

Aquaculture 101 for Coral Reef Managers

Presenters:



Robert Jones

Global Aquaculture Strategy Lead
The Nature Conservancy



Julio Camperio

PhD Student – Aquaculture
University of Miami



Jonathan MacKay,

Marine Spatial Scientist
The Nature Conservancy



Steven Victor

Micronesia Program Director
The Nature Conservancy

Hosts: Cherie Wagner, Reef Resilience Network
Tiffany Waters, The Nature Conservancy

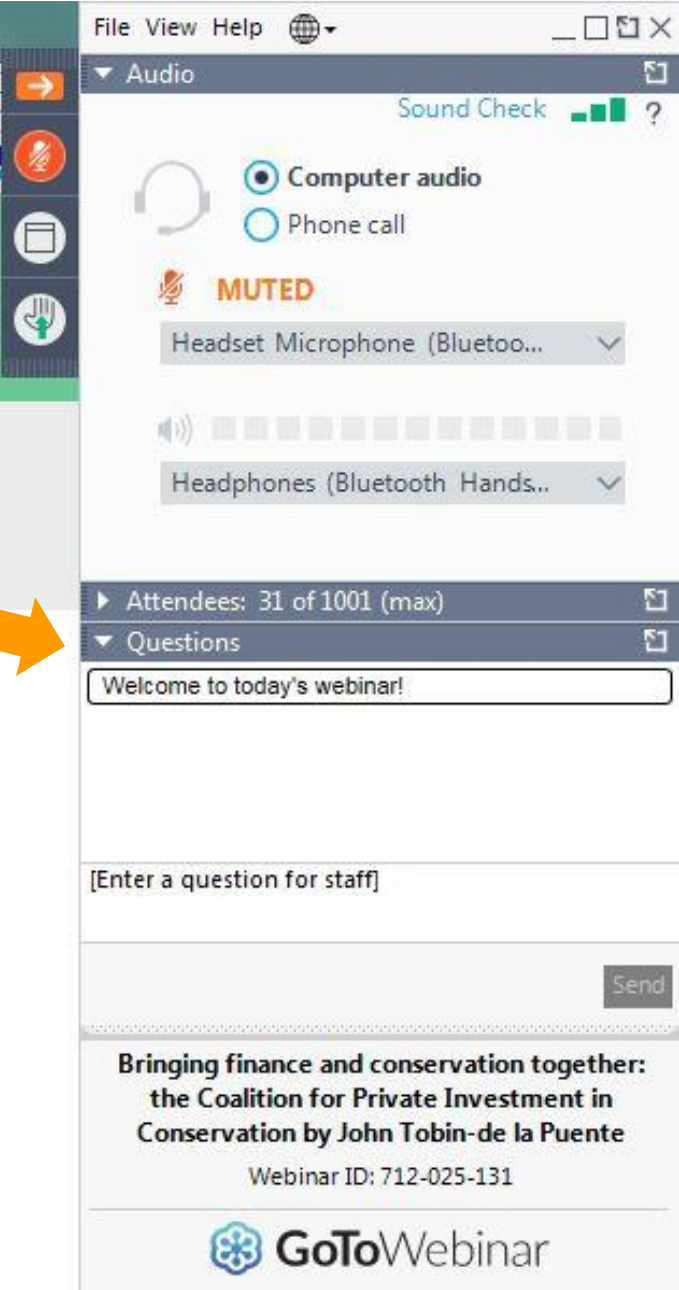
The Nature
Conservancy 

 **Reef
Resilience
Network**

Questions:

There are two ways you can ask questions:

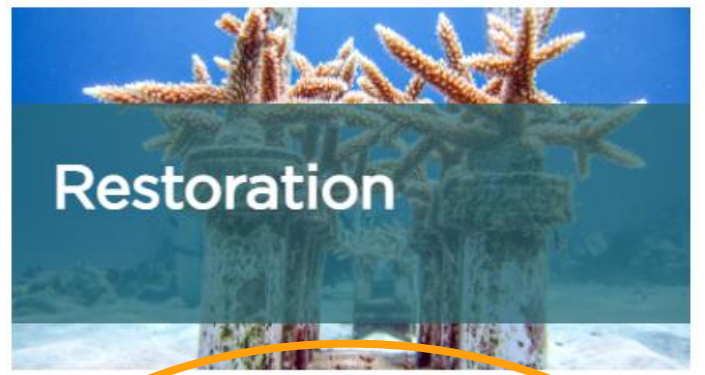
1. Type your question into the Question box
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Aquaculture



Management Strategies

Threat Reduction ▾

Marine Protected Areas ▾

Managing for Disturbance ▾

Restoration ▾

Aquaculture ▲

Aquaculture Introduction ▾

Environmental Impacts & Mitigation ▾

Regulations to Support Sustainable Management

Community Planning

We face an unprecedented challenge ahead. How can we feed a growing world population in the face of decreasing wild fish stocks and increasing environmental impacts from our current food systems? Most importantly, how do we do so in a way that is environmentally sustainable and that benefits coastal communities?

Communities, governments, the private sector, and scientific institutions can and must protect our oceans, increase food security, and improve livelihood opportunities. Sustainable aquaculture and fisheries can be part of the solution to this global challenge, but we must fish and farm in the right ways.

This toolkit explains aquaculture concepts in the context of coastal environments and tropical reef ecosystems, with a special focus on finfish farming:

- [What is aquaculture?](#) - basic concepts of aquaculture and its importance for food security and livelihoods of coastal communities.
- [Global status of finfish aquaculture](#) - the global status of marine finfish

This toolkit is designed for marine managers and practitioners that are working in a reef system that contains nearshore fish aquaculture cages or are considering management decisions on whether or how to permit finfish

Aquaculture Status



Management Strategies

Threat Reduction ▼

Marine Protected Areas ▼

Managing for Disturbance ▼

Restoration ▼

Aquaculture ▲

Aquaculture Introduction ▲

Aquaculture Status

Finfish Farming & Culture Methods

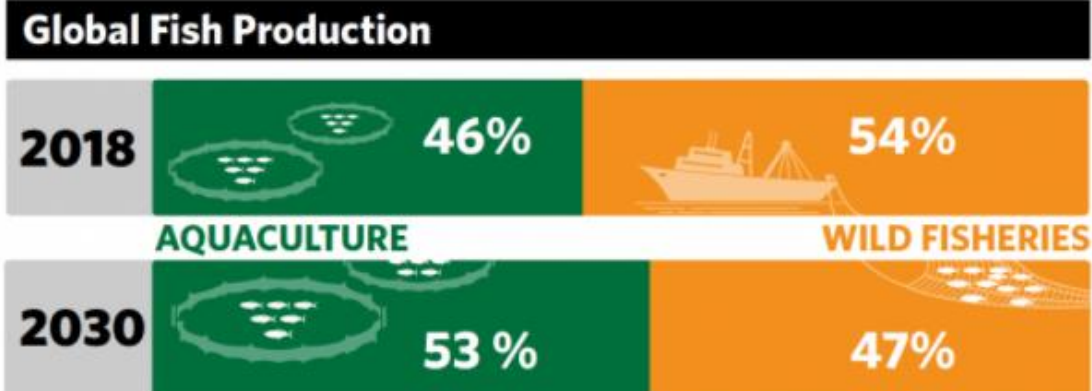
Environmental Impacts & Mitigation ▼

Regulations to Support Sustainable Management ▼

Community Planning

Global fish production (wild and farmed) is estimated to have reached 179 million tons in 2018, with a total value estimated at \$401 billion. While aquaculture makes up less than half of total production at 82 million tons, it is valued at \$250 billion, which is 62% of the total value. Aquaculture's total value per pound is higher than wild fisheries. In 2018, aquaculture production consisted of 82.1 million tons of aquatic animals, 32.4 million tons of aquatic algae, and 26 thousand tons of ornamental shells and pearls. The aquatic animals were dominated by finfish at a total of 54.3 million tons of which 47 million were from inland, and 7.3 million were from marine and coastal areas. ^{ref} Global seaweed production from finfish aquaculture is expected to continue to grow and outpace wild fisheries by 2030.

Global Seafood Production for Finfish Aquaculture



Source: FAO 2020

Environmental Impact Assessments



Management Strategies

Threat Reduction ▼

Marine Protected Areas ▼

Managing for Disturbance ▼

Restoration ▼

Aquaculture ▲

Aquaculture Introduction ▼

Environmental Impacts & Mitigation ▼

Regulations to Support Sustainable Management ▲

Environmental Impact Assessments

Area Management Approaches

Community Planning

Reef Fisheries ▼

Many countries have environmental legislation that requires a review of the potential environmental impacts of a proposed operation before a government permit can be issued (e.g., the United States National Environmental Policy Act). Environmental impact assessments can be defined as “the process of evaluating and mitigating the biophysical, social and other relevant effects of development proposals prior to major decisions being taken or commitments made”.
^{ref} Environmental impact assessments are most frequently applied, and are potentially most useful, in cases where a country may not have a well developed set of aquaculture legislation and regulations that clearly define or constrain which aquaculture operations and practices may be allowed.

Environmental Impact Assessment



Screening and Scoping

Is an Environmental Impact Assessment required and to what scale?



Assessment of Environmental Risk

What data will be collected to determine environmental risk?



Mitigation

What measures will be followed to minimize assessed environmental impacts?

Stakeholder
Engagement

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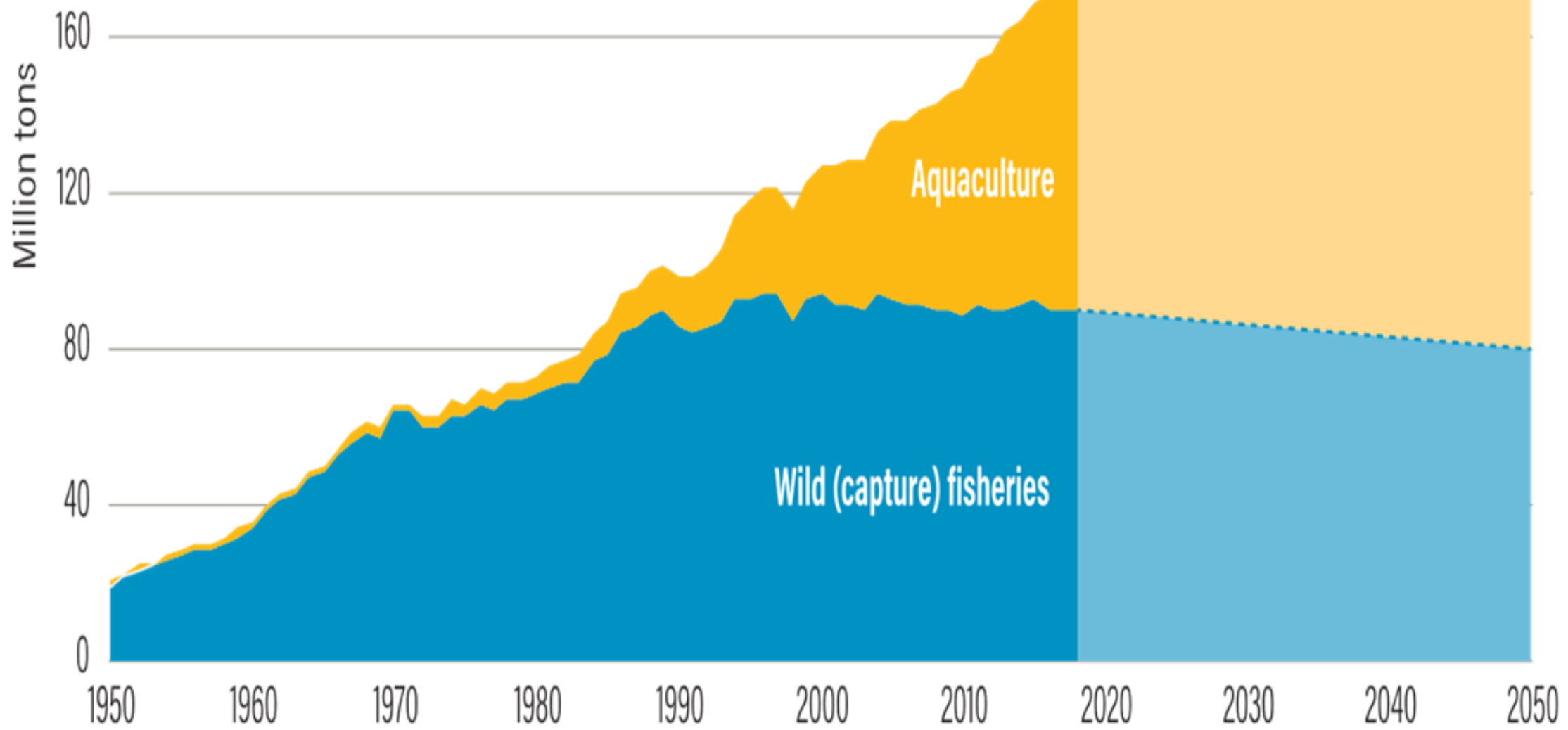
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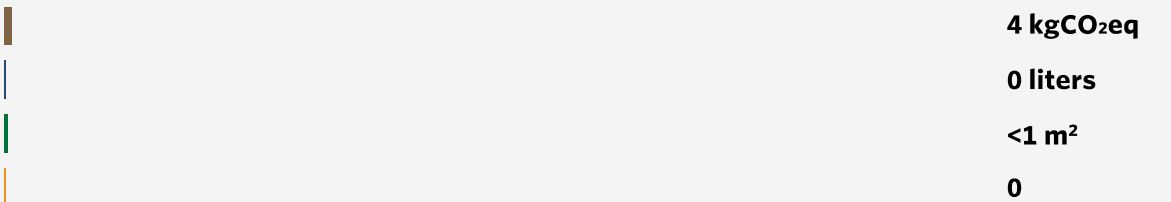
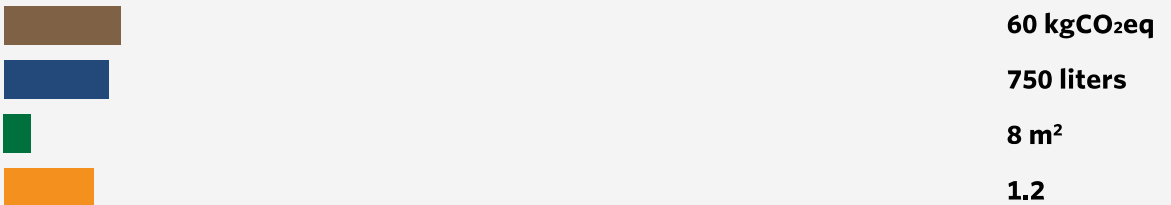
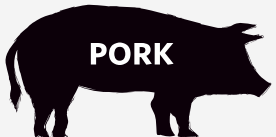
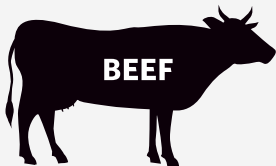




Finfish Aquaculture 101 for Coral Reef Managers



Robert Jones, Global Aquaculture, The Nature Conservancy



Environmental Impact of Animal Protein Production



 GREENHOUSE GAS EMISSIONS: emissions for every 1kg of protein (kgCO₂eq)
 FRESH WATER USE: liters of freshwater used for every 1kg of protein (liters/kg)

 LAND USE: Land use for 1kg of protein (m²/kg)
 FEED CONVERSION RATIO



90% of fisheries are fully
or overfished





Benefits of Seafood



PROTEIN

Provides a low-fat heart-healthy form of protein



LONG CHAIN OMEGA-3 FATS

Essential for optimal brain development and improving risk factors for heart diseases



IODINE

Aids in thyroid function and health and neurodevelopment



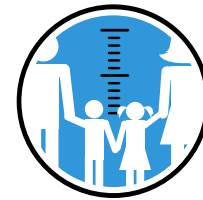
VITAMIN D

Crucial in immune system regulation, mental development, and bone health



IRON

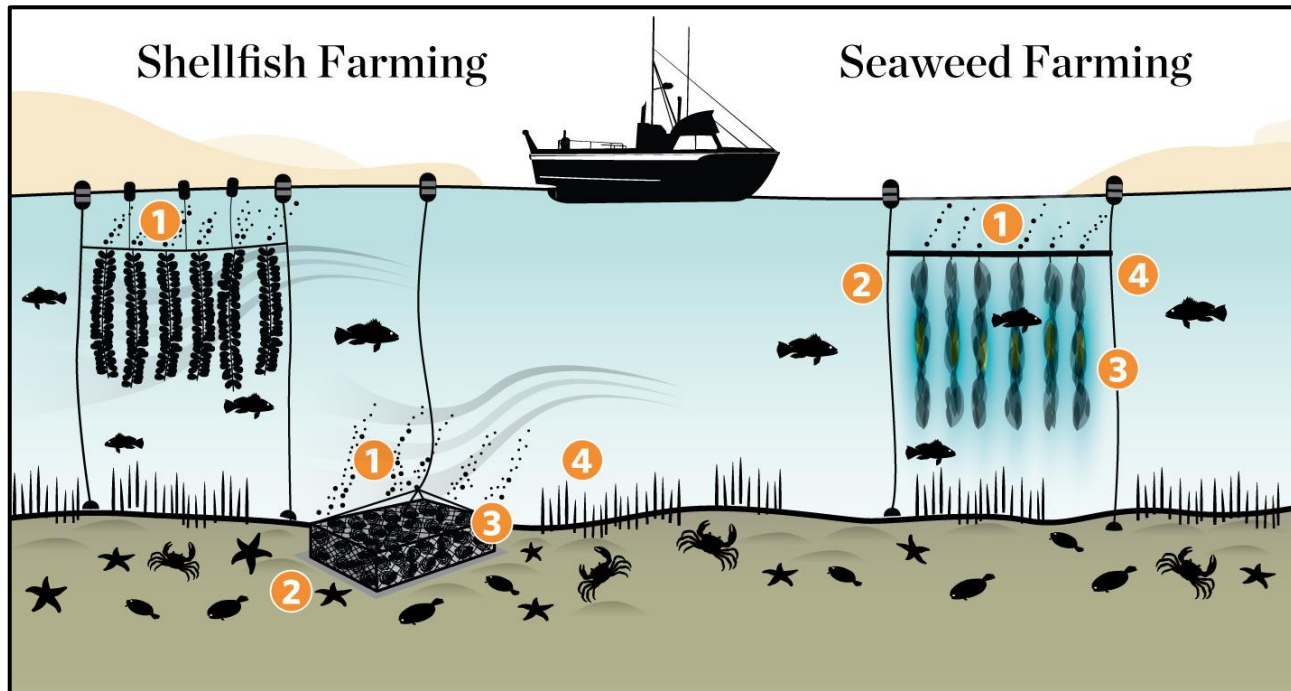
Vital during pregnancy to allow the mother to produce additional blood for the baby



CALCIUM, ZINC, OTHER MINERALS

Deficiencies in essential minerals can slow the development of children

Restorative Aquaculture



1. Mitigate Pollution

Shellfish and seaweed aquaculture can improve water quality by extracting nitrogen and phosphorous from coastal waterways. As filter feeders, bivalve shellfish can improve water clarity. These factors can lessen the symptoms of eutrophication, which effects 415 estuaries worldwide

2. Habitat Provision

85 percent of native oyster populations have been lost worldwide and many seaweed communities are similarly in decline. Shellfish and seaweed aquaculture can provide some of the benefits of these lost habitats.


3. Support Fish Stocks

Shellfish and Seaweed aquaculture gear provides refuge for macro-fauna including fish, crustaceans, and other invertebrates.

4. Reduce Local Climate Change Impacts

Aquaculture can reduce carbon dioxide and oxygenate waterways, and thereby locally mitigate the effects of ocean acidification. Through increased water clarity, shellfish aquaculture may promote the growth of eelgrass beds, a carbon sink.



An aerial photograph of a floating village in Hainan, China. The image shows a dense cluster of wooden rafts, each with a corrugated metal roof, floating on a body of water. Small boats are interspersed among the rafts. In the background, a shoreline with buildings and trees is visible. A white rectangular box with a torn bottom edge is overlaid on the left side of the image, containing the text 'Hainan, China'.

Hainan, China

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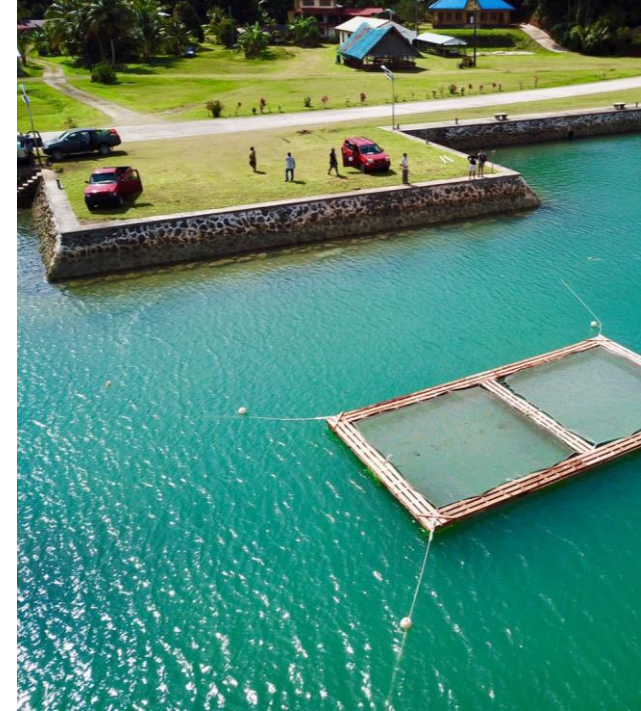
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Environmental Impacts & Mitigation

Julio Camperio



Marine aquaculture:

Culture of marine organisms in a confined and controlled environment

Possible Impacts to be Mitigated

- Any source of protein production can have impacts on the environment
- Impacts can be minimized if proper planning, correct management, and appropriate mitigation strategies are carried out



**Impacts to
Wild Stocks**



Habitat Impacts



Water Pollution



Disease



Impacts to Wild Stocks

- Removal of wild species to use as fry
- Farmed fish escapes
- Entanglement of wild species
- Feed impacts

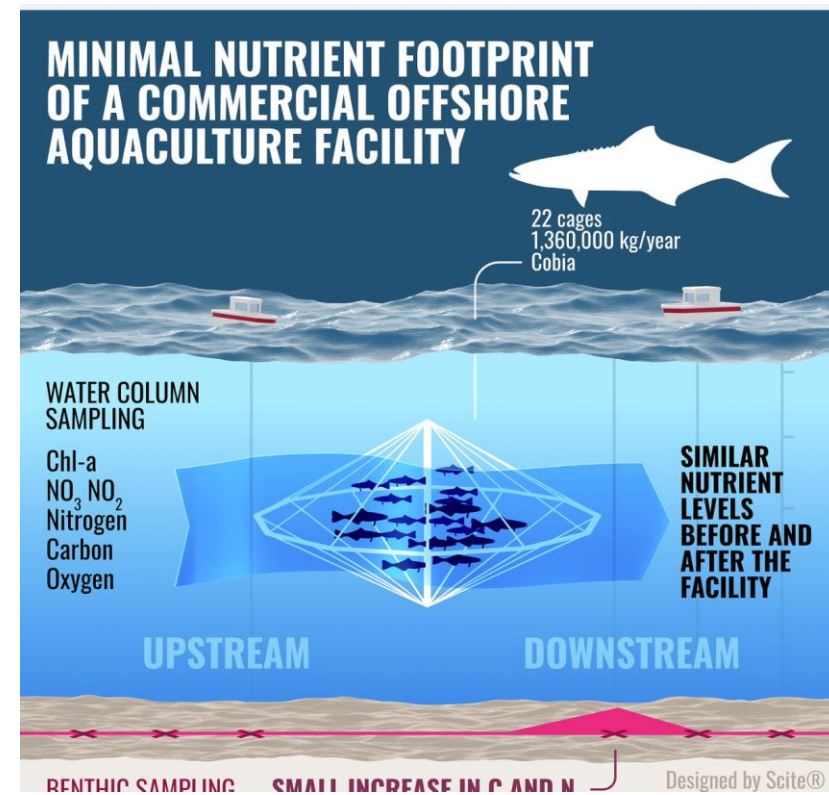
Impacts to Wild Stocks

IMPACT	MITIGATION STRATEGY
Removal of wild species to use as fry	Source fry from hatcheries If no hatchery is available, farm species not overfished
Farmed fish escapes	Engage in regular gear monitoring and maintenance Farm local species Be proactive in gear repairs
Entanglement of wild species	Site cages away from known areas frequented by protected species Carry out regular monitoring to detect nearby animals that might get entangled with gear
Feed impacts	Use commercial pellets rather than whole fish, fish trimmings, and/or animal slaughter waste Do not overfeed fish in cages



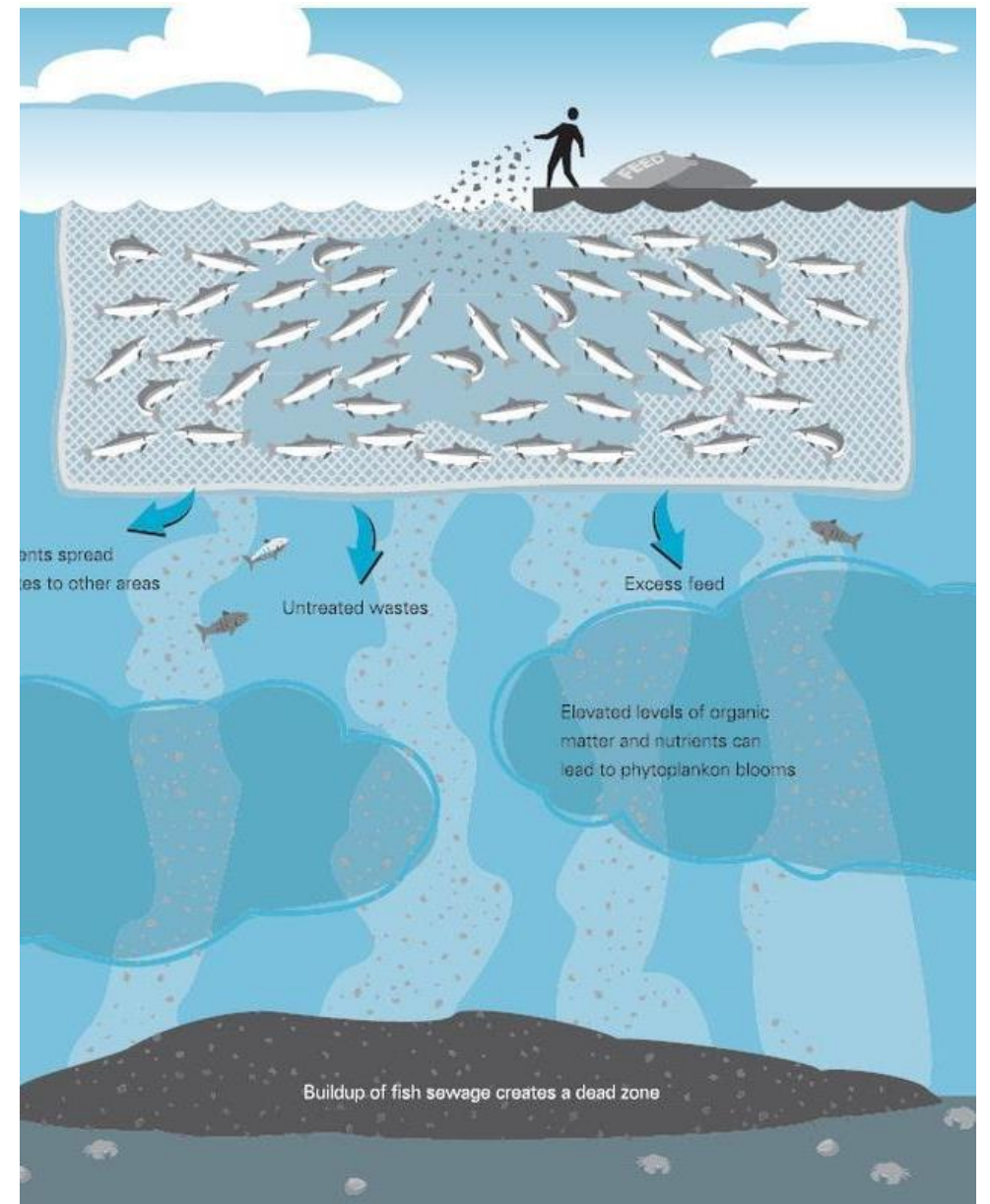
Impacts to Habitat

- Impacts to local sensitive habitats
- Gear loss
- Reduction of water quality



Impacts to Habitat

IMPACT	MITIGATION STRATEGY
Impacts to local sensitive habitats	<p>Appropriate planning and siting is imperative to prevent damage to mangroves, reefs, and nurseries</p> <p>Account for vertical and horizontal distance from sensitive habitats</p> <p>Assess current velocity and direction to dissipate excess nutrients</p>
Damaging of gear	Regular monitoring and maintenance needs to take place
Reduction of water quality	<p>Attempt to carry out an environmental impact assessment for proposed site and production</p> <p>Monitor local water quality before and during finfish production to observe for changes in water quality</p>



Water Pollution

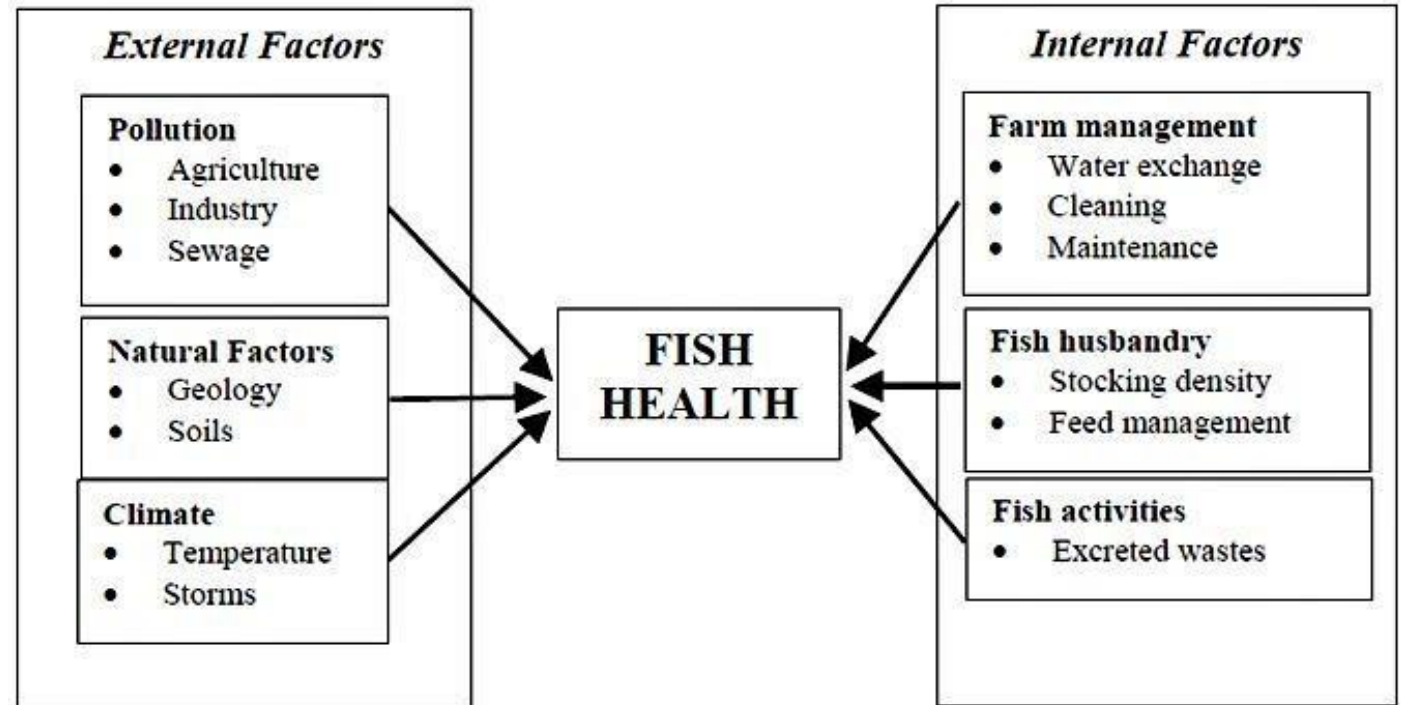
- Excess feed and waste
- Environmental parameters
- Carrying capacity

Water Pollution

IMPACT	MITIGATION STRATEGY
Excess feed and feces	<p>Do not overfeed fish and use commercial pellets</p> <p>Site cages in area with enough depth and distance from sensitive areas</p> <p>Assess and determine current velocity and direction to dissipate nutrients</p> <p>Regular monitoring of water quality before and during production</p>
Excess of carrying capacity	<p>Carry out or determine carrying capacity limit</p> <p>Do not overstock as ecosystem will not be able to sustain nutrient accumulation</p> <p>Proper planning during site and cage type selection are essential</p>

Disease

- Disease can greatly impact productivity
- Internal factors can be controlled
- Be proactive not reactive



Disease

IMPACT	MITIGATION STRATEGY
Biofouling on nets that reduce water flow, reduce oxygen, allow parasites	Regularly clean nets when cages are empty to remove biofouling
Prevalence of diseases and parasite	Maintain a reduced stocking density Do not install cages too close to each other Observe behavioral and physical changes
Nutritional deficiency	Feed with commercial pellets rather than whole fish, fish trimmings, or other animal parts

Take home message

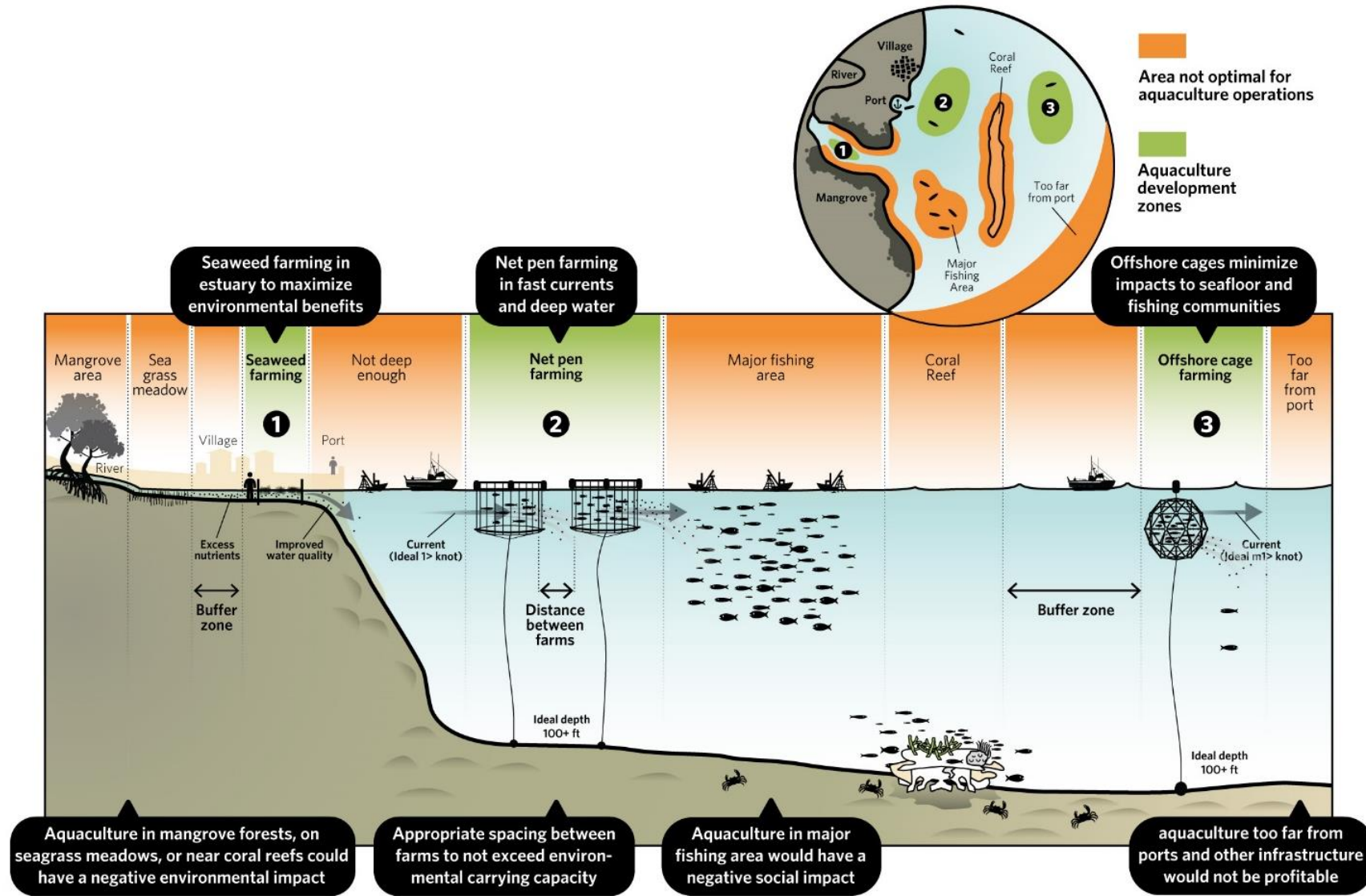
- Plan before any construction takes place
- Locate potential areas through site selection
- Assess environmental parameters of proposed sites
- Monitor environmental quality and health of fish

Finfish Aquaculture 101: Area Management Approaches

Jonathan MacKay

Marine Spatial Scientist

Contractor CSS, Inc.



Site Selection Checklist

20 Key Factors

Finfish Aquaculture Site Selection Checklist

Environmental factors Political, regulatory, and social-cultural factors Operational and logistical factors

	Depth profile / availability of hydrographic maps showing seafloor <ul style="list-style-type: none"> Are there maps available that show the seafloor along with type of bottom? Are bathymetry maps available to evaluate seafloor depth? Is the recommended depth of 20-40m reached?
	Exposure to wind and incidence of storms <ul style="list-style-type: none"> What is the wind velocity and strength in the proposed area? Are the proposed cages protected from any leeward sides of islands? Are the cages in protected bays?
	Tides and currents <ul style="list-style-type: none"> What is the current velocity in the proposed area? Is the recommended velocity of 0.05-0.2m/s achieved? In what direction do the currents flow and are they seasonal? Are there strong tides in the area and in what direction do they flow?
	Wave activity <ul style="list-style-type: none"> Is the proposed area in an area with wave activity? What is the maximum wave height and is wave activity seasonal?
	Water quality, temperature, and salinity <ul style="list-style-type: none"> Have water quality tests been carried out for fecal coliforms, excess nutrients, and harmful algae blooms? Has dissolved oxygen been measured? What are the temperature ranges for this area and is there a thermocline?
	Bottom type; hydrographic maps showing seafloor <ul style="list-style-type: none"> What is the type of sediment under the cages? Is the recommended sandy bottom available? If the bottom is muddy, has the recommended depth >40m been reached?
	Presence of sensitive habitats <ul style="list-style-type: none"> Are there corals and seagrasses present in the area? Are the cages sited far enough away and/or with enough depth to not impact sensitive habitats? Are there mangroves near the area? Are the cages sited far enough away to ensure excess nutrients do not impact the mangroves?
	Plankton occurrence and distribution; red tides <ul style="list-style-type: none"> Has a plankton abundance study in the local waters been done? Will the operation of the cages affect that abundance? Are red tides an occurrence in the proposed area? Could nutrients from the finfish farm affect algae blooms in the local environment?
	River runoff, stratification <ul style="list-style-type: none"> Is there river runoff present in the local area? Will it affect the fish production? Is there a thermocline present in the proposed area? Is there water stratification present in the proposed area?
	Likelihood of impacts from climate change <ul style="list-style-type: none"> Is sea level rise projected in this area? Are there expected water quality or temperature changes due to climate change in this area?



Bioremediation, mitigation needs

- In case cages produce more than minimal pollutants, what mitigation or bioremediation strategies are put in place to reduce ecological risks?



Ease of gaining permits; local public acceptance

- What is the public perception of marine aquaculture in this area?
- Is it difficult to obtain permits for marine aquaculture in this area?



Use conflicts, number of ocean users in area

- Is this an area that local fishermen use and could create user conflict?
- Is this an area with significant tourists that use the marine space?



Extent of tenure rights

- What are the property rights and local jurisdictions of this area?
- Are there indigenous or local communities that need to be consulted prior to putting a farm in this area?



Marine infrastructure

- Are there sewer outfalls in this area? Is the desirable distance more than 1000m away?
- Are there fiber optic cables or other infrastructure in this area? Is the desirable distance more than 200m away?

	Navigation channels and ports <ul style="list-style-type: none"> Are there significant navigation channels or ports in the area? Is the farm enough distance away to ensure that ships and boats will not impact the farms and vice versa?
	Availability and cost of fingerlings <ul style="list-style-type: none"> Is there a hatchery in the local area where fry can be sourced from? If not local, where are the fingerlings procured from and are there risks in the supply chain? What is the cost of fingerlings of the chosen species?
	Availability and cost of feeds <ul style="list-style-type: none"> Is there a local source of feed in the nearby area? If not local, where is feed procured from and are there risks in the supply chain? What is the cost and ingredients for the feed?
	Distance from shore <ul style="list-style-type: none"> What is the distance from shore and how are the cages reached? Is the recommended distance of 0.2-4km achieved?
	Existing aquaculture farms / risk of pathogen transfer <ul style="list-style-type: none"> How many other and what type of aquaculture farms are near this area? Is there a risk of pathogen transfer from other finfish farms?
	Farm security; threat of theft <ul style="list-style-type: none"> Is there a system of security guards or personnel to safeguard equipment being stored on land as well as the cages and fish in the ocean? Are appropriate gear in place to prevent ocean predators from damaging the cage nets?
	Manpower available at all levels <ul style="list-style-type: none"> Is there enough local labor to carry out daily operations of cages? Are there specialized people that can carry out specific tasks such as cage construction, harvest, veterinary services, by delivery and fish harvest?
	Proximity to transportation, markets, processing plants <ul style="list-style-type: none"> Are there roads leading from the hatchery to the dock where boats can bring fry to cages? What kind of processing is locally available? How far is the closest market to sell the product?
	Availability of freshwater, electricity <ul style="list-style-type: none"> Do the cages need electricity or power and from where will it be sourced? Will freshwater be needed for processing and where will it be sourced?
	Piers, docks, anchorage, or mooring areas <ul style="list-style-type: none"> Is there access to a dock where the boats or water vessels can be docked at? Are the cages easily accessible? Is the dock easily accessible? Is there a dock or a storage area where feed can be kept for daily feeding?

Environmental Factors



Depth profile / availability of hydrographic maps showing seafloor

- Are there maps available that show the seafloor along with type of bottom?
- Are bathymetry maps available to evaluate seafloor depth? Is the recommended depth of 20-60m reached?



Water quality, temperature, and salinity

- Have water quality tests been carried out for fecal coliforms, excess nutrients, and harmful algae blooms?
- Has dissolved oxygen been measured?
- What are the temperature ranges for this area and is there a thermocline?

Political, Regulatory, Socio-cultural Factors



Use conflicts, number of ocean users in area

- Is this an area that local fishermen use and could create user conflict?
- Is this an area with significant tourists that use the marine space?

Operational and Logistical Factors

COSTS

- Availability and cost of fingerlings
- Availability and cost of feeds
- Distance from shore



Availability and cost of fingerlings

- Is there a hatchery in the local area where fry can be sourced from? If not local, where are the fingerlings procured from and are there risks in the supply chain?
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Availability and cost of feeds

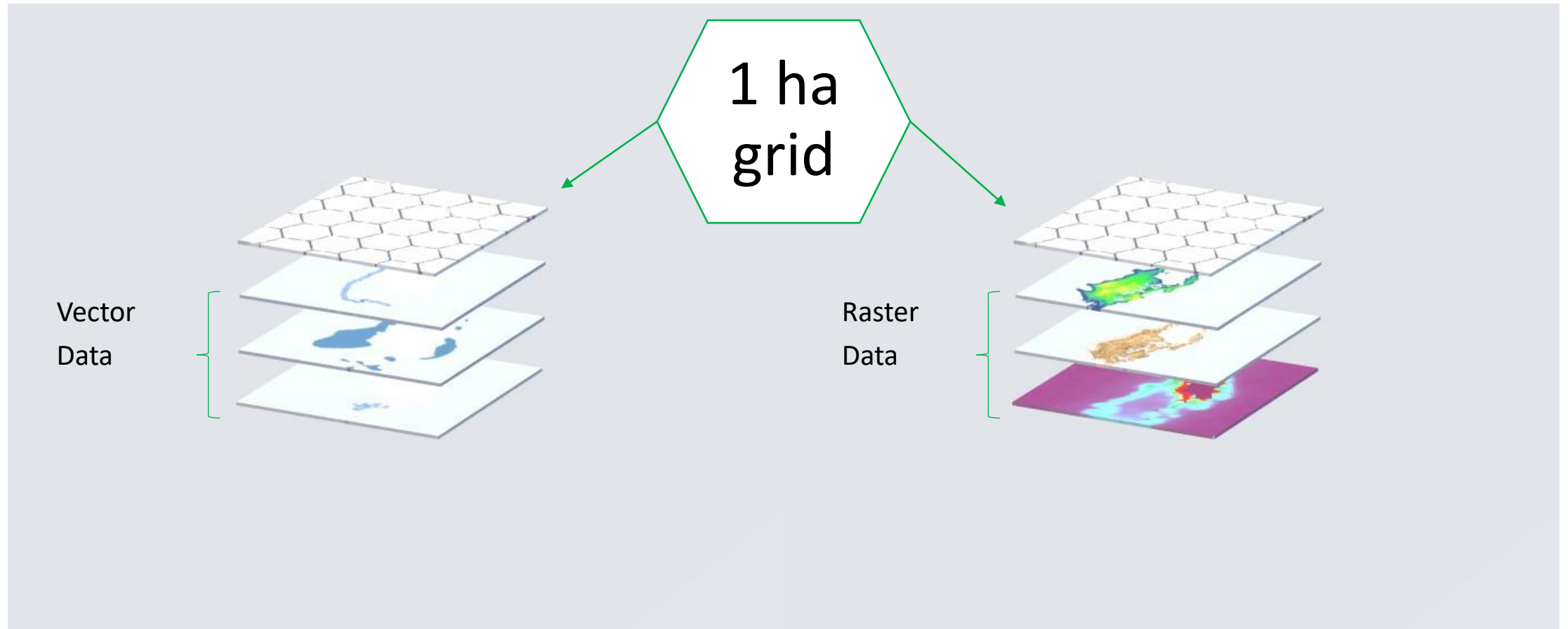
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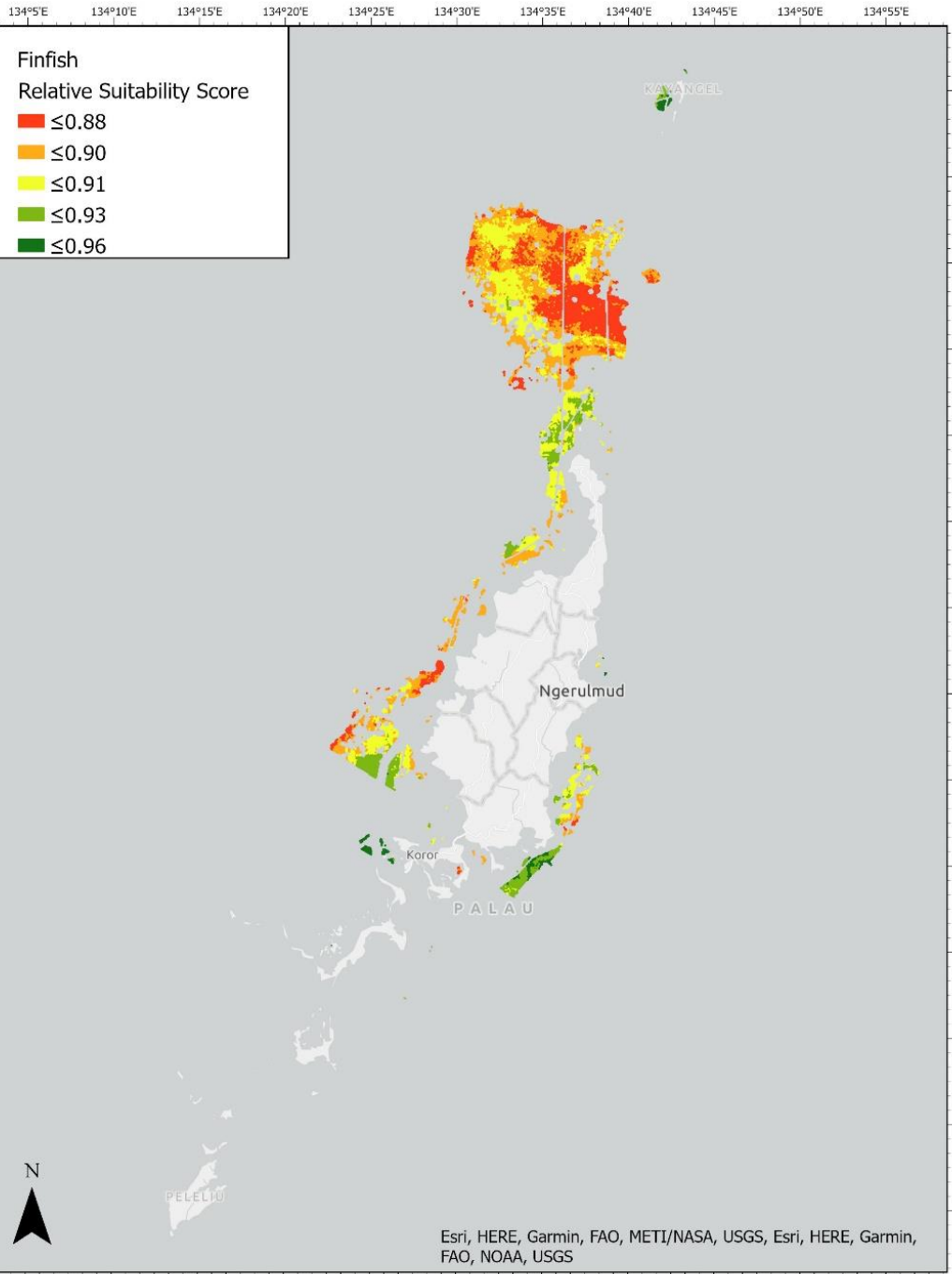


Distance from shore

- What is the distance from shore and how are the cages reached?
- Is the recommended distance of 0.2-6km achieved?

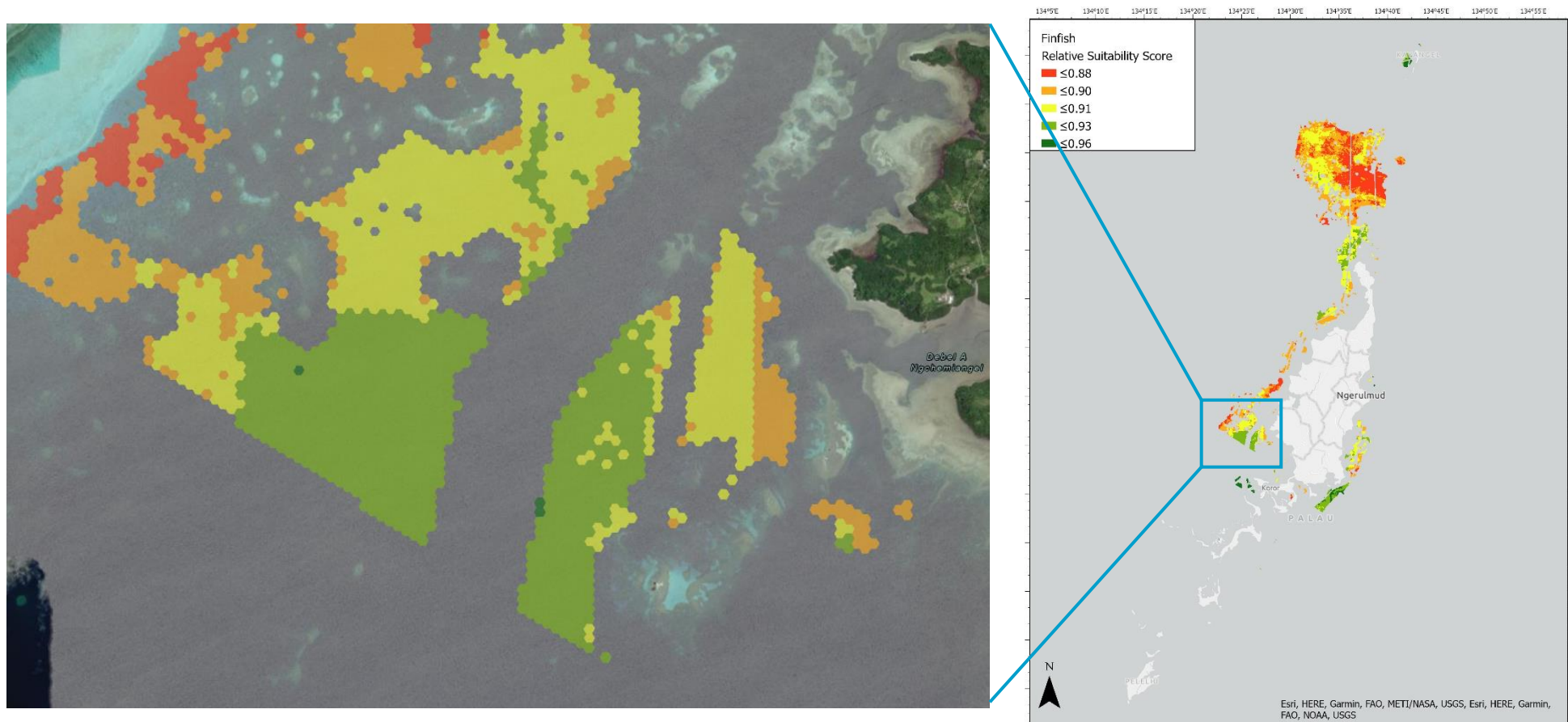
Marine Spatial Analysis - Palau





<https://maps.coastalresilience.org/palau/>

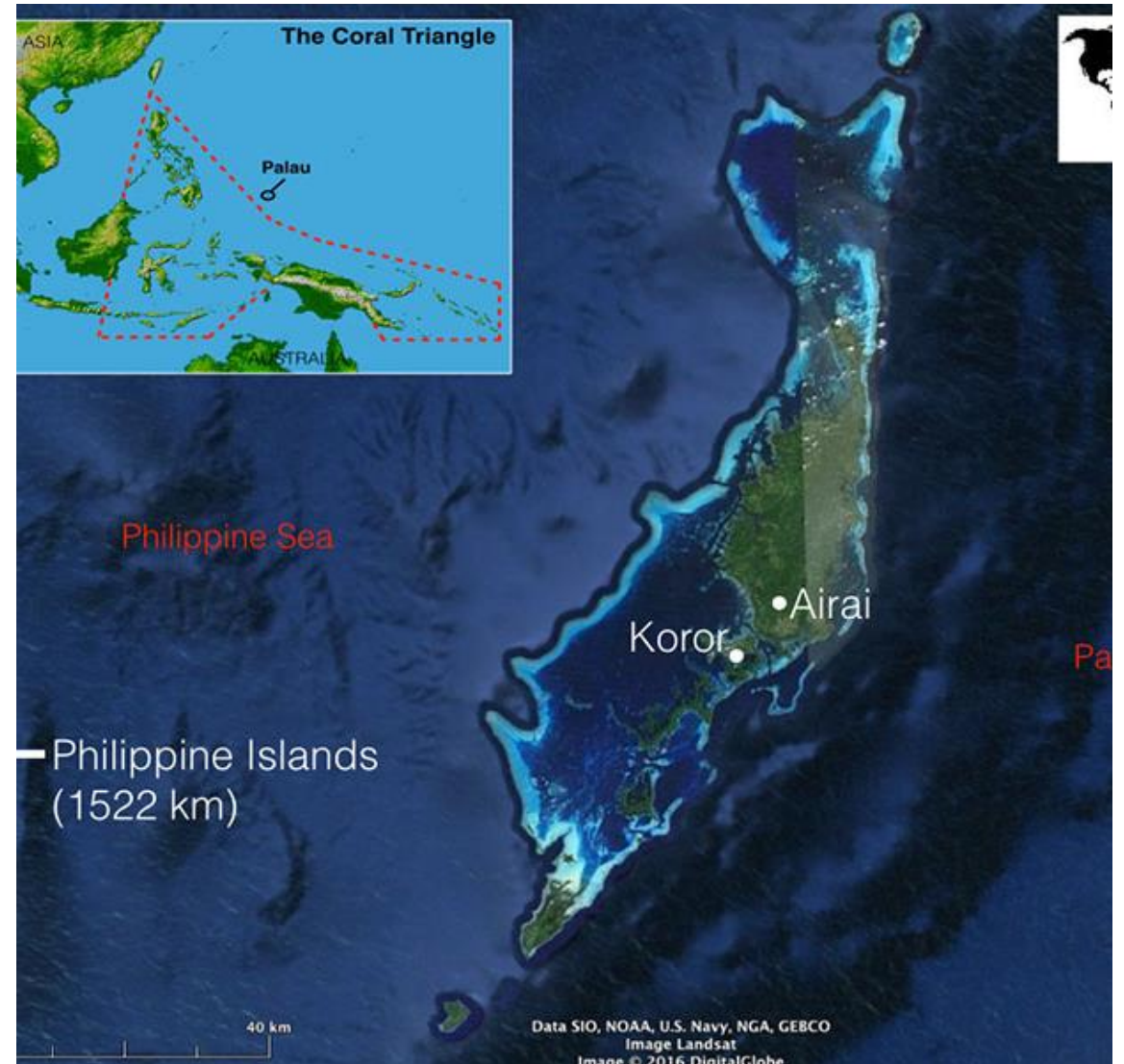
RESULTS



Palau Community Based Rabbitfish Aquaculture

Steven Victor, The Nature Conservancy Micronesia Program

- 20,000 population
- Over 120,000 annual visitors
- Main economy is tourism
- Over 30 PA
- 80% of EEZ to be closed from fishing
- Over 500 islands
- Over 450 coral species
- Over 1500 species of fish
- Some of the most intact coral reef habitat





Heavy
Reliance on
Imported
Food



Climate Impacts





Declining Fisheries

Fishermen catching fish before they have had a chance to reproduce

Why Rabbitfish?





Partnership with Government



Partnering with Fishermen as Farmers

LOOKING AHEAD

- Siting analysis to identify most suitable marine areas to support aquaculture
- Developing regulatory framework to support sustainable aquaculture
- Expanding sustainable aquaculture (giant clam, mangrove crab, milkfish)



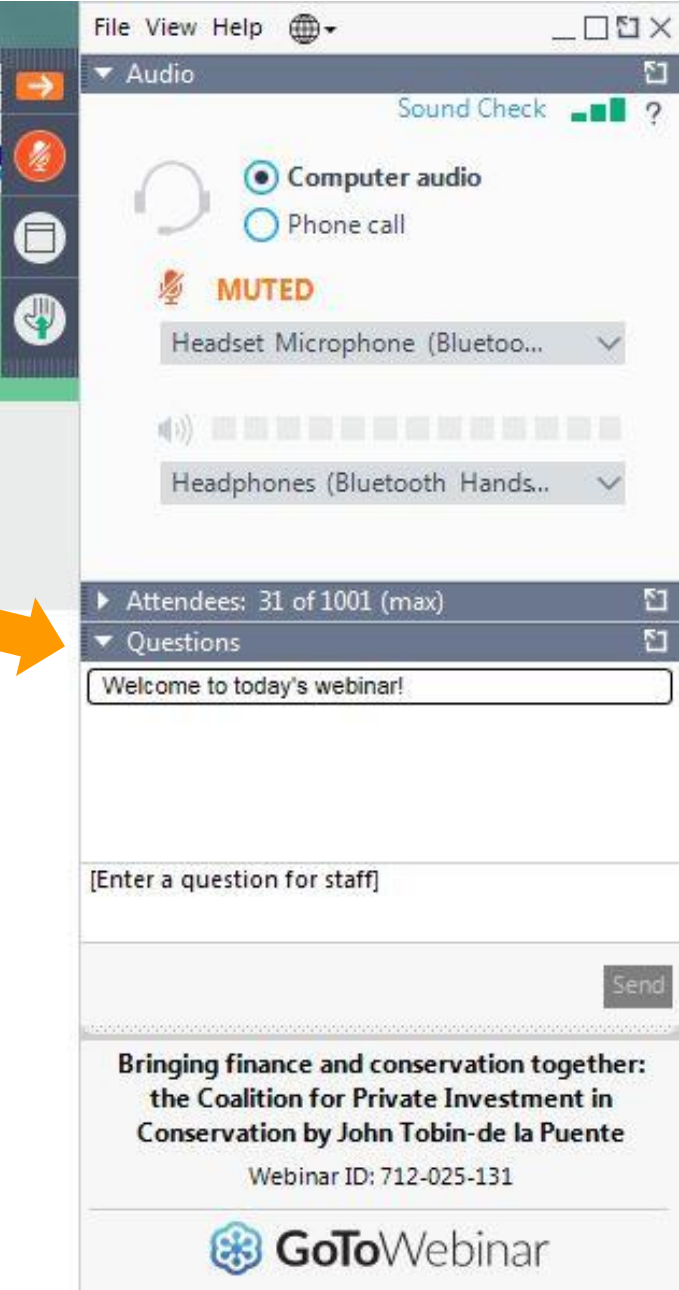


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File View Help

Audio

Sound Check

Computer audio

Phone call

MUTED

Headset Microphone (Bluetoo...)

Headphones (Bluetooth Hands...)

Attendees: 31 of 1001 (max)

Questions

Welcome to today's webinar!

[Enter a question for staff]

Send

Bringing finance and conservation together:
the Coalition for Private Investment in
Conservation by John Tobin-de la Puente
Webinar ID: 712-025-131

GoToWebinar



Questions & Discussion

Resources

- Reef Resilience Network Aquaculture toolkit:
<https://reefresilience.org/aquaculture/>
- Reef Resilience Network Forum:
<https://forum.reefresilience.org/network-forum/>

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