Questions:

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Management Strategies

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
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. Global seaweed production from finfish aquaculture is expected to continue to grow and outpace wild fisheries by 2030.
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". 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.
Aquaculture 101 for Coral Reef Managers

Presenter:

Robert Jones
Global Aquaculture Strategy Lead
The Nature Conservancy

Hosts: Cherie Wagner, Reef Resilience Network
Tiffany Waters, The Nature Conservancy
Finfish Aquaculture 101 for Coral Reef Managers

Robert Jones, Global Aquaculture, The Nature Conservancy
Environmental Impact of Animal Protein Production

- **BEEF**
  - 499 kgCO₂eq
  - 7,280 liters
  - 1,636 m²
  - 13

- **PORK**
  - 76 kgCO₂eq
  - 11,110 liters
  - 17 m²
  - 6

- **FISH**
  - 60 kgCO₂eq
  - 750 liters
  - 8 m²
  - 1.2

- **SHELLFISH**
  - 4 kgCO₂eq
  - 0 liters
  - <1 m²
  - 0

**Legends:**
- GREENHOUSE GAS EMISSIONS: emissions for every 1 kg of protein (kgCO₂eq)
- LAND USE: land use for 1 kg of protein (m²/kg)
- FRESH WATER USE: liters of freshwater used for every 1 kg of protein (liters/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
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.
Hainan, China
Aquaculture 101 for Coral Reef Managers

Presenters:

Julio Camperio  
PhD Student – Aquaculture  
University of Miami

Jonathan MacKay,  
Marine Spatial Scientist  
The Nature Conservancy

Steven Victor  
Micronesia Program Director  
The Nature Conservancy
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

• Removal of wild species to use as fry
• Farmed fish escapes
• Entanglement of wild species
• Feed impacts
## Impacts to Wild Stocks

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

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

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

- Excess feed and waste
- Environmental parameters
- Carrying capacity
**Water Pollution**

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

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

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

- **Bioremediation, mitigation needs**
  - Does cage grows 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 conflicts?
  - 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 outlets 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?
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?
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?
- What is the cost of fingerlings of the chosen species?

**Availability and cost of feeds**
- 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**
- 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

1 ha grid

Vector Data

Raster Data
https://maps.coastalresilience.org/palau/
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)
Thank you
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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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