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GUAM AQUACULTURE FEASIBILITY STUDY

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FOREWORD

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EXECUTIVE SUMMARY

Aquaculture is the fastest growing food production sector on the planet (FAO 2020). More than half of global seafood consumed is farm raised. In Guam, the vast majority of food products consumed are imported. Fish and seafood products are no exception with approximately 5 million pounds worth \$20 million imported annually (Department of Commerce, Annual Economic Review 2018). Current aquaculture production is estimated at 210,000 pounds, which is less than 5 percent of the total consumption of fish and seafood products on Guam.

With its pristine water, stable temperatures, high local demand, strategic location and US legal structure, Guam has good potential for aquaculture to be a growth sector for Guam's economy. Economic development from aquaculture can help diversify and stabilize the tourism and military dependent economy and increase economic self-reliance for Guam along with supporting preferred rural lifestyle and its associated cultural practices.

Expansion of the aquaculture industry on Guam will increase food security on the island and benefit Guam's people by providing a high quality source of locally produced seafood. These needs will increase over the next few years as the population increases and the resulting pressure on the Island's wild fisheries increases.

Guam is however a high-cost location for aquaculture production due to competition for land, labor and water supplies, combined with high-energy costs and the fact that most inputs for aquaculture such as feed and specialized equipment need to be imported. For Guam aquaculture to achieve the necessary high prices of its products, it must focus on three areas: supplying live or extremely fresh, high-quality seafood to the local market, supplying niche markets in which Guam has a competitive advantage, and supplying very high priced export products.

It is recommended that aquaculture development on Guam first emphasize expansion of farming shrimp and tilapia, which are already cultured on a small scale; and anticipate developing other species to fully exploit the local market potential and suitable export markets, including SPF shrimp broodstock, and native high value marine species such as grouper, rabbitfish and giant clams.

We envision successful development of the Guam aquaculture industry to sustainably build capacity and generate new jobs and income suited to the Island's unique resources and communities. The island's ideal tropical growing climate, vast marine biodiversity and strong local seafood demand create the necessary base for building a closedloop economic system that provides quality jobs, natural resource protection, equitable economic development, and linkages to high-tech innovation and commercialization opportunities.

Guam's recent CEDS (Comprehensive Economic Development Strategy) identifies aquaculture as a high priority target for development with the goal to build a sustainable aquaculture industry that provides a living that is satisfying and financially rewarding for island fish farmers and reduces seafood imports. Aquaculture development connects across value-chain and supply-chain domains to supporting sectors including transportation, warehousing, value-added processing and manufacturing, scientific research, diagnostic testing, educational services, business services, waste management, environmental services, wholesale, retail, marketing, and finance.

Guam has a unique opportunity to build its aquaculture industry through a collection of projects that correct past systemic barriers to growth and respond to the current pandemic-related downturn by providing the physical and human capital needed to create a robust aquaculture economy in line with their diverse communities' values. The industry has an exceptional opportunity to grow the aquaculture economy in Guam. Guam imports around 90% of its seafood, equating to twenty million dollars leaving the Territory each year. Diverting just 20% of that capital to local producers would double the sector's market share and every 10% that is diverted would represent 40 new jobs.

At this time, only a small fraction of locally grown aquaculture products are sold in mainstream retailers. All of the projects detailed below are designed to provide the necessary certifications for training, facilities, value-added processing, and distribution to allow locally produced seafood to be sold at all retailers, grocers, and clubs across our island state. We believe these investments, interventions, and greatly expanded markets, will help accelerate workforce development, wage growth, overall economic growth, and industry innovations, while collectively scaling meaningful growth and opportunities for all stakeholders.

Based on financial models detailed below, we estimate that if aquaculture in Guam is developed to its full potential by diversifying target species and applying state-of-the-art technologies, production could increase to 1 million pounds, valued at \$5 million. Aquaculture production would account for 25% of domestic fish and seafood consumption, replacing imports as well as providing

opportunities for exports. In terms of employment, if fully developed, aquaculture in Guam can create 2 full time jobs per \$100,000 in sales. At \$5 million in sales, that's 100 jobs.

The main strategy recommended for Guam's aquaculture development is establishment of a Guam Aquaculture Innovation Center (GAIC) including a multispecies marine hatchery and an associated Aquaculture Development Park (ADP). The GAIC will support and coordinate aquaculture industry development by providing facilities for applied research in aquaculture that will include assessing feasibility of local species for food and non-food production, evaluating commercial marine ornamentals, culture and reproduction of species for reef restoration, evaluation of aquaponics systems, and incubation of aquaculture businesses. The GAIC marine hatchery will supply the sector with seed. This is of utmost importance, since without a reliable seedstock supply the industry cannot develop.

A coastal plot of at least 5 acres and approximately \$3 million are needed for establishment of the GAIC. Potential sites for the GAIC were evaluated and the Tanguisson Beach area is recommended for the new GAIC facility under the condition that the historic power plant on the site is fully decommissioned. Alternatively, the site at the University of Guam Marine Lab can be used, however space availability at this site needs to be further evaluated.

Other specific recommendations developed through this study and designed to stimulate sustainable development of Guam aquaculture include:

- Develop Aquaculture Programs at University of Guam (UOG) and/or Guam Community College (GCC) to support aquaculture workforce development, aquaculture R&D and innovation and accelerate aquaculture development.
- Implement or expand programs to revitalize and maximize productivity of existing aquaculture infrastructure.
- Develop a program to increase the quality, quantity and affordability of aquaculture seedstock to the industry.
- Develop and commercialize sustainable marine ornamental production in Guam and the Pacific.
- Develop a Public-Private Partnership to demonstrate Guam's first offshore fish farming project. Target Grouper production in offshore submersible fish pen as a demonstration project.
- Develop a Department of Aquaculture in the Guam government to demonstrate commitment and accelerate aquaculture development.
- Convene an international conference in Guam focused on Aquaculture in the Pacific.
- Develop a tech-enabled shipping and logistics facility to facilitate transportation of aquatic products within the region and to potential export markets.

Successful development will require strong commitments from the Government by providing tax and other financial incentives such as income tax rebates, abatement on property tax, and a rebate on corporate dividend taxes. Funding and loan programs can help start-up companies establish their businesses. The Government of Guam should also establish a clear aquaculture policy that recognize aquaculture as a desirable form of economic activity which can lead to economic development while ensuring environmental sustainability and supporting the culture of Guam. It should include extending all programs for agriculture to aquaculture, passage of legislation stating support of aquaculture development, identification of aquaculture as a coastal-dependent activity and acknowledged in coastal land use plans, and priority consideration in land use plans and the use of water supplies. In order to support upcoming aquaculture businesses with legal issues, the Government should facilitate this by establishing a one-stop-shop for permitting of aquaculture operations. Commitment to develop the aquaculture industry on Guam offers potential for diversifying the economy and extending its benefits to segments of the population that may not be able to directly participate in the growth of the tourism industry or in the benefits resulting from the military build-up.

INTRODUCTION

WHY AQUACULTURE

Aquaculture is the fastest growing food production sector on the planet (FAO 2020). More than half of global seafood consumed is farm raised (Figure 1). Aquaculture's importance and potential as an industry has recently been recognized at the national level in the United States (US). With the passage of the Aqua Act of 2021, aquaculture is declared a national interest. The Act adopts the national policy to encourage the development of aquaculture in the US.



NOTE: Excludes aquatic mammals, crocodiles, alligators and caimans, seaweeds and other aquatic plants. SOURCE: FAO.

Figure 1: Global capture fisheries and aquaculture production between 1950 and 2018

IMPORTANCE OF AQUACULTURE IN GUAM

The request to develop a strategy for aquaculture demonstrates Guam's recognition of the potential of aquaculture as an industry and its potential as a growth sector for Guam's economy. Well-planned aquaculture development on Guam can utilize Guam's natural resources (land, water and abundant offshore marine resources) and its uniform tropical climate in a sustainable manner. Aquaculture production on Guam can provide significant import substitution in fishery products. Seafood imports to Guam are approximately 5 million pounds annually. A local aquaculture

industry could produce a significant component of this to achieve import substitution. In addition, an export industry for high value, high quality aquaculture products, such as Specific Pathogen Free (SPF) shrimp broodstock, can be developed.

The economic benefits of developing an aquaculture industry include:

- 1) economic growth and diversification;
- 2) increased investment opportunities for both domestic and foreign capital;
- 3) increased employment opportunities;
- 4) food security;
- 5) import substitution;
- 6) export revenues from aquaculture products and/or technology;
- 7) increased tax revenue;
- 8) a higher economic multiplier effect as compared to service oriented industries;9) sustainable (non-polluting) industry;
- 10) productive utilization of natural resources; and
- 11) fisheries enhancement.

Guam's major economic sectors are tourism and the US military. The collapse of tourism caused by the Covid pandemic clearly illustrates the need for Guam to diversify its economy and increase food security. The pandemic has also greatly strained global supply chains and Guam's import dependent food supply is fragile. Even though these industries are important contributors to the present economy, broadening the economic base to a resource-based industry is preferable. Economic development from aquaculture can help diversify and stabilize the tourism and military dependent economy and increase economic self-reliance for Guam along with supporting preferred rural lifestyle and its associated cultural practices.

Fully utilizing Guam's limited natural resources will help maximize the potential economic and social development of the island community and provide a more stable economy based on a commodity production industry rather than a service-oriented industry. This document provides recognition of these conditions and provides specific strategies and programs to pursue the development of the island's natural resources through aquaculture.

When developing the aquaculture sector, the Government's role would be to provide infrastructure, technical assistance, finance, and policies designed to incentivize and stimulate private sector investment. Once the industry is firmly established, the Government's role will be to manage and promote further expansion through an entrepreneur support initiative and a market development program.

Aquaculture development on Guam should first emphasize culture of shrimp (*uhang*, Chamorro name) and tilapia; and anticipate developing other species to fully exploit the local market potential and suitable export markets. This will involve local research and development complemented by assistance and coordination with regional organizations (e.g., CTSA, USDA, NOAA, South Pacific Commission, Pacific Basin Development Council, SEAFDEC, and ICLARM) to maximize production per unit of effort and expenditure.



Figure 2. Guam map

ECOLOGICAL IMPACTS OF AQUACULTURE

Developing an aquaculture industry on Guam can have an overall beneficial impact on the local environment and bolster island wide sustainable initiatives. It has been well documented that aquaculture, when strategically planned and researched, can have positive impacts on the biodiversity within localized habitats (Diana 2009). Cultured seafood can reduce fishing pressures on overexploited wild seafood stocks, allowing natural populations to re-grow and maintain healthy stock densities (Naylor et al. 2000). The introduction of naturally occurring aquacultured seafood products into the natural environment can enhance natural populations, especially of depleted stocks (Bell 1999; Kaneko, Kobayashi, and Yoshiura 2015). This enhancement of depleted stocks can ultimately boost the natural production potential of native populations, thus increasing species diversity.

Since only native species will be produced in Guam, the potential for aquacultured non-native or invasive species introduction into Guam's natural environment is eliminated. Culturing native seafood products not only eliminates the negative impacts associated with destructive non-native species introduction, but also decreases the introduction of novel, transmissible diseases to the local environment. Novel diseases can have a devastating effect on wild stocks of organisms, completely extirpating whole localized populations.

THE HISTORY OF AQUACULTURE IN GUAM

Guam does not enjoy a long tradition in aquaculture. Efforts to develop aquaculture on Guam were first initiated in 1973 with the government's experimental demonstration ponds located in Talofofo. Since then, interest in aquaculture's potential focused on Guam's desire for food security and economic self-sufficiency.

The vast majority of food products consumed on Guam are imported. Fish and seafood products are no exception with approximately 5 million pounds worth \$20 M imported annually (Department of Commerce, Annual Economic Review 2018). Local aquaculture production peaked in the 1990s reaching 460,000 pounds (Table 1). Current production is estimated at 242,000 pounds (see figure 3). This is less than 5 percent of the total consumption of fish and seafood products on Guam.



Figure 3. Aquaculture production (lbs) in Guam (FAO 2018)

Table 1. Guam Aquaculture Production (1990-1996) Pounds harvested

Year	Shrimp	Tilapia	Catfish	Milkfish	Mullet	Total
1990		282,539	57,871	127,644	198	468,252
1991	1,903	270,651	35,160	77,867	2,849	388,430
1992	22,288	303,941	30,573	55,614	1,085	413,501
1993	44,202	328,007	35,537	54,041	821	462,607
1994	50,800	244,000	48,800	33,198	27433	376,798
1995	5,001	101,000	9,357	335,555	112	451,024
1996	24,497	112,497	24,255	205,249	-	366,498
Mean	24,782	234,662	34,508	127,024	1,013	418,159

GADTC and CoreSeed

The Guam Aquaculture Development and Training Center (GADTC) under the University of Guam (UOG) was developed in the 1980s by private Asian investors to produce SPF shrimp. It was later turned over to Guam Government and was managed by the former Guam Department of Commerce as an aquaculture hatchery and training center. After a decade of operations and aquaculture research, new product trials and support to private growers it was turned over to the University of Guam to be an aquaculture hatchery and training center. After falling into serious disrepair, the UOG decided to convert the facility into a commercial facility and formed a public-private partnership with CoreSeed Aquaculture (Guam) Corp. to manage the facility. CoreSeed's Managing Director is Dr. Donghuo Jiang, an experienced aquaculturist with a doctorate in fisheries science from Texas A&M University. CoreSeed raises Pacific white shrimp, black tilapia, and salt-tolerant red tilapia at the UOG facility. Their products are available on a wholesale basis and retail consumers can purchase jumbo-sized Pacific white shrimp and red tilapia at the Guam Fishermen's Co-operative Association. CoreSeed is also raising giant freshwater prawns.

Locally and sustainably raised shrimp and tilapia are now regularly available for Guam residents and restaurants to purchase, contributing to food security on island as well as the local economy.

CoreSeed has been selling about 400 to 500 pounds of shrimp per month and is steadily ramping up production toward producing more than 1,000 pounds per month. Their products are very popular with customers.

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Figure 4: A tank at the UOG Guam Aquaculture Training and Development Center holds red tilapia broodstock.

Specific pathogen-free shrimp

UOG researchers have been working with SPF shrimp at GADTC for many years and currently CoreSeed has started to market SPF shrimp broodstock to Asia. All of the breeding and production of the SPF shrimp is done at CoreSeed. The demand for SPF shrimp broodstock as breeding stocks is high throughout Southeast Asia, as shrimp in those countries routinely test positive for certain pathogens. At CoreSeed, the SPF shrimp are protected from pathogen contamination by strict biosecurity measures.

Saltwater tilapia

Red tilapia grown in seawater at CoreSeed is another product available at the Co-op. The fish has been selectively bred at the UOG facility to be tolerant of saltwater, giving it a reef fish flavor and a soft texture that has been popular among Co-op customers. CoreSeed is working toward producing 1,000 pounds of tilapia per month.

Food security

As an island, food security is an issue for Guam and especially the pandemic showed how important local production of food is. Local seafood production through aquaculture will bring an authenticity to Guam's tourism industry by providing local seafood that tourists expect. CoreSeed's aquaculture operation, made possible through a public-private partnership with UOG through the Research Corporation of the University of Guam, will continue to grow its production and be a consistent and reliable food source for Guam residents and tourists.

Guam has significant potential for expanding its aquaculture industry. The island's cultural heritage and ethnic diversity create a strong local demand for fresh seafood. This demand is augmented by the arrival of more than 1 million visitors a year who visit a tropical island expecting to eat bountiful seafood from its crystal-clear tropical waters. The US military population based on Guam provides additional demand.

SCOPE OF STUDY

This Feasibility Study addresses the potential, identifies constraints and needs, recommends government action to assist development, and provides a process to coordinate governmental actions to develop the aquaculture industry on Guam. The Study follows the requirements outlined in Guam Economic Development Authority's (GEDA) Requests for Proposals. It starts with a

market analysis followed by a strategic plan and conceptual design for potential aquaculturerelated activities. Subsequent chapters provide a site analysis of potential locations suitable for aquaculture activities, a review of existing and required infrastructure, an analysis of potential production systems and species, a financial analysis, tax and other financial incentives, employment impacts, legal and regulatory review, business support opportunities. The final chapter lays out a strategy to set out key product development, marketing and infrastructure objectives, projected milestones, and recommended courses of action including major development needs of the industry and the constraints to its development. This section includes recommendations on what infrastructure and services are needed and how to alleviate the major constraints to development.

Previous analyses and studies focusing on aquaculture's potential in Guam were reviewed in preparation of the present Feasibility Study. Two precursor papers played a vital role in developing the strategies and recommendations outlined in this Study: 1) *Aquaculture Development Plan for the Territory of Guam* (FitzGerald, 1982) which covers the land and water resources, site development, species suitable for culture, pollution abatement, and environmental constraints of aquaculture development and 2) *A Development Plan for Aquaculture on Guam* (Brown, et al 2010).

This Study provides a roadmap to implement the major key programs and actions required for developing sustainable aquaculture industry on Guam.

Figure 5. Pacific white shrimp at the UOG Guam Aquaculture Training and Development Center. The shrimp are being bred and raised by CoreSeed Aquaculture (Guam) Corp. to be sold to aquaculture farms and consumers.



MARKET ANALYSIS OF EXISTING AND NEAR-TERM MARKET DEMAND, BUSINESS POTENTIAL, AND BARRIERS TO ENTRY

LOCAL CONSUMPTION AND IMPORTS

Although the seafood consumption on Guam is not precisely known, annual per capita consumption of seafood on Guam has been estimated to be 60 pounds (Allen and Bartram, 2008). In comparison, US per capita seafood consumption is 16 pounds per year. Guam's total seafood consumption was estimated between 5 and 10 million pounds by those authors.

A survey of fish consumption on Guam in 2005 reported that 51 percent was purchased in a store or restaurant, 9 percent was purchased from a flea market or roadside stand, 24 percent was caught by the respondent or immediate family member, and 14 percent was caught by a friend or extended family member (Beukering et al., 2007). They found that 57 percent of the fish consumed by Guam households was reported to have been caught locally, while the balance was reported to have been imported (Beukering et al. 2007). Other sources indicate that more than 90 percent of seafood is imported.

To estimate the size of Guam's seafood market, monthly import data was compiled over 2 years (pre-Pandemic) (2018 & 2019) from the annual Guam data books (The Bureau of Statistics and Plans Guam www.bsp.guam.gov).

Seafood commodities and their codes used to calculate seafood imports are listed in Table 2. The average annual seafood imports to Guam are about \$19 million (Table 3). Of this, on average between the two years, nearly \$6 million is from shrimp imports (Table 3).

Table 2.	Guam seafood imports commodities and codes.
CODE	COMMODITY
0302	Fish, Fresh, Chilled or Frozen
0305	Fish, Dried, Salted or in Brine and Smoked
0306	Crustacean, in shell or not
0307	Mollusks, Live, Fresh, Chilled, Frozen, Dried & Salted
1604	Prepared or Preserved Fish, Caviar & Caviar Substitutes
1605	Crustaceans, Mollusks & Aquatic Invertebrates

	2018	2019	Average	
Total	\$ 20,230,232	\$ 17,764,032	\$ 18,997,132	
Subtotal Shrimp	\$ 7,809,892	\$ 3,692,730	\$ 5,751,311	

* data from The Bureau of Statistics and Plans Guam www.bsp.guam.gov

LOCAL PRODUCTION FOR IMPORT SUBSTITUTION

Import substitution is a strategic opportunity for Guam aquaculture. To capture a portion of the market demand through the development of aquaculture is significant. If local aquaculture could supply 50 percent of the fish consumed on Guam, the industry could grow to a \$10 million per year 14

industry. Shrimp farming on its own, producing for Guam's market could be a \$2-3 million per year business.

LOCAL PRODUCTION OF SPF SHRIMP BROODSTOCK FOR EXPORTS

In addition to the benefits of import substitution and the diversification of Guam's economy, there is also potential of developing an export industry for aquaculture products. The best near-term aquaculture export product is SPF broodstock.

The public-private venture CoreSeed has the SPF shrimp germplasm necessary to enter the market. In 2019, the global market for SPF *P. vannamei* broodstock was estimated to be about 1.5 million broodstock (Figure 6) (Shrimp Insights 2020). With an average value of \$55 per shrimp broodstock traded in 2019, this equals a market value of \$82 million. SPF Broodstock sells for \$50-75 per piece and is one of the highest revenue generators within the shrimp industry.

The major markets for SPF *P. vannamei* broodstock are China, India, Vietnam, Indonesia, and Thailand, with China being the largest market buying 43 percent of the total supply. Since CoreSeed's CEO is Chinese, he may be able to capture a significant share of that market. Smaller markets are Malaysia, the Philippines, South Korea, Sri Lanka and Taiwan. Latin American shrimp producers generally do not use SPF *P. vannamei* broodstock due to local production systems not always being biosecure.

Global demand for SPF *P. vannamei* broodstock is expected to increase along-side the expansion of shrimp farming in Asia and the Middle East. The outlook for SPF Shrimp broodstock demand is strong.



Figure 6. Global SPF Broodstock 2019 market by country (data from www.shrimpinsights.com - 2019 *L. vannamei* broodstock report).

Production of SPF P. vannamei broodstock in the US is concentrated in Hawaii, Florida, and Texas

producing two thirds of the global SPF *P. vannamei* broodstock. In Asia, SPF broodstock supply is mainly produced in Thailand. The top five companies that produced SPF *P. vannamei* broodstock in 2019 are American Penaeid Inc. (API), Shrimp Improvement Systems (SIS), Kona Bay Shrimp (Kona Bay), CP Foods (CPF) and SyAqua. While CPF produces only for its own hatcheries, the other four major producers sell on the open market. Combined, the top five producers account for 75 percent of total global broodstock production. In Guam, CoreSeed currently produces SPF *P. vannamei* broodstock for overseas export.

Further consolidation in the breeding segment can be expected. In other animal production sectors, genetics is often controlled by a few large players which will likely be the case for shrimp as well. There is an increased focus among broodstock suppliers on developing branded disease tolerant lines. Many companies offer two lines to their clients, one focused on growth, and another focused on disease tolerance.

Specialized breeding companies like Hendrix Genetics and Benchmark have just started their activities on shrimp genetics and have the capacity to expand. Smaller independent companies like CoreSeed may be potential targets for acquisition.

Covid-19 has had a severe impact on shrimp broodstock logistics. The absence of tourist flights to Guam have eliminated shipping opportunities for CoreSeed. Once travel restrictions are lifted, demand for broodstock in most Asian countries will recover quickly. CoreSeed's main challenge is to get established in the market and build a solid collection of customers.

Another export product that could be developed on Guam is for very high value marine fish such as Lapu Lapu (Coral Trout). These fish command a very high price in Hong Kong and China. Another high value product that Guam could farm are sea cucumbers which can be grown on reef flats.

ANALYSIS OF POTENTIAL PRODUCTION SYSTEMS AND SPECIES

CURRENT CULTURE SPECIES

Brief information summaries of the four species that have been commercially farmed on Guam are presented below. By implementing a substantive program to incorporate sustainable intensification, the production of each of these species could be increased.



PACIFIC WHITELEG SHRIMP (PENAEUS VANNAMEI)

Shrimp is a high value aquaculture crop. As of 2021, world farmed production of shrimp and prawns is over 5 million metric tons with a value of exceeding 25 billion dollars (FAO, 2020). Some shrimp farming on Guam has been productive. Local price for fresh shrimp is approximately \$12 per pound.

One white shrimp farmer on Guam reported selling 200-300 pounds per week at the local farmers' market. He reports that when people come to his stand to buy tilapia, they often buy some shrimp at the same time. Local shrimp production faces significant competition from frozen, imported shrimp with a lower price. For most consumers, fresh, locally produced shrimp has little competitive advantage since shrimp is generally consumed in small quantities in mixed dishes where frozen shrimp is adequate. Some tourist and restaurant markets do seek out fresh, high-quality shrimp. It appears that as a food crop, shrimp fits best into a diversified farm scheme. Shrimp farmers also face high feed, energy and labor costs. CoreSeed reports weekly sales of fresh shrimp to the Hyatt Hotel. Market development for fresh local shrimp needs support.

SPF SHRIMP BROODSTOCK

As discussed in the chapter on market analysis, production and export of SPF broodstock is Guam's best aquaculture opportunity and great care must be taken to not jeopardize this. Importation of foreign shrimp seedstock should be strongly regulated or banned entirely to protect the high potential of CoreSeed's SPF broodstock.

SPF broodstock production requires strict biosecurity measures and regular testing for listed shrimp diseases. The SPF shrimp stock at CoreSeed started with SPF stocks per USMSFP's SPF protocols and has been monitored according to the updated pathogen lists annually for 12 years with all test results negative including recent pathogen screening of CoreSeed's stock by University of Arizona conducted in May 2021 (16 pathogens by PCR plus histology).

CoreSeed has potential to develop a selective breeding program to improve their shrimp strains to increase market value. A key issue for a breeding program is to determine the genetic diversity of the stock to be selected.

A recently conducted a microsatellite study of CoreSeed's shrimp stock was carried out to determine genetic diversity. A panel with 16 microsatellite DNA markers among 36 mated pairs and their offspring was used. They found CoreSeed's SPF shrimp have a high level of genetic diversity. They showed the effectiveness of their approach in assessing genetic diversity and high efficacy of parentage assignment to apply to breeding SPF *P. vannamei* at CoreSeed. The application of this microsatellite panel was useful for guiding the critical decision-making process during the selection and improvement in the shrimp breeding program. They established a foundation for further development and implementation of ready to use genetic markers for the selective breeding program.

CoreSeed also supplies SPF postlarvae (PL) to local shrimp farmers on a limited basis. But the Guam-based farmers also source PL from abroad, which has the potential for introducing shrimp disease to Guam. More reliable and larger scale local SPF PL production is needed to sustain and expand shrimp farming in Guam. Imports of shrimp PL (seedstock) should be ceased once sufficient supply is established on Guam.



NILE TILAPIA (OREOCHROMIS NILOTICUS)

Nile tilapia are the "bread and butter" of aquaculture species cultivated on Guam. Global production of tilapia species exceeded 5 million metric tons in 2020 with a farm gate value approximating \$7.5 billion per year (FAO, 2020). Tilapia is rapidly increasing in popularity in the US and has now become the fourth most commonly consumed seafood.

Tilapia farming has a long history in Guam. It was first imported in 1954 for farming. In 1974, using fry imported from Taiwan, tilapia farming on Guam first succeeded, partly due to the hardiness and disease resistance of the species. The large local Asian population in Guam provide strong demand for tilapia of various sizes. More recently, tilapia consumption has spread into the other ethnic groups as they have come to appreciate the food qualities of this fish.

Both earthen ponds and above-ground tanks are used for large scale commercial culture. Backyard farming for combined commercial and home consumption purposes is also popular and can play an important role in household economics and food security. In some cases, effluent is used to irrigate vegetable crops. UOG has an aquaponics demonstration project in which tilapia culture water is circulated in a hydroponic system to produce leafy vegetables.

Prices range from \$3.50-5.00 per pound, depending on size. There is a demand for fish as small as 4-5 pieces per pound as some consumers prepare these smaller fish in a soup. It also allows each person in the family to receive an individual fish. Larger sizes bring higher prices for use as a shared dish or for grilling. Very little value-added processing or fileting occurs on Guam, although there may be potential for this. The total production on Guam was estimated at 200,000 pounds per year.

CoreSeed has several strains of *O. niloticus* including GIFT, Chitralada and Thai Reds, and it supplies fingerlings to the smaller farmers. Larger farmers generally purchase their tilapia seed from off-island sources because CoreSeed is unable to produce large enough batches of fry to stock their ponds on an intermittent basis. Therefore, a tilapia hatchery should be developed on Guam.

Considerable extension effort has been dedicated to developing backyard and aquaponics systems and more could be achieved if additional extension assistance and other forms of support were available to farmers. Tilapia fingerling production using superior strains could also be increased with a more consistent demand, and this could become a viable business for a small hatchery.



Milkfish occurs throughout the Indo-Pacific and is one of the most widely cultured species in Asia (Taiwan, Philippines and Indonesia) due to its herbivorous, euryhaline nature. Food conversion ratios are good and growth is fast. Total world production was approaching 700,000 metric tons in 2020 (FAO 2020).

Although milkfish are indigenous to Guam, the Government of Guam first imported milkfish fry from the Philippines for a small-scale culture operation. Problems with the supply of fry were encountered when the Philippines enforced a moratorium on export of milkfish fry, and local farmers turned to Taiwan for their seed.

Local production still depends solely on imported fry. Earlier attempts at producing fry at the GADTC did not succeed as the broodstock died before reaching maturity. This species does not mature until they reach roughly 5 years of age and approximately 70 centimeter (up to 10 kg).

Milkfish are cultured only in coastal earthen ponds in Guam. The fresh fish is popular among many of the Filipino and Chinese ethnic groups, but the presence of large numbers of small bones limits its popularity among some of the other ethnic groups.

Local milkfish producers face price competition from limited fresh imports from the Philippines and from frozen, imported fish from Asia. Prices for fresh milkfish range from \$3.25 to \$3.50 per pound.

Milkfish production could be expanded if polyculture with other species was developed. One candidate species for polyculture is the Mangrove crab, *Scylla serrata* (see below). Other potential species could be shrimp, tilapia and various shellfish and seaweeds. However, polyculture significantly increases the managerial burdens on the farmer, and is often avoided for this reason.



There have been two species of catfish introduced into Guam – the Asian walking catfish *(Clarias batrachus)* and the Broadhead catfish *(C. macrocephalus)*. Only the larger of the two, *C. batrachus,* is routinely cultured on Guam. Catfish is considered among the most invasive of freshwater fish species (ISSG, 2010).

Catfish are the least in demand among the four commonly produced aquaculture species on Guam. They probably have never constituted more than 5-10 percent of the market because of limited demand by local consumers. All catfish are currently sold in the farmers' market or in other ways directly to the consumer. They are sold whole and must be cut or otherwise processed by the customer. Although the quality of the fish is excellent, catfish are somewhat difficult for the neophyte to butcher.

Like tilapia, catfish can be cultured in earthen ponds or tanks, and could be grown in backyard aquaculture systems. Issues encountered with catfish are the same as for most aquaculture species including production costs, relatively limited market and competition with imported, frozen fish.

POTENTIAL CULTURE SPECIES

Aquafarmers on Guam have long sought higher valued alternatives to their four traditional products.

Emerging trends have made the culture of new species more feasible than they were in the past. Among these trends are:

- Culture technologies for a number of species have become more reliable
- Increased seafood consumption and dwindling wild fisheries stocks
- Growing consumer preference for fresh, locally produced foods
- Improved technical capacity, transportation and awareness is spurring interest in the development of new species
- Increased imports around the region of organisms from Asia presents disease and escapement risks, hence a need for local seedstock sources

Although possibly dozens of new culture species could be developed in Guam, only those candidate species that are indigenous and considered most feasible are discussed here. Some other indigenous marine food fish with potential for Guam such as pompano, jacks and snappers are not discussed due to limitations of space and scope, nor are non-indigenous species such as cobia and barramundi.



Groupers are among the highest valued fish species in the tropical Western Pacific. Their value increases when they are sold live from display aquariums in high-end restaurants.

The culture techniques of many species of groupers, including some indigenous to the Marianas Islands, have been commercialized in Asia.

The small size of the local market for grouper fry and the lack of economies of scale have made it uneconomical to develop a grouper hatchery on Guam for the sole purpose of supporting the local aquaculture industry. However, the local industry could produce and market live grouper for the local tourist industry, if sufficient grouper fry were locally available at an acceptable cost.

In much of Asia, groupers are overfished and both the wild and domestic stocks are contaminated with serious viral diseases. This prevalence of grouper diseases and lack of health certification make import of grouper fry from Asia to Guam a very high risk and should be avoided. The wild grouper stocks around Guam are overfished to the point where recruitment may be permanently suppressed. Both the GFC and the DAWR are strongly supportive of starting a program of stock enhancement. By having two markets for the grouper fry, the cost of production should allow a hatchery to begin the production of local grouper seed for food production and restocking purposes. There is also the possibility that an export market for SPF Grouper fry could be developed for regional or Asian markets.



Rabbitfish (*Siganus spp.*) are medium-sized herbivorous fish native to the Indo-Pacific region. They thrive in coastal areas; some species live on coral reefs while others prefer brackish-water mangrove habitats. Siganid aquaculture has high potential on Guam. They are highly popular around the region. Potential species for aquaculture are Variegated Spinefoot (*Siganus randalli*), streamlined spinefoot (*Siganus argenteus*) and the little spinefoot (*Siganus spinus*). When Dr. Steve Nelson of UOG successfully spawned and cultured local rabbitfish at the GADTC, they were thought to be *S. spinus*, but later found to be a new species, *S. randalli*.

In 1991, a market survey was conducted on both Guam and Saipan. The vendors carrying fresh rabbitfish responded that among Chamorros, Filipinos and Carolinian Islanders (with the possible exception of Palauans) rabbitfish is preferred among the available reef fish.

Adult populations of rabbitfish are often overfished, aquaculture could help relieve fisheries pressure as demand grows and their seed production could benefit both aquaculture and restocking efforts.

Siganus argenteus and *S. spinus* are the most widely caught species on Guam and are commonly collected at the larval stage while recruiting in reef areas. Both species have been tested for aquaculture with some success. *S. randalli* were cultured in cages at the GADTC. The fish initially weighed an average of 13.6 grams and averaged 121.7 grams at the conclusion of the experiment. This was an average weight gain of 0.97 grams per day and demonstrated that economically feasible growth rates for this species could be obtained on Guam.

All three species have been successfully cultured in small-scale trials. All can be grown onland in ponds and tanks.



MANGROVE CRABS (SCYLLA SERRATA)

Mangrove crabs are one of the most popular foods in Micronesia. Previously Guam's supply came mainly from imports from Micronesia. The export of mangrove crabs for commercial purposes is now prohibited in Micronesia, although a limited quantity can be carried out for personal use and some black markets exist.

The commercial aquaculture of mangrove crabs has expanded tremendously in recent years. It grew from approximately 10,000 tons in 2001 to over 210,000 tons in 2017 (FAO, 2020). Presently, the Palau Community College is culturing mangrove crabs on an experimental basis.

Guam has been the second most important market for mangrove crabs from the Philippines after

Hong Kong. Normally, the imported mangrove crabs found in retail markets on Guam are rather small. The smallest easily marketable size is approximately 360g and the average size of crabs appearing in the market is in the range of 410 to 450g. Retail prices on Guam are high for the imported crabs (in the range of \$7.95 to \$9.00 per pound), and the current importation of large amounts of live mangrove crabs is evidence of strong market demand.

The commercial export of wild caught mangrove crabs is prohibited in much of Micronesia. While the production of *S. serrata* larvae has been achieved outside of Micronesia, it has not been done in the region. There are limited farming efforts in Palau and Kosrae based on wild caught juvenile crabs. The mangrove crab offers a significant market both inside the region and as an export product, if the difficulties of low culture densities and seed availability can be overcome.

GADTC previously conducted limited trials in the cultivation of mangrove crabs with some success. Growth rates with seed crabs obtained from Taiwan were excellent. It was estimated that the crabs could be grown to commercial size in 215 days. However, cannibalism at commercial density can be high. The greatest difficulty encountered during the GADTC study was obtaining gravid females. Once the mated females leave the near shore waters to spawn, the deep oceanic waters surrounding Guam make it difficult to obtain egg-bearing females.

If reliable production methods can be developed, aquaculture of *S. serrata* could benefit both Guam and the rest of Micronesia where there is intense interest in culturing this species.



HARD AND SOFT CORALS

Corals are popular marine ornamental invertebrates within the aquarium trade. In 2005, the Convention on International Trade of Endangered Species (CITES) reported that over 1.5 million pieces of live coral were traded globally.

The UOG Marine Laboratory has a long history of research on corals including their sexual propagation which offers a more environmentally friendly alternative to fragmentation (as often practiced).

The GADTC has done some minor work on the maintenance and cultivation of newly settled coral colonies in confined environments. The process is labor intensive and needs further efforts to determine its economic viability.

Currently, most of the corals offered within the aquarium trade originate directly from the harvest of coral fragments from parent colonies. These fragments are obtained by cutting pieces of coral away from the main colony and attaching them to substrate. Some farms maintain cultures of parent colonies and some seek fragments repeatedly from the reef. All of the parent colonies at some point originated from the reef.

Soft and hard corals are also becoming a major aquaculture product in Pohnpei, Kosrae and the Republic of the Marshall Islands. These locations ship their product through Majuro and Honolulu to the US mainland. The sensitivity of the live products and the frequent lack of cargo space availability and delays in transfers make shipping from other islands more risky than from Guam.

Hard corals can be produced from larvae, which would allow breeding and more controlled production. However, hard coral is commonly produced by the fragmentation of a mother coral and embedding the fragments in a waterproof cement base. This allows the corals to be identified as cultured for CITIES import/export documentation. The production of hard corals is technologically simple. However, live hard and soft corals are relatively difficult and expensive to ship and have a limited market.

A limited number of coral species are being cultured in tanks in the US to supply the home aquarium demand. Projects at the Micronesian Aquaculture Development Center in Palau received US funding in the 1990's to investigate hard and soft coral species to evaluate and culture for the international aquarium trade. Similar studies and trials have been done in Pohnpei and the Marshalls.

The collection of coral in Guam is legal under the identified laws set forth by the Judiciary of Guam, under Title 5, Chapter 63, Article 6, Section 63601, Section 63602, Section 63603, 24

with the proper licensing and permitting. However, currently the Director of the Department of Agriculture Aquatic and Wildlife Resources is not issuing any such licensing or permitting to collect or harvest coral for any means other than research. Future discussions with the Director can and should be made to obtain the necessary licensing and permitting required to obtain coral lawfully on Guam for aquaculture purposes.

Yap and Palau have a greater number of coral species that could be grown. They are somewhat handicapped by being isolated from the direct air routes to the markets and could use partners in Guam for consolidation and transshipping.

Finally, as mentioned earlier, there may be a market for cultured hard corals for the environmental remediation of habitat damages or losses from dredging or fill projects done in conjunction with the military build-up.

Biosecurity protocols must be developed and followed to avoid introduction of invasive pests, parasites and diseases to Guam waters and final markets. Guam has over 400 species of hard and soft corals including many not available in the aquarium trade but potentially developable for culture and export.



Giant clams are popular food items throughout their range. Wild stocks across the islands have been greatly diminished by Asian poachers over the last few decades. Early developmental work on the aquaculture of giant clams originally focused on their culture as food items.

Giant clams are considered a high valued food item in Asia, Guam and the rest of the Pacific Islands. However, the export market for their meat has not been developed.

In the US, giant clans are considered a filter-feeding bivalve and therefore fall under the same water sanitation regulations as oysters. There has been no effort to set-up a shellfish sanitation monitoring program in Micronesia. Therefore, they cannot be imported into the US as a food item. Their main market has been the aquarium trade. They are relatively simple to produce but difficult to ship and market. However, smaller, six month old tank produced clams are easier to ship than larger ones that grew for years.

Production of giant clams for the aquarium trade is being done in multiple locations in Micronesia and could be integrated into the production of other aquaculture species. In particular, their production would be highly compatible with the production of hard and soft corals for the aquarium trade or with the production of seaweeds. In addition, local hatchery production of giant clams could provide sufficient seed of Tridacna species to stock onto local reefs for restoration work. Guam could serve as a collection and transshipment point for giant clams produced in Chuuk, Yap, Pohnpei, Kosrae or Palau. Development of an aquaculture transshipping facility at the Guam airport would assist this process but biosecurity protocols must be developed and followed to avoid introduction of invasive pests, parasites and diseases to Guam waters and final markets.



Sea Grapes are a seaweed with the best aquaculture potential based on marketability on Guam. The two most commonly eaten are *Caulerpa lentillifera* and *Caulerpa racemosa*, both called "sea grapes" in English and both native to Guam.

They are traditionally harvested in the wild and sold in local markets in Southeast Asia, Oceania, and East Asia. They are eaten raw in salads and have a characteristic "sea" flavor and a crunchy texture.

Cultivation of *Caulerpa* is convenient because they can propagate through fragmentation. There are several farming techniques being used to cultivate *Caulerpa*, which typically involve tying fragments to different types of infrastructure. Many Pacific countries such as Japan, Philippines, Vietnam, and Samoa use the off-bottom method, where the seaweeds are grown a few meters above the ground on cages or trays. Land-based raceways in hatchery facilities offer a more controlled environment for cultures and have been used more in recent years.

In many Pacific Islands, seaweeds are cultivated in the wild or fenced-off lagoon areas. Eucheuma culture for carageenan production has been established in the Philippines and Indonesia. It was tried in Pohnpei but found vulnerable to rabbitfish predation and not worth the required work needed to culture it by locals. Market values and regulations would probably not support its culture in Guam.

Gracilaria and *Caulerpa* cultivation on Guam in artificial containers would allow the grower to control environmental parameters and minimize problems with predation, disease and pest species contamination.

GADTC worked on developing a method for low-cost, high-yield production of this alga. Yields were best through vegetative cultivation, and if all broodstock are culled at least every three months, sexual reproduction events can be delayed indefinitely. Unlike *Gracilaria* spp., it was discovered that sexual reproduction of sea grapes is not cost-effective since the broodstock dies within one day of reproducing, and the chemical cues given by reproducing algae cause all broodstock within the same system to also reproduce and die.

During 2005 and 2006, GADTC cultured the four primary species of edible seaweeds on Guam *Caulerpa racemosa, Caulerpa lentillifera, Gracilaria salicornia,* and *Gracilaria tsudae* in order to determine their production requirements and marketability. While all of these seaweeds are consumed by Pacific Islanders, the cultivation of *Gracilaria salicornia* was stopped because of a lack of demand on Guam due to toxicity concerns. *G. salicornia* is not normally eaten and could probably not be marketed but *Gracilaria tsudae* is preferred and it is most like Hawaii ogo. *G. tsudae,* not *G. salicornia,* is the species which poisoned Guam consumers due to toxins produced by epiphytes on it (https://www.guampedia.com/seaweed-gracilaria/). This alga was implicated in the deaths of three people on Guam in 1991 (Halstead and Haddock 1992; Haddock 1993). Finally, while *Caulerpa lentillifera* is not preferred on Guam, it is highly prized elsewhere in Asia and the Pacific, and the potential remains for successful cultivation should a market be created on Guam.

OTHER INVERTEBRATES

One of the most valuable aquaculture species in Micronesia is the black lipped pearl oyster, *Pinctada margaritifera.* This oyster is found in Guam and throughout Micronesia. Pearl culture has several advantages. Its products are non-perishable, lightweight and easy to ship. Pearl oyster production integrates nicely with the tourism industry. Excess shells can provide a raw material for handicrafts to provide additional jobs for local residents. Since their independence in 1986, the Marshalls and Nukuoro Atoll in Micronesia have established this pearl culture.

The Japanese experimented with culturing Wool sponges, *Cosinoderma matthewsi*, in the Marshall Islands, Pohnpei, Chuuk, and Palau before the Second World War. Sponges have similar advantages to pearls for aquaculture in the region. They are lightweight, non-perishable and easy to ship. They have an additional advantage in that their culture is relatively low technology as compared to pearl culture. They are propagated by cutting and the cuttings are strung on webs of rope to heal and grow. They do not require feeding during the grow-out period and lack predators. Production of high quality sponges for export has been established in Pohnpei by local culturists.



Sea Cucumbers (Beche de mer) (*Holothurians*) have been a traditional export product for Micronesia. Historically, their harvest has been intermittent as the wild populations are easily over-harvested. After the reef flats of an island are vacuumed, it takes time for the population to recover and for the cycle to begin again. Holothurian culture is being researched in Yap, Palau and Pohnpei, and it offers a significant potential for the region. Local hatchery production of sea cucumbers could also be used for reef restoration projects. Top Shells (*Trochus*) and Green Snail are valuable for their shell, used for buttons and other shiny products, and their flesh which is a popular food. They can be easily reproduced in tanks together with other species like *Tridacna* and seeded to reefs. *Trochus* were introduced to most of Micronesia by Japanese before WW II and since then they have been spread to Kosrae and certain atolls. They can support a processing industry for export production. Green Snails are not native to Micronesia but have been introduced to French Polynesia and their impacts to the reef ecology in Pohnpei were determined by Dr. Masashi Yamaguchi to not be detrimental, in anticipation of their introduction from Okinawa.

STRATEGIC PLAN FOR AQUACULTURE DEVELOPMENT

Guam has significant potential for development of its aquaculture industry. However, successful development will require strong policy and financial commitments from the Government. Commitment to develop the aquaculture industry on Guam offers potential for diversifying the economy and extending its benefits to segments of the population that may not be able to directly participate in the growth of the tourism industry or in the benefits resulting from the military build-up.

Expansion of the aquaculture industry on Guam will increase food security on the island and benefit Guam's people by providing a high quality source of locally produced seafood. These needs will increase over the next few years as the population increases and the resulting pressure on the Island's wild fisheries increases.

Guam imports large quantities of marine fish from throughout Micronesia. Local aquaculture production could alleviate this in part. Marine finfish production is done in raceways, tanks or in offshore net pens. Once hatchery technology is established, Guam could become a supplier of marine finfish fingerlings for growout in the region and re-import the final products to Guam from the regional islands.

Hatchery production of marine fish and corals could also provide a basis for the mitigation of habitat damaged by the ongoing military build-up and other developments or typhoons. It is likely there will be a need for impact mitigation on marine habitats by various projects related to the military build-up.

SWOT ANALYSIS

This SWOT analysis identifies strengths, weaknesses, opportunities, and threats related to the development of aquaculture in Guam.

Strengths

- Guam's cultural diversity includes ethnic groups who prefer seafood, which creates strong local demand for fresh local seafood.
- Guam imports close to \$20 million worth of seafood per year. Aquaculture producers can target import substitution as a development strategy.
- Guam aquafarmers can directly market to consumers at farmers' markets, the fisherman's cooperative and to restaurants.
- The large Asian tourist population (over 1 million per year pre-Covid) are strong seafood consumers and contribute to Guam's high seafood market demand.
- The impending military personnel build-up on Guam could provide additional markets for local produced seafood.
- People are generally more interested in eating healthy, locally produced or organic foods.
- Many people on Guam are comfortable working in an marine environment and well suited to join the aquaculture workforce.
- Guam has many native species with aquaculture potential such as the groupers, snappers, jacks, and pompano.

- UOG has strong research capacity including the Marine Laboratory, WERI, Sea Grant, CNS, and other research units. There is a long history of researching the biology and culture of numerous animal and plant aquaculture species.
- Guam Community College has good workforce development capacity.
- Guam is a US territory, which provides strong legal infrastructure to secure investments.
- There is existing aquaculture infrastructure in the form of several idle aquaculture farms that can be renovated and reactivated.
- Guam's government is supportive of developing commercial aquaculture as an economic diversification and food security issue.
- The US government is making a strong move to support more commercial aquaculture development and maybe a source of funding to help develop Guam's aquaculture industry.
- Guam has excellent air and sea transport capabilities for exporting aquaculture products.



Weaknesses

- There is no centralized institution that supports aquaculture development in Guam.
- There are limited on-land sites for aquaculture on Guam.
- Extension capacity in aquaculture is limited and insufficient.
- Critical imports for aquaculture production such as equipment and feeds are expensive to import and include high shipping costs.
- Aquaculture seedstock/fingerlings are in short supply on Guam so farmers must import seedstock, which has many risks.
- Permits are often difficult and time-consuming to obtain, particularly for new or small farmers. Multiple levels of permitting (local and federal) complicate obtaining permits.

- There are few tax breaks or financial incentives for aquaculture farmers.
- Multiple regulatory constraints exist for aquaculture discharges, mainly water quality standards in the south of the island.
- Operating costs (especially energy) for intensive systems are high.
- Access to capital and financing is difficult to obtain, and capital for start-ups is not available so that most people must rely on self-financing.
- Power outages are common and require back-up power supplies.

Opportunities

- Develop a reliable high quality aquaculture seedstock supply.
- Develop an aquafarmer cooperative to purchase feeds in bulk to lower costs.
- Develop alternative energy sources for aquaculture farmers to reduce costs.
- Develop sufficient finfish hatchery technology to become seedstock self-sufficient and become a regional supplier of high quality fingerlings to Micronesia and Asia.
- Develop and expand backyard aquaponics farmers as a viable, sustainable solution to produce local seafood and leafy vegetables for the local community. Income and food from these systems can be an important part of a family's income and food.
- Develop recirculating aquaculture systems to help reduce discharge permitting issues, costs and water efficiency issues.
- Develop a biofloc demonstration project to produce shrimp and/or tilapia for local consumption.
- Develop a pilot offshore aquaculture demonstration in submersible net pens to grow high value finfish.
- Develop and enforce biosecurity measures to reduce disease risks and position Guam as a supplier of disease-free stock for species such as shrimp, groupers, various invertebrates and algae.
- Develop an aquaculture program at UOG to support workforce development for the industry and provide an attractive major for Micronesian and Asian students.
- Establish a one-stop aquaculture permitting system to expedite obtaining permits and remove a major bottleneck in aquaculture development.
- Develop production capacity of marine ornamentals to export to the global aquarium trade.
- Develop cooperation with Taiwan and Hong Kong for research and investment in aquaculture on Guam.

Threats

- Guam has weak control over imports of potentially diseased live animals that threaten to introduce diseases.
- Freshwater scarcity.
- Typhoons and earthquakes are a significant risk on Guam that increases capital costs of infrastructure, which in turn makes it difficult to start-up.
- Near-shore and off-shore aquaculture may be difficult to site because of the narrow coastal shelf and indigenous use rights of coastal areas.
- Competition from cheaper products from the Philippines and other Asian suppliers.
- Climate change impacts of increased temperatures, acidity, sea level rise and stronger storms.

FIGURE 3.2 : AQUACULTURE & FISHERIES SWOT ANALYSIS

STRENGTHS

Rapid growth of cultured species

Clean ocean

Water & ample natural resources

Guam's geographic location

Research capacity

High health status of stock

WEAKNESSES

Complex permit issues High overheads costs Lack of qualified labor Lack of capacity to handle an inceasing local supply of fish

Inconsistent catch quality

OPPORTUNITIES

Growing population Strong local demand

Global market for high health & premium quality products Island food security

THREATS

Tropical storms

Typhoons

Flooding

Coastal erosion

Continued increasing regulations

Figure 7. A SWOT analysis from Guam CEDS 2020-2025 report.





STRATEGIES AND RECOMMENDATIONS FOR GUAM AQUACULTURE

Recommendations and strategies derived from the SWOT analysis have been grouped into four categories as follows:

Near-term objectives

An important near term focus of the aquaculture development effort should focus on reducing or eliminating obstacles that impede current aquaculture production. Foremost among these would be:

- Develop an Aquaculture Innovation Center.
- Develop a Department of Aquaculture in Government of Guam.
- Develop aquaculture workforce development programs at UOG and GCC.
- Establish programs to assist in rejuvenating existing aquaculture infrastructure/ companies using sustainable intensification and climate smart technologies.
- Ensure a reliable supply of aquaculture seedstock of priority species.
- Establish and enforce biosecurity and disease monitoring of imported seedstock.
- Develop methods to encourage the cooperative purchase of aquaculture inputs.
- Demonstrate energy efficient, small-scale, intensive culture systems.
- Support and expand development of backyard aquaponics systems.
- Position Guam as a producer and exporter of SPF (disease free) shrimp broodstock.
- Develop a public-private partnership to conduct an offshore fish farm demonstration project focused on growing high value finfish such as grouper or yellow-fin tuna or greater amberjack.

Mid-term objectives

- Develop a purpose-built facility called the Guam Aquaculture Innovation Center (GAIC) with a multispecies marine hatchery facility to produce high-value marine species fingerlings.
- Develop sufficient hatchery capacity (public and private) to make Guam seedstock selfsufficient.
- Develop SPF and genetically improved fingerlings and broodstock of high valued species for distribution throughout Micronesia and Asia.
- Position Guam to become Micronesia's hatchery center.
- Continue to develop and support backyard aquaculture projects.
- Develop new commercial scale aquaculture operations using local species as aquaculture

products including: high valued live fish, crabs or shrimp for the premium restaurant market, seaweeds for local consumption and the tourism industry.

• Position Guam as a producer of super high quality (contaminant-free) products to supply fresh high quality seafood exports to China.

Institutional recommendations

- Develop a one-stop permitting system for aquaculture housed in the Department of Aquaculture.
- Develop an Aquaculture Development Park adjacent to the GAIC (or elsewhere) that would utilize a master permit system to allow start-ups to begin operations without adding the up-front costs of permitting to their initial capital investment. This would also reduce regulatory risk for those considering investing in an aquaculture business.
- Develop an administrative lead for aquaculture financing including loan and tax incentive programs that could be used to assist start-up aquaculture operations.
- Develop an investment fund for commercial aquaculture development.
- Revive the regional aquaculture organization to improve communication and cooperation. This organization could forge stronger ties to other regional organizations and government agencies and strengthen collaboration throughout the region.
- Develop an Aquafarmer cooperative for group purchasing of feed at lower costs.
- Improve and formalize the permitting and monitoring for diseases of aquaculture seed imports by specifying specific testing procedures required by the health certificate issued for each of the imported species.
- Guam's power supply is unreliable, in part due to natural factors such as storms, earthquakes and brown tree snakes. Efforts should be made to assist farmers in adopting more energy efficient production techniques. Solar and wind power may offer alternatives and should be investigated for application at all scales of aquaculture.

Species selection and development

- Species selection for Guam aquaculture should be determined by the combination of potential impact and feasibility for prioritization for development efforts. Based on these criteria the highest-ranking products for Guam are marine shrimp (SPF Broodstock and food shrimp) and tilapia. These have high feasibility and high potential impacts.
- Resources for aquaculture development on Guam are limited so efforts must be focused. This is particularly true in the efforts to develop and maintain species for aquaculture on Guam. These choices must be strategic with significant potential.

Several recent developments in the global aquaculture industry indicate that global aquaculture is poised for a sustained period of growth and expansion. If Guam is to capitalize on the commercial opportunity in the global aquaculture industry it will have to undertake a concerted and collaborative effort to raise its global visibility in marine aquaculture. The key emerging factors are listed below.

- There is a clear global demand for more innovative industrial scale aquaculture operations; particularly in open marine environments as traditional wild fisheries no longer have the capacity to meet growing global demand. At the same time, food consumers are demanding traceability and transparency in the origin and safety of their food.
- The Federal government recognizes the increasing demand for sustainably farmed seafood and

is taking steps to support the growth of a US aquaculture industry to mitigate the significant trade deficit in seafood. These steps include recent efforts to open Federal waters in the Pacific Islands Region to commercial fish farming.

- Guam sits in the center of this new area and could, if positioned properly, grow as a base of intellectual property and development of systems capabilities in this sector.
- Recognizing these developments, and the success of the farmed salmon and farmed shrimp sectors, the world's capital markets are beginning to invest into the marine aquaculture sector and there has been a noticeable increase in investor interest in aquaculture companies.
- Given the biosecurity of Guam's remote location and pristine waters, Guam sourced products will be attractive as a disease-free source of genetic material as well as high value end products for the local and global seafood consumers.

THE GUAM AQUACULTURE INNOVATION CENTER (GAIC)

The ability of the local aquaculture industry to grow and meet the increased demand for fresh local seafood will depend strongly upon the support that it receives from the Government. The best strategy to stimulate development of aquaculture in Guam is to develop the Guam Aquaculture Innovation Center (GAIC). An aquaculture innovation center will offer a range of benefits.

The GIAC will provide facilities for applied research in aquaculture that will include assessing feasibility of local species for food and non-food production, evaluating commercial marine ornamentals, culture and reproduction of species for reef restoration, evaluation of aquaponics systems, and incubation of aquaculture businesses. The physical components of GAIC will include laboratories, office space, classroom/conference rooms, indoor and outdoor tanks, and aquaculture incubator spaces.

The GAIC should foremost include a multispecies marine hatchery which would develop hatchery technology for commercially desirable species for Guam. The hatchery can be used for workforce development to train technical staff in aquaculture principles. It can be used to conduct research and development (R&D) projects developing technologies to determine best practices for Guam aquaculture.

Guam Aquaculture Innovation Center's mission is to develop and diversify Guam's economy by providing resources, programs, and facilities to develop innovative research, education and commercial aquaculture opportunities in a sustainable manner.

ROLES OF THE GAIC

A principal role for GAIC will be to be an Administration Center that serves as a champion for Guam aquaculture. In this role, GAIC would be affiliated with other institutions in Guam including Department of Agriculture (DOA), GEDA, UOG - CNAS, RCUOG and Sea Grant. GAIC will seek grants for funding of aquaculture R&D. It will administer grants on behalf of various agencies. It will seek funding from federal agencies including USDA, NOAA, and EDA. It will interact with various Pacific Island organizations such as the Pacific Community and RTMFCA, and various philanthropic groups such as Conservation International and Nature Conservancy, who work in the aquaculture sector in the Pacific.

A major responsibility of the GAIC would be to serve as an aquaculture startup accelerator/

incubator. This would require establishment of an associated investment fund to finance startups.

A third administrative duty for GAIC would be to manage and facilitate the Guam Aquaculture Commercialization Park (GACP) with the purpose to promote commercial aquaculture. GACP would be a master permitted facility that sub-leases land to commercial aquaculture ventures under favorable terms. The parcels would have utilities including seawater, freshwater, electricity and internet service direct to their site provided by GAIC. Parcels could range from 0.25 acres up to several acres depending on project concept and funding. Lease terms could be year-to-year or long leases depending on the project.

Key tasks for the GAIC are:

- Support and coordinate aquaculture industry development.
- Develop a state of the art, purpose-built Aquaculture Innovation Center to include:
- A multispecies marine hatchery to develop marine seedstock for commercial trials.
- An educational visitor center to help educate and familiarize local students, local population and visitors on all things aquaculture.
- Adjacent to GAIC (or elsewhere) would be the Guam Aquaculture Development Park where commercial projects can lease master-permitted parcels that have access to seawater, freshwater, utilities and other infrastructure already in place.
- Develop and disseminate Guam-appropriate aquaculture technology.
- Seek out and coordinate financial resources for aquaculture through private sector investors, legislative initiatives, Federal grants and others.
- Coordinate technical assistance and seedstock sourcing for developing farms in Guam and Micronesia.
- Coordinate aquaculture development with other Pacific Island efforts.
- Incubate startup aquaculture companies to provide a test bed for demonstrating and testing new ideas.
- Provide research facilities for aquaculture R&D focused on developing Guam aquaculture.
- Coordinate workforce development programs to build up Guam's aquaculture expertise and workforce.
- Assist and support aquaculture applications for coral reef restorations in Guam and the Pacific.

GUAM AQUACULTURE COMMERCIALIZATION PARK (GACP)

Adjacent to the GAIC main facility will be an Guam Aquaculture Commercialization Park (GACP), which will include leasable lots of varying sizes where commercial companies can lease sites and test their commercial ideas, with potential for Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) opportunities. Seawater pumping and supply system will provide high quality seawater to labs in GAIC and tenants in the GACP to demonstrate and commercialize onshore and offshore fish, shellfish, and macro algae cage culture.

EXAMPLES OF OTHER AQUACULTURE INNOVATION CENTERS

There are a number of aquaculture innovation centers around the world. This section lists five of them that include elements that are relevant to the GAIC design.
NELHA INNOVATION CENTER IN KONA HAWAII

The Natural Energy of Hawaii Authority (NELHA) is a state agency that operates a unique ocean science and technology park in Kailua-Kona on the island of Hawaii. NELHA's mission is to develop and diversify Hawaii's economy by providing resources and facilities for energy, aquaculture and ocean-related research, education and commercial activities in an environmentally sound and culturally sensitive manner. NELHA's assets include office and laboratory facilities, infrastructure, pristine natural resources, and leasable open land for use by tenant research, education, and commercial projects. A dual-temperature seawater system that is the only one of its kind in the world sets NELHA apart from all other technology parks and creates a prime setting for innovation and new industry development in this island coastal setting. NELHA attracts tenants of all types – research, educational, and commercial entities. Numerous innovative research projects have been completed at NELHA in the past and spawned new commercial enterprises that are established and successful businesses today.

NELHA will design and construct a new Innovation Center building and infrastructure (roads, parking, utilities, etc.) in 2022. The Innovation Center will enclose approximately 20,000 sq. ft. of usable interior area and include office, common, and conference space, laboratory, and wet-room research space with flowing seawater, a "maker-space" workshop and a surfboard rack. The area surrounding the building will include outside workspaces and meeting nooks, support areas for maintenance and storage, vehicular and pedestrian accessible routes, parking areas for motorized and non-motorized vehicles, security, and environmentally appropriate landscaping. Every aspect of the project will reflect NELHA's commitment to environmental stewardship, cultural awareness, and vision for practical, meaningful solutions for now and the future. Figure 8 shows architect renderings of the new center.

RESEARCH CAMPUS EXPANSION TO INCLUDE NEW INNOVATION VILLAGE

Initial planning and design for the new HOST Park Innovation Village consisting of additional buildings, lab and open space to support innovative ocean projects is now complete. The next step, which is the permitting process, has commenced. The village will be located on 7 acres approximately 1,000 ft south of the existing research campus which is currently 90% full. The goal is to complete construction of Phase 2 by end of 2024.



RENDERING - INNOVATION CENTER









Figure 8. Render of the new Innovation Center of NELHA

SINGAPORE AQUACULTURE INNOVATION CENTER

Singapore's Aquaculture Innovation Center (SAIC) mission is to close the loop in sustainable super intensive aquaculture to enhance food security and resilience. Singapore's AIC is funded by Enterprise Singapore that includes a consortium of 11 research institutes, agencies, universities and polytechnics.

SAIC operates through co-operating and co-sharing of expertise, facilities, intellectual properties and resources among the SAIC consortium members to work towards serving the needs of the local aquaculture enterprises for improving farm productivity. SAIC's Goal is sustainable intensive aquaculture production with innovation and technology.

SAIC strives to support and develop the SMEs in the aquaculture industry with the aim of enhancing farming productivity through the following:

- Facilitate new growth areas by regularly scanning the environment; identifying and developing emerging technologies or other areas of growth that are important for capability building to support sustainable development and growth of the aquaculture industry.
- Drive farm productivity and product quality by providing product evaluation or testing services, applied research and innovative technology development including precision technologies that could help drive sustainable and intensive aquaculture.
- Support safety, environmental sustainability and labor productivity by educating and training labor in aquaculture standards and best practices for better farm operation, biosecurity, environmental sustainability and workplace safety.
- Raise resource efficiency and sustainability for applied research and services through cooperation, co-sharing of existing resources, space and pooled expertise from institutes of higher learning, agencies and research institutes.

Services provided by SAIC include:

- Feed development and performance
- Feed quality testing
- Live feed enrichment and production
- Fish meal replacement with alternative food source
- Evaluation of feed or product efficacy
- Breeding, hatchery and larviculture
- Selective breeding and seedstock development
- Diagnostic lab test method development
- Vaccine development
- Pathogen challenge studies
- Water technology and waste treatment strategies
- Material development for Recirculating Aquaculture Systems (RAS)
- Smart urban aquaculture technology development
- Customized training, certification program, seminar & workshop



MAINE AQUACULTURE INNOVATION CENTER

The Maine Aquaculture Innovation Center (MAIC) was established in 1988 by the Maine Legislature with a mission to assist in developing economically and environmentally sustainable aquaculture opportunities in Maine. MAIC sponsors and facilitates innovative research and development projects involving food, pharmaceuticals, and other products from sustainable aquatic systems; invests in the enhancement of aquaculture capacity in Maine; serves as a source of educational information to enhance public visibility and acceptance of aquaculture; and encourages strategic alliances tasked with promoting research, technology transfer, and the commercialization of aquaculture research.

Research projects of MAIC include:

- Pioneering GIS for shellfish site selection
- Developing a low cost environmental data buoy
- Market research on seaweed products
- Sea scallop culture and commercialization
- Developing rapid detection methods for oyster MSX disease

Increasing Maine's aquaculture and marine research capacity:

- Constructed an algal production facility at the Darling Marine Center
- Oceanographic instrumentation lending program to assist aquaculture enterprises to identify optimal culture sites along our coast
- Enhancements to the aquaculture business incubator at the CCAR
- Improvements to the DMC Marine Culture Laboratory for business incubation

Business incubation:

• In partnership with the University of Maine, manage two incubator facilities at the Darling

Marine Center and the Center for Cooperative Aquaculture Research

- Provide business development and support services to incubator tenants (with support from the DECD)
- Recently renovated laboratory space for business incubation at the Darling Marine Center
- Training and education:
- Partnered with the Aquaculture in Shared Waters Project fisheries retraining program
- Developing an electronic aquaculture curriculum
- Developing aquaculture curriculum for Washington County Community College
- Host the Northeast Aquaculture Conference & Exposition, held biennially throughout New England since 1998.



The Maine Aquaculture Association has teamed up with the Maine Aquaculture Hub and the Maine Sea Grant to carry out a 10-year plan for Maine's aquaculture industry says \$15 million is needed to strengthen the sector and the state's working waterfronts.

The Maine Aquaculture Roadmap, 2022-2032, proposes four major goals: Streamline the licensing and permitting process to balance applicant and public rights; educate Maine communities about aquaculture; expand and promote the Maine seafood brand; and become a leader in social, economic and environmental performance.

NEW JERSEY AQUACULTURE INNOVATION

The New Jersey Aquaculture Innovation Center at Rutgers University (AIC) is an extremely flexible facility designed to meet the research, technology, demonstration and extension needs of the aquaculture community. The AIC develops education and training programs to provide the knowledge and skills required by current and future aquaculturists, resource managers, non-governmental organizations and trainees to engage in and support aquaculture operations and programs.

The AIC is poised to play a critical role in the growth of aquaculture. In addition to direct employment, aquaculture producers create jobs in shore-side communities such as seafood processing, marketing, transportation and vessel maintenance. At the AIC, members of the fishing industry, aquaculture entrepreneurs and those interested in aquatic restoration will be able to learn methods of commercially raising seafood, thus enabling them to compete with industries from surrounding states already engaged in the practice.

The AIC covers 22,000 square feet of interior and 7,800 square feet of exterior space. It hosts culture rooms, two algal culture rooms, and a large laboratory area

NATIONAL AQUACULTURE TECHNOLOGY AND INNOVATION HUB (NATIH) AT UNIVERSITY OF STIRLING

A world-class research and innovation facility at the University of Stirling. The National Aquaculture Technology and Innovation Hub (NATIH) will be developed. NATIH builds on the University's internationally renowned Institute of Aquaculture, and will bring together experimental aquatic facilities, including a new tropical aquarium, with state-of-the-art laboratories, and space dedicated to business incubation and acceleration.

The NAITH is funded through a ± 17 million investment from the UK Government, as part of the Stirling and Clackmannanshire City Region Deal.

NATIH will position the University of Stirling's expertise at the forefront of the aquaculture industry's expansion, delivering and increasing the economic, social and environmental benefits for the industry, and informing modern commercial aquaculture markets. The impact of this pioneering work will be felt both in Scotland, where the sector has plans to double its output by 2030, and internationally, where the aquaculture sector has a prominent footprint in Africa, Asia and South America.



CONCEPTUAL DESIGN OF GAIC

A purpose built facility to be home to GAIC should be planned and developed. Key elements of the facility include:

- Water systems: seawater and freshwater
- Offices: 5 offices in different sizes
- Meeting room for 10 people
- Conference/Lecture hall with AV systems for flexible seating up to 50 people
- Wet labs (diagnostics, biochemistry)
- Multispecies Marine Hatchery including larval rearing tanks, algae room, rotifer/copepod room, broodstock rooms with environmental controls (photoperiod and temperature).
- Digital library space
- Indoor and outdoor tank fields (20 x 1000 gallons, 20 x 300 gallons, 30 aquaria, shallow tanks for marine inverts)
- Visitor Center aquarium facility including a viewing station into the marine hatchery

The following conceptual drawing of the proposed GAIC includes the elements listed above. The building design is 10,000 square feet on a lot of 60,000 square feet. This conceptual plan does not include the Guam Aquaculture Commercialization Park which would require additional lands.

Guam Aquaculture Innovation Center Conceptual Design Building plan 10,000 sq ft – not to scale



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PRELIMINARY COSTS ESTIMATES FOR GAIC

Developing the GAIC as shown above will cost about \$3 million.

Table 4: Cost estimates for GAIC

Description	Area	Cost/ft2	Costs
Architecture and engineering	10,000	\$20	\$200,000
Land development	60,000	\$2.50	\$150,000
Building	10,000	\$250	\$ 2,500,000
Specialized equipment		S. M. Same	\$150,000
Subtotal	200	23	\$ 3,000,000

SITE ANALYSIS OF POTENTIAL LOCATIONS SUITABLE FOR AQUACULTURE

DESCRIPTION OF GUAM

Guam is the southernmost island in the Mariana chain and has the best natural harbor available in the chain. Guam is the largest island in Micronesia. It is 30 miles (48 km) long and 4 miles (6 km) to 12 miles (19 km) wide with a land area of 210 square miles (544 km2) and a shoreline of 88 miles (125.5 km). Guam is located in the tropical Western Pacific Ocean at 13.5 N and 144.8 E. It is 1,550 miles (2,500 km) south of Tokyo and 1,590 miles (2,560 km) east of Manila. The closest large US city is Honolulu, which is 3,800 miles (6,100 km) to the Northeast.

While Guam is the largest island in Micronesia, it is still relatively small and potential aquaculture sites are limited by physical, legal and cultural factors. Much of Guam's surface is already heavily developed by either urban or military bases. Other areas, including potential coastal sites are either occupied by the military or are protected from development. This is particularly true of the northern part of the island.

Guam's strategic location in the western Pacific makes it an important US military site. Its proximity to Japan and Korea has resulted in the development of a significant tourism industry with the majority of visitors coming from these nearby countries.

Guam is the business, educational and transportation hub of Micronesia and is connected by direct air service to Palau, Yap and Chuuk. Onward flights from Chuuk connect it to Pohnpei, Kosrae and the Republic of the Marshall Islands. It has excellent air service to Hawaii and many parts of Asia including Taiwan, Hong Kong, South Korea, Japan and Philippines) making transportation of aquaculture products and supplies into and out of Guam feasible.





Guam has a tropical maritime climate with marked wet and dry seasons and limited seasonal temperature variation. The mean annual temperature is 81 F (27 °C) with a mean high temperature of 86 °F (30 °C) and mean low of 76 °F (24 °C). The dry season runs from January to May and the rainy season from July to October with the other months in transition. Total mean annual rainfall is 93 inches (2.36 m) at the airport. One negative aspect of Guam's climate is the frequency of tropical storms and typhoons, which have the potential to cause severe losses and necessitate stronger infrastructure. Guam building codes and infrastructure systems including water and power address the risks from typhoons and earthquakes better than in Hawaii and Asia-Pacific countries. Back-up generators are installed at water wells to pump public water supply in times of power losses.

Guam's climate is well suited to the cultivation of tropical aquatic species. Marine water temperatures range between 27 to 30 degrees. Ambient and water temperatures are higher than in Hawaii, thus leading to higher growth rates for many aquatic species.

GEOLOGY AND HYDROLOGY OF GUAM



Figure 11. Satellite photo of Guam

The northern and southern halves of the island are significantly different in their geology and hydrology. The northern part of Guam is a raised limestone plateau that overlays a volcanic basement. Streams do not exist in the northern section of Guam because of the permeability of the limestone. The northern half of Guam contains the US legally designated "sole-source" aquifer that is the source of more than 80 percent of Guam's water supply. Much of this aquifer floats on salt water forming a basal lens, while other parts of the aquifer rest on the volcanic basement rocks and is termed parabasal. In the floating parts of the lens, it is possible for a well site to produce either fresh or saltwater depending upon its depth. If it is shallow, it will produce fresh water, and if it is deeper, it will produce salt water.

Smaller aquaculture projects on the northern plateau utilize public water supplies, recycle the water and use the effluent for irrigation. The public water is expensive, with high pH, high calcium content and high carbonate hardness. The use of rainwater catchment is not generally practiced.

The protections required by the aquifer designation will limit larger scale aquaculture operations to the area within 1,000 feet of the shoreline. Much of the Northern coastal margin is bounded by stepped limestone cliffs, is incorporated into US military preserves or is highly urbanized. Further limitations imposed by the elevation of the majority of the plateau and the cost of lifting water to such heights will further limit the availability of sites suitable for aquaculture in the northern part of Guam.

The CoreSeed facility is located on a coastal site with both fresh and seawater sources. The seawater produced by the wells on the site is a stable 82 F (27.9 C) with salinity of 34 ppt (parts per thousand); pH is 7.8, which increases upon aeration. Ammonia, nitrites, and nitrates values are all minimal. The fresh water has a salinity of about 1.5 ppt due to seawater intrusion. Typical of northern aquifer water it is very hard due to its passage through limestone and has relatively high nitrate levels. Neither source has had any flow issues due to droughts or other climatic events.

Southern Guam primarily consists of relatively impermeable eroded volcanic basement rocks with isolated areas of limestone caps on the highlands of the southeastern shore. There is a mountain range parallel to the western shore and steep slopes to the ocean. The eastern side has more gentle slopes. Much of the southern half of the island has clay soil of volcanic origin and numerous streams and surface waters. This part of the island is more suitable for the construction of ponds for aquaculture as the eastern half is flatter and has wide valleys. Some aquaculture farms have been located near the southern river mouths.

The low permeability of southern Guam allows less rainwater infiltration, but groundwater discharge contributes 27 to 57 percent of total stream flow in gauged basins. High rainfall events can cause severe flooding (Gingerich, 2003).

Earthen pond aquaculture on Guam is thus severely limited by space and the relative scarcity of water during the dry season. New land based aquaculture businesses on Guam will need to be very water efficient, utilize intensive technology and possibly use tank systems for culture.

The hydrological differences also have significance for water quality and aquaculture. The soils of southern Guam are highly eroded and have very low levels of plant nutrients. This results in very soft water with much lower levels of nitrates and other plant nutrients. However since the soils are highly erodible, they can become highly turbid during the rainy season, while clearing considerably during the dry season. The lower nutrient levels in the waters of the southern streams have resulted in water discharge standards being stricter than those in the northern part of Guam.

The southern part of the island has rivers and numerous farms have been built near the mouths of these as they represent some of the best aquaculture sites. Unfortunately permitting issues may be even more problematic for the southern sites since obtaining permits for pond construction in a flood plain, in or near wetlands or near the designated seashore area is very difficult (see the latter section on legislation and regulations).

Guam's setting in the middle of the Western Pacific provides an immense untapped resource for offshore aquaculture. In the coming few years massive investments will be made in developing offshore aquaculture and Guam's combined resources could make it an excellent location to take advantage of that trend.

SITE SELECTION CRITERIA FOR THE GAIC

Siting/location:

- Located in the coastal zone with clear access to the shoreline
- Size at least 5 acres
- The site should be reasonably leveled
- Not close to river
- High quality seawater available
- Nearshore/offshore Ocean allow ocean net pen farming projects
- Security
- Previous land use
- Away from sources of contamination that would negatively impact aquaculture

Availability of utilities:

- Electricity
- Internet
- Potable water
- Cell phone reception
- Access to roads

CANDIDATE SITES ANALYSIS

GEDA provided the Feasibility team with a set of candidate sites to evaluate for aquaculture development. These sites had been previously identified by GEDA in a search for a new hospital site. The following listing includes the 11 sites identified by GEDA.

Northwest Field Andersen AFB Former FAA Andersen AFB S Finegayan South Finegayan Housing South Finegayan Lot 7163 Andersen South Naval Hospital-Andersen South Barrigada Apra Adacao Harbor Naval UOG Complex Lot 198 Yona Ordnance Annex Lot 508 Merizo

Possible Sites for New Medical Complex (all over 100 acres)

South Finegayan (Navy)

- consists of 289.64 acres and is located west of Route 3 in the Municipality of Dededo across from Astumbo Gardens.
- contains some Navy housing (most appear to have been demolished previously) and is now being used for the 150-bed DoD Expeditionary Medical Facility
- Guam Power Authority plans to construct an alternate energy project (photovoltaic array and substation) that would generate 18 megawatts of electricity on 71 acres located at the southern portion of the South Finegayan property along Route 3 (see Background Information at end)
- The property may experience some noise from aircraft operating out of the Guam International Airport and Andersen Air Force Base.
- Ancestral owners are believed to own most of this property



Adacao (GALC)

- 102 acres transferred by the Navy to GovGuam
- Located across Route 15 from Hawaiian Rock Products
- No ancestral owners.
- No apparent natural or man-made constraints to development



University of Guam

- Public Law 33-02 transferred 140 acres of GovGuam-owned Lot 5397 to the University of Guam for expansion of the Marine Lab and WERI and for use as a conservation reserve and prehistoric site. An undetermined amount of land may be available within this lot.
- Cliff line, historic sites, limestone forests, seashore reserve may pose development constraints



Lot 198, Yona (CLTC)

- consists of 111 acres and is located between the cliffline and shoreline between Pago Bay and Tagachang Bay.
- While its configuration and location may affect developability, there appears to be sufficient acreage to accommodate a new medical complex
- Cliff line, flood hazard, seashore reserve may affect development of the area



Andersen South (GALC)

- Consisting of 395 acres, this property is Spanish Crown property
- located along Route 15 just above property owned by Senator Ted Nelson, the Sgambelluri family and others in the Sasayan area
- GALC attempted to lease this property for industrial/commercial development but the Legislature enacted legislation allowing ancestral owners of property at the airport to trade their Tiyan property for Andersen South. The court nullified the trade but it is believed that ancestral owners may be appealing the court's decision.
- Slide and erosion zone, water wells, historic sites, limestone forests, electromagnetic radiation may affect developability



Former FAA Site (GALC)

- Consisting of 582 acres along the western Guam coastline, this property was transferred to GovGuam by the Navy under Base Realignment and Closure.
- Similar to Andersen South, GALC attempted to lease this property for resort/commercial development but the Legislature enacted legislation allowing ancestral owners of property at the airport to trade their Tiyan property for the former FAA site. The court nullified the trade but it is believed that ancestral owners may be appealing the court's decision.
- the adjacent private property owner is claiming all of the former FAA site as his ancestral property. The status of this claim is unknown at the present time.
- Historic sites, radio frequency interference, aircraft noise and limestone forests affect developability.



Lot 7163-R1, Yigo (CLTC)

- consists of 404 acres located along Route 15 in Yigo
- CLTC attempted to lease the property for quarrying purposes which would terrace the property to allow for residential use by CLTC beneficiaries. However, the Guam Legislature enacted legislation which effectively stopped the lease of the property to a private developer. It is believed that the private developer has or will sue the government to allow it to move forward with the quarrying project.
- Seismic fault, flood hazard, limestone forests, slide and erosion zone may affect developability.



Government of Guam-Owned Parcels (< 100 Acres):

Cross Island Road Talofofo (CLTC)

• 66 acres, outside village, in-land of Cross Island Road



Oka Point (CLTC)

 35 acres at Hospital Point across from Perezville



Lot 5431 Mangilao

Two Lovers Point

research.

Lot 10170-1New-R1 consists of 20 acres Additional GovGuam properties may be adjacent to Lot but need to conduct

- 22 acres, Lot 5431 under CLTC jurisdiction located near Marine Lab
- Portions may have already been leased to the Cushings





LOT 10170-1NEW-R1, TAMUNING

LIGE SPORT LIGE SPORT

Our site evaluations were done from a perspective of finding a site where the GAIC can be developed. The site selection criteria were used to compare sites. As a first step in this process, we developed a rubric to use for site evaluation. The Rubric is listed in Table 5. The rubric was built and used as an Excel spreadsheet where each individual site was scored for all the elements in the Rubric. For a specific site evaluation, a score between 1 and 5 (where a score of 1 is lowest and a

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score of 5 is highest) was recorded for each item in the rubric. These scores were totaled to give a numerical overall score for the site.

Table 5.	Sites	evaluation	rubric.

Major criteria	
1) Site Accessibility	
2) Accessibility to freshwater	
3) Accessibility to Seawater	
4) Available utilities	
5) Prior site usage	
6) Usage conflicts	
7) Contamination	
8) Security	
9) Long term usage (non-Gov Guam)	
7. 0.1	1

Our first application of the Rubric was done to get a preliminary assessment of the 11 sites advanced by GEDA. David Crisostomo and Mike Gawel filled out the rubric and scored the 11 sites. Their individual and combined scores ranked from best to worst are listed in Table 6.

Table 6.	Rubric	site scores	(totals) of	GEDA	sites l	istin	g individual	and	combined	scores	of David
Crisostor	mo (DC)	& Mike Ga	awel (MG)	done 1	1/29/2	21.	Sites are rai	nked	based on	total sco	ore.

Rank	Site Name	MG Score	DC Score	Total Score
1	University of Guam	40	42	82
2	Lot 198 - Yona	40	36	76
3	Lot 5431 - Mangilao	42	30	72
4	Lot 7163-R1, Yigo (CLTC)	39	27	66
5	Cross Island Road - Talofofo (CLTC)	33	32	65
6	Oka Point (CLTC)	28	35	63
7	NCS Beach/Tanguisson	31	31	62
8	Adacao	30	31	61
9	Anderson South	29	22	51
10	Former FAA Site (below cliff)	33	18	51
11	South Finagayan Above/below cliff	28/31	18	48

Six of the sites provided by GEDA were rejected as potential sites (Table 7). They were either too far inland, too high above sea level or inappropriate for other reasons and will not be further considered.

Table 7. Rejected sites with major reasons listed

Rank	Site name	Reason for rejection							
10	Former FAA Site	Private Property - land owner was claiming lands (would be a dispute), also to high elevation (300-400ft elevation)							
8	Adacao	Elevation to high, 300-400ft, inland not near shore, no access to seawa- ter.							
5	Cross Island Road - Talofofo (CLTC)	Too far inland, not close to the coast, high elevation as well.							
6	Oka Point (CLTC)	Elevation too high, too much infrastructure adjacent to site, not enough available area for site and too high in elevation.							
9	Anderson South	Too far inland, too far away from the coast, no seawater access.							
11	South Finagayan	Elevation was too high, too far away from the seawater input.							

Following site visits to all of these sites, three principals (J. Wyban, D. Crisostomo, A. Townsend) compiled a final Assessment for the five remaining potential sites. The combined scores from that effort are listed in Table 8. Note that UOG site still scored highest with NCS/Tanguisson Beach scoring second.

Table 8. GAIC Site Evaluation Final (Scores by Group agreement (DC, AT, JW))

Rank	Site Name	Total score
1	University of Guam (Drone Surveyed)	44
2	NCS Beach/Tanguisson (Drone Surveyed)	36
3	Lot 198 - Yona	31.5
4	Lot 5431 - Mangilao (Drone Surveyed)	31
5	Lot 7163-R1, Yigo (CLTC) (Drone Surveyed)	31

Conclusion

The 2 sites with the highest potential are the University of Guam Marine Lab site and the NCS/ Tanguisson Beach area.

University of Guam

The University of Guam Marine Lab site scored the highest of all sites considered in both evaluations. This is primarily due to the site's seaside location with access to high quality seawater and other infrastructure needs. We conducted a drone assessment around Marine Lab and observed the available land is limited (less than the needed 5 acres) and the nearby government lands are probably unusable because of steep cliffs. This site deserves further evaluation to determine exactly what the boundaries of the land are and how much land could be developed for GAIC.



Figure 12. Satellite image of UOG Marine Lab and WERI.

NCS Beach/Tanguisson

The second highest scoring property was the NCS/Tanguisson Beach area. There is about 5 acres of flat seaside land above the NCS Beach which would be a perfect site for GAIC. Despite several concerns about the site's history (i.e. a power plant oil spill in the 80s and a citizen's death possibly caused by eating seaweed from the ocean in the area in the 90s) the site could be a perfect location for GAIC.

The US government has offered a Quitclaim Deed to the Government of Guam for the Tanguisson Beach Lot property. While the property is listed as 13.74 acres, most of that land is occupied by a steep cliff. An additional caveat about the TCS Beach is the documented presence of radon at the site. Radon is present throughout northern Guam. Its accumulation within living and working structures, if excessive, is controlled by buildings' design. This should not discourage plans for aquaculture facilities.



Figure 13. Tanguisson Beach site satellite image.

Recent proposals to develop a large resort in this area (https://www.pncguam.com/groupopposes-mammoth-vista-del-mar-development/) complicate the issue. The uncertain status of the abandoned Tanguisson Power plant further complicates this situation. At this time, we recommend that the Governor request the US Navy to fund and complete a Tanguisson Power plant Decommissioning Project. Once completed, the site could become part of GAIC facilities if sited at NCS Beach.

Based on the site evaluations, the NCS/Tanguisson Beach area is recommended for the new GAIC facility.

FINANCIAL ANALYSIS

ECONOMIC POTENTIAL OF THE AQUACULTURE SECTOR

Guam's economy has a narrow base, which needs to be broadened. The economy is mainly based on military, government, and tourism expenditures. Aquaculture has the potential if developed in an organized, comprehensive, and dynamic manner to add to Guam's economic stability and selfreliance.

The goals and objectives stated in the 2020 Community Economic Development Plan (CEDS) for agriculture are applicable to aquaculture. The goals include less dependence upon imports, improving the economy through buying food products from the local economy instead of imports, reduction in cost while upgrading the quality of the products, increased employment, promotion of exportation, and strengthening and diversifying the economic base. These basic goals and objectives are common to all commodity production-oriented industries and aquaculture on Guam has the potential of fulfilling all of them in a reasonable timeframe (5-7 years) with sound planning, policies and financial support.

The vast majority of food products consumed on Guam are imported. Fish and seafood products are no exception with approximately 5 million pounds worth \$20 million imported annually including \$7 million of shrimp (Department of Commerce, Annual Economic Review 2018). This high reliance on imports has a detrimental effect on the economy. Local aquaculture production is less than 5 percent of the total consumption of fish and seafood products on Guam.

Import substitution by aquaculture would result in a reduction of imported food products and would have a positive effect on Guam's economy. Replacing imported seafood with Guam aquaculture products would increase the Net Island Product and strengthen the economy. Development of Guam's aquaculture industry would thus contribute to food security and strengthen the local economy.

In addition to the benefits of import substitution and the diversification of Guam's economy, there is also potential of developing an export industry for aquaculture products. The best near-term aquaculture export product is SPF broodstock. There is a large Asian shrimp industry demand for SPF Broodstock of about 2 M pieces per year worth \$50/piece equaling a \$100 M per year market.

In the longer term, high value marine finfish have excellent export potential. It is difficult to determine the extent of the benefit Guam's economy will receive, since much of the information needed is not available, however, it would have a positive effect on the foreign trade multiplier through establishing an export product and by reducing imports along with increased capital investment in Guam's economy.

FINANCIAL MODELS

Aquaculture in Guam was most productive in the 1990s. Table 9 lists data from Government of Guam and FAO showing production value by species of the Guam aquaculture industry in the 90s.

Year		Shrimp		Tilapia		Catfish		Milkfish		Mullet		Total
1990		1	\$	834,775	\$	217,016	\$	478,865	\$	742	\$	1,531,398
1991	\$	13,321	\$	799,649	\$	131,851	\$	292,000	\$	10,684	\$	1,247,505
1992	\$	156,017	\$	898,007	\$	114,650	\$	208,552	\$	4,067	\$	1,381,293
1993	\$	309,416	\$	969,111	\$	133,262	\$	202,653	\$	3,077	\$	1,617,519
1994	\$	355,601	\$	720,909	\$	188,547	\$	141,092	73	man -	\$	1,406,149
1995	\$	40,004	\$	263,977	\$	32,748	\$	1,281,210	\$	280	\$	1,618,219
1996	\$	183,750	\$	281,250	\$	54,770	\$	918,440	23	31.	\$	1,438,210
Mean	\$	176,352	\$	681,097	\$	124,692	\$	503,259	\$	3,770	\$	1,462,899

Table 9. Guam Aquaculture Production (1990-1996) - Total Value (\$)

Table 10. Mean production, value and price in 1990-1996 (FAO)

Production (lbs)	Shrimp	Tilapia	Catfish	h	Milkfish		Mullet	Total
Avg Production (lbs)	24,782	234,662	34,508	2	127,024	1.	1,013	418,159
Avg Value	\$ 176,352	\$ 681,097	\$ 124,692	\$	503,259	\$	3,770	\$ 1,462,899
Avg Price (\$/lb)	\$ 7.12	\$ 2.90	\$ 3.61	\$	3.96	\$	3.72	\$ 3.50

The mean amount of production per year between 1990 and 1996 was 418,159 pounds (Table 10) worth \$1,462,899. These data are from actual Guam aquaculture producers. These numbers are a valid benchmark against which a financial model can be developed. If the Guam industry can be resurrected to match the industry that existed in the 90s, it could produce this amount. It must be recognized that the industry in 90s listed in Table 9 was not benefitting from any of the modern technology available to aquaculture today such as improved genetics, better feeds, and better overall management. Using the mean data from the 90s as a base line, a financial projection for resurrecting that industry but adopting/utilizing modern technology, the industry could grow. Projections based on the base scenario followed by reasonable increases are provided in Table 11.

PROJECTIONS USING EXISTING SPECIES AND NEW TECHNOLOGIES

Table 11. Projected production (lbs) of Guam aquaculture using 1990s industry as base model with improved technologies.

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Production	Shrimp	Tilapia	Catfish	Milkfish	Mullet	Total
2.44. 4						
Low Case	50,000	250,000	50,000	100,000	1,000	351,000
2.141						
Avg Case	150,000	500,000	100,000	250,000	10,000	760,000
	Y LIV. V N					
High Case	500,000	1,000,000	250,000	500,000	25,000	2,275,000

Table 12. Projected value in USD of Guam aquaculture using 1990s industry as base model with improved technologies.

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Value	 Shrimp	187	Tilapia	Catfish	2.3	Milkfish	Mullet	Total
Price (\$/lb)	\$ 12.00	\$	4.50	\$ 5.00	\$	5.00	\$ 5.00	
Low Case	\$ 600,000	\$	1,125,000	\$ 250,000	\$	500,000	\$ 5,000	\$ 2,480,000
Avg Case	\$ 1,800,000	\$	2,250,000	\$ 500,000	\$	1,250,000	\$ 50,000	\$ 5,850,000
High Case	\$ 6,000,000	\$	4,500,000	\$ 1,250,000	\$	2,500,000	\$ 125,000	\$ 14,375,000

Seedstock required and value of seedstock for the production scenarios listed in Table 13 & 14.

Table 13 Projected seed requirements for the scenarios presented in Table 11 and 12.

Production	Shrimp	Tilapia	Catfish	Milkfish	Mullet	Total
	1.2.3					
Low Case	1,666,667	396,825	214,286	285,714	2,041	2,565,533
	5 ~ 20	/				- 11-237
Avg Case	5,000,000	793,651	428,571	714,286	20,408	6,956,916
	22					5
High Case	16,666,667	1,587,302	1,071,429	1,428,571	51,020	20,804,989

Table 14 Projected value of seed requirements in USD for the scenarios presented in table 11 and 12.

Value	Shrimp	all 1	Tilapia	N	Catfish	Milkfish	Mullet		Total
Price	\$5/1000		\$0.2/pc	12	\$0.2/pc	\$0.2/pc	\$0.2/pc	1	
Low Case	\$ 8,333	\$	79,365	\$	42,857	\$ 57,143	\$ 408	\$	188,107
Avg Case	\$ 25,000	\$	158,730	\$	85,714	\$ 142,857	\$ 4,082	\$	416,383
High Case	\$ 83,333	\$	317,460	\$	214,286	\$ 285,714	\$ 10,204	\$	910,998

These data indicate that a low case of production with traditional species and improved technologies could be \$2.6 million per year while the medium case is \$5.8 M and best case is \$14.4 M.

PROJECTIONS USING NEW SPECIES AND TECHNOLOGIES

Projections for production and value of new aquaculture species/products are listed in Table 15 and 16

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		1							0

Production	SPF Broodstock (pc)	Marine Finfish (lb)	Ornamental (pc)	Crabs (lb)
Low Case	20,000	150,000	50,000	100,000
Avg Case	40,000	250,000	100,000	250,000
High Case	100,000	500,000	250,000	500,000

Table 16 Projected value in USD of Guam aquaculture with new species and technologies.

	1112			_			- A - 7a -				19.0.1	
	Value	SPF	Broodstock	М	arine Finfish	0	rnamental	2rl	Crabs	E	103	Total
	Price (\$/pc or lb)	\$	40.00	\$	20.00	\$	20.00	\$	12.00	6	20	152
	Low Case	\$	800,000	\$	3,000,000	\$	1,000,000	\$	1,200,000	\$	6,0	00,000
A	Avg Case	\$	1,600,000	\$	5,000,000	\$	2,000,000	\$	3,000,000	\$	11,6	00,000
3	High Case	\$	4,000,000	\$	10,000,000	\$	5,000,000	\$	6,000,000	\$	25,0	00,000

These data indicate that a low case of production with new species & technologies could be \$6 million per year while the medium case is \$11.6 M and best case is \$25 M.

Calculations of seedstock required and their value are listed in Table 17 and 18.

Table 17 Projected seed requirements for the scenarios presented in table 15 and 16.

		/ 114 1 2 1 1 1 1				
122	Production	SPF Broodstock	Marine Finfish	Ornamental	Crabs	Total
275	Low Case	40,000	300,000	100,000	200,000	640,000
$\langle \rangle$	Avg Case	80,000	500,000	200,000	500,000	1,280,000
~	High Case	200,000	1,000,000	500,000	1,000,000	2,700,000

Table 18 Projected value of seed requirements in USD for the scenarios presented in table 15 and 16.

Total	Crabs	Ornamental	rine Finfish	Ma	= Broodstock	SP	Value
17	\$25/1000	\$2.00/pc	\$1.00/pc	1~	\$10/1000	E.	Price
505,400	\$ 5,000	\$ \$ 200,000	300,000	\$	400	Ş	Low Case
913,300	\$ 12,500	\$ \$ 400,000	500,000	\$	800	Ş	Avg Case
2,027,000	\$ 25,000	\$ \$ 1,000,000	1,000,000	\$	2,000	\$	High Case

TAX REVENUE GENERATION

A previous study entitled, the *General Feasibility Analysis Prawn Aquaculture on Guam* estimated income generated and the revenue returned to the Government from a prawn aquaculture industry. Following the model used in that study, an intermediate size prawn industry would generate \$5.2 million in income and 97 full-time jobs as a result of this new industry (Aquatic Farms, 1979).

Low case Medium case same species High case Annual sales \$2.5 million \$5 million \$12 million \$ 32,000-62,000 \$140,000-250,000 \$380,000-680,000 Income Tax \$ 16,800 **Gross Receipts Tax** \$ 16,800 \$ 16,800 \$ 20,010 \$ 2,015 \$ 6,870 **Property Tax** Total Tax Revenue \$ 50,815-80,815 \$163,670-273,670 \$416,810-716,2810

Table 19 Annual Tax Revenue generated by aquaculture industry development

The sources of revenue include income tax revenues resulting from the increased income of farmers, wholesalers, and retailers; tax revenues generated from gross receipts of wholesalers and retailers marketing aquaculture products who do not specialize exclusively in agricultural and fisheries products and any increase in property taxes resulting from improvements on aquaculture farms.

There have been some criticisms of the property tax on agricultural land, which increases property taxes as the land is developed. An alternative tax law that acts as an incentive to develop idle agricultural land and put into production by taxing idle undeveloped agriculture zoned land at a higher rate than that charged on in-production agricultural land. Under existing Guam zoning law (from 1966) all land not zoned commercial, residential or industrial was by default zoned "agricultural" and includes major areas not suitable for agriculture and many areas that are more valuable for other zone uses. Many agricultural lots have been rezoned piece-meal through a tedious process to allow appropriate developments. Chamoru Land Trust properties leased for agriculture could benefit from enforcement of their use for production.

An initial implementation of such a modification to the property tax law could involve the elimination of property tax on producing agricultural land while maintaining the current tax on idle agricultural zoned land. The greater the disparity between such a taxation rate the greater the effectiveness as an incentive. The revenue generated by property tax on agricultural zoned land is rather low as illustrated in Table 19. The revenue lost by the elimination of property tax on developed and productive agricultural land would be minimal compared to the total revenue from the industry. This total revenue could actually be significantly increased by additional revenue generated through income tax and gross receipts with the implementation of such incentives to expand the industry at different stages of development.

TAX AND OTHER FINANCIAL INCENTIVES

LOCAL INCENTIVES

The **Guam Economic Development Authority (GEDA)** is a public corporation with broad responsibility for the centralized direction, control and supervision of an integrated plan for the economic development of Guam. GEDA's mission is to develop a sound and sustainable economy through innovative programs that preserve and promote local culture, economic opportunities and quality of life.

The most useful assistance that GEDA can provide are tax incentives. GEDA is authorized by law to allow a variety of tax incentives to encourage new investment by qualified investors. GEDA can grant Qualifying Certificates to investors on the basis of investment commitment, potential for creating employment and expanding the base of the island's economy. These incentives are intended primarily for manufacturers, insurance underwriters, commercial fishing operations, corporate headquarters, agricultural operations and the tourism industry.

These tax incentives for qualified firms may include:

- Up to 75 percent in income tax rebates up to 20 years
- 100 percent abatement on real property tax up to 10 years
- A maximum of 75 percent rebate on corporate dividend tax up to five years
- Abatement on gross receipts tax on petroleum and alcoholic beverages made in Guam for up to 10 years.

GEDA currently administers three economic development loan programs through its Loan Department in the Financial Services Division. The current availability of assistance through the programs varies.

The Guam Development Fund Act Loan Program or GDFA was created in 1968 by a direct appropriation of \$6 million from U.S. Congress. The purpose of the GDFA is to provide financial assistance through loans and loan guarantees to private enterprises and industries thus promoting the economic development of Guam.

The Agricultural Development Fund or ADF intended market is limited to individuals, corporations and partnerships that engage in commercial agricultural business. Activities include agriculture, aquaculture, and horticulture and other closely related areas. The program enables bona fide farmers and a commercial farming enterprise to obtain a Line- of-Credit to finance working capital and to provide funding for the purchase of supplies and inventory.

The Micro Loan Program provides financial assistance to support the establishment, stabilization and expansion of a "Micro" or "Small" business which demonstrates the potential for job creation, especially jobs which would be available to low and moderate- income individuals or a "commercial enterprise" with the desire and spirit to succeed in one entrepreneurial endeavor.

The **Division of Agricultural Development (DAD)** has two main programs of interest to aquaculturists: 1) the Agricultural Water Rate program which provides for a reduced water rate for qualified

individuals engaged in crop and livestock production, aquaculture and horticulture; and 2) the Farmers Registration program, a one-time registration for farmers and producers to be eligible for compensation of farm losses due to a natural disaster (this compensation requires a disaster declaration and is dependent upon appropriation of funds from the Legislature).

FEDERAL AGENCIES

Within the **United State Department of Agriculture** there are several agencies that offer assistance to aquaculturists and prospective aquaculturists.

USDA Rural Development (USDARD) has several programs with the potential to assist aquaculture development on Guam. The USDARD programs for Guam are administered out of Hawaii. For aquaculture, these may include:

- Rural Housing Programs- it makes loans and grants to provide rural residents with housing. These programs provide financing either through a direct loan or a guarantee of a loan from a private financial institution.
- Rural Business it provides financial assistance to rural businesses and cooperatives by helping to fund projects that create or preserve quality jobs and/or promote a clean rural environment.
- Community Facilities Programs it provides loans and grants for essential community facilities. These loans and grants help rural communities remain economically viable and enable rural businesses to provide jobs and services to area residents.

The **Farm Service Agency (FSA)** has an office in Guam which provides FSA program services to several of the island territories in much of Micronesia. The FSA administers farm commodity, crop insurance, farm credit, and conservation programs for farmers. FSA programs are primarily directed at agricultural producers or, in the case of loans, at those with farming experience. Some of these programs are:

- Guaranteed Loans the FSA can guaranty a loan from a local agricultural lender who makes and services the loan with a maximum guarantee of up to 95 percent.
- Direct loans are made with Government funds and serviced by FSA officials, who also provide borrowers with supervision and credit counseling.
- The Emergency Conservation Program provides emergency funding for farmers and ranchers to rehabilitate farmland damaged by natural disasters.
- Noninsured Crop Disaster Assistance Program (NAP) provides financial assistance to producers of non-insurable crops when losses occur due to natural disasters.

The **US EPA Brownfields Program** should be considered to clean-up the selected site for the GAIC and development funding.

REGIONAL AGENCIES

The **Center for Tropical and Subtropical Aquaculture (CTSA)** is the regional aquaculture center of USDA for Hawaii and the U.S. Affiliated Pacific Islands. CTSA is administered jointly by the

University of Hawaii and the Oceanic Institute. It provides grants for aquaculture research and extension. The program is directed by an Industry Advisory Committee of which Guam is a member. The CTSA has funded numerous projects on Guam over the years for research at the GADTC, WPTRC, GCES and the UOGML. It has numerous publications on regional aquaculture subjects available on its website at http://www.ctsa.org/.

The **University of Hawai'i Sea Grant College Program (UH Sea Grant)** is part of a national network of 32 university-based programs that promote better understanding, conservation and use of coastal resources. There are currently three PhD. level extension agents serving aquaculture. The Sea Grant Program also funds innovative aquaculture research every year. It has served the other Pacific Islands over the years and has generated much useful information on aquaculture in the region.

Secretariat of the Pacific Community (SPEC) based in Noumea provides aquaculture information. Guam, CNMI and Micronesian countries as well as the US are full members of this regional organization.

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DIRECT AND INDIRECT EMPLOYMENT IMPACT

Local production from both fisheries and aquaculture amounts to an estimated 427,000 pounds (Aquatic and Wildlife Resources Annual Report, 2018). This is less than 10 percent of the total consumption of fish and seafood products on Guam. Development of the local aquaculture sector can provide both direct and indirect employment opportunities. Fitzgerald (1980) argued that using the Multiplier Effect on an import based economy:

"For every \$1000 in income put into the economy (e. g., government salaries) \$5000 in income in an economy would be generated that does not rely on imports, while an economy based heavily on imports generates only \$1250. Assuming an average of 23 percent is spent on food (Guam Consumer Price Index Quarterly Report Vol. VII, No. 2, April 1980), the reduction of reliance on imported food products would have a significantly positive effect on Guam's economy. The closer Guam comes to replacing imported goods with products produced on Guam and/or increasing exports so as to increase the Net Island Product, the stronger the economy becomes with more of the income generated benefitting the residents of Guam plus a larger revenue base for the government to draw upon. Development of Guam's aquaculture industry provides a means to progress towards self-sufficiency and the development of a sounder economy."

The multiplier effect of a seafood industry, which aquaculture could be considered part of, is relatively high compared to most other industries, which makes a single additional job in fisheries more significant than a new job elsewhere. This is attributed to the handling, packing, processing, and the support activity to the fish catching or culturing process. A Rhode Island study (Coastal Resource Management Council, Rhode Island, 1978) indicated a seafood industry multiplier of 4.24 as compared to 1.69 for the average industry of that state. Similar calculations for other states vary according to the amount of onshore fisheries related activity. For example, in Oregon it was calculated at 2.7 to 3.0 (Joint Standing Committee on Marine Resources, Maine, 1979) and in Maine it was estimated at 7.0 (Maguire, Inc., 1978).

Manpower requirements for aquaculture have been estimated on the basis of past observations to be 1.2 full time equivalent jobs (FTE) for each five-acre farm increment (Aquatic Farms, Ltd., 1979). In addition to these newly created direct positions, 1.7 FTE indirect jobs will be established for each direct job. The 100 acres of prawn ponds supported by the proposed hatchery will therefore create 24 FTE direct jobs and 41 FTE indirect jobs for a total of 65 FTE jobs.

A comparison to Hawaii aquaculture is relevant. NELHA in Hawaii contracted the University of Hawaii Economic Research Organization (UHERO) to estimate its economic impact on the State of Hawaii. To estimate expenditures made by NELHA tenants in 2018, UHERO researchers developed a survey where expenditures were broken down into 17 named categories and respondents were asked to provide total expenditures in 2018 and the share of these expenditures that were paid to Hawaii vendors. UHERO received responses from 36 NELHA companies (out of 44). Expenditure levels for the survey non-respondents were estimated using various techniques. Total NELHA tenant expenditures were estimated at \$92.4 million, of which approximately \$64.5 million (or 70%) were paid to Hawaii entities. Following a standard approach, UHERO defined economic impact to be the direct, indirect, and induced economic activities generated by the tenant's spending in the Hawaii economy. The impact of NELHA's in-state expenditures in 2018 on the State's output (sales), earnings, and tax revenues was estimated to be \$104 M, \$26 M, and \$4.8 M respectively. 70

Furthermore, not only do NELHA tenants employ hundreds of people but their expenditures also contribute to hundreds of other jobs in the larger Hawaii economy (509 total excluding NELHA employees; NELHA itself employs an additional 17 people).

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REVIEW OF LEGAL, REGULATORY, AND POLITICAL CONSTRAINTS AND POLICIES

TERRITORIAL GOVERNMENT AQUACULTURE POLICY

US aquaculture development has been identified as an national interest and has been given priority status through congressional mandates (e. g., National Aquaculture Act of 1980; National Academy of Science, 1978; Committee on Merchant Marine and Fisheries, 1975). It is the responsibility of the state to encourage investment of the private sector (local and foreign) in the development of aquaculture. Guam currently does not have an aquaculture policy. The Government of Guam must adopt an aquaculture policy that is conducive to aquaculture development. This has been exemplified in Hawaii with its supportive legislation and programs in aquaculture.

The aquaculture policy should recognize aquaculture as a desirable form of economic activity which can lead to economic development while ensuring environmental sustainability and supporting the culture of Guam. It should include:

- Develop a Department of Aquaculture in Guam Government responsible for aquaculture development and permitting support. This is necessary to reduce division of responsibilities to different agencies (i.e. "siloing") which leads to duplication of efforts and facilities and bureaucratic bottlenecks in the developing industry development support.
- 2) Extend all programs and services available to agriculture to aquaculture. This has been seen in recent agricultural legislation in which aquaculture is defined as an activity of agriculture.
- 3) Passage of legislation stating support of aquaculture development by Guam Government.
- 4) Give preference to the lease of Government of Guam land for aquaculture use where designated by the Department of Land Management for agricultural use (P. L. 15-18).
- 5) Aquaculture should be identified as a coastal-dependent activity and acknowledged in coastal land use plans. Coastal-dependent developments should have priority over other development on or near the shoreline. A simple definition of coastal- Make a provision for the practice of aquaculture within the 100m coastal setback zone where its practice would not adversely affect the environment. If properly sited and designed, aquaculture is a coastal-dependent use that can be compatible with other existing coastal land uses.
- 6) Aquaculture should be given high priority consideration in all land use plans. This should include the use of conservation areas for aquaculture where suitable.
- 7) Aquaculture should receive priority consideration in the use of water supplies from surface waters such as those created by reservoirs (e.g., Ugum River Reservoir).
- 8) Aquaculture can play a significant role in Guam's economic development. Best utilization of Guam's natural resources should emphasize that aquaculture can provide

LEGISLATION

One critical aspect of aquaculture industry development is the regulatory framework that governs aquaculture development. As a Territory of the United States, Guam has the same environmental standards as the US mainland and must comply with all federal environmental laws. These laws were promulgated to protect our natural resources from overexploitation and irresponsible development; therefore regulatory standards which the aquaculture industry must meet can be formidable. This reality creates a formidable barrier to entry for aspiring aquaculture developers either through general prohibitions of proposed activities or by increasing the cost of doing 72
business to a point where the venture is unprofitable.

Numerous US federal and local Guam environmental laws regulate everything from facility siting, raw water sources, how and where wastewater is discharged, and the selection of culture species, to the preparation of fresh product for sale. Knowing and understanding the reasons for these regulations is crucial to the initial planning stages for any potential aquaculture venture.

The permitting of aquaculture activities can be a difficult process depending upon site limitations, facility design, and the species choice to be cultured. Under certain circumstances, multiple permits will be required from different agencies for the same activity. The applicant must possess all of the required permits for a proposed action prior to commencing construction.

Site selection is another very important step. It will be virtually impossible to identify an aquaculture facility site that will be free of regulatory constraints. However, certain sites will have a greater regulatory burden than others. It is highly recommended to conduct a preliminary assessment of the regulatory requirements of any potential aquaculture site prior to investing in a land lease or purchase. It may be prudent to make the land lease or purchase contingent on the issuance of all the necessary permits.

It should be emphasized that permitting is only one issue that needs to be examined when developing an aquaculture business plan. Other equally important issues to consider include determining the target culture species and development of a marketing strategy. Both have their own set of regulations. In this regard, the importance of early and regular communication with regulatory agencies, local extension agents, and other development agencies cannot be stressed highly enough. While forms and permits exist for most activities, this does not mean that permission will be granted by the agency in question. This is particularly pertinent to the importation of non-native species and use of the marine environment for aquaculture.

Guam has several regulatory agencies that are involved with the permitting of aquaculture facilities. These include the Guam Environmental Protection Agency (GEPA), Guam Coastal Management, and the Guam Department of Agriculture, Division of Aquatic and Wildlife Resources (DAWR).

The Federal Government also has regulatory jurisdiction over much of the marine and freshwater resources in Guam, mainly under authority of the Clean Water Act and the Rivers and Harbor Act of 1899. Administrators of these permitting programs include the U.S. Army Corps of Engineers (USCOE) and the U.S. Environmental Protection Agency (USEPA). Assessment of project impacts on federally listed endangered species is usually addressed during the processing of federal permits that a proposed aquaculture facility may require.

Table 20. Overview of regulatory agencies on Guam applicable to the aquaculture sector, their mandate and permits required.

Agency	Mandate	Permits
Guam Land Use and Sea- shore Protection Commis- sions	Zoning, land use and sea- shore protection	Permit for aquaculture in wetland areas and where zoning variance is required (e.g. wetland area de- velopment permit, seashore clear- ance permit)
Guam Environmental Pro- tection Agency	Protection of wetlands and water quality	Clean water act permits: -Water quality certification -Clearing and/or grading permits -Water pollution discharge permit -Well drilling permit -Air pollution permit
Division of Aquatic and Wildlife Resources	Introduction of aquatic species, associated dis- eases, and potential im- pacts on native fisheries and wildlife	Import permits for seed and broodstock.
Bureau of Statistics and Plans - Guam Coastal Man- agement Program	Conservation and sustain- able growth	Coastal zone management consis- tency certification
Guam Historic Preservation Office	Guam Historic Preservation Office	Section 106 permitting

For details on these agencies and permits see Annex 1: Guam Regulatory Programs. Annex 1 also provides an overview of applicable federal legislation.

NOAA Fisheries, in coordination with the Western Pacific Fishery Management Council, prepared a Draft Programmatic Environmental Impact Statement (DPEIS) that analyzes the potential environmental impacts of a Federal aquaculture management program for the Pacific Islands Region (including Guam). The DPEIS analyzes management alternatives for off-shore aquaculture in Federal waters of the Pacific Islands. Under current Federal fisheries management, NOAA does not require a permit or otherwise regulate aquaculture in Federal waters, with limited exceptions. Creating a potential aquaculture management program would support sustainable development of offshore aquaculture and ensure protection for the region's physical, biological and socioeconomic environment.

SUPPORTING AGENCIES

The **Natural Resources Conservation Service (NRCS)** can work on public and private lands and assist in (1) the efficient use of soil and water, (2) protection of the basic resource, including soil and water, and (3) meeting the environmental needs of the community. The NRCS has its Pacific Islands Area Office on Guam in the First Hawaiian Bank Building and a Guam field office which is located at Barrigada Plaza, Suite 101, 494 West Route 8, Barrigada, Guam. Their work is done in cooperation with local Soil and Water Conservation Districts of which Guam has two - the Northern and Southern Districts.

The NRCS provides technical assistance in conservation, development, and utilization of soil and water resources through best management practices to meet the objective of the landowner while protecting the resource. Even though NRCS has no specific program for aquaculture, it is incorporated in its conservation programs and includes:

- Engineering assistance in design of ponds, reservoirs, raceways, dams, waste disposal and water supply systems, and related facilities.
- Interpretation of soil information in the selection of sites for facilities such as ponds, reservoirs, and waste disposal systems.
- Agricultural Management Assistance (AMA) provides cost share assistance to agricultural producers to voluntarily address issues such as water management, water quality, and erosion control.

The NRCS Pacific Islands website is: http://www.pia.nrcs.usda.gov/

The **Farmers Cooperative Association of Guam (FCAG)** was founded in 2007. It was assisted through a USDA, Rural Development Small Minority Producer Grant in conjunction with the University of Guam, Cooperative Extension Service. The objective at the heart of the FCAG mission is to substitute imported produce with local produce through the FCAG's marketing and production coordination efforts. The first target market is the island's hotels and restaurants. Key to this is developing the partnership between the FCAG, Guam Hotel and Restaurant Association, Micronesian Chefs Association, GCES, and the GDA. The FCAG was predated by the **Guam Aquaculture Association** which was established in 1980 and its predecessor, the **Guam Aquaculture Growers Association**, which operated in the late 1990's. There is no active association dedicated sole to aquaculture on Guam.

The website of the Farmers' Coop is: http://guamfarmers.org/

The UH Sea Grant has partnered with the **Pacific Aquaculture & Coastal Resources Center** (**PACRC**) of the University of Hawai'i at Hilo to form a regional center for excellence in Aquaculture. They publish the Hawai'i Aquaculture newsletter and support commercial aquaculture, fisheries and eco-tourism, and transfer technologies developed and tested at the Center to similar coastal areas throughout the world.

The US Sea grant website is: <u>http://www.soest.hawaii.edu/SEAGRANT/index.php</u>

The PARRC website is: http://pacrc.uhh.hawaii.edu/

The **Secretariat of the Pacific Community (SPC)** supports an aquaculture section that has the mandate of supporting aquaculture through its member communities. Guam is a member of the SPC and garners support from this group.

The SPC Aquaculture website is: http://www.spc.int/aquaculture/

The Pacific Aquaculture Association (PAA) was officially formed on July 19, 1989 at a regional aquaculture meeting held in Pohnpei and sponsored by the U.S. Department of Interior. It

stopped functioning in the 1990's. PAA's function was to promote and assist the development of aquaculture as a vehicle for economic and social advancement in the U.S. affiliated Pacific islands. This would be achieved through regionally coordinated planning, education, and financial and technical support. Recent discussions with regional stakeholders suggest that reviving a regional association may be useful. Recently, stakeholders in the Marshall Island began the process to legally constitute the **Pacific Islands Fisheries and Aquaculture Association (PIFAA)**. The Marshall Islands Marine Resources Authority was the convening authority. This new organization could serve a similar purpose as the PAA and become a source of US funding for island aquaculture like the old PAA

SECONDARY AND TERTIARY BUSINESS SUPPORT OPPORTUNITIES

Besides the function as a primary sector, developing the aquaculture industry will provide secondary and tertiary business opportunities. The secondary and tertiary industry in the aquaculture sector consists of post-harvest activities such as processing, storage, transportation services, administration (permitting, monitoring and evaluation, certifications), restaurants, education, and social projects. These activities can generate additional jobs and income.

Potential projects in the aquaculture sector to support secondary and tertiary businesses:

- Develop a contract grower's program where a company provides fingerlings and feed to the grower and buys the market size products back. Such a program could be Pacific region wide with Guam as central hub for input provision and capacity building activities.
- Processing businesses making value added products from aquaculture products by further processing (e.g. filleting, smoking, salting, or drying) or making food products such as sausages, soups, burgers or fish fingers.
- Waste valorization which is reuse of processing waste and farm effluent for other projects. Aquaculture processing wastes could be cooked into fish meal to be incorporated into local feeds supply.
- Genetic improvement programs and other research activities. Genetic programs are crucial in increasing the efficiency and sustainability of aquaculture. Other research could be done on improving sustainability and efficiency of feeds, vaccine development and using innovative farm technologies.
- Laboratories for water quality testing, soil testing (pond aquaculture) residue testing in products etc. To ensure food safety, aquaculture operators need to adhere to certain standards. To prove that operations are within set limits they send samples to laboratories for testing.
- Ice manufacturing. After harvesting it is necessary to maintain the fish or seafood on ice to
 ensure food safety and quality. Chilling should commence as soon as possible after harvesting
 and fish should be transported and processed with care and minimum delay. Temperature
 should be kept below 4°C since bacteria reproduce rapidly between 4 and 60 °C. To ensure
 this, the industry needs access to high quality ice made from potable water.
- Aquaculture supplies production such as tanks, nets, feed, filtration equipment etc. Usually these are important but common used materials can be produced locally, benefiting both producer and aquaculture operators.

CONCLUSION AND RECOMMENDATIONS

Increasing aquaculture production on Guam is a huge challenge. Competition for land, labor and water supplies, combined with high-energy costs mean that aquaculture production has to be high performance and efficient. Most of the inputs required for modern aquaculture such as feed, specialized equipment, and fuel to make electricity must be imported from great distances. As a result, Guam is a high-cost location for aquaculture production. For the industry to thrive, the high costs will have to be offset by high prices for its products combined with efficient technologies.

For the Guam aquaculture industry to achieve the high prices of its products that it needs to develop, it must focus its efforts on three areas: supplying live or extremely fresh and high-quality seafood to the local market, supplying niche markets in which Guam has a competitive advantage, supplying very high priced export products such as SPF Broodstock and possibly supplying seed for augmenting local reef fisheries.

A primary conclusion is the need for an on-island supply of seedstock for the various cultured aquatic species. In the mid to long term, this could be achieved by including a multispecies hatchery as part of the GAIC. This is of utmost importance, since without a reliable seedstock supply the industry cannot develop. This is the base of the aquaculture industry. Insight into how the industry should be organized and scenarios for the development of the industry including the provision of a seedstock supply.

A major detriment to the development of the aquaculture industry is the lack of a coordinated government program for aquaculture. This could be overcome by developing a Department of Aquaculture within the Government of Guam.

The local market has been and will continue to be the main thrust for the local aquaculture industry. Its main products, tilapia, shrimp, and milkfish are all available as lower cost commodity products imported from Asian sources. The local industry has succeeded in producing a high-quality product and receives a price premium over the imported product. However, both tilapia and milkfish are not considered premium seafood products. The industry strongly desires one or more high-end products such as groupers, snappers or mangrove crabs. Efforts should continue to develop these.

Guam has clean, disease free waters and excellent air connections to many Asian markets. Several classes of products could utilize this advantage: SPF shrimp broodstock, domesticated seed stock for other high value aquaculture species, SPF broodstock of additional species for the Asian industry, live or extremely fresh high valued seafood as a premium product and specialty products for the aquarium industry.

Investors expect to receive the necessary governmental permits before they invest in the process. The government needs to clarify and streamline the permitting process and develop a one-stopshop where candidate projects can secure their necessary permits with a reasonable amount of effort and time.

Guam aquaculture is modestly productive. Many existing farms sit idle while their owners wait for permitting issues to be resolved. While 90 percent of Guam's food supply is imported, Guam's local people and Asian visitors are big seafood consumers. The reefs of Guam and Micronesia are home to the greatest marine biodiversity on the planet. However, lack of a comprehensive

aquaculture growth strategy and necessary policies and investments have prevented Guam from unlocking the enormous potential of a modern aquaculture industry.

The development of aquaculture on Guam could supply high quality fresh seafood that supports the local economy and creates important jobs in the community. The very high cost of land, labor, energy and other inputs is a significant disadvantage for Guam and provides a challenge to compete with the Asian market. However, Guam's uniform warm climate is conducive to rapid growth of many tropical species that occur in Guam. Guam's strategic location near the Asian markets, is an opportunity to enter and compete in this large market. The application of advanced technology intensive aquaculture systems of high value crops could allow sustainable intensification and higher production per unit area and allow Guam to compete in the world market. Development of aquaculture products should focus on high value products such as SPF Shrimp Broodstock, marine shrimp for food, high value marine fish such as grouper, and high value marine ornamentals. Application of appropriate advanced intensive culture techniques could also allow for the culture of other species of marine finfish, bivalves and gastropods.

Develop the Guam Aquaculture Innovation Center (GAIC) including a multispecies Marine Hatchery

Developing the GAIC would provide the vital institutional support needed to launch and sustain the industry's development and would be a strong demonstration of Government of Guam's commitment to aquaculture development. Guam's most recent CEDS report (Comprehensive Economic Development Strategy 2020-2025) lists development of an "Aquaculture Hub: Regional Center Development" and "Construction of a New Hatchery Facility" both as High Priorities. We consider the GAIC could fulfill both these goals as the High Priority facilities in the CEDS.

We recommend the GAIC to be developed in stages with near, medium and long-term plans. In the near term, the GAIC would be established as an administrative center committed to supporting and encouraging aquaculture innovation and development. We suggest that the GAIC can first be based at the WERI facility at UOG. WERI is scheduled to vacate their current ocean front building next to UOG Marine Lab and move to a new building on campus. This site has offices and is adjacent to the Marine Lab where there is flowing seawater that could be used for some GAIC activities.

In the medium term (2 year plan), GAIC should develop a new purpose-built facility that would include a visitor/education center, a multispecies hatchery, office space for staff and researchers, and research facilities including a multi-purpose indoor and outdoor tank field, a classroom/ conference room, and aquaculture incubator space. The preferred site to develop the GAIC is Tanguisson Beach site. It has sufficient seaside land to develop the facility illustrated above.

In the long-term, GAIC may also need to develop satellite facilities since no one site has sufficient infrastructure for all the elements GAIC needs. This situation is similar to Ag Extension Services which have several satellite facilities around the island. The additional sites for GAIC would include additional hatchery capacity determined by industry needs plus aquaculture incubator space to train and test new ideas. The Guam Aquaculture Development Park(s) may be developed in several sites to achieve the combined infrastructure required. A holding facility near the airport could be supported for inspecting and quarantining live imports and holding live products prior to loading for export.

The GAIC will offer a range of benefits. It will be an administrative Center that advocates for, encourages and boosts aquaculture development on Guam. It will be a physical Center where applied research projects to solve technical issues, aquaculture startups will be incubated and a 78

visitor center to teach local school children, college students, adults and visitors about the many wonders of aquaculture. It will accelerate innovation by providing a fresh source of ideas. It will enhance risk-taking ability and attract talent. It will drive employee engagement and build a culture of innovation. Mergers and acquisitions (M&A) in the seafood industry reached an all-time high in 2021 with more than \$6.5 B. This shows there is a lot of investment money flowing into the seafood and aquaculture sector.

More details on the GAIC development can be found in chapter on Strategic plan for aquaculture development and the conceptual design of the GAIC. Potential locations for the GAIC are discussed in the chapter on Site analysis of potential locations suitable for aquaculture.

Develop Aquaculture Programs at University of Guam (UOG) and/or Guam Community College (GCC) to support aquaculture workforce development, aquaculture R&D and innovation and accelerate aquaculture development

University of Guam (UOG) has a strong College of Natural Sciences and a world class Marine Laboratory. Many of the necessary courses needed to form an aquaculture program are already in place. To fully commit to this concept, UOG would likely need to add at least one full time faculty in Aquaculture Science. An Aquaculture Program at UOG would add a significant boost to aquaculture workforce development on Guam and would also be a magnet for offshore students from Micronesia and Asia who want to matriculate at a US, English speaking institution.

Workforce development and academic aquaculture training are needed to build the regional aquaculture workforce. Training through GAIC, UOG, and GCC should include aquaculture production biology, implementation of best practices and digital tools for tech-enabled aquaculture production. Workforce development is defined as training programs that provide existing and potential workers with the skills to complete tasks needed by employers to let the organizations stay competitive in a global marketplace.

Developing an academic Aquaculture Program at UOG would be a major step in this direction. In addition to its contribution to workforce development in Guam, it can attract students from Micronesia and Asia with strong interests in this field.

Workforce development helps to identify current trends and forecast future workforce structures that can help to meet service delivery requirements. This in turn can lead to the development and implementation of skills sets to raise labor productivity and increase social inclusion. Its goal should always be to prepare the community for future business continuity, business growth, and business agility.

Implement and/or expand programs to revitalize and maximize productivity of existing aquaculture infrastructure

The quickest way to get aquaculture development moving on Guam is to assist existing operators maximize their productivity. This should include both permitting assistance since existing inactive farms face new permit requirements to reactivate their farms as well as technology transfer to the farmers to upgrade their activities. The concepts of sustainable intensification and climate smart technologies should be applied as strategy to improve economic performance in an environmentally sustainable fashion of existing farms. Sustainable intensification is an approach in agriculture and aquaculture that increases food production from existing farmland without increasing impact on the environment. Climate-smart agriculture (CSA) is an integrated

approach to adapt agricultural methods, livestock and crops to climate change and counteract it by reducing greenhouse gas emissions, taking into account the growing world population to ensure food security. Thus, the emphasis is not simply on sustainable agriculture, but also on increasing agricultural productivity. Sea Grant Guam is currently assisting several existing farmers reestablish their farms and should receive additional support to enhance these activities. Access to quality seedstock is a problem for the industry and must be addressed.

Develop a program to increase the quality, quantity and affordability of aquaculture seedstock to the industry

Successful aquaculture requires a reliable supply of high quality seedstock. Guam's aquaculture industry has struggled with a shortage of high quality and affordable seedstock for years. The Aquaculture Task Force has asked for help to solve this problem. Since the GADTC facility was signed over to CoreSeed, it has adopted a commercial orientation and significant price increases. Some Guam aquafarmers now consider CoreSeed's seedstock too expensive, e.g. juvenile Tilapia are \$1/pc.

It is proposed that the Aquaculture Task Force work closely with the Government of Guam and the industry to find a solution to the seedstock problem. CoreSeed currently supplies Tilapia and shrimp seedstock to Guam aquafarmers on a limited basis. The industry would benefit if CoreSeed's supply could be expanded and distributed to farmers for a lower price. This would be a win-win-win situation because the farmers will have access to affordable seed, CoreSeed will increase its seedstock sales, and the Government benefits from economic development of commercial aquaculture. Such a development is the quickest, most affordable solution to the seedstock problem for shrimp and tilapia.

Further consideration of the strategic issue of seedstock supply for Guam aquaculture suggests that Guam's long term aquaculture potential would be best served by making Guam self-sufficient in aquaculture seedstock supply. In such a case, aquaculture seedstock imports would be prohibited. If the government committed to this strategic goal, it would have to assist in the development of seedstock resources on Guam. This would include both the enhancement of the seedstock supply coming from CoreSeed plus development of a tilapia hatchery and a marine species hatchery for industry needs beyond CoreSeed's capacity.

Develop and commercialize sustainable marine ornamental production in Guam and the Pacific

Guam's tropical oceanic environment is home to one of the most diverse biological communities on the planet. The marine aquarium trade has a mixed reputation, with many specimens being captured from the world's coral reefs. However, a number of pioneers are now farming marine ornamentals – offering hope for a venture that benefits both people and the planet.

The culture of marine ornamentals – including fish, mollusks, live rock, crustaceans and corals – for the aquarium hobbyist segment is a \$5 billion industry. It is a relatively new sector and is often ignored by mainstream aquaculture producers, yet it pushes the boundaries of aquaculture by exploring the culture of new species and improved culture methods. As well as providing considerable profit margins, it also provides huge opportunities for coastal communities in developing countries.

In the United States alone, 15 million households own aquaria, with 2.5 million housing marine fish (Springer, 2018). Approximately 20 percent of the total trade consists of marine species.

Although ornamental freshwater fish, such as goldfish and koi, are extensively cultured, particularly in Southeast Asia and Taiwan, marine fish and invertebrates are still mostly caught in the wild. It is estimated that some 50 million coral reef animals (including fish, corals and other invertebrates) are annually caught and sold to marine aquarium hobbyists.

With consumers becoming more environmentally conscious, wholesalers and retailers are increasingly pressured to meet the requirements of their customers, while also adapting to policy shifts with tighter restrictions on the trade in wild fish. Some national governments are even discussing potential bans on the trade in wild-caught marine ornamental fish.

Develop a Public-Private Partnership to demonstrate Guam's first offshore fish farming project

Guam has a \$20 million seafood trade deficit, importing approximately 5 million pounds of seafood per year. At least half of the imported seafood are produced by aquaculture farms. Meanwhile, demand in Guam for local, fresh, and sustainably produced seafood is growing, and the absence of a local supply to meet this demand represents a lost opportunity for sustainability and economic growth. Expanded domestic seafood production in Guam could promote significant economic development and job creation. Aquaculture, therefore, represents the only realistic option for expanding domestic seafood production.

Indeed, the vast expanses of favorable marine growing areas with suitable depths, current speeds, temperatures, and access to ports give Guam some of the highest offshore aquaculture production potential in the world. Despite huge potential benefits of a reduced trade deficit, local job and revenue creation, and a domestic source of safe and sustainable seafood, marine aquaculture production in Guam lags behind many other countries worldwide. To realize offshore aquaculture potential will require a streamlined, objective, and predictable policy framework for offshore aquaculture planning that identifies optimal locations for sustainable aquaculture development. This type of spatial planning could minimize negative environmental, social, and economic impacts on marine ecosystems and coastal communities while reducing uncertainty for investors and the industry.



Figure 14. Coral trout - Lapu Lapu

The future of seafood production will focus on marine aquaculture, or mariculture. To capitalize on the potential for mariculture, many nations are encouraging its economic development. For example, mariculture is the fastest-growing primary industry in Australia and comprises 43 percent of the nation's seafood production by value.

Until recently, marine aquaculture has primarily been located close to shore and in sheltered coastal waters—areas with high environmental sensitivity that are also already crowded with other ocean uses. Consequently, nearshore mariculture can have high potential for conflicts (e.g., with wild-capture fisheries) and higher risks of environmental impacts (e.g., on the marine benthos and coastal habitats such as mangrove forests). This leaves offshore aquaculture—defined here as farming beyond the nearshore and inshore coastal zone, which typically refers to waters greater than about 20 m in depth—as the most promising option for expanded sustainable seafood production.

Although offshore aquaculture presents significant engineering challenges, recent technological advances have made its development more attractive, as demonstrated by its growth in a number of regions worldwide. Recent estimates suggest that the United States could meet its entire current seafood demand with domestic production if finfish aquaculture were developed in just more than 0.01 percent of the country's exclusive economic zone.

Despite the compelling arguments for development of a vibrant offshore aquaculture industry, the United States and Guam have not taken advantage of the opportunity, largely because of regulatory and policy failures. The United States' aquaculture regulation and permitting system is highly fragmented across multiple state and federal agencies and jurisdictions. The lack of a strong and streamlined policy framework causes regulatory uncertainty that deters potential developers. At the federal level and in Guam, there is no clear roadmap for the permitting and leasing process, making offshore aquaculture permitting and leasing a lengthy and expensive procedure that is rife with uncertainty.

American aquaculture entrepreneurs, companies, and investors are looking to overcome these hurdles, but many have turned to development opportunities outside of the United States, likely to places with weaker environmental and food safety standards, rather than dealing with the cumbersome and risky regulatory process at home. Growth of marine aquaculture is happening on a global scale with or without the United States as a major player, and exporting our production is a lost opportunity for economic development and for promoting sustainable food systems.

Offshore aquaculture has massive growth potential, in part because it is an incredibly spaceefficient way to produce seafood. Offshore aquaculture farms can be sited in select locations that have high yields while taking care to minimize negative impacts on the environment or other economic sectors. With an overarching policy framework guided by scientifically informed planning, Guam can be a leader in sustainable marine aquaculture development.

It is recommended to develop a public-private partnership between GAIC and a private company to conduct a demonstration project to farm Coral Trout or other high value marine fish in offshore submersible net pens to demonstrate the potential of this technology for Guam.



Develop a Department of Aquaculture in the Guam government to accelerate aquaculture development and demonstrate commitment.

The intention of creating a Department of Aquaculture in the Government of Guam is to establish a government branch fully committed to building the sector and to clearly demonstrate Guam's strategic intent to develop an aquaculture industry. The Department of Aquaculture would serve multiple purposes including:

- Develop a sustainable regional aquaculture industry on Guam
- Establish a one-stop-shop on aquaculture permitting to assist commercial projects secure their permits in a timely fashion
- Seek and coordinate aquaculture investment in the industry
- Coordinate aquaculture research and development with other Pacific Island efforts.
- Help new companies develop their business plans to maximize their chances for success

- Seek outside funding for aquaculture R&D and development.
- Build economic resiliency of Guam's communities by increasing opportunities in the aquaculture sector;
- Establish research, monitoring, quarantine and training functions coordinating with UOG and DAWR;
- Boost resident health and food security through ensuring access to locally grown aquaculture products;
- Promote healthy ecosystems through natural-resource regeneration and protection, including through advising other agencies on all programs and projects that affect the aquaculture;
- Develop and implement programs to diversity and expand sustainable forms of aquaculture;
- Report to the Governor and council annually on the Territory's overall performance in meeting aquaculture objectives and any barriers that could be addressed by ordinance.

Convene an international conference in Guam focused on Aquaculture in the Pacific

Convening an international conference will bring outside expertise to Guam to showcase technologies and businesses that could be applied in Guam and introduce outside stakeholders to Guam's aquaculture development potential.

Benefits of developing a conference:

- Showcase Guam's aquaculture development potential to international investors and aquaculture technologists and developers.
- Expose and educate local aquaculture stakeholders to the state of the art in aquaculture technology.
- Gain and share new ideas and best practices.
- Learn about the latest innovations and insights.
- Meet influencers and industry experts face to face.
- Make new contacts and stay connected with friends and colleagues.

The role of an international conference is to gather like-minded individuals from across the country and globe, to learn, discuss thoughts, network, share ideas, create new ideas, and to ignite motivation. One of the most important benefits from convening a conference in Guam is to demonstrate Guam's strategic intent to develop commercial aquaculture.

Develop a tech-enabled shipping and logistics facility to facilitate transportation of aquatic products within the region and to potential export markets.

The development of a shipping and logistics facility to support the transportation of products to identified markets, especially Asia. This goal emerged in developing the EDA grant proposal. It is considered a mid-term goal.

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ANNEX 1. AN OVERVIEW OF AQUACULTURE ENVIRONMENTAL PERMITTING ISSUES IN THE TERRITORY OF GUAM (AFTER BROWN ET AL 2010)

The purpose of this annex is to provide a basic understanding of the Guam environmental regulatory programs as they pertain to aquaculture. By reviewing the regulatory environment, the impediments and opportunities to aquaculture development become visible and can be addressed in the framework of the development plan. A good reference to consult besides this section is the Guidebook to Development Requirements on Guam (GCMP, 2005).

Application forms for various permits can be found at website links included in this annex. These forms will provide aspiring aquaculturists with an understanding of the level of detailed information required by the various regulatory agencies in order for their project to be evaluated.

GENERAL REGULATED AQUACULTURE ACTIVITIES

In order to gain a perspective of the regulatory world that faces all aspiring Guam aquaculturists, a list of potential aquaculture related activities has been identified. This list is not exhaustive; however, it should assist the aquaculturist in understanding the regulatory requirements that may be associated with a project. Not included are the normal operating permits than any business needs to operate such as an Occupancy Permit, Business License or Food Handlers permit.

The list of activities is divided into three groups: general aquaculture facility and infrastructure, aquaculture facility discharge, and import/export of aquaculture products. Further discussion for each of the permits is included in Sections III, IV, and V.

GENERAL AQUACULTURE FACILITY AND INFRASTRUCTURE ACTIVITIES

- Set up of any commercial and possibly personal or backyard aquaculture facility.
- Excavations of any kind for any reason (e.g., ponds, drainage ditches, infrastructure development and building foundations).
- Construction of piers or docks over ocean/lagoon waters, suspended and anchored nets or cages within the water column, or cages sitting on or just above the bottom substrate.
- Presence of an on-site power generator system for the aquaculture facility.
- Construction of wells for either potable water or brackish water supply.
- Construction of a water intake structure that is physically attached to the bottom substrate in marine waters or intermittent/perennial streams that are physically connected to the ocean.

AQUACULTURE FACILITY DISCHARGE ACTIVITIES

- Direct pipe discharge of aquaculture associated effluent into oceanic waters or intermittent/perennial streams that are physically connected to the ocean.
- Construction of a water discharge structure that is physically attached to the bottom substrate in oceanic waters or intermittent/perennial streams that are physically connected to the ocean.

- Discharge of any amount of aquaculture associated effluent to the island's wastewater disposal system.
- Construction of a wastewater disposal system for on-site facilities such as, toilets, showers, kitchens, housing units, etc.

IMPORT/EXPORT OF AQUACULTURE PRODUCTS

- Importation of any live animals or plants (including CITES listed species) for commercial aquaculture purposes.
- Direct importation from an international source (includes Republic of the Marshall Islands, Republic of Palau, Federated States of Micronesia, Taiwan, The Philippines, People's Republic of China, etc.)
- Direct importation of live CITES listed animal or plant species from other U.S. states or territories.
- Exportation of live or dead animal or plant species or products (not limited to aquacultured products) for commercial purposes.
- Direct exportation of non-CITES or CITES species to any international destination.

GUAM REGULATORY PROGRAMS

Clearance from Guam State Historic Preservation Officer in Department of Parks and Recreation is required for all TLUC /TSPC permits and construction permits. Four agencies administer programs applicable to aquaculture development and operations on Guam. These agencies include the Guam Land Use and Seashore Protection Commissions (GLUC/GSPC) administered through the Department of Land Management; the Guam Environmental Protection Agency (GEPA); the Division of Aquatic and Wildlife Resources (DAWR) of the Guam Department of Agriculture; and the Guam Coastal Management Program (GCMP) at the Bureau of Statistics and Plans (BSP). These four agencies have both local and federal regulatory program oversight and support functions that apply to aquaculture development. Responsibilities for each agency follow:

- The GLUC is responsible for permitting aquaculture and other activities in wetland areas and whenever a zoning variance is required. The GSPC permits activities along Guam's shores. Both the GLUC and GSPC permit systems are largely concerned with public necessity, growth management, and the concerns and requirements of various resource agencies on development proposals. Regulatory agency programs directly support the Commission's review process and permitting requirements.
- The GEPA is concerned primarily with the potential for water pollution impacts and protecting wetlands. The agency also issues the CWA Section 401 Water Quality Certification in support of Federal Clean Water Act permits.
- The DAWR is concerned with the introduction of aquatic species, associated diseases, and potential impacts on native fisheries and wildlife, as well as the overall health of natural ecosystems. The DAWR issues import permits for all aquacultural seed and broodstock entering Guam. They can provide information on past imports and on which

species they may be willing to consider allowing onto Guam in the future. Beginning the process of investigation at DAWR is highly recommended if one is considering culturing a species that does not have a history of cultivation on Guam.

The GCMP is responsible for the review and coordination of government positions on permit and development proposals to ensure conservation and sustainable growth practices are addressed throughout the coastal environment. The agency also reviews projects for Federal Consistency (programs, laws, regulation, and policy) and issues consistency statements in support of federal permits such as the US Army Corps of Engineers (USCOE) CWA Section 404 permits.

Given the close integration of program objectives, long-standing regulatory network relationships, and the island's small size, there is frequently significant regulatory overlap and double duty by the local resource agencies.

The regulatory agencies and their programs and mandates as they relate to aquaculture development are described below. Key program policies and permit requirements and procedures are also summarized. Tips to help navigate the permit process are included, wherever possible.

GUAM LAND USE AND SEASHORE PROTECTION COMMISSIONS

The Guam Land Use Commission (GLUC) is a decision-making body empowered to grant subdivision approvals, zone variances, conditional uses from land use laws and regulations, and Seashore Reserve and Wetland Permits. Members of the GLUC also serve on the GSPC, so many of the administrative and operational procedures of the commissions are similar. The Department of Land Management through its Planning Division is responsible for the routine administration of the Commission's work with other agencies and applicants. The Division also offers pre-application consultation services to ensure that information is accurate and meets the minimum requirements of the permit program. Permit enforcement is the responsibility of the Building Official at the Department of Public Works. Could back-yard aquaculture use in single-family residential and agricultural lots be permitted in the zoning approvals?

The GLUC and GSPC rely upon the Application Review Committee (ARC), which is composed of representatives of eight core agencies: Department of Land Management, Bureau of Statistics and Plans, Department of Public Works, Guam Environmental Protection Agency, Department of Agriculture, Guam Waterworks Authority, Department of Parks and Recreation, and the Guam Power Authority to review and develop position statements on permit proposals. The ARC review processes typically require three to four months to complete, with additional time required on complex, larger projects or when information submitted is deemed insufficient. The ARC has advisory but not regulatory powers and is the technical arm of the GLUC/GSPC.

Wetland Area Development Permit Procedures

Regulated Activity: Any development in a wetland such as clearing, grading, excavation, fill, water supply, water discharge, roads, structures, and similar activities.

To obtain a wetland area permit from the GLUC, a project proponent/applicant must provide a tentative plan for the proposed development, including specific information such as applicant and owner information, survey maps, existing and proposed structures, access, topography, utilities, drainage plan (detailed construction drawings), performance bonding, and a wetland 92

delineation map, among other requirements. The government may also require that an environmental impact assessment (EIA) be conducted on the proposal. The Guam Chief Planner will certify that complete and accurate information necessary to evaluate the proposal has been provided and will then submit the documents to the ARC for review. Most, if not all, of these wetland requirements are also necessary for other Federal and local permits.

The ARC will review and consider the wetland development proposal, and each agency will submit an official position statement with recommendations for approval or disapproval to the Commission.

The Commission will approve, approve with conditions, disapprove in whole, or disapprove in part the proposed tentative development plan. The applicant should apply for other permits as may be required by the Federal government after approval by the Commission. This order, local then federal permitting, allows the Government of Guam to present a unified position and set of standards for wetland development.

Upon Commission approval of an EIA or tentative plan for commercial development within a wetland, the developer may be requested to demonstrate that sufficient funding is available for the project, prior to issuance of a Wetland Permit. The project site must remain open to the government for compliance inspection during all phases of a proposed development project. If a project is not completed or operations totally cease within a prescribed time period, the developer will be required to restore the natural appearance and biological character of the wetland to its prior condition to the maximum extent practicable.

Comments submitted to the Commission by the ARC agencies will serve as the Government of Guam's position on the project for the U.S. Army Corps of Engineers (USCOE) permit process. By federal definition, the wetland to be impacted is considered "isolated" if it does not have a surface connection to waters of the United States and therefore is subject only to this (GLUC) wetland area permit requirement. There may be substantial differences in permit conditions for isolated wetlands, mainly because the Government of Guam's wetland regulations are less comprehensive than United States federal regulations.

The majority of larger wetlands on Guam are delineated on the official wetland area maps, which are available at the BSP, GEPA, DAWR, and other agencies. Smaller wetland areas (less than a couple acres) and certain types of emergent wetlands are not identified on the wetland area maps because the maps were developed using remote sensing techniques with limited ground verification. One of the first steps to siting and aquaculture development near rivers and river valleys is to request that regulatory agencies help verify the presence of wetlands.

If wetlands are present and a permit is required, then an environmental consultant may be retained to perform a delineation and to assist in obtaining a permit. The next project-planning step is to try to design the facility to avoid impacts to wetlands if at all possible and, if not, then to greatly minimize impacts. The regulatory agencies will look for this mitigative approach to project development when they evaluate a permit request.

Wetland delineations require special expertise, and there may be only a handful of consultants who are able to provide this service. GEPA and the USACE should be able to identify individuals who provide this service. Delineation work for large areas (greater than a couple acres) can take several months to complete, from initial research and surveying to field verification by the regulatory agencies. One way to reduce permitting time and effort is to delineate only the

immediate areas to be impacted and implement generous buffers and other best management practices throughout the rest of the project.

The level and scope of environmental impact assessments should be determined early on. Both the GEPA and USCOE regulatory programs include an environmental assessment format. The best approach is to adequately prepare one environmental assessment that will satisfy each permit requirement or format. Conducting agency scoping at the start of a project can save substantial time and effort later.

Primary Statutory and Regulatory References: Territorial Planning Commission - 21 GCA §60405 Wetland Areas - 18 GAR Chapter 3, Article 5 (§3505 Procedures for Development Within Designated Wetland Areas of Particular Concern)

Seashore Clearance Permit Procedures

Regulated Activity: Any development that encroaches upon the Seashore Reserve such as excavation, fill, water intake structures, outfall structures, and construction or installation of pens, cages, traps, and similar activities. Guam Territorial Seashore Protection Plan is required under local law and is currently being drafted by the Bureau of Statistics and Plans and should address aquaculture issues.

The Guam Territorial Seashore Reserve is a valuable natural resource. The Guam Seashore Protection Act (GSPA) of 1973 (21GCA, Chapter 63) seeks to permanently protect the natural, scenic, and historical resources of the seashore reserve, the natural environment, and the ecological balance of the seashore reserve to prevent its deterioration. The Seashore Reserve is defined as property from ten (10) meters inland from the Mean High Water Mark (MHWM) or situated seaward to the 10-fathom contour.

Any person wishing to perform any development within the Seashore Reserve must obtain a permit from the GSPC. A number of requirements must be satisfied in order to meet the minimum threshold to obtain a Seashore Clearance permit. The requirements include that the project not result in substantial adverse environmental or ecological affect; access to beaches is maintained or improved, recreation and historical areas are protected, and natural reserves are increased to the maximum extent possible though appropriate dedication; there should be no substantial interference with or detraction from the line of sight toward the sea from any highway nearest the coast; and adequate and properly located public recreation areas and wildlife preserves are reserved.

The GSPA also specifies that there should be provisions made for solid and liquid waste treatment and management to minimize adverse effects on coastal resources. Additionally, alterations to existing landforms and vegetation and construction of structures should not cause or increase the risk of floods, landslides, erosion, or siltation.

A permit filing fee and notice of public hearing are required. As with the wetland area permit procedure above, the ARC will meet with and review the development proposal and application with the applicant. The focus of the ARC review will involve environmental impact considerations and how the activity may limit or enhance public use of the Seashore Reserve. Each agency will prepare an application position statement, which will be forwarded to the Commission for consideration and a decision. The Commission will act on a permit application within sixty (60)

days after the hearing.

A Seashore Clearance permit will likely include a number of strict conditions on the design, siting, construction, and operation of any aquaculture operation in marine waters. Some of those concerns will undoubtedly focus on potential adverse effects on fisheries and marine resources, waste management, exclusive use, and similar considerations. A permit is also required if an aquaculture facility is proposed outside the Seashore Reserve but will require a supply of seawater or pond/tank water disposal. In this case, the environmental concerns would likely focus on the physical impact of extraction and discharge piping infrastructure, as well as the water quality and associated biological effects of water withdrawal and waste discharge. Most point- source discharges will also require a Federal National Pollution Discharge Elimination System (NPDES) permit (i.e., CWA Section 402).

Primary Statutory and Regulatory Reference: Guam Seashore Protection Act of 1974 - 21 GCA Chapter 63 (§63108 Interim Permit Control)

Regulation-none. Contact

Information: Guam Land Use Commission and Guam Seashore Protection Commission Department of Land Management PO Box 2950 Hagåtña, Guam 96932 590 S. Marine Corps Drive Suite 733 ITC Building Tamuning, Guam 96913 Executive Secretary Tel: (671) 649-5390 Fax: (671) 649-5383 Web site: www.dlm.guam.gov

GUAM ENVIRONMENTAL PROTECTION AGENCY

The **Guam Environmental Protection Agency (GEPA)**, as part of their regulatory function in monitoring Guam's waters, regularly collects data on water quality can provide information on historic trends of water quality fluctuations that can be useful to some aquaculturists near regular monitoring sites. The GEPA website is: <u>http://epa.guam.gov/</u>

The Guam Environmental Protection Agency Act (10 GCA, Chapter 45, §45102) identifies the policy and purpose for GEPA's programs as calling for: "...A united, integrated, and comprehensive island-wide program of environmental protection and to provide a framework to fulfill that task."

This integrated framework includes several programs that will likely play an important role in the development of an aquaculture facility. In order to protect the island's ground and surface water resources, GEPA's regulatory programs include requirements for individual wastewater disposal systems, surface or underground injection control, well drilling and operations, dewatering, erosion control, solid waste management, air pollution control, and above/ underground storage tanks (ASTs and USTs). GEPA also maintains authority to issue CWA Section 401 Water Quality Certifications for Federal CWA permits.

Those GEPA regulatory programs most likely to be encountered for aquaculture facilities include the following:

- CWA Section 401 Water Quality Certification
- Soil Erosion and Sedimentation Control
- Water Pollution Control
- Water Resources Management Program
- Aboveground and Underground Storage Tanks
- Air Pollution Control Program

Guam CWA Section 401 Water Quality Certification

Regulated Activity: Required for applicable Federal Clean Water Act permits administered by the US Environmental Protection Agency (USEPA) or USCOE.

A water quality certification, pursuant to Section 401 of the Federal Clean Water Act, is required for any application for a Federal license or permit to conduct an activity in Guam waters, including but not limited to the construction and operation of facilities that may result in any discharge, as defined in Sections 502(6), 502(12), 502(16) of the Federal Clean Water Act. The Administrator of the GEPA issues the CWA Section 401 Water Quality Certifications (WQCs) in Guam.

GEPA has developed three different Section 401 WQC forms based on the location of the surface water system and the type of regulated activity. Two of these forms address aquaculture development activities. Form 401-B covers activities for industrial, commercial, agricultural, and residential storm water discharges, irrigation, and aquaculture water supply and discharges. Form 401-C covers activities such as wetland dredging, filling, construction of bridges, walkways, culverts, and other structures in wetlands, streams or rivers, compensatory mitigation projects, restoration activities, and similar activities in wetlands. WQC forms are available at http://epa.guam.gov/documents/forms-and-applications/

A Section 401 WQC application should be filed as early as possible. The conditions included in the WQC become enforceable under the associated federal permit, and federal permit issuance is usually held up until the WQC is issued. Section 401 WQC applications are submitted to the Administrator and must include a complete description of the discharge associated with the activity for which certification is sought. Each application should include the following:

- 1. A description of the facility or activity (construction or operation), and of any discharge into the territory's waters that may result from the conduct of any activity.
- 2. A description of the function and operation of equipment or facilities to treat wastes or other effluents that may be discharged.
- 3. The date or dates on which the activity will begin and end, if known, and the date or dates on which the discharge will take place.
- 4. A description of the methods and means being used or proposed to monitor the water quality and characteristics of the discharge, and the operation of equipment or facilities employed in the treatment or control of wastes or other effluents.
- 5. A description of the recreational uses of the territory water at the discharge, the basic water quality criteria, and the applicable Guam water quality standards that must be met.
- 6. Plans, specifications and copies or citation of an Environmental Impact Assessment or Environmental Impact Statement, as it may apply.

- 7. A historical overview and ecological evaluation of the site.
- 8. A sediment physical characterization may be required for wastewater discharges.

An evaluation and approval of the request for certification will include statements by the Administrator that there is a reasonable assurance that the activity will be conducted in a manner that will not violate applicable Water Quality Standards and any conditions that the administrator deems necessary or desirable with respect to the discharge or the activity. A public hearing may be required prior to a decision by the Administrator if the proposal is controversial or involves significant adverse impacts on the environment. WQCs may be issued for up to five years.

Primary Statutory and Regulatory References

Water Pollution Control - 10 GCA Div II Chapter 47 §47108 Classification and Standards Water Quality Standards - 22 GAR Div 2 Chapter 5 Appendix F Guidelines for the Review and Issuance of 401Water Quality Certification

Soil Erosion and Sedimentation Control

Regulated Activity: Any land disturbance activity, including but not limited to clearing, grubbing, grading, excavation, fill, and stockpiling.

A grading and/or building permit is required for just about any construction in Guam. Grading and building permits are issued by the Guam Department of Public Works and are subject to review by a number of Guam regulatory agencies not only including GEPA (this includes review by the SHPO, fish and wildlife, professional licensing, etc – check the DPW permitting process). GEPA's part in the review includes a requirement under the Soil Erosion and Sediment Control Regulations to approve all building or grading permits, with respect to compliance with the requirements of the SESC regulations. There is no such thing as an ECP – only a grading or building permit. However, in the case where a DPW permit is not required, a GEPA grading permit is required and the applicant must submit the application on the form provided at GEPA's website. Clearing and or grading permits will not be issued to prepare sites or construct facilities without an approved ECP. Clearing and grading permit forms are available at http://epa.guam.gov/documents/forms-and-applications/. Additional information concerning requirements for grading permits is available at http://epa.guam.gov/programs/water-pollution-control/

In addition to the Erosion and Sediment Control Regulations, all grading or building permits are reviewed by other relevant GEPA programs and must meet those requirements, as well. Additional information that must be included with an application typically includes a solid waste disposal plan and dust control plan, but may also include other requirements depending on the activity or location.

An ESCP must be prepared, and the Agency has 30 working days (not calendar days) from the submittal of the erosion and sediment control plan (not the application) to complete its review. Note that this is not from the date of submittal of the application – an application that does not contain an ESC plan is incomplete and the clock does not start. Standard enforceable conditions and several special conditions that reflect site-specific concerns and performance targets.

The primary purpose of the regulations is to ensure that earthmoving activities are conducted in a manner that prevents accelerated land erosion, transportation of sediment to and along waterways, and siltation of rivers, estuaries, and marine waters. All developers engaged in earthmoving activities are subject to the regulatory requirements of Sections 10108 through 10113, which specify procedures for preliminary site evaluations, ESCP preparation, methods and specifications, and similar requirements. The ESCP and supporting plans and specifications are useful to support any Federal permits.

In addition, if the water table is encountered during excavation work, for example when constructing aquaculture ponds, a Dewatering Permit may be required to control and treat water pumped from an excavation prior to final discharge. The dewatering permit request and approval may be a component of a site clearing and grading or building permit request. The dewatering permit requirement is under the Water Resources Development and Operating Regulations (22 GAR Chapter 7), and is applied for using the Application for Well Drilling Permit which can be obtained at http://epa.guam.gov/documents/forms-and-applications/

Primary Statutory and Regulatory References:

Water Pollution Control - 10 GCA Div II Chapter 47 §47106 Pollution Unlawful: Permits Guam Soil Erosion and Sedimentation Control Regulations- 22 GAR Div 2 Chapter 10 Water Resources Development and Operating Regulations – 22 GAR Chapter 7

There is a requirement to obtain coverage under the federal NPDES Construction General Permit for any construction work that results in disturbance of an area 1 acre or larger in cumulative size – some info is available on the GEPA website for the Water Pollution Control program linked above.

Water Pollution Control

The Water Pollution Control Act (WPCA) affords broad authority for the Administrator of GEPA to regulate water pollution from any human activity, including treatment plants, small wastewater systems, construction activities, industrial discharges, and agricultural activities, among others. To date, the aquaculture industry on Guam has not been required to obtain discharge permits.

All of the current aquaculture facilities on Guam fall below the threshold identified under CWA Section 402. Water pollution discharge permits are identified here because the potential for regulation is likely in the near future. The Guam WPCA states in Section 47106(b) and (c) that "It shall be unlawful for any person to construct, install or operate a new sewage conveyance system, disposal systems, or treatment works, extensions, modifications or additions to factories, manufacturing establishments or business enterprises, the operation of which could cause a substantial increase in waste discharges to the waters of the territory or otherwise substantially alter the physical, chemical or biological properties of the waters of the territory, or to make or cause to be made any new outlet for the discharge of sewage, industrial waste or other wastes into any sewage conveyance system or into the waters of this territory without first securing such permit as the Administrator may require, including the submission of plans and specifications and such other information as he deems relevant in connection with the issuance of such permits." Permits cannot be issued under this part of the WCPA for any use in violation of Guam Water Quality Standards.

Primary Statutory and Regulatory References:

Water Pollution Control Act - 10 GCA Div. II Chapter 47 §47106(b) 98

Water Resources Management Program

Regulated Activity: Drilling (construction) and operating groundwater wells.

Water well development is divided into two permitted parts or phases, well drilling and well operations. Both phases require permits from GEPA in the form of a Well Drilling Permit for exploratory and development work and a Well Operating Permit for actual production and use of water resources.

Most well drilling permits are issued to utility contractors, but any individual who requires a private source of water (fresh, marine, or brackish) is required to obtain a well permit. Initial evaluations are conducted for the proposed drilling location based on historical records from previous drilling activities and on water resource and aquifer management studies. The Well Operating Permit is necessary to establish operating conditions such as allowable pumping rates, infrastructure requirements, long-term monitoring, and inspections. Although, pumping surface water (rivers and wetlands) does not constitute "well" operations, the Agency should be consulted. Pumping surface waters may involve adverse biological or hydrologic conditions.

Well drilling permit forms are found at <u>http://epa.guam.gov/documents/forms-and-applications/</u>.

Wellhead Protection provisions of the Water Resources Development and Operating Regulations, 22 GAR §7130. This section can be very confusing to read, but applies to any aquaculture activity located within either the groundwater protection zone (GPZ) or within 1,000 feet of a production well. The following is a wellhead protection review determination from a recent military project that illustrates how GEPA currently interprets its implementation:

 Guam's wellhead protection requirements are provided in 22 GAR Chapter 7, specifically within §7130 "Wellhead Protection for Public Water Supply Wells." "Wellhead protection area" is defined under §7103(tt) to mean "the surface and subsurface area within a minimum of 1,000 feet radius of a water well or wellfield, supplying a public water system through which contaminants are reasonably likely to move towards and reach such water well or wellfield." §7130(d) expands the jurisdiction of its requirements to include the larger groundwater protection zone (GPZ) in addition to the more narrowly defined wellhead protection areas. The GPZ as currently mapped for Guam encompasses nearly all of inland northern Guam, and all of the proposed project site.

The wellhead protection provisions of §7130 require, in short, written approval from the Guam EPA Administrator prior to the construction or implementation of the any of the following: septic tanks and leaching fields; sanitary sewer; storm water disposal practices; other liquid waste storage, disposal or treatment; storage or use of toxic or hazardous materials; land use changes; excavations; or pipelines that convey toxic or hazardous chemicals. In reviewing any such regulated activity proposed to occur within a wellhead protection area or the GPZ, Guam EPA must consider a number of factors including but not limited to facility design, management practices, and the location of regulated activities as far as possible from production wells. Based on the submitted documentation, the entire project site is located outside any wellhead protection area, but inside the GPZ. This satisfies the criteria requiring the location of potential sources of contamination outside of wellhead protection areas or located as far as possible from a production well. Storage of hazardous materials is proposed to occur within an enclosed building. Site runoff will first be treated for water quality within the project site, before discharging to off-site drainage and disposal systems previously approved. Therefore, our review indicates that the project is in compliance with the wellhead protection requirements at 22 GAR §7130. Final approval will be granted by the Guam EPA Administrator via the construction (clearing and grading) permit, pending review of construction plans.

Primary Statutory and Regulatory References: Water Resources Conservation Act - 10GCA, Div II, Chapter 46 (§§46104 - 46105 Well Drilling and Operating Permits) Water Resources Development and Operating Regulations - 22GAR Div II Chapter 7

Welling Drilling and Operating Permits Aboveground and Underground Storage Tanks Regulated Activity: Storage of fuel and other oil products.

Clearance or notification is necessary for any aboveground or underground fuel or oil storage tanks that are part of the aquaculture facility. Aboveground storage tanks are subject to the Federal Spill Prevention Control and Countermeasure (SPCC) program administered through GEPA if the tanks have a capacity of 1,320 gallons or more. New rules come into effect in 2009 that specifically apply to farms, including fish and other aquatic animal production valued at \$1,000 or more annually. Most small and even large aquaculture farms on Guam will not likely require tanks of this size for standby or even primary power sources, but GEPA should be consulted for site-specific considerations because of the proximity to surface waters or the Northern Aquifer. This program is focused on ensuring proper design, installation, and maintenance of aboveground storage and related transfer facilities to prevent and control spills and leaks.

Underground storage tanks on Guam must be registered with the Agency to ensure compliance with local and federal UST regulations. Federal law requires UST owners to submit a USEPA notification form, which is available online at the Agency's Web site, for all USTs storing regulated substances that were brought into use after May 8, 1986, or USTs that were in the ground as of May 8, 1986 that have stored regulated substances at any time since January 1, 1974. Section 9002 of the Resource Conservation and Recovery Act (RCRA) requires the information requested on the notification form, as amended. The application form contains more detailed instructions and information.

UST notification forms are available at <u>http://node.guamepa.net/permits/hazwaste.html</u>.

Primary Statutory and Regulatory References:

Spill Prevention, Control, and Countermeasure (SPCC) rule at 40 CFR Part 112 Underground Storage Tanks Section 9002 of the Resource Conservation and Recovery Act (RCRA), as amended.

Air Pollution Control Program

Regulated Activity: Electrical generators, incineration, dust emissions, and other source of air pollution.

Air pollution permits are issued according to the dry weight pollutant per year anticipated to be emitted from a facility classified as either a minor or major source. There are many types of potential air pollution sources or land use activities that require operating permits. The most likely operating permit requirement associated with aquaculture facilities would be for standby electric generators (>30kw) as minor stationary sources.

Permit inquiries should include information about the generator manufacturer, model number, horse power rating, electrical power output capacity, and the anticipated number of hours the unit will be in operation on an annul basis. There are annual fees required for each permitted minor source.

Air permit applications are available at <u>http://node.guamepa.net/permits/air.html</u>.

Also – dust control requirements for construction permitting – must be submitted with grading or building permit application.

Primary Statutory and Regulatory References:

Air Pollution Control - 10GCA, Div II Chapter 49 §49107 Air Pollution Control Permit Program Guam Air Pollution Control - 22GAR, Div 1 Chapter 1 §1109 - Permits to Operate

Contact Information:

For water testing laboratory questions, please direct them to Mr. Rudy Paulino, <u>rudy.paulino@epa.</u> <u>guam.gov</u>

For wetland information, Mr. Bob Salas, <u>bob.salas@epa.guam.gov</u>. For Section 401 Water Quality Certification, Mrs Margaret Agular, <u>margaret.aguilar@epa.guam.</u> <u>gov</u>.

Guam Environmental Protection Agency Administration Building: 17-3304 Mariner Avenue, Tiyan, Guam 96913 Operations Building: 15-6101 Mariner Avenue, Tiyan, Guam 96913 PO Box 22439 GMF Barrigada, Guam 96921 USA Tel: (671) 475-1658/9 Fax: (671) 477-9402 Web site: www.gepa.guam.gov

Solid waste regulations with respect to construction waste management plan to be submitted with building or grading permit.

Guam Water Quality Standards contain many provisions specific to treatment and disposal requirements for discharge of wastewater, of any sort, to both surface and groundwater – this would include aquaculture wastes.

Septic system rules – might also apply. Aquaculture wastes cannot be discharged to a septic system - Guam Individual Wastewater Disposal Systems Regulations 22 GAR Chapter 12.

DEPARTMENT OF AGRICULTURE, DIVISION OF AQUATIC AND WILDLIFE RESOURCES LIVE AQUATIC ANIMAL IMPORT PERMIT

The importation and exportation of aquaculture products is also jointly regulated by both Guam and Federal Governments. If certain species being considered for culture are listed by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), an additional layer of regulatory requirements must be complied with for international shipments (export, import, and re-export). Local Micronesian examples of these regulated species include the giant clams (Family: Tridacnidae) and hard or reef building corals (Order: Scleractinia).

Regulated Activity: Importation of live aquatic animals.

The Department of Agriculture requires that the importation of live aquatic animals and plants be permitted and inspected upon arrival. An import permit must accompany aquatic animals from the US, while those from a foreign country require a certificate of origin. In addition, a certificate of health must accompany the animals from a certified agent in the country of origin verifying that the animals are disease free. Permit forms and other information may be obtained from the Department of Agriculture. Similar clearance requirements are administered by the US Fish and Wildlife Service, Department of Interior.

Primary Statutory and Regulatory References: Plants and Animals 5 GCA Chapter 61

CONTACT INFORMATION:

Department of Agriculture 163 Dairy Road Mangilao, Guam 96923 Tel: (671) 734-3944 Fax: (671) 734-6570 Web site: www.agricultureguam.gov

Specific details on the importation and exportation of CITES regulated aquaculture products is a separate issue and is beyond the scope of this document.

GUAM COASTAL MANAGEMENT PROGRAM

The Guam Coastal Management Program housed within the Bureau of Statistics and Plans (BSP) is responsible for coordinating and assisting in the development and implementation of plans, policies, and programs that affect the management, use, and preservation of Guam's land and ocean resources to ensure consistency between the plans, policies, and programs to ensure Guam's resources are effectively used for the benefit of present and future generations.

The **Bureau of Statistics and Plans (BSP)** is responsible for coordinating the Government of Guam's data management activities to ensure availability of and access to the information required for government-planning and policy purposes. The BSP collects and publishes economic information and statistics about Guam. It publishes annually the **Guam Statistical Yearbook**. It oversees the Government of Guam's **Geographic Information System (GIS)**, and it houses the **Guam Coastal Management Program (GCMP)**.

The GCMP is responsible for coordinating and assisting the development and implementation of plans, policies and programs which affect the management, use and preservation of Guam's land and ocean resources. In addition, the GCMP provides funding for positions in other Government of Guam agencies that are concerned with the planning and implementation of projects for the development of the local fisheries. Most of this effort is directed towards commercial fisheries; however, aquaculture does receive some attention, especially in the areas where aquaculture can be of benefit to commercial fisheries.

Regulated Activity: Required for applicable Federal permits, including the regulatory programs under the Clean Water Act.

The GCMP is also an expression of Guam's policy to guide the sustainable use and protection of land and ocean resources within Guam's coastal zone. The "coastal zone" of Guam includes all non-federal property within the island, including offshore islands and the submerged lands and waters extending seaward to a distance of three (3) nautical miles. In accordance with the Coastal Zone Management Act of 1972 (PL 92-583), as amended (PL 94-370), BSP, as the lead agency of the GCMP, is responsible for conducting federal consistency review for the following:

- 1. Federal Agency Actions
- 2. Activities Requiring a Federal License or Permit
- 3. Federal Assistance to Local Governments

For the purpose of guiding aquaculture development, it is the need for federal permits such as the USCOE Section 404 permit that triggers federal consistency review. The process for obtaining a coastal zone management consistency certification (Subsection 307(c)(3)(A), National Coastal Zone Management Act) involves the following three essential steps:

1) Applicant submits materials to the BSP for review, including:

- A consistency certification statement with a detailed description of the proposed activity and its associated facilities
- An assessment of the proposed activity's impacts with respect to the enforceable policies of the Guam Coastal Management Program with findings
 - 2) BSP conducts review of the submitted materials for completeness and will notify the applicant of any deficiencies. At this time, conferences may be arranged with the

applicant to clarify information submitted, to resolve potential issues related to the proposed activity, or to discuss possible alternatives to assure consistency with GCMP.

Other Guam agencies may be asked by the BSP to review the submitted materials and may participate in conferences. Their comments will be considered by the BSP in preparing an official response to the consistency certification. Whenever possible, the BSP will issue joint public notice with the Federal permitting or licensing agency to minimize duplication of efforts and to avoid unnecessary delays.

3) Although the BSP under the National CZMA has six (6) months to review the submitted materials, it will at the earliest practicable time notify the applicant and the Federal agency of the results of its review. If it agrees with the consistency statement and conflicts have

been resolved, the BSP will state its concurrence with the applicant's certification. In cases where conflicts have not been resolved, the BSP may declare a formal objection to the certification. The applicant, Federal agency, and US Office of Coastal Zone Management will be notified in writing of such an objection. A formal appeal and mediation process is available to applicants.

Guidelines for achieving Federal Consistency guidelines and related forms are available at http://www.bsp.guam.gov/content/view/44/37 .

CONTACT INFORMATION:

Bureau of Statistics and Plans Guam Coastal Management Program 414 W. Soledad Ave., Suite 303 GCIG Building Hagåtña, Guam 96910 Mail: PO Box 2950 Hagåtña, Guam 96932 Tel: (671) 472-4201-3 Fax: (671) 477-1812 Web site: www.bsp.guam.gov/GCMP

FEDERAL REGULATORY PROGRAMS

The US Congress has passed several environmental laws that will likely affect the siting, design, or operational aspect of any aquaculture facility. These laws include the Clean Water Act (CWA), the Rivers and Harbors Act (R&HA), the Endangered Species Act (ESA), and others. The more difficult and complex of these Congressional actions are the Clean Water Act and Endangered Species Act. As a note of caution, regulatory compliance with conditioned permits issued under the auspices of these acts could potentially reach a point where business ventures are no longer viable. It is important to have a basic understanding of the regulatory constraints that these laws impose when selecting a facility site or when developing the operations plan. Following a brief overview of the relevant components of each Act is a summary of the regulatory program for each Federal agency that is involved in administering the intent of the Acts.

CLEAN WATER ACT OF 1977, AS AMENDED:

The Federal Water Pollution Control Act of 1948, later completely revised and renamed the Clean Water Act (CWA) in 1977, was passed by the U.S. Congress in order to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters." The CWA regulates virtually all physical alterations and discharges into "waters of the US." For Guam, this term includes; all territorial seas (three nautical miles seaward from the mean high water mark); intermittent and/or perennial surface water streams with a physical connection to the ocean; surrounding wetlands or marsh lands; and other non- isolated wetlands. If you are not sure whether any regulated natural resource features are found on a potential aquaculture site, contact the USCOE Regulatory Office and they will be able to arrange for a site visit and make a determination of jurisdiction as a public service.

The CWA covers several different water related issues, however, with respect to aquaculture, Sections 402 and 404 of the CWA are the more relevant federally administered programs and are discussed below.

(a) Section 402 National Pollution Discharge Elimination System (NPDES): Section 402 NPDES, specifically regulates the discharge of pollutants into "waters of the US." Aquaculture related activities that would be regulated under this program would include the discharge of aquaculture associated with tank or pond effluent into nearshore marine waters, lakes, or certain wetlands. There are two related issues associated with Section 402 NPDES; those activities that involve direct discharges into near shore waters or other "waters of the US ' and therefore require individual permits, and those project (or construction) sites that may have storm water discharge issues with near shore waters.

The latter situation is covered under a Construction General Permit.

(b) Section 404:

Section 404 specifically regulates the discharge of fill material into "waters of the US". This includes most earthmoving activities (e.g., dredging) within the territorial sea or in or along intermittent streams that have a physical connection to the ocean or jurisdictional wetlands.

RIVERS AND HARBORS ACT OF 1899:

Section 10 of this Act regulates the placement of structures in "navigable waters." Potential aquaculture activities regulated by this program include placing structures in the territorial sea. Examples include: dock or pier pilings, breakwaters, bulkheads, pipelines, anchoring or mooring buoys, and floating platforms. In contrast to the CWA's definition of "waters of the US" which is very broad, "navigable waters" as defined by the Rivers and Harbors Act is limited to those waters within the territorial sea. When comparing the two terms, "navigable waters" could be considered a subset of "waters of the US". When compared with the Section 404 Permit, the Section 10 Permit is relatively straight forward and usually easier to obtain.

ENDANGERED SPECIES ACT OF 1973, AS AMENDED:

The Endangered Species Act (ESA) was initially passed by Congress in 1973 and has been reauthorized and amended several times (<u>http://www.fws.gov/endangered/pdfs/ESAall.pdf</u>).

The purpose of the Act is to conserve "the ecosystems upon which endangered and threatened species depend" and to conserve and recover listed species. Those wildlife species which have been determined to have dangerously low population levels or are in imminent threat of extinction and thus requiring Federal protection are classified as endangered or threatened. Endangered is defined in Section 3(6) of the Act as "...any species [including subspecies or qualifying distinct population segment] which is in danger of extinction throughout all or a significant portion of its range." A threatened species is defined in section 3(19) of the Act and is defined as "...any species within the foreseeable future throughout all or a significant portion of its range."

Under Section 9 of the ESA, it becomes unlawful to "take" an endangered or threatened (e.g., listed) species. The term "take" is defined by the ESA as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct." The term "harm" has been further defined to include "significant habitat modification or degradation." This would include the clearing of forests (or other types of vegetation) that are being utilized by endangered species.

If project plans cannot be modified to completely avoid impacting an endangered species or its habitat, the USFWS or NMFS will likely make a "may affect, likely to adversely affect"

determination. If your project has a federal nexus, the endangered species issue will be resolved through the ESA Section 7 consultation process. If your project does not have a federal nexus, then the issue will be addressed through the more complex ESA Section 10 Incidental Take Permit (ITP). Both of these authorizations can be costly and involve a significant time period before completion. To the best possible extent, it is recommended to avoid impacting federally protected species or their habitat.

U.S. ARMY CORPS OF ENGINEERS (USCOE)

The USCOE has been administering the Rivers and Harbors Act Section 10 regulatory program (regulates placement of structures in "navigable waters") for over 100 years. The Clean Water Act Section 404 regulatory program (regulates the discharge of fill material into "waters of the US") is also directly administered by the USCOE, however the USEPA has environmental guidance and oversight. Although the two above regulatory programs were created from different Congressional Acts, the USCOE has only one comprehensive application and processes both permits simultaneously as if they were one.

An overview of the USCOE permitting program may be found at <u>http://www.usace.army.mil/</u><u>CECW/Documents/cecwo/reg/reg_juris_ov.pdf</u>.

Administrative reviews and assessments of pending USCOE applications are conducted by the NMFS, USEPA, USFWS, the general public, as well as Guam resource agencies.

These reviews focus on potential project impacts to endangered species (known as ESA Section 7 consultation) and to the aquatic ecosystem in general. Another administrative review is conducted by the local Guam Historical Preservation Officer and their federal counterpart, the Advisory Council on Historical Preservation (ACHP). The ACHP review is required under Section 106 of the National Historic Preservation Act (http://www.achp.gov/regs-rev04.pdf) and focuses on potential project impacts to historic properties, especially those that are, or can be considered eligible as a national historical landmark. Basically, all these agencies act in an advisory role to the USCOE and recommend specific mitigative measures to be included as conditions should a permit be issued. It should be noted that local Guam permits may be required in order to authorize the same activity that is being applied for with the USCOE application. For example, a CWA Section 401 WQC that would be issued by GEPA must be issued to validate the Federal Section 10/404 permit and vice versa.

Of all the regulatory permits that one may encounter with aquaculture ventures, the CWA Section 404 permit can be the most complex (depending upon what activities are being permitted) and possibly expensive. First of all, the proposed project must be able to meet the water dependency test outlined in the CWA Section 404(b)(1) Guidelines (http://www.usace.army.mil/CECW/Documents/cecwo/reg/materials/40cfr230.pdf). This includes but is not limited to, whether there are any practicable alternatives available for the proposed project that will not affect jurisdictional wetlands or "waters of the US". If this test is passed, then the USCOE could require compensatory mitigation in the form of creating new habitat, improving existing habitat, or habitat restoration (e.g., wetland) to offset project related impacts to the impacted natural resource (e.g., wetland). At this point, and depending upon the mitigation plan, compliance costs could exceed project budget.

Pre-planning strategy should involve avoidance of this permit foremost, and secondarily, minimization of project impacts on those regulated resources being affected. Although Guam is

under the administrative authority of the USCOE Honolulu District http://www.poh.usace.army.mil/), the point of contact for all CWA regulatory issues is the USCOE Guam Regulatory Office. At a minimum, the USCOE requires a completed and signed Engineering Form 4345 (see www.orn.usace.army.mil/cof/apply.htm) and related documentation identified in the application form. It is highly recommended that the supplemental Environmental Application form, obtained from the local Guam USCOE office, also be completed and submitted. This additional information will assist the reviewing agencies in developing the impacts analysis.

CONTACT INFORMATION:

U.S. Army Corps of Engineers Guam Regulatory Branch Mr. Ryan H. Winn, Field Office Manager PSC455, Box 188 FPO AP 96540-1088 Tel: (671) 339-2108 Fax: (671) 339-2306 E-mail: ryan.h.winn@usace.army.mil Web site: www.poh.usace.army.mil

U.S. ENVIRONMENTAL PROTECTION AGENCY (USEPA)

US Congress gave the USEPA authority over the CWA Section 402 NPDES regulatory program. Although the USEPA has not delegated responsibility of the NPDES regulatory program to the GEPA as it has with various states in the US mainland, the two agencies coordinate closely in the processing of this permit.

An individual Section 402 NPDES permit will be required for any discharge of aquaculture related effluent into near shore marine waters or "waters of the US." (see <u>http://cfpub.epa.gov/npdes/home.cfm?program_id=45</u>).

Completed application forms (<u>http://cfpub.epa.gov/npdes/doctype.cfm?sort=name&program_</u> id=45&document_type_id=8) must be submitted to the USEPA Region 9 (San Francisco, CA) office for processing. Long term effluent monitoring may be required as a part of any issued permit and can become costly. These projected costs need to be included in evaluating the overall operating costs for the facility.

Construction site storm water issues are also covered by the Section 402 NPDES program. However, the USEPA has developed a Construction General Permit (CGP) or Multi-Sector General Permit (MSGP) for storm water discharges on various construction sites. The purpose of these 'general' permits is to decrease the regulatory burden by eliminating the need to obtain an individual Section 402 NPDES permit for earthmoving activities at construction sites. If the area of the aquaculture facility exceeds the threshold area identified by the regulations for a permit, then it is necessary to comply with the regulations. A permit will not actually be issued by the USEPA, but the USEPA will need to be provided with a Notice-Of-Intent (NOI) for the pending construction work. The NOI form can be completed and submitted on-line (see <u>http://cfpub.epa.</u> gov/npdes/stormwater/enoi.cfm). Additional documentation, such as the development of the storm water pollution prevention plan (SWPPP), may be required.

On June 30, 2004, a new rule under the Section 402 regulatory program was promulgated that established effluent limitations guidelines for concentrated aquatic animal production (CAAP), or aquaculture, facilities. The regulations apply to CAAP facilities that generate wastewater from

their operations and discharge that wastewater directly into waters of the United States. This final rule applies to existing and new CAAP facilities with the following characteristics: (1) uses a flow-through, recirculating, or net pen system, (2) a direct discharge of wastewater, and (3) produces at least 100,000 pounds of fish a year.

See <u>http://www.epa.gov/guide/aquaculture/fs-final.htm</u>for brief overview.

CONTACT INFORMATION: U.S. Environmental Protection Agency Pacific Islands Office Walter S. Leo Guerrero, Administrator Tel: 671.300.4751 17-3304 Mariner Avenue Tiyan Barrigada Guam 96913 E-mail: <u>walter.leoguerrero@epa.guam.gov</u> website: <u>www.epa.gov/region9/</u>

U.S. FISH AND WILDLIFE SERVICE (USFWS): IMPORT/EXPORT ISSUES

If the aquaculture business plan involves the international importation or exportation of any animals or animal products to or from Guam, a USFWS-Import/Export License will be required. With respect to the Pacific Island region, international sources include the Republic of Palau, the Republic of the Marshall Islands, and the Federated States of Micronesia. The cost for this License is \$100 per year and is renewable annually. The USFWS-Import/Export License application form may be found at http://www.fws.gov/forms/3-200-3.pdf.

Each international wildlife shipment arriving into or leaving the United States must be cleared by the USFWS. A declaration for importation or exportation of fish or wildlife must be filed ahead of the shipping and cleared by USFWS at the port-of-entry or exit. The USFWS has an automatic inspection fee of \$89.00 for every international shipment, whether it is physically inspected or not. There is a surcharge for importation or exportation of live animals of \$56.00 for a total charge of \$140.00 per shipment. Other charges (overtime) may be incurred if the wildlife shipment is cleared outside of normal working hours.

CONTACT INFORMATION:

U.S. Fish & Wildlife Service (Regional Office) Office of Law Enforcement Mr. Paul Chang, Special Agent in Charge P.O. Box 9 Sherwood, Oregon, USA 97140-0009 Tel: (503) 521-5300 Fax: (503) 521-5316 Web site: http://www.fws.gov/pacific/lawenforcement/

U.S. Fish and Wildlife (Guam Office) Division of Law Enforcement Mr. Art Taimanglo, Wildlife Inspector 415 Chalan San Antonio Road, Suite 209 Tamuning, Guam 96913 Tel: (671) 647-6064 Fax: (671) 647-6068 E-mail: arthur_taimanglo@fws.gov
ENDANGERED SPECIES ISSUES: U.S. FISH AND WILDLIFE SERVICE (USFWS) AND NATIONAL MARINE FISHERIES SERVICE (NMFS)

Enforcement of the ESA is shared between the U.S. Fish and Wildlife Service (Department of Interior) and the National Marine Fisheries Service (Department of Commerce). Jurisdiction of the USFWS extends to terrestrial and freshwater wildlife species while the NMFS's primary responsibility is with the marine wildlife species.

With respect to Guam, as of October 2015, the USFWS Pacific Island Eco-region's website (<u>http://www.fws.gov/pacificislands/index.html</u>) identified 13 listed species (2 mammals, 6 birds, 4 marine turtles and 1 plant)

NMFS has identified 10 wildlife species (6 marine mammals, 5 marine turtles, 4 sharks, 7 invertebrates (coral and giant clams)) that are protected by the ESA and occur in the Marianas archipelago (<u>http://www.fpir.noaa.gov/Library/PRD/ESApercent20Consultation/</u><u>Marianaspercent20Speciespercent20Listpercent20Aprpercent202008.pdf</u>). Additionally, keep in mind that all other marine mammals not protected by the ESA are protected by the Marine Mammal Act. With respect to Guam aquaculture, the biggest hurdle will be encountered if the project site contains habitat that could be used by a listed species, or if a listed species is found on the project site. Unavoidable impacts to endangered species can be addressed or resolved through two regulatory mechanisms found in the ESA: Section 7 consultation or the Section 10 Incidental Take Permit. These are discussed briefly below:

(a) Section 7 of the Endangered Species Act (ESA):

Section 7 of the ESA requires that any Federal action agency coordinate or consult with the USFWS or NMFS to ensure that the project does not jeopardize the continued existence of a listed species or destroy or adversely modify designated critical habitat. With respect to aquaculture projects, the requirement of any Federal permit (e.g., a USCOE-Section 10 or 404 Permit or USEPA-Section 402 NPDES Permit) will constitute a federal action (or "federal nexus") and therefore trigger the Section 7 consultation for the entire project, not just the specific action requiring a permit.

The Section 7 consultation process is between the federal action agency and either the USFWS or NMFS; the applicant has little to no direct involvement. If endangered species or its habitat, or designated critical habitat, occurs on the project site, the consultation process can get more involved and require more time as the USFWS or NMFS must issue a Biological Opinion (Bi Op) prior to the USCOE or USEPA issuing their permit.

If this situation occurs, be sure to fully understand the regulatory obligations for compliance with the non-discretionary Reasonable and Prudent Measures that will be included in the Bi Op and subsequent to federal permit issuance. In addition, the project description may also be modified to include specific conservation measures that the permittee must implement. The cost to implement some of these permit conditions may jeopardize the business venture.

The USFWS has designated Critical Habitat for the Micronesian kingfisher, Mariana fruit bat and Mariana crow in Guam (<u>http://ecos.fws.gov/docs/federal_register/fr4349.pdf</u>). NMFS has not designated any Critical Habitat in Guam waters. If a project will be sited within an area designated as critical habitat, one should coordinate with the USFWS to see if your construction plans will become an issue. (b) Section 10 of the Endangered Species Act:

The Section 10 Incidental Take Permit (ITP) is a regulatory mechanism whereby permit applicants can resolve endangered species issues if their project does not have a federal nexus. If the proposed aquaculture project will not require any federal permits and has no other federal connection, then this route may be appropriate should listed species or their habitat occur on the proposed site and a "may effect" is anticipated. Although the applicant would be working directly with the USFWS or NMFS for the Section 10 ITP permit, the local DAWR will also be involved. Overall, this permit is very difficult to obtain, costly, and will require special expertise in order to collect the necessary biological information that will likely be required by the USFWS or NMFS.

CONTACT INFORMATION:

U.S. Fish and Wildlife Service Pacific Islands Ecoregion Earl Campbell, Ph.D. Field Supervisor Pacific Islands Fish and Wildlife Office U.S. Fish and Wildlife Service 300 Ala Moana Blvd., Room 3-122 Honolulu, Hawai'i 96850 Cell Phone: 808.285.2273 Email: Earl_Campbell@fws.gov http://pacificislands.fws.gov/

FWS Ecological Services Guam Office, contact: "jacqueline_flores@fws.gov" <jacqueline_flores@fws.gov>

National Marine Fisheries Service Ms. Alecia (Lisa) Van Atta, Assistant Regional Administrator - Protected Resources 1601 Kapiolani Blvd., Suite 1110 Honolulu, Hawaii 96814 Tel: (808) 944-2200 Fax: (808) 944-2142 E-mail: alecia.vanatta@noaa.gov Web site: http://www.fpir.noaa.gov/PRD/prd_esa_consultation.html

INTERNATIONAL WILDLIFE REGULATORY PROGRAMS - CITES

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is an international cooperative conservation agreement that has been signed by 175 countries as of September 2009; including the United States (see http://cites.org/). The agreement was first drafted in 1973 with actual ratification occurring in1975. The purpose of CITES is to monitor the international trade of endangered species to ensure that commercial trade in these animals will not threaten the species with extinction.

Wildlife species were grouped according to their present threat of extinction and classified as either Appendix I, II, or III. Appendix I species (for example, the giant panda of China and the gorillas of Africa) are the most vulnerable to extinction and therefore have the most strict import/ export regulations. Appendix II and III listed species are not immediately faced with extinction and commercial trade is being allowed provided all shipments implement special import/export rules and are properly documented. With respect to the US, the USFWS is both the management 110

and scientific authority for all CITES related import/export/re-export shipments. For more information see (<u>http://www.fws.gov/international/DMA_DSA/CITES/CITES_home.html</u>).

CITES regulations are only implemented when CITES listed species are commercially shipped between Guam (e.g., the US) and another country. For instance, if corals (Appendix II) or giant clams (family: Tridacnidae; Appendix II) are cultured in Guam waters, the product can be commercially shipped without CITES documentation anywhere in the US (CNMI, Hawaii, and the US mainland).

On the other hand, if the aquaculturist requires CITES listed animals (e.g., corals or giant clams) for culture purposes and wishes to import them from the Republic of Palau, Republic of Marshall Islands (RMI), or the Federated States of Micronesia (FSM), then CITES regulations for Appendix II species must be followed. Although the RMI and FSM are not signatory to CITES, the appropriate in-lieu documentation has been developed to enable export of these species into Guam, provided the local DAWR issues the appropriate authorizations. The Republic of Palau joined CITIES in 2004, therefore normal CITES documentation procedures should be followed. The Guam aquaculturist should at least be aware of what may be required should CITES listed species be targeted for culture. Local contact information for CITES issues are the same as under the USFWS.

Examples of presently or potentially cultured species within the Micronesian region that are currently listed by CITES under Appendix II include: giant clams (all species in family Tridacnidae); blue corals (all species in the Order Coenothecalia); organ-pipe corals (all species in the Family Tubiporidae); black corals (all species in the Order Antipatharia); stony corals (all species in the Order Scleractinia); fire corals (all species in the Family Milleporina); and lace coral (all species in the Order Stylasterina).

ADDITIONAL INFORMATION

In 2021, NOAA published a series of documents listing State by State permitting requirements for various aquaculture activities. Guam's permitting requirements are listed in each of those;

State by State Summary of Finfish Aquaculture Leasing/Permitting Requirements (2021) Prepared by Benjamin Hurley for NOAA. This information is current as of August 2021. <u>https://www.fisheries.noaa.gov/resource/document/state-state-summary-finfish-aquaculture-leasing-permitting-requirements-2021</u>

State by State Summary of Shellfish Aquaculture Leasing/Permitting Requirements (2021) Prepared by Benjamin Hurley for NOAA. This information is current as of August 2021. <u>https://www. fisheries.noaa.gov/resource/document/state-state-summary-shellfish-aquaculture-leasingpermitting-requirements-2021</u>

State by State Summary of Seaweed Aquaculture Leasing/Permitting Requirements (2021) Prepared by Benjamin Hurley for NOAA. This information is current as of August 2021. <u>https://media.</u> fisheries.noaa.gov/2021-09/Report-State-by-State-Summary-of-Seaweed-Aquaculture-Leasing-Permitting-Requirements-2021.pdf