

Final Report to
Gulf States Marine Fisheries Commission

Applicant Name: Gulf Offshore Research Institute (GORI)

Title: Advancing the Viability of Oil Rig Associated Aquaculture

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I. Executive Summary

The objectives of this project were to advance our understanding of the viability of oil rig/platform-associated aquaculture from the preliminary assessment conducted in 2020 to a more holistic and rigorously studied level which will allow it to be presented as a viable investment opportunity to investors and a valuable and plausible ocean use to regulators and other stakeholders.

GSMFC funded a project in 2020 entitled “MMEERSET Phase One: developing platform-based offshore aquaculture using a multi-use approach at Station Padre”. This project generated important information on the environment at the Station Padre site located about 30 miles offshore in the Western Gulf of Mexico (GOM) and the potential economic performance which will be essential inputs for future work. However, the concept is still very much theoretical and represents a high risk for companies or investors to pursue. The Station Padre platform is located at North Padre Island OCS Block 175 in about 155 feet of water. It is a retired oil and gas platform that produced natural gas and liquids until 2015.

In this Phase 2 research, without analogous oil rig/platform-associated aquaculture systems, it was necessary to begin the preliminary design process, produce technical drawings, and complete stress analyses to ensure that a system can be designed that is cost-competitive with alternative production systems (priority 1). The production model must be better defined, including production costs and financial returns versus grid-based mariculture systems, species selection, and interactions with the rig/platform owner (modifications to the oil rig, liability, and insurance implications, etc.). This project investigated these areas and produced models and analyses that reduce uncertainty as much as possible (priority 2). Finally, this project describes the permitting process and regulatory uncertainties and performs preliminary stakeholder engagements (priority 3). The results of the study were presented at Aquaculture America 2023 and will be disseminated through the Blue Silo, GORI, and Innovasea websites.

Species selection

The species selection report summarizes the selection criteria for open ocean aquaculture for the Station Padre Aquaculture project development in the Gulf of Mexico. The evaluation was based on biological, technological, market, socio-economic, and ecological criteria, and aimed to identify candidate species for commercial aquaculture development using offshore net cages. The top five candidate species identified were Red Drum (*Sciaenops ocellatus*), Almaco jack (*Seriola rivoliana*), Pompano (*Trachinotus carolinus*), Red Snapper (*Lutjanus campechanus*), and Cobia (*Rachycentron canadum*). Market criteria included market demand and value, acceptance by target populations, organoleptic characteristics, appearance, and level of processing. Technological criteria included the availability of hatchery, nursery, and grow out technologies. Socio-economic and regulatory criteria considered the social and economic impact and regulatory situation. Ecological criteria included whether the species is native, endemic, or exotic to the region. Biological criteria were deemed the most important and included the ability to withstand temperature, salinity, and environmental variations, as well as the type of diet. The report also suggested an Integrated Multi-Trophic Aquaculture (IMTA) approach to take advantage of infrastructure, generate additional revenues, and minimize environmental impacts.

Aquaculture Performance Index

The Aquaculture Performance Index (APIX) methodology was used to rank the species based on various criteria, including feasibility level, feed conversion rate, growth rate, survival rate, stocking density, feed costs, fish processing yield, and marketability. The report evaluates the feasibility of several pelagic, demersal, reef, and coastal fish species for commercial aquaculture development in offshore net cages in the Gulf of Mexico. Red Drum was identified as the top candidate species due to its ability to thrive in the

temperature range of the site, high stocking density, and lower feed costs. The report also suggests the use of an IMTA approach, combining marine fish with seaweeds and bivalves culture. The Lion's Paw scallop, Atlantic oyster, hard clam, and *Euchema* spp., *Gracilaria* spp., and *Hypnea* spp. seaweed species were suggested based on their commercial feasibility and potential uses. Further market research and economic analysis are recommended for Red Drum and an IMTA system.

Stakeholder Engagement

NOAA has released its first-ever strategic plan for expanding the U.S. aquaculture industry over the next five years, co-authored by representatives of NOAA Fisheries, the National Sea Grant College Program, and the National Centers for Coastal Ocean Science. The 20-page report outlines the benefits of aquaculture in fighting climate change, replenishing wild stocks, and aiding in the recovery of threatened and endangered species. The plan also outlines four goals for improving oversight of the U.S. aquaculture sector, including crafting more efficient and -effective management processes and supporting the economic viability and growth of the industry. The U.S. currently imports at least 70 percent of its seafood and ranks 17th globally in terms of aquaculture production. The report, along with the recent establishment of a bipartisan aquaculture caucus in the U.S. Congress, shows growing governmental backing for aquaculture.

The Stakeholder Engagement Report discusses the potential for open-ocean aquaculture in the Gulf of Mexico, focusing on technical, policy, environmental, and social challenges. The Food and Agriculture Organization (FAO) of the United Nations puts the United States toward the top of the list of countries with large marine aquaculture potential, but the country lags far behind other nations. The findings of a workshop conducted by the Meridian Institute and Ocean Strategies called the Multi Sectional Scenario Planning and Solution Building for the Future of U.S. Marine Aquaculture. The report also discusses the seafood market, noting that aquaculture represents 57% of global seafood production and that establishing a sustainable alternative to a stable or declining wild-caught production gives a positive market outlook for Gulf of Mexico open-ocean aquaculture farming for Gulf native species. Finally, the report identifies five candidate species for the project, with Red Drum and Pompano considered the top species for initial production.

In addition, the report outlines the plan for Blue Silo Aquaculture to operate in the open ocean waters of the Gulf of Mexico using existing oil and gas platforms as operational bases. The fishnet pens to be used will be completely enclosed and capable of being submerged during storm events. A hydraulic feed delivery system will be used to pump seawater containing custom-blended feed to the net pens. The report notes potential conflicts with commercial fishermen and environmental groups but suggests joining the Sustainable Seafood Coalition and engaging in advocacy and outreach efforts. The lengthy permitting process is also highlighted, and the report suggests engaging with elected representatives and government officials.

Financial Model

The financial model report presents the results of a financial model for an open ocean finfish farm partially operated from an adjacent converted oil rig in the Gulf of Mexico. The model uses red drum and Florida pompano as the most suitable species and includes infrastructure delivery, installation, and sales volume. The model is constrained by the spatial limitations of net pens situated close enough to the oil platform. The financial outlook is promising, but there are uncertainties due to the novelty of using an oil platform as an operation base and the lack of data to support a more rigorous analysis. The financial potential for

other species was not evaluated. The report suggests further research and due diligence to reduce risks and increase the project's chances of success.

Deposition

The study analyzed the potential impact of a farming operation near the Station Padre oil rig using the TROPOMOD deposition model. The farm layout and environmental conditions were taken into consideration while developing the model. The results showed that the nutrient loading was low, and the maximum carbon flux was below the threshold for high or severe impacts. The nutrients primarily moved towards the southeast due to the predominant current direction, and the open ocean environment in this location is likely to be more robust due to nutrient contributions. The modeling efforts suggest that the planned farming activities would have a modest impact on the benthic ecosystem relative to farming operations modeled elsewhere. However, the study acknowledges that the model was based on a limited dataset.

Permitting Pathway

The objective of this document is to provide improved clarity on the permitting process for offshore aquaculture projects in the Gulf of Mexico. The information is a compilation and summarization of publicly available Federal, state, and local agency information. Gulfstream Aquaculture, LLC (GSA) extracted some segments of text from these sources verbatim and updated the source contact information. The permits, authorizations, and consultations associated with the Permitting Pathway described would remain relatively similar whether applied to a small demonstration scale operation or a much larger, commercial scale operation. The timeline, level of effort, and costs provided are commensurate with an EA and FONSI, and not an EIS and ROD.

Title: Advancing the Viability of Oil Rig Associated Aquaculture

Species Selection for Offshore Aquaculture Station Padre Project

Final Report by Daniel Benetti

Species selection criteria for open ocean aquaculture

Biological, technological, and market criteria have been evaluated to suggest and rank several pelagic, demersal, reef, and coastal fish species for the Station Padre Aquaculture project development. Criteria analyzed were divided into *experimental*, *technological*, and *commercial* feasibility levels, according to their respective prospects for commercial aquaculture development using offshore net cages. Our preliminary evaluation indicates that Red Drum (*Sciaenops ocellatus*), Almaco jack, also known as Kampachi (*Seriola rivoliana*), Pompano (*Trachinotus carolinus*), Red Snapper (*Lutjanus campechanus*), and Cobia (*Rachycentron canadum*) are to be considered top candidate species for commercial aquaculture development in offshore systems in the area selected in the Gulf of Mexico.

The following criteria related to the species to be cultured were considered for the final selection:

1. *Market criteria*: Market and marketing related criteria are crucial for species selection. Market demand and value are decisive for the business planning and implementation of the operation. This is where it all starts and how the revenues are generated. Whether the species selected already has a high market demand and reasonable price are the most important considerations. At the very least, the species must have the potential to be turned into an appealing and high-quality product that will meet consumer expectations. Relevant considerations include acceptance by a large segment of the target population, which may include mass markets and/or specific niche markets such as white tablecloth restaurants, Japanese restaurants (sashimi grade), live products, etc. It is also important to understand the changes in the market and the market behavior in response to certain predictors. Organoleptic characteristics such as flavor, taste, odor, etc. may be more important to certain market niches than others. Also, the appearance of the product (external and flesh: white flesh, red muscle tissue, “marble” color, fat content, etc.), as well as its texture (firm, mushy, fatty, etc.), are key factors in the process, as is the level of processing (whole fish, gutted, fillet, frozen, fresh, fresh/flash-frozen, ready-to-eat portions, etc.). The processing level is determined by the target market's needs.

2. *Technological criteria*: The level of readily available technological development for the culture of the species from egg to market is also a crucial consideration. It is important to ensure that there are hatchery, nursery, and grow out technologies available to raise the species throughout its entire life cycle, from egg all the way to harvest. Technological criteria encompass maturation, spawning, incubation, larval husbandry, fingerling production, nursery techniques, adequate feeds, grow out equipment, and methods, including cages, net cleaning/replacement, and harvesting techniques.

Technology is available for all the pre-selected priority species for this project. In addition, recent developments in seaweed and bivalve cultures in offshore systems are leading the team members to consider an IMTA approach, which can take advantage of the infrastructure, generate additional revenues and minimize environmental impacts.

3) *Socio-economic and regulatory criteria*: It has become increasingly important to take social and economic considerations into account when selecting a species for commercial aquaculture development. Responsible aquaculture development must be socially accepted and viewed as a powerful means of generating high quality food/protein, jobs, and income, with a minimal environmental footprint. In

essence, aquaculture should never compete with existing fisheries. Instead, aquaculture should be regarded as a harmonic complement to fisheries diminishing the pressure upon declining and overfished stocks. It is also important to consider the regulatory situation and the role of the government in establishing laws, rules, and regulations for open ocean aquaculture development. The process for obtaining the concession of an area is still relatively complex, requiring expertise to navigate the system. This process is being carefully carried out and will be discussed further.

4) Ecological criteria: Whether the species is native, endemic, or exotic to the particular region in question is an important ecological consideration. The introduction of non-native species for aquaculture is not recommended since it is unlikely to be authorized. In addition, many NGOs and environmentalists are against the introduction of non-native species, and that can also create undesired public opposition to the project. These considerations are highly relevant for obtaining permits for new operations and must be taken into account when selecting a species for commercial aquaculture development. This is even more important when cages are to be used in exposed areas in the open ocean, considering that escapements, even though mitigated, could potentially occur. For such reasons, only native species to the Gulf of Mexico are being considered.

5) Biological criteria: In terms of priority, biological criteria are likely to be the most important for species selection because they determine the technical feasibility and express the aquaculture performance of any given species in terms of densities, survival, growth to market size, and feed conversion rates. These characteristics are recognized as the most important criteria for species selection for commercial aquaculture. The selected species need to have physiological characteristics that will enable it to thrive and grow to market size in the proposed site. Technically, an ideal species for aquaculture must be able to withstand wide ranges of temperature (eurythermal) and salinity (euryhaline) as well as other environmental variations such as low dissolved oxygen levels, high ammonia, pH variations, etc. Another important biological aspect is fish diets. It is well known that marine fish species can be carnivorous, herbivorous, or omnivorous. Whilst herbivorous and omnivorous species are less demanding when it comes to animal protein requirement in their diets – which represent the highest costs in the feeds –, these species also tend to have a lower demand and a lower price in the market. On the other hand, carnivorous marine fish require higher levels of animal protein – mainly derived from fish meal and fish oil – yet in turn present higher levels of omega-3 and invariably have a higher demand and higher prices in the market. Other biological criteria are the species' behavior (schooling and gregarious species are preferred over territorial and aggressive species), and cannibalism (especially in the hatchery/nursery stages). Finally, the species need to be hardy, that is, resistant to diseases (viral, parasitic, bacterial, and fungal) under environmental fluctuations. Generally, native species exhibit these characteristics when cultured within their respective habitat ranges.

Feasibility levels

The criteria used for establishing the feasibility of each species are somehow subjective and restricted to the level of control and results to date related to the following basic aspects:

1. Maturation: broodstock availability and management; easy to obtain, handle, keep, and feed; resistant to diseases; adaptability to captivity; ease of domestication.
2. Spawning: volitional, natural, environmentally conditioned, and/or hormone-induced; controlled reproduction is of paramount importance.
3. Larval rearing: level of control of larval husbandry techniques.
4. Survival rates: during the larval rearing, nursery, and grow-out stages.

5. Feed conversion rates: feeds and feeding strategies mastered; basic information on nutritional requirements known and well-established.

6. Market and marketing: established, stable, good demand and value.

Experimental feasibility: Research level. The species is generally hard to be raised, with little or no control over maturation, spawning, and larval rearing. Survival rates from fry to harvest size are low (between 0-1 percent). The species has been and can be experimentally raised but results cannot be consistently repeated. Research at this level is generally conducted at universities or research institutions and is funded by government grants.

Technological feasibility: Research and development level. High level of control over maturation, spawning, and larval rearing. Survival rates are generally low to medium (between 1-20% at the hatchery). The species has been and can be raised but not yet on a commercial basis. Results can be repeated consistently- R&D is generally conducted in private companies, universities, and research institutions using both private and government funds.

Commercial feasibility: Economic feasibility level. Total control is achieved over all stages of the production cycle (maturation, spawning, larval rearing, nursery and grow out). Survival rates are generally medium to high (10-30% at the hatchery and 70-90% at the grow out). The species has been and is being commercially cultured at a profit by the private sector.

Overview of Pre-Selected Candidate Species

The minimum and maximum sea surface temperatures at the site are estimated to be 22.5 °C and 26 °C respectively, with a mean annual temperature of 24.5 °C. This data was obtained using the Aquamapper (NOAA). This temperature range was considered to determine the survival and growth rate of the selected species.

Below we present a table listing and ranking the species being considered as a priority for project development to date. We applied a methodology called Aquaculture Performance Index (APIx) pointing out the marine fish species selected and a detailed table considering all criteria and respective weights assigned for each criterion (market price and demand, level of feasibility, biological characteristics, and adequacy for offshore cage production at the site, etc.). A full APIx equation was constructed to assign a species a final APIx score, which would be out of 29 possible APIx points of the biological, productivity, and market variables. These variables were assigned a weight of 1. Adding to that, we incorporated the level of feasibility, which was given a weight of 2, since it indicates the species' readiness for commercial aquaculture.

APIx = feed conversion ratio (FCR) + growth rate to market size + survival rate + stocking density + cost of feeds + fish yield + marketability + market price + processing level + 2x (level of feasibility). The maximum number of APIx + feasibility level points is 35.

Table 1: Ranking the species using APIx

Common Name	Scientific name	Feasibility Level	APIX	APIX + Feasibility level
RED DRUM	<i>Sciaenops ocellatus</i>	Commercial	26	32
POMPANO	<i>Trachinotus carolinus</i>	Commercial	25	31
ALMACO JACK	<i>Seriola rivoliana</i>	Commercial	23	29
COBIA	<i>Rachycentron canadum</i>	Commercial	23	29
RED SNAPPER	<i>Lutjanus campechanus</i>	Technological	24	28
SEAWEED	<i>Euchema spp.</i>	Commercial		
SEAWEED	<i>Gracilaria spp.</i>	Commercial		
SEAWEED	<i>Hypnea spp.</i>	Commercial		
EASTERN OYSTER	<i>Crassostrea virginica</i>	Commercial		
HARD CLAM	<i>Mercenaria mercenaria</i>	Commercial		
LION'S PAW SCALLOP	<i>Nodipecten nodosus</i>	Commercial		

All species listed above are technically feasible to produce at the site. Red Drum (*Sciaenops ocellatus*) was the top selected using the APIx grade + feasibility level. First, there is a long history of Red Drum production in Texas which makes fingerlings and feed readily available as well as an established market. Even though it has a lower market value when compared to the other fish species considered, it was found to be the most feasible for this operation since it thrives at the temperature range of the site (22.5 °C-26 °C), allowing for a higher stocking density >30 kg/m³, and has a lower feed cost since good results were obtained using a high percentage of soy protein (up to 86%) as a substitute for fish meal. As a competitive advantage, the Red Drum produced in the offshore cages will have a different taste (no *off-flavor*) when compared to pond-reared fish and for this reason, it has a possibility of being marketed as premium. Nonetheless, we recommend a thorough economic analysis coupled with market research once the species are chosen. The team is considering an innovative approach of combining the proposed marine fish operation with seaweeds and/or bivalves culture in an IMTA system. The species of native bivalves and seaweeds were suggested on a feasibility level (commercial) basis and according to the temperature ranges and salinities at the site.

Criteria

FCR

1. Poor FCR; ranges from 2.5 and beyond
2. Average FCR; ranges from 1.5 to 2.5
3. Excellent FCR; ranges from 1 to 1.5

Growth rate

1. Slow growth rate to market size
2. Average growth rate
3. Fast growth rate

Survival

1. Very poor survival; 0%-40%
2. Poor survival; 40%-60%
3. Acceptable survival; 60%-80%
4. Excellent survival; 80%-100%

Feed costs

1. High feed costs; 70% or higher of total production costs
2. Average feed costs; 50-70% of total production costs
3. Low feed costs; less than 50% of total production costs

Fish yield

1. Poor fish yield; 0%-30%
2. Moderate fish yield; 30%-50%
3. Good fish yield; 50%-75%
4. Excellent fish yield; 75%-100%

Marketability

1. Poor marketability
2. Moderate marketability
3. Good marketability
4. Excellent marketability

Market Price

1. Low market price; at or below \$5/lb
2. Average market price; \$5 - \$10/lb
3. High market price; at or above \$10/lb +

Stocking density

1. Low stocking density; less than 10 kg/m³
2. Average stocking density; 10 – 20 kg/m³
3. Excellent stocking density; greater than 20 kg/m³

Processing Level

1. Requires processing; fillets, canning, etc.
2. Does not require processing; head on and gutted

Feasibility level

1. Experimental
2. Technological
3. Commercial

APIX = FCR + growth rate + survival rate + cost of feeds + fish yield + marketability + market price + stocking density + processing

THE AQUACULTURE PERFORMANCE INDEX (APIX) APPLIED TO AQUACULTURE SPECIES SELECTION FOR THE STATION PADRE OIL RIG OFFSHORE AQUACULTURE PROJECT.

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Biological, technological, and market criteria have been evaluated to rank several pelagic, demersal, reef, and coastal fish species for the Station Padre Aquaculture project development. Feasibility levels (*experimental*, *technological*, and *commercial/economical*) were also considered according to species prospects for commercial aquaculture development using offshore net cages. Red Drum (*Sciaenops ocellatus*), Almaco jack, also known as Kampachi (*Seriola rivoliana*), Pompano (*Trachinotus carolinus*), Red Snapper (*Lutjanus campechanus*), and Cobia (*Rachycentron canadum*) were considered top candidate species for commercial aquaculture development in offshore systems in the area selected in the Gulf of Mexico and were ranked taking into consideration the characteristics of the site. We applied a methodology termed Aquaculture Performance Index (APIX). In short, the APIX equation considers the following basic criteria, each assigned different weights to calculate a respective final value: feasibility level, feed conversion rate, and growth rate to market size, survival rate, stocking density, feed costs, fish processing yield, and level, marketability (market demand and price). A full APIX equation was constructed to assign each species a final APIX score. Red Drum (*Sciaenops ocellatus*) was the top selected using this methodology. Even though Red Drum has a lower market value when compared to other fish species considered, it was found to be the most feasible for this operation since it thrives at the temperature range of the site (22 – 26 °C), allows for a much higher stocking density >30 kg/m² 10 kg/m³, and has a lower feed cost since good growth and survival results can be obtained using a high percentage of soy protein as a substitute for fish meal. In addition to that, there is a long history of Red Drum production in Texas, which makes fingerlings and feed readily available as well as an established market. As a competitive advantage, the Red Drum produced in the offshore cages will have a different taste (no *off-flavor*) when compared to pond-reared fish, and for this reason, it has a possibility of being marketed as premium. However, we suggest thorough market research to establish the price and run the economic analysis model for the species in offshore cages. The team is considering an innovative approach of conducting trials combining the proposed marine fish operation with seaweeds and/or bivalves culture in an IMTA system. The species of native bivalves and seaweeds were suggested on a commercial feasibility level basis and according to the temperature ranges of the site. The bivalve molluscs suggested were the Lion's Paw scallop (*Nodipecten nodosus*), the Atlantic oyster (*Crassostrea virginica*), and the hard clam (*Mercenaria mercenaria*). *Euchema* spp., *Gracilaria* spp., and *Hypnea* spp were the seaweed species suggested based on their application for agar and carrageenan production among other potential uses (biostimulants, feed, cosmetics, etc).

Stakeholder Engagement Report for Station Padre Open Ocean Aquaculture Project

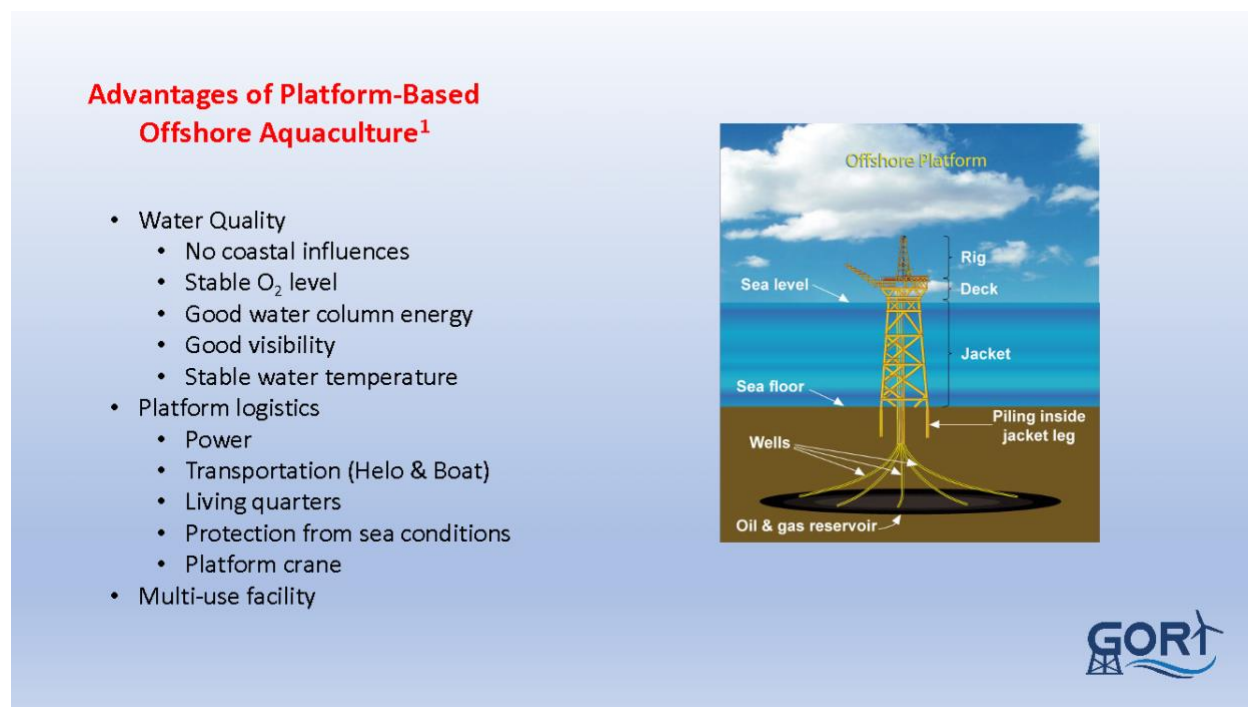
By: Kent Satterlee, Ivan Puckett, and Brian Quartano

Blue Silo Aquaculture LLC

One component of the Gulf Offshore Research Institute's grant from the Gulf States Marine Fisheries Commission was to perform stakeholder engagement. This consisted of three segments: 1) Regulatory/Government/Academic, 2) Seafood Markets, and 3) Suppliers. The stakeholder engagement was performed by the three principals of Blue Silo Aquaculture and was designed to better understand the potential obstacles that the project might face as it advances through design, permitting, and commercialization. The goal is to make an aquaculture application that addresses all or most of the concerns of stakeholders.

Platform-assisted open-ocean aquaculture has several benefits compared to either open-ocean (with no platform) or onshore aquaculture as seen in the illustration below:

Figure 1: Benefits of platform-assisted open-ocean aquaculture



Regulatory/Government/Academic

At the heart of this project is the repurposing of two offshore platforms located off the coast of Port Mansfield, Texas. The platforms produced natural gas and ceased production in about 2015. The owners of the platforms contracted with GORI to research various alternate uses and prepare the permit applications to the Bureau of Ocean Energy Management (BOEM) and the Bureau of Safety and Environmental Enforcement (BSEE). The applications were made pursuant to 30 CFR 585 Subpart J and authorized by the Energy Policy Act of 2005. One of the proposed uses of the repurposed platforms was platform-assisted open-ocean aquaculture. BOEM and BSEE received the permit application and went through three rounds of requests for additional information. In the end, they rejected the applications because the platform owners had not completed an underwater inspection of the platforms. BSEE

subsequently ordered the company that installed the platforms (Shell) to remove them. GORI has continued to work with the platform owners and Shell to find a way to re-apply for permits to repurpose the platforms. Kent Satterlee met with BOEM's Gulf of Mexico Region Director and BOEM's Deputy Director of the Headquarters in Washington DC. The BOEM representatives confirmed that they support platform repurposing for legitimate marine-related purposes. Satterlee also met with the Congressional offices of Scalise (R-LA-1), Carter (D-LA-2), and Graves (R-LA-6); and the Senate offices of Kennedy (R-LA) and Cassidy (R-LA). There were no concerns expressed by the staff members, and all were enthusiastic about the opportunities for Louisiana and the Nation.

Texas state and local government representatives were also consulted for this study. GORI met with the Port Director of Port Mansfield in Willacy County, the Willacy County local government representatives, and the Texas General Land Office representatives. All were enthusiastic about the proposal. The Willacy County Port Director, Ron Mills, confirmed that there is ample space at the port for our project. Blue Silo has worked with a fishing guide from Port Mansfield named Bart Reid. Bart has played a key role in engaging with the fishing community at the port. The community is very supportive of preserving the offshore platforms because the platforms are a frequent destination for recreational fishermen and sports divers. They have become concerned that the platforms may be removed and are considering a public campaign to stop the removals.

The Coastal Conservation Association (CCA) www.joincca.org is a nationwide association representing recreational fishing. The association places artificial habitats in the coastal areas of the Gulf of Mexico to enhance fisheries and provide anchor points for fishermen. The CCA Louisiana Director, David Cresson, has given his unconditional support for open-ocean aquaculture. Additionally, Harlon Pearce, President of Harlon's LA Fish and Chairman at Gulf Seafood Institute, has given his unconditional support for open ocean aquaculture. Harlon believes that without open-ocean aquaculture, the wild catch fisheries will continue to be strained and the Gulf Coast will soon be in short supply of fresh seafood.

The National Oceanic and Atmospheric Administration (NOAA) plays a key role in open ocean aquaculture. An Executive Order on "Promoting American Seafood Competitiveness and Economic Growth" was signed in 2020. It gave the Department of Commerce and NOAA a lead role in implementing the directive. Commerce and NOAA have made good progress in making this directive a reality. GORI and Blue Silo Aquaculture have worked closely with Dr. Ken Riley of NOAA to conduct this study. Dr. Riley, NOAA Fisheries Chief Scientist for Aquaculture, has provided excellent advice along the way and has made several introductions to other government and academic personnel that can guide the project. Blue Silo also met with Andrew Richard for a pre-application meeting. Mr. Richard is the Regional Aquaculture Coordinator, Southeast Regional Office, NOAA Fisheries, U.S. Department of Commerce.

The following was taken from the NOAA Fisheries website and explains their role and progress made to date:

NOAA has released its first-ever strategic plan for expanding "a resilient aquaculture industry" in the U.S. over the next five years. The plan was co-authored by representatives of NOAA Fisheries, the National Sea Grant College Program, and the National Centers for Coastal Ocean Science. The 20-page report states that domestic seafood is a vital resource for the United States and that aquaculture can be effective in fighting climate change, replenishing wild stocks, and aiding in the recovery of threatened and endangered species. "Aquaculture is a key component of our seafood systems and is one of the most climate-friendly and resource efficient ways to achieve food security, economic, and environmental restoration outcomes," the plan states. "With limited arable land and fresh water to expand terrestrial

farming, human populations will increasingly turn to coastal, marine, and Great Lakes resources, and to technologies that efficiently use space, water, and nutrients to source food and reduce climate impacts.”

In its report, NOAA outlined four goals for improving its oversight of the U.S. aquaculture sector – crafting more efficient and -effective management processes; performing research to improve sustainability; improving education and information exchange between U.S. aquaculture stakeholders as well as the public; and supporting the economic viability and growth of the industry.

Specifically, NOAA aims to:

Provide expertise to Congress and other stakeholders to resolve issues related to the federal regulatory framework for sustainable aquaculture and the expansion of federal research and development programs through national legislation or other mechanisms.

Explore opportunities for more accessible pathways for authorizing small scale or time-limited aquaculture activities (e.g., research, commercial trials, or restoration projects).

Work with states and federal agencies to execute directives under existing executive orders, policies, plans, and statutes to promote sustainable aquaculture as part of NOAA’s seafood portfolio.

Identify aquaculture opportunity areas to support planning for commercial aquaculture development in locations that reduce user conflict, maximize compatible uses, and minimize impacts on public trust resources through scientific analysis and public engagement.

Provide and use the best available science, information, and tools (e.g., siting, water-quality and genetics models, peer-reviewed publications) for permit reviews and environmental consultations.

Foster an environment for communication between all stakeholders and make aquaculture “a key component of a resilient seafood sector.”

The U.S. has discussed expanding its aquaculture industry for years. While it has the second-largest exclusive economic zone in the world behind only France, very little of it is used for farming purposes. America is ranked 17th globally in terms of aquaculture production. Domestic support for aquaculture is not universal. Some in the industry see it as a threat to wild fisheries and believe fish farming practices could lead to environmental issues. However, the report, along with the recent establishment of a bipartisan aquaculture caucus in the U.S. Congress shows governmental backing for aquaculture is growing. “Currently, the United States imports at least 70 percent of its seafood,” the report states. “While we continue to sustainably manage our wild-harvest fisheries, we cannot meet the increasing domestic demand for seafood through those fisheries alone. Increasing the sustainable farming of finfish, shellfish, and macroalgae is essential to increase domestic seafood supplies and provide a source of safe, nutritious, and sustainable seafood for consumers in the United States and global marketplace.” NOAA is conducting a Programmatic Environmental Impact Statement (PEIS) on the siting of offshore aquaculture in the Gulf of Mexico. They held several scoping meetings to receive public comments on the direction of the PEIS. The results of the 191 public comments are listed in the graphs below:

Figure 2: Programmatic Environmental Impact Statement Public Comments

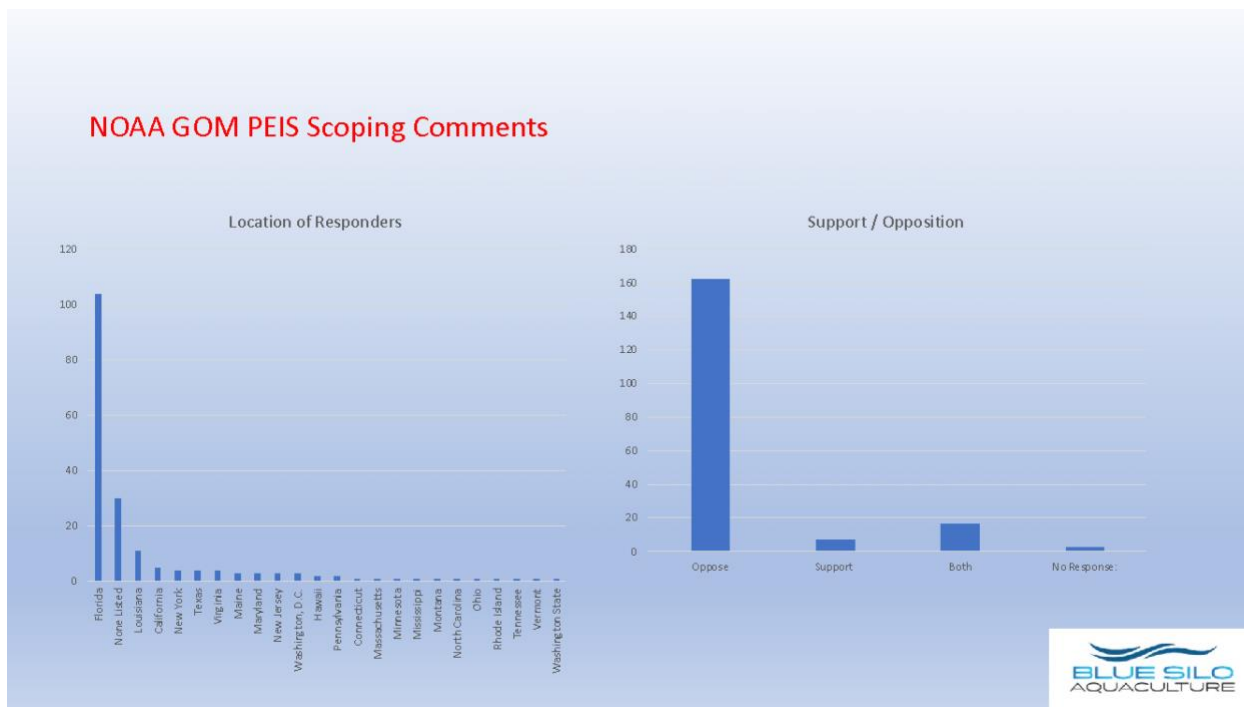
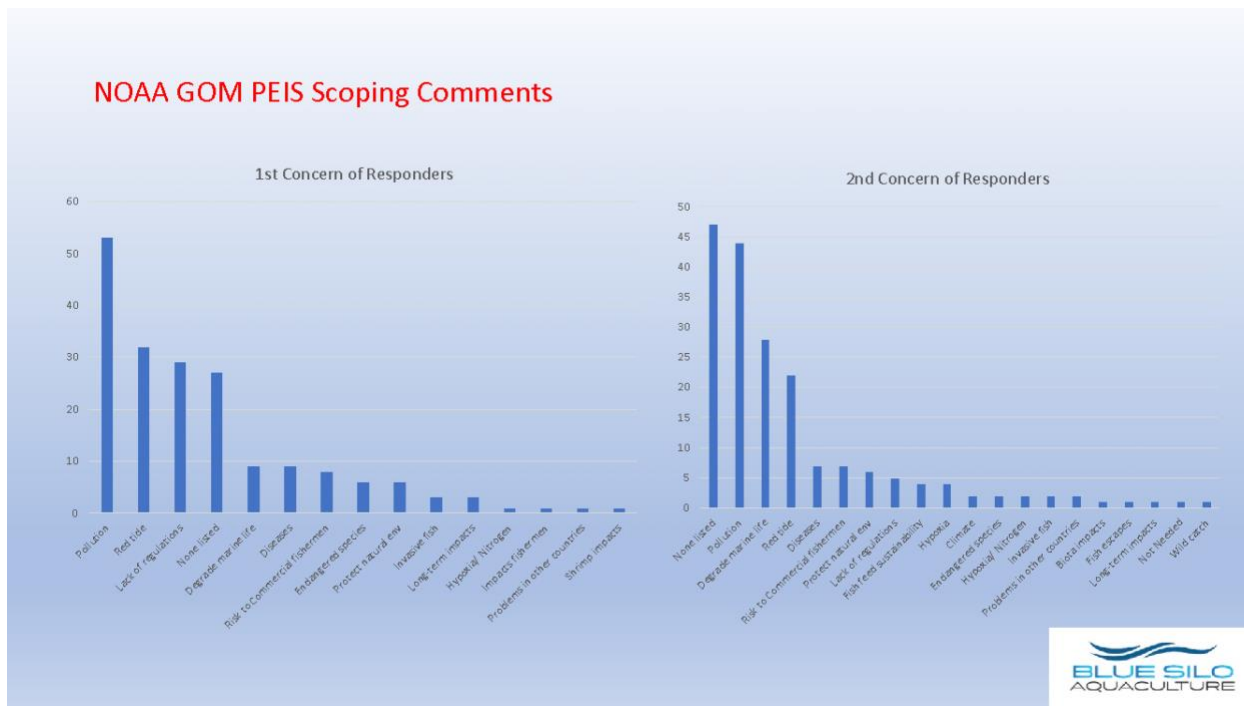


Figure 3: Programmatic Environmental Impact Statement Public Comments



Based on these comments, it can be concluded that there is quite a bit of education needed for the public, especially along the western coast of Florida, to get comfortable with offshore aquaculture and its potential impacts and benefits. While not conclusive, the people of Louisiana and Texas do not appear to be uncomfortable with locating aquaculture off their shores. One of the prime movers for generating opposition to offshore aquaculture is an organization named, “Don’t Cage our Oceans”. It appears to be composed of environmental groups, RAS farms, and commercial fishing interests as illustrated below:

Figure 4: “Don’t Cage our Oceans” Collaborators



According to USDA, our terrestrial protein food sources (beef, chicken, pork, and turkey) are 90-100% domestically produced compared to seafood which is about 15% domestically produced and only a small portion of that amount is farmed. This presents a food supply vulnerability for U.S. consumers especially when we experience supply chain disruptions as we did with the COVID-19 pandemic. Additionally, seafood has inherent health and environmental benefits that terrestrial protein sources lack. While these percentages are disappointing, they point to a major opportunity for the betterment of the health and welfare of Americans and as a growth initiative for the domestic economy.

At the same time, researchers have highlighted the technical, policy, environmental, and social challenges of developing offshore fish farms. Interest in growing fish, seaweed, and shellfish has grown markedly in recent years in recognition of the growing and potential contribution of aquaculture to marine food production, nutrition, and economic development. Siting aquaculture operations in waters where there are fewer claims on marine space and higher water quality may reduce constraints on marine food production systems. The space available for growing food offshore is considerably larger than is needed to meet global food demand under certain assumptions. Efforts to expand aquaculture into new areas are nascent; therefore, it will be challenging but important to consider ecological risks associated with ongoing offshore activities such as oil and gas extraction and commercial fishing, which of course can be considerable.[1]

A recent study by the Food and Agriculture Organization (FAO) of the United Nations puts the United States toward the top of the list of countries with large marine aquaculture potential.[2] Yet, the U.S. is well below its potential and lags far behind other countries. The challenges to open-ocean aquaculture are described by Knapp & Rubino [3] as:

1. Marine aquaculture is relatively small, diverse, and (with few exceptions) unproven.
2. Marine waters are public resources.
3. Some Americans fear the potential negative effects of marine aquaculture without offsetting benefits.
4. Aquaculture faces significant social opposition.
5. The governance system for leasing and regulation hinders the development of U.S. marine aquaculture.

The Meridian Institute and Ocean Strategies conducted a workshop in the Spring of 2022, called the Multi-sectional Scenario Planning and Solution Building for the Future of U.S. Marine Aquaculture. Their findings are summarized below:

Figure 5: Meridian Institute and Ocean Workshop Findings

Meridian Institute Workshop Summary Report - 2022	
<u>Environmental & Siting Dynamics</u> • Interaction with other ocean users • Water Quality • Species Selection and Seed/stock sourcing • Impacts of farm infrastructure • Interaction with other animals • Climate change and food production • Navigation safety	<u>Social Dynamics</u> • Engaging local communities • Local food production and connection to seafood <u>Economic Dynamics</u> • Species selection and market competition with wild-caught seafood • Building seafood and working waterfront resilience • Workforce development • Community economic development

Blue Silo also met with staff from the Environmental Defense Fund (EDF) to discuss their proposed legislation, the SEAfood Act, that addresses closing sustainability gaps with offshore aquaculture. They have also established a working coalition called the Sustainable Seafood Coalition, which Blue Silo will consider joining. Fujita, et al, described in detail the sustainability gaps in their report published in Marine Policy 147 (2023) 105351.[1] We also met with Drue Winters of Stronger America Through Seafood (SATS) and discussed their advocacy efforts to get the AQUAA Act passed. We support the AQUAA Act and have signed on to a support letter. Continued work with EDF and SATS will be needed to hammer out the differences in these pieces of legislation.

Seafood Markets

From 1961 to 2020 total global seafood production has grown from under 50 million metric tons to over 200 million metric tons. In the late 1980s, wild-caught production approached just under 100 million metric tons and has remained relatively level since. It is likely that due to worldwide conservation regulations of wild species the level of production will continue to remain constant or decline. The increase in demand and corresponding production has been met by aquaculture. Presently aquaculture represents 57% of production (122.6 MT) compared to wild caught 43% (91.4 MT). In the United States,

the 2022 import value of seafood was \$29.941 billion, a 6.4% increase from 2021 while domestic landings were valued at only \$6.343 billion (Uner Barry's Vol. 18, #2 Spring 2023). This is due in part to the demographic shift with fewer younger workers willing to join the commercial fishing industry combined with an increase in the consumption of seafood. Of the 122 million metric tons of aquaculture products produced globally in 2020, 110 million metric tons were produced by ten countries and that list does not include the U.S. The conclusion is that establishing a sustainable alternative to a stable or declining wild-caught production gives a positive market outlook for Gulf of Mexico open-ocean aquaculture farming for Gulf native species. In addition, with a negative trade imbalance and supply chain disruptions, the U.S. must reduce dependence on foreign supply.

There are two main market advantages of U.S. aquaculture produced seafood to the alternative sources of these species. First, wild-caught production is limited both in quantity and seasonality. Farm production can even out the seasonal supply peaks and valleys of wild caught and therefore can offer the product on a more consistent supply and price year-round. This is a desired product feature that leads to expanding markets to both the restaurant and retail distributors. Second, freshly imported products have a very high transportation cost that will be mostly eliminated with domestic production. Transportation costs and time to market will be reduced.

Daniel Benetti of the University of Miami has identified five candidate species for this project (see species selection report). All the candidate species can be marketed at different levels of the distribution system. At initial production levels, white tablecloth restaurants would be the targeted market. As volume increases seafood distributors and grocery store chains would be an added target. The two top species by rating were Red Drum and Pompano. In addition, both species have a very limited wild caught supply which will help alleviate the resistance from commercial fishermen. They are both highly desirable and accepted white fish products. We believe the market size can be increased as the supply side grows and would be targeted against other imported white fish alternatives in and beyond the Gulf states.

In a recent discussion (February 2023) with Fortune Fish & Gourmet's purchasing director, we confirmed both price and market demand for all five species and specifically Red Drum and Pompano. He expressed his full support for offshore aquaculture. In summary, the US has a well-established seafood market that is presently being supplied by a disproportionate dependence on foreign countries. The technology and untapped water resources of the US Gulf of Mexico provide what is needed for successful economic aquaculture production. This establishes a high confidence level that we will be able to produce and supply our products to the US market.

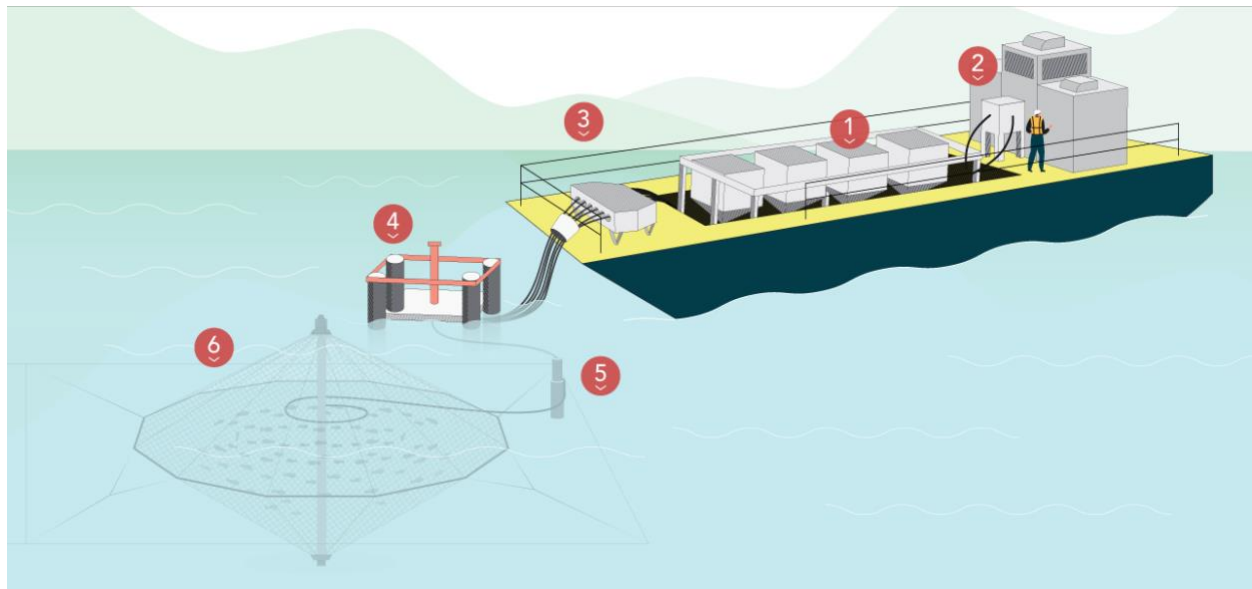
Suppliers

Blue Silo Aquaculture will be operating in the open ocean waters of the Gulf of Mexico adjacent to existing oil and gas platforms. The platforms will function as operational bases and host support equipment, feed storage and feeder system(s), living accommodations for the crew, and a laboratory to monitor cultured marine life. We know that weather will be a hurdle that will have to be overcome using technology. The fish net pens we intend to use are completely enclosed and have the capability of being completely submerged to allow the net pens and the fish to escape the high energy environment during storm events.

Because the net pens can be submerged and the fish still need to be fed, a hydraulic feed delivery system will be used to pump seawater containing feed to the net pens regardless of where the net pens are in the water column. There are a few manufacturers of hydraulic feed delivery systems. Here is an example

of one such system from Innovasea. While this example uses support vessels to deliver feed, our system will be somewhat simpler because of the platform operating base we intend to utilize. Seawater will be pumped from the Gulf up to the upper deck of the platform where feed storage, feed/water mixing, and a pen selector valve will be installed. There will be no need for a feeder mooring buoy because the feed lines will be attached to the platform and the pens with enough slack to allow movement between the pens and the platform leg.

Figure 6: Hydraulic Feed Delivery System



1. Feed Storage

Modular hoppers store the feed.

2. Feed/water mixer

Dry feed is mixed with water so it can be pumped down to the pens.

3. Pen Selector

An innovative selector valve directs feed to the appropriate pen.

4. Feed Mooring Buoy

Independently moored buoy connects to vessel with enough slack in the feeding hoses so as not to transfer wave action to the fish pens.

5. Feed Line

Carries feed to the pens.

6. Feed Dispenser Helix

Patented design consisting of a pipe spiral that is capable of distributing feed 360 degrees around the spar. Has the capability to be mounted at different locations vertically on the spar.

Feed pellets will be custom blended to meet the health and nutritional requirements of the fish being cultured. In addition, the pellets will have a buoyancy requirement depending on the preferred way the fish species like to feed. The negatively buoyant feed would be delivered above the fish and allowed to sink through the pens. Neutrally buoyant feed would be delivered near the center of the biomass of fish

and positively buoyant feed would be delivered near the bottom of the pens and allowed to float upward.

To manage transportation costs, we prefer that the feed be milled somewhere along the gulf coast. We believe two manufacturers have been identified and can mill feeds to our specifications. Rangen Inc., a subsidiary of Wilbur-Ellis Nutrition is in Angleton, Texas. Cargill has a feed mill located in Franklinton, Louisiana. We have had high level conversations with both, and we are comfortable that they can meet our requirements.

Conclusions:

The user conflicts for platform-based open-ocean aquaculture in the Central and Western Gulf of Mexico should be significantly less than in other offshore areas. This is primarily because of the existing industrialization of the Gulf for oil and gas activities.

Expect resistance from commercial fishermen and their advocacy groups (e.g., Don't Cage our Oceans) due to the threat of downward pressure on product prices caused by an increase in supply. There are also environmental groups that work with the fishermen to raise funding for their outreach campaigns.

Expect a very cumbersome and lengthy permitting process unless there is a national political consensus that can be cobbled together. There are currently two different, but not mutually exclusive, efforts working towards building this consensus. These are through the National Aquaculture Association (NAS) and Stronger America Through Seafood (SATS). The SATS group has legislation, named the AQUAA Act, that will be introduced this year again in Congress.

Consider joining the Sustainable Seafood Coalition (SSC), coordinated and led by the Environmental Defense Fund (EDF). EDF is also advocating for legislation called the SEAfood Act. This bill proposes starting with four "pilot" offshore aquaculture projects.

Blue Silo Aquaculture will need to engage in both advocacy and outreach efforts to gain a social license to operate. In addition to the efforts with NAA, SATS, and SSC discussed above; Blue Silo should begin meeting with elected representatives and State and Federal government representatives. These include the following individuals:

- Congressman Garret Graves (R-LA-6), Ranking Member for the House Transportation and Infrastructure Subcommittee on Aviation and is the Ranking Member for the new Select Committee on Climate Change. He also serves on the House Natural Resources Committee.
- Sharon Hewitt, LA State Senator and candidate for governor. Sharon is a former Shell colleague.
- James Kendall, Director of the Gulf of Mexico Region of BOEM.

References:

[1] R. Fujita, P. Brittingham, L. Cao, H. Froehlich, M. Thompson, T. Voorhees, "Toward an environmentally responsible offshore aquaculture industry in the United States: Ecological risks, remedies, and knowledge gaps". Marine Policy 147 (2023) 105351.

[2] Kapetsky, J. M., J. Aguilar-Manjarrez, and J. Jenness. A Global Assessment of Offshore Mariculture Potential from a Spatial Perspective. FAO Fisheries and Aquaculture Technical Paper 549, Rome: Food and Agriculture Organization of the United Nations (2013).

[3] G. Knapp, M. Rubino, "The Political Economics of Marine Aquaculture in the United States, Reviews in Fisheries Science & Aquaculture", 24:3, 213-229
<http://dx.doi.org/10.1080/23308249.2015.1121202>

Deposition Model

The deposition of a potential farming operation near the Station Padre oil rig was modeled using the TROPOMOD deposition model. TROPOMOD was considered to be the most appropriate model for the project since the environment and species being considered are closest to those used to develop this model (as opposed to MERAMOD or DEPOMOD).

The farm layout is described in the grid analysis report of this document. The model used current data collected with a Nortek Signature 500 ADCP deployed adjacent to Station Padre for 30 days in the summer of 2020. The deployment period captured data from Hurricane Hanna which passed nearly directly over the study site. However, data collected during the storm was excluded from the deposition modeling as it was deemed to be unrepresentative of normal operating conditions at the site. This left only 22 days of data available for modeling. Data was collected hourly with a 90-second averaging interval.

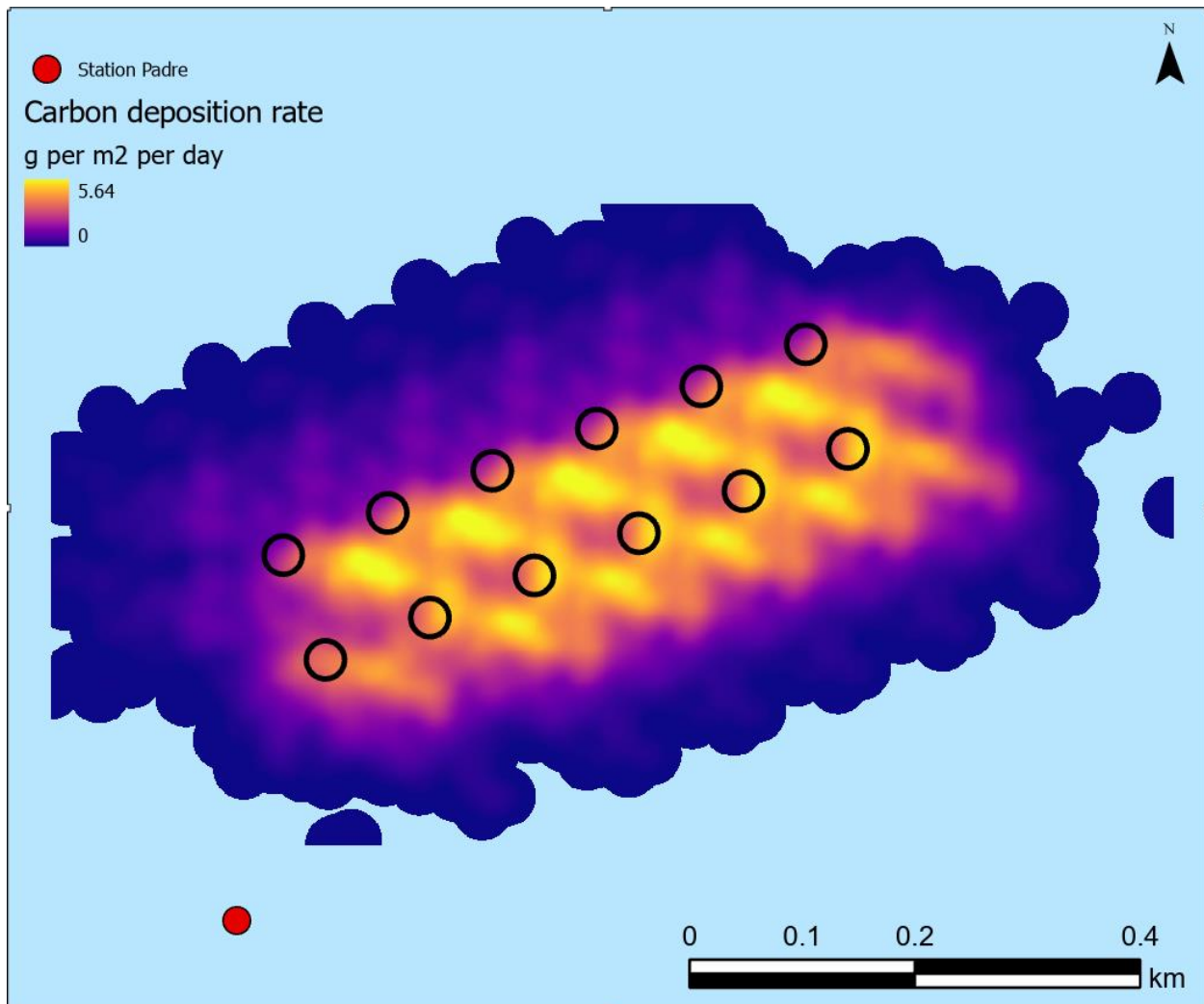
The farm was assumed to have a maximum stocking density of 25 kg/m³ which was fed at a rate of 1% total biomass per day. Feed was assumed to have a carbon content of 40% of which the fish assimilate 75%. The fecal settling rate was presumed to be 0.84 cm/s (White *et al.* 2013 which modeled milkfish and similar to Rensel *et al.* 2006 which modeled cobia but lower than Keifer *et al.* 2008 which modeled striped bass). Feed wastage was assumed to be 10%.

The results show a low amount of nutrient loading relative to other studies. The maximum carbon flux of 5.64 g/m²/day is modest, and well below the threshold for high impact (15g total solids /m² /day) or severe impacts (15g total solids /m² /day) used in White *et al.* (2006). This is expected of open ocean sites where the strong currents disperse nutrients efficiently. Furthermore, open ocean environments are typically oligotrophic so the tolerable nutrient load before changes in benthic biodiversity are observed is likely to be higher.

The nutrients moved primarily towards the southeast, which is the predominant current direction in this location, but several different hydrology patterns can be observed here. The currents are driven by the Gulf of Mexico loop current which creates smaller eddy systems in several areas. The loop current can also spin off larger eddies which can have dramatic changes in local current patterns. As mentioned above, this deposition model was based on approximately 22 days of current data which are believed to be representative of "normal" conditions but may have been affected by Hurricane Hanna, or episodic alterations as a result of the loop's current behavior.

The results of the modeling efforts indicate that the planned farming activities would create a fairly modest impact on the benthic ecosystem relative to farming operations that have been modeled elsewhere. The environment in this location is also likely to be more robust to nutrient contributions.

Figure 7: Carbon Deposition Rate



Works Cited:

Keifer, D., Rensel, J., and O'Brien, F. 2008. AquaModel simulation of water and sediment effects of fish mariculture at the proposed Hubbs-SeaWorld Research Institute Offshore Aquaculture Demonstration Project. Prepared by System Science Applications, Inc. Los Angeles, CA, and Rensel Associates Aquatic Services, Arlington, WA, for Hubbs-SeaWorld Research Institute, San Diego, CA.

Rensel, J., Keifer, D., and O'Brien, F. 2006. Modeling water column and benthic effects of fish mariculture of cobia (*Rachycentron canadum*) in Puerto Rico: Cobia AquaModel. Prepared by System Science Applications, Inc. Los Angeles, CA for the National Oceanic and Atmospheric Administration, Washington, DC. 60pp.

White, P., Cromey, C., Palerud, R., Hernandez, J., Rosario, W., Regpala, R., and Lopez, N. 2013. Mitigating aquaculture impact in the Philippines: PHILMINAQ outputs and recommendations. Project Number: FP6-2004-INCO-DEV-SSA-031640 for PHILMINAQ.

Appendix I - Financial Model Report



Financial Opportunity Analysis for Oil Rig Associated Aquaculture in the Gulf of Mexico

Jan 12, 2023

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Certain information set forth in this report contains forward-looking information, including future-oriented financial and operational information. Except for statements of historical fact, the information contained herein constitutes forward-looking statements and may include, but are not limited to, the (i) projected financial performance of the project; (ii) projected operational performance of the project; (iii) sources and availability of third-party financing for the project; and (iv) future liquidity, working capital and capital requirements. Forward-looking statements are provided to allow stakeholders the opportunity to understand beliefs and opinions in respect of the future so that they may use such beliefs and opinions as one factor in evaluating an opportunity. These statements are not guarantees of future performance and undue reliance should not be placed on them. Such forward-looking statements necessarily involve known and unknown risks and uncertainties, which may cause actual performance and financial results in future periods to differ materially from any projections of future performance or result expressed or implied by such forward-looking statements.

Although forward-looking statements contained in this report are based upon what the authors of this report believe are reasonable assumptions, there can be no assurance that forward-looking statements will prove to be accurate, as actual results and future events could differ materially from those anticipated in such statements. The authors undertake no obligation to update forward-looking statements if circumstances, estimates or opinions should change. The reader is cautioned not to place undue reliance on forward-looking statements.

1. Introduction

The results of a financial model describing an open ocean finfish farm that is partially operated from an adjacent converted oil rig, are presented in this document. The model is based on Blue Silo's operation plans which include using the Station Padre Oil Rig as an offshore support base for certain farm operations including feeding. Other elements of farm operations are based on existing open ocean farms. These farms are located primarily in Hawaii and Latin America, but there are examples in Asia and Europe as well. The Hawaiian and Latin American farms are considered to be the most closely comparable to the planned farm in the Gulf of Mexico due to the close proximity, similar oceanography, and selection of equipment (submersible net pens). Those farms are leaned on more heavily to build equipment requirements, personnel needs, and estimate operational expenses. The model was run using red drum (*Sciaenops ocellatus*) and Florida pompano (*Trachinotus carolinus*), the top two most suitable species as determined by the University of Miami's species selection study.

The model captures a realistic growth plan, which was developed in consultation with GORI and Blue Silo Aquaculture. Both the rate at which infrastructure can be delivered and installed, as well as the ability to sell product at the volumes produced are ambitious but achievable. This growth rate is reflective of an optimal commercial roll-out and does not include any proof-of-concept stage, even if the current project does have plans for this.

The size of the farm is constrained by the spatial limitation of having net pens situated close enough to the oil platform for farm support systems (feed lines, air lines, and data cables) to reach from the rig to the pens. As such, the total number of grid systems deemed to be feasible at this site, using the oil rig support strategy, was two each with twelve pens in a 2 x 6 arrangement.

The model provides the best estimation of the capital outlay and financial performance of an open ocean fish farm operated with support from an oil platform in the Gulf of Mexico and is based on the most relevant and recently available data. The assumptions used in the model have been achieved by operating farms on a commercial scale but never for this species or in this location. The most impactful of these assumptions include growth rate, mortality rate, fish price, cost of feed, feed conversion ratio (FCR), and stocking density. Furthermore, the concept of oil rig associated aquaculture has never been demonstrated on a commercial scale so many assumptions on how such a farm would operate and the financial impact of those assumptions are largely speculative. As such, there is uncertainty in the projections.

All dollar values shown are in USD. All future dollar amounts are nominal values and are not adjusted for inflation.

2. Model Description

2.1. Model Construction

The Innovasea Financial Model is a discounted cash flow model, driven by a biological growth sub-model. The installation date for each pen, along with the species to be produced are entered and the model ensures that the necessary equipment and infrastructure is in place to

support that pen or adds a capital expense to purchase the necessary items. Production in each pen is driven independently by the growth equation below which is populated with values from scientific literature on land-based and net pen operations. The specific growth rate (SGR) is a standard growth metric in aquaculture and appropriate for modeling where data is insufficient for more robust models such as multi-stage thermal growth coefficients. Operating expenses and personnel needs scale with either production volume or equipment and are based on commercial farms operating in the United States and Latin America.

$$SGR = (\ln(\text{final weight in grams}) - \ln(\text{initial weight in grams}) \times 100) / t \text{ (in days)}$$

The production volumes are converted to sales for three possible product types for red drum and pompano independently: fillet, head-on gutted (HOG), or whole (in the round). Revenue and costs are aggregated by year to create financial statements and cash flows which are in turn used to create investment opportunity indicators as well as pro forma income and cash flow statements.

2.2. Data Sources

The financial model is built on Innovasea's experience in designing and working with fish farms around the world. The modeling team includes several previous farm managers and other personnel who have worked on farms in various capacities. The scaling factor between capital equipment needs, operating expenses, and personnel requirements with production capacity is based both on this experience and on relationships with commercial farms operating today. Specific non-public information about clients' operations or financial performance cannot be disclosed, however most parameters agree with facilities at research institutions, specifically those at the University of Miami who were partners on this project. Consideration is given to data sources that are most applicable for a net pen farm in the western Gulf of Mexico. Data is supplemented with information from scientific literature, publicly traded companies, and personal communications within the industry.

The cost of capital expenses supplied by Innovasea are based on estimates made in Nov. 2021 but are subject to change. Most values represent estimations that include uncertainty resulting from the lack of design work completed at this point in the project, fluctuations in commodity pricing, and the uncertainty of shipping costs. Items not sold by Innovasea are based on the cost of that item when it was last purchased by a sister company, internet searches for suitable products, or estimates from Innovasea experts.

The labor cost was based on benchmark salary ranges provided by the US Bureau of Labor Statistics and validated against Posadas (2021). The corporate tax rate was taken from Price Waterhouse Coopers (PwC) for 2021.

The species-specific production data and market prices are two of the largest drivers of variance in financial performance between projects. Inputs were obtained from a variety of sources. The University of Miami provided production data in their species assessment and all values generally agreed with Sink *et al.* (2019) and Wierich *et al.* (2021).

The Innovasea team reviewed all values and deemed them to be appropriate for the project.

3. Results

3.1. Project Returns and Capital Outlay

The red drum iteration produces \$58.58 million in annual revenue at 22% operating margins once it reaches full maturity (year 4). The cost of goods sold is projected to be \$5.89/kg leading to an EBIT of \$1.95/kg when selling 80% whole fish and 20% fresh fillets.

The Florida pompano iteration produces \$64.17 million in annual revenue at 23% operating margins once the farm reaches maturity (year 4). The cost of goods sold is projected to be \$8.22/kg leading to an EBIT of \$1.92/kg when selling 80% whole fish and 20% fresh fillets.

Figure 1 shows the EBIT of the red drum and Florida pompano models respectively. The year-to-year fluctuations after the farm reaches full size are a result of producing species with a production cycle not equal to twelve months while modeling on a monthly basis. This causes certain years to have higher harvests than others.

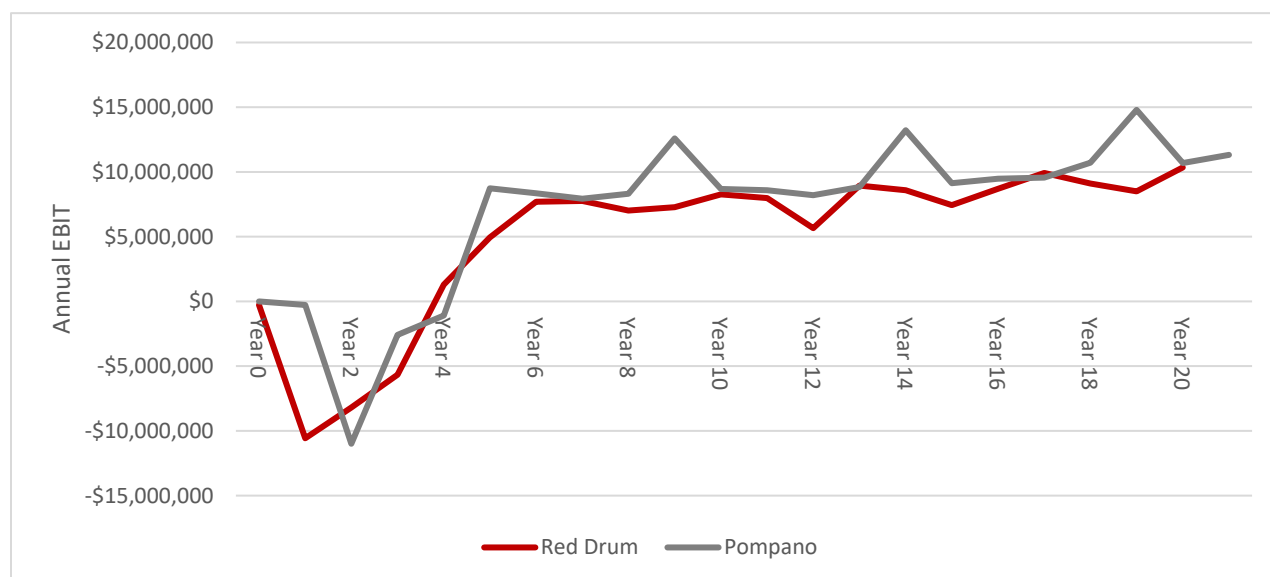


Figure 1: Earnings before interest & taxes for the red drum and Florida pompano models

The red drum iteration shows a net present value (NPV) of \$52.2 million when nominal cash flows are discounted at a rate of 10%. The internal rate of return (IRR) for the project is 12.1%. The Florida pompano iteration shows an NPV of \$92.1 million and an IRR of 17.8%. Both of these values indicate a competitive investment, although the pompano model shows stronger returns. The pompano model requires a larger initial investment in net working capital as well as a higher risk associated with depressing the market price when the large volume of farmed product reaches the market.

Figures 2 and 3 show the free cash flows and cumulative cash position for the two models. In both iterations, farm operations achieve a net cash flow in year 4. The models achieve positive cash position in years 10 and 7 for the red drum and Florida pompano iterations respectively.

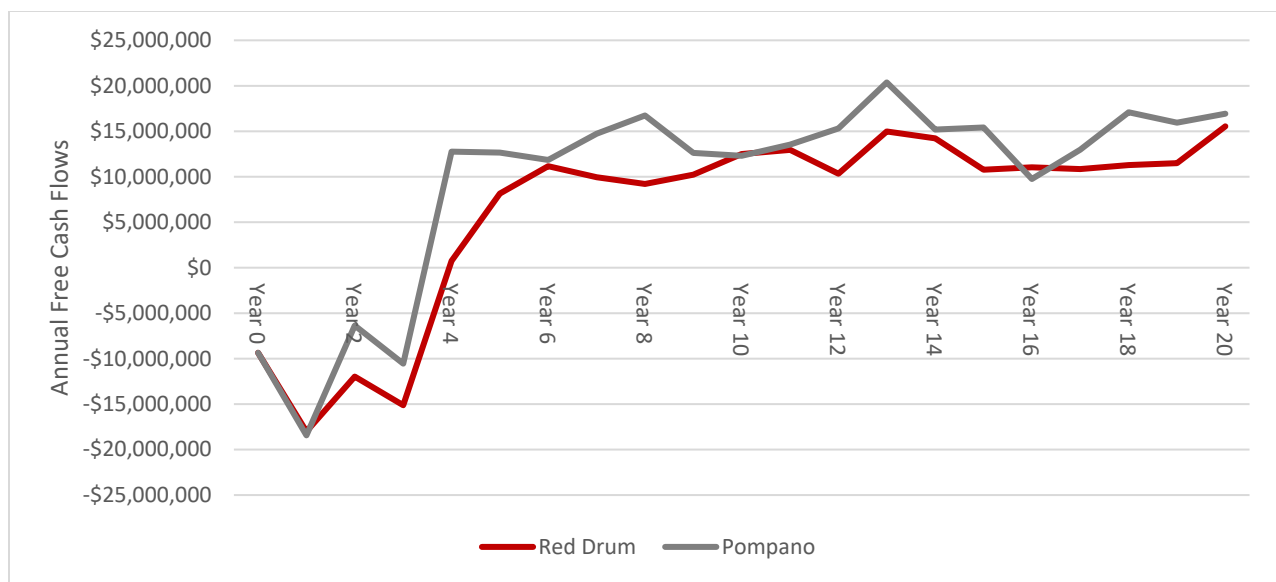


Figure 2: Annual free cash flows for the red drum and Florida pompano models

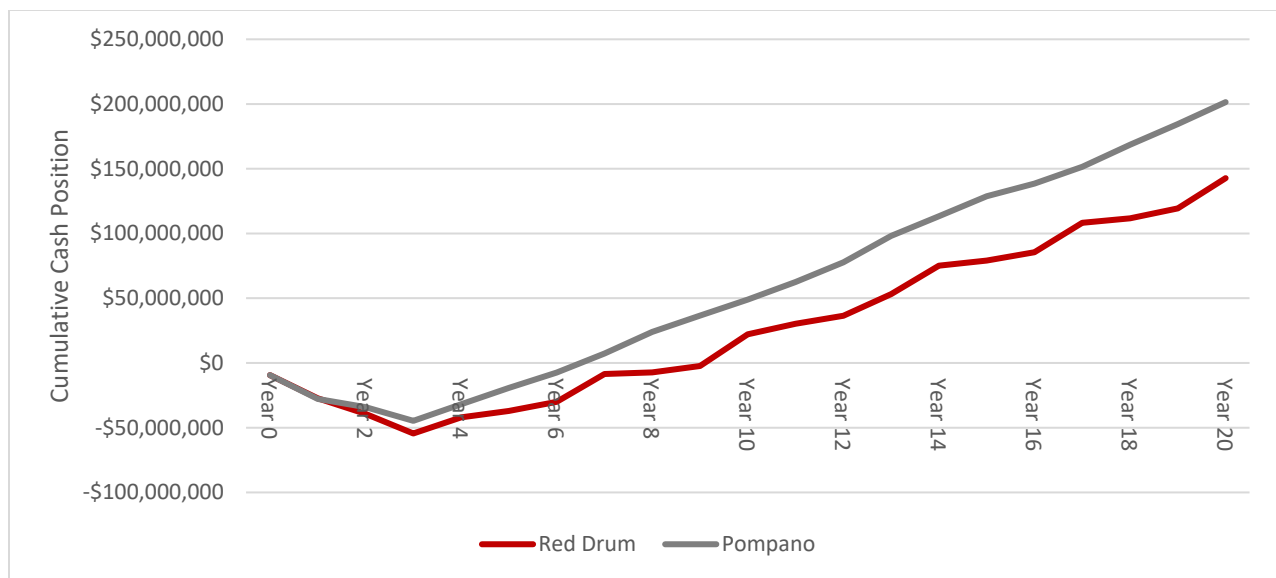


Figure 3: Cumulative cash position for the red drum and Florida pompano models

3.2. Sensitivity

Understanding the sensitivity of the model to changes in key parameters is critical to evaluating how the results presented here may differ from what might be achieved in actuality. Neither red drum, nor Florida pompano are produced in significant quantities in open ocean environments, making the uncertainty around the input variables higher than for other species.

Figure 4 shows the percent change in the NPV of the project with a 10% change in each major parameter. Figures 5 and 6, show the change in the project IRR with 10 and 25% increase and decreases in the same parameters.

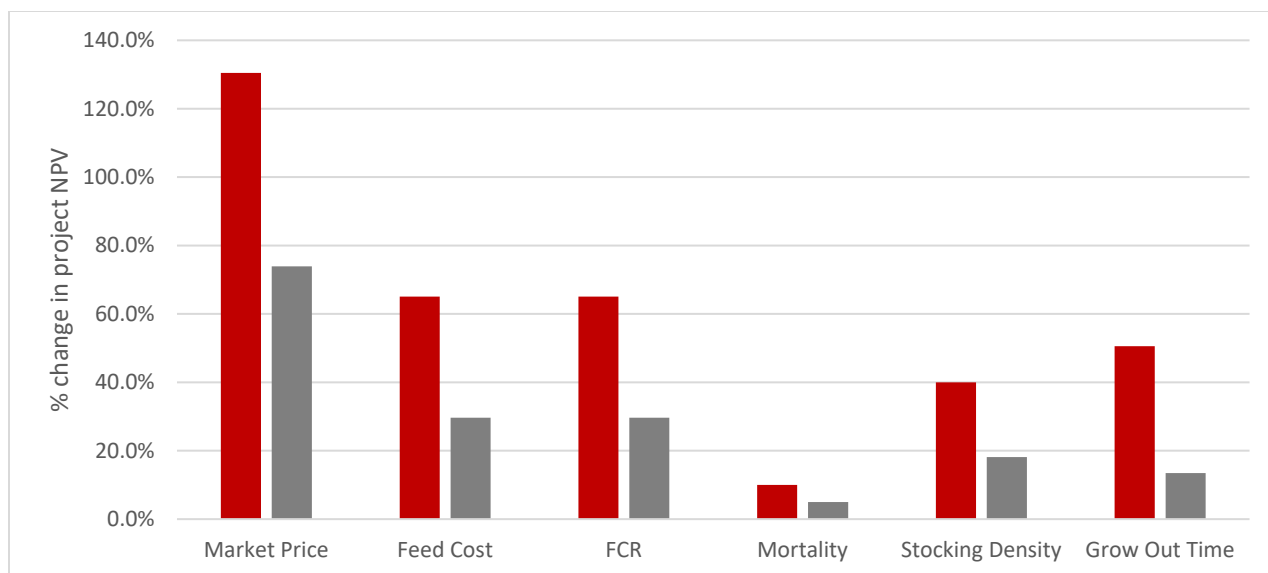


Figure 4: The percent change in the project NPV with a 10% change in key parameters

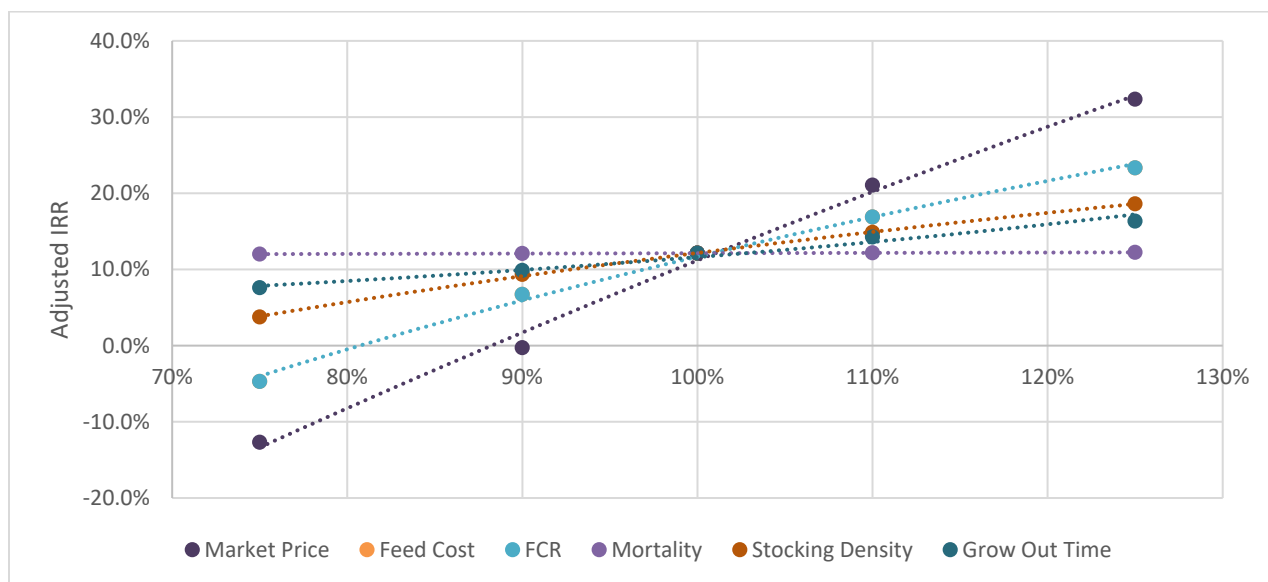


Figure 5: The adjuster IRR values when a 10 or 25% increase or decrease in key parameters is made for the red drum model

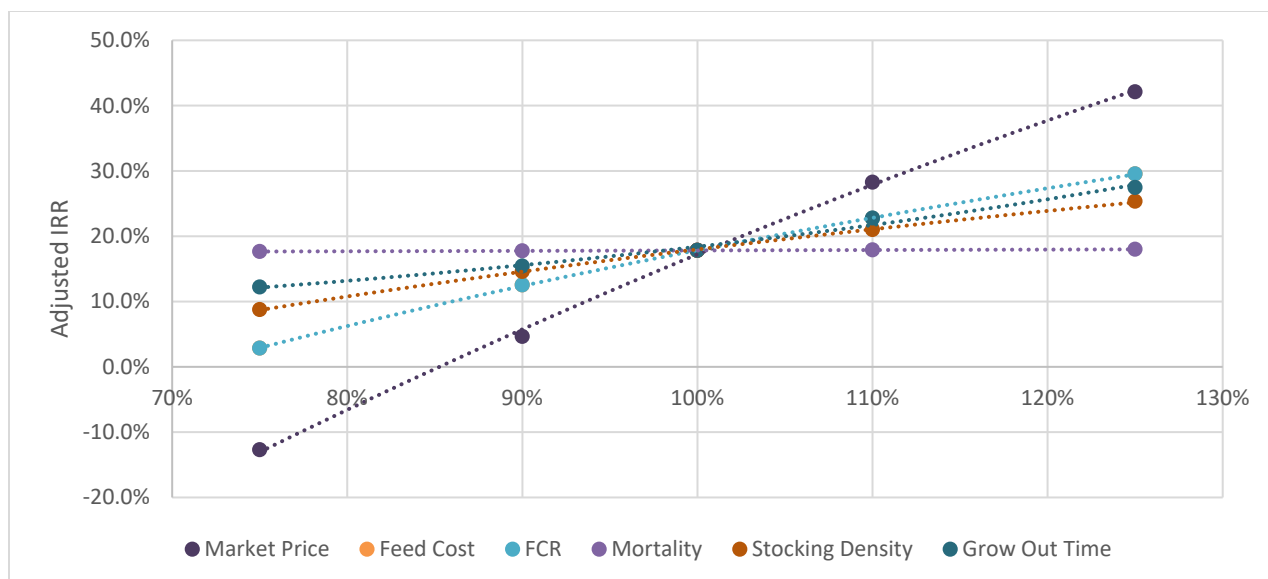


Figure 6: The adjusted IRR values when a 10 or 25% increase or decrease in key parameters is made for the Florida pompano model

4. Model Limitations

The model has several important limitations. The financial returns indicated above are only achieved if the farm reaches the specified scale of operation. The grow out time for red drum and Florida pompano are between 9 and 16 months which means investment in infrastructure will not provide revenue until over a year later. During that time, further investment will be needed to operate the farm, most of which is feeding the fish. Due to these large investments without revenue, the early stages of farm growth can be difficult for companies that do not have sufficient capital to support their expansion plans and operating costs. Many new farms have had to sell equity or take on large amounts of debt to finance the first few years of operations. Farms can be profitable at smaller production levels but would not see the same NPV created from operating at high volumes and high efficiencies in perpetuity. However, slowing the company's growth can offer advantages in certain situations by conserving capital and allowing the company to reach a positive cash position earlier.

Several cost drivers are well studied for the species modeled here, while others are less so. Some parameters, such as growth rate, mortality and market price, are more likely to be different from the assumptions used here since they often vary regionally which can have a large impact on farm profitability. Cost of feed, stocking density, and feed conversion ratio do not vary as much between locations and environments so there is less reason to expect them to differ from established trends.

Open ocean aquaculture is a relatively new sector of the industry. There are only a handful of companies producing fish in submerged net pens, none of which are operating in the continental United States. Without direct comparisons, the uncertainty in the assumptions used to build the model are higher than they are in other industries. There are no farms that base their net pen operations from an oil rig so the impact of that element of the analysis is largely speculative, further increasing uncertainty.

The COVID-19 pandemic has changed seafood purchasing patterns, distribution networks, and

farming and processing systems. The model assumes that markets and farm operations will return to a similar state as before the pandemic since farm equipment will not be deployed for months to years from now. However, it is not known if the pandemic will have lasting effects on the industry that may lead to material differences in costs or the market price of seafood.

5. Conclusion

The prospects for GORI and Blue Silo Aquaculture's planned oil rig associated open ocean farm look promising. The internal rate of return of 12-18% is competitive within the industry but reflective of an aggressive growth strategy to achieve economies of scale farming a high-value product. This level of returns has been achieved for many net pen operators, but examples with warm water species and submerged net pens are less plentiful, mainly as there are not very many operators of this type.

The results also indicate the oil rig associated farming is a viable strategy for the industry in general. The costs associated with obtaining, maintaining, and operating the platform were largely offset by capital savings in the feed barge and operational savings in transporting personnel and equipment. These impacts did not depress the financial outlook beyond possible viability, but also did not present major cost-saving synergies. It would be worth revisiting the true costs of obtaining, maintaining, and operating an oil rig platform once validated empirical data is available.

There are three primary sources of risk that should be further evaluated: the uncertainty associated with starting a farm in a new region, the availability of capital to ensure the farm can scale up quickly, and the novelty of using an oil platform as an operations base. These sources of risk are difficult to mitigate as they are either company specific and up to the management group, or simply reflect the novelty of the concept and lack of data to support more rigorous analysis. A novel business concept is both a risk and an opportunity, so this is not something to be avoided, simply noted.

Finfish aquaculture has fewer examples than other industries to lend support to modeling efforts. The model described here is based heavily on the growth, operations, and biological performance of several open ocean farms, but none of them are perfect comparables and few of them have production volumes approaching the 5,000 to 7,000 tonnes per year modeled here. The model results are reflective of the best available information, but further research and due diligence are required to give the project the best chance of success.

The model results look promising at this point in the analysis, but further analysis to reduce risk as much as possible will make the project more attractive. The financial potential for other species was not evaluated and should not be assumed to be poorer than the species presented here.

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Appendix II - Permitting Pathway

Advancing the Viability of Oil Rig Associated Aquaculture
Permitting Pathway
Gulfstream Aquaculture, LLC (GSA)

Introduction:

The objective of this document is to provide improved clarity on the permitting process and serve as a road map that will enable the Gulf Offshore Research Institute (GORI), Blue Silo Aquaculture, and all other parties engaging in similar projects to have a greater understanding on the process, timeline, and cost of permitting activities. Information and data provide here within is a compilation and summarization of publicly available Federal, state (Texas), and local agency information gathered from their respective publications and websites. As such, in an attempt to streamline information for this particular project without unnecessary paraphrasing and repetitious descriptions, Gulfstream Aquaculture, LLC (GSA) admittedly has extracted some segments of text from these sources verbatim (found within “quotations”) and gives full credit to the original source material authors. GSA has; however, updated many of the source contact information via website, email, and phone conversation confirmations, to ensure that points of contact and address information is as relevant and up to date as possible, as of the publication and submittal of this document.

Project Description:

Offshore oil and gas platform sites were investigated to develop the first platform-based offshore aquaculture pilot project in the Gulf of Mexico (GOM). Two platform sites (North Padre Island 975 and 969, located at 26°50′31N, 96°58′47W and 26°49′57N, 96°56′23W, respectively) are of interest to evaluate site-specific system designs, financial assessments, a permitting roadmap, and conduct stakeholder engagement. The two Station Padre platforms are located in federal waters 35 miles NE of Port Mansfield, TX (and 23-25 miles off the coast of Padre Island, TX) in water depths of 155 and 156 ft., respectively (**Figure 1**).

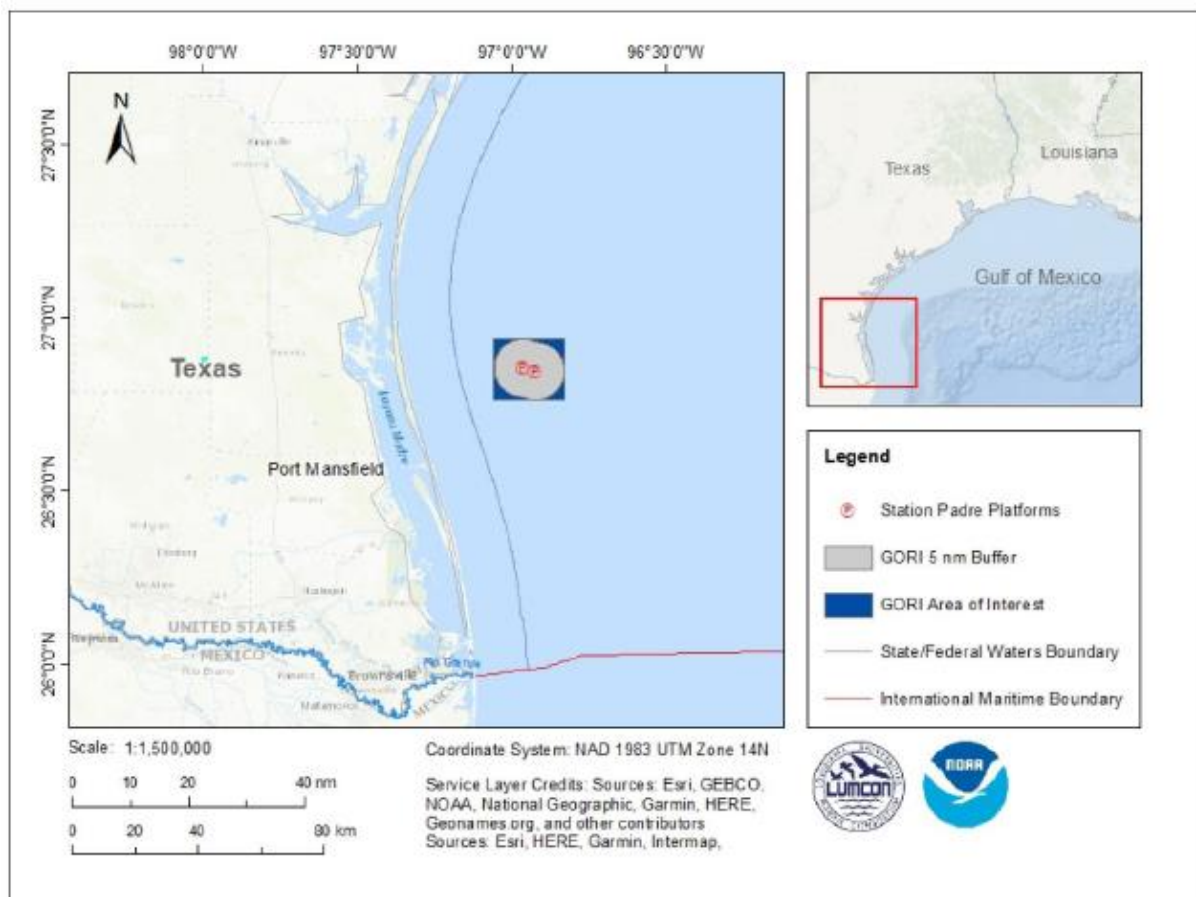


Figure 1. Location of the North Padre Island platform sites 975 and 969 in the GOM.

Background:

This permitting pathway presumes that the project will utilize private and/or non-federal investment funding for the actual project execution and therefore the permitting actions, level of effort, and support funding would be the responsibility of the project action proponent, and not the federal government. This does not preclude the interest and beneficial involvement of the Federal government agencies but concludes that the primary responsibility for the permitting and supporting documentation preparation is the project action proponent.

Since the project is proposed to occur in Federal waters of the GOM (see Figure 1), the emphasis of this permitting pathway and requirements is with Federal agencies. It is encouraged; however, that appropriate coordination and communication be conducted with Texas State departments and divisions as a professional courtesy, and to learn of and discern if any new or future requirements may affect the project. As such, Texas State aquaculture information is provided in this pathway evaluation as well.

Three (3) of the most useful and relevant documents prepared to assist potential aquaculture entrepreneurs (and quoted routinely here within) are 1) *“Improving Regulatory Transparency for Aquaculture: A Guide for Permitting Marine Aquaculture in the United States; A Guide to the Permitting and Authorization Process for Aquaculture in U.S. Federal Waters of the Gulf of Mexico”* (Updated October 2019; EPA, 2019); 2) *“Guide to Permitting Marine Aquaculture in the United States”* (NOAA, 2022); and 3) *“Memorandum of Understanding for Permitting Offshore Aquaculture Activities in Federal Waters of the Gulf Of Mexico”* (BOEM, 2016).

This permitting pathway will highlight the necessary permit, authorization, and consultation requirements to establish an aquaculture operation in Federal waters of the GOM. All required Federal permits, authorizations, and consultations must be obtained prior to beginning any operations (i.e., deploying any structures or stocking any animals) in Federal waters of the GOM. Each of the above agency references strongly support the use of a Pre-Application meeting to initiate dialogue and coordination among all interested regulatory organizations (Federal, state, and local).

Permitting Pathway:

As best described in the first reference document above (EPA, 2019), “there is a three-phase process for obtaining and operating under permits and authorizations for establishing an aquaculture operation in Federal waters of the GOM”; 1) Pre-Application Phase, 2) Permit Application & Development Phase, and 3) Permit Issuance & Operation Phase.

Pre-Application Phase - The project action proponent submits detailed project information and data in the form of a Pre-Application Checklist. Although NOAA Fisheries does not currently require a Federal permit¹ for aquaculture operations in the GOM, acting under authority delegated from the Secretary of Commerce, NOAA is responsible for conserving and managing fisheries from the seaward boundaries of states out to 200 nautical miles. As such, the NOAA Regional Aquaculture Coordinator (RAC) is an effective resource in the Pre-Application Meeting process. The NOAA RAC would assist with coordinating and scheduling the Pre-Application Meeting. Federal agencies have established regional coordination groups to assist with a more efficient and streamlined regulatory process, including USACE, EPA, NOAA, USFWS, USDA, DOD, BOEM, BSEE, and the USCG (BOEM, 2016). The NOAA RAC for this proposed project would be Andrew Richard; NOAA Southeast Regional Office; (727) 551-5709; andrew.richard@noaa.gov. NOAA RAC would schedule a Pre-Application Meeting approximately 30 days after receiving completed Pre-Application Checklist information. All project action proponents participate in the Pre-Application Meeting via conference call with all relevant Federal agencies to review and discuss any questions or supplemental information needed to detail the Pre-Application Checklist data items more completely.

¹Although Federal regulations (50 CFR Subpart F) require that aquaculture operations in Federal waters of the GOM acquire a Gulf Aquaculture Permit (GAP) from NOAA Fisheries, this permit is not currently required due to a recent Court decision vacating those regulations; the Court’s decision remains in effect. NOAA Fisheries, under the Magnuson-Stevens Fishery and Conservation Management Act (MSA); however, may require an exempted fishing permit (EFP), under 50 CFR 600.745, authorizing the otherwise prohibited harvest of a species managed under a Fishery Management Plan (FMP).

Permit Application and Development Phase – The project action proponent initiates the completion of the Federal permit applications, authorization processes, and supporting consultation documents. Timelines, approximate level of effort, and subsequent costs associated with the Permit Application and Development Phase are provided in Table 2 as the summary to this GORI Permitting Pathway. Sufficient time and effort should be devoted to these application, authorization, and consultation documents to “get it right the first time” prior to submittal to the responsible agencies. As the recommended/suggested timelines for each of these approvals are only valid with “completed and accepted” application submittals. The applicant is “encouraged to maintain open communication with the relevant point of contact at each Federal agency”, as this will beneficially facilitate the application and review process. GSA strongly recommends maintaining a bi-weekly teleconference call with the core members (NOAA, USACE, EPA, and BOEM) of the Pre-Application Meeting Federal team to keep one another apprised of any supplemental data requirements and changes to the proposed action. More frequent ad hoc communications may take place as needed to expedite the permitting pathway process. The following permit applications, authorizations, and consultations have been determined as required actions for the GORI project, and not an exhaustive list for all aquaculture actions in the GOM:

Permit Requirements:

- ***EPA - National Pollutant Discharge Elimination System (NPDES) Permit***

Agency -	U.S. Environmental Protection Agency (EPA)
Authorization -	Sections 402 and 403 of the Clean Water Act https://www.epa.gov/cwa-404/clean-water-act-section-402-national-pollutant-discharge-elimination-system
Timeline -	180 days after receipt of a “complete” application
Applications -	Form 1 and 2B, and a Baseline Environmental Survey (and Report) https://www.epa.gov/sites/default/files/2019-05/documents/form_1_epa_form_3510-1.pdf https://www.epa.gov/sites/default/files/2019-05/documents/form_2b_epa_form_3510-2b.pdf
POC -	EPA Region 6 Jim Afghani; (214) 665-6615; afghani.jim@epa.gov
Purpose:	“Required for the discharge of pollutants to waters of the U.S. If the operation will add feed, nutrients, pharmaceuticals, antifouling agents, disinfectants, or any other substances or materials directly to, or that will be discharged to waters of the U.S., permit coverage is required” (EPA, 2019).
Resources -	https://www.epa.gov/npdes/aquaculture
Support Docs -	Best Management Practices (BMP) Plan, Environmental Monitoring Plan (EMP), Facility Damage Prevention and Control (FDPC) Plan, and Quality Assurance Project Plan (QAPP)
Fee:	None

- ***USACE - Section 10 Permit***

Agency -	U.S. Army Corps of Engineers (USACE); Galveston District
Authorization -	Section 10 of the Rivers and Harbors Act (33 U.S.C 403) https://www.epa.gov/cwa-404/section-10-rivers-and-harbors-appropriation-act-1899
Timeline -	Approximately 60 - 120 days
Applications -	ENG Form 4345 https://www.nae.usace.army.mil/Portals/74/docs/regulatory/Forms/Eng_Form_4345_2019.pdf
POC -	USACE Galveston District Kristi McMillan; (409) 766-3931; kristi.m.mcmillan@usace.army.mil
Purpose:	“Required in navigable waters of the U.S. to protect navigation for commerce” (EPA, 2019).
Resources -	https://usace.contentdm.oclc.org/digital/collection/p16021coll11/id/2341/ https://www.ars.usda.gov/SCA/Fact%20Sheets/USACE%20Federal%20Aquaculture%20Regulatory%20Fact%20Sheet%20Series.pdf
Support Docs -	
Fee -	General Permit, None; Individual Permit, Maximum \$100

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- **USACE - Section 404 Permit**

Agency -	U.S. Army Corps of Engineers (USACE)
Authorization -	Section 404 of the Clean Water Act (CWA) https://www.epa.gov/cwa-404/overview-clean-water-act-section-404
Timeline -	180 days after receipt of a “complete” application
Applications -	ENG Form 4345 or ENG 6082 – Nationwide Permit Pre-Construction Notification https://www.sas.usace.army.mil/Portals/61/docs/Regulatory/DIGITAL%20APPLICATION/ENGFORM_6082_UNLOCKED.pdf?ver=gadZU5i5tcqlsREx3Hirog%3D%3D
POC -	USACE Galveston District Kristi McMillan; (409) 766-3931; kristi.m.mcmillan@usace.army.mil
Purpose:	“Required for discharges of dredged or fill material into Waters of the U.S.” (EPA, 2019).
Resources -	https://www.epa.gov/cwa-404/overview-clean-water-act-section-404
Support Docs -	https://www.usace.army.mil/Missions/Civil-Works/Regulatory-Program-and-Permits/Obtain-a-Permit/
Fee -	None

Authorization Requirements:

- **USCG - Private Aid to Navigation (PATON) Formal Authorization**

Agency -	U.S. Coast Guard (USCG), District Eight
Authorization -	33 U.S.C. 1221 et seq 33 CFR §66
Timeline -	90 days, following USACE Section 10 permit approval https://www.law.cornell.edu/cfr/text/33/part-66
Applications -	Private Aids to Navigation Application Form (CG-2554) https://media.defense.gov/2017/Oct/16/2001827524/-1/-1/0/CG_2554.PDF
POC -	Sector / Air Station Corpus Christi Tim Boriskie; (504) 671.2328 D8oanpaton@uscg.mil
Purpose:	“Ensure safe navigation Authorize Private Aids To Navigation” (EPA, 2019).
Resources -	https://www.atlanticarea.uscg.mil/Our-Organization/District-8/District-Units/Sector-Air-Station-Corpus-Christi/Units/ANT-SPI/
Support Docs -	https://www.atlanticarea.uscg.mil/District-8/District-Divisions/Waterways/PATON/
Fee -	None

- **Military Aviation and Installation Assurance Siting Clearinghouse - Informal Review**

Agency -	Department of Defense (DoD)
Authorization -	Part 211 of Title 32 CFR https://www.ecfr.gov/current/title-32/subtitle-A/chapter-I/subchapter-M/part-211
Timeline -	50 days
Applications -	https://www.acq.osd.mil/dodsc/contact/dod-review-process.html
POC -	OSD Pentagon OUSD A-S Mailbox ASD EIE-RP-SC; osd.pentagon.ousd-a-s.mbx.asd-eie-rp-sc@mail.mil Executive Director; Steven J Sample, CIV OSD OUSD A-S (USA); steven.j.sample4.civ@mail.mil Matthew C Senska, CIV USN ASSTSECNAV EIE DC (USA) matthew.c.senska.civ@us.navy.mil Daniel W Townes, CTR OSD OUSD A-S (USA); daniel.w.townes.ctr@mail.mil Scott E Kiernan, CIV OSD OUSD A-S (USA); scott.e.kiernan.civ@mail.mil
Purpose:	“Minimize conflicts with military readiness operations” (DoD, 2022).
Resources -	
Support Docs -	
Fee -	None

- ***BOEM - Right of Use and Easement (RUE) Permit for Alternate Use of Outer Continental Shelf (OCS) Facilities for Energy or Marine-related Purposes***

Agency -	Bureau of Ocean Energy Management (BOEM)
Authorization -	Outer Continental Shelf Lands Act, Right of Use and Easements in 30 CFR §585 https://www.ecfr.gov/current/title-30/chapter-V/subchapter-B/part-585?toc=1
Timeline -	45 days
Applications -	https://www.acq.osd.mil/dodsc/contact/dod-review-process.html
POC -	Office of Leasing and Plans Michelle Uli Picou; (504) 736.2747; michelle.picou@boem.gov
Purpose:	“Required for any offshore aquaculture operations that utilize or tether to existing oil and gas facilities. A formal RUE is established using the facility for the purpose of aquaculture” (EPA, 2019).
Resources -	
Support Docs -	
Fee -	None

Consultation Requirements:

- ***BSEE - Consultation***

Agency -	Bureau of Safety and Environmental Enforcement (BSEE)
Authorization -	Outer Continental Shelf Lands Act, Right of Use and Easements in 30 CFR §585
Timeline -	45 days
Applications -	https://www.acq.osd.mil/dodsc/contact/dod-review-process.html
POC -	Office of Leasing and Plans Michelle Uli Picou; (504) 736.2747; michelle.picou@boem.gov
Purpose:	“Required for any offshore aquaculture operations that utilize or tether to existing oil and gas facilities. A formal RUE is established using the facility for the purpose of aquaculture” (EPA, 2019).
Resources -	
Support Docs -	
Fee -	None

- ***ESA – Section 7 Consultation***

Agency -	NOAA Fisheries; Protected Resources Division
Authorization -	Section 7(a)(2) of the Endangered Species Act (ESA) https://www.law.cornell.edu/cfr/text/50/402.01
Timeline -	180 days
Applications -	https://www.fisheries.noaa.gov/topic/consultations/endangered-species-act-consultations
POC -	Section 7 Team Lead; Interagency Cooperation Branch Karla Reece; (727) 824-5348; karla.reece@noaa.gov
Purpose:	“Requires federal agencies to consult with the NOAA’s NMFS (NOAA Fisheries), the U.S. Fish and Wildlife Service, or both, before taking any action that may affect an endangered or threatened species or their critical habitat to insure their actions are not likely to jeopardize any listed species or result in the destruction or adverse modification of designated critical habitat” (NOAA, 2022).
Resources -	<i>Biological Assessments & Biological Evaluations</i> https://www.nrc.gov/docs/ML0921/ML092170770.pdf https://www.fisheries.noaa.gov/region/southeast
Support Docs -	https://www.fisheries.noaa.gov/southeast/consultations/section-7-consultation-guidance
Fee -	None

**Advancing the Viability of Oil Rig Associated Aquaculture
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- **MSA – Essential Fish Habitat (EFH) Consultation**

Agency -	NOAA Fisheries; Habitat Conservation Division
Authorization -	50 CFR Part 600; Magnuson-Stevens Act Provisions - EFH https://www.federalregister.gov/documents/2002/01/17/02-885/magnuson-stevens-act-provisions-essential-fish-habitat-efh
Timeline -	180 days
Applications -	https://www.fisheries.noaa.gov/national/habitat-conservation/consultations-essential-fish-habitat
POC -	Habitat Conservation Division Jocelyn Karazsia; (561) 249-1925; jocelyn.karazsia@noaa.gov
Purpose:	Requires Federal agencies “to consult with NOAA Fisheries when activities they authorize, fund, or undertake, or propose to authorize, fund, or undertake, may adversely affect EFH and EFH-HAPC. The consultation process results in NOAA’s preparation and transmittal of conservation recommendations, which may be adopted by the permitting agency” (NOAA 2022).
Resources -	EFH Assessments https://www.fisheries.noaa.gov/national/laws-and-policies/habitat-conservation-and-restoration-policy-directives
Support Docs -	https://media.fisheries.noaa.gov/2022-01/03-201-11_GUIDE%20to%20EFH%20CONSULTATIONS_final%20for%20signature%20%281%29_0.pdf https://media.fisheries.noaa.gov/2022-01/03-201-05_COMBINING%20EFH%20with%20ESA%20CONSULTATIONS_final_for%20signature%20%281%29.pdf
Fee -	None

- **MMPA – Consultation**

Agency -	NOAA Fisheries; Protected Resources Division
Authorization -	Section 118 of the Marine Mammal Protection Act (MMPA) https://www.fisheries.noaa.gov/topic/laws-policies/marine-mammal-protection-act
Timeline -	90 days
Applications -	https://www.fisheries.noaa.gov/topic/marine-mammal-protection
POC -	Protected Resources Division Jessica R. Powell; 727-824-5327; jessica.powell@noaa.gov
Purpose:	“Prohibits the “taking,” which includes harassing, hunting, capturing or killing, of marine mammals or attempting to do so. Section 118 of the MMPA addresses the incidental capture of marine mammals during commercial fishing operations. Section 118 also establishes the Marine Mammal Authorization Program (MMAP), which provides a mechanism to legally authorize incidental take of a marine mammal in a commercial fishery” (EPA, 2019).
Resources -	Protected Species Monitoring Plan https://www.fisheries.noaa.gov/topic/laws-policies/marine-mammal-protection-act https://www.fisheries.noaa.gov/region/southeast
Support Docs -	https://www.fisheries.noaa.gov/alaska/endangered-species-conservation/guidance-developing-marine-mammal-monitoring-plan https://www.bsee.gov/what-we-do/environmental-compliance/environmental-programs/protected-species-program
Fee -	None

- **NHPA - Section 106 Consultation**

Agency -	Bureau of Ocean Energy Management (BOEM) (<i>likely</i>)
Authorization -	Section 106 of the National Historic Preservation Act (NHPA; 36 CFR Part 800) https://www.law.cornell.edu/cfr/text/36/part-800
Timeline -	Approximately 120 days
Applications -	Baseline Environmental Survey Report – Archaeological Evaluation
POC -	Office of Leasing and Plans (<i>likely</i>) Michelle Uli Picou; (504) 736.2747; michelle.picou@boem.gov Texas State Marine Archaeologist Amy Borgens; (512) 463-8882; amy.borgens@thc.texas.gov
Purpose:	“Requires any Federal agency issuing a permit to account for potential effects of the proposed aquaculture activity on historic properties, e.g., shipwrecks, prehistoric sites, cultural resources. If a proposed aquaculture activity has the potential to affect historic properties, these details must be provided by the applicant as part of the application package” (EPA, 2019).
Resources -	Baseline Environmental Survey Report – Archaeological Evaluation https://www.boem.gov/environment/environmental-assessment/national-historic-preservation-act https://www.thc.texas.gov/project-review/national-historic-preservation-act/section-106-review-process
Support Docs -	
Fee -	None

- **NEPA - Environmental Assessment (EA) with a Finding of No Significant Impact (FONSI), or Environmental Impact Statement (EIS) with a Record of Decision (ROD)**

Agency -	Bureau of Ocean Energy Management (BOEM) (<i>likely</i>)
Authorization -	40 CFR 1500-1508; National Environmental Policy Act (NEPA) https://www.energy.gov/nepa/downloads/national-environmental-policy-act-1969
Timeline -	180 days (EA); 360 days (EIS)
Applications -	https://www.boem.gov/national-environmental-policy-act-nepa
POC -	Office of Leasing and Plans (<i>likely</i>) Michelle Uli Picou; (504) 736.2747; michelle.picou@boem.gov
Purpose:	“Requires Federal agencies to prepare an Environmental Impact Statement (EIS) for any major federal action significantly affecting the quality of the human environment. An Environmental Assessment (EA) may be prepared to assist the permitting agency in determining whether significant environmental impacts are likely to occur. The EIS or EA requirement does not apply if the permitting agency determines the activity is categorically excluded from NEPA review” (NOAA 2022).
Resources -	https://www.doi.gov/nepa/requirements-guidance/DOI-requirements
Support Docs -	https://www.boem.gov/environment/environmental-assessment/environmental-assessments https://www.boem.gov/environment/environmental-assessment/environmental-impact-statement-eis-format-and-content-process
Fee -	None

- **CZMA – Coastal Consistency Determination**

Agency -	Bureau of Ocean Energy Management (BOEM) (<i>likely</i>)
Authorization -	Coastal Zone Management Act of 1972 (CZMA); 16 U.S.C. Ch. 33 § 1451 et seq. https://coast.noaa.gov/czm/act/ https://www.boem.gov/environment/environmental-assessment/coastal-zone-management-act
Timeline -	120 days
Applications -	Coastal Zone Management Act (CZMA) – Coastal Consistency Determination (CCD) https://www.boem.gov/national-environmental-policy-act-nepa
POC -	Office of Leasing and Plans (<i>likely</i>) Michelle Uli Picou; (504) 736.2747; michelle.picou@boem.gov
Purpose:	“Coastal states with an approved coastal zone management program are authorized to review certain Federal actions affecting the land or water uses or natural resources of its coastal zone for consistency with its program. Under the CZMA, a state may review activities conducted by, or on behalf of, a Federal government agency within or outside the coastal zone that affects any land or water use or natural resource of the coastal zone; an application for a Federal license or permit; and any plan for the exploration or development or, or production from, any area that has been leased under the Outer Continental Shelf Lands Act for offshore minerals exploration or development. The CZMA requires Federal agency activities to be consistent to the maximum extent practicable with the enforceable policies of a state’s approved coastal zone management program” (EPA, 2019).
Resources -	https://www.doi.gov/nepa/requirements-guidance/DOI-requirements
Support Docs -	https://www.boem.gov/sites/default/files/environmental-stewardship/Environmental-Assessment/CZMA/CZM-Program-Policies-for-GOM-States.pdf https://www.boem.gov/sites/default/files/documents/The%20Coastal%20Zone%20Management%20Act%20of%201972.pdf#:~:text=The%20Coastal%20Zone%20Management%20Act,zone%20management%20plans%20(CZMPs)
Fee -	None

Permit Issuance and Operation Phase - All of the above required permits, authorizations, and consultations must be obtained prior to beginning any operations (i.e., deploying any structures or stocking any animals) in Federal waters of the GOM. The project action proponent should be aware that these permits and authorizations “contain a variety of terms and conditions with which the operator must comply, so the operator should read the permit and develop the necessary systems and schedules to ensure that all operational requirements are met, all monitoring is conducted according to methods and schedules, all records are properly kept, and all reports are submitted on time” (EPA, 2019).

Summary:

At the time of preparation, the overall size and complexity of the proposed GORI Project (i.e., number of offshore netpens associated with the oil rigs) was unclear. The permits, authorizations, and consultations associated with the Permitting Pathway described here within would remain relatively similar whether applied to a small demonstration scale operation or a much larger, commercial scale operation. Obviously, the detail, level of effort, and cost associated with applications preparation, support documentation, and consultation for a much larger, commercial scale operation would scale increasingly in proportion to the complexity of the project. **Figure 2** provides a notional approach for the Permitting Pathway associated with a small demonstration scale operation; thus, the timeline, level of effort, and costs are commensurate of an EA and FONSI, and not an EIS and ROD.

Permitting Pathway

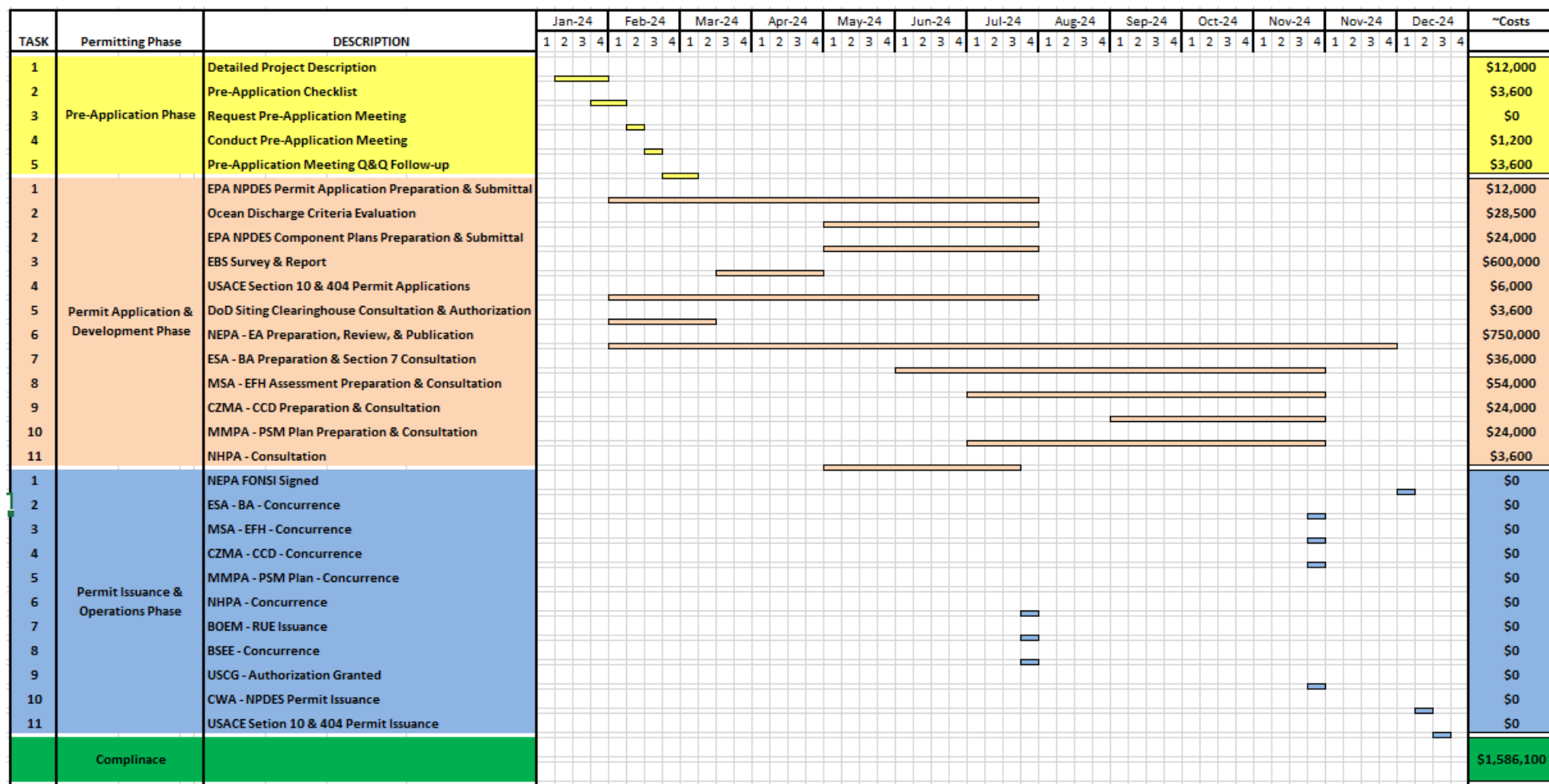


Figure 2. Permitting Pathway: Timeline, Level of Effort, and Costs Commensurate of a Small Demonstration Scale GORI Project Operation in the GOM.

Texas State Resources:

Texas Department of Agriculture

<https://www.texasagriculture.gov/Regulatory-Programs/Aquaculture>

“As of September 1, 2021, the State of Texas and Texas Department of Agriculture no longer requires licensing of aquaculture facilities. Please contact the Texas Commission on Environmental Quality (TCEQ) for issues relating to wastewater discharge. Aquaculture facilities must still abide by the statutes set forth in Chapter 134 of the Agriculture Code, which includes special provisions for shrimp production in the coastal zone, record-keeping requirements, and provisions related to exotic species aquaculture. The contact at Texas Parks and Wildlife Department (TPWD) for Exotic Species Permits is IFpermits@tpwd.texas.gov”.

Texas Commission on Environmental Quality

https://www.tceq.texas.gov/permitting/wastewater/general/TXG13_AIR.html

“Discharge wastewater into or adjacent to water in the state from an aquaculture facility or a related aquaculture activity” requires either a general permit or an individual permit.

Applying for Coverage under the Aquaculture General Permit TXG130000

https://www.tceq.texas.gov/permitting/wastewater/general/TXG13_steps.html

“...any aquaculture facility that utilizes cages or other enclosures placed within public waters for the propagation or rearing of aquatic species with a harvest weight equal to or less than 10,000 pounds per year...”

https://www.tceq.texas.gov/permitting/wastewater/industrial/TPDES_industrial_wastewater_AIR.html

Appendix III – Grid Design

Station Padre Grid Analysis

2 x 6 Submerged Grid with 6,400 m³, Kikko-Brass Seastations in the Gulf of Mexico Adjacent to Decommissioned Oil Rig, Station 975

Advancing the Viability of Oil Rig Associated Aquaculture

Gulf Offshore Research Institute (GORI)/Gulf States Marine
Fisheries Commission (GSMFC)

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PROPRIETARY INFORMATION

Executive Summary

This document outlines the results from the quasi-static and Orcaflex simulations that were run to investigate anchor, grid, node, and bridle line specifications for a prospective grid installation in the Gulf of Mexico for Blue Silo. This analysis focused on the grid materials alone and omitted any pen analysis or engineering.

The analysis looked at a 2 x 6, submerged grid of SeaStation fish pens in 47 - 49 meters (m) of water. An ADCP deployment and a search of available wave and current data provided the inputs for the environmental conditions. Three sets of environmental conditions (see below) were used in the overall analysis.

Standard Operating Conditions

Depth: 49 m
Waves: 1.2 m height, 6.7 second (s) period, towards SE, JONSWAP spectrum
Current: 0.41 m/s at surface, 0.1 m/s at seabed, power law distribution

Extreme Conditions (Design Load Case)

Depth: 49 m
Waves: 4.0 m height, 8.4 s period, towards SE
Current: 1.0 m/s at surface, 0.46 m/s at seabed, power law distribution

Survival Load Case

Depth: 49 m
Waves: 7.3 m height, 10.2 s period, towards SE
Current: 2.07 m/s at surface, 1.3 m/s at seabed, power law distribution

The design load conditions were used in a preliminary quasi-static analysis. This analysis set a baseline of required strength and target equipment for the grid. After this gear was established, Innovasea ran a set of dynamic analyses using Orcaflex software to revise and finalize the required equipment for safe deployment at the site. The outline of required rope, anchor and chain sizes recommended for this analysis is shown below. This recommendation is based on the data that was available at the time of analysis. If any additional data on the site becomes available, the extremes analysis should be undertaken again to ensure the input conditions remain applicable.

Table 1: Summary of recommended grid components.

Recommended Grid Configuration					
Component		Specification	Amount Per Assembly	Number of Assemblies	Total Amount
Anchor Line Assembly	Anchor Line	55 mm (2-3/16 in) 12-strand polyester, with Newco TT 6-7 thimbles	115 m	40	4,600 m
	Anchor Chain	2" (51 mm) Studlink	55 m		2,200 m
	Anchor	4.0 mT, Delta Flipper Style Anchor	1		40
Grid Lines		55 mm (2-3/16 in) 12-strand polyester, with Newco TT 6-7 thimbles	80	32	2,560 m
Node Line Assembly	Node Line	51 mm (2 in) 8-braid Copolymer, with Newco TT 6-7 thimbles	29 m	21	609 m
	Node Buoy	1.2 mT Spar buoy, ASTM A36 steel	1		21

The pricing for the above equipment (materials and manufacturing) has been accounted for in the separate financial analysis completed by Innovasea. The values included in the financial model are non-binding and is to be considered for budgetary purposes only. A high fidelity, detailed quote would need to be requested to make an order for the above equipment.

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Introduction

Purpose

The purpose of this analysis was to investigate a potential deployment of a 12-cell grid for Blue Silo in the Gulf of Mexico. There is interest in installing a 2 x 6 grid of 6,400 cubic meter (m³) Kikko-brass net SeaStations adjacent to decommissioned oil rig Station 975. The primary goal was to specify appropriately sized anchor, grid, node, and bridle lines and hardware for the proposed site. The analysis used available wave and current data as well as provided bathymetry to simulate and validate appropriate grid configurations based on those inputs.

Scope

This report covers an investigation of the following:

- 2 x 6 grid assembly and recommended configuration of lines and anchors
- Pen selection
- Recommended site location and orientation

Methods and Procedures

Innovasea completed the environmental analyses, quasi-static analysis and post-processing using a combination of mathematical programming software (MATLAB, OCTAVE) and Excel-based calculation workbooks.

The dynamic analysis software, Orcaflex was used to run the simulations of the various grid layouts. Orcaflex is the leading dynamic analysis package used across various industries to analyze offshore marine systems. The grid systems and net-pens were constructed in the Orcaflex environment based on design parameters and adjusted with real-world information. The software is used to apply forces from ocean environmental conditions (waves and currents primarily) to quantify how the system would respond to those conditions.

Grid, Mooring and Pen Assumptions

The pen specifications for the quasi-static and dynamic analyses were based on the bill of materials and hydrostatic properties of the SeaStation 6,400 m³ with Kikko and brass netting (SS6400KC). The pen spar has a diameter of 42 inches (in) with an overall length of 24 m including a variable buoyancy chamber 17 m long. The rim assembly has a total diameter of 32 m and is composed of twelve sections, each 9 m long. Kikko net is a hexagonal woven net made of UV stabilized

Polyethylene Terephthalate (PET) monofilaments. The brass netting is a copper alloy monofilament wire that is woven into pickets to form a diamond mesh.

The proposed grid configuration is two rows by six columns (2 x 6) of 80 m square grid cells. Each node on the outer edge of the grid is anchored with two lines for a total of 40 anchor lines. The 2 x 6 grid is meant to hold one SS6400KC in each cell, with the grid plane sitting 15 m below the surface.

Pen:

SeaStation 6,400 m³ (SS6400KC)
Upper Mesh: 3.7 mm Diameter Large Mesh Kikko
Lower Mesh: 4.0 mm Wire, 45 mm Bar brass

Grid:

- Nominal grid depth assumed to be 15 m below sea surface
- Scope assumed to be 5:1
- 2 shots of chain initially specified
- Drag embedment style anchors
- The preliminary sizes of the lines consider necessary strength, wear considerations and ideal hardware for offshore mooring systems.

Environmental Inputs

Environmental data on waves and currents as well as bathymetry at the site came from multiple sources. The project team deployed a bottom mounted Acoustic Doppler Current Profiler (ADCP) on site in 2020. Additional environmental data was found via the National Oceanic and Atmospheric Administration (NOAA) National Data Buoy Center (NDBC) and historical current models from the Hybrid Coordinate Ocean Model (HYCOM) were used as well. This available data resulted in the following three test conditions:

Standard Operating Environment (Operational Load Case)

Depth: 49 m
Waves: 1.2 m height, 6.7 s period, towards SE
Current: 0.41 m/s at surface, 0.1 m/s at seabed, power law distribution

Simulations in standard operating conditions were done with the pens surfaced to capture the highest loading that the pens would experience under these conditions. The standard operating environment was found by calculating the values correlated to the 90% threshold of the cumulative density function (CDF) of the available wave and current datasets. Note that to reduce skew from extreme events the data recorded by the ADCP during the hurricane in 2020 was omitted. The 90% CDF current speed at the grid depth (15 m) was 0.23 m/s. Due to the short length of the dataset, the team decided to scale the value by an industry standard (Norwegian Standard NS-9415 (1)) scalar

multiplier of 1.65. Note this scalar is usually applied to find 10-year design values and should be considered conservative. The standard operating current speed used in simulation was 0.38 m/s towards the SE. The current profile obtained from the bottom mounted ADCP shows a decreasing magnitude with depth, so the team applied a power law and adjusted this in Orcaflex to best fit this profile, with a preference for the most accurate current speed at grid depth. Significant wave height and peak period were also found as a 90% CDF of all wave data excluding hurricane data. For design purposes it was assumed that the wave direction was almost collinear with the current.

Extreme Conditions (Design Load Case):

Depth: 49 m
Waves: 4.0 m height, 8.4 s period, towards SE
Current: 1.0 m/s at surface, 0.46 m/s at seabed, power law distribution

The design load case is intended to model the worst case outside of an extreme weather event, and so uses the maximum values in the datasets excluding the data corresponding to the hurricane. The average of the maximum currents that would affect the pens was taken from the ADPC deployment data, discounting the hurricane event. This resulted in a velocity of 0.53 m/s. Due to the short dataset, an industry standard (Norwegian Standard NS-9415 (1)) scalar multiplier of 1.85 to get an established design value for a 50-year event. The resulting design velocity was 0.98 m/s. As in the standard operating case, the current in the water column is modelled with a power law adjusted in Orcaflex to be as accurate as possible at grid depth and fit the profile found in the data from the bottom mounted ADCP. The design wave significant height is the maximum height recorded by the National Data Buoy Center (NDBC) over several years excluding the hurricane, multiplied by an industry scalar, and its corresponding peak period was found using a Bretschneider nomogram(2). Both the current and the waves are directed towards the SE.

Survival Load Case:

Depth: 49 m
Waves: 7.3 m height, 10.2 s period, towards SE
Current: 2.07 m/s at surface, 1.3 m/s at seabed, power law distribution

The most extreme load case is a survival load case, simulating a hurricane using data from a hurricane at the site in July 2020. Innovasea again applied a power law current profile, adjusted in Orcaflex to match the maximum current recorded at grid depth – 2.07 m/s. The significant wave height is the maximum recorded at the site by NDBC and the corresponding peak period was found from the same dataset. Both the current and the waves are collinear towards the SE, just slightly more South than the other two load cases.

Location and Orientation

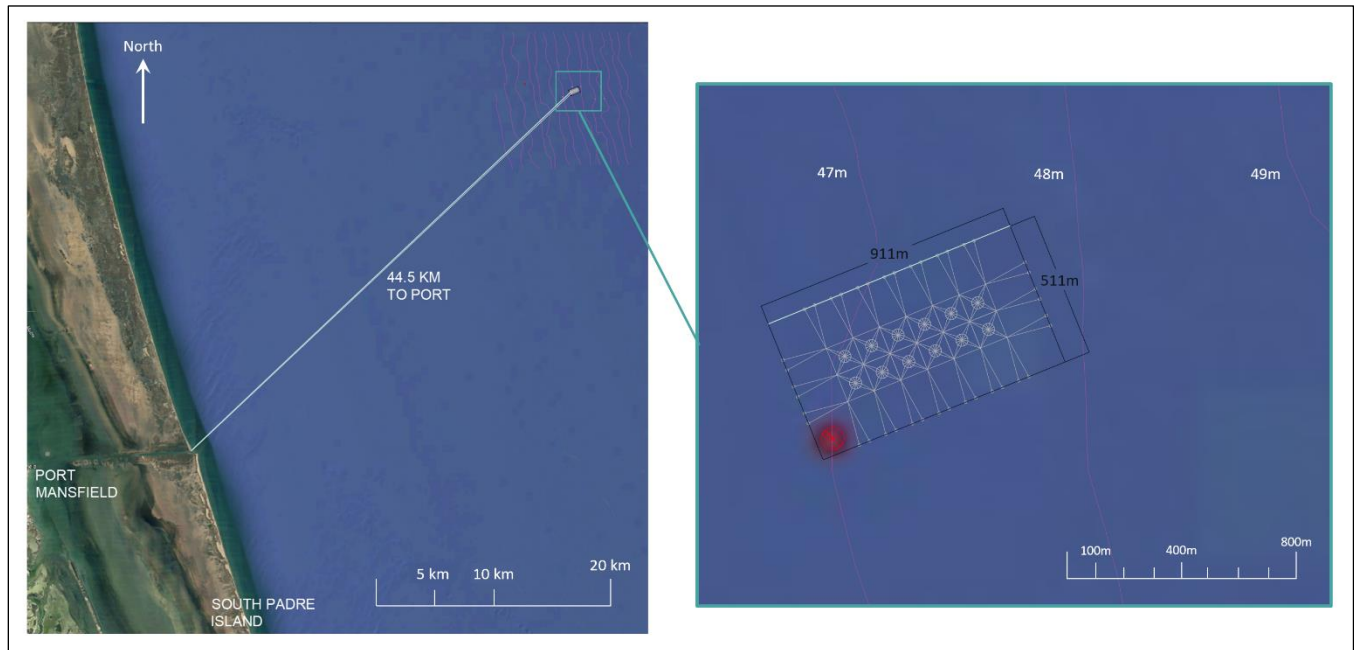


Figure 1: Geographic Layout of the proposed Station Padre grid.

The proposed Grid deployment location is adjacent to decommissioned Oil Rig Station 975 which is at $26^{\circ} 49' 57.65''$ N $96^{\circ} 56' 23.64''$ W. All pens will be located NE of the oil rig. This location was selected based on dominant current directions under standard conditions as well as directions of extreme conditions from hurricane events.

Bathymetry

Preliminary calculations assume flat bottom seafloor due to the gradual slope indicated by the bathymetric contours. Initial trials were completed assuming a 49-meter depth. After consulting with the team, trials were rerun at 47 m depth to ensure no issues arose in the pen selection or grid design in shallower waters. These were successful and no changes to the design path were made. The final grid design assumes an average depth between 47 and 49 m to match the minimum expected bathymetry surrounding Station 975.

Additional Assumptions

- Grid orientation: 248 - 68 degrees (deg)
- Grid plane depth: 15 m below the surface
- Water depth: 49 m
- Cell side length: 80 m
- Seabed substrate: Sand or mud

- Two anchor lines per grid node
- Pens assumed to be submerged for extreme weather events
- Anchors assumed to be pinned at their locations (i.e., proper set on install)

Analysis Procedure

Innovasea first identified loading conditions at the site from the provided environmental data. Next, Innovasea completed a quasi-static analysis using these loading conditions, an assumption of 49 m site depth, and a 5:1 scope, resulting in a preliminary configuration of mooring gear.

Innovasea built a model of the grid in Orcaflex using this preliminary gear recommendation. This model consisted of a 2 x 6 submerged grid including twelve (12) 6,400 m³ Kikko-brass SeaStations, with anchor and grid lines in 76 mm (3 in) Copolymer 8-Braid. The simulated load cases were applied to the model, and peak loads on structural lines were recorded. These peak loads and the minimum breaking strength (MBS) of the specified lines were used to calculate factors of safety. Visual inspection of simulation results, focused on buoyancy, geometry, and chain configurations, were used to make iterative changes to the gear. Note the following sections highlight three of the most relevant revisions analyzed.

At the end of the first round of analysis, two potential configurations of gear were specified (Revision A and Revision B). Both Revision A and Revision B used Copolymer 8-Braid for all lines, requiring lines up to 3 in diameter. These configurations were then simulated in the survival load case, with the result that Revision B did not survive under extreme hurricane conditions.

The third configuration (Revision C) focused on the reduction of grid system line diameters. The team selected Polyester 12-Strand rather than Copolymer 8-Braid. The associated size reduction minimizes the variety of hardware necessary - without compromising on strength. Revision A and Revision C both resulted in a factor of safety (FOS) higher than 2.5 in the standard operating case and in the design load case, and greater than 1.0 in simulated hurricane conditions.

Finally, Innovasea completed a fatigue analysis over an expected lifecycle of ten years on the Revision C gear, the results indicated that fatigue failure is not a concern.

Data

Peak tensions in key structural lines from each model were extracted from Orcaflex simulations using a MATLAB-based post processing script. The tables below summarize the relevant results from the three different proposed configurations of mooring gear. Note that the case taken

as representative of standard operating conditions models the pens as surfaced, assuming that these are the conditions in which pens will see highest loading.

Revision A:

- Anchor, grid, and node lines: 76 mm (3 in) Copolymer 8-Braid
- Bridle lines: 67 mm Copolymer 8-Braid
- Anchor chain: 57 mm Studlink
- Node ballast block: 1.73 metric ton (wet weight); concrete and rebar

This first proposed gear configuration was the result of iteration on the preliminary line lengths and sizes found through quasi-static analysis. After adjusting to minimize grid squat, and node ballast block sliding, the peak loads observed in all three environmental cases were far below the allowed maximum. In the lower energy cases, all FOS were greater than 2.5, and the simulation showed approximately 13 m of chain left on the bottom. This configuration also survived the hurricane load case, with $FOS > 1$. Because FOS were not a concern, the next iterations downsized the gear.

Revision B:

- Anchor, grid, and node lines: 64 mm (2.5 in) Copolymer 8-Braid
- Bridle lines: 51 mm Copolymer 8-Braid
- Anchor chain: 51 mm (2 in) Studlink
- Node ballast block: 1.73 metric ton (wet weight); concrete and rebar

This second configuration is the result of downsizing the Revision A configuration. All components are smaller, but their lengths are the same. In the standard operating and the design load case, the peak loads still result in acceptable (though lower) FOS. However, this configuration fails in the hurricane load case. The lines that fail are highlighted in red in the table below; note the $FOS < 1$.

Table 2: Failure of Revision B in Survival (Hurricane) Load Case

Variable	Tension	Unit	FOS
Max anchor line tension	777.20	kN	0.75
Max grid line tension	608.37	kN	0.95
Max node pennant line tension	10.22	kN	57.00
Max bridle line tension	407.61	kN	0.95

A subsequent simulation completed used this configuration with a change applied to “break” the lines that fell below the FOS threshold. Those results indicated that the grid would be susceptible to a cascading failure, meaning that lines would continue to be overloaded and be likely to fail. Thus, Revision B was discarded.

Revision C:

- Anchor and grid lines: 55 mm (2-3/16 in) Polyester 12-Strand
- Node lines: 64 mm (2.5 in) Copolymer 8-Braid
- Bridle lines: 51 mm (2 in) Copolymer 8-Braid
- Anchor chain: 51 mm (2 in) Studlink
- Node ballast block: 1.73 metric ton (wet weight); concrete and rebar

For this revision, the team investigated alternative materials as well as downsizing the equipment.

Polyester 12-Strand is stronger at smaller diameters, so the team compared the minimum breaking strength of the line to the peak loads that were observed in the survival load cases to select an appropriate line. As an added benefit, the switch to Polyester 12-Strand rather than Copolymer 8-Braid allows the chain to be downsized to 51 mm from 57mm, and minimizes the different sizes of hardware (shackles, thimbles, etc.) that must be used across the full mooring system. The peak loads in this gear configuration are summarized in the table below. Tension units are presented in Kilonewtons (kN).

Table 3: Peak loads in three conditions using Revision C

All Pens Surfaced, Standard Operating Conditions			
Variable	Tension	Unit	FOS
Max anchor line tension	52.16	kN	15.82
Max grid line tension	64.40	kN	12.81
Max node pennant line tension	18.93	kN	30.76
Max bridle line tension	28.78	kN	13.43
All Pens Submerged, Design Load Case			
Max anchor line tension	249.04	kN	3.31
Max grid line tension	312.27	kN	2.64
Max node pennant line tension	11.91	kN	48.92
Max bridle line tension	109.69	kN	3.52
All Pens Submerged, Survival Load Case			
Max anchor line tension	809.02	kN	1.02
Max grid line tension	746.80	kN	1.10
Max node pennant line tension	8.85	kN	65.78
Max bridle line tension	379.90	kN	1.02

This configuration has comparable performance to Revision A while using smaller lines and chains. All FOS in the lower energy load cases are greater than 2.5, and all are greater than 1 in the survival load case. A discrepancy to note is that while the final recommendation lists 51 mm Copolymer 8-Braid for the node ballast pennant lines, the simulations use 64 mm Copolymer 8-Braid. This is a

holdover from previous iterations of the gear configuration, but due to the extremely high FOS on node lines in all load cases (all FOS > 30), downsizing to 51 mm line is not a concern. The 51 mm Copolymer 8-Braid in the recommendation, like the change to Polyester 12-Strand in anchor lines and grid lines, allows the use of all similar sized hardware.

Having selected this configuration of gear, the mooring team conducted a simplified fatigue analysis by using the tension range observed in standard operating conditions and the strength of the structural lines to calculate the projected number of cycles to failure (N) and comparing to the number of cycles in a 10-year lifespan (n). It was found that the ratio of n/N was on the order of 10^{-9} . This indicates that the number of cycles in a 10-year lifespan is well below the fatigue life of the ropes and thus fatigue will not be the primary mode of failure for this gear configuration. Applying the same tension range to the B1 S-N curve as given by DNV-GL (3), it was shown that the shackles on these lines also have a fatigue life far beyond a 10-year lifespan.

Results Summary

Table 4: Factor of safety comparison

Minimum FOS Comparison: Revision A, Revision B, Revision C in Different Environmental Conditions				
Revision	Variable	Operational Loadcase	Design Loadcase	Survival Loadcase
A	Anchor line	15.65	3.34	1.00
	Grid line	12.04	2.67	1.15
B	Anchor line	11.85	2.54	0.75
	Grid line	9.05	2.06	0.95
C	Anchor line	15.82	3.31	1.02
	Grid line	12.81	2.64	1.10

Table 4 summarizes the results of Orcaflex simulations of three different gear configurations in three different environmental conditions by showing the minimum FOS in each case. Red cells highlight FOS < 1, indicating a broken line. The yellow highlighted cell shows FOS < 2.5, not broken but lower than acceptable.

Note that Revision A and Revision C have comparable results – high FOS in lower energy cases and FOS > 1.0 in the survival case. The distinguishing factor between these two configurations is in the material chosen for the anchor and grid lines. In Revision A, all lines are Copolymer 8-Braid, requiring very large lines (up to 76 mm or 3 in). Lines this large require increasing the size of hardware. Revision C, however, uses Polyester 12-Strand for anchor and grid lines, allowing these to be thinner and therefore use the same size hardware as the rest of the lines. Revision C also allows the anchor line assembly to use smaller chain – 51 mm as compared to 57 mm studlink.

Fatigue analysis on Revision C also demonstrated that within the expected 10-year life of the gear, fatigue from normal waves and current will not be a concern.

Conclusions & Recommendations

The recommended grid mooring system configuration for the site at Station 975 is summarized in the table below. It assumes a 2 x 6 grid of 80 m cells that each contain one 6,400 m³ Kikko-brass SeaStation. The grid should ideally be oriented 22 degrees off from east-to-west (248 deg - 68 deg). Each outside node of the grid should be anchored by two anchor line assemblies for a total of 40. A more complete bill of materials is provided as a supplement to this report.

Table 5: Final Recommended Grid Configuration.

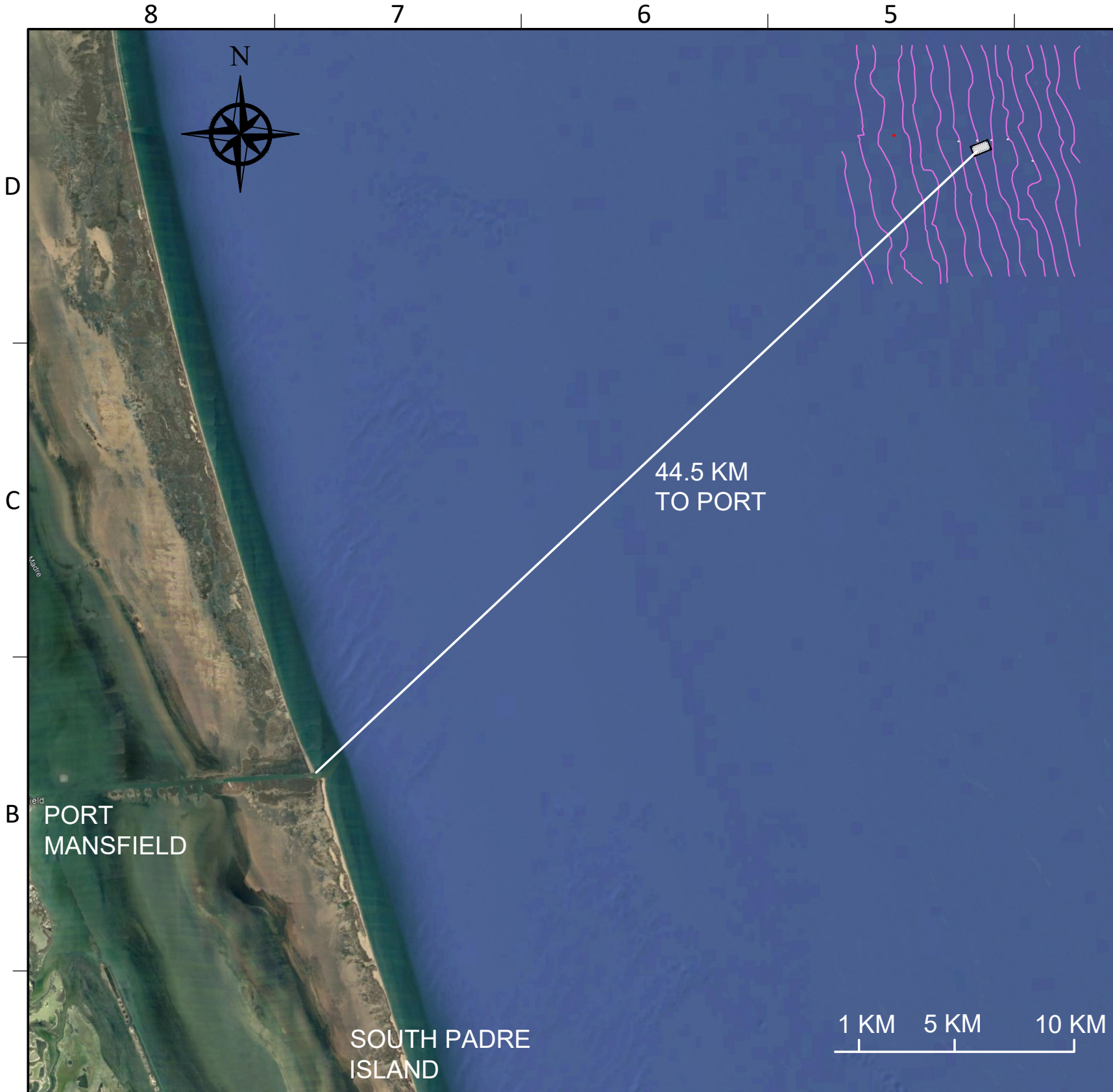
Recommended Grid Configuration					
Component		Specification	Amount Per Assembly	Number of Assemblies	Total Amount
Anchor Line Assembly	Anchor Line	55 mm (2-3/16 in) 12-strand polyester, with Newco TT 6-7	115 m	40	4,600 m
	Anchor Chain	51 mm (2 in) Studlink	55 m		2,200 m
	Anchor	4.0 mT Delta Flipper Style Anchor	1		40
	Crown Line	51 mm (2 in) 8-braid copolymer, with Newco TT 6-7	43 m		1720 m
Grid Lines		55 mm (2-3/16 in) 12-strand polyester, with Newco TT 6-7	80 m	32	2,560 m
Node Line Assembly	Node Line	51 mm (2 in) 8-braid copolymer, with Newco TT 6-7	29 m	21	609 m
	Node Buoy	1.2 mT Spar buoy, ASTM A36 steel	1		21
	Ballast Block	1.73 mT (wet weight), concrete and rebar*			
Bridle Lines		51 mm (2 in) 8-braid copolymer, with Newco TT 6-7	45 m	96	4,320 m

*Node ballast block is assumed to be a concrete and rebar assembly. The recommended wet weight is 1.73 mT, with an estimated size of 1.36 m x 1.36 m x 0.75 m to achieve that weight.

The above recommendation is the result of iterative simulation in Orcaflex and keeps lines as uniform as possible while maintaining a FOS above 2.5 for standard operating and design load cases. It also survives potential hurricane conditions with a FOS greater than 1 on all structural lines.

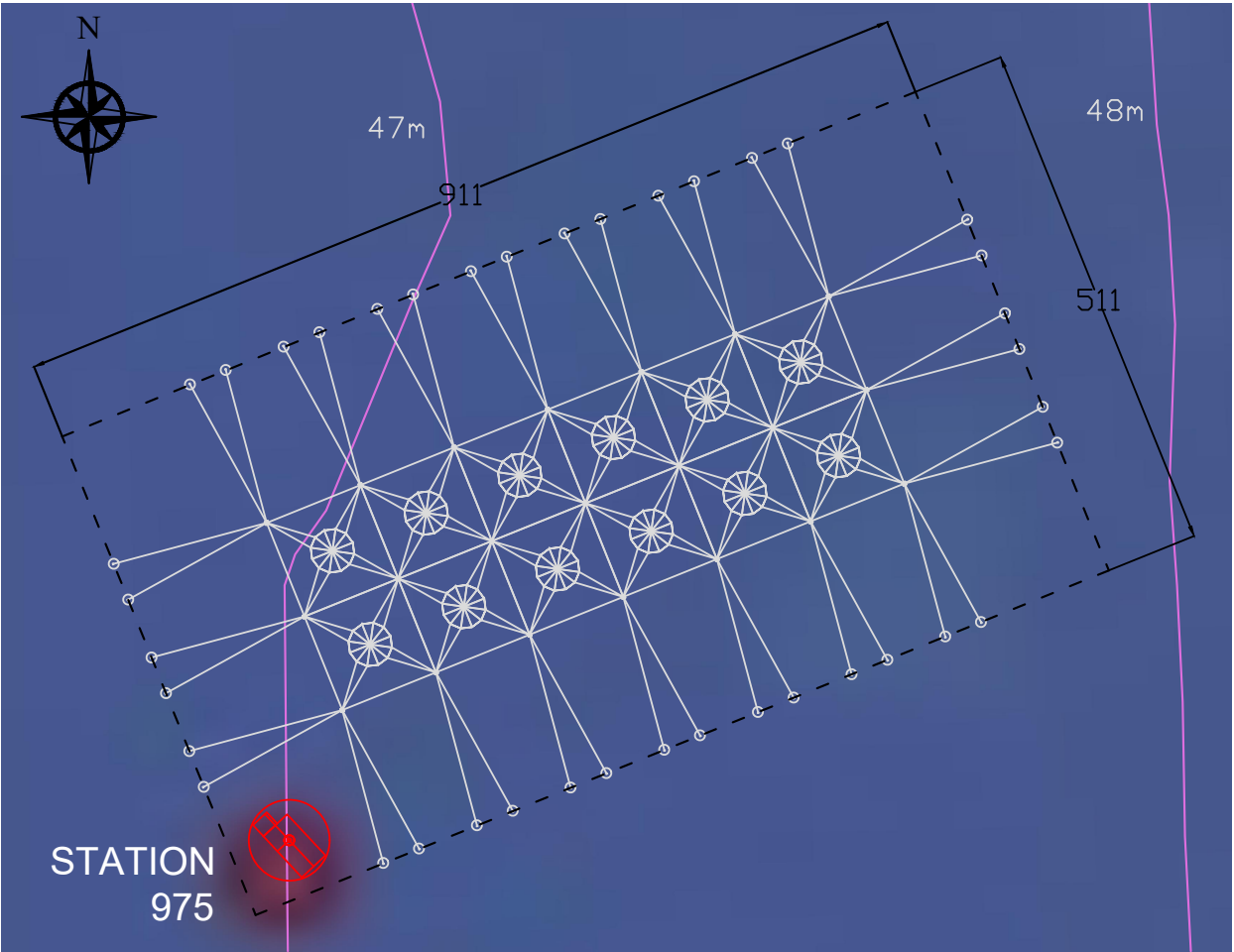
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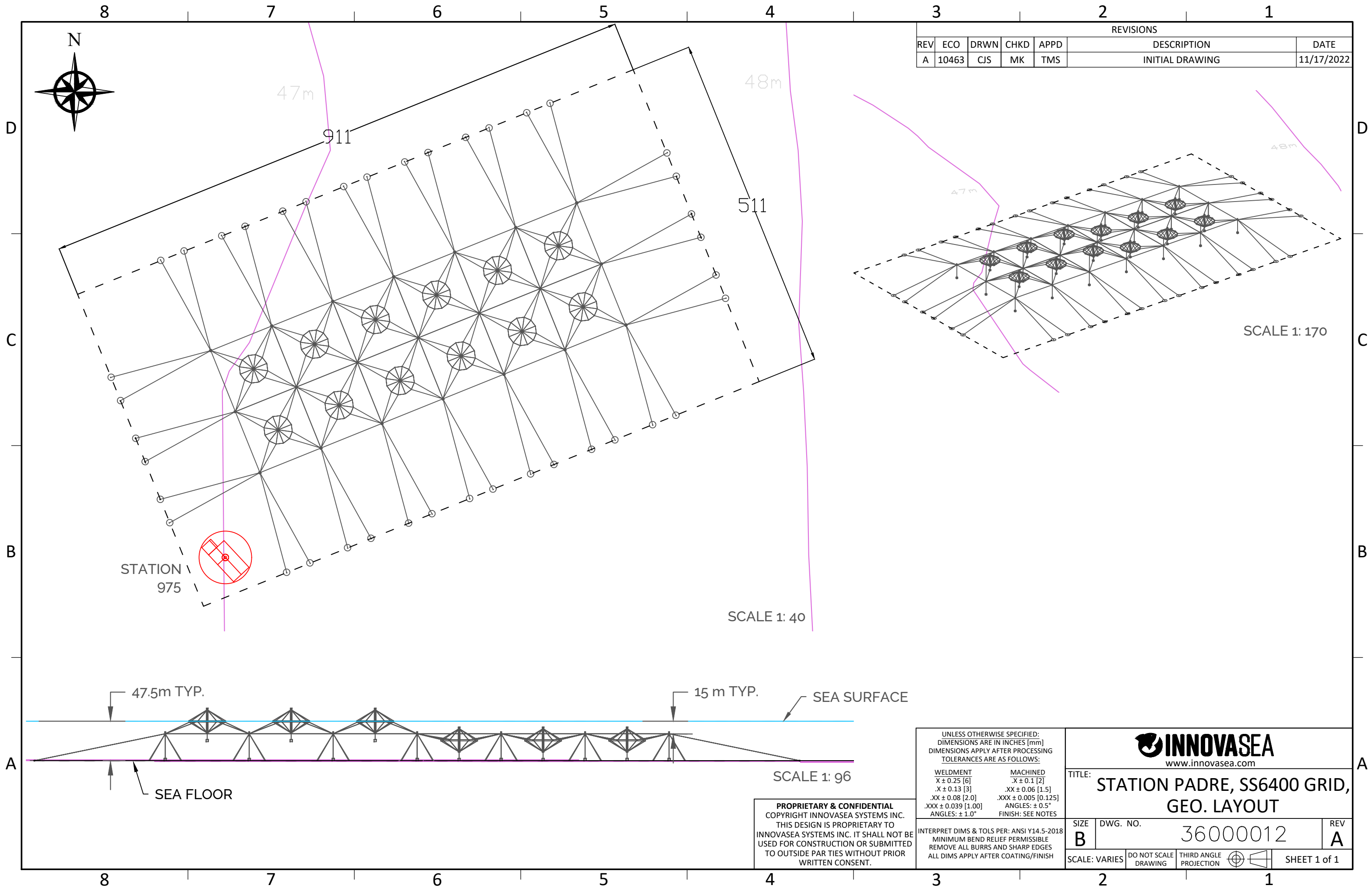
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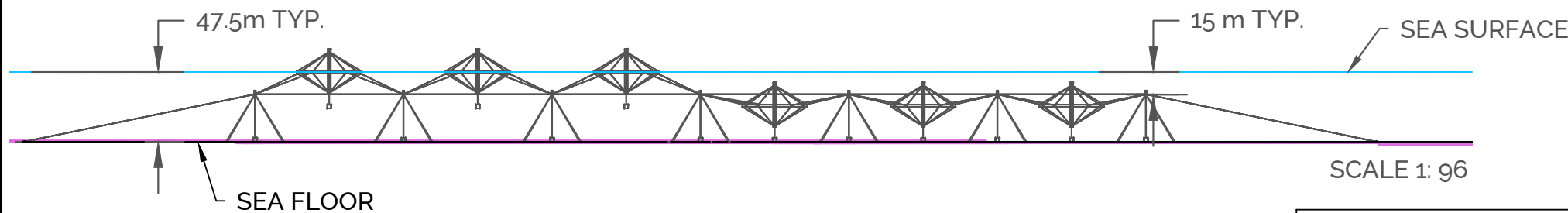
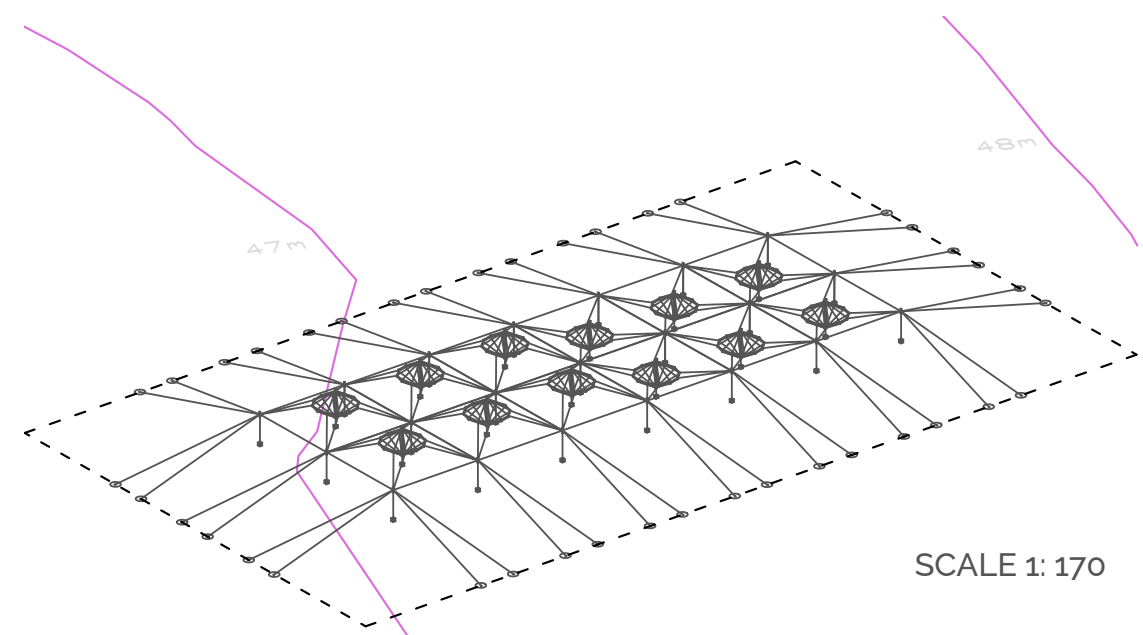
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