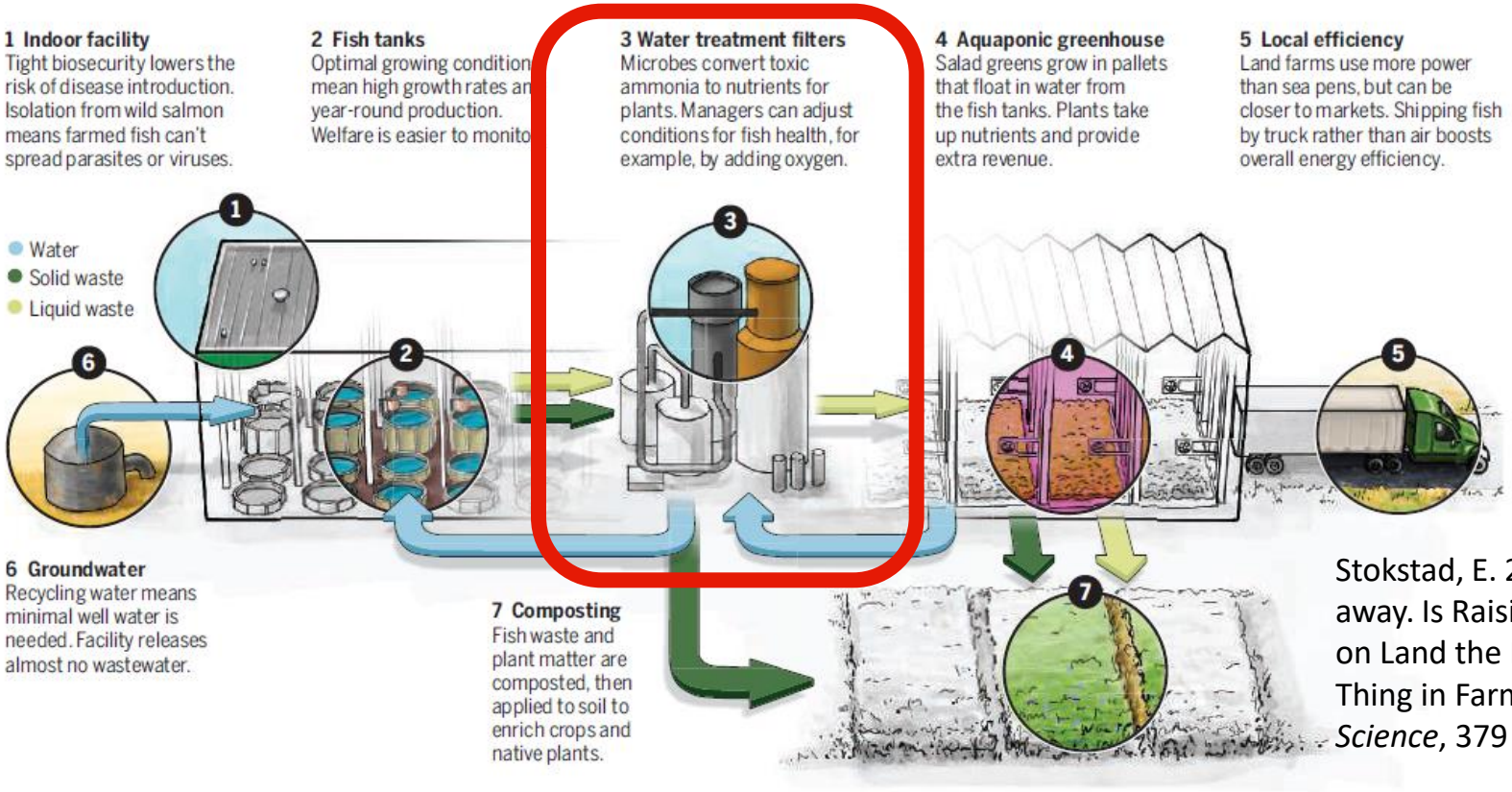


Brummett, R.E. and B.A. Costa-Pierce. 2002. Village-based aquaculture ecosystems as a model for sustainable aquaculture development in Sub-saharan aquaculture, p. 145-160. In: B.A. Costa-Pierce (Ed.) *Ecological Aquaculture: The Evolution of the Blue Revolution*. Blackwell Science, Oxford, UK.

SUPERIOR Fresh

Salmon and salad

New land-based salmon farms have environmental advantages over marine production. But they face the challenge of dealing with the waste from the many salmon in tanks. One company, Superior Fresh, recycles the water and converts fish waste into fertilizer for an adjacent greenhouse. The rest is added to fields.



Stokstad, E. 2023. Oceans away. Is Raising Salmon on Land the Next Big Thing in Farming Fish? *Science*, 379 (6632)

1 kg feed produces 11 kg food

	Sizes m^2 (ha)	Production (MT/y)
Fish Salmon (FW)	3716 (0.4)	72.6
Plants	11427 (1.1)	816.5
TOTAL	15143 (1.5)	889.0

Sludge used in regenerative agriculture

ONLY FISH ARE FED = FCR 1.1
Plants Receive Supplements

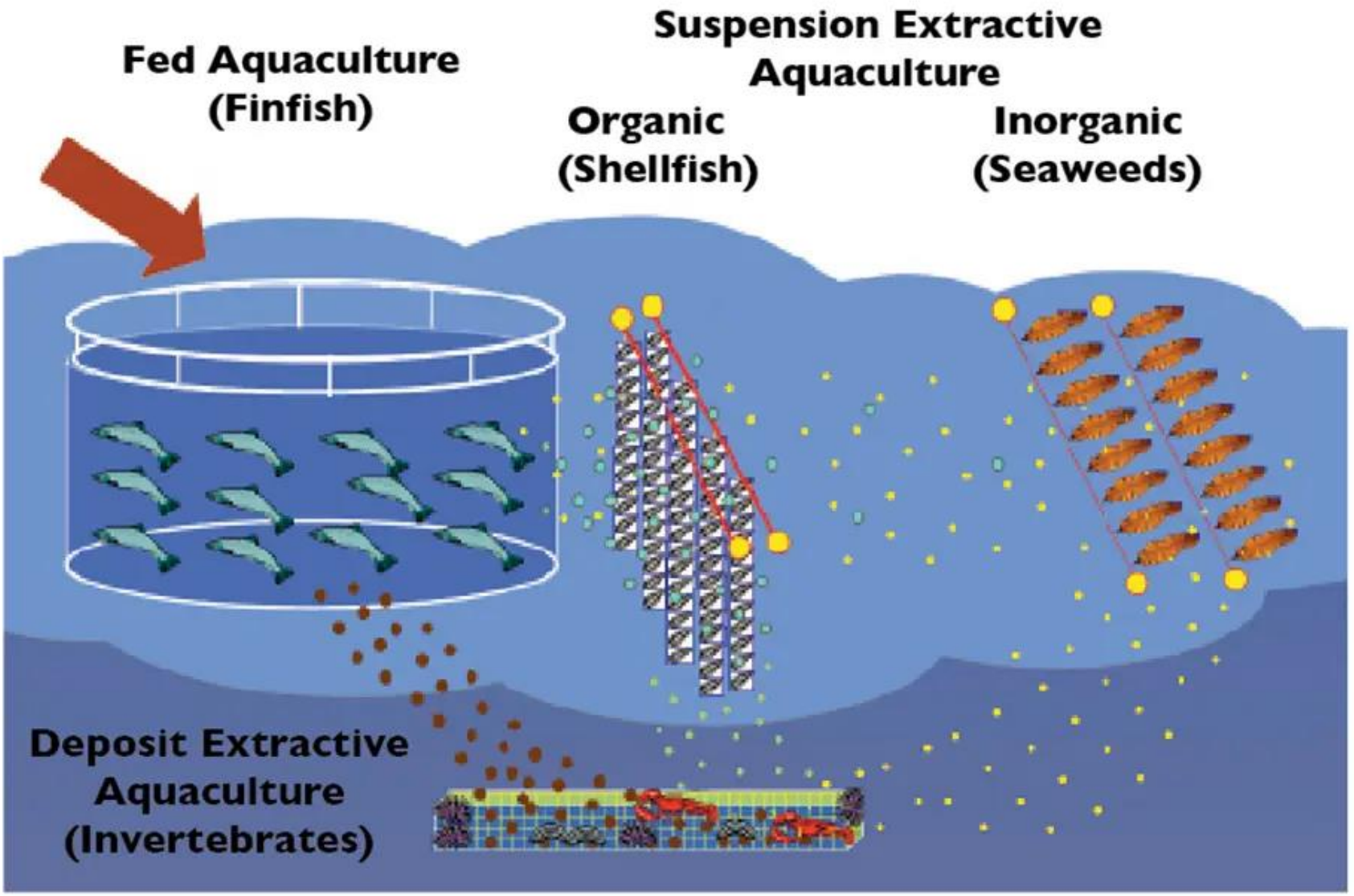
72.6 MT fish x 1.1 FCR

= 79.9 MT feed required

yields

889.0 MT BLUE-GREEN FOOD


SEAS: Sustainable Ecological Aquaculture Systems
Ocean Aquaculture
Ocean Food Systems


Fed Aquaculture
(Finfish)
Suspension Extractive
Aquaculture
Organic
(Shellfish)
Inorganic
(Seaweeds)
Deposit Extractive
Aquaculture
(Invertebrates)

MARINE ALGAE

SEA VEGETABLES!

IMTA

20-30% of production

The Nature Conservancy

Revised: 14 May 2023 | Accepted: 22 May 2023

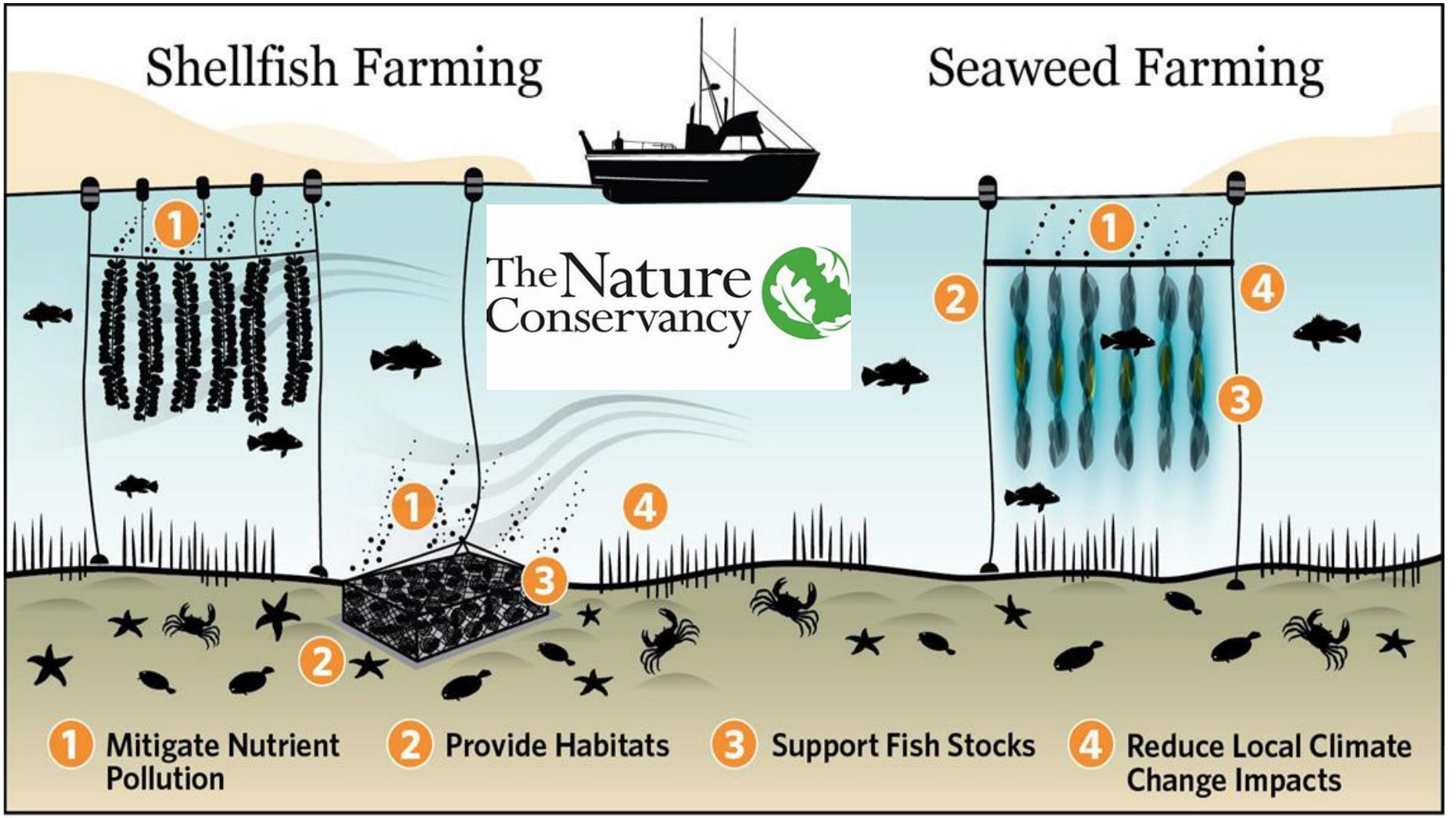
DOI: 10.1111/csp2.12982

RESEARCH NOTE

Conservation Science and Practice
A Journal of the Society for Conservation Biology
WILEY

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

Heidi K. Alleway[1] | Tiffany J. Waters[1] | Randall Brummett[2] | Junning Cai[3] | Ling Cao[4] | Megan Reilly Cayten[5] | Barry Antonio Costa-Pierce[6] | Yun-Wei Dong[7] | Steffen Cole Brandstrup Hansen[8] | Shurong Liu[4] | Qing Liu[9] | Colin Shelley[10] | Seth J. Theuerkauf[1] | Lisa Tucker[1] | Yue Wang[9] | Robert C. Jones[1]


Shellfish Farming
Seaweed Farming
The Nature Conservancy
1 Mitigate Nutrient Pollution
2 Provide Habitats
3 Support Fish Stocks
4 Reduce Local Climate Change Impacts

https://aquavitaeproject.eu/


“Jackets”
Beatrice Wind Farm, U.K.

Project to grow corals on offshore wind turbine foundations launched

Ørsted will trial cultivating corals on the steel surfaces of four wind turbine foundations

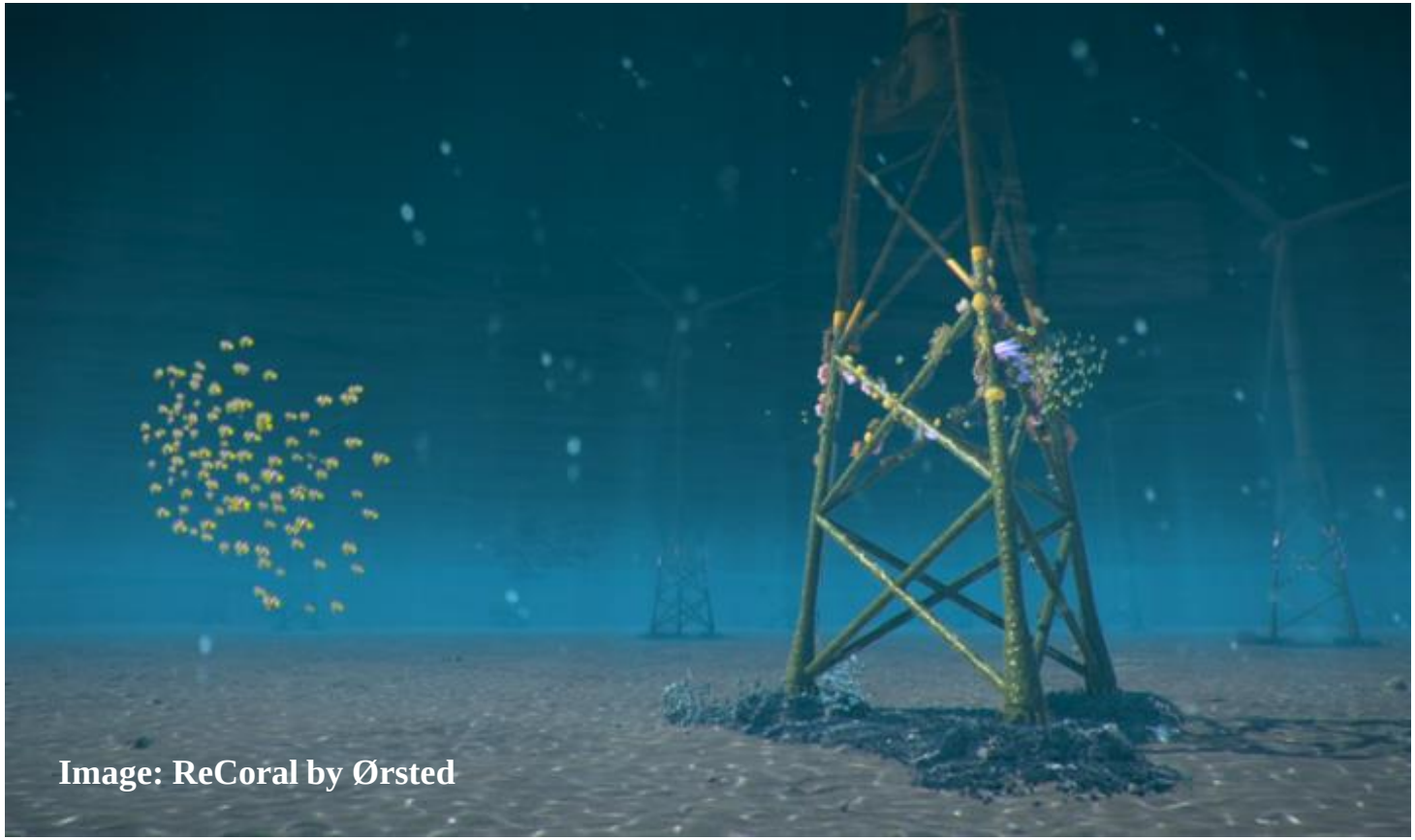
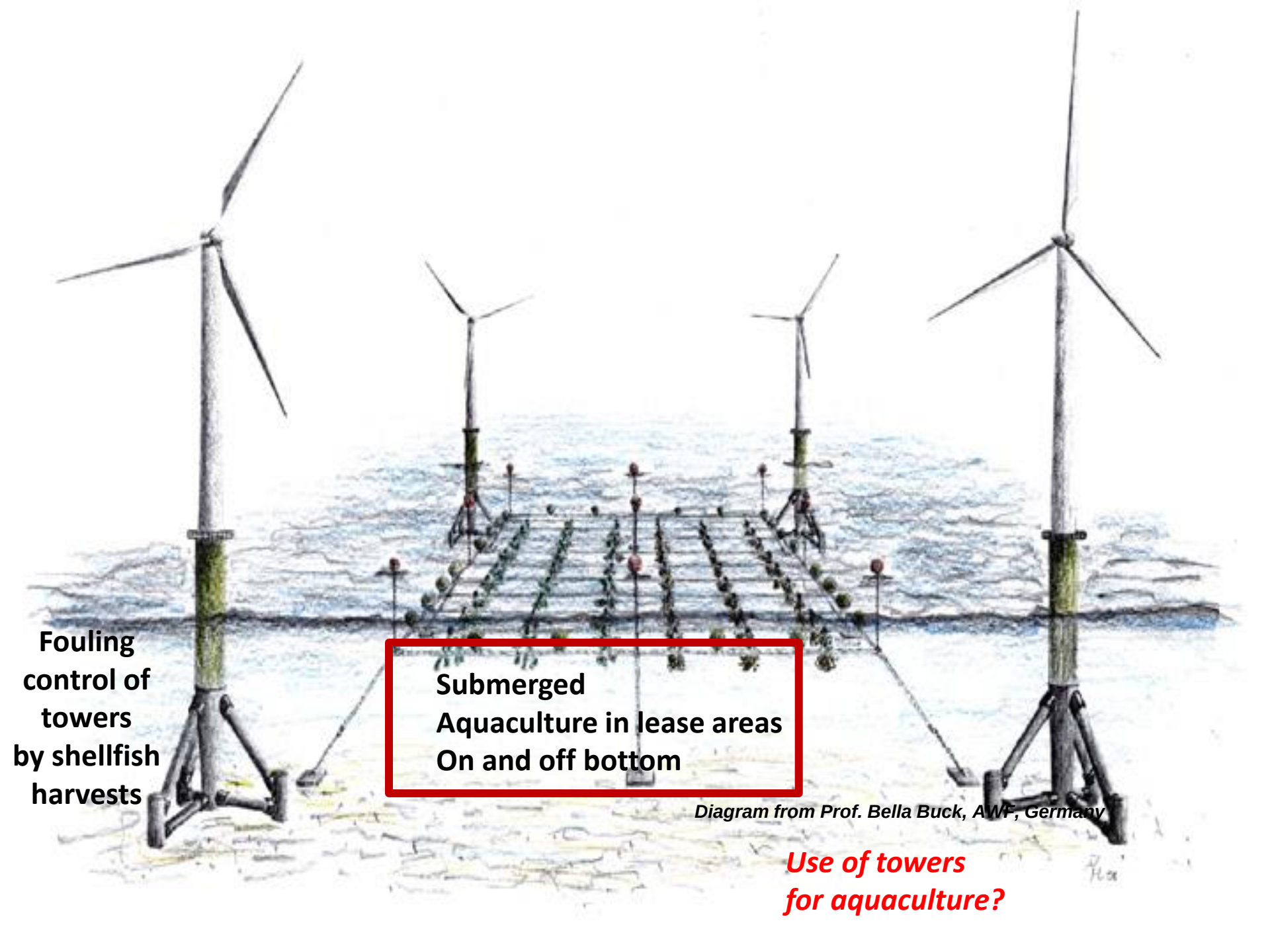


Image: ReCoral by Ørsted

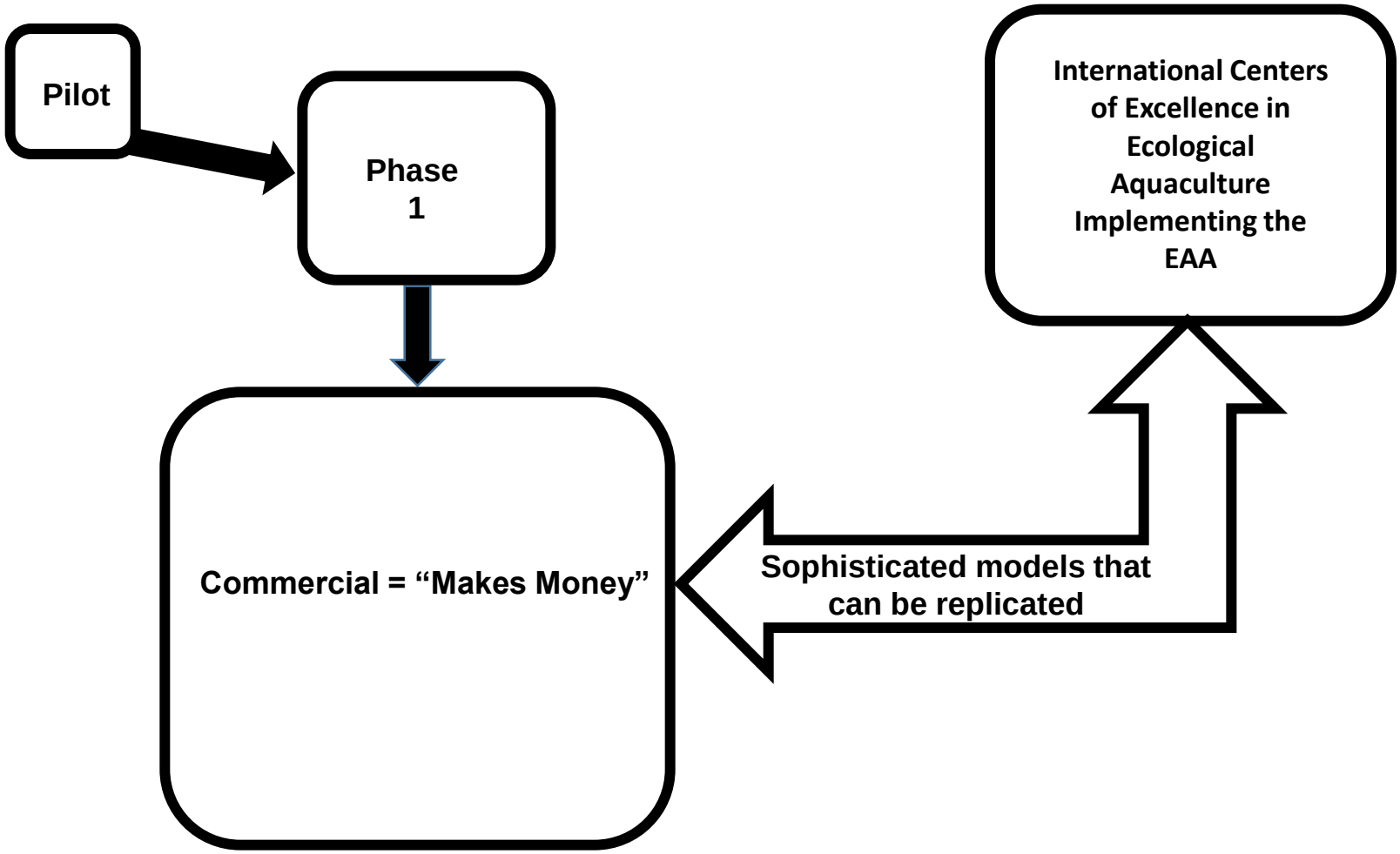

Fouling control of towers by shellfish harvests
Submerged Aquaculture in lease areas On and off bottom
Diagram from Prof. Bella Buck, AWI, Germany
Use of towers for aquaculture?

Scale is one of the most controversial aspects of aquaculture today

Scaling issues play a central role in the political and regulatory obstacles to advancing aquaculture

Nearshore oceans are common property resource areas

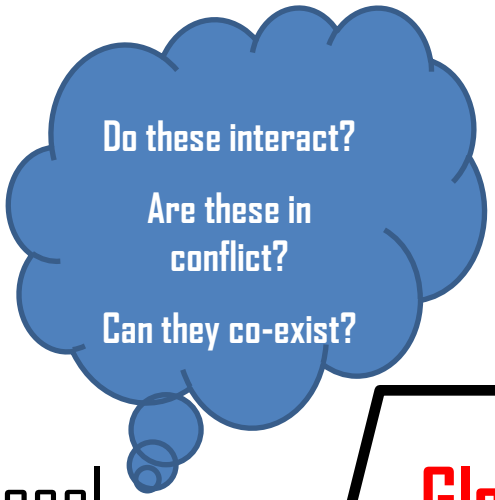
Most aquaculture development occurs in rural areas


Pilot
Phase 1
International Centers of Excellence in Ecological Aquaculture Implementing the EAA
Commercial = "Makes Money"
Sophisticated models that can be replicated

Scale

HyperLocal

Small



Global

Intensive

Development Models for Scaling Aquaculture

Pilot

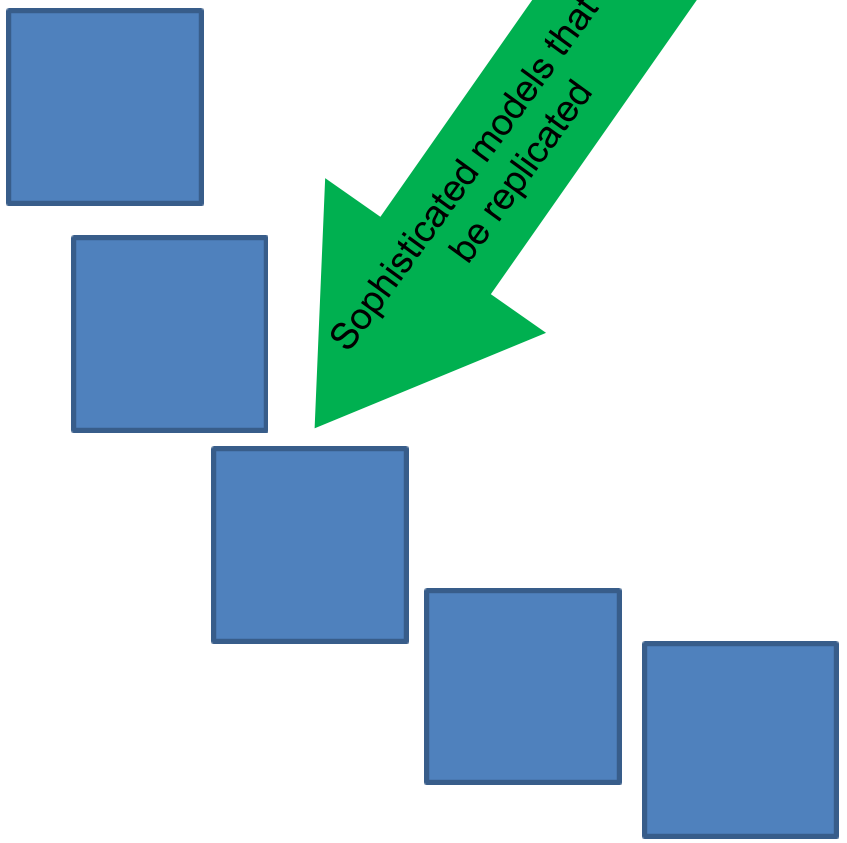
Phase 1

Commercial = "Makes Money"

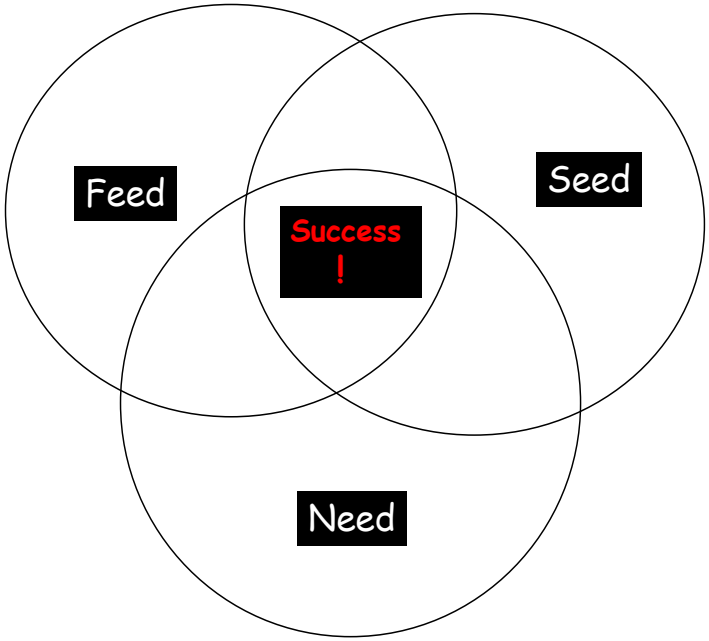
"Organize international R&D platforms involving countries active or intending to initiate…development projects"

Ecological Aquaculture Centers to Implement EAA

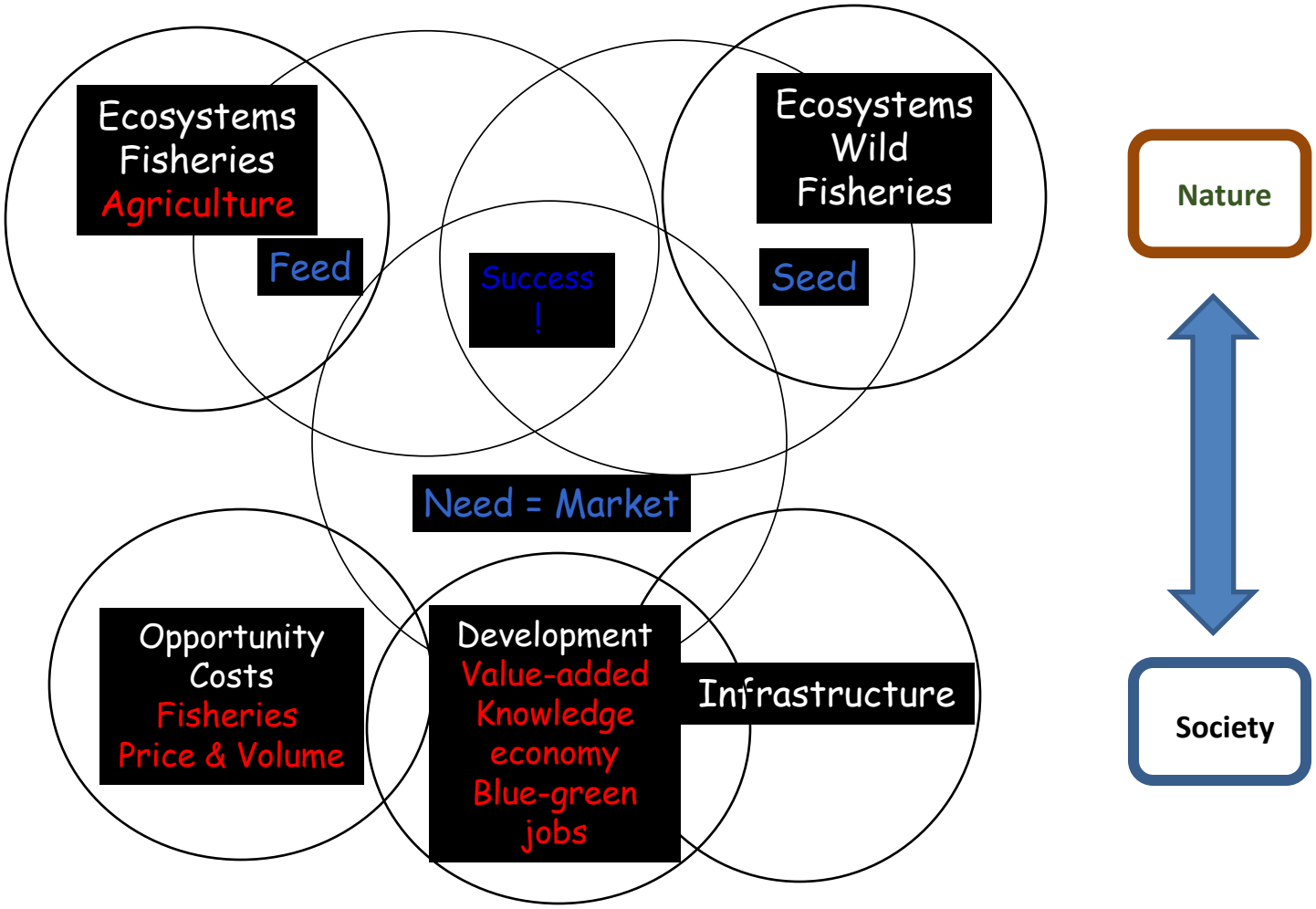
Sophisticated models that can be replicated



Aquaculture Business Success



Society's Success



Ecological Aquaculture: Transdisciplinary Approaches

Social-ecological systems: carrying capacity, marine/aquatic spatial planning

Ecological design

plans at **scale for food systems that include aquaculture ("blue foods")*

Ecological engineering ("Industrial Ecology")

**uses green/renewable, appropriate technologies, uses LCAs*

**blue-green biomanufacturing – seaweeds!*

Ecological economics

**plans for both economic and social profits – full cost accounting -*

**regional multiplier effects*

**circular, "blue" economies*

Ecological governance

**Not government! Where does the power for decisions lie?*

**Evolutionary – sustainability systems trajectories of change*

Thank You

Tusen takk
Tack så mycket
Muchas gracias
Shukran jazilan
Mahalo nui loa
Terima kasih