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DEVELOPMENT OF SUSTAINABLE AQUACULTURE IN COASTAL COMMUNITIES:

CASE STUDIES AND ENABLING CONDITIONS FOR SUCCESS

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Cover: Harvesting seaweed on Pemba Island, Tanzania.

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EXECUTIVE SUMMARY

Many coastal communities have historically relied on wild-capture fisheries to support livelihoods and subsistence; however, recent decades have been marked by a rapid global increase in aquaculture (aquatic farming). This is often characterized as a market response to declining wild stocks and increased demand for seafood from an expanding global population with increased protein requirements. Governments, NGOs, and industry associations, in some instances, have aimed to support or accelerate the adoption of aquaculture in coastal communities with varying degrees of social, economic, and environmental success. The factors that led to the success or failure of these initiatives warrant further analysis.

This document assesses five different community-based aquaculture initiatives around the world: the Grouper Livelihood Project in Palawan, Philippines; Project Wave in Cedar Key, Florida, USA; Community-based sea cucumber farming in Madagascar; Seaweed Mariculture Project in Placencia and Turneffe Atoll, Belize; and Aquaculture in Shared Waters in Maine, USA.

Each of these projects was led by NGO, government, or industry associations with socio-economic goals of building resilience in the community by diversifying sources of nutrition and/or income and providing alternative job opportunities to people reliant on wild capture fisheries. The Belize Seaweed Mariculture project was the only project designed with an explicit environmental goal.

Through a case studies approach, this document develops a structured analysis of key enabling conditions that contributed to the successes and challenges each project encountered. The enabling conditions analyzed include project leadership, stakeholder engagement undertaken, the extent and type of financial support, community and cultural context, availability of logistics and infrastructure, the policy and regulation environment, market conditions, and environmental conditions. The socio-economic and environmental outcomes of each initiative are discussed to the extent the data collected by the project allows.

Fostering effective stakeholder engagement in which community members' voices are heard, needs are met, and ideas are implemented, builds a foundation of trust between project managers and the community.

Among the five initiatives, the most significant factors leading to project success included strategic planning and project implementation that centered on the input of local community members and build on their existing skills and knowledge. Successful aquaculture initiatives also tended to effectively create benefits for the entire community, both those directly involved in farming and those who were not. Creating a sense of ownership in the project by the broader community and fostering effective stakeholder engagement in which community members' voices are heard, needs are met, and ideas are implemented, builds a foundation of trust between project managers and the community.

The most frequently encountered challenges for projects included lack of appropriate financial support, difficulty securing materials and equipment, and reliable services to operate the business effectively. Weather events created difficult operating conditions and theft presented a challenge in some remote project sites. The projects that were able to overcome these challenges were able to develop appropriate business and funding models to reflect the needs of the community and timelines for aquaculture production. When faced with challenges accessing equipment and materials, necessary machinery was secured abroad and brought back to the project region, and the production model for a separate project was updated to require fewer materials.

Out of the five projects assessed, each has made progress toward its socio-economic goals and objectives; mainly toward improved livelihoods of farmers and the broader community. Additionally, while the Belize Seaweed Mariculture Project is the only one of the five projects assessed to have an explicitly stated environmental goal, each project has anecdotally reported ecological benefit from their operation, including enhancement of wildlife abundance near the farming operations.

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INTRODUCTION

The role of sustainable aquaculture in coastal communities is recognized globally as being an important part of the successful realization of the United Nations Sustainable Development Goals (FAO, 2021), which aim to "end extreme poverty, reduce inequality, and protect the planet by 2030."

Many coastal communities have historically relied on wild-capture fisheries to support livelihoods and local subsistence; however recent decades have been marked by a global increase in aquaculture production. This is often characterized as a market response to declining wild stocks and increased demand for seafood from an expanding global population with increased protein requirements. Currently, over 1 billion people rely on fish as a nutrition source, and the livelihoods of approximately 500 million people globally are supported by small-scale fisheries (Blue Ventures, 2021).

Aquaculture production can be viewed as a resilience strategy allowing the community to diversify its sources of nutrition and/or income.

In some communities, aquaculture expansion is supported by a shift from a sole reliance on wild-capture fisheries to the incorporation of aquaculture production and can be viewed as a resilience strategy allowing the community to diversify its sources of nutrition and/or income. Ecological, social, political, and economic factors influence the need for and success of these shifts.

This document uses the case study approach to examine the enabling conditions present in projects that have aimed to introduce aquaculture development into a previously wild-capture-focused community. Using a normative framework, this approach provides insight into the complexities, nuances, and multifaceted strengths and challenges associated with sustainable aquaculture development. Initiatives included in this document describe projects undertaken as partnerships between members of coastal communities, non-governmental organizations, regulatory agencies, and/or the industry and supply chain. These initiatives have been implemented as strategies to increase the economic and social resilience of coastal communities in environmentally responsible ways.

Coastal communities are highly diverse and the factors influencing their social, economic, and environmental well-being are often nuanced and complex. With this understanding, this analysis acknowledges the presence of the "triple bottom line" of factors influencing the success or failure of aquaculture development efforts in coastal communities. Ecological, social, and economic factors can be within the control of a project (e.g., funding, siting, and engagement with appropriate stakeholders), while other factors are external to the control of a given project, but can influence its success (e.g., changes in government administration or policy, climate change impacts). This analysis assesses case studies across 8 enabling conditions:

ENABLING CONDITIONS

LEADERSHIP

This category describes the need for leaders within the management structure of a project to ensure there is a clear project goal and capacity for the project's ongoing implementation. A leadership team will likely include individuals with technical knowledge, understanding of local contexts (ecological, social, logistical, economic), and appropriate connections. This team will strategically plan a project that is realistic and adaptable given the ecological, social, and economic context of the community, and provide stability and continuity in the governance of the project. In addition to strategic planning and management, the dedication and consistent involvement in a project from necessary parties help maintain support and forward movement.

STAKEHOLDER ENGAGEMENT

Stakeholders include members of the community, supply chain actors, management bodies (governments, project managers, etc.), and other Affected Communities[1] that may influence, or be influenced by the project. Early and well-researched stakeholder engagement and buy-in from stakeholders and the community can help create the most locally appropriate strategy and project plan.

FINANCIAL SUPPORT

The structure and timeline of financial support, as well as the expectations of those providing and receiving it, can have a significant impact on the success of an initiative. Whether a project is sufficiently capitalized, as well as the type, duration, and purpose of funds, and the ability of recipients to manage finances can influence the success of an initiative.

COMMUNITY CONTEXT

The social dynamics of a coastal community should be accounted for and woven into the strategic planning for an aquaculture operation. Beyond identification and engagement with appropriate stakeholders, the needs, values, priorities, expectations, and perceptions of aquaculture by the broader community can influence the developing aquaculture sector. These factors can be influenced by cultural history, socio-economic conditions in the community (availability of jobs, general level of income, availability of food, access to health care, etc.), and political climate. Additionally, relationships throughout the supply chain, as well as resource competition or overlap in space between aquaculture and other natural resource-based activities (recreational use, wild capture fisheries, tourism, etc.) can influence the development of an aquaculture sector.

1 "Local communities directly affected by the project" (IFC, 2012)

LOGISTICS AND INFRASTRUCTURE

The availability of adequate supply chain infrastructure such as input providers (feed and seed), transport requirements (ice, appropriately sized vehicles, etc.), processing facilities, roads, access to markets, and electricity can influence the success of a project or program. These factors can be taken into account during the planning process; however, their consistent availability is often beyond the control of an initiative, and changes to the supply chain can influence the success of an initiative.

POLICY AND REGULATION

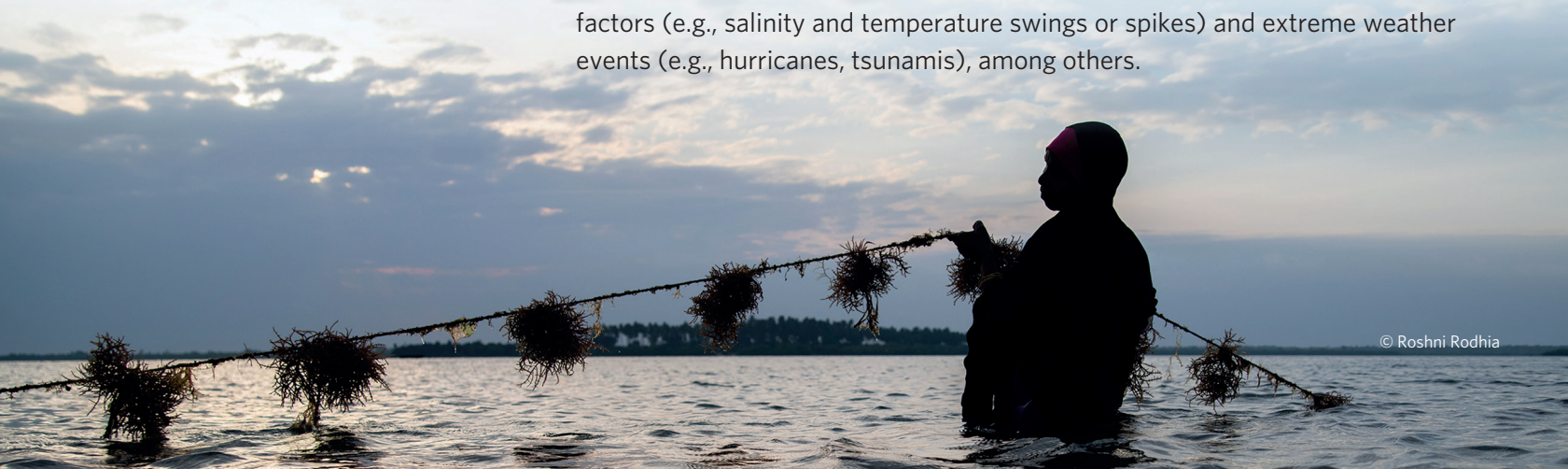
The regulatory infrastructure and political atmosphere can significantly influence the success of a community aquaculture project and industry development. Events such as changes in government administration may result in changes to policies, permitting processes, regulations, tariffs, etc. This category also includes the presence (or lack thereof) of appropriate or adequate governance systems managing the sustainability of the aquaculture industry and/or the conservation of natural ecosystems it could potentially impact.

MARKET CONDITIONS

The market for farmed seafood is dynamic, with shifting prices, demand, and global trade patterns. While seafood is a highly traded global commodity, supply and demand also vary by geography, and market demand for cultured species and products can be significantly differentiated from wild-caught fish. Access to markets is also a factor for aquaculture projects in isolated areas. Often beyond the control of a single initiative, market factors can significantly affect the success of an aquaculture sector.

ENVIRONMENTAL CONDITIONS

Some ecological factors can be taken into account in the strategic planning and implementation of an aquaculture project to ensure appropriate conditions for the cultured species and to minimize the risk of environmental effects on production (e.g., siting to minimize interaction with wildlife or likelihood of impact of storms, stocking to decrease the risk of pathogen or parasite infestation). However, while measures can be taken to minimize risk, the occurrence of individual incidents that can detrimentally affect production are largely outside a project's control. These factors can include changes in abiotic factors (e.g., salinity and temperature swings or spikes) and extreme weather events (e.g., hurricanes, tsunamis), among others.



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CASE STUDIES

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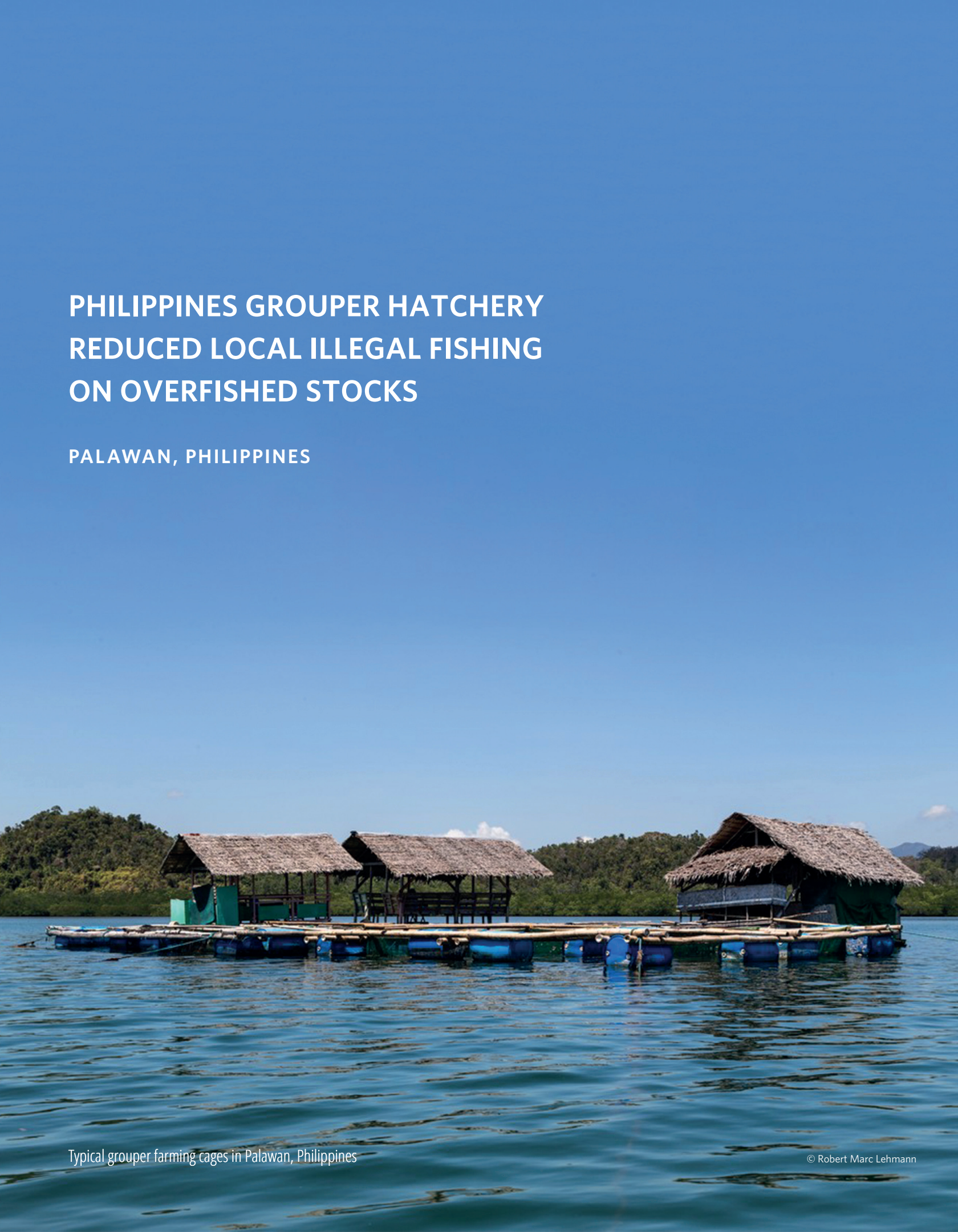
PHILIPPINES GROUPER HATCHERY REDUCED LOCAL ILLEGAL FISHING ON OVERFISHED STOCKS

PALAWAN, PHILIPPINES



Typical grouper farming cages in Palawan, Philippines

PROJECT SUMMARY

PROJECT LEAD:

Centre for Sustainability (formerly Fins and Leaves) (Dutch NGO)

PROJECT NAME:

Grouper Livelihood Program

PROJECT DATES OF OPERATION:

2006-2016

PROJECT OBJECTIVE:

Reduce the use of wild grouper fingerlings; Capacity building for sustainable mariculture; Increase livelihoods of small-scale growers; Ensure food security of the local community.

Grouper are a highly valuable species in the Coral Triangle region, fetching high prices, especially when sold live. Cyanide has been used to catch grouper to sell these large fish to restaurants often in China and Hong Kong, where live fish are stocked in restaurant fish tanks.

The impacts of cyanide on coral reefs and the marine life that relies upon them are well-documented. In addition to these impacts, coastal communities began capturing live, juvenile grouper, which were kept in captivity and grown to a size where they could be sold. The practice of removing juvenile fish from reef ecosystems before reaching breeding size exacerbated the decline of wild fish populations. In the Philippines, the Bureau of Fisheries and Aquatic Resources (BFAR) recognizes 6 native species of grouper as Vulnerable or Nearly Threatened based on information from FishBase.org and an identification guide for live fish in Hong Kong's wet markets (BFAR, 2019). Both of these sources reference the IUCN Red List of Threatened Species (FishBase.org, 2019; Hau, Ho, and Shea, 2019).

To decrease the ecological impact to reef ecosystems from cyanide fishing, and provide local communities with a more consistent supply of economically valuable fish, the organization Fins & Leaves (formerly the Centre for Sustainability) began its Grouper Livelihood Program (GLP) in Palawan, Philippines with the stated objective to "Provide a sustainable alternative for wild grouper fisheries by promoting grow out of hatchery bred grouper fingerlings" (van Beijnen, 2015). This project aimed to reduce the use of wild grouper fingerlings, build capacity for sustainable aquaculture in Palawan, increase the livelihoods of small-scale aquaculturists, and increase food security (ibid.).

Species of grouper raised by the GLP included; orange-spotted grouper (*Epinephelus coioides*), tiger (Brown-marbled) grouper (*E. fuscoguttatus*), Malabar grouper (*E. malabaricus*), giant grouper (*E. lanceolatus*), and the humpback grouper (*Cromileptes altivelis*). The program operated between 2006-2016, providing hatchery-reared grouper fingerlings to local community members who would grow them to market size for live sale to other Asian countries.

At the time of this project, full-cycle grouper aquaculture was already practiced in Indonesia and Taiwan, but was not yet successful in the Philippines, despite multiple attempts, and infusions of money by large, global organizations.

FACTORS INFLUENCING THE PROJECT

LEADERSHIP

The GLP benefitted from a small, clearly structured leadership team that included the lead organization Fins & Leaves (then called the Centre for Sustainability), investment organizations (for the first two years of operation before the project becoming financially sustainable), and an operations manager. The GLP was run by Dutch project leaders and was supported by the Vice President of Fins & Leaves, Jonah van Beijnen, who brought technical knowledge of aquaculture operations to the project and was supported by an administrative manager who managed the necessary permits, tracking of finances, and administrative duties.

Operations at the facility were managed by a Filipino Hatchery Manager who had attended university internationally and worked in aquaculture across Southeast Asia and the Middle East. This individual returned to the Philippines to continue his career with the GLP.

Project leaders were initially of Dutch descent. The leadership provided a workplace environment that encouraged staff to stay, with many remaining on for the duration of the project. Many staff were local Filipinos who had been formerly incarcerated and had been experiencing homelessness until they were able to secure jobs at the facility. In general, as stated by van Beijnen, there is a sense of willingness and passion from local communities to improve their living situation and be able to more consistently provide for their families. After 6 years of implementation, the project was entirely run by local staff, which led to a high level of trust between staff and leadership of the program.

STAKEHOLDER ENGAGEMENT

During the planning and operation stages of the GLP, communication between project leadership, local affected communities, and supply chain members was consistent. GLP leadership maintained ongoing dialogue and opportunities for feedback and engagement with local community members through the sale of juvenile grouper, training workshops, and provision of technical guidance documents.

Additionally, GLP leadership maintained a relationship with the local government to ensure its continued approval, and financial support. The direct relationship of GLP leadership with local community members and maintained relationship with local government officials fostered a sense of trust in the work of the GLP. However, a change in local government administration in 2014 resulted in less engagement and support, which led to the eventual closure of the project. This is further discussed in the Policy and Regulation section below.

FINANCIAL SUPPORT

Initial development of the project, construction of the hatchery and growout facility, and purchasing of equipment were funded by investors, local and foreign donors, as well as personal funds from the project leaders. The largest amount of funding was donated by the City Government of Puerto Princesa. Throughout the operation of the GLP, additional large donors included the Interchurch Organisation for Development Cooperation (ICCO), USAID, and Transpetrol. The project was eventually able to produce approximately 100,000 fingerlings (3 inches) annually, and by 2012 operation of the project became largely financially self-sustaining. Demand for fingerlings was high, and before the change in administration, the GLP had plans to expand up to 10 times its initial size, however, these plans were not able to be brought to fruition.

COMMUNITY CONTEXT

As noted earlier, many people in the community look for ways to improve their livelihoods. In 2009, approximately 24% of families in Palawan were living beneath the poverty threshold (NEDA, 2013). University programs in the Philippines produce a high number of fishery and aquaculture graduates, however, with very few jobs available, the majority leave the county in search of work. For entry-level positions, the GLP hired local staff who were largely uneducated and had fewer options for careers. At its peak, direct employment by the GLP provided 25 local community members with jobs and a steady income.

Community members who purchased the juvenile grouper to grow out had improved income due to a more consistent supply of high-quality grouper to raise and sell.

Beyond the direct employment of the GLP, community members who purchased the juvenile grouper to grow out had improved income due to a more consistent supply of high-quality grouper to raise and sell. Farmers were able to sell lower-priced grouper species for approximately 500 PHP/kg (approximately $10/kg), while others fetched higher prices. This level of income, in some cases, enabled families to send their children to university.

In addition, the GLP informally trained farmers in the community to improve farming practices. It provided a 50-page manual describing best practice techniques, small brochures containing streamlined and more accessible information, and training sessions. In addition, the GLP assisted local farmers with finding buyers for their products. Occasionally, the GLP also released juvenile grouper into the wild to restock wild populations. These actions forged a strong relationship with fishermen and the broader community.

LOGISTICS AND INFRASTRUCTURE

The initial development of the GLP facilities experienced some unanticipated challenges. Much of the necessary equipment for developing the hatchery facilities was not manufactured in the Philippines and therefore needed to be

imported. Project leaders traveled to Malaysia to purchase equipment and bring it back in person so it could be tracked. This added additional costs to the development of the facilities.

In addition, the electrical power grid in the region is weak and prone to outages. Generators were frequently required, especially at night, which resulted in the project leader spending many nights at the facility to ensure the welfare of the juvenile grouper. Air blowers that must run constantly also required a high level of maintenance and frequent replacement due to the poor electrical supply, when under normal circumstances they would rarely need to be replaced.

POLICY AND REGULATION

To build and operate an aquaculture facility in the Philippines, there are various permits, licenses, and leasing arrangements that must be obtained. In the Philippines, BFAR, housed within the Department of Agriculture regulates the country's aquaculture industry. Within municipal waters, Fisheries and Aquatic Resources Management Councils (FARMC) are tasked with the preparation and implementation of municipal and integrated (multiple municipalities in a water body) fishery development plans, as well as their enforcement.

In general, the GLP project leaders found that the process for getting a visa as a foreign investor was relatively simple, as the Philippines is very supportive of foreign investment opportunities. Tax discounts and exemptions for non-profit organizations were offered, and at the national level, the process of becoming licensed to start a business was not as expensive, complex, or time-consuming as it can be in many other areas of the world. While the visa process proved to be conducive to foreign investment, navigation of import regulations and policies proved to be challenging.

For the first 8 years of the GLP operation, the local government was highly supportive of conservation initiatives and was enthusiastic about the project's mission to decrease the prevalence of cyanide fishing for grouper. It facilitated siting, as well as the necessary permitting, licensing, and leasing, and became the largest donor throughout the project.

However, a change in local administration in 2013 resulted in a shift in the dynamic between the GLP's mission and the policies of the new local political leader. The new administration made changes to many of the policies and programs of the former administration, many of which had supported the GLP. The project leadership team found it increasingly difficult to maintain the project's permits and licenses under the new administration, and eventually forfeited the facility in 2016, at which point it ceased operations.

MARKET CONDITIONS

Many local aquaculturists had previously relied on cyanide fishing, or other destructive fishing methods to collect small grouper to raise to market size, and switched to raising hatchery-reared fish. There was high demand for grouper from other Asian countries, therefore demand for hatchery-raised juveniles was high as well. The GLP was able to sell juvenile grouper for approximately $1.00 per 8 cm fish, which allowed the project to break even on costs.

ENVIRONMENTAL CONDITIONS

Palawan remains largely undeveloped, with many natural ecosystems still intact. It includes sandy beaches, a mountain range extending the length of the island, and plains areas that are mainly used for rice production (Province of Palawan, no date). While many of the Philippine islands are regularly subjected to destructive typhoons, Palawan is rarely impacted by them (ibid.).

The main economic activities on the island include agribusiness and manufacturing (mining, mineral processing, pharmaceuticals, shipbuilding, electronics, and semiconductors) (Bajpai, 2020). Tourism, forest product gathering, and pearl farming are other important industries on the island (UNESCO, 2013).

The Philippines is generally well suited for grouper aquaculture. All of the species grown by the GLP are native to the area, which is a broad indication that they can be cultivated in the area. The area in which the hatchery and growout sites were located was selected for its good water quality, exchange rates, and depth. These factors, along with protection from strong weather patterns, accessibility, and distance from critical habitats influenced the location of the hatchery and growout sites.

OUTCOMES

Throughout the operation of the project, it was proved that a grouper hatchery could operate and provide a consistent source of juvenile grouper to local farmers, thereby successfully reducing local demand for wild juveniles sourced through cyanide fishing.

SOCIO-ECONOMIC

Many community members who had relied on wild-caught juvenile grouper for their growout stock switched to hatchery-bred juveniles. This was an attractive shift, as hatchery-bred groupers could be fed dry feed pellets, whereas wild-caught juveniles would only eat fresh fish which was inconsistent in price, quality, and availability. Additionally, hatchery-raised groupers are subject to biosecurity protocols, resulting in a lower risk of disease in farmed stocks. Making the switch to hatchery-raised groupers allowed a consistent, year-round supply of juvenile grouper, with uniform growth rates. Grouper are

cannibalistic, and many grouper growers stocking wild fish experienced losses of their stock when they kept fish of different sizes together. The provision of hatchery-raised grouper that were all of the same approximate sizes, with the same growth rate mitigated the risk of cannibalization.

ENVIRONMENTAL

The GLP itself did not include monitoring of the reef ecosystem, however, anecdotal evidence from local community members indicates that species of grouper that had become very rare in Honda Bay (specifically *C. altivelis*) rebounded during the timeframe the hatchery was operating. It is unclear, however, what role the hatchery played in this increase.

While data from the Filipino Bureau of Agricultural Statistics show a rough correlation between the volume of grouper produced in aquaculture facilities and the volume captured in the wild during the years that the GLP was operational (2006-2016), given the significantly lower volume of aquaculture production, it is difficult to draw any conclusions about any possible direct influence on stock replenishment due to the release of eggs and juveniles from the GLP.

GROUPER PRODUCTION 1997-2018 (MT)

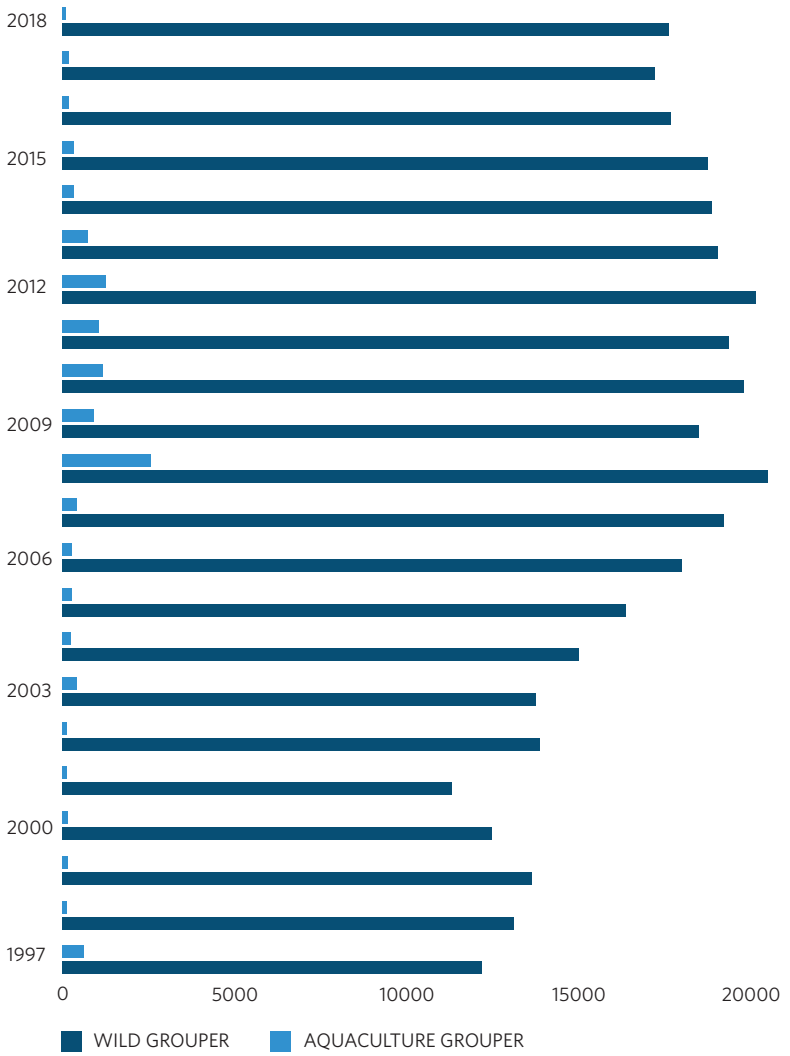


Figure 1: Historical wild and aquaculture grouper production in the Philippines.

LESSONS LEARNED

Although they experienced challenges, the GLP was a successful venture for 10 years from 2006 – 2016. The project team successfully navigated the technical aspects of grouper aquaculture while also engaging and supporting the local community in positive and constructive ways.

The initiative yielded some valuable information for future ventures considering the operation of a marine fish-culture project within an existing fishing community.

Project leaders must take the time to understand and respect local cultures, and their social and cultural norms.

- The GLP was run by Dutch project leaders and was supported by Dutch funders and a Dutch university. Social norms can be very different between the Dutch and Filipinos (e.g. expectations around time management). The project leaders of the GLP ensured that their communications, time management, and expectations of the local staff were aligned with local norms.

- Allow space for reflexivity in the approaches to planning and implementation to better respond to social and cultural norms.

The local political structure and local politics can significantly impact an initiative's success or failure.

- Understanding the political structures and climate at the time of project implementation is critical, as is understanding how dynamics in the community tend to shift as administrations change. The GLP leadership team found it increasingly difficult to maintain the project's permits and licenses under the new administration, and eventually forfeited the facility in 2016, at which point it ceased operations.

Table 1. Influential factors in the Palawan Grouper Livelihood Program

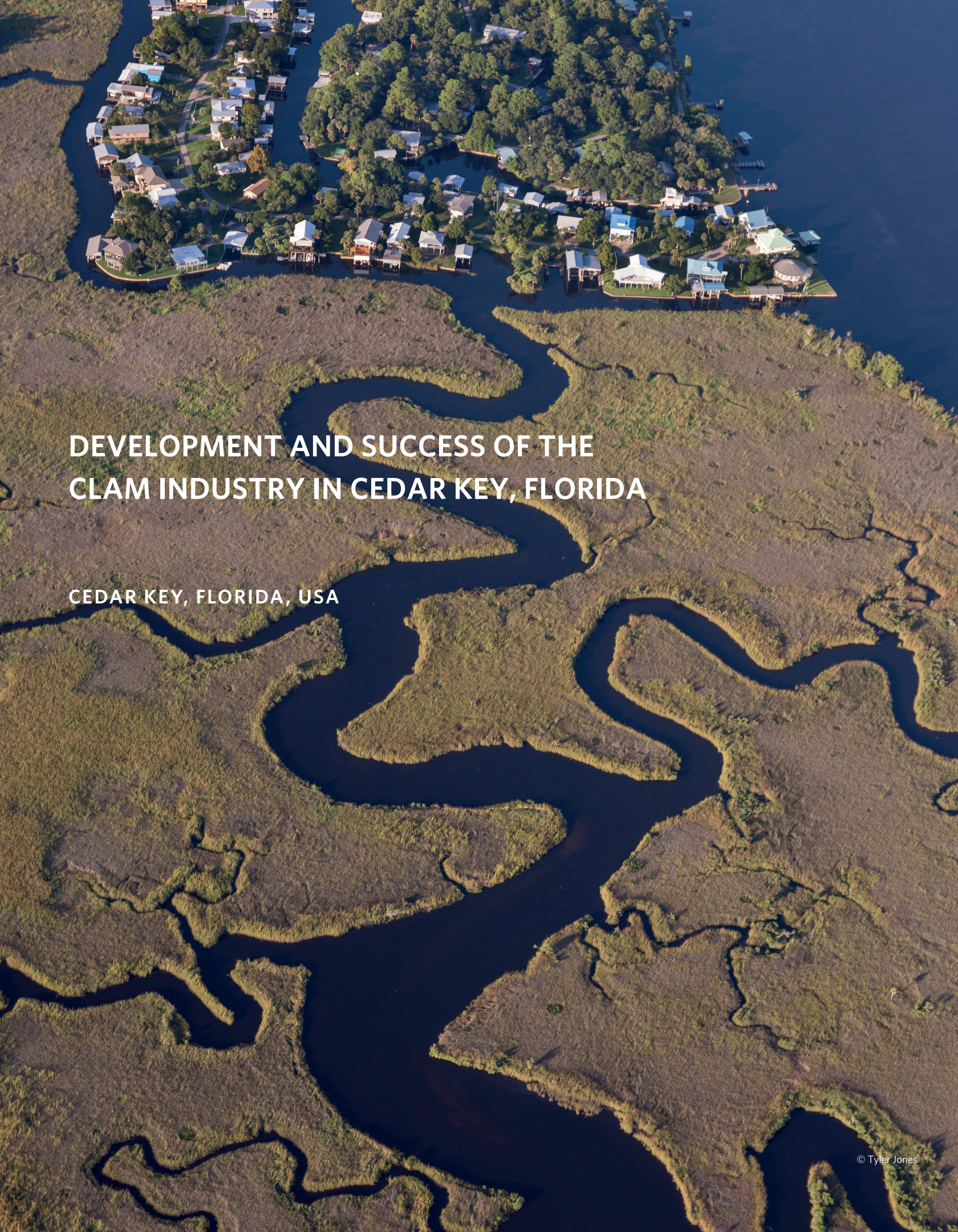
CATEGORY	STRENGTHS	CHALLENGES
LEADERSHIP	• Clear project need project goals • Leadership included a technical expert in aquaculture, local hatchery manager, administrative support, and financial backing • Dedicated leadership team	• Labor, resource, and time-intensive for the leadership team in the early stages of the project

STAKEHOLDER ENGAGEMENT	• Local community was engaged via:
	  • Employment of locals
	  • Sale of juvenile fish to locals for growout operations
	  • Training of local community members on aquaculture techniques
	  • Assistance with finding buyers for grown grouper
	• Local government was engaged and supportive of the GLP, as it was consistent with government policies
	• Local government facilitated lease, licensing, permits, and ongoing legality
		• Change in local government administration resulted in changed political priorities and conflicting interests
		• Relationships strained leading to difficulty maintaining necessary legal requirements for operation

FINANCIAL SUPPORT	• Financial support from external funders covered costs in the early years of operation and infrastructure investment. • After 6 years the GLP was financially self-sustaining	
COMMUNITY CONTEXT	• Local community were open to new methods of ensuring livelihoods • Aquaculture was accepted by the public	
LOGISTICS AND INFRASTRUCTURE		• Limited access to necessary aquaculture equipment, had to travel to obtain it • Inconsistent electricity resulted in common reliance on a generator and increased need for equipment maintenance

CATEGORY	STRENGTHS	CHALLENGES
POLICY AND REGULATION	• Relatively easy process for foreign investors to obtain visas • Tax discounts and exemptions for non-profit organizations • Licensing process for business operation is relatively cheap and streamlined	• Inconsistent regulatory priorities • Local agency leader's conflict of interest influenced permitting processes
MARKET CONDITIONS	• Only successful grouper facility in the Philippines resulted in a market advantage • Local grouper aquaculturists purchased juveniles to grow out (consistent demand)	
ENVIRONMENTAL CONDITIONS	• All species grown were native, and well suited to the environmental conditions • Siting of hatchery, nursery, and growing facilities based on environmental conditions • Island not subject to the strong weather patterns that affect much of the surrounding area	

PROJECT	PROJECT GOAL	GOAL REACHED?
SOCIO-ECONOMIC	• Increase livelihoods of small-scale growers • Ensure food security.	• Yes, during the time the GLP was operating. Did not continue after GLP closure. • Increased access to resources for growers during GLP operation.
ENVIRONMENTAL	• Reduce the use of wild grouper fingerlings • Capacity building for sustainable mariculture.	• Yes, at a small scale during GLP operation. Did not continue after GLP closure. • Did not continue after GLP closure.



DEVELOPMENT AND SUCCESS OF THE CLAM INDUSTRY IN CEDAR KEY, FLORIDA

CEDAR KEY, FLORIDA, USA

PROJECT SUMMARY

PROJECT LEAD:

State of Florida (Extension, Department of Agriculture and Consumer Services)

PROJECT NAME:

Project Wave (formerly Project Ocean)

PROJECT DATES OF OPERATION:

1991-1993 (Project Ocean); 1994-1998 (Project Wave)

PROJECT OBJECTIVE:

Train out of work oyster harvesters (Project Ocean) and fishermen (Project Wave) to grow clams.

In the late 1980's an effort was made in Apalachicola Bay, Florida to develop a training program for oyster aquaculture using funding available through the Job Training Partnership Act and emergency disaster relief funds that had been made available in the aftermath of a hurricane. The introduction of the oyster aquaculture industry in the region was seen as an economic resilience strategy by the governor. This program began in 1989 and ran for 3 years before it was terminated after very little success (Pers. comm., L. Sturmer, 2020).

In 1990, a series of closures of oyster beds in the Suwannee Sound due to excess levels of bacteria from leaking septic systems resulted in widespread unemployment or underemployment in the Big Bend region. In 1991, the Florida Department of Labor and Employment Security began a series of federally-funded training programs for unemployed or underemployed oyster harvesters in the region (Northern Economics, Inc., 2015). This project, called Project Ocean, used a "bottom-up" approach to training and extension in multiple aspects of developing a shellfish farming business and stationed an aquaculture extension agent in Cedar Key to provide on-site support to program graduates (ibid.). While the original training efforts had focused on oyster production, this training program included clams in its curriculum. The northern hard clam (*Mercenaria mercenaria*) was introduced to Cedar Key from the east coast of Florida where it is native.

State legislators and county commissioners were engaged in the program and worked to support the leasing of sovereign submerged lands for shellfish aquaculture. Through this program, trainees were educated in both the technical and business aspects of shellfish aquaculture and were provided with free equipment, seed and lease sites (Northern Economics, Inc., 2015). This training program ran through 1993 and resulted in 130 individuals receiving aquaculture leases (ibid.).

In 1994, the state of Florida voted to ban gill nets in state waters, which left many members of the Cedar Key fishing community and seafood supply chain without work (Northern Economics, Inc., 2015; Pers. comm., L. Sturmer, 2020). Both state and federal funds supported the continuation of the training program, which was updated to focus solely on clam aquaculture and cater directly to retraining out of work gillnet fishermen (Northern Economics, Inc., 2015). Renamed Project Wave, the program ran between 1994 and 1998. Approximately 70 individuals completed the training, totaling 200 people between 1991 and 1998 when the training program ended. An extension position established in 1995 still provides guidance and assistance to members of the industry in Cedar Key. By 2018, the USDA Census of Aquaculture showed 102 clam operations in Florida reporting sales of clams worth $14.3 million (USDA, 2019), and accounted for 92% of the state's shellfish aquaculture sales (DACS, 2020). This production occurs on 2,208 acres of coastal waters leased by the

Department of Agriculture and Consumer Services (DACS) approximately 0.03% of the total area of marine waters managed by DACS for the harvest of shellfish for human consumption (Northern Economics, Inc., 2015).

FACTORS INFLUENCING THE PROJECT

LEADERSHIP

The University of Florida's Extension program (Extension) has supported and championed the Cedar Key clam industry since its inception, providing training, extension services, research, and technical and management guidance for the industry, regulators, supply chain representatives, and the general public (IFAS, 2019b). The "bottom-up" approach to training and the early efforts by Extension to learn the needs of the Cedar Key community fostered trust between the community and leadership. This trust resulted in a high level of community support and social license for the industry to become established and expand.

In addition to the leadership provided by Extension, the hard clam industry in Cedar Key benefits from strong leadership at the state agency level, as well as local, state, and regional organizations that support and promote it. The DACS houses the state's Division of Aquaculture (DOA) and is the lead regulatory, coordination, and development agency for the industry (DACS, 2019). It is the responsibility of the DOA to ensure aquaculture activities in Florida are consistent with the Florida Aquaculture Plan, the Aquaculture Certification Program, best management practices, resource management requirements, and public health standards (Northern Economics, Inc., 2015).

The Cedar Key Aquaculture Association, the Florida Aquaculture Association, and the East Coast Shellfish Growers Association assist by supporting the industry through market development, promotion, research, education, and political advocacy (Ruth, Sturmer and Adams, 2005; Northern Economics, Inc., 2015).

STAKEHOLDER ENGAGEMENT

The target audience for the retraining programs and the clam industry in Cedar Key was narrow in scope, targeting underemployed and unemployed fishermen in the community. Other stakeholders influential in the process of developing the industry included state and federal funding partners and regulatory agencies.

The training program was developed based on the needs and strengths of the community. While many former fishermen and oyster harvesters were underemployed, they were a workforce that was already familiar with making a livelihood on the water. Many already operated vessels that could be reequipped for clam aquaculture.

In addition, there has been longevity to support, communication, outreach, and research from key leaders championing the industry. The Extension services that were brought in at the beginning of the program remain available, and research through the University of Florida has continuously supported the industry.

FINANCIAL SUPPORT

Development of the Cedar Key clam industry has been supported through a variety of funding mechanisms, including federal and state funds, and research grants. In the early stages of the training program, federal funding was administered by the Florida Department of Labor and Employment Security to start the retraining program. Most participants were underemployed and did not have the financial resources to invest in a new business. While the financial characteristics of operating a 2-acre clam farm were detailed by a Sea Grant economist to help participants secure loans, attempts to arrange lending programs through a variety of financial institutions and banks were unsuccessful (Pers. comm., L. Sturmer, 2020). To help with the transition, the training program worked to incorporate the needs of participants. Clams harvested from the training site could be sold by the participants. Trainings included information on how to rear seed in a land-based nursery, which allowed farmers to grow their own crop from seeds they had nursed. In addition, underemployed and unemployed fishermen and oyster harvesters were provided with equipment, seed, and lease areas upon completion of the training (ibid.). While these training programs are no longer in place, the industry has become self-sustaining.

The industry is seeing its third generation of clammers, and consists of both local companies as well as companies owned by people who moved to the area.

The cost of entry into the industry has been relatively low. Equipment, seed, and lease areas were provided to the original trainees in the 1990s for free (Northern Economics, Inc., 2015). Clam farming is characterized by a need for only minimal technology and equipment and relatively low operating costs. While seed can be costly, it is not prohibitively expensive, and farmers can still receive a return on their investments.

COMMUNITY CONTEXT

In the early days of the training program, some members of the community and agency stakeholders were apprehensive about the development of a clam industry in Cedar Key due to the recent failure of the oyster industry in Apalachicola Bay. Oyster farming was not viewed favorably (Northern Economics, Inc., 2015). It was very important for leadership to engage with the community and build interest and trust in clam farming as a viable alternative to fishing and oyster harvesting. A series of outreach, education, training, and initial farming efforts succeeded in proving the benefits and resilience of the clam industry in Cedar Key. As a result, in 1994 when the gillnet ban was enacted, clam aquaculture was readily adopted as an alternative to fishing and oyster harvesting (Pers. comm., L. Sturmer, 2020).

While there is often controversy around the practice of leasing public lands for private commercial gain, the community as a whole embraced the socio-economic benefits the industry brought to Cedar Key. Currently, the industry is seeing its third generation of clammers and consists of both local companies as well as companies owned by people who moved to the area.

LOGISTICS AND INFRASTRUCTURE

While the clam industry was new to Cedar Key in the early 1990s, the harvest, processing, and transportation of shellfish was not. At the start of the clam industry, these pieces of infrastructure were already in place due to the oyster fishery. The northern hard clam, *M. mercenaria*, was transported to Cedar Key from the east coast of Florida where it was native, and seed was maintained at the Harbor Branch Oceanographic Institute until it became commercially available in 1998 (Northern Economics, Inc., 2015). Infrastructure necessary for the supply chain has expanded along with the industry.

Clams are sold to certified shellfish wholesalers in Florida who purchase from farmers using their own trucking services. These wholesalers then process the clams, create value-added products, and distribute them to markets (ibid.).

POLICY AND REGULATION

The regulatory structure has been amended throughout the industry's history to identify appropriate lease areas for aquaculture, streamline and simplify the application process, and make ongoing compliance with regulations manageable for farmers (Northern Economics, Inc., 2015).

The DACS implements the leasing program and works with the U.S. Army Corps of Engineers, the Florida Department of Environmental Protection, and the Florida Fish and Wildlife Conservation Commission to review applications for consistency with all applicable state and federal regulations (Northern Economics, Inc., 2015). This streamlines what might otherwise be a complex time and money-intensive process.

The streamlined regulatory and permitting process for aquaculture in Florida ensures that the cost of application and permitting is not prohibitive to entry and participation in the industry. There is a processing fee of $200 for applications, and leases charge an annual rental fee that is based on the size of the lease in acres (in 2012 the rate was $16.73/acre). There is an additional surcharge amount of $10/acre. An additional $100 is required to obtain an aquaculture certificate (Northern Economics, Inc., 2015).

MARKET CONDITIONS

Demand for clams from Cedar Key is high, and the industry now benefits from well-established supply and market chains. While demand is relatively consistent, prices for clams fluctuate, leading to an interest in expanding market development.

Demand for clams from Cedar Key is high, and the industry now benefits from well-established supply and market chains.

While the market and costs associated with clam production in Cedar Key generally work in favor of the industry, the industry has faced challenges associated with larger-scale events that have influenced the marketability and demand for products. The 2007-2012 recession resulted in lower demand for clams, which challenged the industry in Cedar Key. During this timeframe, the 2010 Deepwater Horizon oil spill in the Gulf of Mexico also affected the marketability of clams from Cedar Key. While the ecosystem in Cedar Key was not directly impacted by the spill, seafood from the Gulf of Mexico as a whole was viewed negatively by consumers, resulting in lowered marketability of clams from the area. With time, the industry rebounded and has seen demand for the product increase again.

ENVIRONMENTAL CONDITIONS

The natural ecosystem in the Cedar Key area was extremely conducive to clam aquaculture, with water temperatures, salinity, water flow, and benthic characteristics all enabling successful production (Northern Economics, Inc., 2015). Large areas of protected conservation area surround Cedar Key, including approximately 100,000 acres of land owned by the Suwannee River Water Management District that is maintained as floodplains (Northern Economics, Inc., 2015). The Sewannee and Cedar Key Natural Wildlife Refuges are maintained by the U.S. Fish and Wildlife Service. The Big Bend Seagrasses Aquatic Preserve covers nearly 1 million acres and is managed by the state (ibid.). This results in minimal development in the area and few sources of pollution.

Before the year 2000, closures of oyster harvesting areas in the Suwannee Sound were common due to excess levels of bacteria. Learning from the experiences of the Suwannee Sound region, in the late 1990s, local leadership in Cedar Key invested in the development of a comprehensive stormwater management system. A study of the area's main risk factors for water quality identified failing septic systems as the single largest issue (Northern Economics, Inc., 2015; Pers. comm., L. Sturmer, 2020). Funds were made available for the

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creation of a municipal sewage system, and subsequent removal of leaking septic systems. This resulted in significant improvement to water quality, and closures due to water pollution are now very rare in Cedar Key (ibid.).

Only two closures of clam areas around Cedar Key have occurred due to red tide events caused by the phytoplankton *Karenia brevis*. While not harmful to clams, this phytoplankton can cause Neurotoxic Shellfish Poisoning in humans (Northern Economics, Inc., 2015). Therefore, while stocks of clams generally are not affected by its presence, harvesting events may be disrupted and postponed. Clam industries in the southwestern region of Florida have been severely impacted by closures due to red tide events, however, the hydrology and prevailing water currents in Cedar Key are such that closures rarely occur.

While water temperatures have historically been conducive to clam production, Cedar Key is at the southern limit of the ecological range for *M. mercenaria*, and increasingly high temperatures have resulted in summer mortalities. This has led to research around breeding strategies to select more heat-tolerant traits to increase the resilience of the species in the face of climate change (Baker, Scarpa, and Sturmer, 2012).

Lastly, Florida and the Gulf of Mexico are often subjected to strong weather events such as hurricanes, which can cause damage to farm or supply chain infrastructure. The 2004 and 2005 hurricane seasons in Cedar Key were notably challenging.

OUTCOMES

SOCIO-ECONOMIC

The clam industry in Cedar Key has created clear economic benefits for the area. Producing over 90% of the state's clams (Pers. comm., L. Sturmer, 2020), in 2012 it supported 543 jobs, generated $14.7 million in labor income, $1.4 million in state/local tax revenues, and $2.7 million in federal taxes (IFAS, 2019a). In 2017, the industry reported $14.2 million in sales (USDA, 2018).

The industry supports direct jobs for clammers, as well as many associated jobs throughout the supply chain, including hatcheries, bag makers, boat builders, equipment manufacturers, wholesalers, processors, and truck drivers (IFAS, 2019a). In 2012, it was estimated that the total contribution to the state's gross revenue was $38.7 million (ibid.). In 2015, there were 14 hatcheries, and 90 other land-based companies supported by the clam industry (Northern Economics, Inc., 2015).

ENVIRONMENTAL

The clam industry in Cedar Key was developed as an economic resilience strategy for the region, as a response to the unreliable harvest of wild oysters and a gillnet ban at the state level. It was not a direct response to the overfishing of stocks by the Cedar Key community. Therefore, there were no direct conservation goals specified by the project when developing the industry.

The presence of the industry has resulted in increased water quality monitoring and data collection in Cedar Key. Between 2002-2012 continuous monitoring was funded by the USDA and carried out by the DOA and University of Florida to identify conditions that could negatively impact the clam industry in various lease areas (Northern Economics, Inc., 2015). In addition, the DOA monitors water quality throughout Shellfish Harvest Areas which requires routine sampling for water-borne toxins, bacteria, and viruses that can cause human illness (ibid.). The collection of these data contribute to the overall understanding of water quality conditions in Cedar Key.

The University of Florida has assessed the ecological contributions of Florida's hard clam industry on coastal ecosystems. In 2012, the University of Florida estimated that 544 million gallons of seawater were filtered by the statewide production of 136 million clams. These clams removed over 25 thousand pounds of nitrogen were removed. The economic value of these benefits was estimated at $99,680, which came at no cost to the public (University of Florida).

LESSONS LEARNED

The successful development and operation of the clam industry in Cedar Key has yielded valuable information about the successes and challenges it has faced.

Trusted technical and regulatory support is critical to support farmers

- The presence of a dedicated Extension agent in Cedar Key has proved crucial for facilitating ongoing technical, political, and financial support to the industry at all stages.
- This agent has been a consistent, trusted leader in the industry and community since its inception, which has allowed the growth and success it exhibits today.

The use of a "bottom-up" approach to planning and decision-making fosters a sense of ownership and responsibility among stakeholders

- Members of the community, local leaders, and local fishermen, were provided opportunities to shape the industry in a way that worked with their skills, knowledge, and goals, while also feeling ownership and responsibility for its success
- This approach also contributed to an understanding of financial constraints on new, or potential farmers, and the development of solutions.

Proposed species should be perceived as appropriate by stakeholders

- The clam species chosen was not associated with the same challenges as oyster culture, which facilitated support from community members, potential trainees/industry members, and local and state regulators.

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Table 2: Influential factors for Project Wave

CATEGORY	STRENGTHS	CHALLENGES
LEADERSHIP	• Long-term engagement and support from Extension agent • Clear, streamlined support from regulatory bodies	
STAKEHOLDER ENGAGEMENT	• "Bottom-up" approach to planning • Clear audience for retraining programs	
FINANCIAL SUPPORT	• Initial support from federal and state funds and grants • Training model provided participants with the necessary equipment, and allowed them to sell final products, and develop seed	• Potential members of the industry are generally unemployed, or underemployed without funds to invest in clam aquaculture • Banks failed to set up loan programs
COMMUNITY CONTEXT	• Outreach and education efforts grew community trust • Embraced clam aquaculture as an alternative to gillnet fishing	• Initial skepticism due to failed oyster industry
LOGISTICS AND INFRASTRUCTURE	• Infrastructure for harvest, processing, and transport of shellfish is already in place • Streamlined lease application process decreases time and cost of startup and operation	
POLICY AND REGULATION	• Local and state agencies supportive of the initiative, and facilitated attractive lease options	
MARKET CONDITIONS	• High demand for products	• Fluctuating prices • 2007-2012 recession decreased demand • Deepwater Horizon spill (2010) decreased demand despite Cedar Key not being impacted by the spill
ENVIRONMENTAL CONDITIONS	• Protected conservation lands around Cedar Key • Natural ecosystem conducive to clam aquaculture • Comprehensive sewage management system in place to minimize the risk of bacteria-related closures	• Occasional, rare closures due to phytoplankton causing red tide events • Hurricane seasons in 2004 and 2005 caused damage to clam farms

PROJECT	PROJECT GOAL	GOAL REACHED?
SOCIO-ECONOMIC	• Train out of work oyster harvesters and fishermen to grow clams	• Yes. 200 people completed the trainings, and the Cedar Key clam industry now supports ~52% of all FL clam producers (>90% of FL clam production by volume)
ENVIRONMENTAL	• No stated objective	• Increased water quality monitoring and data collection • Sewage management system was implemented before the introduction of the clam industry to prevent closures due to marine pollution • Ecosystem services such as water filtration, nitrogen removal, and carbon sequestration

BLUE VENTURES COMMUNITY-BASED AQUACULTURE: DEVELOPMENT OF COMMUNITY-BASED SEA CUCUMBER (*HOLOTHURIA SCABRA*) FARMING IN MADAGASCAR

TAMPOLOVE, AMBOLIMOKE AND ANTSATSAMOROY, MADAGASCAR

PROJECT SUMMARY

PROJECT LEADS:

Blue Ventures (NGO), Zanga Management Committee

PROJECT NAME:

Community-based sea cucumber farming

PROJECT DATES OF OPERATION:

2007-present

PROJECT OBJECTIVE:

Provide an alternative or supplementary income to fishing, thereby increasing food security and resilience to climate change

In southwest Madagascar, coastal communities have historically relied on wild-capture fisheries for livelihoods and subsistence due to the arid nature of the landscape which does not support agriculture. Declining wild fisheries have resulted in increased vulnerability of coastal communities to food insecurity and poverty (Ateweberhan *et al*., 2013). Development and operation of the Madagascan sea cucumber industry have been ongoing since 1999 as a multi-stakeholder initiative engaging communities, local and international organizations, universities, governments, and the private sector.

Between 1999-2007 field trials were conducted and the first hatchery was constructed (Robinson and Pascal, 2009; Blue Ventures, 2013; Razafimamonjiraibe, 2021). It was during this time that the Velondriake Locally Managed Marine Area (Velondriake LMMA) was established. Aquaculture was included as a conservation measure within the marine area's plan to provide an alternative and supplementary income to fishermen and women, to increase food security and resilience to climate change (Vincent and Razafimamonjiraibe, 2020).

The first sea cucumber aquaculture pilot project in Velondriake was started in 2007 in partnership with the Women's Association of Andavadoaka. While this initial attempt did not last longer than one year, it provided valuable technical and strategic lessons, as well as piquing the interest of the local community in the potential for sea cucumber farming (Razafimamonjiraibe, 2021). Additional pilots were implemented in 2010 in Tampolove and Ambolimoke modeled on the findings from the initial pilot. These pilots involved collaboration between Blue Ventures and Toliara-based company, Indian Ocean Trepang (IOT), who had constructed an industrial scale hatchery and could provide juveniles to stock community farms. Trainings, materials, and technical support were provided by Blue Ventures. This initial model operated village-based farms with pens allocated to pairs of farmers and expanded to 40 farms by 2015 (Vincent and Razafimamonjiraibe, 2020). Due to damage to farming infrastructure from a cyclone in 2015, as well as an outbreak of a skin ulceration disease in the farmed sea cucumber population, there was a temporary cessation of stocking juveniles in 2016 while the operating model was reevaluated and updated (ibid.).

After a year of trials, research, and strategic planning, an updated farming model was implemented in 2017 in Tampolove and Ambolimoke, which was operated until mid-2020. Additional updates to this model occurred partway through 2020 which improved the ability of farmers to pay operational costs and further integrated the construction, maintenance, and management of the sites (Razafimamonjiraibe, 2021). In addition, a third site was added at Antsatsamoroy in mid-2020, using yet another production model (communal

pens) different from the ones used at Tampolove and Ambolimoke. By 2020, there were 81 farms in Tampolove and Ambolimoke, with the addition of the site in Antsatsamoroy occurring partway through the year. There are 212 farmers (60% women) and since November of 2018, there have been 83,743 individual sea cucumbers harvested, resulting in 33.5 mt. (ibid.).

FACTORS INFLUENCING THE PROJECT

LEADERSHIP

Throughout the development of Madagascan community-based farming, the different models used have implemented varying strategies for leadership, trust-building, and decision-making. The initial pilot and the original model (2007-2015) suffered from the theft of farmed sea cucumbers, which threatened harvests and the safety of farmers.

With the closure of the farms in 2016, the reassessment of the farming model included developing a strategy for minimizing the occurrences of theft. It had been determined that thefts were occurring by clans that had not been included in the farming model and subsequently had less opportunity to participate and benefit from the additional income (Razafimamonjiraibe, 2021). A new system of leadership was developed that integrated leaders of all local clans. Leaders were allowed to designate farmers from their clans to participate in the program. Additionally, a community fund was set up to benefit the entirety of the community, even those not directly involved with farming (Vincent and Razafimamonjiraibe, 2020; Razafimamonjiraibe, 2021). Within this governance structure, farmers, operating organizations, and regulatory decision-makers all work together to develop, implement and enforce the agreed-upon governance system (ibid.). The leadership committee overseeing sea cucumber aquaculture that was formed through these agreements is called the Zanga Management Committee (ZMC) and consists of a general assembly, advisory board, and a hired operational body. Farmer groups are formed by the ZMC, with each group including a technical professional, and a local decision maker who facilitates social decisions. Lease agreements are the foundational documents established at the level of the ZMC, in which technical, environmental, and social rules and bylaws are stipulated. Before commencing any operations, all farmers must sign a lease agreement.

A community fund was set up to benefit the entirety of the community, even those not directly involved with farming.

The Advisory Board includes the President of the Velondriake LMMA, and a Velondriake aquaculture representative, as well as a technical expert from Blue Ventures, traditional village leaders, clan chiefs, and the President of the Fokotany (local neighborhood structure) (Vincent and Razafimamonjiraibe, 2020). This group of people provides oversight of decisions made by the ZMC and is responsible for approving new regulations (ibid.). The General Assembly

consists of all farmers in the community, as well as the hired operational body, which consists of personnel hired by the ZMC who have operational roles in the farming activities like supervisors and guards (ibid.).

The inclusion of all clans in the more recent operational models has greatly reduced the occurrence of thefts. The implementation of transparent guidelines, bylaws, and rules designed by multiple stakeholder groups, as well as the presence of a community fund has increased trust and buy-in from farmers and community members.

STAKEHOLDER ENGAGEMENT

Strategic stakeholder engagement for management of marine areas begins with the establishment of LMMAs. During the process of LMMA development, local community stakeholders provided information about conservation priorities. Representatives from each village attended meetings, eventually developing an agreement for area use for the entire LMMA (Harris, 2009). Within the LMMA, aquaculture is conducted in areas designated specifically for farming, often as "no-take zones."

The sites at Tampolove and Ambolimoke have been challenged with use conflicts, as fishermen and women were no longer able to access the areas used for aquaculture. However, the process of stakeholder engagement and integration of sea cucumber aquaculture into the larger marine resource use plan was able to minimize the conflict between these groups. It is also worth noting that many sea cucumber farmers are also engaged in wild capture of sea cucumbers and other fish, which likely helped facilitate this integration.

As is noted in the Leadership section, the ZMC manages sea cucumber aquaculture and engages stakeholders in a way that reflects existing community leadership structures. It is important to note that in Blue Ventures' community-based sea cucumber farming, approximately 60% of farmers are women.

FINANCIAL SUPPORT

Financial support for the development and operation of the sea cucumber industry has come in a variety of forms during its duration. The industry's origin is in a project involving the Institut Halieutique et Marine Sciences (IHSM) and Toliara based commercial companies, funded by the Belgian University Cooperation for Development and the Government of Madagascar to develop the technology and facilities necessary for sea cucumber aquaculture (Robinson and Pascal, 2009). In 2009 a small grant was secured by Blue Ventures and Trans/Mad Development from the Regional Programme for the Sustainable Management of the Coastal Zones of the Countries of the Indian Ocean (ReCoMaP) in 2009 for the establishment of sea cucumber farming as an alternative livelihood in southwest Madagascar (Vincent and Razafimamonjiraibe, 2020). Shortly after, in 2010, the Royal Norwegian Society for Development (Norges Vel) became the principal funder for the project and remained a major donor from 2010-2019.

When the Velondriake farming model was reorganized after the 2015 cyclone, additional donors were brought on board. Funding structures changed to a system where farmers receive income at harvest and were transitioning to being able to cover all of their operational costs (including the cost of juveniles, and transportation). In addition, farmers contribute to the salaries of ZMC supervisors and guards, as well as a community fund that supports the development of the community as a whole. Currently, farmers can cover all of these costs on their own and are free of debt. Startup costs (all capital and operational costs during the first year) and training of farmers are covered by external funding, and farmers have been able to earn an average of $35.7/month ($60 in Tampolove) with an average monthly return rate of 60% (Vincent and Razafimamonjiraibe, 2020).

In addition to funding from outside sources, a great deal of financial support comes from IOT, which supplies juveniles to farmers and buys harvested sea cucumbers back from farmers to process and export. In mid-2020, IOT committed to providing juveniles to farmers free of charge, lowering the

buy-back price instead. With the implementation of the updated operational farming models, farmers have decreased their equipment and infrastructure costs and increased their efficiency.

COMMUNITY CONTEXT

The country of Madagascar is characterized as having overlapping challenges relating to "poor health, unmet family needs, gender inequality, food insecurity, environmental degradation, and vulnerability to climate change" (Vincent and Razafimamonjiraibe, 2020). Over 90% of the population survives on the equivalent of <$2/day, with some of the poorest communities being semi-nomadic fishing communities along the southwest coast. Sea cucumber farming is centered in this area in the communities of Tampolove and Ambolimoke, both within the Velondriake LMMA (ibid.). In these villages, sea cucumber aquaculture is a strategy for diversifying livelihoods and reducing pressure on wild-capture fisheries.

As is noted in the Leadership section, the theft of farmed sea cucumbers posed a threat to the model before its restructuring (Blue Ventures, 2013; Vincent and Razafimamonjiraibe, 2020). After the development of the ZMC, the inclusion of all local clans, and the development of a community fund that is contributed to by farmers, theft has tapered off (Vincent and Razafimamonjiraibe, 2020).

With the reassessment of the former model and implementation of the updated model and funding structure, farmers can cover their operational costs. However, the shift to this system was a challenge for the community, which has been accustomed to ongoing income from wild capture fisheries, as opposed to being paid at harvest. At the onset of farming operations, farmers have to wait approximately 9-14 months to harvest full-grown sea cucumbers. While sea cucumbers are stocked either monthly or quarterly to allow for a rolling harvest, the initial waiting period before the first harvest can be sold proved challenging to many members of the community who are likely spending less time collecting wild sea cucumbers and fish to sell, to tend to their sea cucumber farm that is not yet providing income.

LOGISTICS AND INFRASTRUCTURE

From the outset of the community-based farming model, pilots were organized in close collaboration with research and development initiatives in Toliara led by IHSM and commercial operators. This ensured the provision of hatchery-reared juveniles for the community pens. As the project gained traction, IOT expanded its hatchery production, enabling a regular supply of juveniles to match the needs of the farmers and its own industrial private farms. While this provides relative ease in the access to juveniles for stocking, due to the remote, and isolated location of the farming sites, obtaining some materials necessary for farming has posed a challenge.

Additionally, it has been shown that using an adaptive model is necessary, as there are still lessons to be learned to enhance the efficiency and sustainability of production. However, this generally leads to a site-specific approach to farming, which can result in complicated logistics, and an inability to apply a working model to a different location.

POLICY AND REGULATION

The Madagascan sea cucumber industry as a whole is supported by government agencies that are in the process of finding and acquiring land in the northwestern region of Madagascar to develop an additional hatchery and expand the industry (Razafimamonjiraibe, 2021).

In the Velondriake region where the community-based sea cucumber farming initiative operates, the Velondriake LMMA (covering 823 km2 along 40 km of the southwest coast of Madagascar) operates special management areas designated and managed by local communities to reflect key conservation priorities (Harris, 2009; Vincent and Razafimamonjiraibe, 2020). While there is potential for conflicts over the use of natural marine resources for aquaculture, and the subsequent exclusion of wild-capture fishers from previously open fishing grounds, the transparency, and inclusivity of the Velondriake LMMA process, along with the ability of fishers to engage in aquaculture activities largely minimizes these issues.

MARKET CONDITIONS

Sea cucumbers grown in Madagascar are exported to various Asian countries where they are sold for medicinal purposes, as a health food, a delicacy, and as an aphrodisiac (Blue Ventures, no date). There are many local collectors in Madagascar that are linked to Chinese collectors and importers. IOT processes and exports sea cucumbers from this specific project to Asian markets. Demand for sea cucumbers has increased, while wild stocks have dwindled, leading to a higher market price (Blue Ventures, 2013). Producers in Madagascar sell sea cucumbers to their commercial partner, who sells them for approximately $200/kg in Asian markets (Razafimamonjiraibe, 2021).

ENVIRONMENTAL CONDITIONS

The sea cucumber Holothuria scabra is native to the tropical areas of the West Indian Ocean and Madagascar. Ideal sites for aquaculture production of the species are sheltered from high energy waves, maintain at least 15-20 cm depth, and have fine sediment. Generally, the presence of seagrass is an indicator of suitable habitat. Predation by crabs can lead to reduced production volumes (Blue Ventures, 2013), however adequate maintenance of infrastructure can minimize impacts.

While environmental conditions are generally conducive to the industry, two cyclones in 2013 and 2015 resulted in damage to infrastructure, and subsequent dips in production volume while farms were rebuilt, and stocking was put on hold (Vincent and Razafimamonjiraibe, 2020).

OUTCOMES

SOCIO-ECONOMIC

The introduction of sea cucumber farming to Madagascar has provided community members with a livelihood that helps to support not only those directly engaged in the activity but the community as a whole, through the implementation of community development funds. Net income from sea cucumber farming has increased each year since the first sale in 2009, except in 2013 and 2015 when cyclones and disease resulted in the loss of sea cucumbers (Vincent and Razafimamonjiraibe, 2020). Since the redesign of the farming model in 2016, farmers can operate their farms without debt, and contribute to community funds.

Approximately 212 farmers are active in the community farming sites, with the average net income around $35.7/month ($60 in Tampolove). The return rate is approximately 60%, which is twice the rate of an industrial farm (Razafimamonjiraibe, 2021). In a country where 92% of the population lives

on <$2/day, this is a significant income and a strong alternative source of livelihood for those who are using community-based sea cucumber farming to supplement income from wild capture fisheries. While the model is still reliant on external funding and support for the startup of farms and training, it has become increasingly self-sufficient.

ENVIRONMENTAL

In the process of the development of the Velondriake LMMA, marine areas were designated for different purposes. The sites that are used for sea cucumber aquaculture are designated as "no-take zones", which means that beyond being designated to support aquaculture, the areas are protected from other marine resource-using activities. There are approximately 26 ha of these protected areas.

It has been noted that natural reproduction of sea cucumbers within farm sites could contribute to the repopulation of the species in the vicinity of the farms (Razafimamonjiraibe, 2021). Additionally, a recent study conducted by the University of Edinburgh found that seagrass growth improves in areas with high populations of sea cucumbers (300 g m2), and showed a positive impact on seagrass ecosystem function from 18 months of continuous sea-cucumber farming (Arnull *et al*., 2020).

LESSONS LEARNED

A case study of community-based sea cucumber farming in Madagascar completed by the Reef Resilience Network provides a list of lessons learned, and observations of factors leading to the success of the project (Vincent and Razafimamonjiraibe, 2020). Additional lessons learned are included from Razafimamonjiraibe, (2021).

Appropriate financial and technical support is required throughout the project

- Ongoing availability of technical support is important – whether it is from external organizations or trained local community members. Longer-term, well-trusted technical support is more likely when supervisors are recruited by a local, respected organization.
- Planning and implementation of farm projects need to include progressive models for technical and financial training for farmers to become self-sufficient.
- It is important to know the farming parameters that are required at a specific site for successful growout. This includes stocking density and growth rate throughout the entirety of the growout cycle.

Relationships between direct project stakeholders as well as the broader community must be developed and maintained with appropriate, and adequate governance strategies implemented

- There needs to be a strong relationship and trust built between communities, the private sector, NGOs, farmers, and researchers. It is important to include all parties in the planning, design, and implementation stages of a project to create a transparent, trusted, and beneficial system for everyone.
- Inclusion of communities in governance system design and implementation
- Formalized agreement describing best practices to be followed, as well as farmer's rights and obligations
- Enforcement system that centers around the community and other farmers
- Management of the farming activity needs to be part of a broader resource management strategy that is planned, designed, and enforced by members of the local community
- Expectations for the ability of sea cucumber farming to create benefits for the community should be set appropriately. It can be viewed as a tool to decrease poverty; however, it cannot solve all issues, and should not be expected to.

Strategic planning should address social, economic, and ecological factors potentially influencing a project, with attention given to potential unintended consequences of proposed models

- Site-specific research and trial studies must be carried out to determine conditions that are socially, economically, and ecologically appropriate.
    - This must take a precautionary, and risk-averse approach, as it can create significant social and environmental risks specifically when it comes to the security of the communities.
- Projects require a business model that avoids creating debt for farmers, supports farmers during the initial period before their first harvest, and allows farmers to become financially self-sustaining, and is not reliant on subsidies.
- Must ensure partnerships are in place with necessary supply chain members. In the case of Madagascan sea cucumber, it is necessary to have consistent access to juveniles from a hatchery like the one owned by IOT.

Table 3: Factors influencing the Community-based sea cucumber farming industry in Madagascar

CATEGORY	STRENGTHS	CHALLENGES
LEADERSHIP	• Adheres to established community leadership structures	
STAKEHOLDER ENGAGEMENT	• Initial pilot piqued interest of broader community • Subsequent models were inclusive of all interested parties in planning and implementation	• Initial pilot not inclusive of all interested stakeholders leading to theft
FINANCIAL SUPPORT	• Consistent, long-term support from one organization • Business and financial models allow farmers to start, and operate a farm debt-free • After initial harvest, rolling harvests make income consistent • Partnership with IOT for juvenile supply and harvest buy-back	• Lag time between initial investment and first harvest where there is no income from aquaculture
COMMUNITY CONTEXT	• Open to aquaculture as a strategy for diversifying livelihoods and increasing resilience • Inclusion of a community fund in the business and financial models to benefit those not directly involved with farming	• Theft of sea cucumbers in initial stages by members of clans not included in the first pilot. • Lack of security for farmers (safety, financial) during pilot due to theft • Shift from relatively instant payment from wild capture fishing to having to wait through the growout period for aquaculture
LOGISTICS AND INFRASTRUCTURE	• Partnership with IOT and access to hatchery before scaling up operations	• Difficulty obtaining some materials necessary for farming due to remote location • Site-specific nature of farming makes models non-transferable
POLICY AND REGULATION	• Supportive national government • Formation of the Velondriake LMMA facilitated minimal conflicts between marine resource users	

CATEGORY	STRENGTHS	CHALLENGES
MARKET CONDITIONS	• High, consistent market demand from Asian countries	• Fluctuating prices • 2007-2012 recession decreased demand • Deepwater Horizon spill (2010) decreased demand despite Cedar Key not being impacted by the spill
ENVIRONMENTAL CONDITIONS	• Availability of areas suitable for sea cucumber culture	• Two cyclones (2013 and 2015) damaged farms

PROJECT	PROJECT GOAL	GOAL REACHED?
SOCIO-ECONOMIC	• Provide an alternative and supplementary income to fishing • Increase food security • Increase resilience to climate change	• Sea cucumber farming represents a significant portion of the income of those engaged in it, as well as contributing to the community as a whole • Malagasy do not eat sea cucumber. It is all exported. Farming decreases pressure on wild stocks, and increases financial security, but does not contribute directly to improving food security • Provides a more controlled, consistent source of sea cucumbers than wild capture
ENVIRONMENTAL	• No stated objective	• Designation of sea cucumber aquaculture areas has established 26 ha of "no-take zone" protected areas • Sea cucumber culture at a certain density improves seagrass growth • Anecdotal evidence that reproduction within farm sites contributes to the repopulation of wild stocks near farms

DEVELOPMENT OF THE SEAWEED INDUSTRY IN BELIZE MPAS SHOWS EARLY EVIDENCE OF INCREASED BIODIVERSITY AROUND FARMS

PLACENCIA AND TURNEFFE ATOLL, BELIZE

PROJECT SUMMARY

PROJECT LEADS:

The Nature Conservancy (NGO), Placencia Seaweed Farmers (cooperative), Belize Women Seaweed Farmer's Association

PROJECT NAME:

Belize Seaweed Mariculture Project

PROJECT DATES OF OPERATION:

2010-ongoing

PROJECT OBJECTIVE:

Develop an innovative sustainable seaweed mariculture industry that provides ecosystem benefits in addition to alternative income

Prior to the landfall of Hurricane Iris in 2001, many Belizean coastal communities relied on fishing as a primary source of income. Fishing effort was primarily directed towards lobster, conch, and reef fish. In the aftermath of the hurricane, developers saw an opportunity for growth in the real estate market, leading to a shift in the local economy. Tourism-based industries became an increasing source of income. While commercial fishing remained, recreational fishing charters for vacationers became a larger piece of the industry. Today, out of a total population of approximately 400,000, about 15,000 Belizeans are dependent on the income of a fisherman or someone in the fishing-related tourism industry (Correa, 2020).

Efforts to develop a seaweed industry began in 2010 as the communities of Placencia and Turneffe Atoll were experiencing diminishing catches of wild lobster, conch, and reef fish. Fishermen are having to go farther out to sea to catch species that were once readily available closer to shore. This results in increased fuel costs and the amount of time it takes to land their catch. In addition to overfishing of nearshore sites, it is also suspected that warming sea temperatures may be responsible for conch and lobster species moving further from shore (Correa, 2020).

The culture of the native seaweed *Eucheuma isiforme* was developed with the intent of supplementing and diversifying income for fishermen and relieving pressure on wild stocks fishery resources (PSF, 2020). Wild seaweed has been harvested in Belize for many years and is used in local beverages believed to have nutraceutical properties. The Nature Conservancy (TNC) has supported seaweed aquaculture development in Belize since 2016 by providing farmer training and the associated logistics, conducting ecological studies, mentoring farmers and fostering the development of farming cooperatives, and encouraging the development of government policy to enable sustainable growth. The Placencia Producers Cooperative Society Limited (PPCSL), formerly a fishermen's cooperative, has played a lead role in the seaweed development effort and shifted its focus entirely toward seaweed production through its Placencia Seaweed Farmers (PSF) division. More recently, with support from TNC the Belize Women Seaweed Farmer's Association (BWSFA) was founded in 2019.

Both groups are based out of Placencia and farming sites for both groups are based in Little Water Caye, and Hatchet Caye (respectively). Further effort is being made in Turneffe Atoll to expand the industry. Between these groups, there are a handful of pilot farms operating and one commercial farm. Until recently, all farming has taken place within mixed-use Marine Protected Areas under research permits.

Eucheuma isiforme is the sole culture species, however, research is ongoing to determine an appropriate species of Gracilaria for production as well. Annual production volumes for *E. isiforme* in Placencia and Turneffe Atoll vary, with production from the largest farm in the PSF totaling 1,300 lbs to date. Total production of *Eucheuma* spp. in Belize varies as well, with production peaking at 10 mt in 2013 (FIGIS, 2020).

A strong local market exists for seaweed within Belize. Many local shops using seaweed in smoothies and milkshakes and purchase seaweed for USD 15 per pound, which is far higher than the global average price. One producer includes it in hair products sold in local markets, while another includes it in soaps. The industry intends to scale up and sell to those who have expressed interest internationally, potentially into a cosmetics market that would value the pristine waters in which the seaweed is farmed. Farmers and supporting organizations are also optimistic that there is a market for Belize seaweed as a "superfood," given its nutritional properties.

FACTORS INFLUENCING THE PROJECT

LEADERSHIP

Leadership within the industry is a joint effort between community members and organizations supporting initiatives in the area. In Placencia, the BWSFA and PSF both operate near each other, each with its own governance system, and strategies for attracting members. The BWSFA, although nascent, is well-organized, and engages female members of the community. Most members of the BWSFA are daughters of commercial fishermen and some make their livelihood on the water already, such as through the recreational dive industry and water tours. The PSF has been led by a member of the community who grew up in the local fishing industry and has become a champion for seaweed farming in the region. Both are supported by TNC, which also supports the development of the industry in Turneffe Atoll. In addition, industry development in Turneffe Atoll is co-managed by the Turneffe Atoll Sustainability Association (TASA). There is a national Seaweed Working Group (SWG), coordinated by TNC, representing both regions that reflects the voices of all stakeholders.

STAKEHOLDER ENGAGEMENT

In the early stages of the industry's development, stakeholder engagement happened organically, with the PPCSL showing interest in its potential by developing the PSF. In 2016, TNC became involved in the industry and assisted to formalize the development strategy, which included a focus on the development of structured training programs, and the creation of partnerships between local organizations.

An industry meeting was held in early 2017 that convened 14 fishermen and seaweed growers from seven towns and communities; each presented their current status and needs for successful industry development (Robinson, 2018). This information led to the development of pilot farms, and the subsequent development of the Seaweed Working Group comprised of TNC, BELTRAIDE, The Belize Fisheries Department, the Belize Department of Cooperatives, the Belize Federation of Fishers, TASA, BWSFA, a fisheries representative from Turneffe Atoll, and the PPCSL to represent the voices of affected stakeholders (ibid.).

Community members who are interested in seaweed farming can enroll in training events that are supported by TNC in partnership with the PSF in Placencia, and TASA in Turneffe Atoll. The lead trainer is the same community member who leads the PSF, and the assistant trainer is a member of the BWSFA. The training curriculum was developed and sponsored by TNC, Fragments of Hope, BELTRAIDE, and the UNDP's GEF Small Grants Programme, in addition to other supporters (Robinson, 2018). In addition, the University of the West Indies has been engaged with the possibility of creating a certified seaweed training program to house future training.

FINANCIAL SUPPORT

In 2019, the Belize Women Seaweed Farmer's Association (BWSFA) was established, encouraging women in the community to join the industry. The relatively recent inclusion of women in the seaweed industry has challenged the status quo of the male-dominated fishing cooperatives and the initial development of the seaweed industry.

Financial support for the industry has come in a variety of forms during the past 10 years. There is no specific funding structure supporting all organizations involved with seaweed development. Funders have provided support for specific initiatives proposed and undertaken by the organizations, typically in partnership.

The early formation of the PSF was funded by a small grant from the UNDP's Global Environment Facility Small Grants Programme (GEF SGP) (PSF, 2020). TNC has funded the equipment and start-up costs for a handful of farms, however, for a variety of reasons, several of them have not been successful past the first few months of operation.

Currently, funding and logistical support for training by the PSF are provided by grants secured by TNC and BELTRAIDE. In addition, TNC has supported the formation and strategic planning of the BWSFA with financial, logistical, and technical assistance. Additional funding and support for training in Turneffe Atoll have come from grants secured by TASA.

Farms and supporting organizations alike have an objective to ensure the industry is self-sustaining and not reliant upon grants. Among other things, this requires the development of business models and funding structures that will support consistent production, and eventual financial stability in the industry.

COMMUNITY CONTEXT

Fishermen in the community have seen the decline in wild species populations firsthand and broadly support the need for additional income streams and conservation measures. The seaweed industry has been welcomed by the community as an opportunity to increase their economic resilience and conserve the wild fish they rely on, while still making a living on the ocean.

In 2019, the Belize Women Seaweed Farmer's Association (BWSFA) was established, encouraging women in the community to join the industry (BWSFA, 2020). The relatively recent inclusion of women in the seaweed industry has challenged the status quo of the male-dominated fishing cooperatives and the initial development of the seaweed industry (Robinson, 2020). This has led to a bit of friction, but TNC aims to foster an environment in which the PSF and BWSFA will be able to successfully operate in a way that contributes to the overall well-being of the industry (Pers. comm., S. Chan, 2020).

Training events for those interested have been attended by members of the community, cooperation officers, government representatives, and members of local sustainability organizations (PSF, 2020). The lead trainer is a former fisherman and well-respected member of the community who is a champion

for seaweed aquaculture in the region. The assistant trainer is a member of the BWSFA. Along with providing training information, she helps women to feel empowered to be a part of the industry (Pers. comm., S. Chan, 2020).

Until recently, trainings were co-managed by TNC and the PSF in Placencia, and TNC and TASA in Turneffe Atoll. It is the goal of the industry to have these trainings led solely by local organizations in the future. Some support for this has come from the University of the West Indies (UWI), as they assist with designing a system for training and obtaining a certificate from the University upon completion of the course.

In addition to trainings, TNC is currently working with the PSF, SWG, and the Fisheries Department to develop a national management system for the seaweed industry. The community is engaged in this process through the PSF and SWG, as well as a series of public consultations that are being conducted by consultants to inform the policies.

LOGISTICS AND INFRASTRUCTURE

In the early stages of the industry, farmers faced challenges around the collection and successful transport of seed stock. It was necessary to travel offshore to collect seed stock, and survival rates of seed were often only approximately 10% (Polanco, 2020a). Ensuring the success of the surviving plants was a very time and resource-intensive process.

However, farming sites are currently very far away from the inhabited areas of Belize. Hatchet Caye/Little Water Caye and Turneff Atoll are more than 15nm from locations that the farmers live in Placencia and Belize City, respectively. Identifying sites that are closer to the mainland is a future consideration of the project leads.

Most seaweed and seaweed products produced in Placencia and Turneffe Atoll are destined for local markets, requiring minimal infrastructure or logistics. Processing generally consists of rinsing and drying on racks in the sunlight, relying on minimal equipment beyond drying racks.

Additional infrastructure to ensure the proper quality of seaweed products is planned for the industry as it scales up in order. While drying of seaweeds is a relatively simple process of laying them out in the sun, a drying facility will be developed which will ensure seaweeds are dried on surfaces that will ensure the cleanliness of seaweed as it is processed. There is currently a challenge associated with the consistent quality of seaweed handling as it is processed.

One further challenge is around the current absence of industry-scale leadership resulting in the onus of planning and implementation of training events consistently falling on TNC rather than local organizations. It is a goal of all stakeholders to have the logistics of these trainings maintained by local organizations, however, they cannot currently manage them without the support of external organizations.

POLICY AND REGULATION

The development and implementation of the seaweed industry in Belize have been supported by the Fisheries Department, which has maintained engagement and communications with project leaders and has expressed interest in the potential of the industry. Project leaders were able to obtain and maintain the necessary research permits to conduct seaweed farming operations.

There is no industry-wide governance system in place to guide and manage strategic planning for the development of the industry. The Fisheries Department, The Nature Conservancy, and the SWG are collaborating to develop policies to guide and govern the seaweed industry and are in the process of creating an industry-wide plan for socio-economic and ecological sustainability. There is a potential for a new national policy and regulations that guide the application process; the monitoring, extraction, exportation of seaweeds; and the general development of the industry (Polanco, 2020) including farm design, and determining appropriate locations for farm sites.

While seaweed farming is conducted using a research permit, however, there is an ongoing effort between TNC, the SWG, and the Fisheries Department to develop a system for leasing land, and permitting farms (Pers. comm., S. Chan, 2020)., Permitting costs are not currently associated with any costs to the industry.

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MARKET CONDITIONS

Seaweed is currently produced at a small enough scale that the demand is high. *Eucheuma isiforme* from Placencia generally sells for USD 15/lb locally due to the high quality, whereas lower quality products from other countries generally sell for approximately USD 2/lb (Correa, 2020). In Placencia, this is the same cost/lb as lobster and three times the price of conch (ibid.).

While the vast majority of seaweed is sold locally, interest in the products has been expressed internationally, resulting in the PSF applying for an export permit, which currently allows a small amount of product exported to the USA (Pers. comm., S. Chan, 2020). It is the hope that the industry will be able to scale to a point where local and international buyers can be consistently accommodated. The Department of Cooperatives has expressed interest in assisting the farmers with their organization to export their products (Polanco, 2020a), and BELTRAIDE has supported the industry through assistance with trainings to help scale the industry for export and trade.

OUTCOMES

ENVIRONMENTAL CONDITIONS

Eucheuma isiforme and *Gracilaria* are both native to Belize, making appropriate environmental conditions readily available for the culture of these species. Farming sites are being developed away from the immediate subtidal areas, where waters are generally calm, well-oxygenated, and are not subject to any pollutants from the coast (Polanco, 2020a).

While this benefits the industry, species of *Sargassum* seaweeds, which are also native, can become tangled in the cultivation equipment, requiring removal (Polanco, 2020a). In addition, it is expected that climate change will be a challenge in the future. In 2019 water temperatures increased slightly, which resulted in die-offs of cultured seaweed (Pers. comm., S. Chan, 2020). This has led to experimentation with new farm designs. Currently, the industry uses floating raft systems, however these result in seaweed staying close to the surface of the water, usually hanging 1-2 feet below the surface where the temperature fluctuates the most. The new system being tested has seaweed submerged closer to the seafloor, where temperatures are expected to remain more consistent, and infrastructure is less vulnerable to extreme weather events (ibid.).

SOCIO-ECONOMIC

The seaweed industry in Placencia and Turneffe Atoll has been welcomed by community members and is viewed as a conservation strategy for wild fish populations, and subsequently a resilience strategy for livelihoods in the community. While the industry is supported, becoming self-sufficient remains a challenge.

While interest in the industry is high, and trainings are in high demand, even with financial support for the infrastructure and start-up of a farm subsidized by TNC, farmers cannot afford to maintain the farm in the period before the first harvest.

With about a dozen community members actively engaged in farming, the industry does not currently have a significant large economic impact. The lead and assistant trainers are compensated by funders co-managing the trainings, however, it is the hope that in the future trainings will be managed solely by local organizations, including payroll for trainers.

ENVIRONMENTAL

Monitoring studies have been conducted by TNC at two seaweed farming sites in Placencia and generally show minimal impact and potential for ecological benefits from seaweed farming activities. Ecological studies have

included assessment of impacts on benthic composition, seagrass density; seagrass density, canopy height and biomass; nitrates; fish species richness and abundance; macrofaunal species richness and abundance; light intensity; temperature; and dissolved oxygen (DO)(Foley, 2019).

It was determined that rafts used for seaweed production may increase the cover of seagrass species below and adjacent to them (Foley, 2019). At one monitoring site, an increase from 60% to 75% of seagrass coverage under rafts and 60% to 65% adjacent to rafts were observed. At the other monitoring site, no significant differences were noted below or adjacent to rafts (ibid.). While it was noted that cover may increase, there is potential that total above-ground biomass adjacent to nets may decrease affected due to trampling from farmers tending to cultured seaweed (among other potentially influencing factors such as nitrate availability, and changes to light penetration due to rafts). While this could affect the stem and leaf biomass, it was noted that seagrasses responded by increasing root biomass, contributing to the increased % cover, and an increased density overall (ibid.).

Monitoring of nutrient concentrations has been limited to date, however, no significant phosphate concentrations were present at the single site tested (Foley, 2019). In this same monitoring area, nitrate levels were lower at the farm site than at the control site, however, the reason for this change is unknown, and requires further monitoring. It was noted that total seagrass biomass mirrored nitrate availability (lower in the farm area, and higher at the control site), however, further monitoring is required to determine whether these changes are related (ibid.).

Monitoring of fish species richness and abundance was carried out at two separate farming sites in Placencia. At one site, species richness was consistently higher and increased more at the farm site than at the control area during the monitoring period (Foley, 2019). Fish present at the farm site (but not the control site) included species of parrotfish, grunts, and snappers, butterflyfish, and damselfish; all of which are known to promote reef health (ibid.). While the highest richness was at the farm site, the control site was characterized by the highest abundance of a single species; the Sharpnose puffer. However, mean abundance across all species was higher at the farm site, with the French grunt having the highest abundance (ibid.).

On the other side, it is noted that fish abundance is naturally higher in control areas with sandy bottom than seagrass areas (Foley, 2019). The addition of rafts is associated with an increase in abundance in sandy areas and a decrease in abundance in seagrass areas. Conversely, species richness was determined to be higher in seagrass areas than sandy areas (ibid.). Species richness increased with the addition of rafts in both seagrass and sandy areas, however, the increase was notably higher in seagrass areas. While additional

monitoring is needed, these preliminary observations show that the presence of rafts may have larger benefits for fish biodiversity and abundance when placed over sandy areas than seagrass areas (ibid).

Monitoring of macrofaunal species richness and abundance was carried out at two separate sites in Placencia. The study found that at new farm sites there was an initial stage of increased species richness, characterized by opportunistic, mobile species (shrimps, and amphipod species). However over a few months, mean overall abundance decreased, and species composition shifted toward gastropods, crabs, and polychaetes (Foley, 2019). During the monitoring periods at each site, species richness increased (ibid.). It was found that species richness was highest

Observations of macrofaunal richness and abundance suggest species biodiversity is highest under seaweed rafts in sandy areas, while species abundance is highest under rafts in seagrass areas.

Additionally, it is noted that at one of the monitoring sites species richness remained high after approximately 70% of seaweed was harvested from the site and replaced with seedlings, suggesting that macrofaunal diversity can maintain increased levels if harvesting of sites is done strategically.

Monitoring of light penetration indicated a decrease of approximately 22.96% under rafts, however, rafts used in this study were not maintained in a way that kept them static. Instead, they moved around in the water more than typical rafts used for seaweed farming will, resulting in more light penetration than normal. Further study using rafts that are more static in the water will be required to obtain a more accurate estimation of light penetration below rafts. It was found that at the surface, light was scattered both within, and adjacent to rafts, and that light intensity was highest in the rafts, rather than adjacent to them (ibid.).

Monitoring of seawater temperatures indicated that during the day thermoradiation was partially absorbed by seaweed near the surface, likely causing thermostratification resulting in warmer temperatures toward the surface, and cooler near the bottom (Foley, 2019). At control sites there was a smaller difference between temperatures at the surface and the seafloor, indicating better light penetration (ibid.). During the night, heat was retained by seaweed, resulting in warmer areas in rafts than adjacent to them (ibid.). Negative thermostratification occurred during the night adjacent to rafts where surface waters became cooler, with warmer waters close to the bottom. This did not occur in raft areas, likely due to a lack of light penetration and subsequent heating of water below the rafts during the day (ibid.).

Monitoring of dissolved oxygen (DO) concentrations established a baseline for further study. No comparisons between sites, or between control and farmed sites have been made to date. Further monitoring is planned for the future of the projects.

LESSONS LEARNED

As the seaweed industry develops in Placencia and Turneffe Atoll, community members and stakeholders are gaining knowledge about what is necessary for their area to make the industry self-sustaining. While the local communities have embraced the industry as a positive opportunity, the industry has been slow to develop, and several farmers attempting to start seaweed farms have exited the industry. These failures are helping to inform the refinement of future development efforts.

A strong local market is not enough to drive an industry forward. While an exceptional market for seaweed exists, it has not been sufficient to drive the development effort alone. An appropriate business model, farmer trainings, and enabling policy are critical elements to achieve successful development.

Costs and accessibility to farm sites must be appropriate to enable operational success. Several farmers have exited due to high costs of farm maintenance, which is in part driven by the remote nature of sites. Until recently, farming operations were restricted to MPAs which limited access to sites closer to the mainland. This has led to high maintenance costs and vulnerability to poaching.

Cultural considerations play a big factor in development efforts. The early successes of the BWSFA have demonstrated that women in communities are strong candidates for entrepreneurial aquaculture activities and that fishermen should not be the sole target of conservation-oriented aquaculture development efforts.

Tropical seaweed provides early evidence of yielding broader ecosystem benefits to biodiversity.

Table 4: Factors influencing the development of the Belize Seaweed Mariculture Project

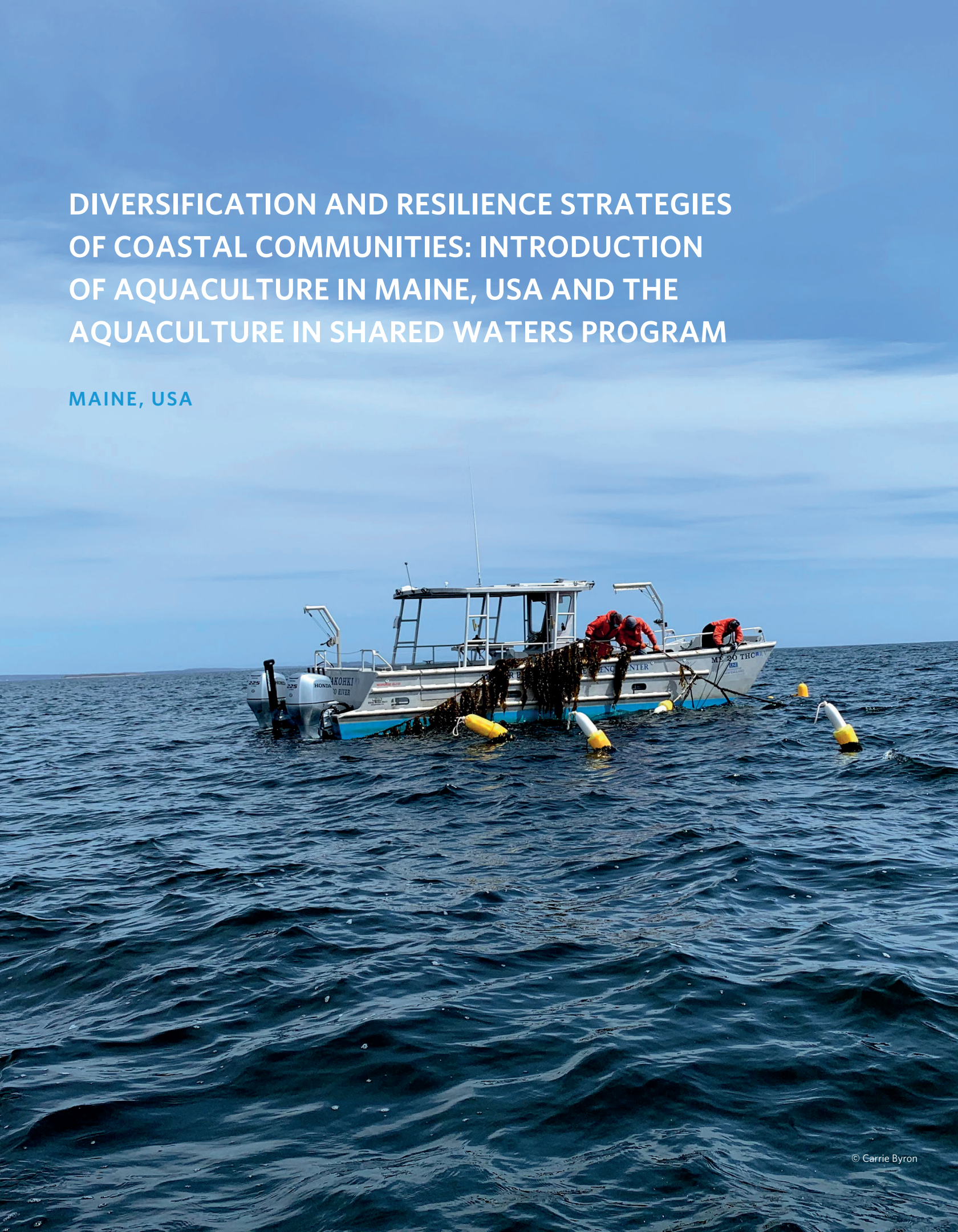
CATEGORY	STRENGTHS	CHALLENGES
LEADERSHIP	• Joint effort between community members and supporting organizations (international and local NGOs) • Each industry and supporting organization has a governance system • Well-respected community member champions the industry	• Insufficient senior leadership currently championing issues at the national government level. • Friction between the PSF and BWSAF
STAKEHOLDER ENGAGEMENT	• Inclusive of appropriate stakeholders in industry development efforts, and government policy development • BWSFA encouraging women to join the industry despite prior lack of representation • Industry and trainings inclusive of all interested parties	
FINANCIAL SUPPORT	• Multiple organizations external to the industry are dedicated to providing support for its successful development • Lack of national permitting structure results in no fees for leasing, producing, etc.	• Supporting organizations (NGOs) cannot provide sufficient funding to overcome the costs needed by farmers to maintain and operate farms. • Lag time between farm setup and the first harvest
COMMUNITY CONTEXT	• Widespread support for the seaweed industry in the community • Tool for conservation of wild fish, leading to increased economic resilience for coastal communities	• Changing the status quo of fishing and seaweed production being male-dominated industries • Tourism industry may present more attractive opportunities for some community members.
LOGISTICS AND INFRASTRUCTURE	• Vast majority of production destined for local markets • Minimal infrastructure required for start-up, aside from boats to access current sites; utilization of prior infrastructure for fishing operations. • Additional infrastructure planned	• Distance to farming sites (fuel costs, time commitment) • Lack of industry-scale leadership to manage logistics of trainings and strategic industry development • Inconsistent quality of processing

CATEGORY	STRENGTHS	CHALLENGES
POLICY AND REGULATION	• Government agencies engaged and supportive of the industry	• Current policy limits farming to research permits • No overarching government policy or regulations are in place for seaweed aquaculture
MARKET CONDITIONS	• Unusually high local demand and price for seaweed products	
ENVIRONMENTAL CONDITIONS	• Availability of appropriate culture sites, however, the current policy environment restricts farming to remote sites. • Currently developing updated farm infrastructure to address concerns about water temperatures aand weather events	• Rising water temperatures • Weather events such as hurricanes can damage or foul farm and shoreside infrastructure • Other native species (*Sargassum* spp.) become tangled in cultivation equipment requiring removal

PROJECT	PROJECT GOAL	GOAL REACHED?
SOCIO-ECONOMIC	• Provide supplemental income for fishermen	• Only one commercial farm currently. The industry has not become self-sustaining, and farmers often can't afford to stay in the industry • Women in the community are now presenting themselves as strong candidates to continue the seaweed development effort.
ENVIRONMENTAL	• Provide ecosystem benefits to fish stocks	• Measurable net benefit to ecosystem health in terms of fish/invertebrate diversity • The project demonstrates that seaweed farms have the potential to serve as nursery sites, and can help replenish wild populations • Greatest benefit and minimal degradation observed in sandy areas

DIVERSIFICATION AND RESILIENCE STRATEGIES OF COASTAL COMMUNITIES: INTRODUCTION OF AQUACULTURE IN MAINE, USA AND THE AQUACULTURE IN SHARED WATERS PROGRAM

MAINE, USA



PROJECT SUMMARY

PROJECT LEADS:

Maine Sea Grant, Maine Aquaculture Association

PROJECT NAME:

Aquaculture in Shared Waters

PROJECT DATES OF OPERATION:

2010-ongoing

PROJECT OBJECTIVE:

Prepare fishermen to start an aquaculture venture

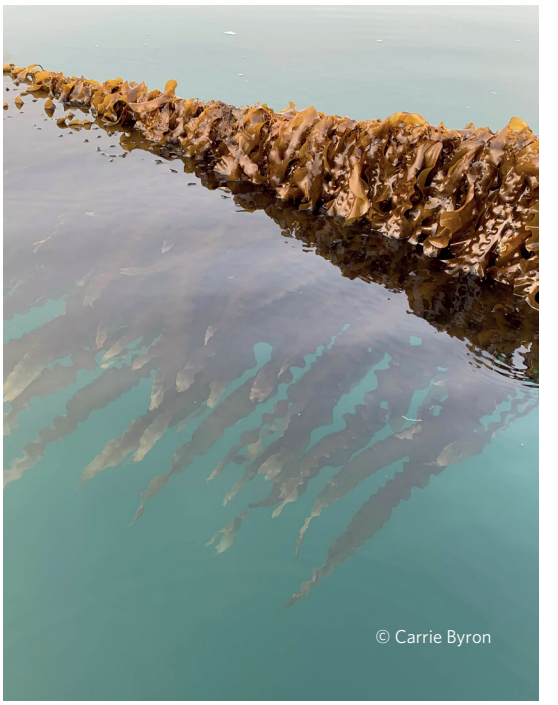
The aquaculture industry in Maine has been in operation since the mid-1970s when production of oysters, mussels, and Atlantic salmon began in the Gulf of Maine. By 1994, the industry had grown to 1200 acres of production, where it remained static for more than 20 years (Pers. comm., S. Belle, 2020). Since 2017, expansion has increased, with production area for salmon, oysters, mussels, seaweed, and other species covering 1600 acres. There are currently 107 aquaculture companies operating in 190 sites in Maine (ibid.).

Maine coastal communities have historically relied on working waterfront industries, including fishing, processing, packaging, and transport. Groundfishing has historically been a major sector, however a decline in stocks, and subsequent fluctuations in quotas and license availability have resulted in a more consolidated wild-capture industry, which now focuses mainly on lobsters. While lobster stocks are currently regarded as well-managed and healthy (Sustainable Fisheries Partnership, 2017), there is a concern for future impacts from climate change, which could result in negative impacts on the livelihoods of fishermen (Le Bris *et al*., 2018).

Aquaculture has been promoted as an industry that allows working waterfront communities to diversify incomes and continue to thrive making a living on the water. The species with the highest production volumes include Atlantic salmon, oysters (6,300 mt), mussels (1,065 mt), and seaweeds (127 mt) (DMR, 2020), all of which are grown commercially. Confidentiality measurements restrict the public disclosure of salmon production data; however, it is the highest in both volume and value (Pers. comm., S. Belle, 2020).

The Maine Aquaculture Association (MAA) was founded in 1978 and provides representation for the industry at the state, federal, and international levels. In addition, the MAA provides trainings, market support, and guidance for developing sustainable aquaculture business practices (MAA, no date). One such training is the Aquaculture in Shared Waters (ASW) program, which trains fishermen and their families on the technical and financial aspects of running a seaweed or shellfish operation in Maine. This program was started in 2010, originally focusing on cod aquaculture, but shifted to shellfish and seaweed due to declining prices, and higher start-up costs (Pers. comm., S. Belle, 2020).

There are two additional aquaculture training programs in Maine; one is run by the Island Institute and targets fishermen in the lobstering industry and the other is run by the Manomet preserve and focuses on clam aquaculture. Between the three programs, it is estimated that approximately 250 people have been trained. Approximately 50% of trainees have continued to start businesses (Pers. comm., S. Belle, 2020).



FACTORS INFLUENCING THE PROJECT

LEADERSHIP

Leadership of the Maine aquaculture sector is advanced through many different organizations, including heads of state agencies, industry associations, farmers, and academic groups. While leadership is generally perceived as being strong, Sebastian Belle of the MAA notes that there is a need for a younger generation of leaders who are engaged in the sector and can be its champions in the future.

The MAA is a multi-species industry association founded in 1978. Aiming to foster interconnectedness in the industry, its Board is comprised of representatives from companies representing all species, production systems, and scales of operations in the industry (Pers. comm., S. Belle, 2020). As the leading industry organization, the MAA informs legislation and policies, serves as a source of information about aquaculture for the community, facilitates connections between the public and the industry, and creates and maintains relationships with other sectors reliant on natural resources such as wild-capture fisheries, agriculture, tourism and conservation (MAA, no date).

The sector is currently in the process of renewing and updating its 10-year Economic Development Plan. Leadership for this process includes a "Meeting of the Minds" group comprised of Maine Sea Grant, Coastal Enterprises, Maine Aquaculture Innovation Center, the Aquaculture Research Institute, and the MAA that has identified strategic focus areas in research, development, and education through extensive outreach with industry and other key stakeholders (Noll and Davis, 2020; Pers. comm., S. Belle, 2020).

While the MAA facilitates cooperation and coordination within the sector, the inherently competitive nature between members operating in the same sector can occasionally make the MAA's pre-competitive activities challenging (Pers. comm., S. Belle, 2020). This has been observed both among commercial companies as well as within the research community when seeking grant opportunities. This can lead to some challenges with logistics and planning of events, meetings, and working groups (ibid.), however, it is not identified as a major challenge influencing the sector.

STAKEHOLDER ENGAGEMENT

Stakeholders in the sector are generally reached through efforts by the MAA. The MAA has dedicated outreach staff, who engage with community members, and ensure that the work of the association reflects those interests, concerns, or questions (Pers. comm., S. Belle, 2020).

Programs are now being developed to complement the ASW program and will operate within community colleges, technical high schools, and at the 4-year academic level. It is the hope that these programs will create a system in which younger generations can visualize a career path in the aquaculture industry, and be supported through training to meet the necessary occupational standards.

In the process of updating the 10-year Economic Development Plan, input is being sought from Sea Grant, industry representatives, state and federal regulators, municipal leaders, harbormasters, the NGO community, commercial fishing associations, landowners, members of the seafood supply chain, and additional focus groups. People involved in the aquaculture sector were identified using the registration list from a recent conference, the MAA membership list, the University of Maine's Aquaculture Research Institute mailing list, a list of Limited Purpose Aquaculture license holders, and the list of aquaculture leaseholders (Noll and Davis, 2020). Information from these groups is incorporated into the draft Plan by the sector leaders in the "Meeting of the Minds" group and is reflected in the priorities identified in the Plan. To date, feedback from the groups engaged has identified areas of focus for Research, Development, and Education (ibid.).

To engage with relevant stakeholders, the ASW program sends a solicitation to every fisherman with a commercial license in the state. Existing aquaculture lease holders are sent an invitation to participate in an advanced level of the course that includes information on business management (Pers. comm., S. Belle, 2020). Admission to the program has varied, with some years focusing on members of the wild capture fishing community and their families, and other years allowing entry to a broader group. In recent years the focus has been on members of working waterfront families (ibid.). This change was made due to some individuals who were interested in aquaculture as a hobby rather than the commercial sector. While the MAA is supportive of hobbyists, it was determined that given the curriculum, and the importance of the commercial aquaculture sector in Maine, spaces in the ASW program are best suited to those who are interested in pursuing aquaculture as a livelihood (ibid.).

Research for the update to the 10-year Economic Development Plan also identified the need for education programs for younger generations who will become leaders and members of the industry. Programs are now being developed to complement the ASW program and will operate within community colleges, technical high schools, and at the 4-year academic level (Pers. comm., S. Belle, 2020). It is the hope that these programs will create a system in which younger generations can visualize a career path in the aquaculture industry, and be supported through training to meet the necessary occupational standards (ibid.).

FINANCIAL SUPPORT

Historically the aquaculture sector in Maine has been supported by a variety of sources of funding. Producers are generally self-sufficient and have been able to start and maintain a business without subsidies from the government or other organizations. However, access to funding, particularly for new farmers, has been a challenge.

Within the sector, research projects and initiatives are often supported by grants. The NOAA National Sea Grant award recently provided $1.6 million to Maine Sea Grant in partnership with the University of Maine and other institutions to lead four projects in collaboration with the Maine aquaculture industry (Zydlewski, 2019). In addition, the State of Maine received a $2 million Economic Adjustment Assistance award for the development of a broader Marine Economy initiative, and action plan for economic growth and resiliency in the marine sector (Hamilton and Whitney, 2020). Perhaps

the most significant award in recent years was a $20 million award from the National Science Foundation in 2014 to support the University of Maine and partners to establish the Sustainable Ecological Aquaculture Network. Consistent research funding availability and strong university capacity to support sustainable industry development is likely one of the contributing factors leading to recent growth of the sector in Maine.

The MAA's operation is funded by membership dues which are determined on a sliding scale, recognizing the size and income level of a company (Pers. comm., S. Belle, 2020). Individual projects led by the MAA may be supported by external funding. For example, a grant from the USDA covered costs of Covid-19 training for members; and grants, with matching from the industry fund the ASW program (ibid.).

COMMUNITY CONTEXT

The aquaculture sector in Maine is an important part of the marine economy, particularly in rural areas of the state. For approximately 20 years the industry remained static with little growth beyond the ~1200 acres of lease area. During the past 5-8 years, however, the industry has expanded to ~1600 acres, which has resulted in the growth of both the immediate aquaculture industry as well as associated supply chain service providers such as specialized equipment manufacturers, veterinary and diagnostic services, and transportation services (Pers. comm., S. Belle, 2020). Producers are now beginning to work together to create marketing, trucking, and equipment buying cooperatives. This expansion has resulted in local service providers expanding, as well as non-local businesses entering the Maine sector (ibid.).

Growth of the aquaculture sector in Maine is in the economic interest of the industry and the State when practiced with ecological limits. However, the aquaculture industry remains somewhat controversial with the broader public, as it is in the United States as a whole (Knapp and Rubino, 2016). This controversy sometimes plays out in Maine in the process of lease applications, where soliciting public comment is a part of the application process (Pers. comm., S. Belle, 2020). Those who oppose the industry do so for a variety of reasons, most often relating to concerns about the impact of commercial operations on their viewscape, other forms of resource use, or the environment. These are often characterized as concern about access to recreational fishing areas, waterways, concern about the risk of ecological impacts, and concern about the risk of impact to waterfront property values.

These controversies are reflected in the priorities identified by stakeholders during the process of collecting information for the updated 10-year Economic Development Plan for the sector. There is a need to develop resources for public education about aquaculture (Noll and Davis, 2020). In addition to this,

it is noted that there is a need for training of producers on community relations, and communication strategies for the general public (ibid.). This speaks to the need to encourage the social license of the industry to improve.

LOGISTICS AND INFRASTRUCTURE

LOGISTICS AND PHYSICAL INFRASTRUCTURE

The expansion of the industry in recent years has resulted in a need for expanded supply chain infrastructure. Offloading, processing, and packaging operations have needed to increase their capacity, which has challenged the sector in terms of being able to find appropriate spaces to develop facilities at a cost that the industry can afford (Pers. comm., S. Belle, 2020).

In addition to this, transportation of products has been a challenge, logistically. Many farms are located on long, thin peninsulas, and do not produce volumes large enough to necessitate, or afford a truck coming to pick up and deliver products (Pers. comm., S. Belle, 2020). Producers have begun to work together to develop trucking cooperatives, and "bus stop pick-ups" of products (ibid.), however, the logistics of this can be challenging as well.

INFORMATION

Research priorities were identified during the process of information collection for the 10-year Economic Development Plan. Priorities that are relevant to all species produced in Maine (shellfish, seaweed, and finfish) include further research into breeding for domestication, value-added product development, biosecurity risk management, disease management, farm, and business management, and management of invasive species (Noll and Davis, 2020). To further support the industry, it was noted that guidelines for Best Management Practices for both the shellfish and seaweed industries should be developed that are more granular than the industry code of conduct developed by the MAA. In addition, it is identified that research describing the benefits of aquaculture should be conducted (ibid.).

These priorities serve to outline some of the current challenges that the industry in Maine is currently facing in terms of knowledge gaps.

POLICY AND REGULATION

Aquaculture in Maine is regulated primarily at the state level by the Department of Marine Resources (DMR), which is the lead leasing and permitting agency. In addition, federal permits are required by the U.S. Army Corps of Engineers (USACoE) as well as the Maine Department of Environmental Protection (DEP) (for finfish aquaculture) (DMR, 2017). The DMR established the Aquaculture Advisory Council (AAC), which is composed of 5 members of the aquaculture industry and makes recommendations for how to spend the State's Aquaculture Management Fund (Maine Revised Statutes, 2011).

While the industry has grown under this regulatory structure, there is a sentiment amongst the industry that it creates a barrier to entry and expansion (Noll and Davis, 2020), due to the cost, timeline, and complexities of the permitting process. In addition, the DMR is an agency tasked with conserving natural resources. It is the view of the industry that aquaculture operates in concert with the natural environment and should be regulated similarly to agriculture, rather than as a natural resource (Pers. comm., S. Belle, 2020).

The MAA and other organizations lobbied for changes to Maine's regulatory system to make it more efficient (Pers. comm., S. Belle, 2020). Before these efforts, leasing options for aquaculture included the standard lease, which has a term of up to 10 years and covers an area of up to 100 acres, or an experimental lease, which is a non-renewable 3-year term in an area up to 4 acres (DMR, 2017). Neither of these options was viewed as suitable for a new permit applicant looking to start a long-term business at an initially small scale. Lobbying resulted in the development of the Limited Purpose

Aquaculture (LPA) license in 1999 (Pers. comm., S. Belle, 2020). This option is renewable annually and can cover up to 400 square feet. One person can hold up to 4 LPAs (DMR, 2017). This system allows interested parties to produce certain species of shellfish, seaweed, or sea urchins in their chosen area and test whether that site is appropriate for their operation. If their chosen site is performing as expected, they can apply for a standard lease to scale their commercial operation. Currently, there are 750 LPAs in operation in Maine, most are run by members of working waterfront communities, many of whom have completed training programs (Pers. comm., S. Belle, 2020). The opening of the LPA program may also provide a benefit in allaying public concern about proposed aquaculture projects, given permits are issued for small-scale operations, which generally coincide with less visual impacts and use conflicts.

MARKET CONDITIONS

Aquaculture products grown in Maine are largely sold domestically, usually east of Denver and north of Atlanta, within trucking distance (Pers. comm., S. Belle, 2020). As the sector in Maine expands, the industry is looking to develop new markets. For shellfish and finfish produced in Maine, there is a strong, consistent demand. Seaweed production in Maine is still relatively new in the commercial market, and while production has grown from 23mt to 227mt between 2015-2019, the demand for these products is still being determined (ibid.). The Maine brand has great market recognition and fuels the growth of the industry. On average, Maine brand seafood products sell for approximately 20% more than competitors' products (ibid.).

ENVIRONMENTAL CONDITIONS

Site selection is an important part of the process of growing shellfish, seaweed, and finfish. The Maine coastline is generally conducive to these species, however, as with aquaculture anywhere in the world, specific sites with characteristics suitable for the species and farming operations must be chosen. The ASW program includes a module on site selection and LPA lease terms make site selection and testing a less risky undertaking for someone entering the industry (Pers. comm., S. Belle, 2020).

The largest environmental challenge facing the industry is the impact of climate change, which has already displayed significant impacts on Maine's oyster industry due to acidifying waters (Pers. comm., S. Belle, 2020; Fernandez et. al 2015). Input informing the update to the 10-year Economic Development Plan for the industry highlights the need for predictive climate change modeling as a high priority for the industry.

OUTCOMES

SOCIO-ECONOMIC

In 2014, aquaculture farms in Maine produced $73.4 million in products and employed 571 people, accounting for $35.7 million in labor income (Noll and Davis, 2020). Approximately 70% of the jobs are full-time and year-round. When including up and downstream segments associated with the industry, aquaculture in Maine generates $137.6 million in sales and revenue annually, supporting 1,078 full and part-time jobs creating $56.1 million in labor income (ibid.). Except for one large, vertically integrated finfish company, many of the aquaculture businesses in Maine are small companies with a small workforce. Many do not have the capacity for staff development or training, nor do they have the capacity for research or development on their own (ibid.).

To date, most aquaculture companies remain in business and there have been very few failed operations. Those that have not succeeded tend to have been started by hobbyists who were not fully prepared for the intensive work that goes into maintaining a farm (Pers. comm., S. Belle, 2020). The seaweed industry in Maine is still in its early stages of commercialization, and it remains to be seen what its survival rate is (ibid.).

ENVIRONMENTAL

The potential for aquaculture to affect the natural ecosystem positively or negatively varies by species, site, production method, and management at the farm level (Theuerkauf *et. a*l., in press). Several studies indicate that the cumulative impact of aquaculture production in Maine at its current production levels does not have a significant adverse environmental impact on the marine environment (Voorhees, 2016; Simke, 2020; Tucker, 2020).

While a significant body of literature demonstrates the ecosystem service potential of bivalve and seaweed culture globally (Alleway et. al, 2019), information collected for the update to the 10-year Economic Development Plan for the industry identifies a knowledge gap regarding the ecological contributions of aquaculture production in Maine (Simke, 2020; Tucker, 2020). It remains unclear whether seaweed and shellfish production in Maine has improved water quality or improved habitat provisioning. Several studies are currently being undertaken by organizations such as the University of New England, the Nature Conservancy, and Bigelow Laboratories to better understand the habitat, climate, and nutrient benefits and impacts of farming operations within the state.

Data collection undertaken by farmers could be potentially utilized in the future to better understand the ecological effects of farming operations. For production to remain successful, producers routinely monitor water parameters and quality, and these data can provide a unique insight into patterns over time, and potential changes to the natural ecosystem (Pers. comm., S. Belle, 2020).

LESSONS LEARNED

As the sector expands, to effectively meet the goals and expectations of stakeholders involved while maintaining ecological sustainability, it becomes increasingly necessary to understand the motivations of those who are engaged and to create systems in which these parties can coordinate their efforts strategically. Planning for the sector, and implementation of initiatives can be challenging as more perspectives and priorities are shared.

As a sector expands, leadership must have the organizational capacity and structure to align the needs and priorities of a growing number of interested parties.

- Clarity around the motivations, requirements and expectations of parties developing, planning, and implementing initiatives to support the aquaculture sector is necessary to ensure there is alignment among stakeholders and to properly set expectations for initiative outcomes.
- Strategies are necessary for the prioritization of topics identified by an expanding group of stakeholders to strategically address issues with focus.

Table 5: Factors influencing the Aquaculture in Shared Waters program

CATEGORY	STRENGTHS	CHALLENGES
LEADERSHIP	• Strong state and industry leadership for strategic planning and funding	• Need for a new generation of leaders and champions
STAKEHOLDER ENGAGEMENT	• Efforts mainly led by MAA • Inclusive, transparent, ongoing	
FINANCIAL SUPPORT	• Grants for specific initiatives within the sector or research • Industry generally self-sustaining	• Competition within the sector, and the research community
COMMUNITY CONTEXT	• Aquaculture is generally viewed favorably by working waterfront community • Significant part of the state's economy	• Aquaculture is controversial with the broader public • Consistent communication strategies used by industry • Occasional legal challenges to siting • Occasional pitting of working waterfront members against each other
LOGISTICS AND INFRASTRUCTURE	• Industry cooperatives developed to address transportation challenges • Development of LPA permitting structure	• Finding appropriate, affordable space for needed expansion of supply chain infrastructure • Transportation of small volumes of product • Regulatory structure (prior to LPA development) • Need BMPs for shellfish and seaweed • Need studies of whether shellfish and seaweed in Maine provide benefits
POLICY AND REGULATION	• Reflexive state government permitting and leasing processes • MAA capacity for lobbying	• Initial lease options were incompatible with needs of small-scale aquaculturists with regard to size and duration
MARKET CONDITIONS	• Strong market for shellfish and finfish • Looking to expand market	• Demand for seaweed is still unknown, despite rapid growth in production volume
ENVIRONMENTAL CONDITIONS	• Maine coastline is generally conducive to aquaculture of finfish, shellfish, and seaweed	• Risk of impact from climate change • Need for predictive modeling

PROJECT	PROJECT GOAL	GOAL REACHED?
SOCIO-ECONOMIC	• Prepare fishermen to start an aquaculture venture	• Approximately 250 people have been trained • Approximately 50% of trainees have started their own businesses. Most remain in business
ENVIRONMENTAL	• No stated objective	• General assumption of benefits from seaweed and shellfish unspecific to Maine • Moderate ecological impact from finfish

SYNTHESIS

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Table 6: Synthesis table of key factors relevant in five case studies.

	PHILLIPINES		CEDAR KEY		MADAGASCAR		BELIZE		MAINE	
	S	C	S	C	S	C	S	C	S	C
LEADERSHIP	✓		✓						✓	
STAKEHOLDER ENGAGEMENT					✓					
FINANCIAL SUPPORT					✓		✓	✓		
COMMUNITY CONTEXT	✓		✓		✓	✓			✓	
LOGISTICS AND INFRASTRUCTURE		✓								
POLICY AND REGULATION	✓	✓	✓		✓			✓	✓	✓
MARKET CONDITIONS					✓		✓		✓	
ENVIRONMENTAL CONDITIONS						✓				

S = Strengths

C = Challenges

	PHILLIPINES		CEDAR KEY		MADAGASCAR		BELIZE		MAINE	
	G	R	G	R	G	R	G	R	G	R
SOCIO ECONOMIC	✓	✓		✓	✓	✓	✓	✓	✓	✓
ENVIRONMENTAL				✓		✓	✓	✓		✓

G = Specified Goal?

R = Result

Note: The presence of checkmarks in both the strength and challenge cells of a factor for a given initiative may refer to different stages of a project; areas where efforts are being made, but a solution has not yet been identified, or simply the presence of both strengths and challenges.

The case studies included in this document span a range of geographic scopes, strategies, and goals. The factors influencing each initiative are nuanced and specific, however certain factors have emerged as cross-cutting in their importance. This is not a comprehensive assessment of factors important to the development and implementation of aquaculture initiatives and industries, but a synthesis of common themes.

LEADERSHIP

Strong leadership and representation in the planning and implementation of an initiative are important for ensuring its success. Multiple case studies illustrate the importance of individual "champions" who carry and inspire enthusiasm for a project or industry among stakeholders. While the GLP in Palawan, Philippines was supported by a committed team, the dedication of the project's founder to both the project and his team made its success possible.

In Cedar Key, the leadership of the State of Florida Extension agent located on-site has enabled the ongoing success of the clam industry from its inception. She has led the industry through the initial trainings, development of a business and financial model that allowed early aquaculturists to afford the gear and seed necessary to get started, been a spokesperson and public face for the industry, and provides ongoing technical assistance.

The seaweed industry in Belize also benefits from the leadership of multiple champions. The newly formed Belize Women Seaweed Farmer's Association is dedicated to both the advancement of the industry in Belize, as well as the role of women in its expansion. Additionally, the ongoing industry support and publicity created by a former fisherman who currently runs a seaweed farm has resulted in international recognition of the Belizean seaweed industry. Until the founding of the BWSFA in 2019, leadership in the seaweed industry was predominantly male, matching the composition of the fishing industry. The social shift toward the increased inclusion of women in a historically male-dominated industry has caused some friction among leaders and members of the industry. However, there are collaborative efforts and recognition of the shared goal of industry advancement by both groups.

Just as the significance of champions is evidenced in multiple case studies, the importance of inclusivity and equal opportunity is also highlighted as a theme among initiatives. Challenges have arisen in initiatives where leadership did not include important figures. The scope of the initial pilot for sea cucumber farming in Madagascar included only the members of the Women's Association of Andavadoaka. This resulted in the theft of sea cucumbers and compromised the safety and security of farmers.

A common theme among all initiatives is the need for input into the planning, development, and operation of an initiative directly from local community stakeholders, as well as the ability of leadership to constructively solicit and react to their feedback and criticism. While this general theme is exhibited differently in each of the case studies, there is an overall need for the motivations, requirements, and assets of local stakeholders to be well-considered and integrated into the planning and operation of an initiative.

In Palawan, Philippines there were differences in cultural norms regarding time management and communication. The leadership for the project was Dutch, operating a project in the Philippines, where social expectations are very different, initially creating a difficult situation for effective engagement and trust-building. Leadership for the GLP was able to recognize these cultural differences between their team and local stakeholders and adjust their operation and communication style to better align with local cultural norms, allowing the project to move forward without the friction that can be caused by mismatched expectations.

The clam industry in Cedar Key used a "bottom-up" approach to the initial development of the industry. This approach identified the needs of potential industry members (technical and business training), while also highlighting

their existing skillsets, equipment, and expertise. Building a new industry using the assets of these former fishermen created a sense of pride and ownership and allowed the development of a system that met their needs, and was politically tenable in the community. In Belize, multiple stakeholders jointly recognized the opportunity for seaweed culture early in the development of the industry and a working group facilitated by an NGO continues to provide a forum for interaction between community, government, and NGO partners.

The development of the sea cucumber industry in Madagascar has faced both challenges and successes regarding the inclusion of stakeholders. While initial pilot operations were inclusive of only one local association, these initial trials failed partially due to the theft of sea cucumbers by community members excluded from the project. Upon researching the root causes for the thefts and conducting research mapping the clans present in the region, an equitable system for participation in the industry was developed based on existing social structures, as well as ways for the industry to benefit the community as a whole. This greatly reduced the incidence of theft, as the industry was now benefitting the entirety of the community, rather than just a few individuals.

Equitable, reflexive stakeholder engagement strategies that foster pride and ownership of an industry by its members can significantly influence the success of an initiative. Furthermore, it is also important to ensure that there is clarity to the mission and goals of an initiative and that stakeholder engagement processes have a transparent and streamlined approach to decision-making. In Maine, as the aquaculture industry has grown and the number of interested parties increases, it has become necessary for Industry Association leadership to find effective ways to equitably engage stakeholders and foster constructive dialogue. Advancing dialogue within the MAA effectively has, in part, relied upon setting clear parameters and guidelines for the scope of discussion and meeting procedures.

FINANCIAL SUPPORT

The initiatives illustrate the importance of the timing, duration, type, and management of financial support for an initiative. Expectations and requirements of both the funder and the recipient need to be clarified. This includes identifying when funding is needed, and who needs it; whether, and when an initiative intends to become financially self-sufficient; and what types of training may be needed to appropriately manage the finances for implementation of an initiative, as well as farm operation.

The integration of aquaculture into historically wild-capture-focused communities is a seemingly natural progression for increasing resilience in the face of diminishing wild fish stocks and climate change. While it allows members to continue working on the water, often using preexisting equipment or infrastructure, aquaculture requires different business and financial models

from wild capture fisheries. The details of these plans and the clarity of the needs and expectations of funders and farmers significantly affect farmers' abilities to operate their farms while receiving necessary income.

Wild capture fisheries provide, in theory, a steady, consistent source of income. Once established, aquaculture can also provide a consistent source of income assuming stocking of farmed species happens on a rolling basis. However, aquaculture inherently has a lag time between initial stocking and harvest of the first crop during which there is no income for a farmer. In Belize, this lag time is a reason why some farmers have not been able to stay in the industry. Despite financial assistance from external funders that covers the costs of equipment and infrastructure, many farmers cannot afford to wait for the income from the seaweed crop they have planted. This creates frustration on the part of the farmer who feels as though their needs have not been adequately supported despite attempting to create a more sustainable livelihood through a program promoted as leading to that outcome. Additionally, the funder may feel frustration having invested in a farm only to have it become abandoned and be disinclined to continue supporting the project.

This occurs in the sea cucumber industry of Madagascar to a much smaller degree. While the initial lag period between the first stocking and harvest deters some from staying in the industry, many of the sea cucumber farmers in Madagascar have mitigated this challenge by continuing to engage in wild fisheries at a lower scale, while utilizing aquaculture as a supplementary income. In this way, they can financially withstand the lag time between first stocking, and harvest and payment for aquaculture products, as they are not without income.

The incorporation of business and financial planning into training curriculums has benefitted the industries in both Cedar Key and Maine. Both of these industries have high retention rates and have now been operating self-sufficiently for multiple generations. This is due to multiple factors, however, the treatment of farms within these industries as businesses from the onset combined with training efforts that emphasize both financial competency and farm management has enabled farmers to become successful entrepreneurs.

Leaders of an aquaculture initiative must recognize the broader-scale context in which it is operating and understand the underlying challenges facing farmers. Farms must be treated and operated as businesses, and initiatives should develop strategies to advance farm financial management and resilience, as well as technical expertise. Project leaders should not attempt to address all the socio-economic challenges facing a coastal community, especially those outside the project's area of expertise or sphere of influence. The development of a viable aquaculture business model and concurrently creating broader societal benefits can be difficult to simultaneously achieve. This can be especially difficult when funds are provided by an international organization that does not have a thorough understanding of the local socio-economic needs and often seeks to advance its own strategic goals and theories of change. This sentiment was shared by the founder of the GLP, who expressed that during his time in Palawan he saw multiple international NGO initiatives developed, with large amounts of money spent, only to cease operations shortly after without leading to any notable improvements in the livelihoods of community members.

COMMUNITY CONTEXT

The dynamics of a community and relationships between stakeholders in an industry can significantly affect the success of an initiative. In Palawan, employees of the project, many of whom had been previously incarcerated and were experiencing homelessness upon their release, directly benefited from a stable income and were able to afford housing. The broader community benefited from the consistent availability of juveniles for growout, allowing more families to afford education for their children. This favorability was sustained until a change in local political leadership shifted priorities, and the project was no longer considered favorable by authorities, resulting in its eventual closure.

The sea cucumber industry in Madagascar began in a way that excluded parties that were interested in participating, which led to theft and concerns about the security and safety of farmers and their crops. Upon reorganization, the equitable inclusion of community members, and community-wide benefits resulted in a significant decrease in the challenges previously faced.

In all initiatives, the industry is viewed as a way of increasing economic resilience in areas that are struggling with a lack of access to fishery resources that had previously been more readily available. In Palawan, Madagascar, and

Belize this is due to a decrease in wild fishery populations. In Cedar Key this is due to repeated closures of oyster beds as well as a ban on gillnet fisheries, while Maine has experienced variability in wild stocks, resulting in shifting quotas, and limited licensing options. The prospect of an aquaculture industry that can offset some of these impacts, while making use of some existing infrastructure and potentially providing more jobs in the community through an expanded supply chain is a promising one for many in coastal, working waterfront communities.

While coastal communities reliant on marine resources for livelihoods generally see the potential positive aspects of aquaculture, challenges can arise due to the integration of additional use of aquatic resources. The perception of some community members may be that an aquaculture industry is competition for those resources. Additionally, there may be concerns about the ecological sustainability of aquaculture activities. In Madagascar, the sea cucumber industry benefits from inclusion in the Velondriake LMMA, which manages marine resource use through the creation of zones for wild-capture fisheries and aquaculture (among other uses of marine resources). This inclusion in a larger resource use planning system has minimized the challenges associated with competition for those resources.

The aquaculture industry in Maine is occasionally challenged in the process of lease applications, where public comment is sought. Concerns raised generally relate to a fear of losing access to recreational fishing areas or waterways, the potential impact on property values, and the potential for ecological impact from aquaculture operations.

LOGISTICS AND INFRASTRUCTURE

Further affecting the successful development and operation of an aquaculture industry is its ability to access necessary equipment and materials for initial start-up and ongoing maintenance and operation. Additionally, the presence of supply chain infrastructure and a farm's proximity to it can greatly influence the ability of farmers to get their products to market. Due to their remote locations, the initiatives in Palawan and Madagascar struggled with obtaining the necessary equipment and materials for start-up and upkeep of the initiatives (respectively). Aquaculture industries in Cedar Key, Madagascar, and Maine all benefited from the preexistence of supply chain infrastructure already available to support aquaculture production from the fishing industry. In the case of Maine, the service provider industry has expanded to accommodate the growing aquaculture industry. Trucking companies now offer services to transport small volumes of harvested products to processors, as most producers do not grow large enough volumes to necessitate a truck. In Belize, the remote nature of aquaculture sites, which have been selected primarily due to regulatory constraints, has made policing sites from theft a challenge.

POLICY AND REGULATION

Permitting and regulatory structures can significantly affect the ease with which an aquaculture initiative can develop and operate. In the case of the GLP in the Philippines, the clam industry in Cedar Key, and community-based sea cucumber farming in Madagascar, local and national administrations were supportive of the development of aquaculture, and actively facilitated relatively simple processes for siting and permitting.

In Palawan, the GLP initiative was able to obtain necessary leases, permits, and licenses to start and operate affordably, with incentives for its investment in the community. In Cedar Key a streamlined, affordable approach to permitting is now used, allowing industry members to obtain and maintain the necessary permits with minimal relative ease. In Belize, while government officials are highly supportive of the project, a lack of a national aquaculture policy and enabling regulations has required farming under research permits and restricted access to suitable sites.

In the early stages of the ASW program, the complex permitting process, and incompatible size and duration of lease options was a barrier to entry into the Maine aquaculture industry. However, the ability of state agencies to receive feedback from the industry and revise available lease options created a system in which small-scale farmers can become established in a way that is time and resource efficient. These regulatory structures significantly influence the ease of entry into the aquaculture industry, as well as a farmer's ability to remain in it. Each of the five initiatives benefitted from a permitting process that has been developed in a way that makes compliance with regulatory requirements affordable and relatively streamlined.

While the GLP in Palawan benefitted from an actively engaged and supportive local government for the first eight years of operation, political priorities shifted with a change in administrations. Regulatory systems implementing permitting processes were not stable or consistent and became increasingly difficult to navigate and comply with. This eventually led to the inability of GLP leadership to secure the necessary permits to maintain operation, which led to the closure of the facility.

MARKET CONDITIONS

Demand for a product has a clear effect on the ability of an aquaculture industry to be successful. Each initiative focused on developing species for which there is established and strong market demand for its aquaculture products. Grouper grown in Palawan and sea cucumbers grown in Madagascar are predominantly exported to Asian markets where they are consumed as luxury items and at high prices. Products from Cedar Key, Belize, and Maine are primarily all consumed locally or domestically. The Maine seaweed industry is an exception, as it is relatively new, and lacks a clear, well-established market at an acceptable price point. It will require additional product and market development efforts to enable the industry to grow.

ENVIRONMENTAL CONDITIONS

Each of the initiatives, except the clam industry in Cedar Key, uses species that are native to the region in which they are being grown. Because of this, coastal areas utilized in these initiatives are naturally conducive to the culture of these species.

Multiple initiatives are sited in areas that are within, or near protected areas and/or areas that remain largely undeveloped. This generally results in good water quality, and less interaction between farms and other marine resource uses. While these qualities are generally favorable for aquaculture, the process of site selection is often based on complex requirements of the produced species and can require some trial and error. In Belize, it was determined that exposed, oceanic sites were less conducive to seaweed growth and yield, requiring other more suitable sites to be located, although efforts are underway to test gears that can withstand open sea conditions.

The potential for climate change to affect aquaculture initiatives is present in each of the initiatives. Severe weather events are a consideration in the planning of new aquaculture initiatives. In Madagascar, two cyclones damaged farm infrastructure, while hurricane seasons in two separate years challenged the clam industry in Cedar Key. While the Philippines are known for significant storms, Palawan is relatively sheltered and is not prone to damage from these events. However, each of the initiatives provided information around the need to create resilient systems that can withstand potential impacts from climate change.

OUTCOMES

SOCIO-ECONOMIC

The stated goals of each of the initiatives include elements of social and economic improvement, such as improving livelihoods, increasing food security, and increasing economic resilience. Each of the initiatives, except Belize, has indicated an increase in the livelihoods of individuals directly involved in the industry, as well as those indirectly influenced by it. Whether the model is community-based like the sea cucumber industry in Madagascar or based on the development of individual farms within a broader aquaculture industry like the one in Maine, the improvement in livelihoods goes beyond those directly involved, and into a community fund, into the supply chain, and associated service-providing industries.

While increased food security was included as a stated goal of multiple initiatives, this has not been a direct outcome of any of them. Indirectly, improved livelihoods can increase access to available food resources, however, both initiatives that specified food security as a goal export their products to international markets.

ENVIRONMENTAL

Of the five initiatives included in this study, only Belize had a stated environmental goal. However, despite the focus on socio-economic improvements rather than monitoring and evaluation of environmental indicators, each initiative has noted localized ecological improvements due to its operation. A study at two seaweed farming sites in Belize determined that species abundance and species richness generally increased in and around the farming areas. While none of the other initiatives specifically monitored their impact on wild stocks, operations in both Palawan and Madagascar have anecdotally reported rebounds in populations local to the production area, in Palawan due to restocking efforts, and in Madagascar due to broadcast spawning by the farmed stocks. Research efforts have assessed the nutrient removal benefits of clam farming in Cedar Key.

Additionally, aquaculture sites may function as protected areas for wild species. In Madagascar, sea cucumber farming sites are designated as “no-take zones,” providing protection to wild species within them, as well as improving seagrass growth when sea cucumbers are raised at certain densities. In Belize, a study of the effects of seaweed farming showed that in general ecological health is strengthened both within and near seaweed farms.

RECOMMENDATIONS

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Future aquaculture development initiatives can learn from the five case studies presented in the report by replicating their successes and avoiding their shortcomings. This analysis has informed the development of this list of recommendations for new sustainable community aquaculture projects.

LEADERSHIP

- **The leadership team should include individuals that adequately reflect the social structure in which an initiative is operating, are well-versed in the strengths and challenges of the local community and are trusted by farmers.**
- **The goals, objectives, and strategies of an initiative should be reflective of the strengths and challenges of the local community and should be flexible and adaptable to changes in the needs of the local community.**
- **Goals and objectives should be clearly stated and agreed to by all parties involved in an initiative, ideally in a signed document.**
- **Leadership should be proactive and equitable in strategies for accepting and soliciting feedback, especially from local community members. Transparent processes for addressing concerns should be developed.**
- **Leadership should adapt expectations to reflect the cultural norms of the community they are operating in.**

STAKEHOLDER ENGAGEMENT

- **Stakeholder engagement is important at all stages of an initiative to build and maintain trust between parties.**
- **To develop clear, actionable strategies, stakeholder engagement efforts and opportunities should identify the motivations, requirements, and strengths of local stakeholders as well as those of other participating organizations.**
- **This information should be used to develop clear, actionable strategies that build on the strengths of a community and address the root causes of challenges they face.**
- **Opportunities to engage with leadership and participate in decision-making processes should be equitable, and where appropriate, should reflect the current social structure of the region.**
- **Efforts to engage with stakeholders should reflect cultural norms for communication styles and responses.**

As an initiative evolves, it must be kept in mind that stakeholder engagement strategies may also need to shift to continue to ensure ongoing equitable feedback opportunities.

FINANCIAL SUPPORT

Research should be conducted that describes the broader socio-economic context in which an initiative is being planned, and whether it is necessary for business and financial planning to incorporate solutions for stressors beyond the direct scope of an aquaculture project.

- For example, a lack of access to healthcare or health insurance may impact many individuals who are local conservationists. If a project leader or members of a local implementing organization become ill and are unable to continue the work, it affects the local community and the success of a project. The provision of healthcare and health insurance may be beyond the scope of a funding organization focusing on ecological conservation, but an acknowledgment of these stressors can lead to a better understanding of the requirements of the community, and potentially innovative solutions.

- While it cannot be expected that a funding organization will address all priorities in a community, it must be recognized by a funder that the project does not exist in a vacuum, and may be significantly affected by factors beyond the scope of their understanding, expertise, or influence.

In scenarios where large funding organizations are providing support for an initiative, strategic planning for the use of funds should be in deference to a locally-based leadership organization with a thorough understanding of the priorities and dynamics of the local community.

Business and financial plans should be developed for an initiative that clearly identify how much funding is needed, when funding is needed, for how long, and by whom; whether and when an initiative intends to become financially self-sufficient; and what types of capacity building are necessary for the financial management of an initiative.

Financial models should support farmers through the lag time between the first stocking and harvest of farmed species.

Training programs developed for farmers should include business and financial management modules in addition to technical information.

COMMUNITY CONTEXT

- Before planning an initiative, project leaders should conduct an assessment of the dynamics of the socio-economic context in which an initiative will operate, as well as relationships among community members, stakeholder groups, and supply chain actors.
- Strengths and connections, as well as potential areas of conflict, should be identified and addressed to the extent possible during strategic planning.
- The cultural values of local communities and potential cultural differences between project teams and communities should be evaluated closely. Efforts should be made to ensure projects, including leadership teams are staffed by members of the community.
- Project teams should identify how stable or volatile a community's local politics are and whether that may influence the success of a project.
- The ability of an initiative to provide direct and indirect benefits to community members should be assessed and included in strategic planning.
- Strategic planning efforts should take into account other existing uses of the marine environment such as fishing and tourism.

LOGISTICS AND INFRASTRUCTURE

- Project planning should include identification of suppliers for equipment and materials for setup, operation, and maintenance of aquaculture facilities.
- Siting should incorporate the availability and accessibility of transportation and supply chain infrastructure such as hatcheries and processors.
- Basic services, such as reliability of electricity, access to fresh water, and sanitation, are also key considerations for operating an aquaculture facility.
- Sites should be located in areas that can be accessed and monitored routinely, ideally 24 hours.

POLICY AND REGULATION

- Aquaculture initiatives should be targeted in locations that have the following enabling conditions:
- Regulatory systems for licensing and permitting are robust and protective of the environment and take into account broader resource utilization and management, but streamlined to facilitate transparent, efficient application and review processes.

- Regulatory systems are constructed to ensure the availability of lease options that match the needs of the industry concerning siting, size, and duration of lease.
- Timelines for permit review are predictable in the short and long term.
- Regulatory systems and permitting processes that are not subject to change with each new administration.
- Administrative agencies have transparent and reflexive processes for feedback and regulatory adaptation.

MARKET CONDITIONS

- Select culture species that have attractive prices and consistent market demand.
- Consider market conditions in the immediate term, but also demand and pricing as the initiative goes to scale and more products come online.

ENVIRONMENTAL CONDITIONS

- Aquaculture initiatives should select native species. In addition to the environmental risk that may be posed by non-native species, native species are generally well-suited to local environmental conditions.
- Site characteristics should be appropriate for the species being grown, and their potential ecological impacts. Biophysical conditions such as depth and current need to be conducive to the species, as well as water quality, and the surrounding habitat type. The potential ecological impacts to these factors from aquaculture must also be taken into account.
- Site selection should take into account the likelihood of extreme weather events and be done in a way that minimizes these risks.
- Site and farm construction should be able to withstand extreme weather events.
- To the extent possible, the potential impacts from climate change on the ecosystem and farming operation should be identified, and contingency plans put in place.

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