A SOCIAL-ECOLOGICAL APPROACH TO THE DEVELOPMENT OF INTEGRATED OFFSHORE FOOD/WIND ENERGY SYSTEMS

Barry Antonio Costa-Pierce, Ph.D., Fellow, AAAS

Emeritus Professor, University of Rhode Island
Emeritus Professor, University of New England
Emeritus Director, Rhode Island Sea Grant College Program
Emeritus Director. Mississippi-Alabama Sea Grant Consortium

President & CEO
Ecological Aquaculture Foundation LLC

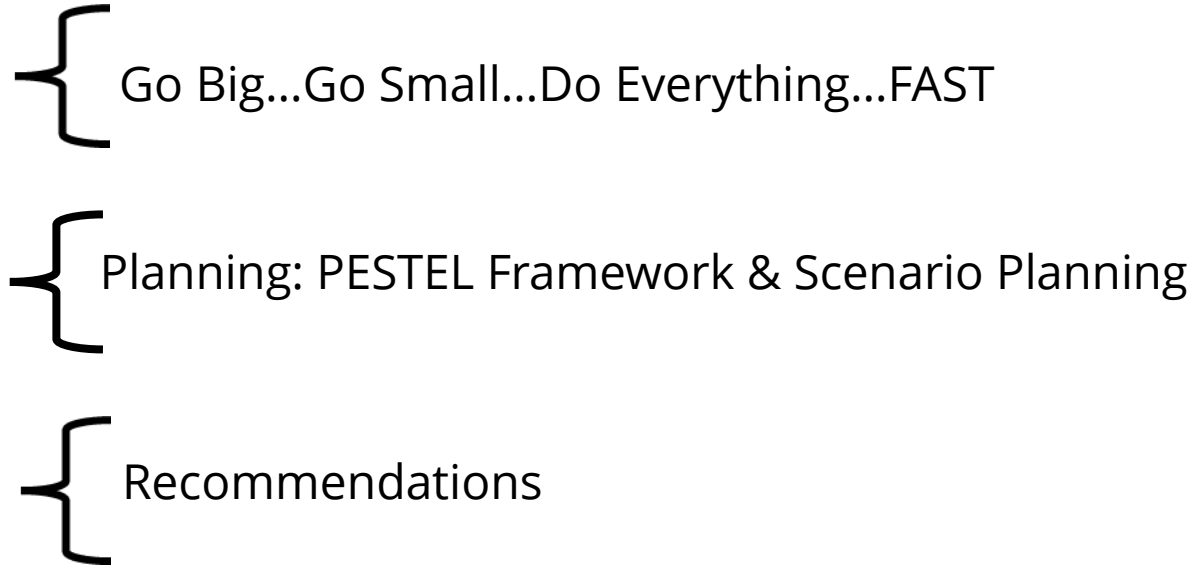
Ecological Aquaculture
A GLOBAL FOUNDATION FOR BLUE FOODS

https://oceanfoods.org

Professor II
Faculty of Biosciences and Aquaculture
Nordic Masters in the Sustainable Production & Use of Marine Bioresources

NORD University

Bodø, Norway


Go Big...Go Small...Do Everything...FAST
Planning: PESTEL Framework & Scenario Planning
Recommendations


#1: Build a Long-Term Learning Community
Local to Global…
Make it Structural by Investments in People & Process
#2: Fund More Science
Yes…BUT the RIGHT KIND of Science
#3: Build New Communities
PORTS are the Top Priority

Go Big...Go Small...Do Everything...**FAST**

Planning: PESTEL Framework & Scenario Planning

Recommendations

EU (2018) NET ZERO USE OF CARBON ENERGY by 2050

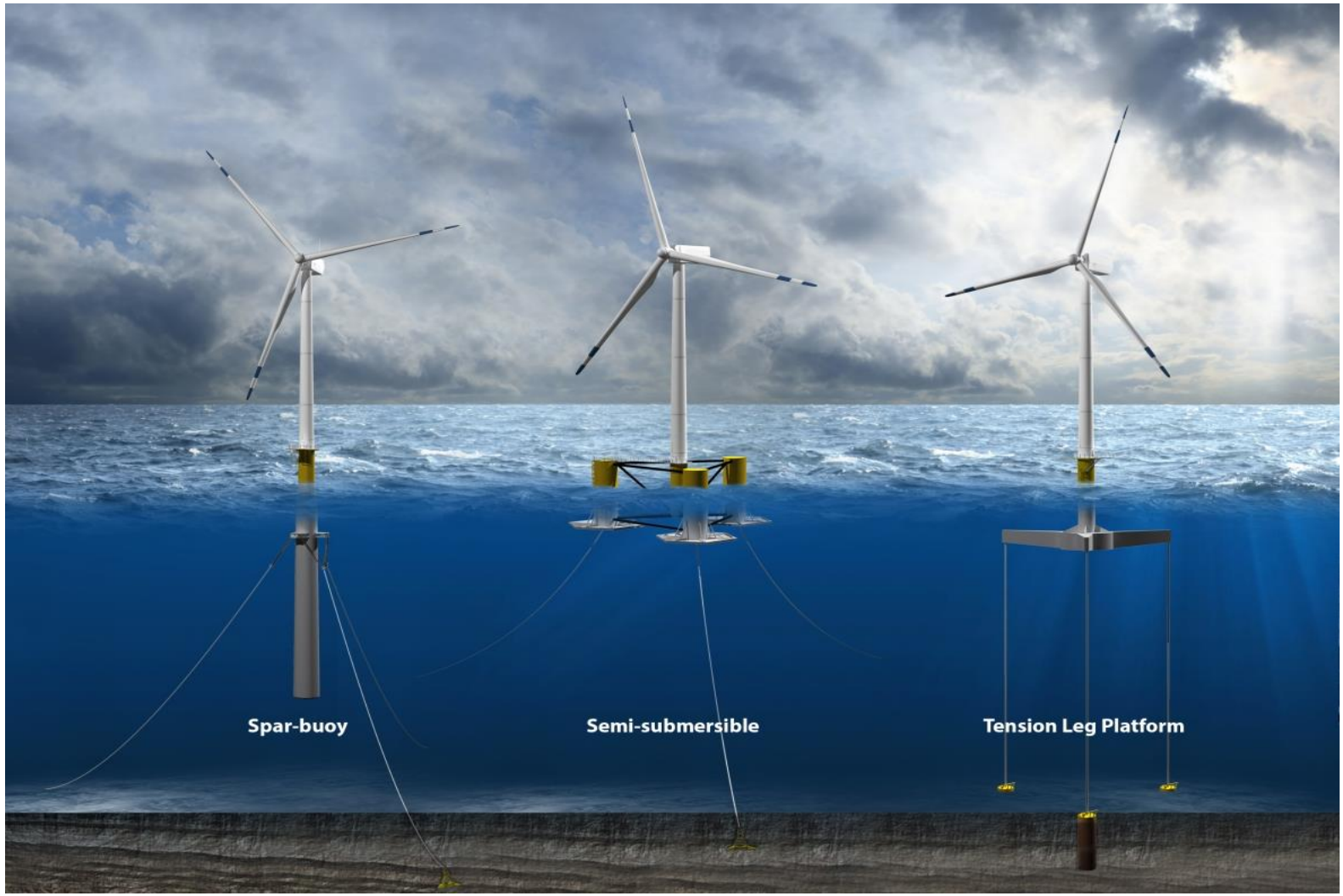
"To achieve this level…a significant scaling up (15-22% annual growth rates) of offshore wind is needed."
(High Level Panel for a Sustainable Ocean Economy, 2019)

Europe has **4000 GW** of floating wind above 60 m depth
(James and Ross, 2015)

Further Offshore & Floating Wind Are Key

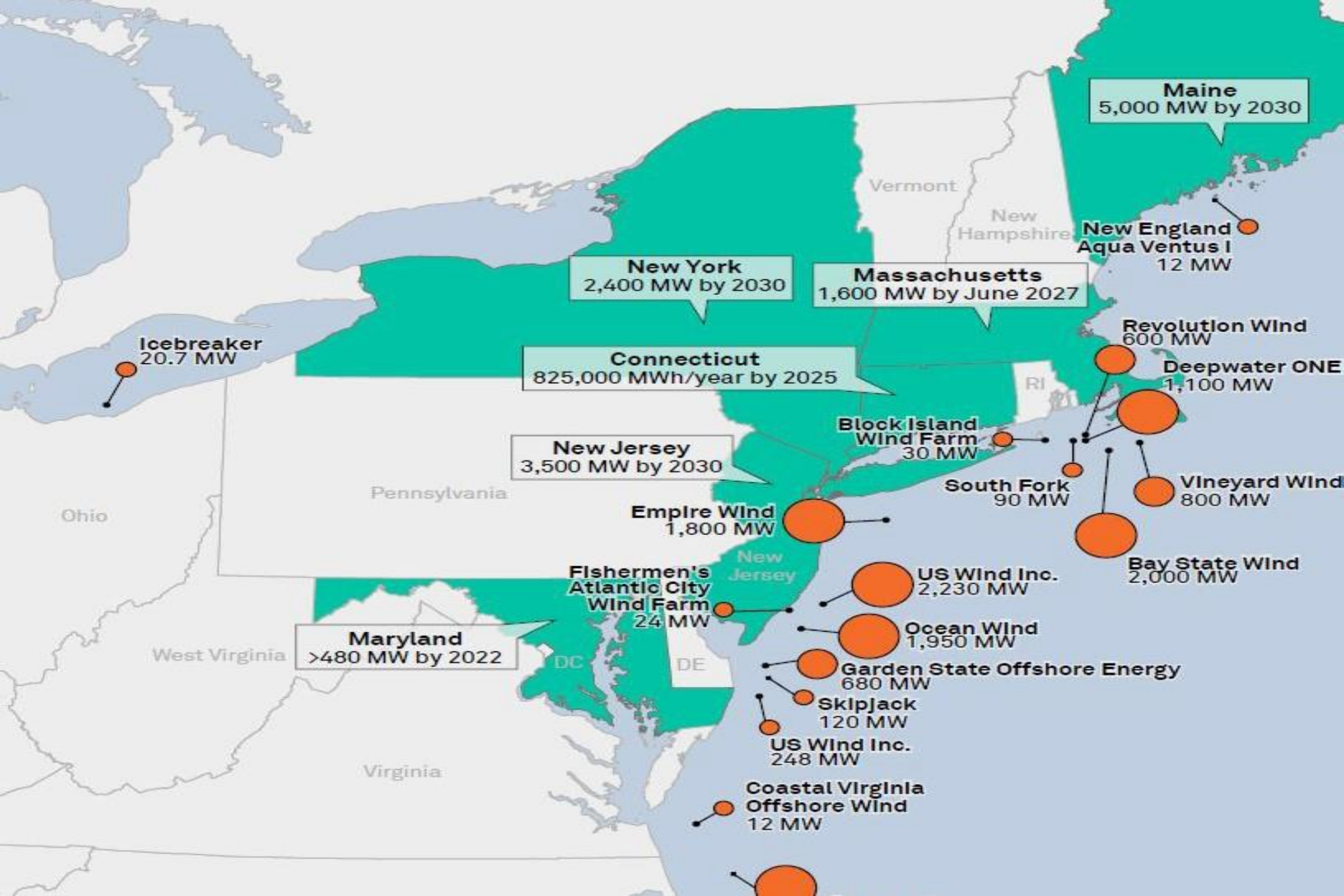
High Level Panel for a Sustainable Ocean Economy (2019)

Wind power increases as a cube of wind speed. Doubling of the wind speed provides an 8X increase in wind power
($2^3 = 2 \times 2 \times 2 = 8$)



Siemens Gamesa 10 MW @ 193 m ~580’

1 MW = ~1000 homes


Maine
5,000 MW by 2030
New England
Aqua Ventus I
12 MW
Vermont
New
Hampshire
New York
2,400 MW by 2030
Massachusetts
1,600 MW by June 2027
Revolution Wind
600 MW
Deepwater ONE
1,100 MW
Icebreaker
20.7 MW
Connecticut
825,000 MWh/year by 2025
RI
Block Island
Wind Farm
30 MW
New Jersey
3,500 MW by 2030
South Fork
90 MW
Vineyard Wind
800 MW
Pennsylvania
Ohio
Empire Wind
1,800 MW
Bay State Wind
2,000 MW
New
Jersey
Fishermen's
Atlantic City
Wind Farm
24 MW
US Wind Inc.
2,230 MW
Ocean Wind
1,950 MW
Maryland
>480 MW by 2022
West Virginia
DC
DE
Garden State Offshore Energy
680 MW
Skipjack
120 MW
US Wind Inc.
248 MW
Virginia
Coastal Virginia
Offshore Wind
12 MW

DoE 2021 Offshore Wind Market Report

30 GW by 2030 10 million homes

States want ~40 MW offshore wind by 2040

EU (2018) ZERO carbon energy by 2050

"To achieve this level…a significant scaling up (15-22% annual growth rates) of offshore wind is needed. (HLPSE, 2019)

Europe has **4000 GW** of floating wind above 60 m depth (James and Ross, 2015)

Gulf of Maine ZERO by 2045

156 GW available

Just 3% of this yields carbon neutrality

Requires $20 billion…

Would produce 10,000 jobs (MEAIB, 2022)

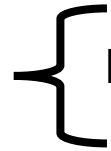
The German environmental protection agency commissioned an LCA study of the electricity generation from wind turbines in Germany.

Results showed that the primary energy used over the life cycle of the systems can be recovered as generated wind electricity **after six months to one year of system operations**.

The offshore wind farms achieved the lowest CO_2 emissions due to their higher amounts of full load hours.

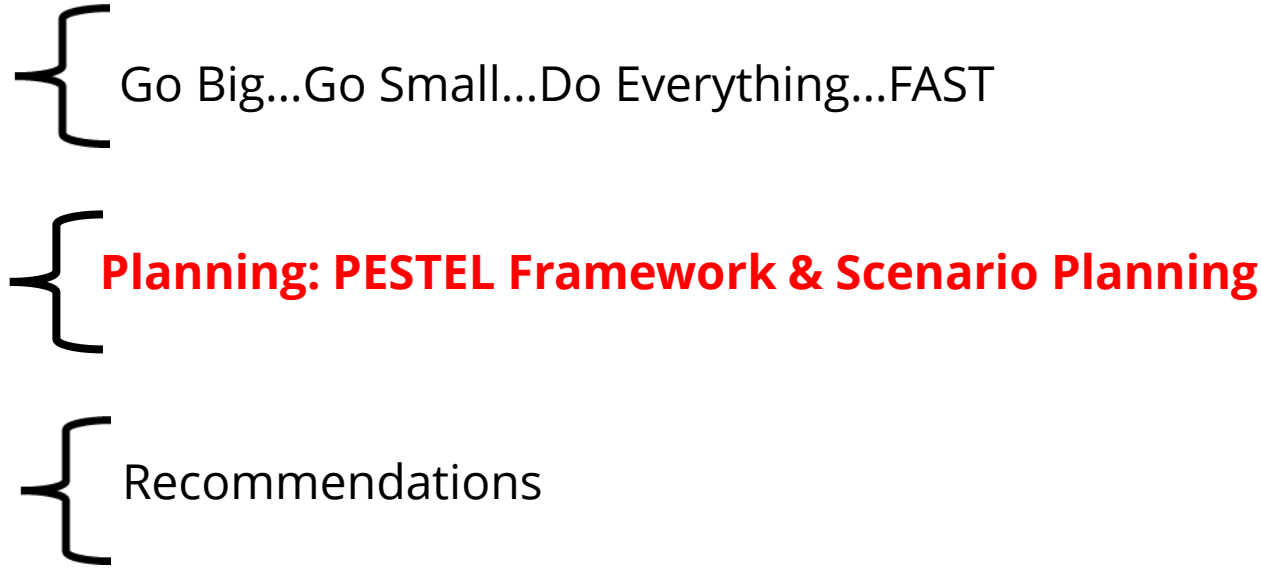
g CO_2 eq./kWh electricity fed into the German grid	
Offshore	**5.4 to 11.8**
Onshore	6.1 to 15.6

Go Big…**Go Small**…Do Everything…FAST



Planning: PESTEL Framework & Scenario Planning

Recommendations


Go Big…Go Small…Do Everything…FAST
Planning: PESTEL Framework & Scenario Planning
Recommendations

PESTEL Matrix (Oxford College of Marketing, 2016)

Production
Ecological Health
Social Influences
Technological Influences
Economics
Legal

PESTEL Matrix (Oxford College of Marketing, 2016)

Production
Ecological Health
Social Influences
Technological Influences
Economics 
Legal

DoE 2021 Offshore Wind Market Report

30 GW by 2030 10 million homes

States want ~40 MW offshore wind by 2040

$12 billion/year over next 10 years

Germany, Denmark, Netherlands, Belgium

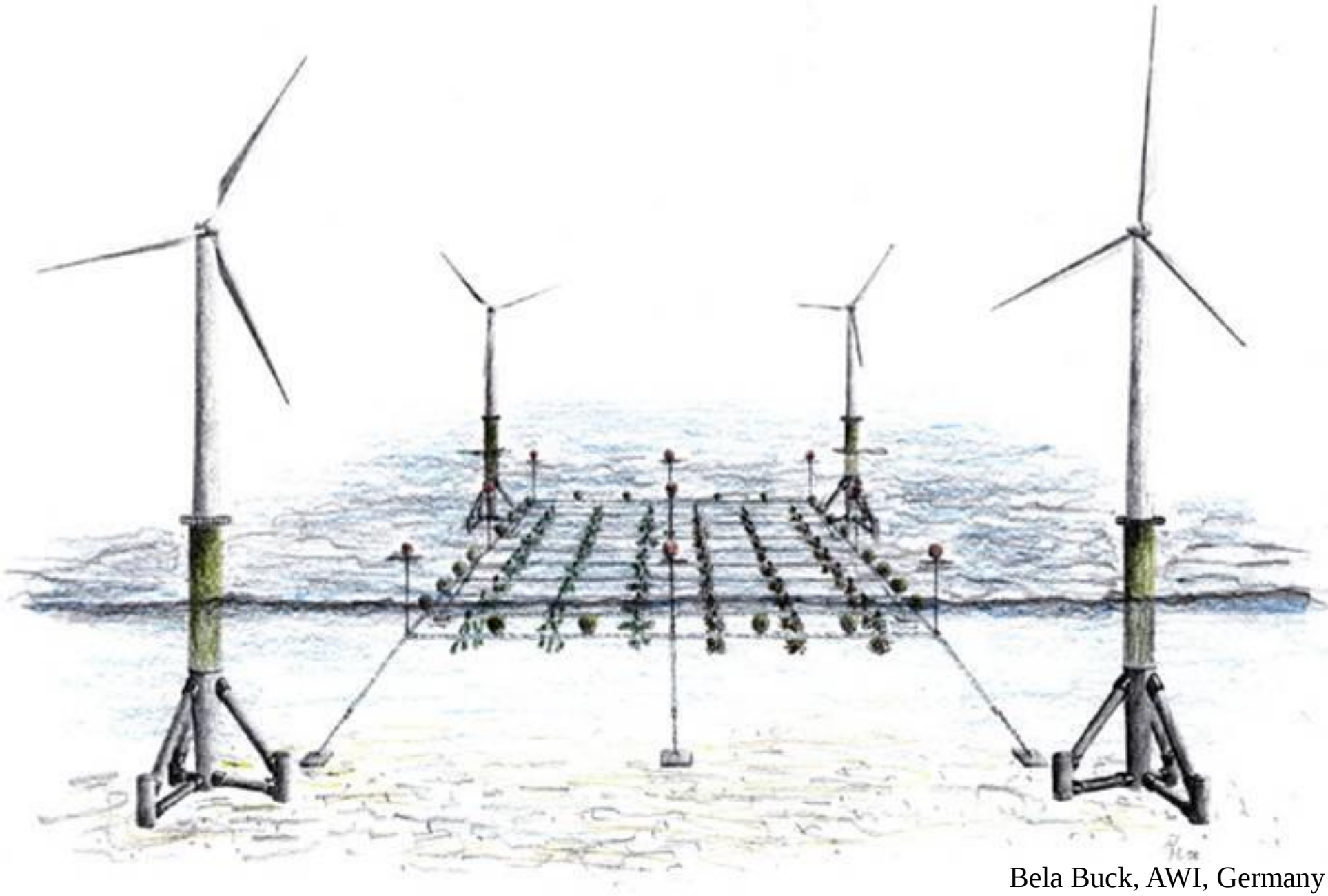
150 GW, **Euro 135 billion**, >200 million homes

½ of EU (**Euro 800 billion**)

PESTEL Matrix **(Oxford College of Marketing, 2016)**

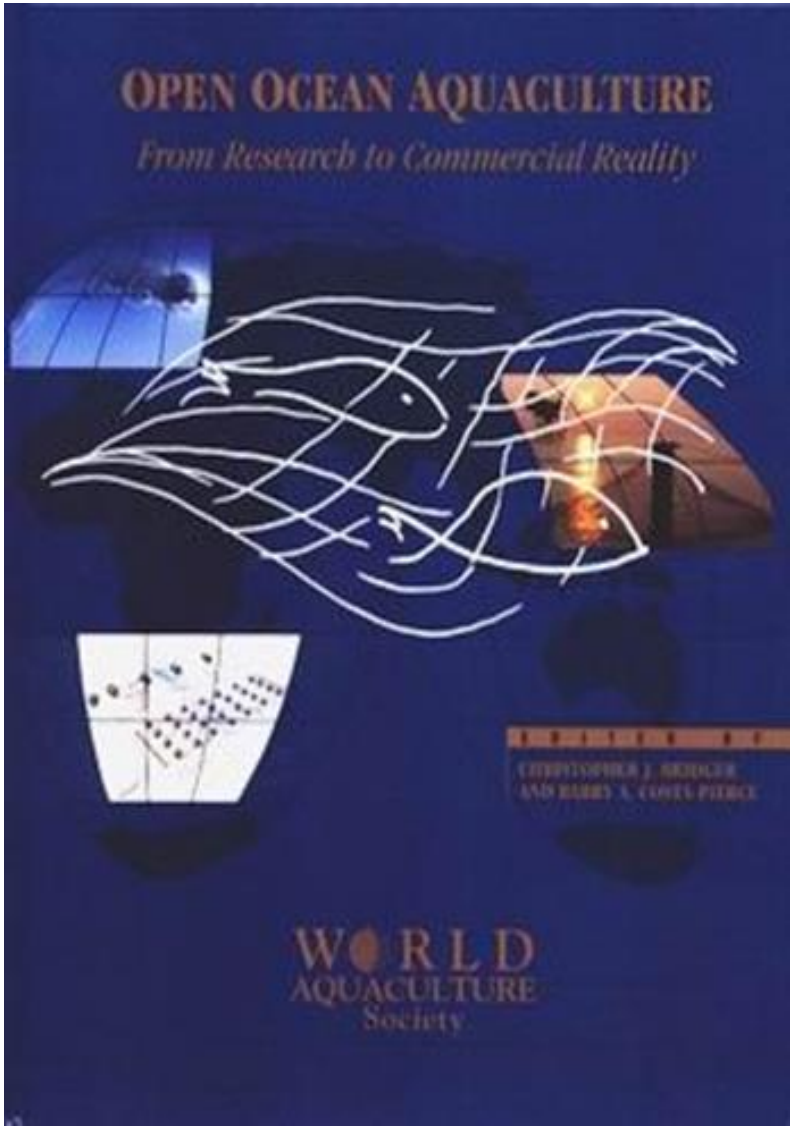
Production
Ecological Health
Social Influences
Technological Influences
Economics

Legal

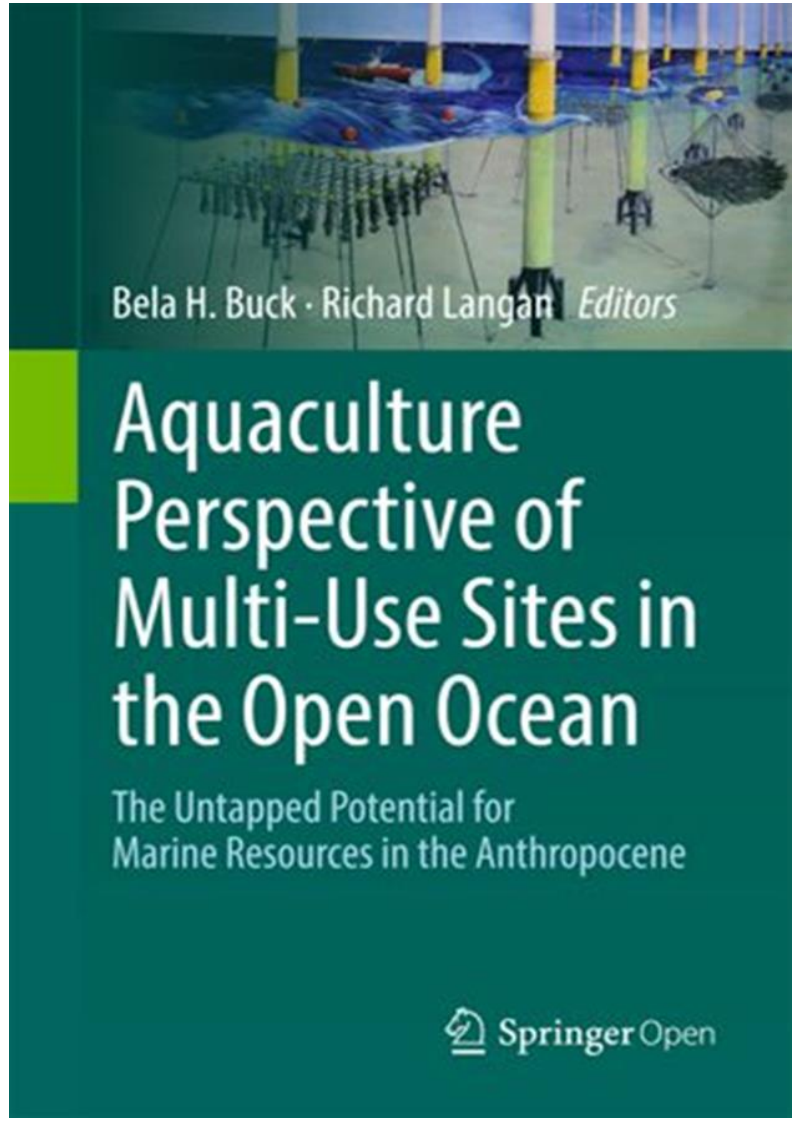


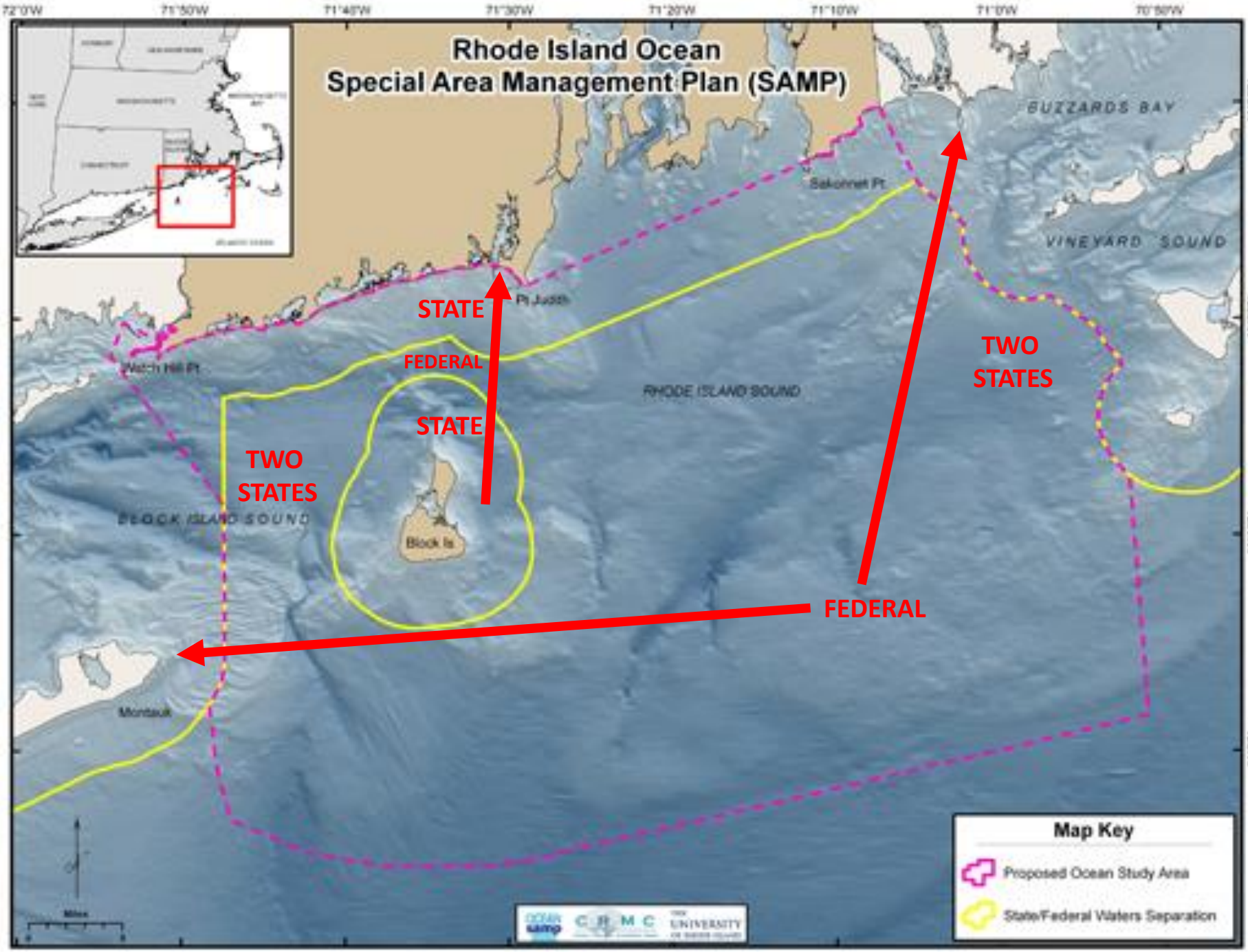
Bela Buck, AWI, Germany

Bridger, C.J. & B.A. Costa-Pierce. 2003.
***Open Ocean Aquaculture: From Research to Commercial Reality*.**
World Aquaculture Society, Baton Rouge, LA.



~20YEARS




Rhode Island Ocean
Special Area Management Plan (SAMP)
BUZZARDS BAY
VINEYARD SOUND
RHODE ISLAND SOUND
BLOCK ISLAND SOUND
Sakonnet Pt
Pt Judith
Watch Hill Pt
Block Is
Montauk
STATE
FEDERAL
STATE
TWO STATES
TWO STATES
FEDERAL
Map Key
Proposed Ocean Study Area
State/Federal Waters Separation
Miles

PESTEL Matrix

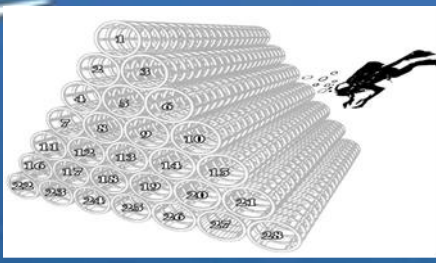
Production
Ecological Health
Social Influences
Technological Influences
Economics
Legal

CLOSED

Biodiversity Enhancement

OPEN

Fisheries Enhancement

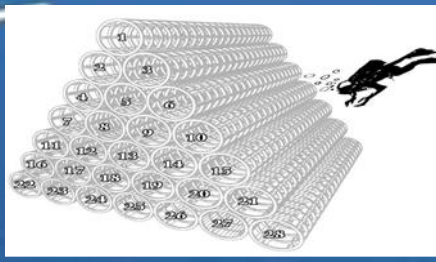


Aquaculture

CLOSED

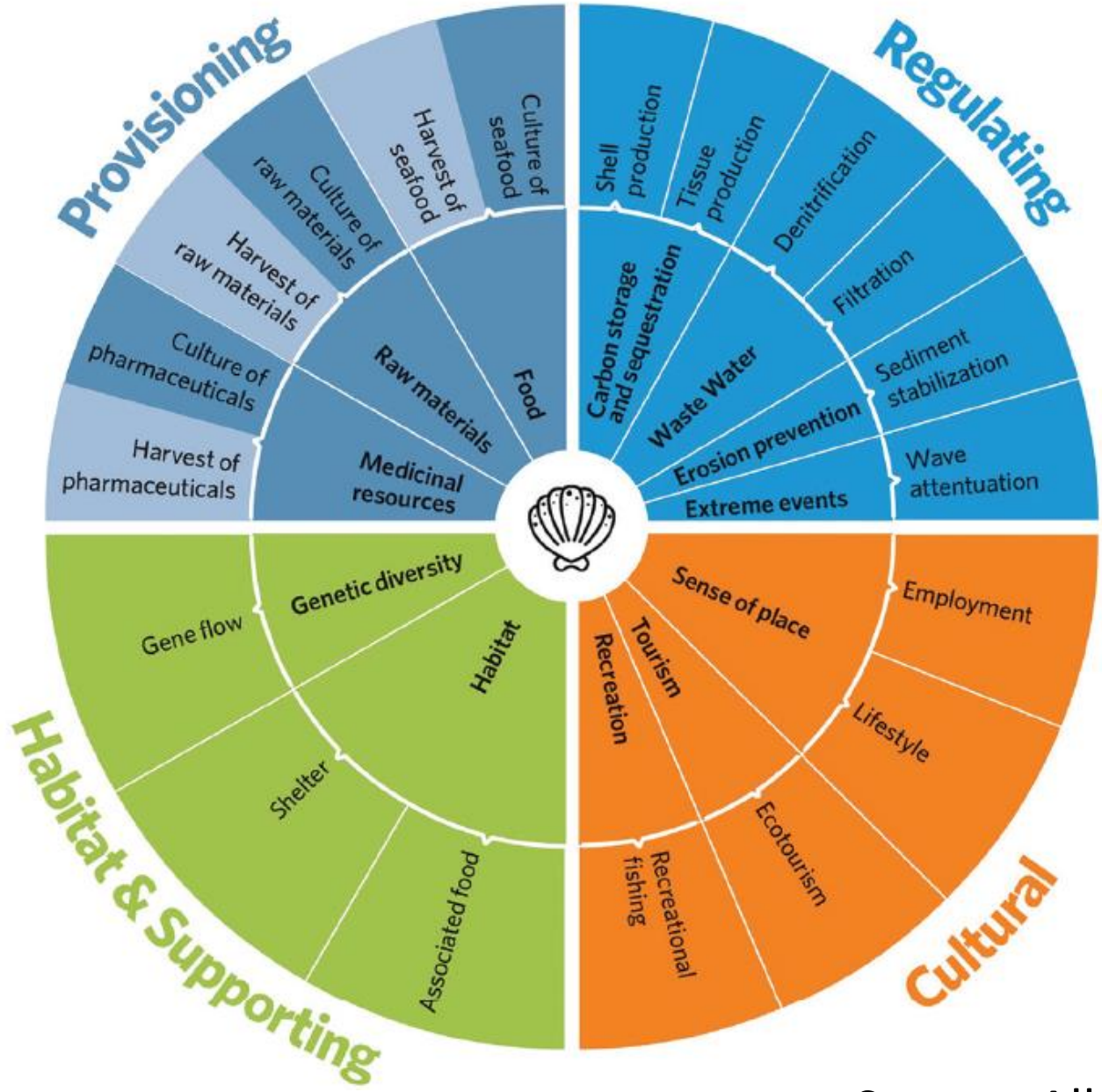
Biodiversity Enhancement

Fisheries Enhancement



Aquaculture

OPEN



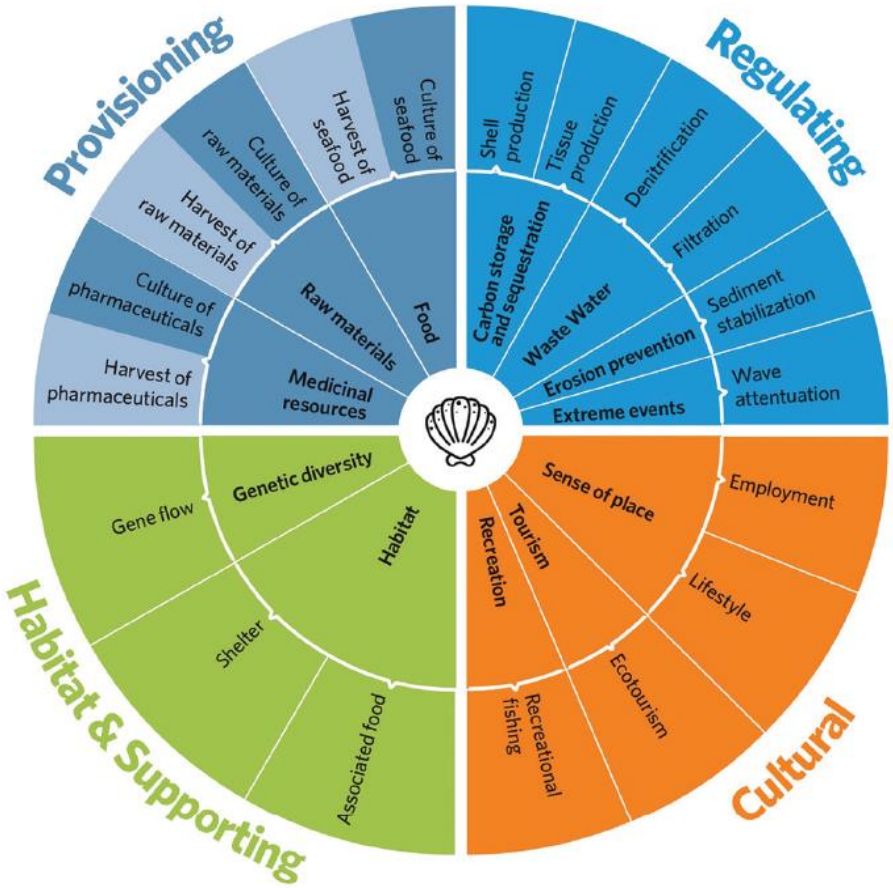
Source: Alleway et al. 2018

“Basal Ecosystem” The ecosystem and associated functions

Prior to agricultural intervention

What was added?
What was removed?

Agroecology
What was added?
What was removed?



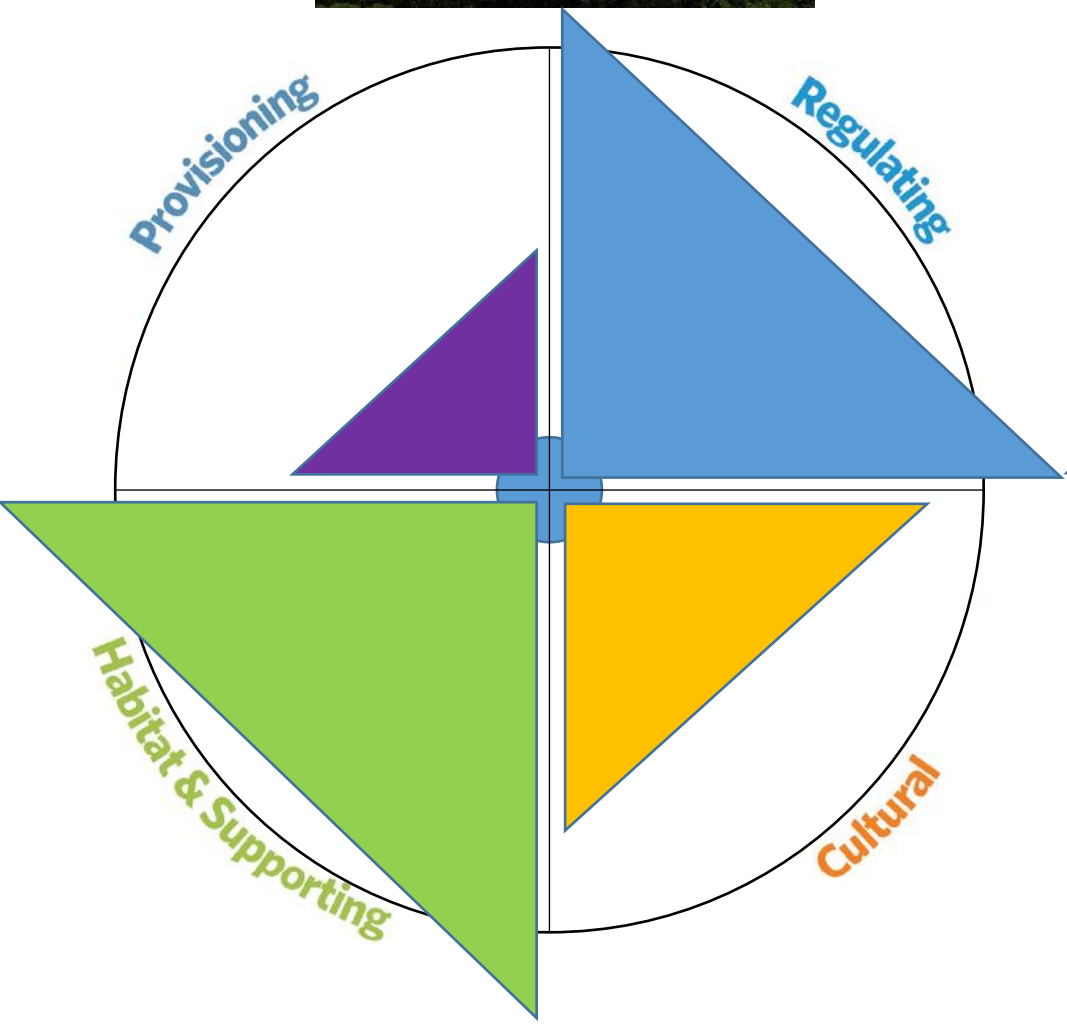
Source: Alleway et al. 2018

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

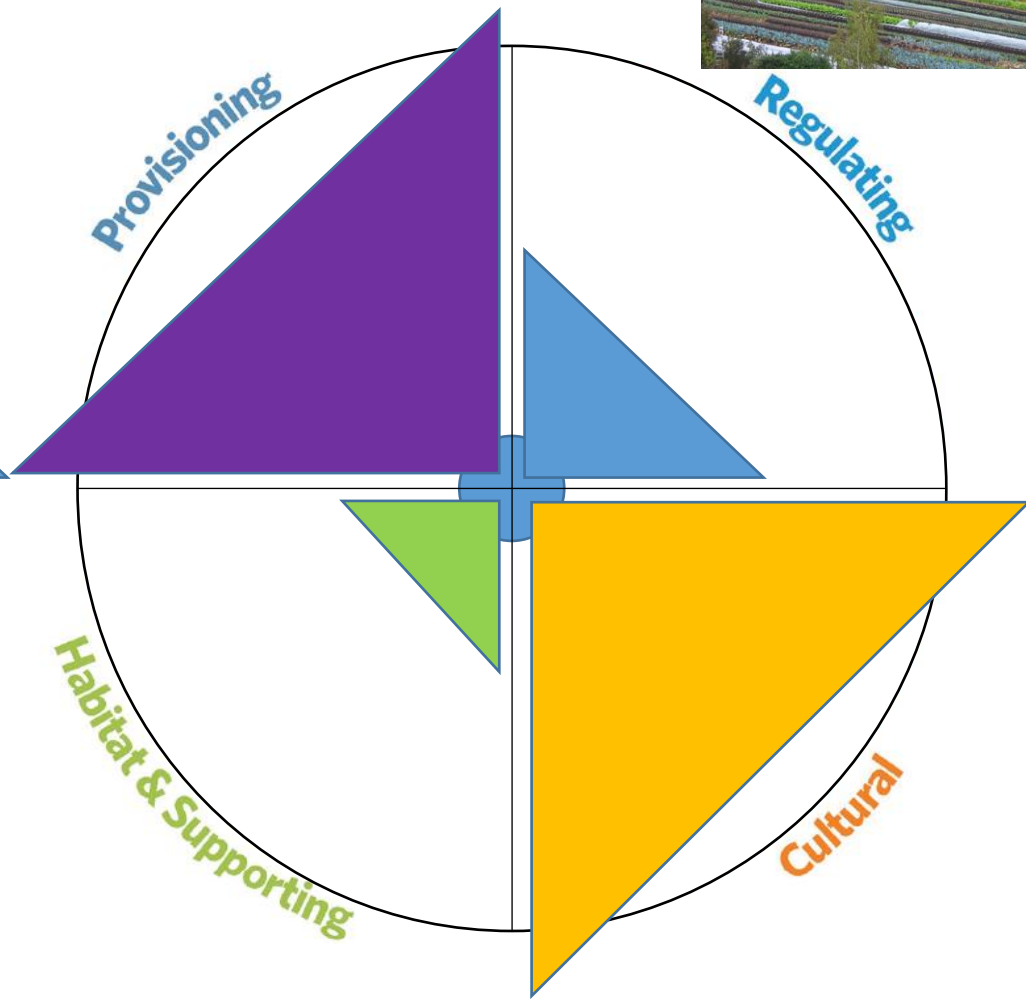
Regulating Services are the services that ecosystems provide by acting as regulators eg. regulating the quality of air and soil or by providing flood and disease control.

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

PESTEL Matrix

Production
Ecological Health

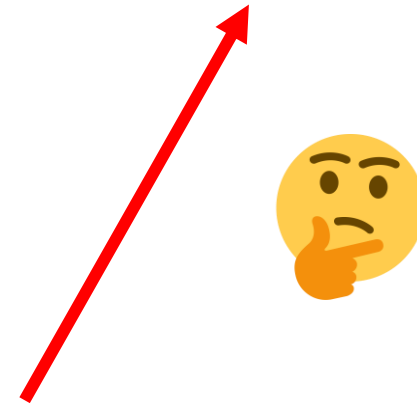
Social Influences
Technological Influences
Economics
Legal

Wicked Problems with No Tame Solutions

SCENARIO PLANNING

PESTEL Matrix

Production
Ecological Health



Social Influences ⟷ Technological Influences

Economics
Legal

Scenario Planning

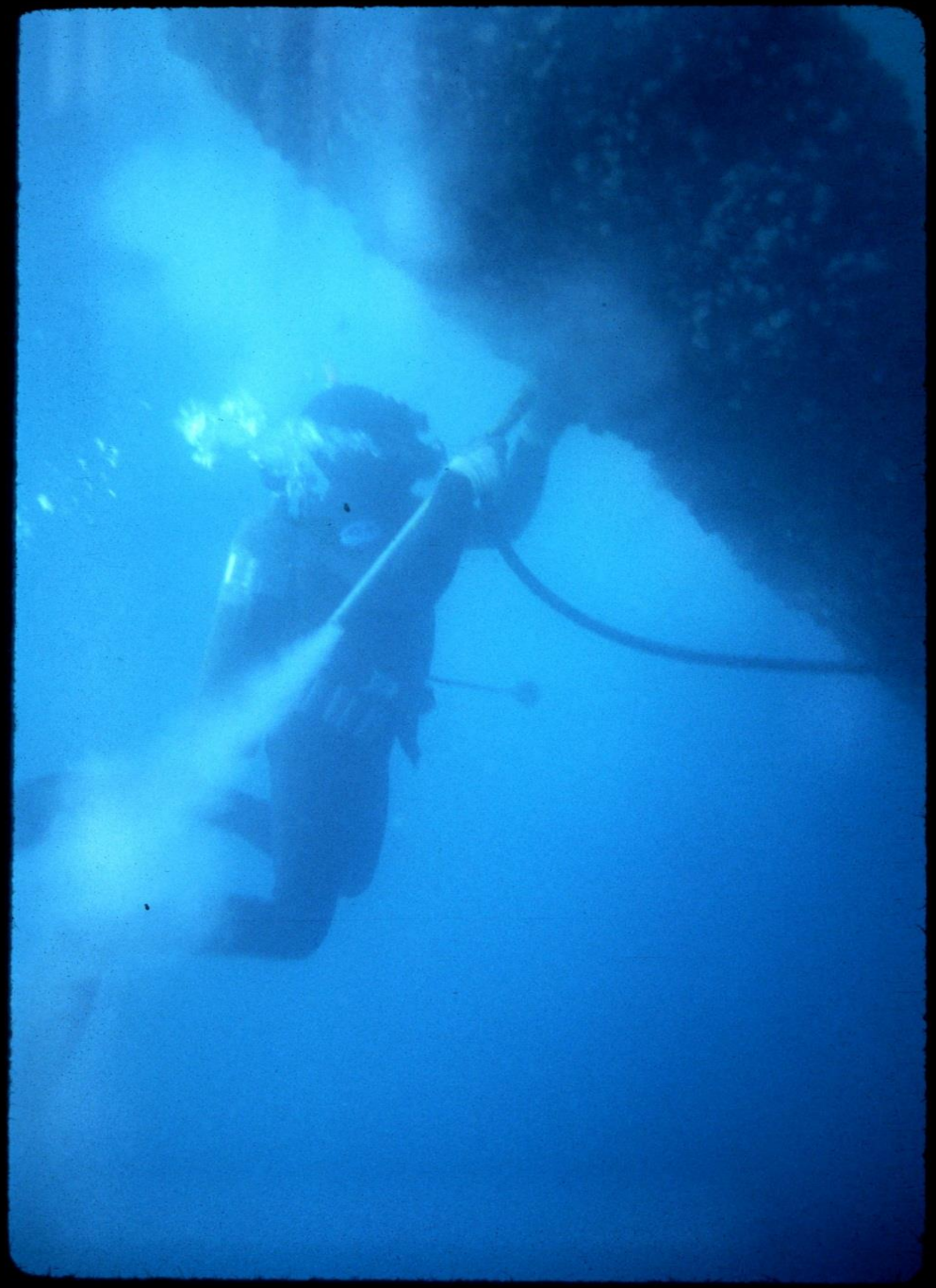
Problem → Opportunity	Win = Win	Business Structures?
(1) Energy operations	Removal of fouling maintains structural integrity and produces new ocean foods	Separate?
(2) Most operations offshore (short sea shipping, fishing, aquaculture)	Electric charging stations offshore add income to fisheries and energy companies	Integrated?
(3) Fishing & Aquaculture		


Monopiles
Jackets


NOT on
Me Legs!

Scenario Planning

Problem → Opportunity	Win = Win	Business Structures
(1) Energy operations	**Removal of fouling maintains structural integrity and produces new ocean foods**	**Separate?**
(2) Most operations offshore (shipping, fisheries, aquaculture)	Electric charging stations add income to fisheries and energy companies	Integrated?



Three California companies harvested mussels from the California oil platforms

“ECOMAR”

*Obtained all regulatory approvals for human consumption and harvested **$50-75,000 of shellfish per platform every 16-20 months**

Between **1992-97**, mussel production rose in California from **~85 MT to ~214 MT with most production coming from the southern California oil platform harvests**

.

Scenario Planning

Problem → Opportunity	Win = Win	Business Structures
Energy operations	Removal of fouling maintains structural integrity and produces new ocean foods	Separate?
(2) All offshore operations (shipping, Food systems (fisheries, aquaculture)	**Electric charging stations add income to energy and fisheries companies**	Integrated?

The Offshore Grid

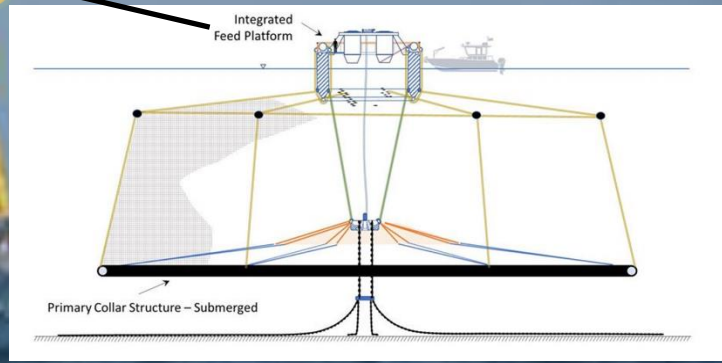
Short sea shipping

Electric trawlers

Electric workboats

Electric fishing

Do we really need all cables to shore?



Norwegian Prime Minister Erna Solberg christens the *Evoy 1*

100 kWh battery pack powering a 900 hp engine…Zips at 20-25 knots

Lithium Titanium Oxide (LTO) batteries designed for frequent, fast charges

·International: Battery Research from Xalt Energy, **Michigan**. Hull from Helgeland Plast, **Norway**. Motor from **Germany**. Frequency converter from ABB, **Switzerland** and **Sweden**

Nordbas

A hybrid trawler with an integrated power system allowing the ship **to go diesel-free for hours on renewable electricity**

High coastal population = Clogged roads

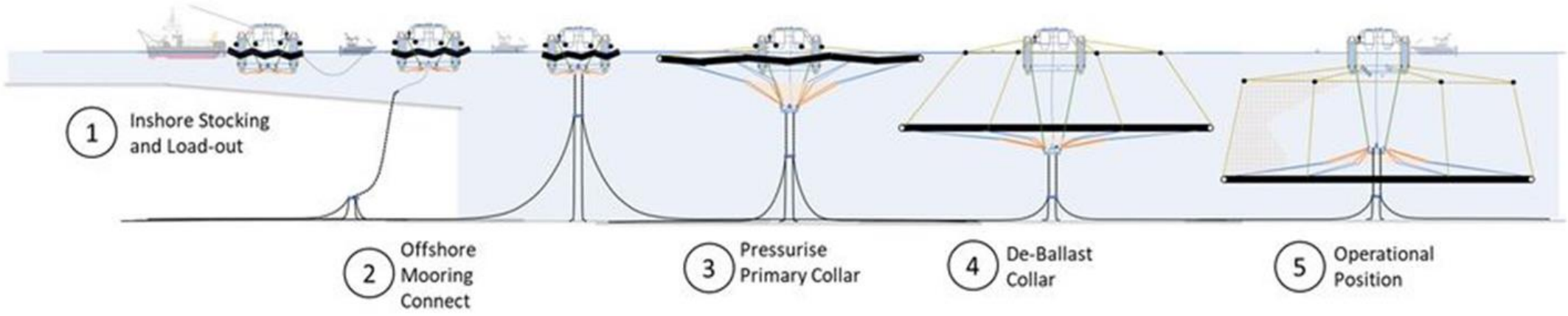
Older vessels = Higher emissions

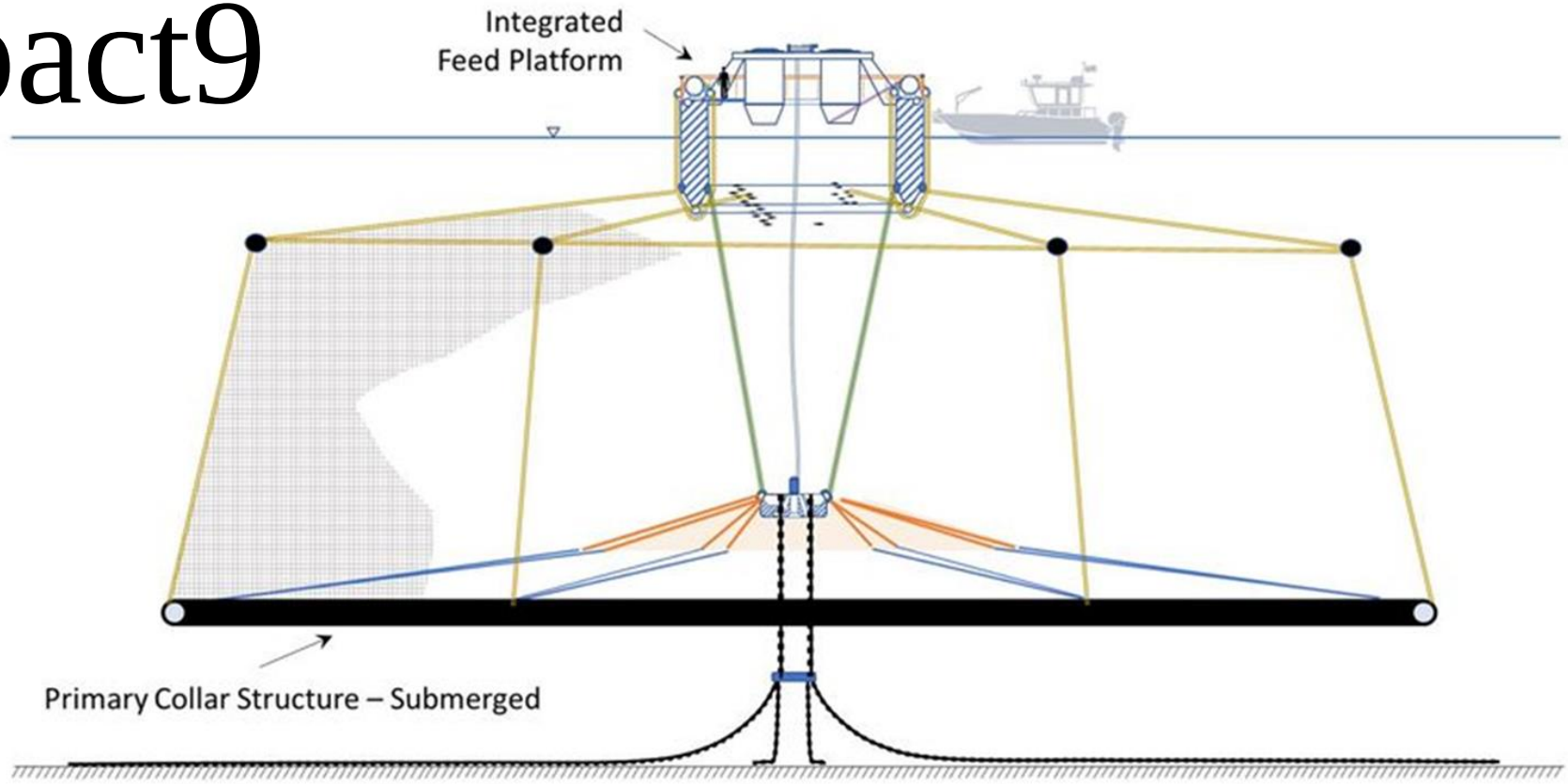
North Sea Container Line, a Norwegian shipping line has introduced a totally new concept for shortsea shipping

https://vimeo.com/111445660


ZERO EMISSION ELECTRIC LOBSTER BOAT
Oceans North & Membertou First Nation
Google Canada & RBC Foundation
Replace 82 mil kg CO_2
70% of lobster boats ~20 km from shore

Impact9


1
Inshore Stocking
and Load-out
2
Offshore
Mooring
Connect
3
Pressurise
Primary Collar
4
De-Ballast
Collar
5
Operational
Position


Integrated
Feed Platform
Primary Collar Structure – Submerged

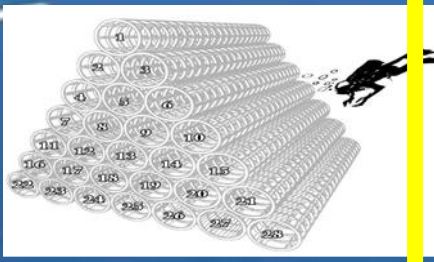
Scenario Planning

Problem → Opportunity	Win = Win	Business Structures
(1) Energy operations	Removal of fouling maintains structural integrity and produces new ocean foods	Separate?
(2) Most operations offshore (shipping, fisheries, aquaculture)	Electric charging stations add income	Integrated?
(3) Ocean Food Systems Fishing/Aquaculture	**Win = Win** **Win ≠ Lose ??**	**Vessel Innovations Fishing** **Trawling**

CLOSED

Biodiversity Enhancement

Fisheries Enhancement



Aquaculture

OPEN

Ocean & Coastal Management 102 (2014) 7–18

Contents lists available at ScienceDirect

Ocean & Coastal Management

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

Investigating the co-existence of fisheries and offshore renewable energy in the UK: Identification of a mitigation agenda for fishing effort displacement

Jiska de Groot [a, *], Maria Campbell [b], Matthew Ashley [c], Lynda Rodwell [d]

[a] Plymouth University, School of Geography, Earth and Environmental Sciences, Portland Square Building A503, Drake Circus, PL4 8AA, UK
[b] Plymouth University, School of Marine Science and Engineering, Room 614 Davy Building, Drake Circus, Plymouth PL4 8AA, UK
[c] Plymouth University, Marine Institute, Marine Building, Drake Circus, Plymouth PL4 8AA, UK
[d] Plymouth University, School of Marine Science and Engineering, Room 123 Reynolds Building, Drake Circus, Plymouth PL4 8AA, UK

Multiple Uses of offshore wind energy areas in the Belgian North Sea

Effects of marine windfarms on the distribution of fish, shellfish and marine mammals in the Horns Rev area

Wind EUROPE

Rhode Island Ocean
Special Area Management Plan

oceanSAMP

VOLUME 1

Adopted by the Rhode Island Coastal Resources Management Council
October 19, 2010

Impacts of Offshore Wind Turbines on Fish and Fisheries of Different Gear Types: The European Experience.

Based on the **European experience**, review and summarize the **current state of knowledge about the effects of offshore wind farms on fish and fisheries of different gear types**. This includes but not limited to turbine construction and associated underwater noise emissions; cable laying; various turbine foundations; and wind farm operation. Summarize methods for mitigating the potential impacts of offshore wind farm construction and operation on fish and fisheries. **Summarize European protocols for fisheries monitoring at offshore wind farms as well as the outcomes of such monitoring programs. Provide insight into fishermen's concerns** with regard to offshore wind farms as well as the potential impacts of offshore wind farms on fishermen's livelihoods (differentiated by gear type).

Marine habitat complexity — the number of different structural elements per unit area — is a key driver of community composition, and a positive determinant of biodiversity. Complexity increases the range of niches available to species, thus increasing the number and diversity of species in an area.

Hutchinson GE. 1957. Population studies. *Cold Spring Harb. Symp. Quant. Biol.* **22**, 415-427.

Ritchie ME, Olff H. 1999. Spatial scaling laws yield a synthetic theory of biodiversity. *Nature* **400**, 557-560.

Oil platforms off California are among the most productive marine fish habitats globally

Jeremy T. Claisse[a,1], Daniel J. Pondella II[a], Milton Love[b], Laurel A. Zahn[a], Chelsea M. Williams[a], Jonathan P. Williams[a], and Ann S. Bull[c]

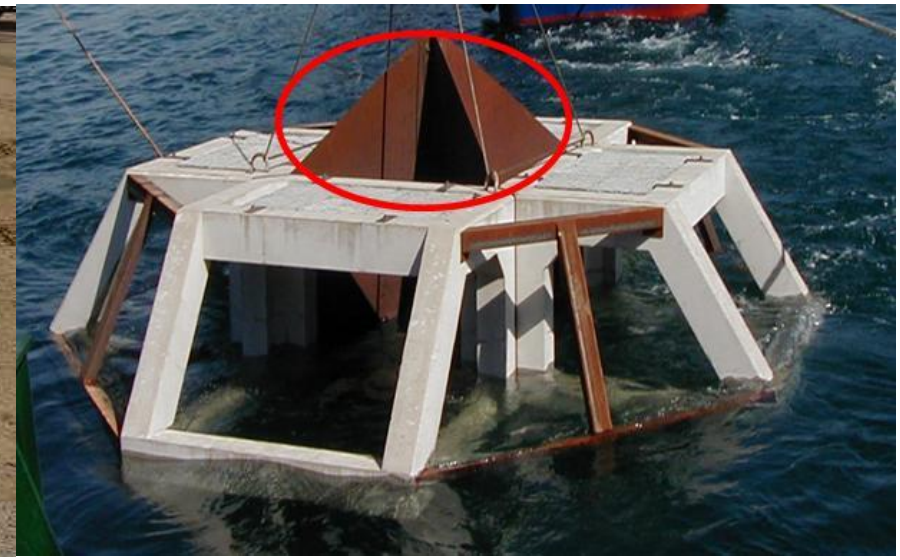
Oil and gas platforms off the coast of California have the highest secondary fish production per unit area of seafloor of any marine habitat that has been studied. The mean annual Total Production/m^2 of seafloor…was…27.4X (greater) per m^2 (than) on natural rocky reefs located at similar depths in the study region. When platforms (were) evaluated individually, their average annual Total Production (range = 104.7–886.8 g/m^2/y) tended to be an order of magnitude higher than that of fish communities in other marine ecosystems where similar types of measurements have been made (range = 0.9–74.2 g/m^2/y).

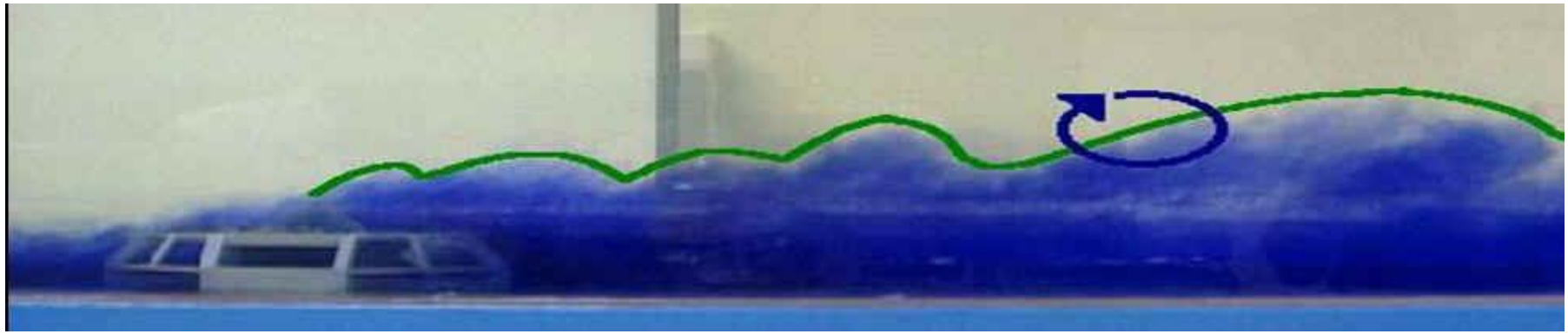
Do you think offshore structures improve the quality of your offshore fishing in Louisiana?

99% (882) Yes

1% (11) No

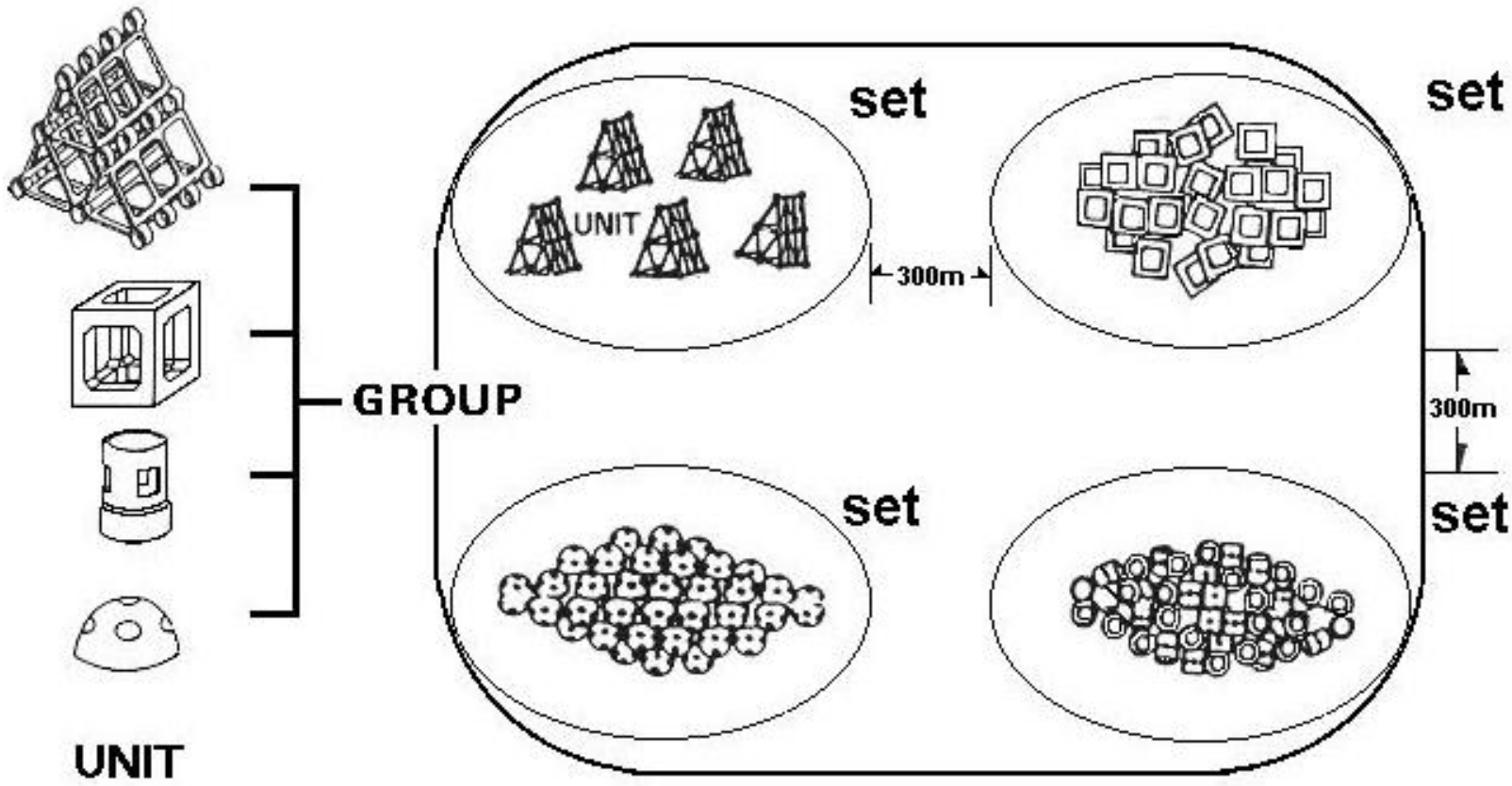
Upwelling Enhancement





Y. Suenaga

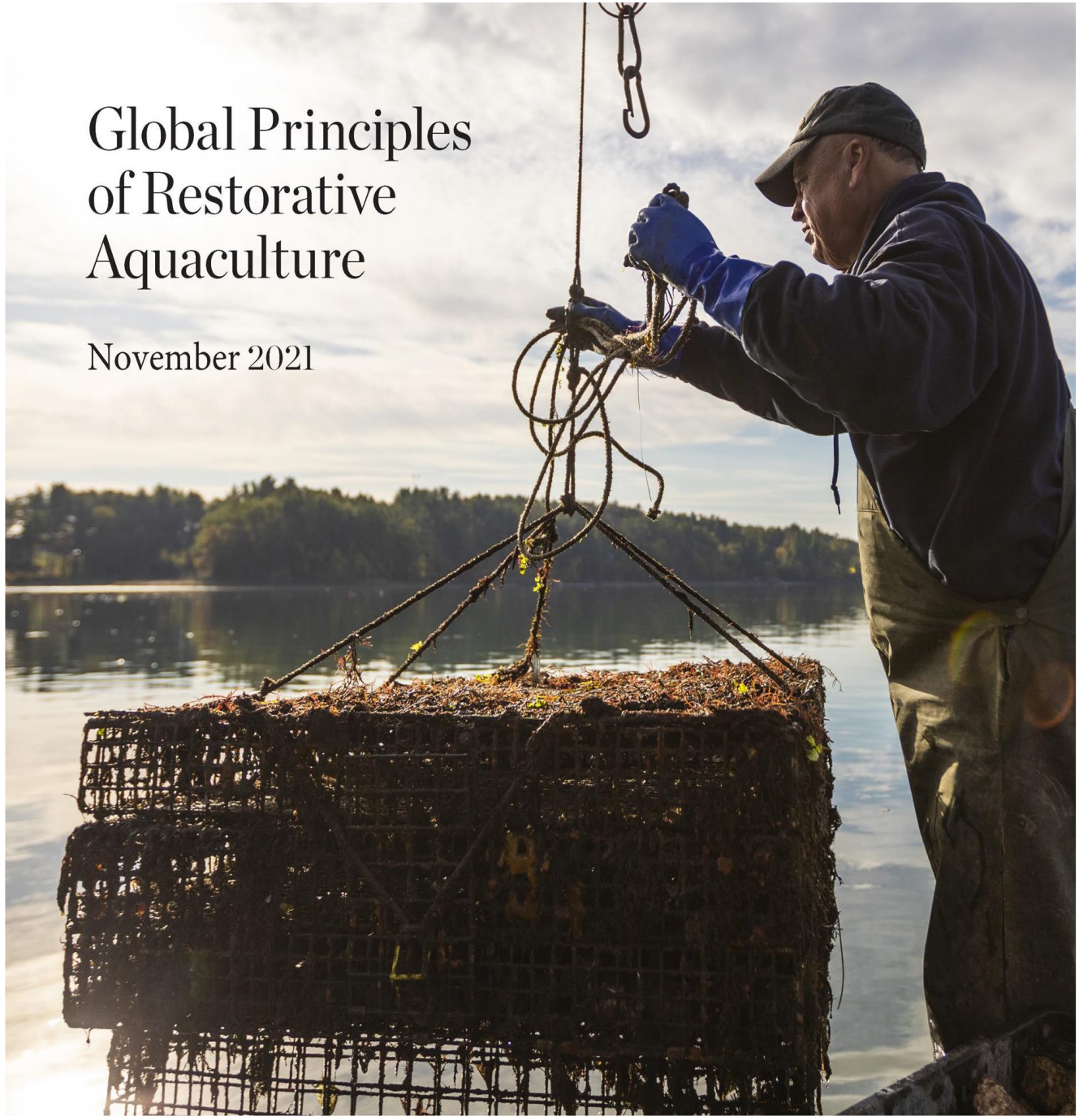
Using Different Modules for Different Species or Life Stages



C.G. Kim

Global Principles of Restorative Aquaculture

November 2021



The Nature Conservancy

Project to grow corals on offshore wind turbine foundations launched

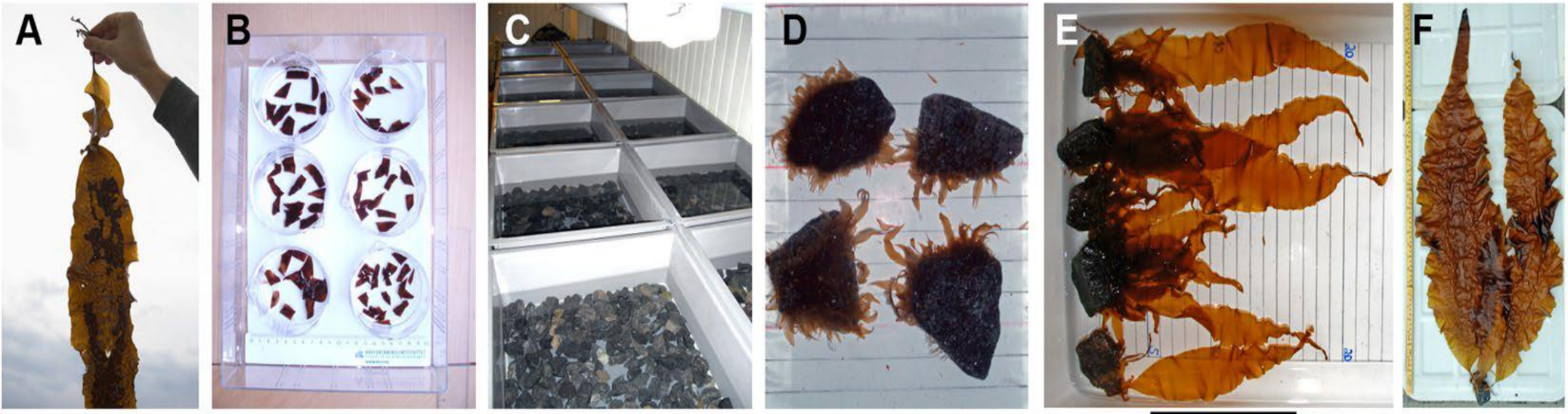
Ørsted will trial cultivating corals on the steel surfaces of four wind turbine foundations

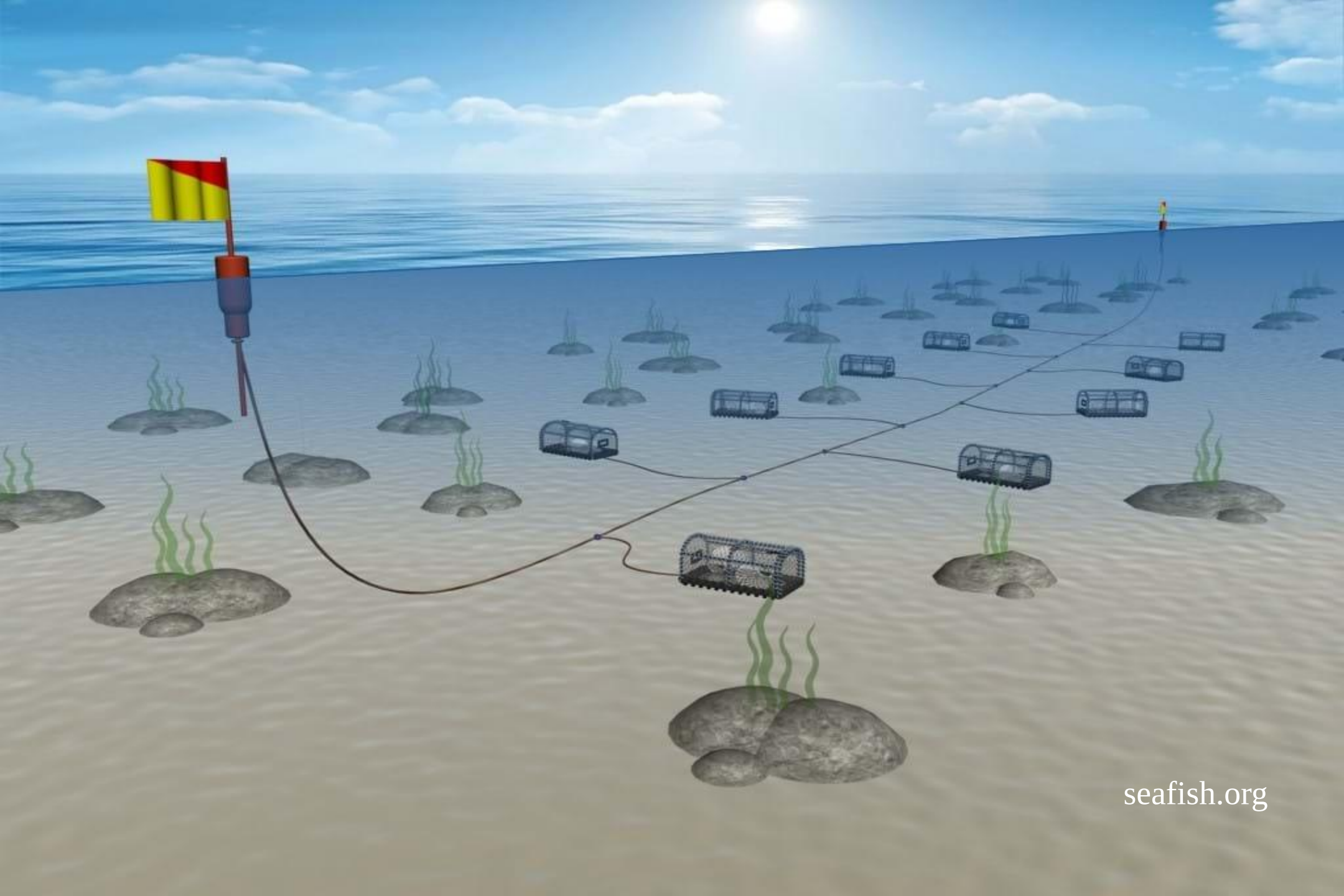
Image: ReCoral by Ørsted

Green gravel: a novel restoration tool to combat kelp forest decline

Stein Fredriksen et al.

Scientific Reports | *(2020) 10:3983* | https://doi.org/10.1038/s41598-020-60553-x


A
B
C
D
E
F
Collect fertile kelps
Induce spore release
Seed spores on gravel
Incubation 14 d low flow 55 d high flow
Scatter gravel on reef
In situ growth 2.5 mo.

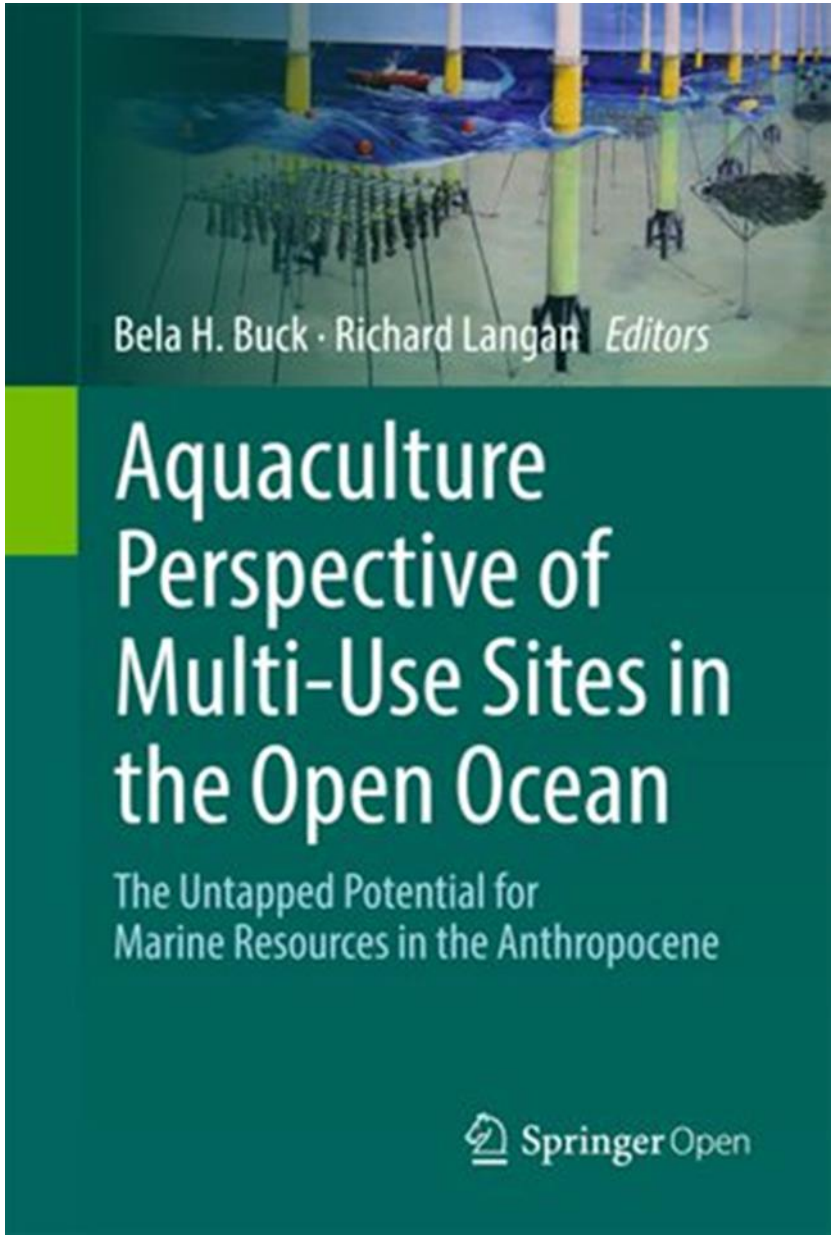

seafish.org

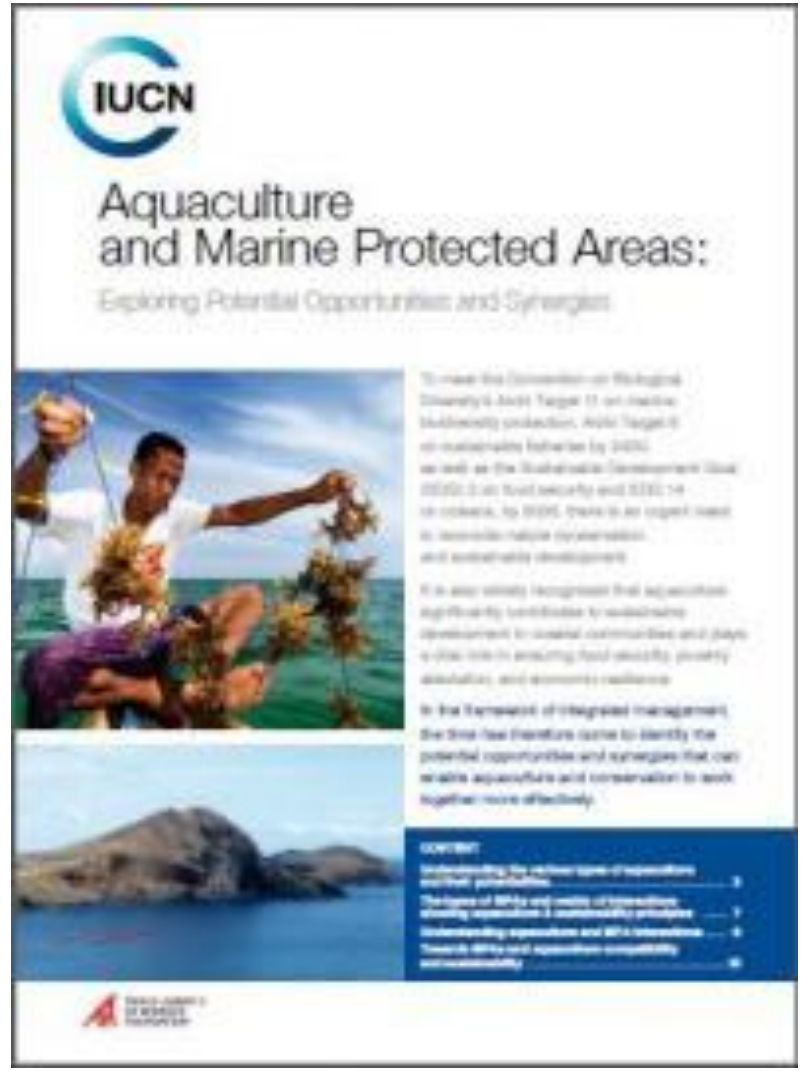
Irish fishing representatives demand government switch to floating wind turbines

November 9, 2022

Six Irish fisheries representatives recently visited a floating offshore wind farm…. Six Irish Sea wind farm developments are now moving into their planning stages. Ireland plans to put 7 GW of wind energy by 2030. “Fishing vessels could be displaced if there is an untrammeled development of offshore wind turbines”

Many of vessels are involved in long-established fisheries for species such as **Dublin Bay prawns** – a valuable resource traditionally fished in the Irish Sea.


Bela H. Buck · Richard Langan Editors
Aquaculture Perspective of Multi-Use Sites in the Open Ocean
The Untapped Potential for Marine Resources in the Anthropocene
Springer Open


IUCN
Aquaculture and Marine Protected Areas:


SUSTAINABLE DEVELOPMENT GOALS
1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
4 QUALITY EDUCATION
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
8 DECENT WORK AND ECONOMIC GROWTH
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
15 LIFE ON LAND
16 PEACE, JUSTICE AND STRONG INSTITUTIONS
17 PARTNERSHIPS FOR THE GOALS
SUSTAINABLE DEVELOPMENT GOALS

Background paper for FAO Shanghai Symposium - "Aquaculture and the SDGs"

Perspectives on aquaculture's contribution to the SDGs for improved human and planetary health

Troell, M.[1,2], B. Costa-Pierce[3], S. Stead[4], R.S. Cottrell[5,6,7,8], C. Brugere[9], A. Farmery[10], D. Little[11], Å. Strand[12], D. Soto[13,14], R. Pullin[15], M. Beveridge[16], K. Salie[17], R. Yossa[18], P. Moraes-Valenti[19], J. Blanchard[5,7], J. Dresdner[20], P. James[21], E. Allison[18,22], C. Devaney[11] and U. Barg[23]

Success is financial success or there is no aquaculture sustainability

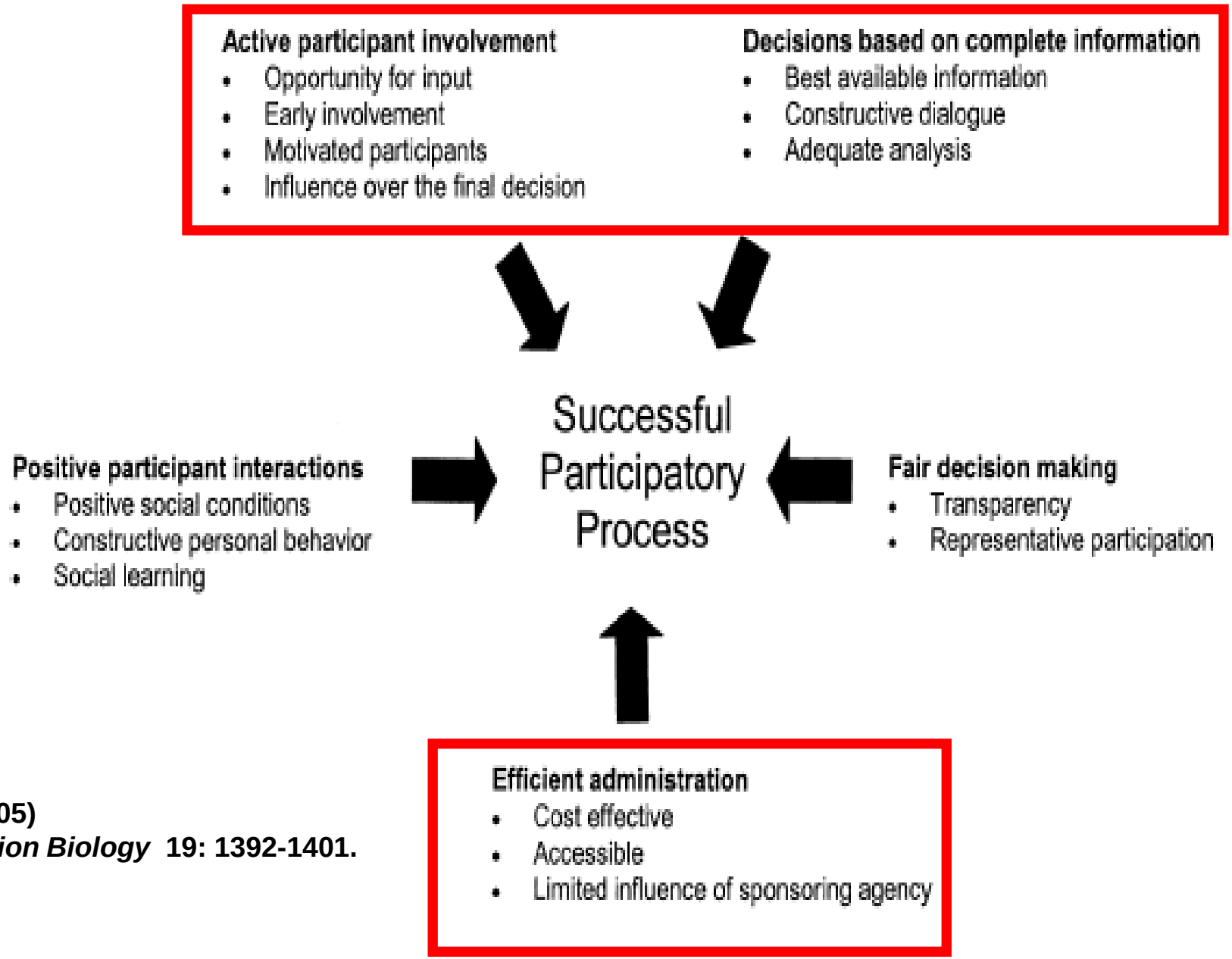
Go Big Go Small Do Everything

Planning: PESTEL Framework & Scenario Planning

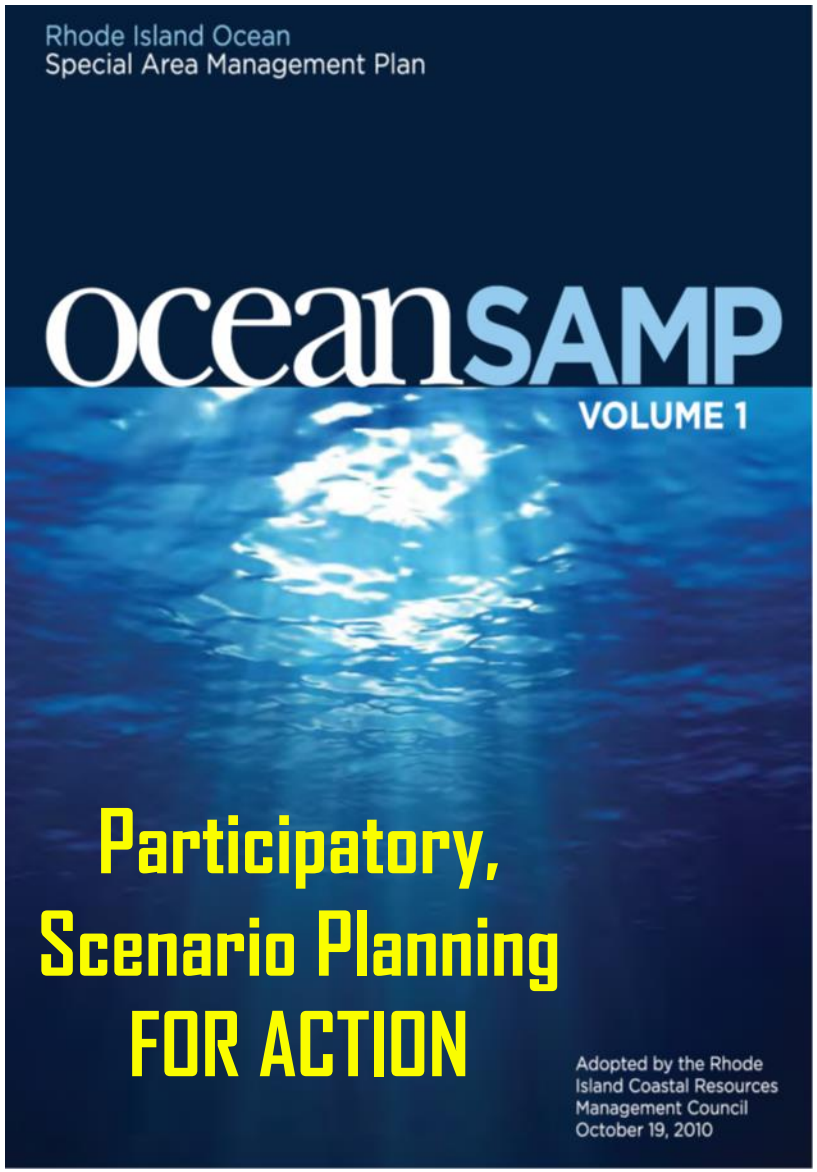
Three Recommendations


#1: Build a Learning Community
Local to Global…but
Make it Structural by
Investments in People & Process

A Long Term Learning Community was the Magic in Rhode Island



Dalton (2005)
***Conservation Biology* 19: 1392-1401.**



Some Metrics

VOLUME 1: 11 Review Chapters

VOLUME 2: 24 Research Chapters

18 Stakeholder Meeting Summaries

8 Project Management Documents

5 Fisheries Documents

23 Presentations

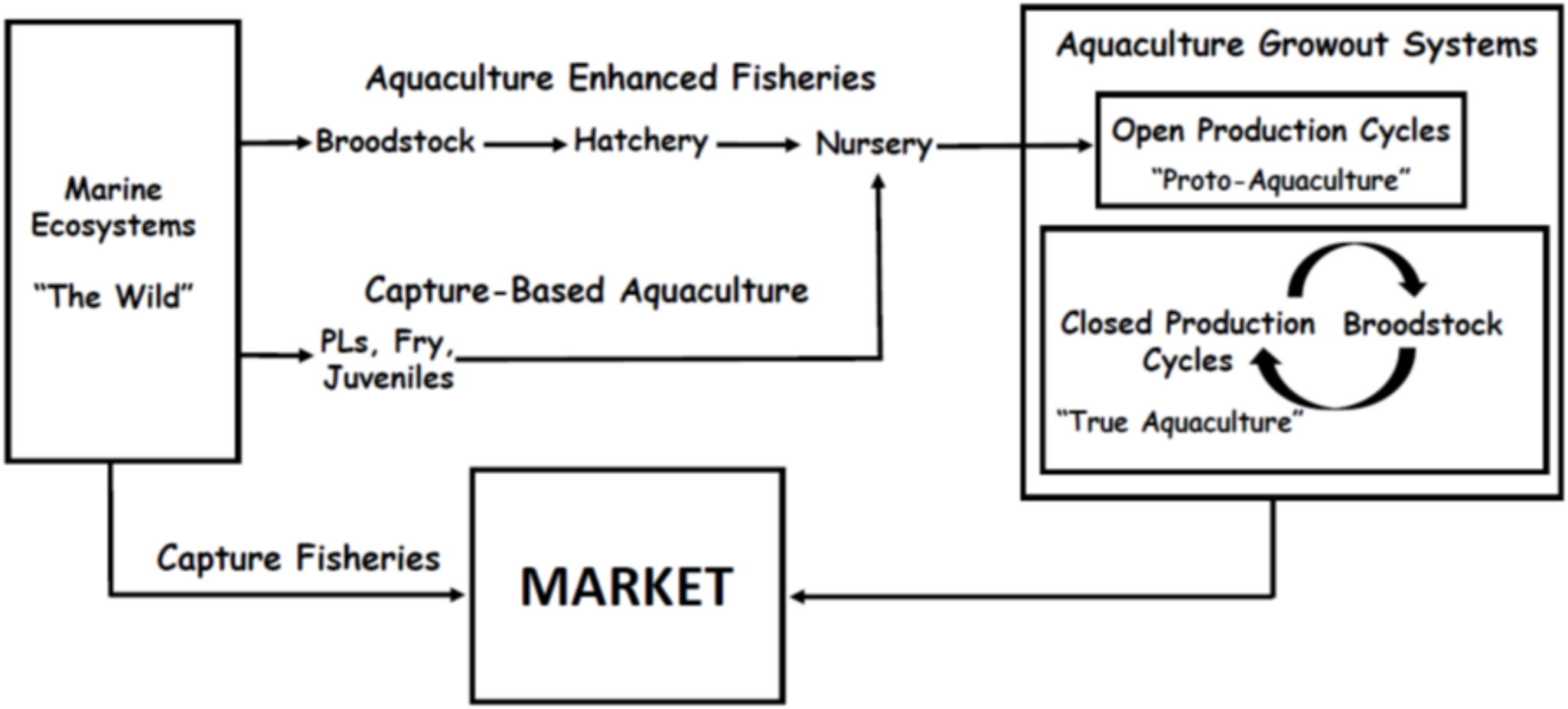
3 Fact Sheets

25 News Articles

7 Podcasts
(one "Amazing Woman")

Keys to success

- Leadership & **Investment**
- Relatively Long Term, **well-funded**, with an Expert Extension Process
- Trusted, Long Term, **well-funded** Partnerships
- Outstanding, Very Responsive Spatial Assessment/GIS Expertise



Costa-Pierce BA, Thorarensen HT and Strand Å (2022) Editorial: Ocean/aquatic food systems: Interactions with ecosystems, fisheries, aquaculture, and people. *Frontiers in Sustainable Food Systems* 6:1021801. doi: 10.3389/fsufs.2022.1021801


#2: Fund More Science
Yes...
BUT the Right Kind of Science

The RIGHT TYPE OF SCIENCE!

"Transdisciplinarity today is characterized by its focus on "*wicked problems*" that need *creative solutions*, its 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.

Volume TWO

The Planning and **Policy** Context
Characterizing the **Physical Oceanography** of Coastal Waters Off Rhode Island, Part 1: Literature Review, Available Observations, and A Representative Model Simulation
Characterizing the Physical Oceanography of Coastal Waters Off Rhode Island, Part 2: New Observations of Water Properties, Currents, and Waves
Benthic Habitat Distribution and Subsurface **Geology** in Selected Sites from the Rhode Island Ocean Special Area Management Study Area
Investigations into Block Island's Submerged **Cultural Sites and Landscapes** for the Rhode Island Ocean Special Area Management Plan 2010
High Resolution Modeling of **Meteorological, Hydrodynamic, Wave and Sediment** processes in the Rhode Island Ocean SAMP study area
Typical Meteorological Conditions and Occurrence of Disturbances in Support of the Rhode Island Ocean SAMP
Analysis of **Extreme Wave Climates** in Rhode Island Waters South of Block Island
Spatial and Temporal Variability of Surface Chlorophyll, **Primary Production**, and Benthic Metabolism in Rhode Island and Block Island Sounds
Marine Mammals and Sea Turtles of Narragansett Bay, Block Island Sound, Rhode Island Sound, and Nearby Waters: An Analysis of Existing Data for the Rhode Island Ocean Special Area Management Plan
The Spatial Distribution, Abundance, and Flight Ecology of **Birds** in Nearshore and Offshore Waters of Rhode Island
Acoustic Noise, and Electromagnetic Study in Support of the Rhode Island Ocean SAMP
Baseline Characterization: Data sources, methods, and results (Chapter 5. Commercial and Recreational Fisheries Appendix A)
Fisheries Ecology and Benthic Habitat in Rhode Island and Block Island Sounds for the Rhode Island Ocean Special Area Management Plan 2010
Fisheries Activity Maps: Methods and Data Sources (Chapter 5. Commercial and Recreational Fisheries Appendix B)
Application of Technology Development Index and Principal Component Analysis and Cluster Methods to Ocean Renewable Energy Facility Siting
High Resolution Application of the Technology Development Index (TDI) in State Waters South of Block Island
Development of a Technology Type Factor for **Jacket Structures** for Offshore Wind Turbines in Rhode Island
Wind Resource Assessment in the Vicinity of a Small, Low Relief Coastal Island
Evaluation of Wind Statistics and Energy Resources in Southern RI Coastal Waters
Meteorological Model based Wind Resource Assessment in the Vicinity of Block Island
Report of the Ocean Special Area Management Plan Stakeholder Process to the Rhode Island Coastal Resources Management Council
Ecological and Service Valuation, a Principal Component and Cluster Analysis Approach: An Ecological and Service Typology in the Ocean SAMP Area
The Northwest Atlantic Marine Ecoregional Assessment: Implications for the Rhode Island Ocean SAMP region. The Nature Conservancy, Rhode Island Chapter, Providence, RI.
Enhanced ocean landscape and ecological value characterization for the Rhode Island Ocean Special Area Management Plan study area using Habitat Typology and Habitat Template approaches
Rhode Island Ocean Special Area Management Plan: Studies Investigating the Spatial Distribution and Abundance of Marine Birds in Nearshore and Offshore Waters of Rhode Island
Ocean Special Area Management Plan Science Research Agenda
Ecological Value Map (EVM) for the Rhode Island Ocean Special Area Management Plan – May 2011 Update
Funding Support for Renewable Energy Projects

SCIENCE

SAVE OUR BIRDS!

Cats kill 2.4 billion birds/y
Towers 3.2 million/y

Painting one blade black reduced bird collisions by 70% - contrast made blades easier to see and avoid

Ecology & Evolution 27 August 2022


#3: Build New Communities
PORTS are the Top Priority


HAVE FUN


Thank you URI