

Restorative Aquaculture

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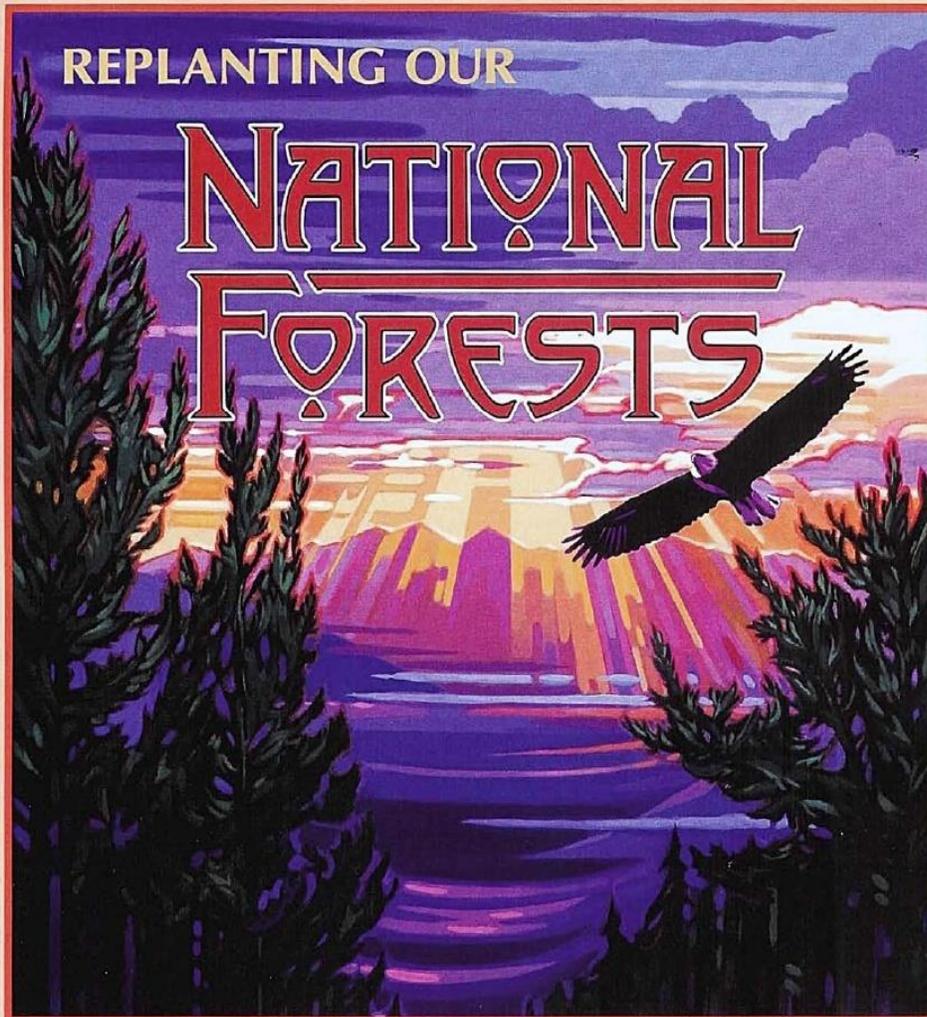
Alleway, H. K., Waters, T. J., Brummett, R., Cai, J., Cao, L., Cayten, M. R., Costa-Pierce, B. A., Dong, Y.-W., Brandstrup Hansen, S. C., Liu, S., Liu, Q., Shelley, C., Theuerkauf, S. J., Tucker, L., Wang, Y., & Jones, R. C. 2023. Global principles for restorative aquaculture to foster aquaculture practices that benefit the environment. *Conservation Science and Practice*, e12982.
<https://doi.org/10.1111/csp2.12982>

Costa-Pierce, B.A. 2024. Restorative aquaculture for people, profit and planet. *INFOFISH International (FISHINFO Network, United Nations Food and Agriculture Organization)*, 3: 49-54.

“Nature supports humanity through the delivery of ecosystem services, such as the provision of food and raw materials, the maintenance of clean air and water, and the creation of spiritual and cultural connections that foster well-being.”

Alleway et al. 2019

The Ecosystem Services of Marine Aquaculture: Valuing Benefits to People and Nature. *BioScience* (2019), 69: 59–68, <https://doi.org/10.1093/biosci/biy137>



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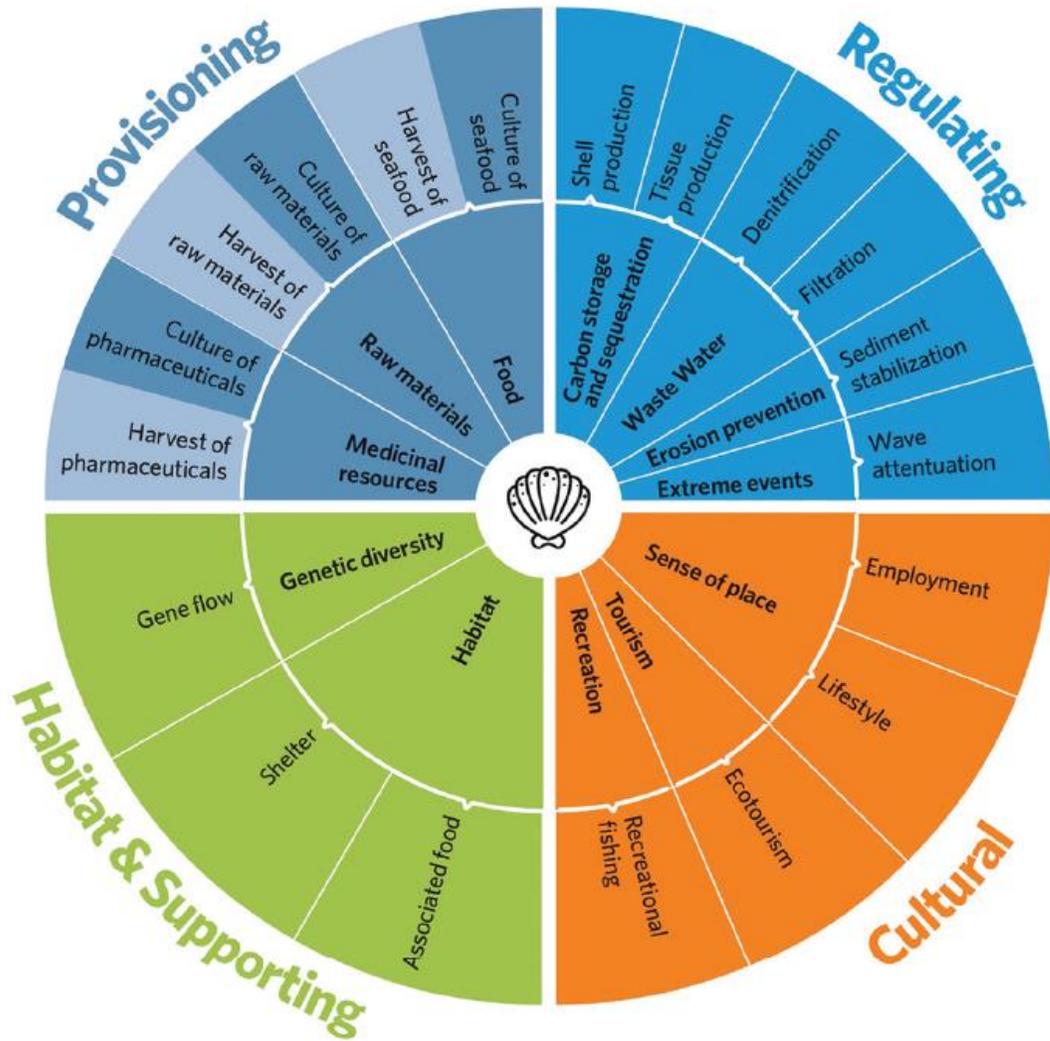
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What are ecosystem services?



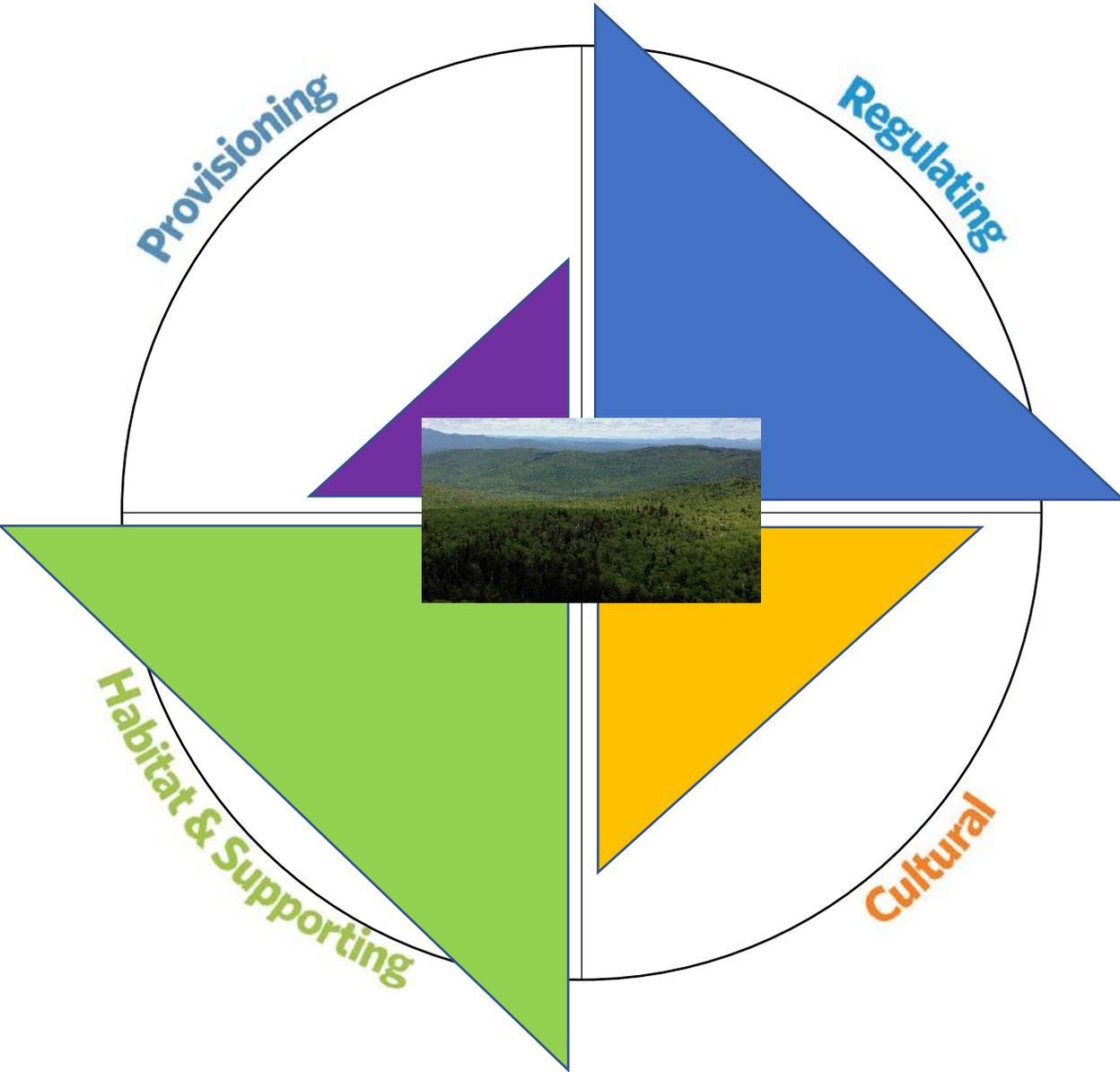
Provisioning Services are ecosystem services that describe the material or energy outputs from ecosystems. They include food, water and other resources.

Regulating Services are the services that ecosystems provide by acting as regulators eg. regulating the quality of air and soil or by providing flood and disease control.

Habitat and Supporting Services allow the Earth to sustain basic life forms and whole ecosystems and people. Without supporting services, provisional, regulating, and cultural services cannot exist.

Cultural Services are a non-material benefits that contribute to the development and cultural advancement of people, including how ecosystems play a role in local, national, and global cultures; the building of knowledge and the spreading of ideas; creativity born from interactions with nature (music, art, architecture); and recreation.

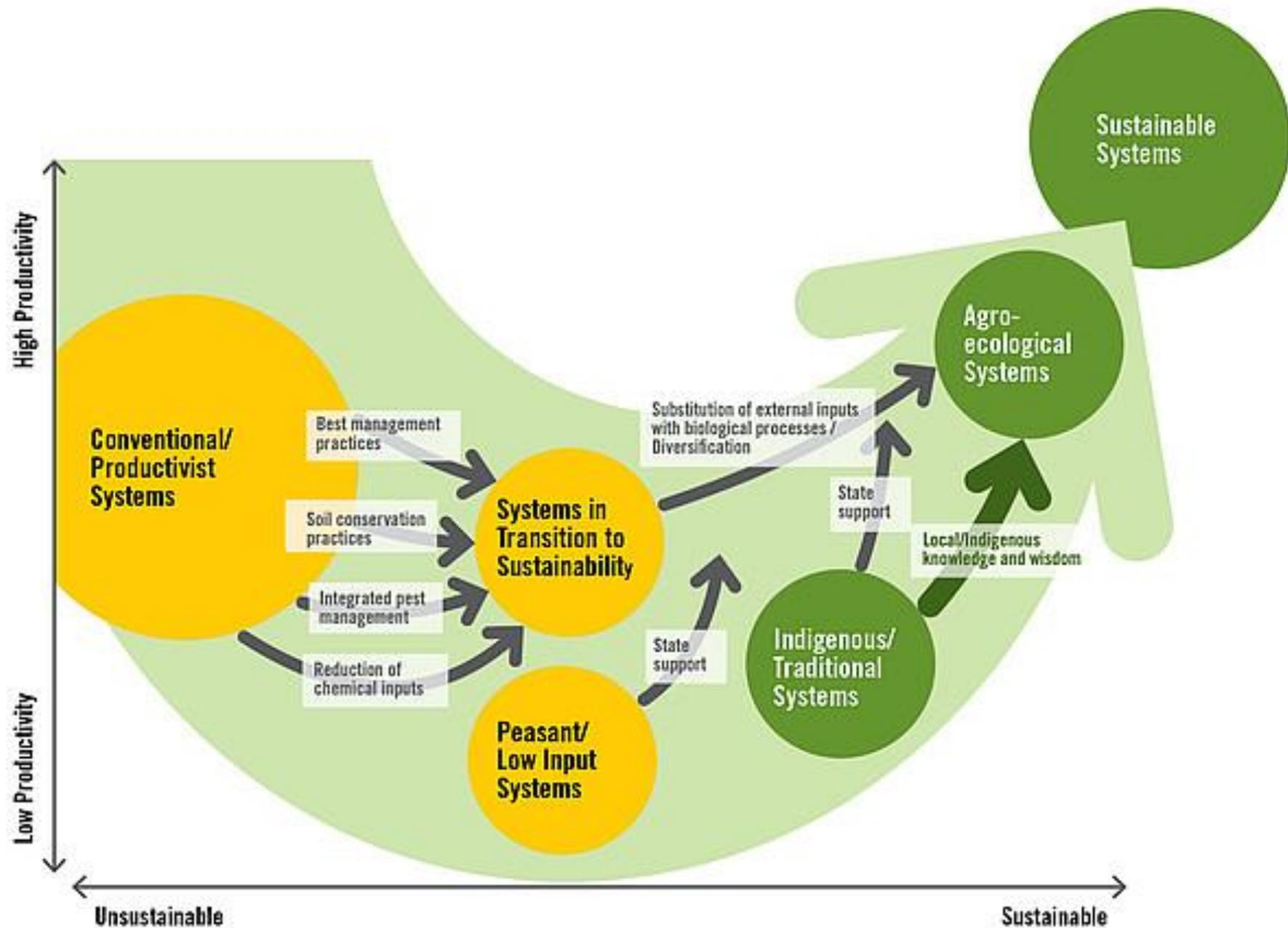
Natural Ecosystem



Managed Ecosystem



How does aquaculture contribute to ecosystem services?



“Basal Ecosystem”
The ecosystem and
associated functions

Prior to agricultural
intervention



what was added, what was removed?

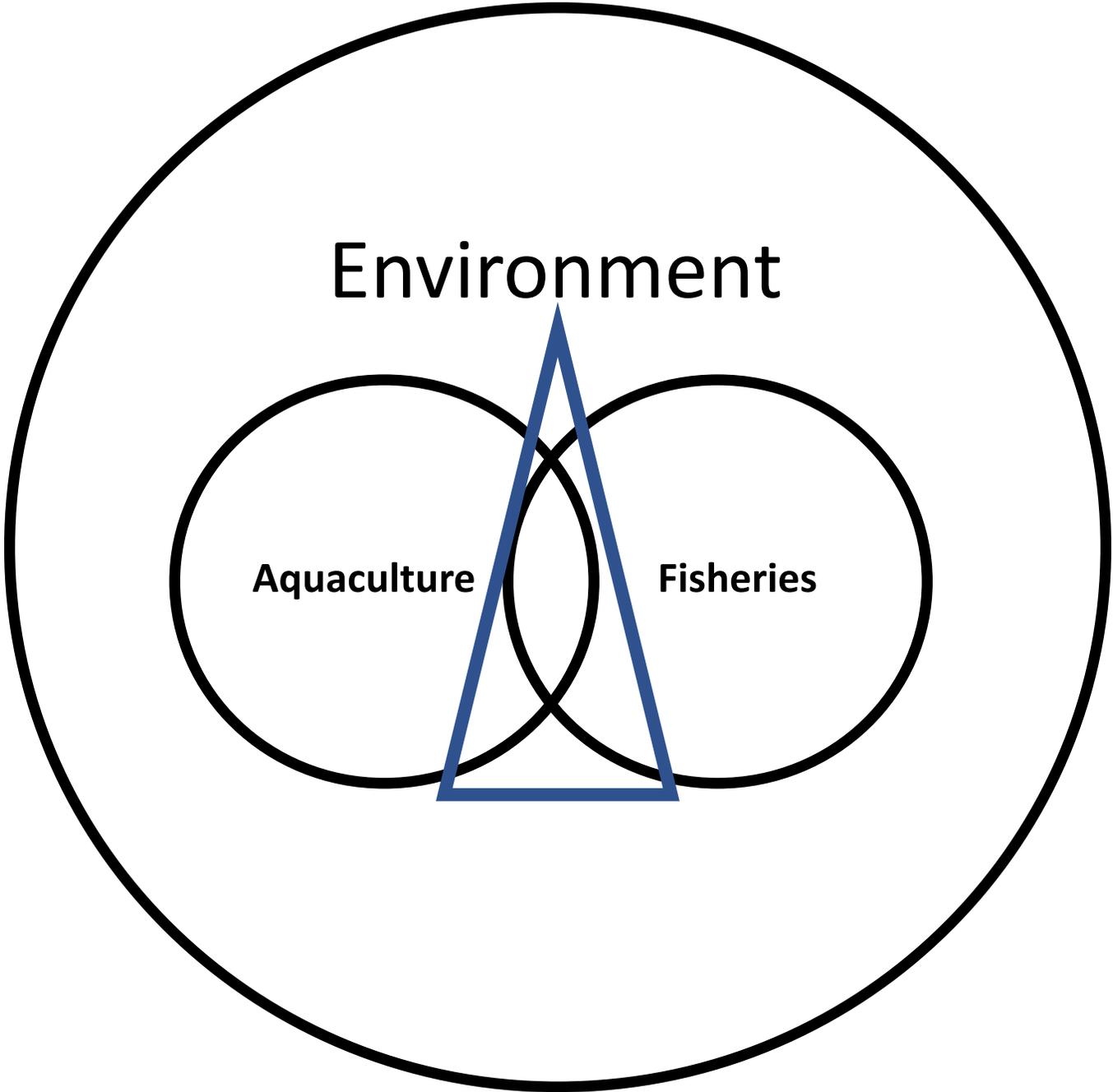


Agroecology: what was added, what was removed?



What about this? What was added? What was removed?





Environment

Aquaculture

Fisheries

Restorative Aquaculture 24 years ago!

Costa-Pierce, B.A. and C.J. Bridger. 2002. The role of marine aquaculture facilities as habitats and ecosystems, p. 105-144. In: R. Stickney & J. McVey (Eds.) *Responsible Marine Aquaculture*. CABI Publishing Co., Wallingford, U.K.

USE THE Aquaculture Toolbox

to

Restore Marine Fisheries,
Marine Ecosystems and Coastal
Societies

*Beyond old arguments, artificial
divides and balkanization*

The “aquaculture toolbox”

Conservation/Restorative Aquaculture

Marine Agronomy for Environmental Rehabilitation & Enhancement

- *Spartina* Aquaculture
- Mangrove Aquaculture
- Seagrass Aquaculture
- Live Rock Aquaculture

Coastal Wetland Habitats

Nearshore Habitats

Reef Habitats

Costa-Pierce, B.A. and C.J. Bridger. 2002. The role of marine aquaculture facilities as habitats and ecosystems, p. 105-144. In: R. Stickney & J. McVey (Eds.) Responsible Marine Aquaculture. CABI Publishing Co., Wallingford, U.K.



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An effective seed protection method for planting *Zostera marina* (eelgrass) seeds: Implications for their large-scale restoration



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ABSTRACT

We describe an innovative method of planting *Zostera marina* (eelgrass) seeds in which hessian bags filled with high-silted sediments are used as a seed protecting device. Here, we evaluated the effectiveness of the method through a field seed-sowing experiment over a three year period. The suitable seed planting density required by the seeds of *Z. marina* in this method was also investigated. In the spring following seed distribution, seedling establishment rate of *Z. marina* subjected to different seed densities of 200–500 seeds bag⁻¹ ranged from 16% to 26%. New eelgrass patches from seed were fully developed and well maintained after 2–3 years following distribution. The seed planting density of 400 seeds bag⁻¹ may be the most suitable for the establishment of new eelgrass patches. Our results demonstrate that seed-based restoration can be an effective restoration tool and the technique presented should be considered for future large-scale *Z. marina* restoration projects.

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Farming the reef: is aquaculture a solution for reducing fishing pressure on coral reefs?

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Ecological engineering for successful management and restoration of mangrove forests

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Received 2 January 2004; received in revised form 22 September 2004; accepted 29 October 2004

Abstract

Great potential exists to reverse the loss of mangrove forests worldwide through the application of basic principles of ecological restoration using ecological engineering approaches, including careful cost evaluations prior to design and construction. Previous documented attempts to restore mangroves, where successful, have largely concentrated on creation of plantations of mangroves consisting of just a few species, and targeted for harvesting as wood products, or temporarily used to collect eroded soil and raise intertidal areas to usable terrestrial agricultural uses. I document here the importance of assessing the existing hydrology of natural extant mangrove ecosystems, and applying this knowledge to first protect existing mangroves, and second to achieve successful and cost-effective ecological restoration, if needed. Previous research has documented the general principle that mangrove forests worldwide exist largely in a raised and sloped platform above mean sea level, and inundated at approximately 30%, or less of the time by tidal waters. More frequent flooding causes stress and death of these tree species. Prevention of such damage requires application of the same understanding of mangrove hydrology.

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Keywords: Mangrove forests; Restoration of mangrove forests; Ecological restoration; Mangroves



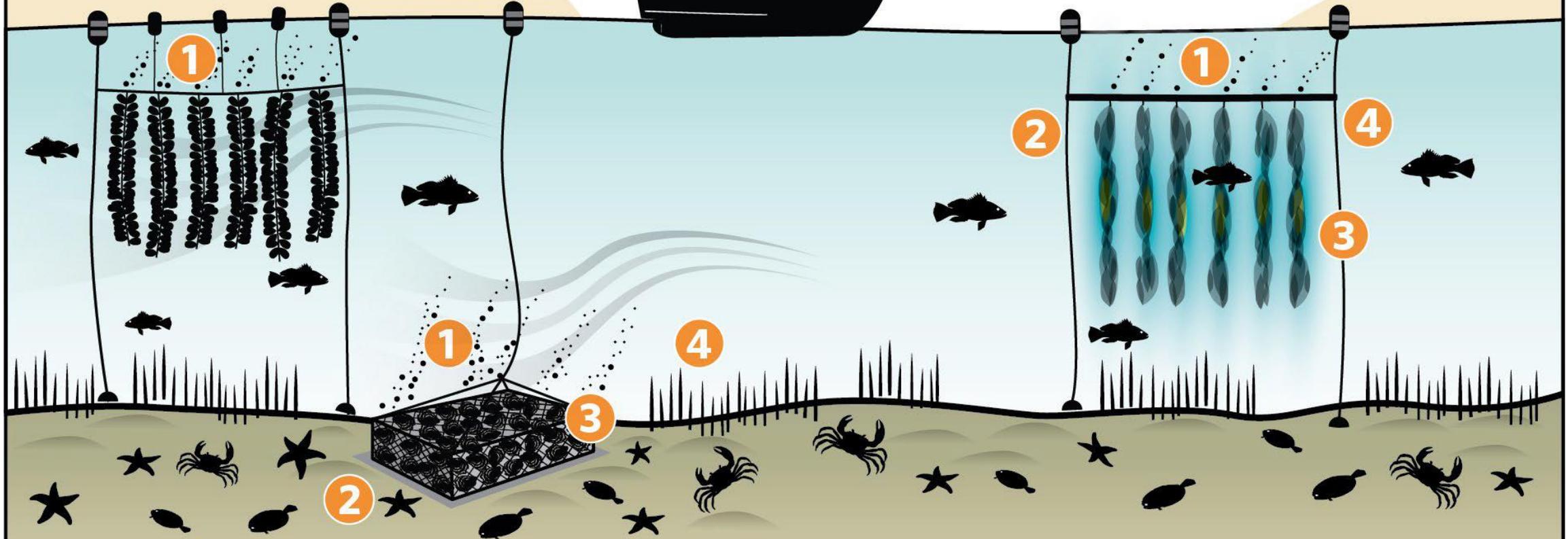


The Nature Conservancy (Alleway, H., R. Brummett, J. Cai, L. Cao, M. R. Cayten, B.A. Costa-Pierce, P. Dobbins, Y-w Dong, S.C. Brandstrup Hansen, R. Jones, S. Liu, Q. Liu, C.C. Shelley, S. Theuerkauf, L. Tucker, T. Waters, and Y. Wang). 2021. *Global Principles of Restorative Aquaculture*. The Nature Conservancy, Arlington, VA.

https://www.nature.org/content/dam/tnc/nature/en/documents/TNC_PrinciplesofRestorativeAquaculture.pdf

Shellfish Farming

Seaweed Farming



1 Mitigate Nutrient Pollution

2 Provide Habitats

3 Support Fish Stocks

4 Reduce Local Climate Change Impacts

Regulating

Habitat/Supporting

Provisioning/Supporting

Regulating





Aquaculture and Nature-based Solutions

Identifying synergies between sustainable development of coastal communities, aquaculture, and marine and coastal conservation

R. le Gouvello, C. Brugere and F. Simard



INTERNATIONAL UNION FOR CONSERVATION OF NATURE



Nature-based Solutions



Aquaculture and Marine Protected Areas:

Exploring Potential Opportunities and Synergies



To meet the Convention on Biological Diversity's Aichi Target 11 on marine biodiversity protection, Aichi Target 6 on sustainable fisheries by 2010, as well as the Sustainable Development Goal 14.6 on food security and SDG 14 on oceans, by 2030, there is an urgent need to reconcile nature conservation and sustainable development.

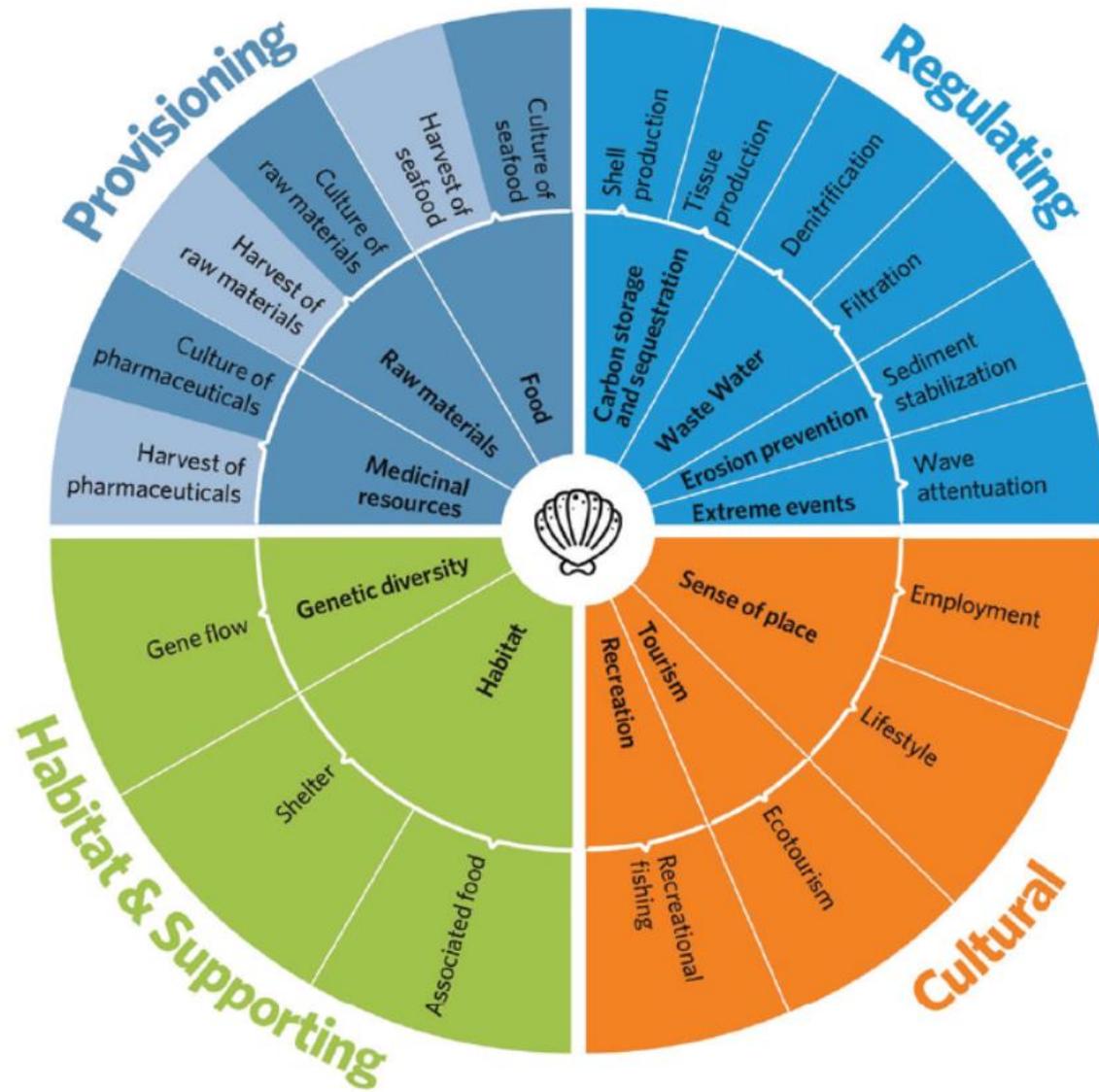
It is also widely recognized that aquaculture significantly contributes to sustaining development in coastal communities and plays a vital role in ensuring food security, poverty alleviation, and economic resilience.

In the framework of integrated management, the time has therefore come to identify the potential opportunities and synergies that can enable aquaculture and conservation to work together more effectively.

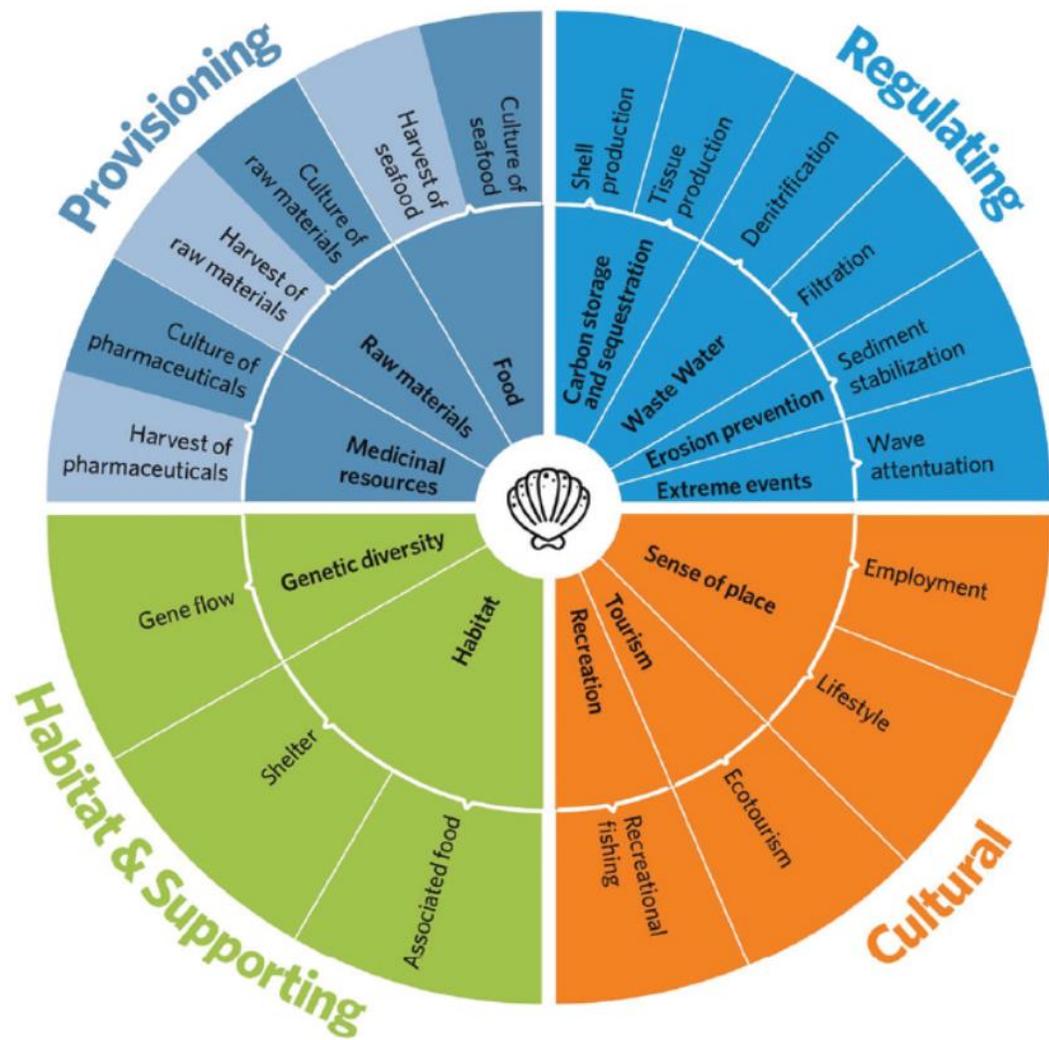


- Understanding the various forms of interactions between aquaculture and marine protected areas
- The types of MPAs and needs of sustainable, healthy aquaculture & sustainable fisheries
- Understanding opportunities and MPA limitations
- Towards policy and operational compatibility and sustainability





The Ecosystem Services of Marine Aquaculture: Valuing Benefits to People and Nature. *BioScience* (2019), 69: 59–68, <https://doi.org/10.1093/biosci/biy137>



Shellfish ecosystems



Shellfish mariculture



Shellfish ecosystems

+

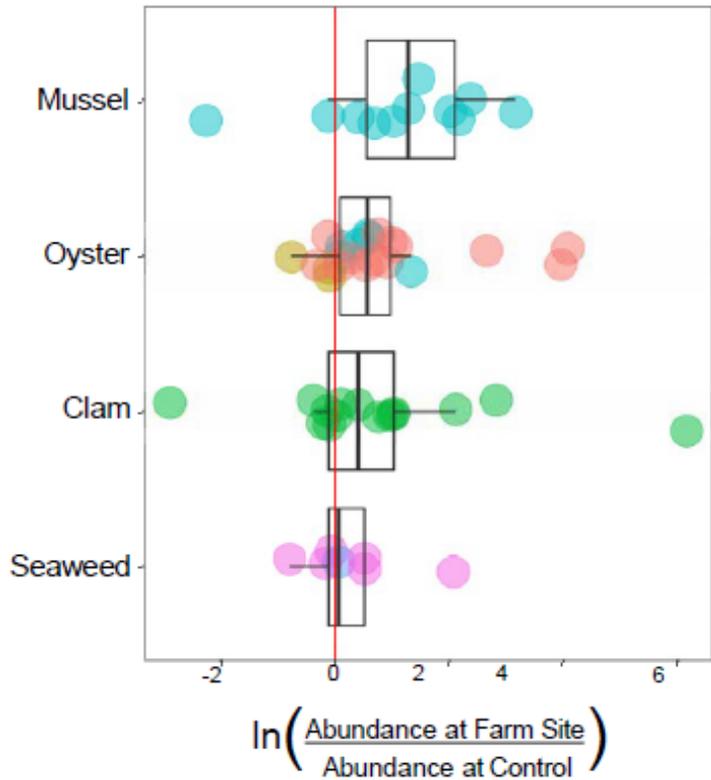


Shellfish mariculture

=

?

Abundance effect



Fish &
Invertebrate
Multiplier

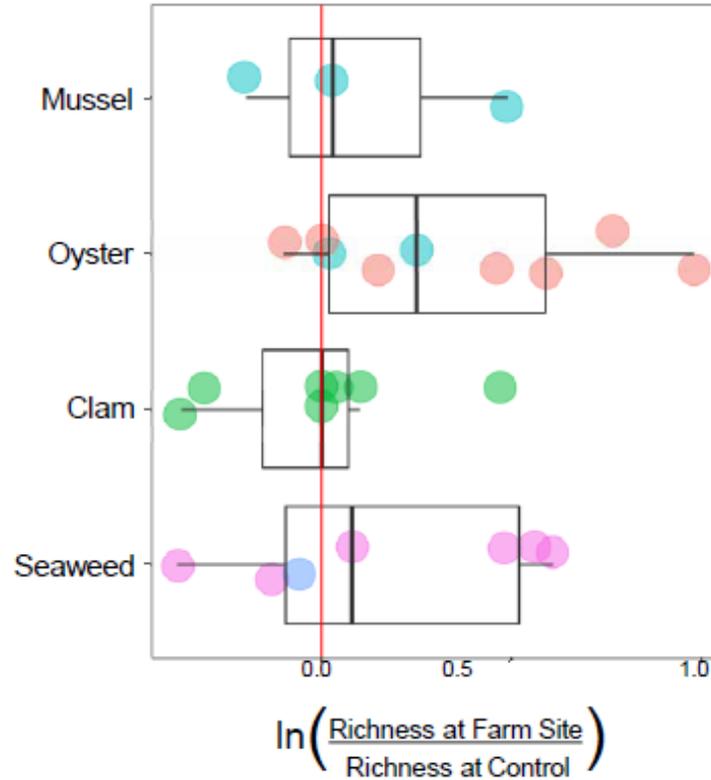
1.1x

1.9x

1.4x

1.1x

Species richness effect



Fish &
Invertebrate
Multiplier

1.1x

1.3x

1.0x

1.2x

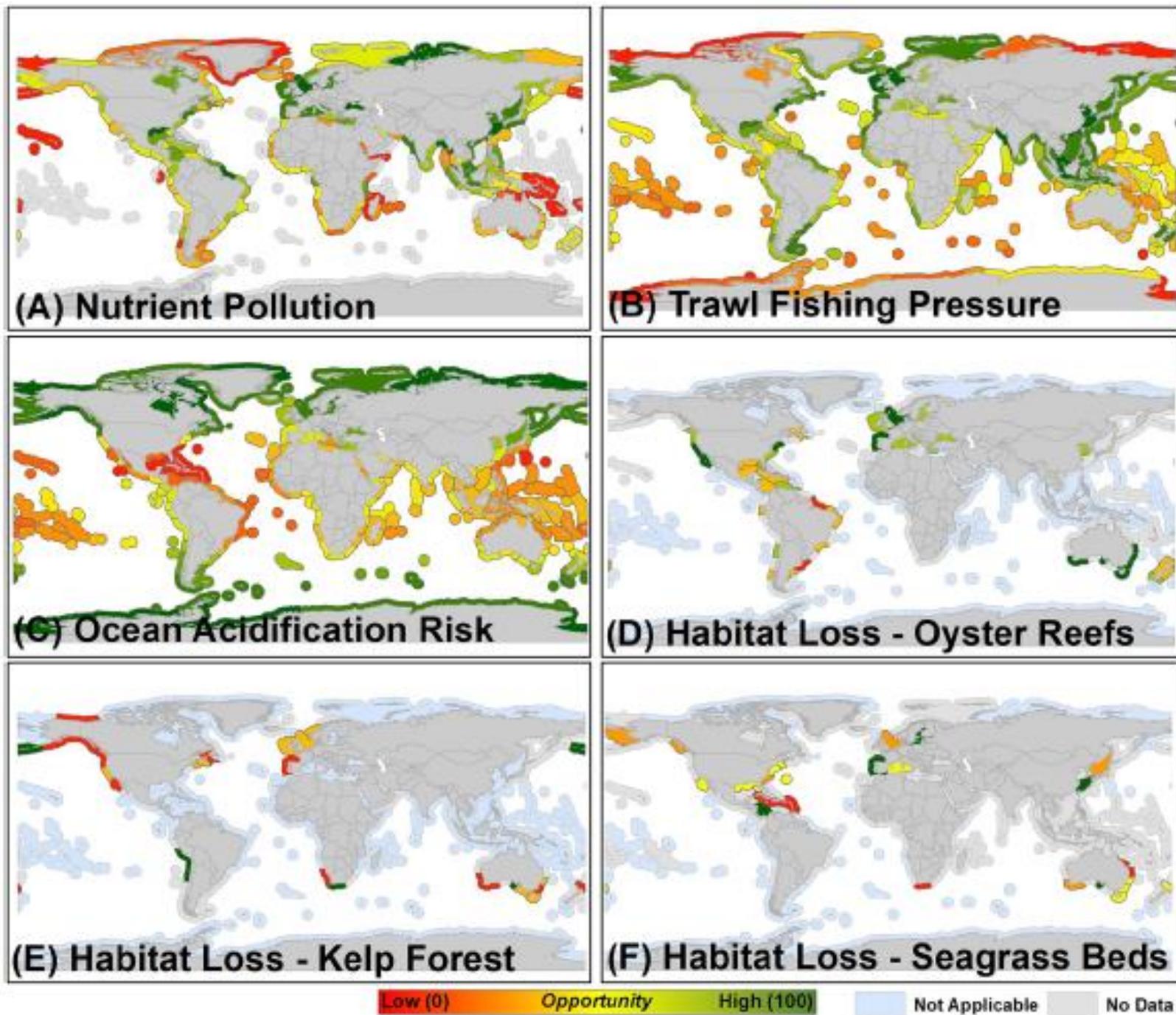
- Elevated (rack and bag)
- On-bottom
- On-bottom with gear
- Suspended (longlines)
- Suspended (raft)
- Suspended (seaweed)

Theuerkauf, S., L. Barrett, H. Alleway, B.A. Costa-Pierce, A. St. Gelais and R. Jones. 2021. Habitat value of bivalve shellfish & seaweed aquaculture for fish & invertebrates: pathways, synthesis & next steps. *Reviews in Aquaculture* 2021;00:1–19. doi: [10.1111/raq.12584](https://doi.org/10.1111/raq.12584)

Table 1. Examples of abiotic and biotic factors and processes, across successive ecosystem scales, that might influence the capacity of different types of mariculture to deliver ecosystem services.

	Local (farm) scale^a	Regional (landscape) scale^b	Biogeographical scale^c
Abiotic factors	<ul style="list-style-type: none"> • Cultivation method, infrastructure and gear used, and farming inputs (e.g., feed, fertilizer) • Local hydrodynamics (e.g., current strength and direction, tidal movement, waves and exposure to wave energy) • Depth or elevation of cultivation • Benthic sediment type—sediment stability and nutrient absorption capacity • Water quality and chemistry parameters and ranges (e.g., pH; dissolved oxygen, nitrogen, phosphorus, and carbon dioxide; and turbidity) • Benthic habitat type (e.g., baskets, bags or rack oyster culture) 	<ul style="list-style-type: none"> • Regional hydrodynamics • Water temperature and salinity ranges • Weather patterns (e.g., rainfall, prevailing wind direction) • Distance between and density of aquaculture operations • Distance from and discharge magnitude of nutrient and pollutant sources • Water quality and chemistry parameters and ranges (e.g., pH; dissolved oxygen, nitrogen, and phosphorus; turbidity) • Solar irradiance (particularly seaweeds) 	<ul style="list-style-type: none"> • Nutrient status of ecosystem (e.g., oligotrophic, eutrophic) • Additional anthropogenic inputs (e.g., land-based runoff, estuarine or delta inputs) • Water temperature and salinity ranges • Weather patterns (e.g., rainfall, prevailing wind direction) • Vulnerability to climate-related disturbances, such as ocean acidification • Solar irradiance (particularly seaweeds)
Biotic factors	<ul style="list-style-type: none"> • Stocking density of species • Coculture and interaction with multiple species • Benthic habitat type • Benthic community structure and biodiversity • Pathogen dissemination pathways • Marine pest presence and dissemination pathways • Phytoplankton availability (bivalves) 	<ul style="list-style-type: none"> • Prevalence of disease and parasites • Reproductive status of stock (nonreproductive or spawning potential) • Distance to natural habitats • Distance from critical or sensitive habitats, key biodiversity areas, or protected areas • Regional species pool of available colonists • Regional biodiversity and use of hard substrate 	<ul style="list-style-type: none"> • Culture of endemic or naturalized species • Population status of existing wild harvest resources • Conservation status of existing coastal habitat and biodiversity

Note: Factors can occur at multiple scales but at each might generate a different strength of effect. ^aLess than 1 kilometer. ^bBetween 2 and 20 kilometers. ^cMore than 20 kilometers.



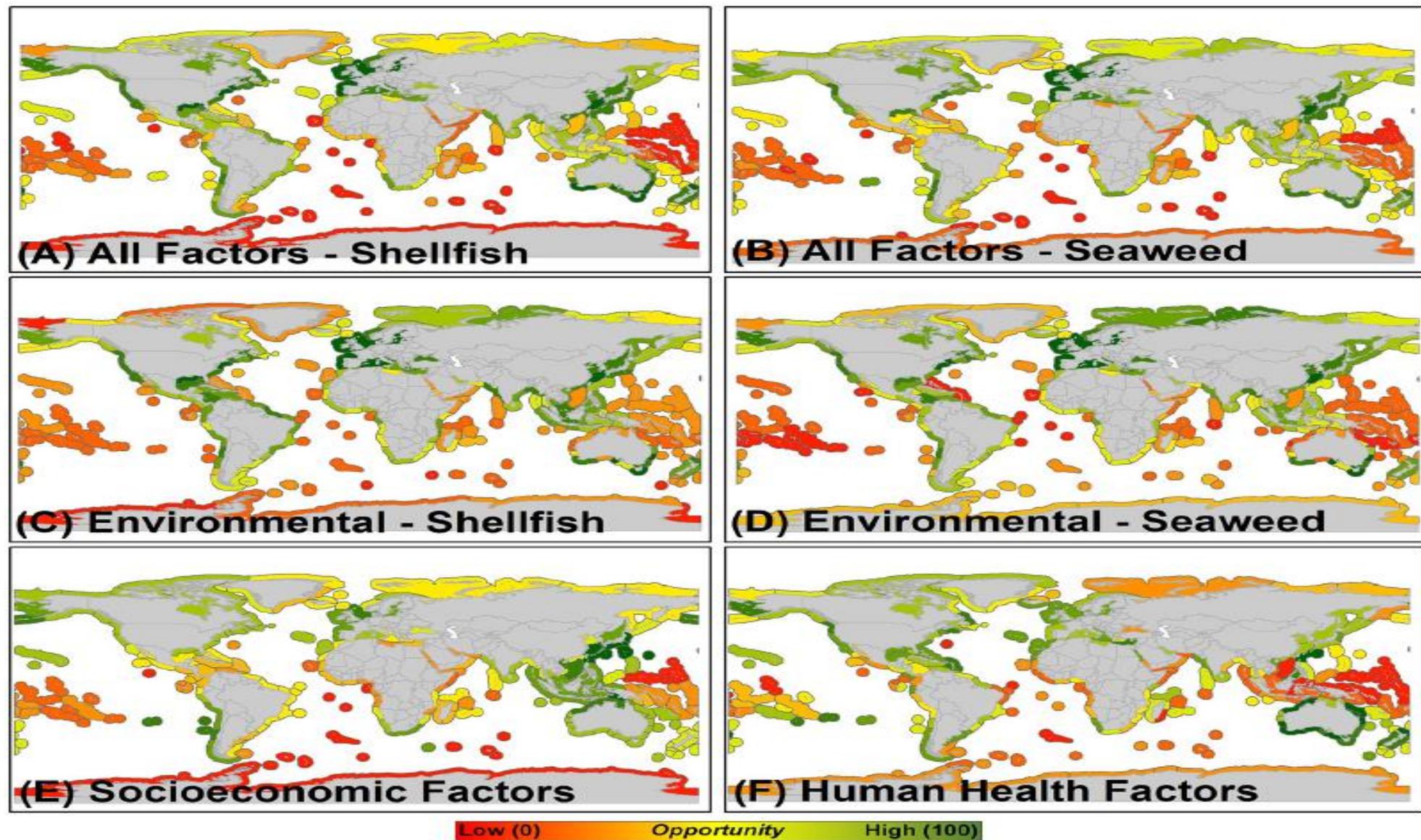


Fig 4. High (green) to low (red) opportunity marine ecoregions for development of (A) shellfish aquaculture and (B) seaweed aquaculture based on the synthesis of all environmental, socioeconomic, and human health factors (Table 1) according to their assigned weights (Table 2) within the restorative aquaculture opportunity index. High opportunity marine ecoregions based on the synthesis of all environmental factors only (C) and (D), socioeconomic factors only (E), and human health factors only (F) according to their assigned weights.



A global review of the ecosystem services provided by bivalve aquaculture

Andrew van der Schatte Olivier¹ , Laurence Jones², Lewis Le Vay¹, Michael Christie³, James Wilson⁴ and Shelagh K. Malham¹

1 School of Ocean Sciences, Bangor University, Menai Bridge, UK

2 Centre for Ecology and Hydrology, Bangor, UK

3 Aberystwyth Business School, Aberystwyth University, Aberystwyth, UK

4 Deepdock Ltd, Bangor, UK

Provisioning : \$23.9 billion

Regulating: \$1.2 billion

Total Non-Food Services: \$3-10 billion

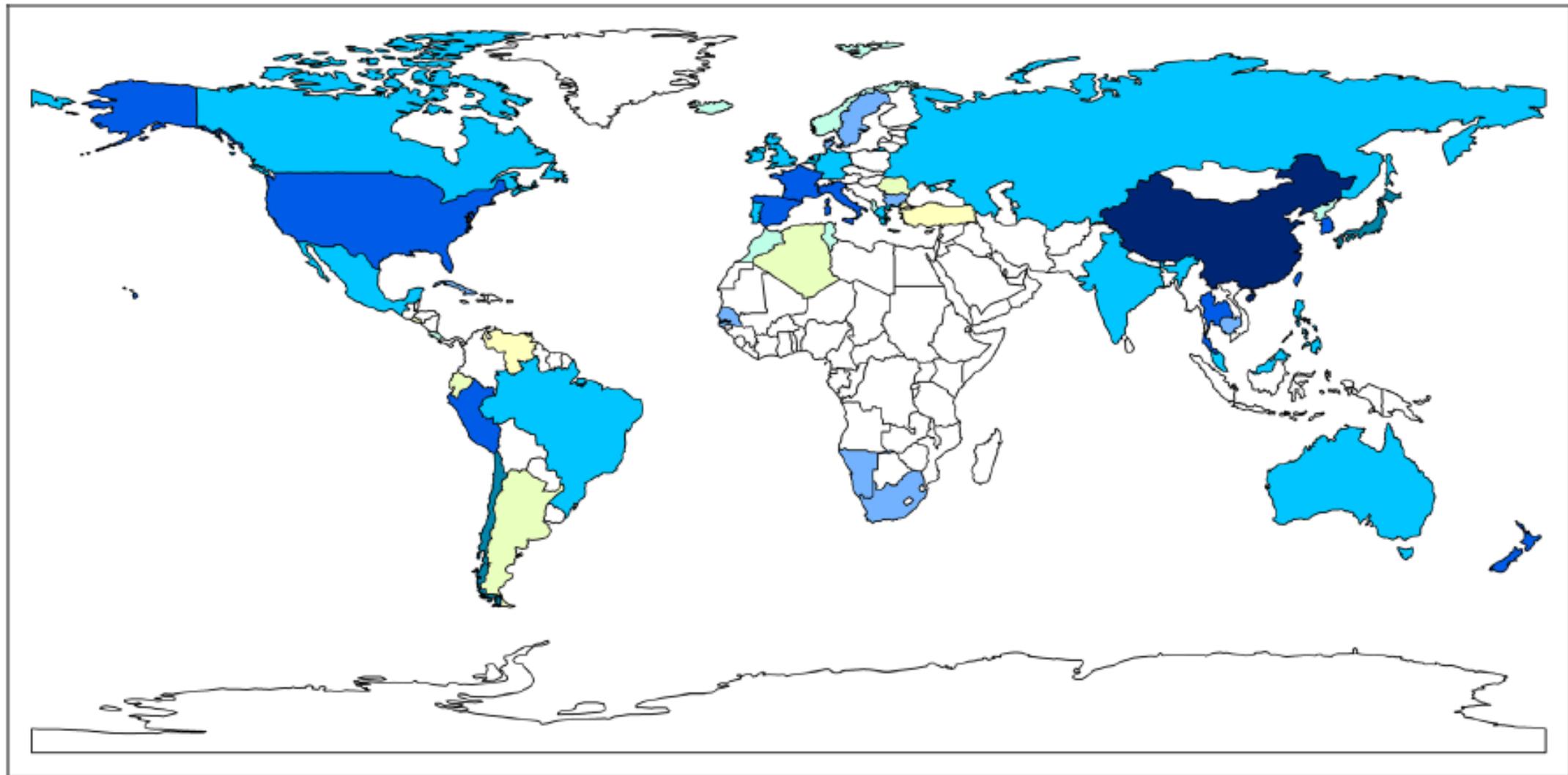


Figure 2 World map showing the potential combined value of carbon sequestration, nitrogen and phosphorus remediation and the use of oyster shells for aggregate (\$). (□) No FAO data; (□) $\leq 10,000$; (□) 10,001 – 100,000; (□) 100,001 – 1,000,000; (□) 1,000,001 – 10,000,000; (□) 10,000,001 – 100,000,000; (□) 100,000,001 – 1,000,000,000; (□) 1000,000,001 – 10,000,000,000; (□) 10,000,000,001 – 25,000,000,000.

Aquaculture farms as nature-based coastal protection: Random wave attenuation by suspended and submerged canopies

Longhuan Zhu^{a,*}, Kimberly Huguenard^a, Qing-Ping Zou^b, David W. Fredriksson^c, Dongmei Xie^d

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^d *College of Harbour, Coastal and Offshore Engineering, Hohai University, Nanjing, 210098, China*



Contributed Paper

Aquaculture and the displacement of fisheries captures

Stefano B. Longo ,^{1,5} Brett Clark,² Richard York,³ and Andrew K. Jorgenson⁴

“In modern aquaculture, animal-production technology is used to increase aquatic food sources. Such controlled rearing of seafood can, in principle, shift the pressure off wild stocks and aquatic ecosystems by reducing fishing activities, which may advance marine conservation goals...We estimated 9 models to assess whether aquaculture production suppresses captures once other factors related to demand have been controlled for. Only 1 model predicted significant suppression of fisheries captures associated with aquaculture systems within nations over time.

These results suggest that global aquaculture production does not substantially displace fisheries capture; instead, aquaculture production largely supplements fisheries capture.”

“...In the 21st century, aquaculture developers will need to spend as much time on designing ecological approaches to aquaculture development that clearly exhibit stewardship of the environment as they do on technological advances coming to the field. Clear, unambiguous linkages between aquaculture and the environment must be created and fostered, and the complementary roles of aquaculture in contributing to environmental sustainability, rehabilitation and enhancement must be developed and clearly articulated to a highly concerned, increasingly educated and involved public.”

Costa-Pierce, B.A., Bridger, C.J. (2002) The role of marine aquaculture facilities as habitats and ecosystems. In: R. Stickney & J. McVey (Eds.) *Responsible Marine Aquaculture*. CABI, Wallingford, U.K.

Tusen takk

Tack så mycket

Muito obrigado

Thank you

Muchas gracias

Shukran jazilan

Mahalo nui loa

Terima kasih

