# Ecological Aquaculture (2023 Update)

**Barry Antonio Costa-Pierce**
Faculty of Biosciences & Aquaculture
**Nord University**
Bodø, Norway
barry.costa-pierce@nord.no

**Ecological Aquaculture International, LLC**
bcp@oceanfoods.org


# 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?


Special Issue of the *Journal of the World Aquaculture Society* containing thematic reviews from the FAO Global Conference on Aquaculture published in Open Access: https://onlinelibrary.wiley.com/toc/17497345/2023/54/2

Mair, G.C., Halwart, M., Derun, Y., & B.A. Costa-Pierce. 2023. A decadal outlook for global aquaculture. *Journal of the World Aquaculture Society* 54(2): 196-205. https://doi.org/10.1111/jwas.12977

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

Costa-Pierce, B.A. 2021. The principles and practices of ecological aquaculture and the ecosystems approach to aquaculture. *World Aquaculture* 52 (1): 25-31.

Costa-Pierce, B.A. and T. Chopin. 2021. The hype, fantasies and realities of aquaculture development globally and in its new geographies. *World Aquaculture* 52 (2): 23-35.

Costa-Pierce, B.A. 2021. The social ecology of aquaculture in its new geographies *World Aquaculture* 52 (3): 43-50.

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

# Changes (or Not) in Aquaculture in 20 years

Blue Foods Blue Communities Blue Economies

New Geographies → Common Property Resources

Global to Global → Local

Transdisciplinary Approaches

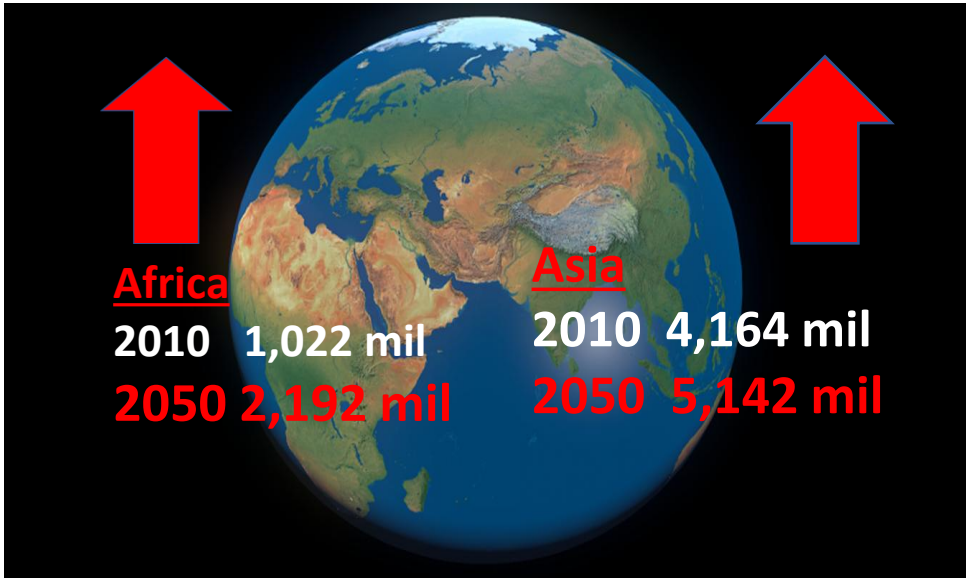
Social-Ecological Systems → Systems Thinking

Inter-Generational Change:

YOUTH, DIVERSITY, WOMEN, INDIGENOUS

2.2

5.1




India has surpassed China as the World's most populous nation

Chin et al. Special Section on Population. *Science* 333: 540-594.

**Europe**

BILLIONS

2010 738 mil
*2050 719 mil*

0.7

**North America**

2010 345 mil
2050 447 mil

0.5

**Latin/South America**

2010 590 mil
2050 751 mil

0.7

1.9

# The Global Village of 1000

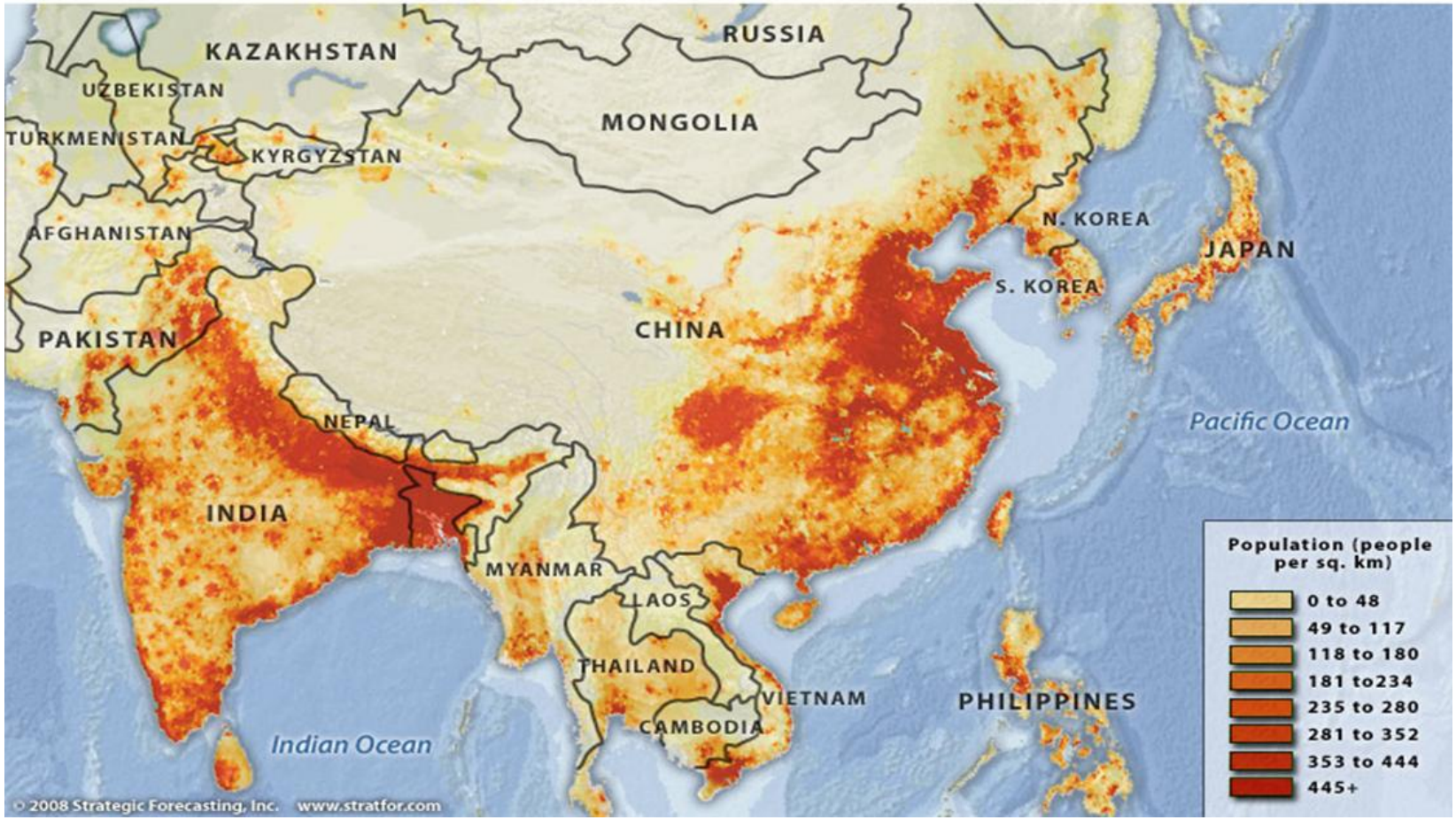
714
- 589 Asia
- 125 Africa

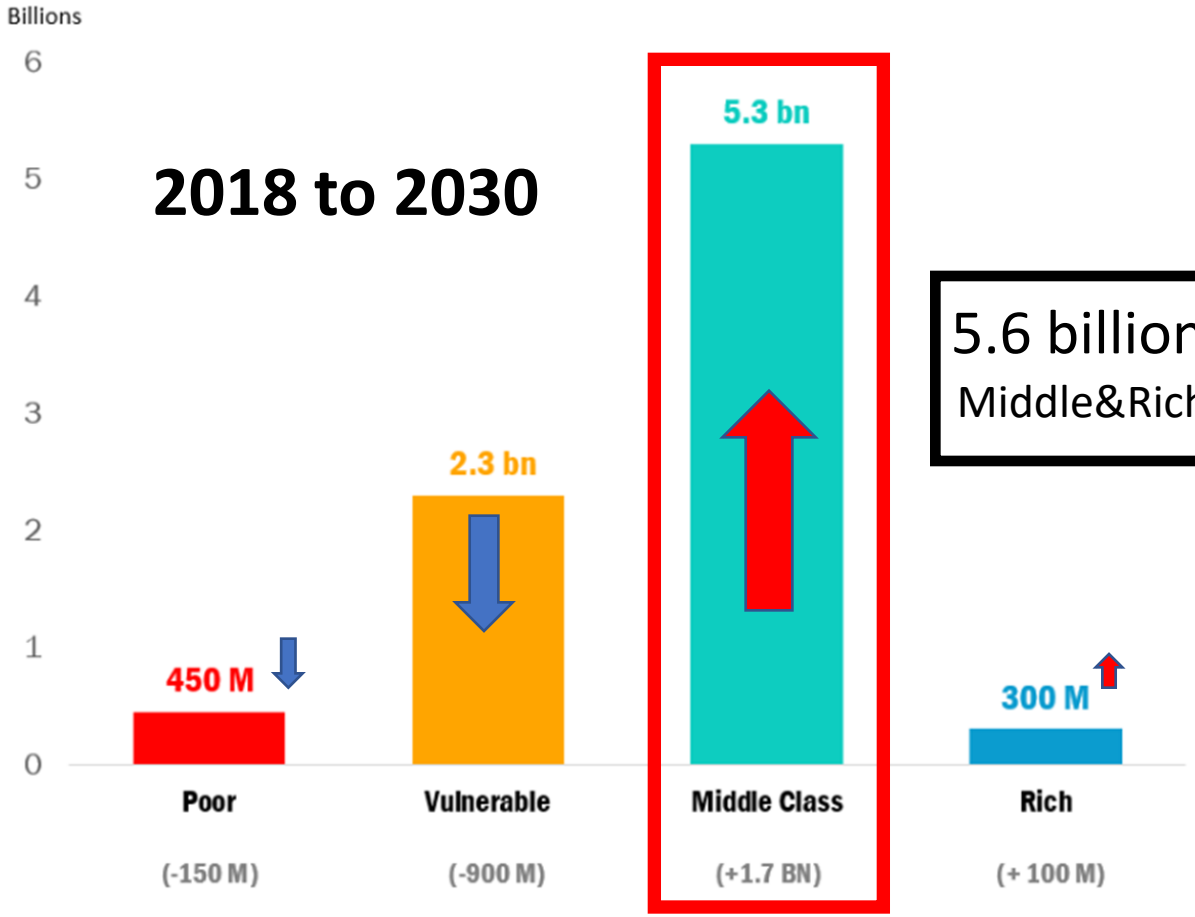
150 Europe, Russia, Mideast

84 Latin/S. America

52 North America

# POPULATION DENSITY MAP OF ASIA






5.6 billion > 2.75 billion

Middle&Rich Poor&Vulnerable

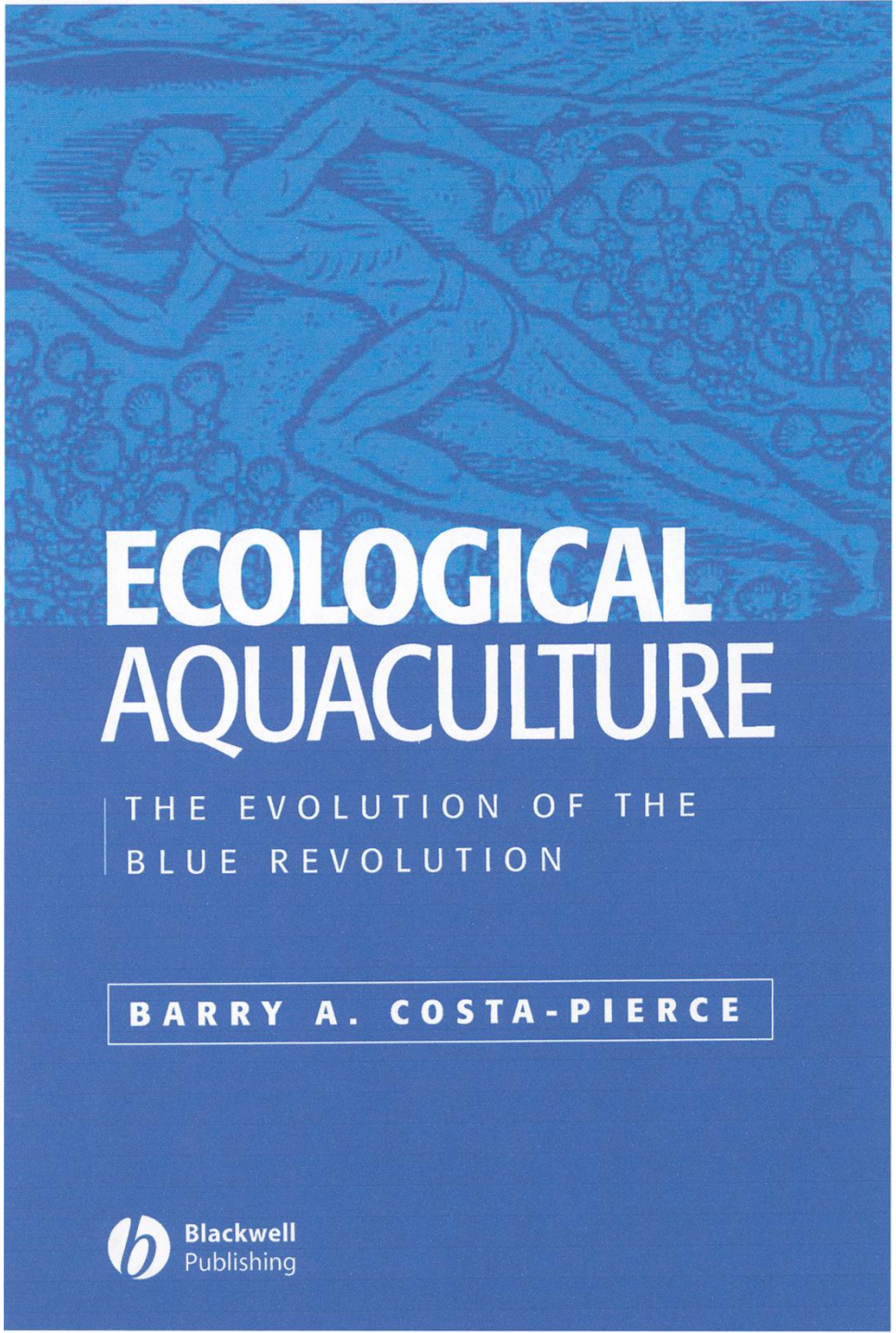
Homi Kharas and Kristofer Hamel Thursday, September 27, 2018. A global tipping point: Half the world is now middle class or wealthier.
*https://www.brookings.edu/blog/future-development/2018/09/27/a-global-tipping-point-half-the-world-is-now-middle-class-or-wealthier/*

* Asia, Africa Dominate Global Population

* Rise of China, India Consumer Classes

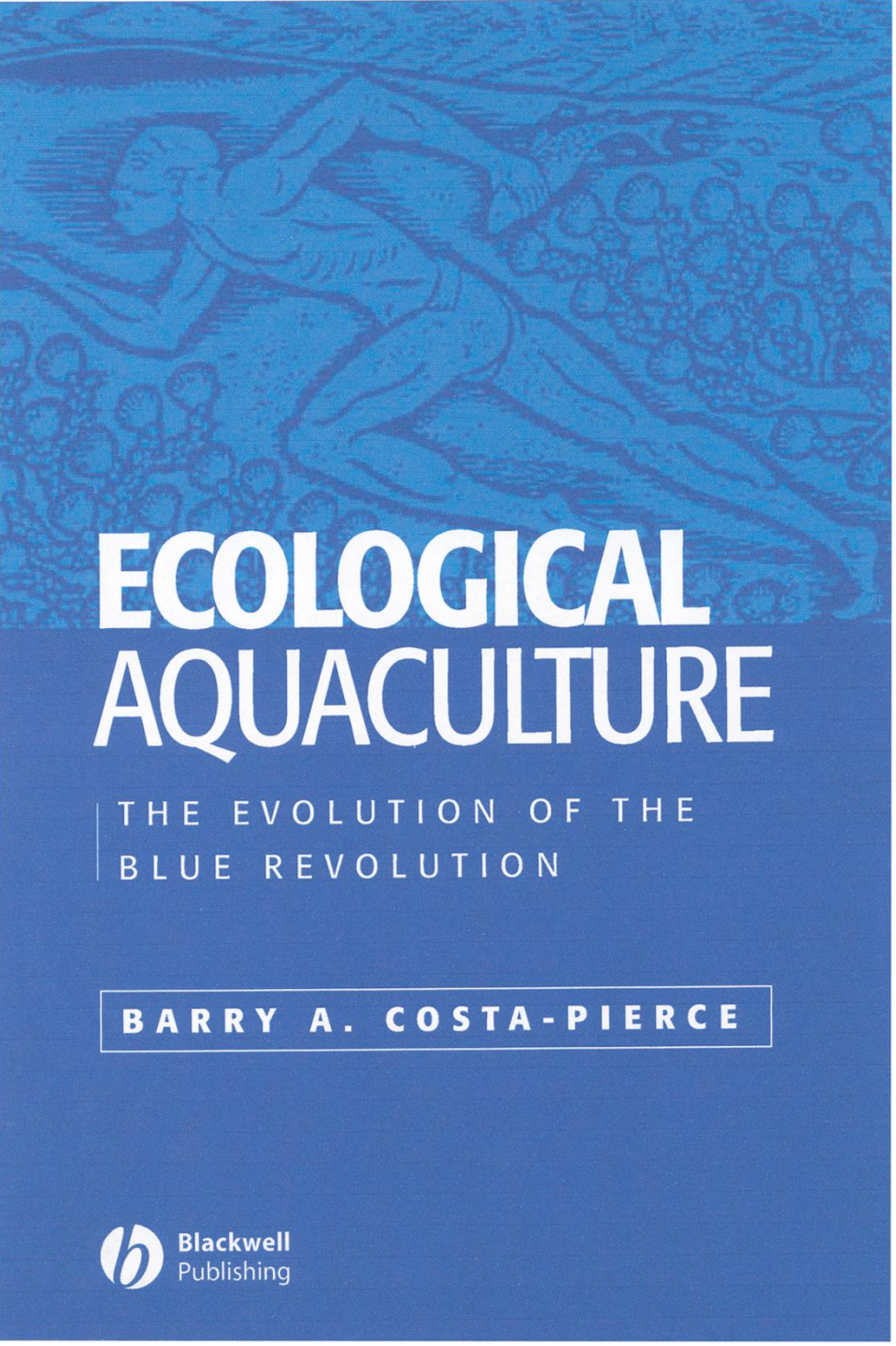
* Global Population Lives in Mega-Cities - 40% Along the World's Coasts (100 km)

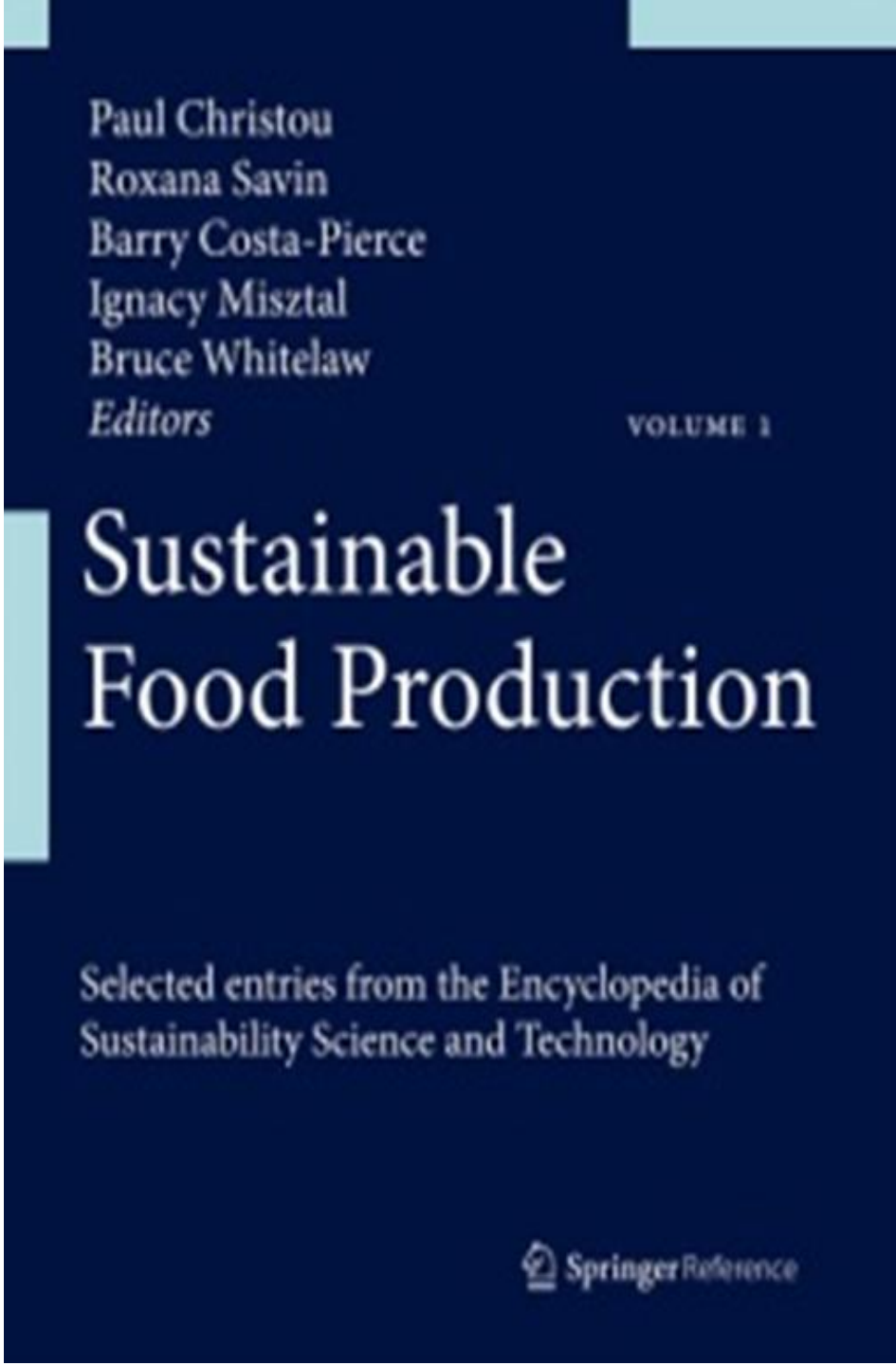
* Migration and Mobility Increasing from Desperation (Poverty, War, Violence, Climate Crisis)

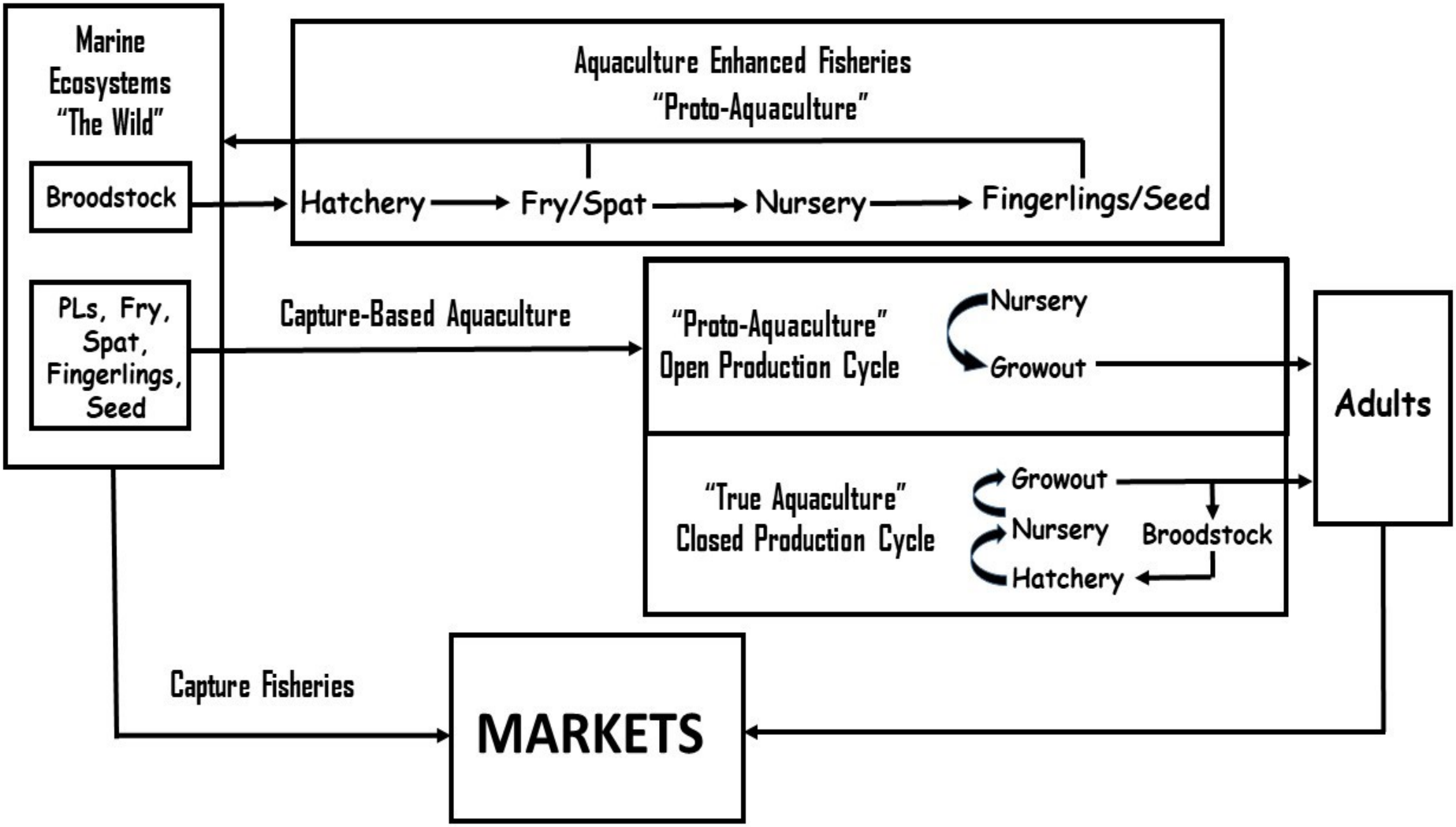



# Radical Transformation of the Global to Local Food Systems – Blue Foods –

## Transdisciplinary
## Transgenerational
## Transformative


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


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




Costa-Pierce, B.A. 2023. Ocean food systems and hybrid seafood production: Transdisciplinary case studies of cod, eels, salmon and lobster. *Sustainable Development Research* 5(1):31-43. https://doi.org/10.30560/sdr.v5n1p31

The ***overall goal*** of ecological aquaculture is the adoption by societies of an accelerated social license to develop aquaculture throughout the World, especially 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.

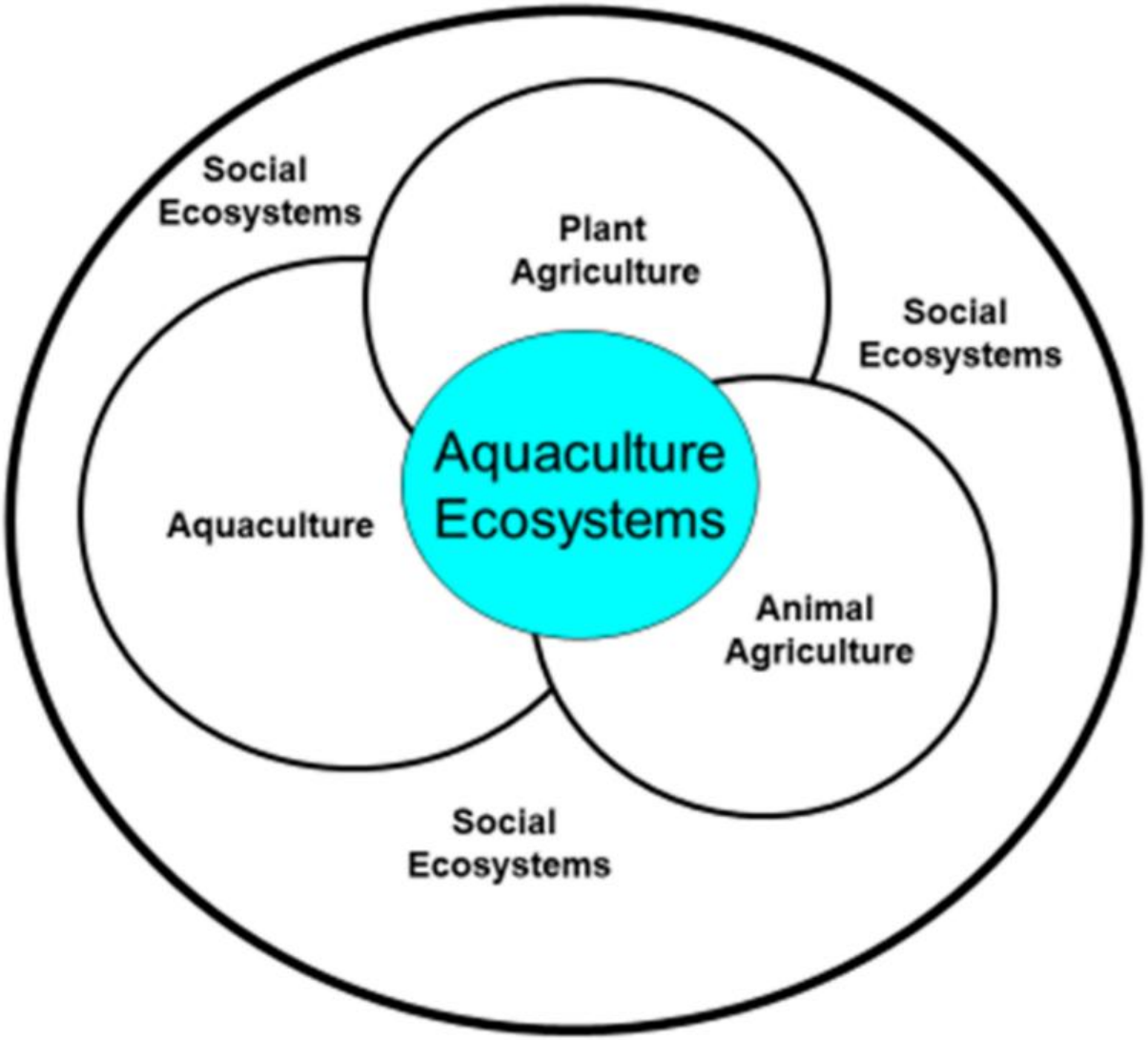
# Aquaculture Ecosystems

## SEAS: Sustainable Ecological Aquaculture Systems


SEAS: Sustainable Ecological Aquaculture Systems
Inland Aquaculture ("land-based")
Integrated Aquaculture
Food Systems

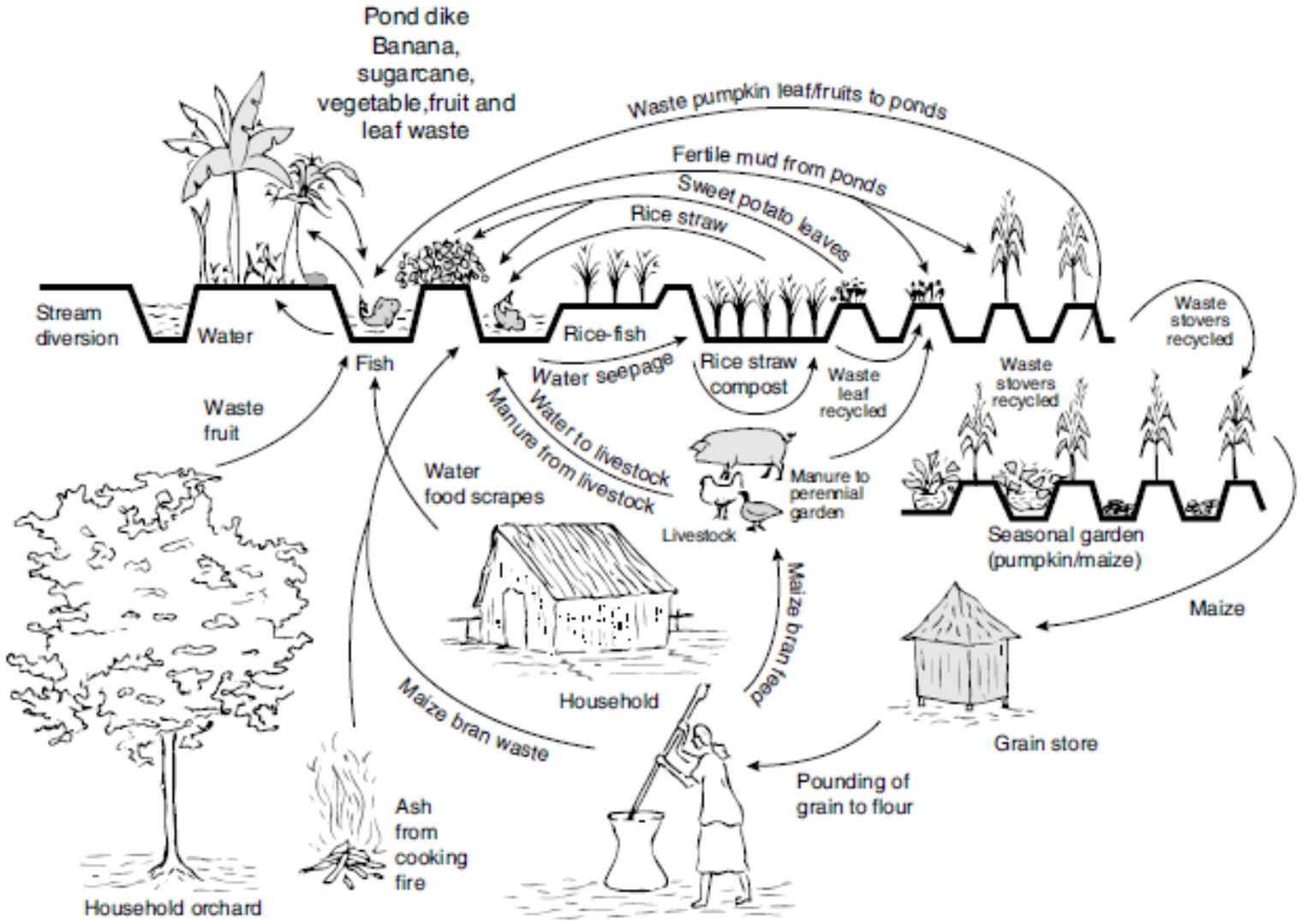
***Table 3a.*** *Top Ten Global Aquaculture Nations and Principal Species in 2014 (FAO, 2016).*

| 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.

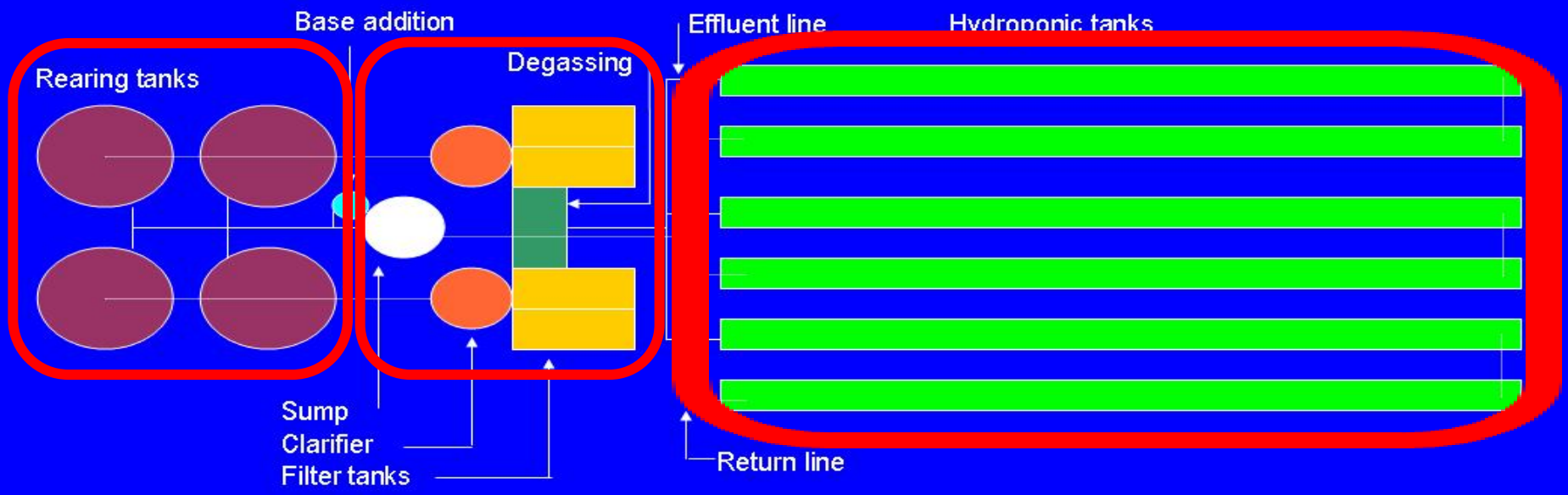
*Ecological Aquaculture: The Evolution of the Blue Revolution*
Edited by Barry A. Costa-Pierce


Chapter 9

# An Integrated Fish and Field Crop System for Arid Areas

*James E. Rakocy*
*University of the Virgin Islands*

# UVI Aquaponic System




Graphic: UVI Aquaculture Program

# Indonesian Aquaponics Bumina and Yumina


| | Sizes $m^2$ | Production per year |
|---|---|---|
| Fish | 3,716 | 72,575 kg (72.6 MT) |
| Plants | 11,427 | 816,466 kg (816.5 MT) |
| TOTALS | 15,143 | 889,041 kg (889.0 MT) |

**@FCR 1.1 x 72.6 MT fish =**
**79.9 MT feed yields 889.0 MT FOOD**

**FEED/FOOD RATIO 0.09**

**1 kg feed produces 11.1 kg food**

# Urban Aquaculture

Edited by
B. Costa-Pierce, A. Desbonnet, University of Rhode Island, USA,
P. Edwards, Asian Institute of Technology, Thailand, and
D. Baker, Cornell University, USA.

**The world is in the midst of the greatest human migration of all time, with millions of people moving from rural, inland areas to coastal cities. Meeting the basic human needs for protein foods in the future will be a difficult challenge. Fishery products are the world's most important source of animal protein, especially for the poor. This has led to a doubling of the demand for fish since the 1950s. As we can not expect to catch more food from the sea, we must turn to farming the waters, not just hunting them. The new challenge for planners now is to accelerate aquaculture development and to plan for new production, making urban areas not only centres of marketing and distribution, but also of production, particularly using recycled urban wastewater. This book includes papers from authors in the USA, Europe and Asia that review these developing issues from the perspective of both developed and developing countries. This book will be of significant interest to those researching or working in aquaculture, water resources, urban planning and geography.**

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875 Massachusetts Avenue, 7th Floor, Cambridge, MA 02139, USA.




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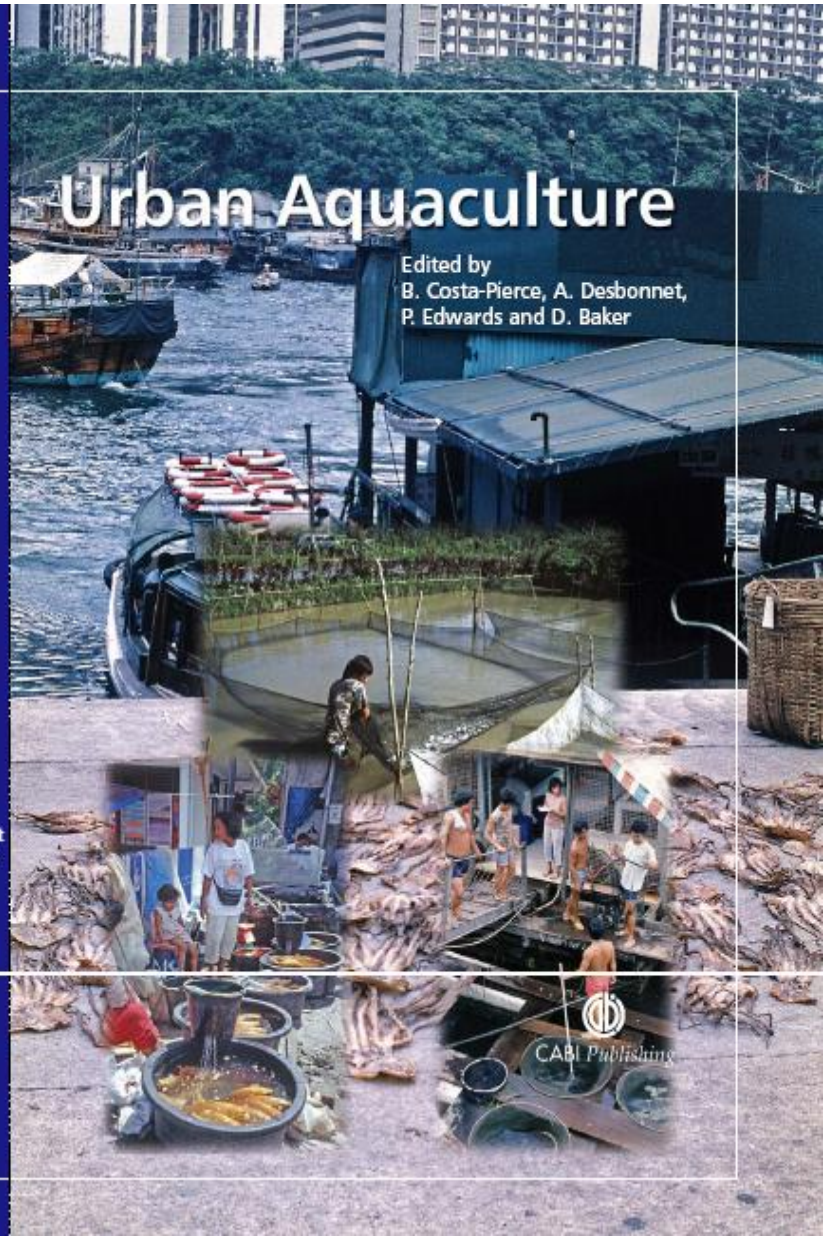
6mm from trimmed edge and spine fold

Urban Aquaculture

Costa-Pierce
Desbonnet
Edwards
Baker

CABI




SEAS: Sustainable Ecological Aquaculture Systems
Ocean Aquaculture
Ocean Food Systems

# MARINE ALGAE

# SEA VEGETABLES!

Fed Aquaculture
(Finfish)

Suspension Extractive
Aquaculture

Organic
(Shellfish)

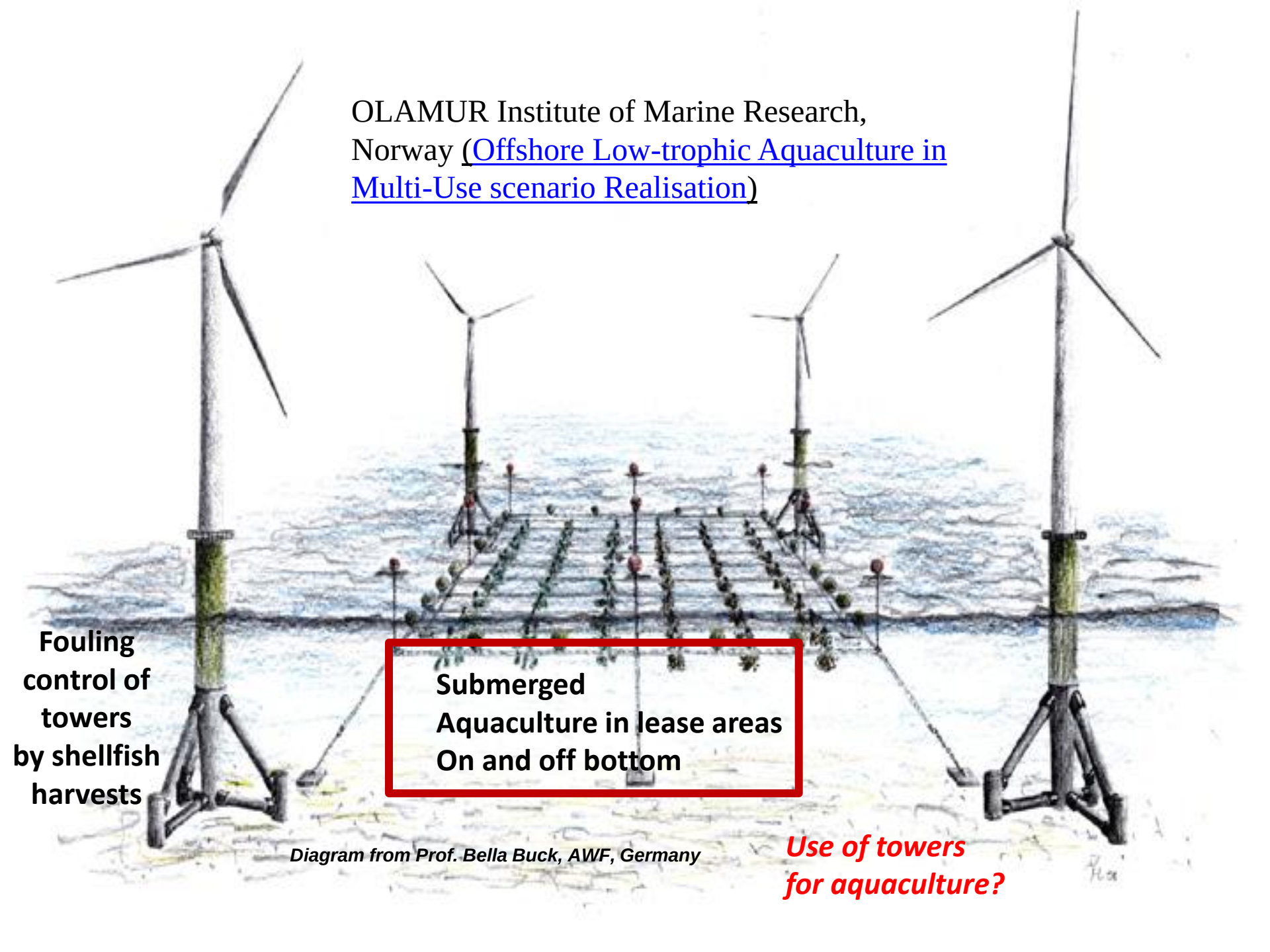
Inorganic
(Seaweeds)

Deposit Extractive
Aquaculture
(Invertebrates)

IMTA

20-30% of production


“Jackets”
Beatrice Wind Farm, U.K.


OLAMUR Institute of Marine Research, Norway (Offshore Low-trophic Aquaculture in Multi-Use scenario Realisation)
Fouling control of towers by shellfish harvests
Submerged Aquaculture in lease areas On and off bottom
Diagram from Prof. Bella Buck, AWF, Germany
Use of towers for aquaculture?

Scale is one of the most controversial aspects of marine aquaculture today

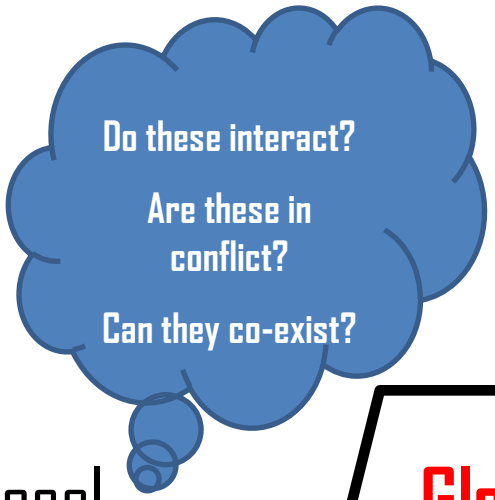
Scaling issues play a central role in the political and regulatory obstacles to advancing marine aquaculture

**Nearshore oceans are common property resource areas**

Scale

HyperLocal

Small




Global

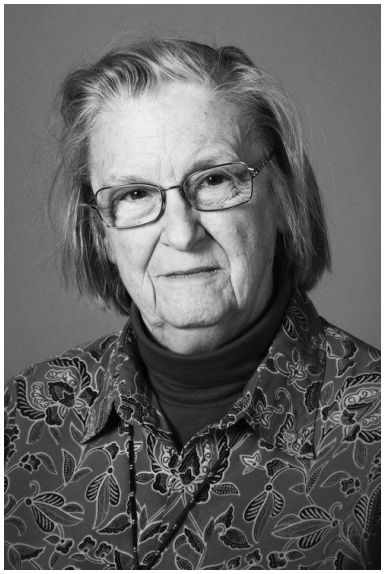
Intensive

# Common Property Resources

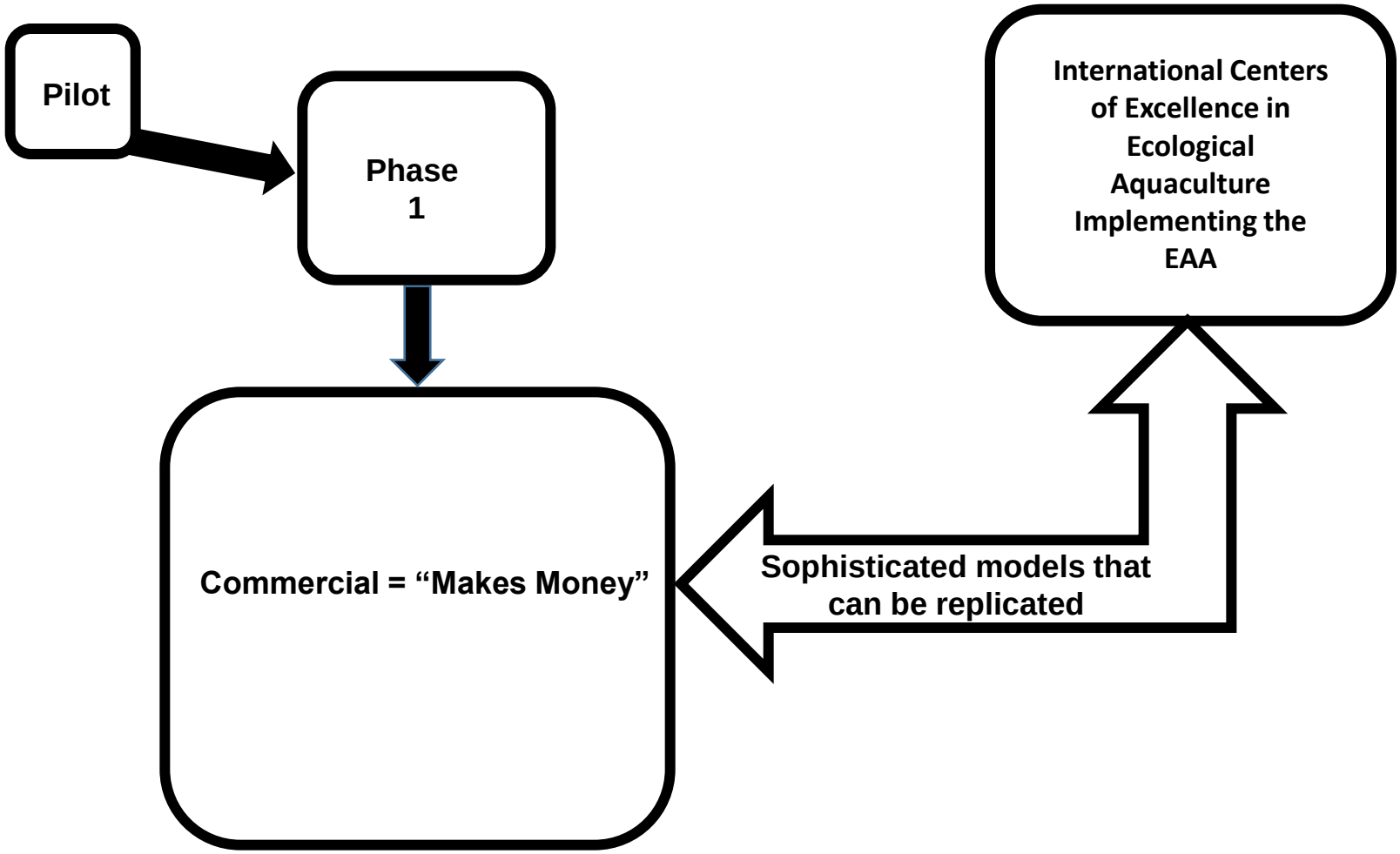
**Hardin's**
**Tragedy of the Commons**

**vs.**

**Ostrom's**
**Enlightened Self Interest**



**TRAGEDY OF THE UNMANAGED COMMONS!**


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

# Development Models for Scaling Aquaculture

Pilot

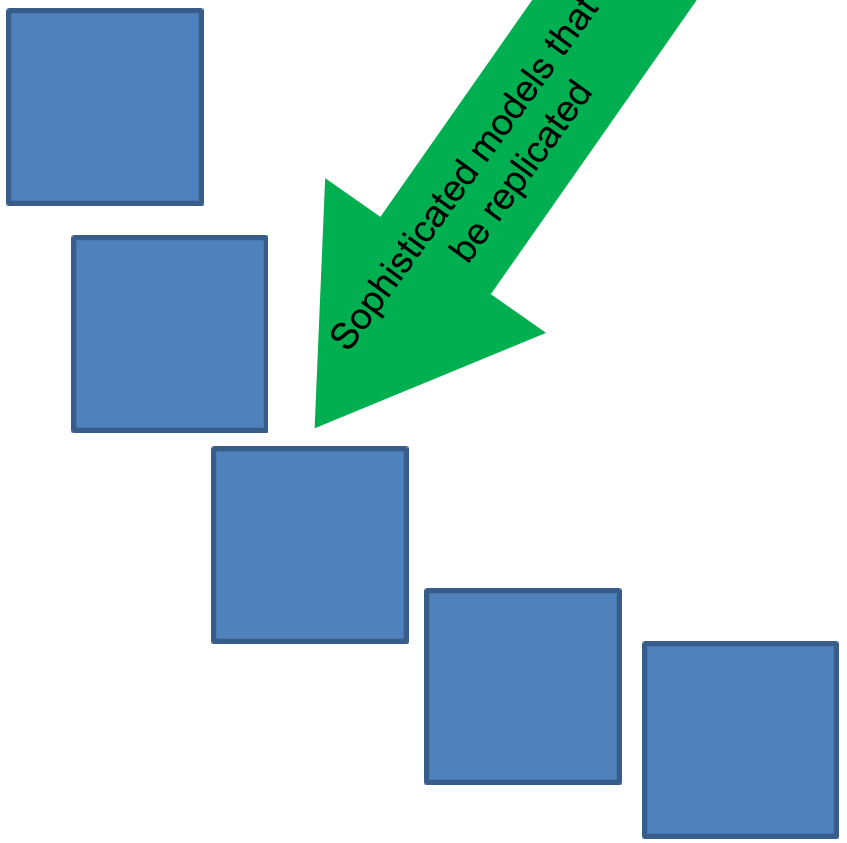
Phase 1

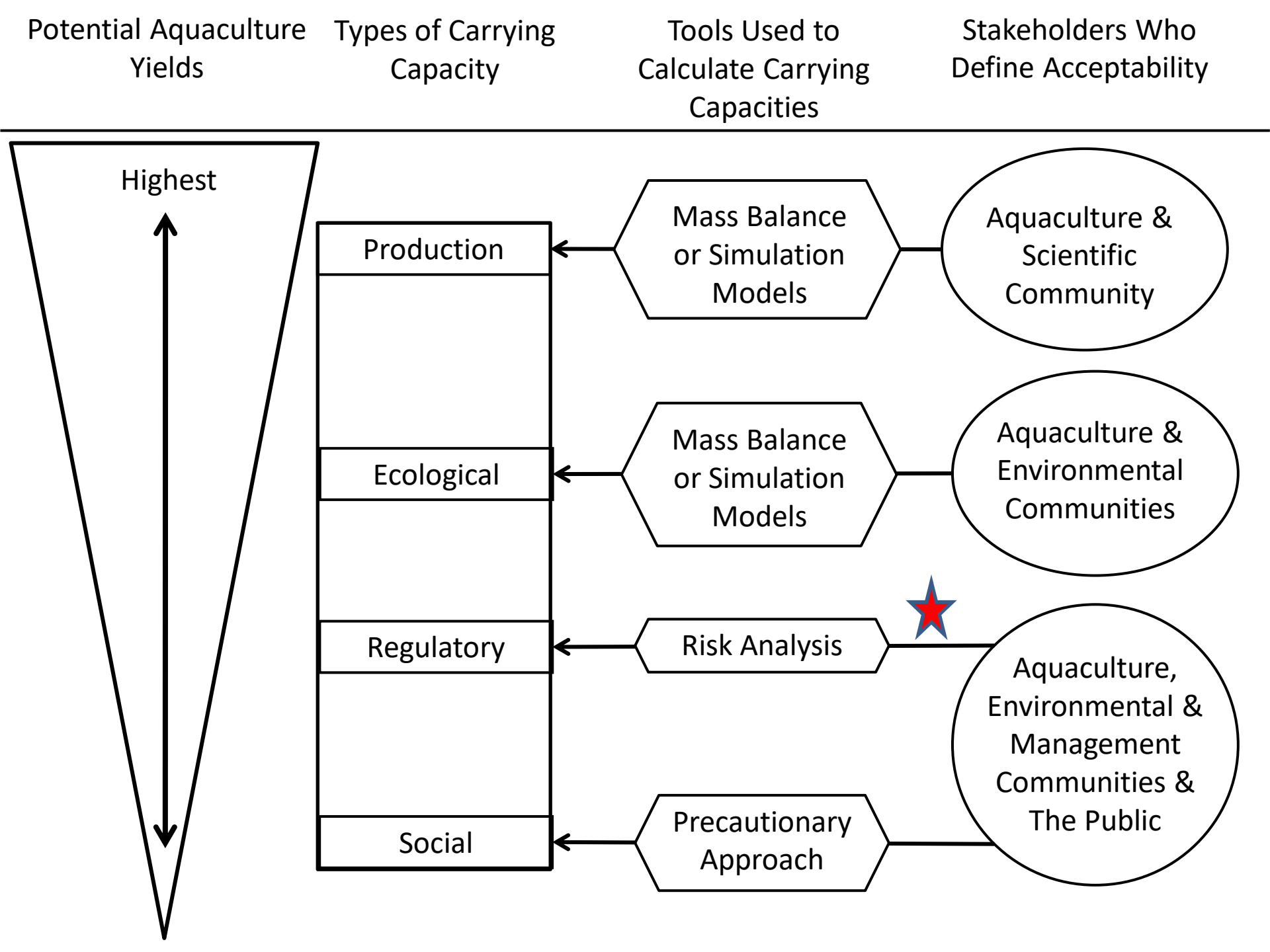
Commercial = "Makes Money"

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

Ecological Aquaculture Centers to Implement EAA

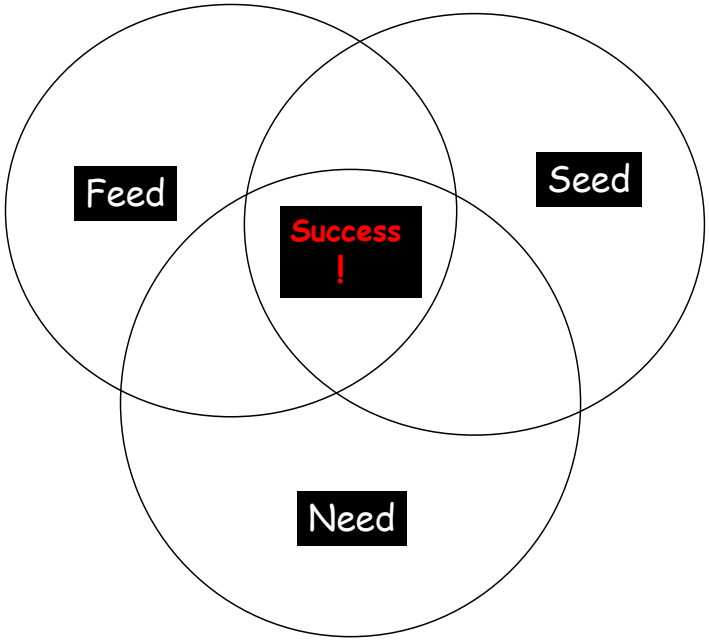
Sophisticated models that can be replicated



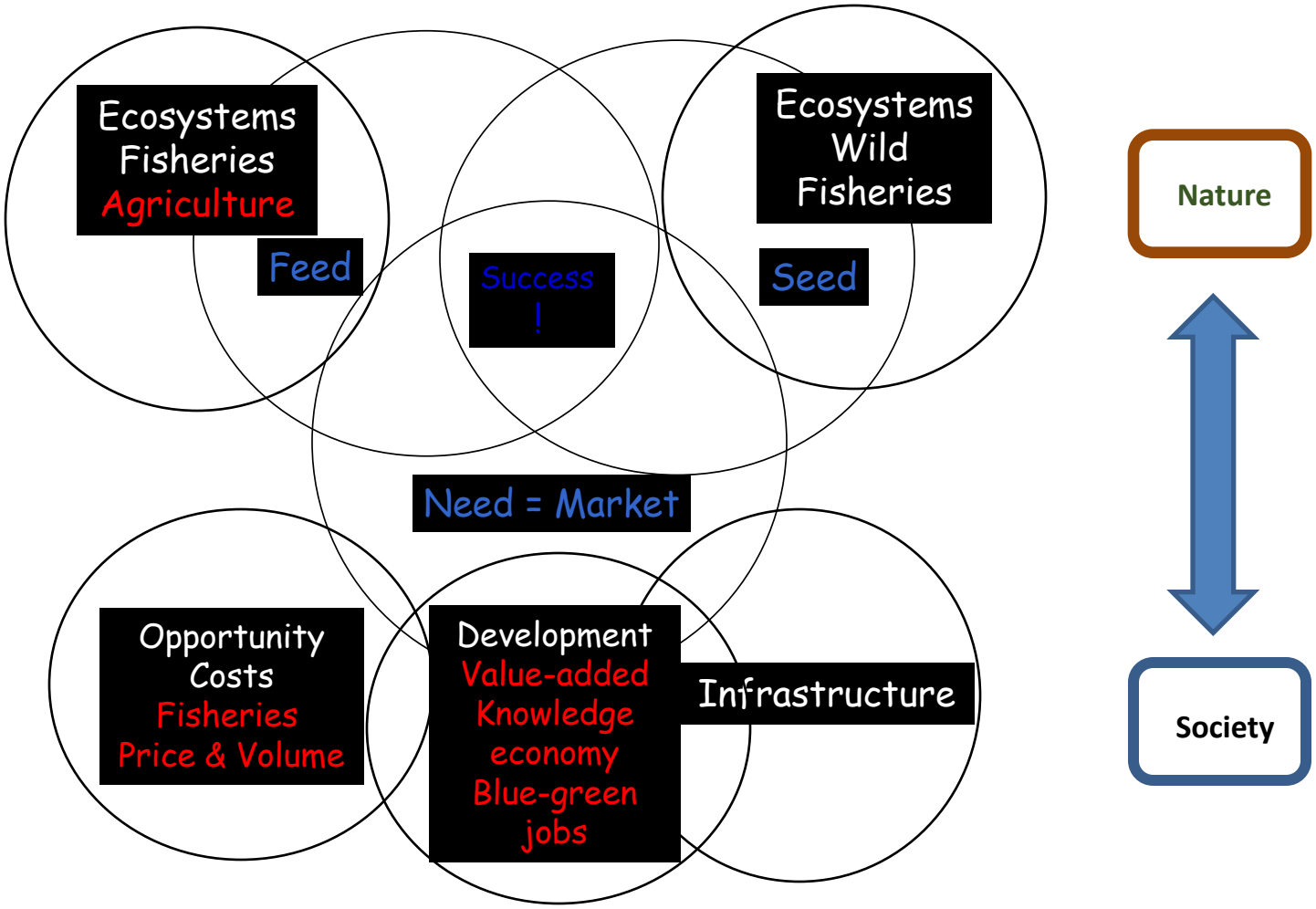

Potential Aquaculture Yields
Types of Carrying Capacity
Tools Used to Calculate Carrying Capacities
Stakeholders Who Define Acceptability
Highest
Production
Ecological
Regulatory
Social
Mass Balance or Simulation Models
Mass Balance or Simulation Models
Risk Analysis
Precautionary Approach
Aquaculture & Scientific Community
Aquaculture & Environmental Communities
Aquaculture, Environmental & Management Communities & The Public

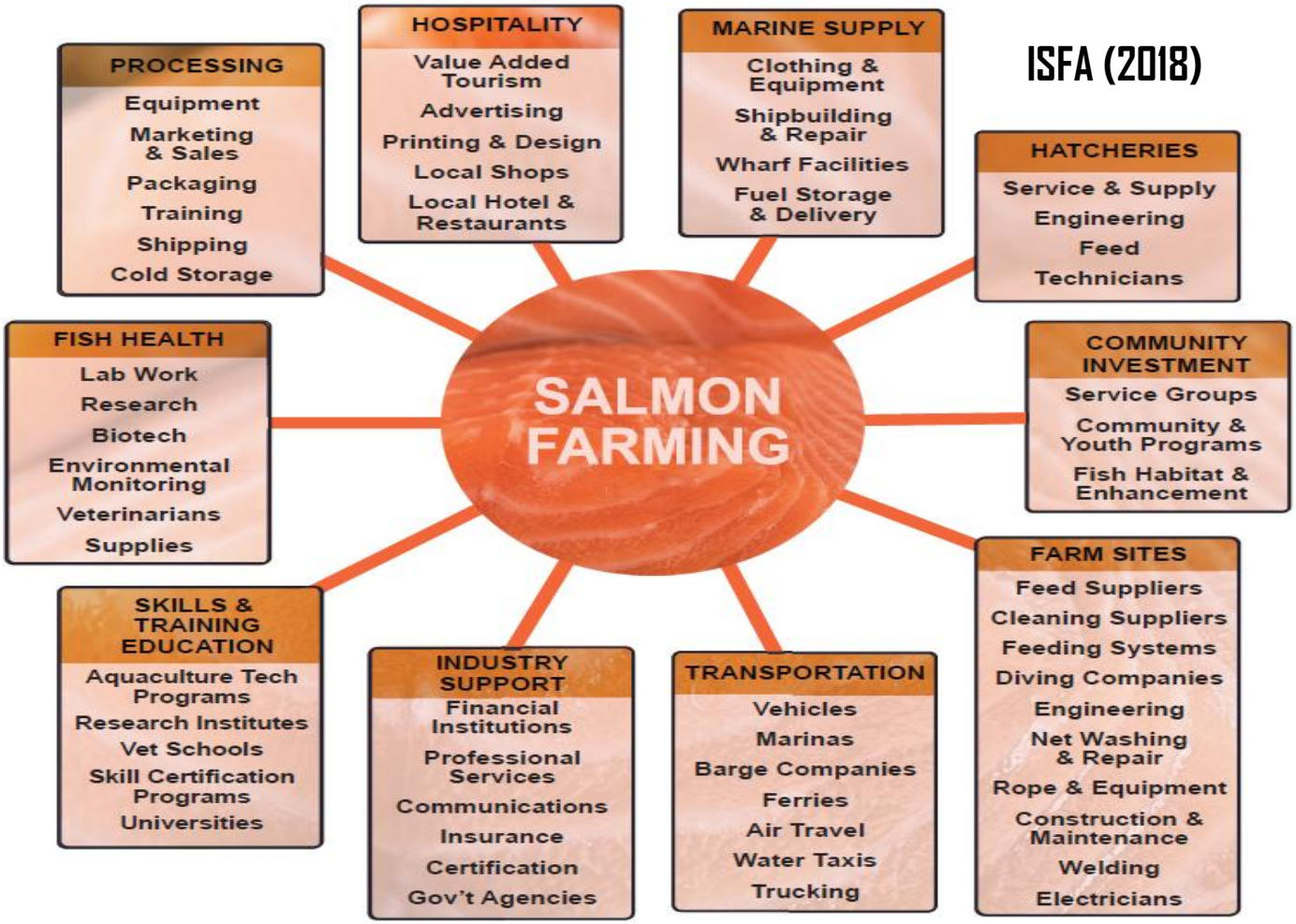
Most aquaculture development occurs in rural areas

# Aquaculture Business Success



# Society's Success




SALMON FARMING
PROCESSING
Equipment
Marketing & Sales
Packaging
Training
Shipping
Cold Storage
HOSPITALITY
Value Added Tourism
Advertising
Printing & Design
Local Shops
Local Hotel & Restaurants
MARINE SUPPLY
Clothing & Equipment
Shipbuilding & Repair
Wharf Facilities
Fuel Storage & Delivery
HATCHERIES
Service & Supply
Engineering
Feed
Technicians
FISH HEALTH
Lab Work
Research
Biotech
Environmental Monitoring
Veterinarians
Supplies
COMMUNITY INVESTMENT
Service Groups
Community & Youth Programs
Fish Habitat & Enhancement
SKILLS & TRAINING EDUCATION
Aquaculture Tech Programs
Research Institutes
Vet Schools
Skill Certification Programs
Universities
INDUSTRY SUPPORT
Financial Institutions
Professional Services
Communications
Insurance
Certification
Gov't Agencies
TRANSPORTATION
Vehicles
Marinas
Barge Companies
Ferries
Air Travel
Water Taxis
Trucking
FARM SITES
Feed Suppliers
Cleaning Suppliers
Feeding Systems
Diving Companies
Engineering
Net Washing & Repair
Rope & Equipment
Construction & Maintenance
Welding
Electricians

ISFA (2018)

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.


https://www.mianpo.org/

***The Kaua'i, Hawai'i partnership with Kaua'I Sea Farms LLC is located on the southern shores of Kaua'I Island in the Hawaiian Archipelago in the Central Pacific Ocean. EAF recognizes it is owned and located on lands of the Hawaiian Nation whose sovereign rights were stolen and sacred sites desecrated by colonialism, racism and hatred. EAF recognizes the Hawaiian owners as distinct, sovereign, legal and political entities with self-governance and self-determination.***

***The Maine, USA office and 2 ha farm of the Ecological Aquaculture Foundation is located about 1 km inland from the North Atlantic Ocean. EAF 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. EAF 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.***

# PRINCIPLES OF SERVICE

**Track to The EARTH CHARTER and the United Nations SDGs**

**Prioritize decolonization and inclusion of the full panoply of human diversity**


**Integrate an entrepreneurial mindset to business development building full cost, circular bioeconomies**

**Consider PLANETARY BOUNDARIES**

Muchas Gracias !

Thank you !

Mahalo !

Tusen Takk !

Ecological Aquaculture Foundation

https://oceanfoods.org

EARTH
OCEAN FOOD SYSTEMS
ETHOS