Cape Higher Education Consortium (CHEC) /

Western Cape Government (WCG)

JOINT RESEARCH PROGRAMME 2021/2022

Project Final Report

Can Fish Farming Be a Viable and Feasible Economic Development Strategy for the Bergriver Municipality?

Picture 1: Nile Tilapia (*Oreochromis niloticus)* Juvenile Fish, (Google Images).

1. COVER PAGE:

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2. ABSTRACT AND BACKGROUND:

The aquaculture sector in South Africa is said to be small and underdeveloped when compared to countries that have similar socio-economic dynamics. However, the sector has undeniable potential and opportunities for growth and development due to the increasing demand for fish (DFFE Aquaculture Yearbook, 2019). Over the past decade, production volumes for aquaculture commodities have continued to surpass projected figures and this trend is expected to continue well into the future, provided that conditions remain suitable.

South Africa boasts a long coastline of approximately 3900 kilometres which includes mainland South Africa and Prince Edward Islands which comprise of Marion Island and Prince Edward Island in the Southern Ocean. Its vast ocean area (Exclusive Economic Zone) of some 1.5 million square kilometres (compared to the land-mass of approximately 1.2 million square kilometres) and the fact that South Africa is uniquely surrounded by three oceans, the Atlantic Ocean in the West, the Southern Ocean in the South and the Indian Ocean in the East which is rich in biodiversity and other natural resources, provides opportunities for sustainable utilisation and economic growth.

As part of the development of an Oceans Policy, an economic study was commissioned in 2010 to determine the contribution of the ocean to the South African Economy, in terms of Gross Domestic Product (GDP) and Jobs. This study focused on the monetary value of the structured oceans economy and did not include the valuation of the ecological and natural capital. The South African Maritime sector has been existence for many decades and whilst there is recognition for its contribution to the overall Oceans Economy, some of the sub-sectors remained nascent and under-explored.

In promoting the Oceans Economy as a sector for sustained economic growth, it is important to address the multitude of constraints that impede growth and development, including transformation and implementing a set of interventions to advance the sector. From the economic analysis of the total ocean sectors (in 2010), it was estimated that the Oceans Economy could contribute between R129 to R177 billion by 2033 and create between 800 000 to 1 million jobs.

In an attempt to stimulate the Oceans Economy, the South African Government initiated Operation Phakisa in 2014 as a results-driven approach with clear plans and targets, based on the Big Fast Results (BFR) methodology which was successfully implemented in the Economic Transformation of the Malaysian Economy. Whilst the implementation of the detailed plans of Operation Phakisa has had varying successes and impacts, further work is required in some subsectors. The development of the Oceans Economy Master Plan builds on the foundation of the initiatives of Operation Phakisa and expands the scope to sub-sectors that had not been dealt with during this process. The Oceans Economy sector is quite complex and will be dealt with at sub-sector level as these sub-sectors are quite unique with its own dynamics and opportunities. A first draft version of the Oceans Economy Master Plan is available.

Research for Impact is one of Stellenbosch Universities six institutional strategic themes that will position the institution to attain its Vision 2040. Stellenbosch University wishes to pursue excellence, remain at the forefront of its chosen focus areas, gain standing based on its research outputs, and be enterprising, innovative, and self-renewing. This requires a careful balance between, on the one hand, continuity and consistency and, on the other, transformation and rejuvenation of Stellenbosch Universities academic researcher cohort. At the same time, Stellenbosch University research strives to be socially relevant. Ultimately, our research efforts are not only aimed at academic success but also at making a significant impact in the world. Research for impact at Stellenbosch University implies optimising the scientific, economic, social, scholarly and cultural impact of our research. Our focus is on interdisciplinary research that benefits society on a national, continental and global scale. At the same time, we remain committed to strengthening basic and disciplinary research excellence, as it forms the basis for applied and translational research.

Adequate progress was made with the initial stages of the project. A literature review was conducted, site visits were done, and several interviews were performed. An appointment was made with the Velddrif Business Chamber.

3. INTRODUCTION AND PROJECT AIMS / QUESTIONS:

The proposed research will, in the main, investigate the viability/feasibility of fish farming (Aquaculture) as a growth and development sector within the Bergriver Municipality. If potentially viable/feasible, the research will include policy proposals and financing linkages.

Figure 1: Map indicating the location of the West Coast District Municipalities, (Google Images).

Existing commercial Aquaculture related businesses are well established in this region. The following are examples of existing Aquaculture commercial farms:

a. Mussel farming operations in Saldanha Bay
b. Oyster farming in Paternoster
c. Abalone farming in Britannia Bay and Doringbaai
d. Marine finfish farming in Langebaan Lagoon
e. Aquaponics projects in Hopefield, Vredenburg, Porterville, Clanwilliam
f. Tilapia farming in Bio-floc system on a farm outside Vredenburg, JP von Hage
g. AVI Aquaculture Feed Company in Mooreesburg

The proposed research have incorporated the roles and responsibilities of the social partners (Academia, Business, and Government) in supporting a fish farming strategy in the Municipality. Reference was made to the potential replicability of fish farming technology throughout the region.

The envisaged outputs included the following, i.e.,

1) Viability and Feasibility Argument

- Technically, Aquaculture is viable and feasible in this region. Environmentally and biologically also viable and feasible. The challenge is economically. Aquaculture projects normally must reach a certain scale of production to become economically viable and sustainable business units in the long term. It is very important that the breakeven point in price and volume is achieved. If a project is started on a too small scale volume wise it unfortunately will be challenging to make the project economically viable in the long term.

2) International and National Best Practices Guide

- Information already available. Several existing documents are available on Best Management Practices, Production Standards, Standard Operating Procedures, and Code of Practice in Aquaculture Commercial Production. These documents can be shared by the author on request.

3) Fish Farming Technical Guide

- Various information documents and Technical Manuals are already available. These electronic documents can be shared by the author on request.

4) Fish Farming Organization and Structure

- Recommendations will be made. There are several Aquaculture Producer Associations in South Africa for instance the Abalone Farmers Association of South Africa, Bivalve Association of South Africa, Marine Finfish Farmers Association, AquacultureSA, Aquaponics Association of South Africa, Tilapia Aquaculture Association of South Africa etc. Membership to these associations are open to all stakeholders. Existing Best Management Practices and Production Standards documentation are also available and can be shared by the author on request.

5) Legislative and Policy Proposals

- Existing Aquaculture National Policies (Aquaculture Development Act) are in place. These documents are available on the Department of Forestry, Fisheries and the Environment's (DFFE) website. Local governments need to adhere to this National legislation. Creating an enabling environment on the ground for entrepreneurs are very important and this is where local governments can play a very important role.

6) Financing Linkages
- Information Document will be supplied and is available on request from the author. (Title of the document: A Directory of Development Finance and Grant Funding Organizations for Aquaculture Operations in South Africa).

7) Social Partners Roles and Responsibilities
- None profit organisations, NGO's and Development Organisations can play an important role to give support to local community organisations and assist them to get new Aquaculture projects initiated and implemented successfully.

The outcome was a Fish Farming Strategy for the Municipality that potentially can be replicated throughout the region.

Picture 2: Piketberg Commercial Aquaponics Project (Paul Botha).

4. The methodological framework of the study:

Conducting a desktop survey on the potential of aquaculture development in the Velddrif region of South Africa required a systematic approach to gather the relevant information and data. Here's the description of the methodology followed:

- Define Objectives:

The objectives of the survey were defined clearly. What specific information are needed and what decisions or recommendations will be based on this research?

- Literature Review:

The start of the survey was done by conducting a comprehensive literature review. The online search included existing studies, reports, and publications related to aquaculture in South Africa, and specifically in the Velddrif region. This helped to understand the current state of aquaculture in the area, to identify the challenges, and discover the potential opportunities.

- Data Collection:

Key data points and topics were identified for data collection in this study. This included information on:

- Water quality and availability in the region.
- Suitable aquaculture species and their growth requirements.
- Environmental regulations and permits for aquaculture.
- Market demand for aquaculture products.
- Infrastructure and resources available for aquaculture.
- Competitors and existing aquaculture operations in Velddrif.

- Data Sources:

Credible sources for the data were identified. This included government agencies, research institutions, local businesses, and industry associations. Relevant experts or stakeholders were contacted for insights and information.

- GIS Mapping:

Utilization of Geographic Information System (GIS) tools to map out the physical geography of the Velddrif region. This helped to identify potential aquaculture sites, proximity to water bodies, and other spatial factors. This information were found in a previous seaweed feasibility study.

- Data Analysis:

The data collected were analysed to identify trends, opportunities, and potential challenges. Statistical analysis could be used if applicable. One would then look for correlations and patterns that can inform the recommendations.

- SWOT Analysis:

A SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis was conducted to assess the feasibility of aquaculture development in the region. This helped to identify internal and external factors affecting the industry.

- Stakeholder Engagement:

Local stakeholders were engaged, including government officials, community leaders, and potential investors, to gather their insights and opinions on aquaculture development in Bergriver municipality.

- Regulatory Assessment:

A review was done and the regulatory framework for aquaculture in South Africa and the specific regulations that apply to the Velddrif region were summarized. Permits or licenses required were highlighted.

- Market Analysis:

- The market potential for seafood and aquaculture products in the region and beyond were accessed. Factors like consumer demand, pricing, and distribution channels were considered.

- Report and Recommendations:

- Findings were compiled into a comprehensive report that includes an executive summary, methodology, recommendations, and addendums with additional information. Clear and actionable suggestions for aquaculture development in Velddrif were suggested.

- Presentation:

- A presentation was done of the findings and recommendations to relevant stakeholders, including local government officials of the Economic Development Committee from the municipality. All questions or concerns were addressed.

- Follow-Up and Monitoring:

- After the survey, a continuation of monitoring the developments in the aquaculture industry in Velddrif are very important and necessary. This will help ensure the relevance of the recommendations over time.

5. Technical Feasibility:

Climatic conditions:

Velddrif is located on the west coast of South Africa and experiences a Mediterranean climate characterized by mild, wet winters and warm, dry summers. Here's a general overview of the climatic conditions:

Summer (December to February): Summers in Velddrif are warm and dry. Temperatures typically range from around 20°C to 30°C (68°F to 86°F). The region can experience occasional heatwaves, pushing temperatures higher. Rainfall is scarce during these months.

Autumn (March to May): Autumn sees mild temperatures with gradually decreasing warmth. Average temperatures range from around 15°C to 25°C (59°F to 77°F). Rainfall may start to increase slightly towards the end of this period.

Winter (June to August): Winters in Velddrif are mild and relatively wet compared to the rest of the year. Temperatures range from around 10°C to 20°C (50°F to 68°F).

Rainfall is more frequent during these months, with occasional cold fronts bringing cooler temperatures.

Spring (September to November): Spring sees a gradual warming of temperatures. Average temperatures range from around 15°C to 25°C (59°F to 77°F). Rainfall starts to decrease as the season progresses.

Keep in mind that these are general trends and actual conditions can vary from year to year. For the most accurate and up-to-date weather information for Velddrif, I recommend checking with reliable local weather sources, such as meteorological websites, apps, or news outlets.

The climatic condition from this area is suitable for Aquaculture activities to take place. Specific climatic conditions for the town of Velddrif is indicated in die diagrams below.

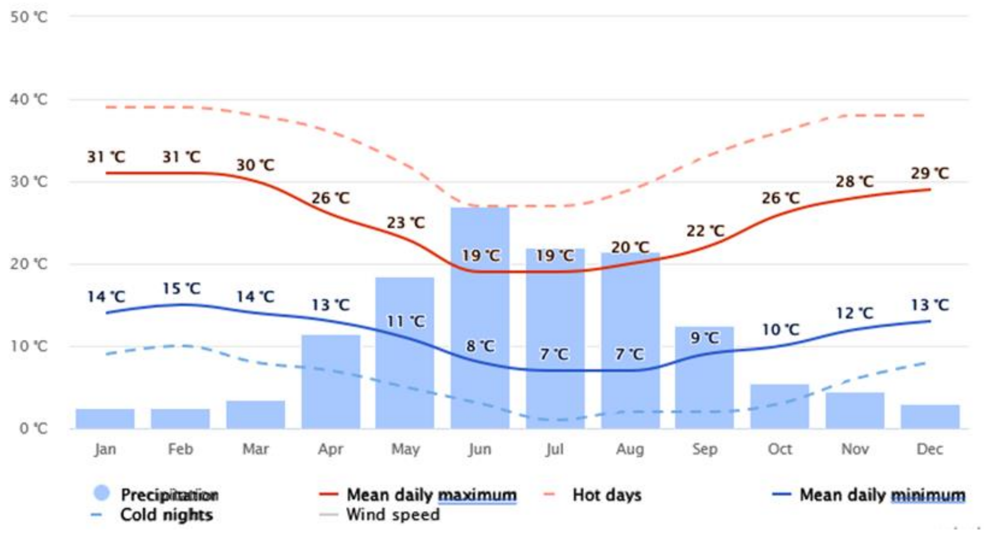


Diagram 1: Average temperatures and precipitation, (https://wwwmeteoblue.com).

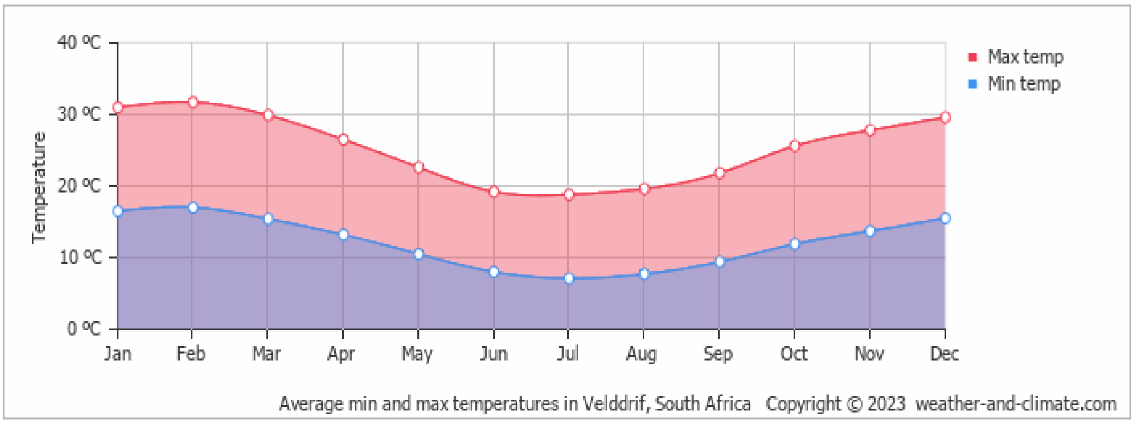


Diagram 2: Average min and max temperatures for Velddrif, (Google Images).

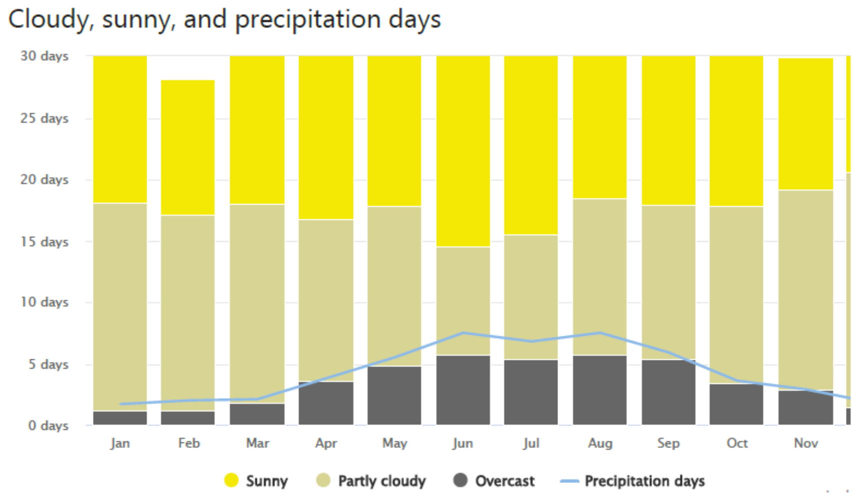


Diagram 3: Indication of cloudy, sunny and precipitation days, (https://wwwmeteoblue.com).

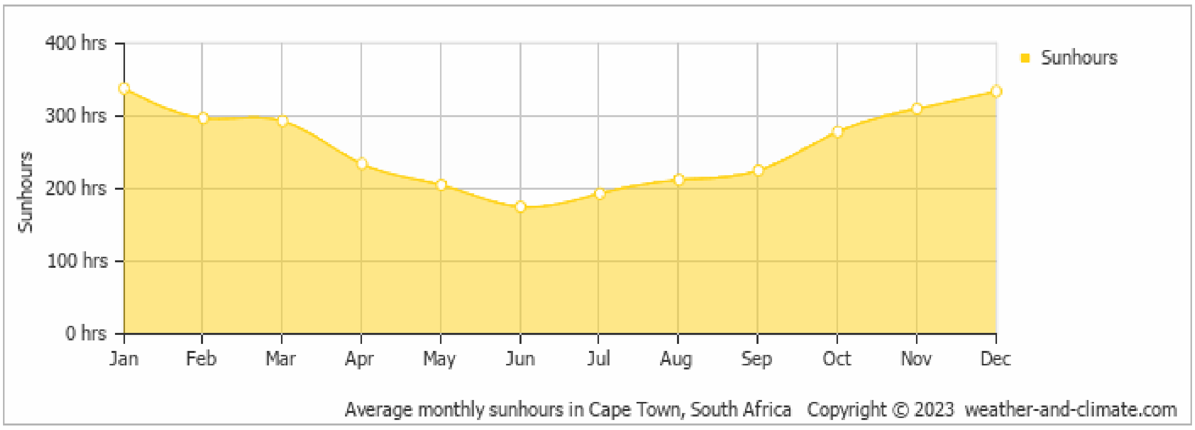


Diagram 4: Average monthly sunshine hours, (Google Images).

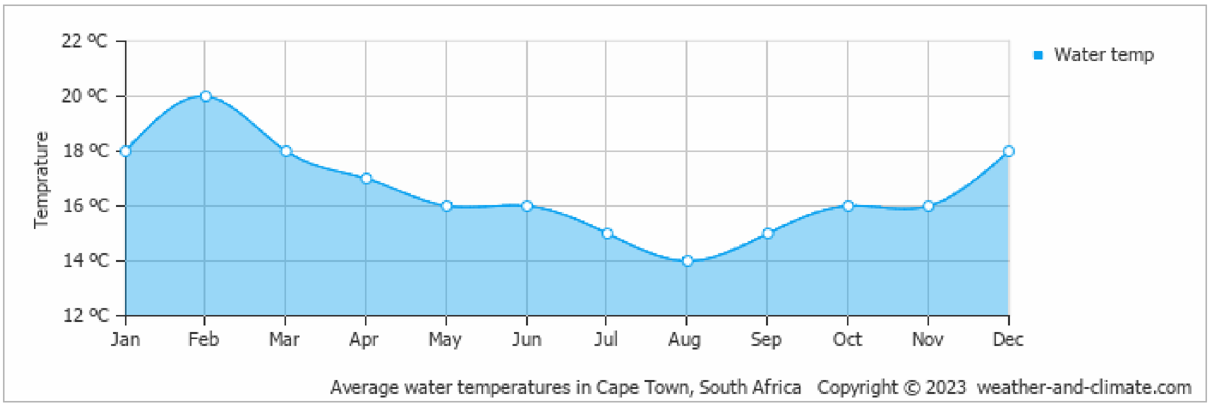


Diagram 5: Average water temperatures, (Google Images).

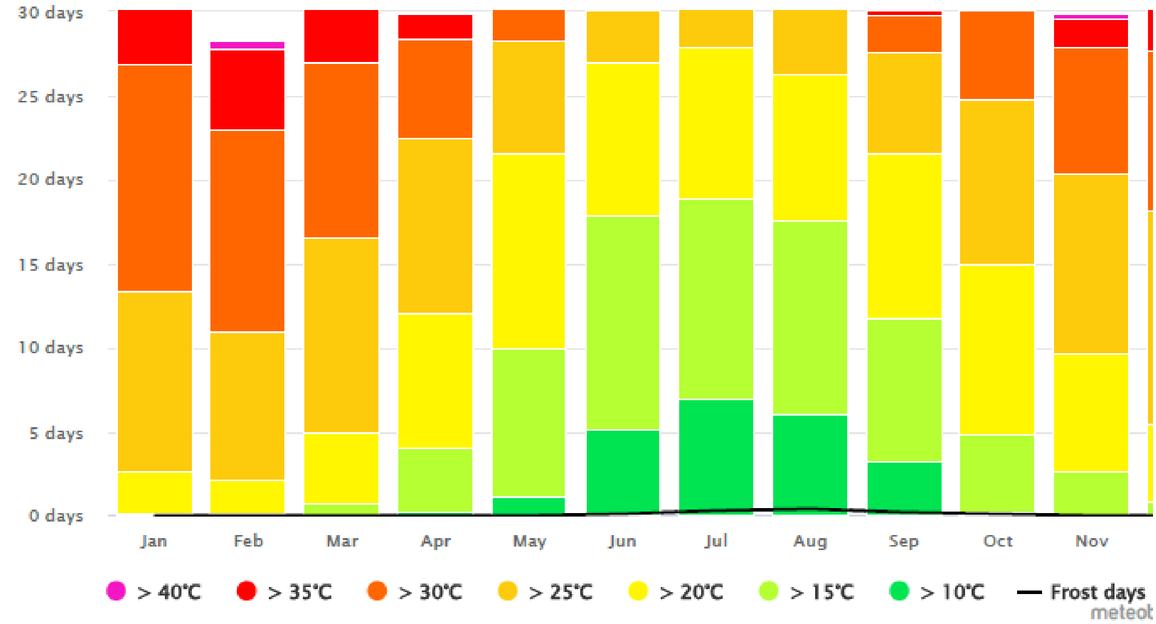


Diagram 6: The maximum temperature diagram for Velddrif displays how many days per month reach certain temperatures, (https://wwwmeteoblue.com).

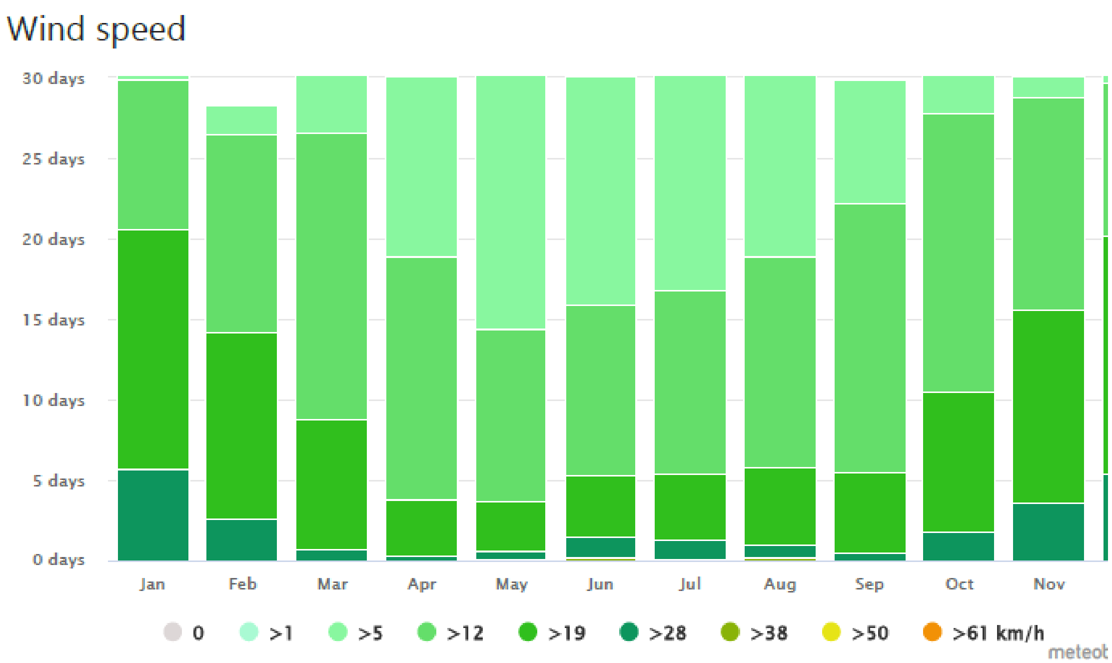


Diagram 7: Indication of the average wind speed in Velddrif, (https://wwwmeteoblue.com).

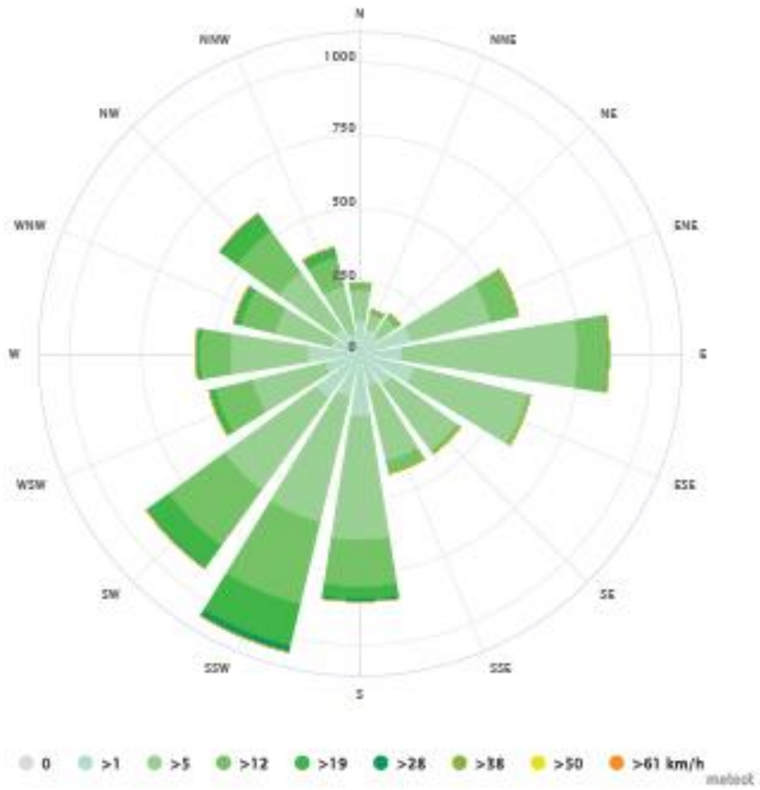


Diagram 8: Windrose indicating the wind directions for Velddrif, (https://wwwmeteoblue.com).

See Addendum 9.2 - Final Report: Pre-feasibility Study on the potential for commercial cultivation of African kelp along South Africa's West Coast, Appendix C (OFFSHORE GIS STUDY) for detail information on the ocean conditions on the West-Coast.

6. Market Assessment:

Seafood products are among the most important internationally traded food commodities. The world seafood industry plays a significant role in the economic and social wellbeing of many nations, as well as in the feeding of a significant part of the world's population. Fishing and fish farming have emerged as one of the major food processing occupations of mankind. In ancient times, economically and socially backward people were employed in this profession. The advent of modern mechanized fishing vessels has brought vast changes in the attitude of the public fishing and seafood processing. From low income and socially backward communities the profession has shifted to the hands of industrialists and technologists. Today fishing and processing activities provide employment to millions of people around the world.

Please note that for the most current and accurate information, you should consult more recent sources or market research reports.

- Coastal Location Advantage:
  South Africa's extensive coastline provides a significant advantage for the fish and seafood market. The country has access to both the Atlantic and Indian Oceans, offering a diverse range of fish and seafood species. This allows for a steady supply of fresh and varied products.

- Demand and Consumption:
  Fish and seafood are an essential part of South African cuisine and diet, and there is a consistent demand for these products. With a growing population and an increasing interest in healthier food options, the demand for fish and seafood has the potential to remain strong and expand further.

- Export Opportunities:
  South Africa has the potential to become a hub for fish and seafood exports. The country can tap into international markets, especially in Europe and Asia, where there is a high demand for quality seafood products. This could lead to economic growth and job creation in the sector.

- Aquaculture Development:
  Aquaculture, or fish farming, has been identified as an area of growth potential. The government has shown interest in supporting aquaculture initiatives to reduce pressure on wild fish stocks and create new economic opportunities.

- Sustainable Fishing Practices:
  Concerns about overfishing and environmental sustainability have led to an increased focus on responsible fishing practices. South Africa has taken steps to manage its fisheries and protect marine ecosystems. Businesses that prioritize sustainability can position themselves well in the market.

- Challenges:
  Despite the potential, there are also challenges in the fish and seafood market in South Africa:

  - Regulations and Compliance: The industry is subject to various regulations and compliance standards to ensure sustainability and food safety. Meeting these standards can be complex and costly for businesses.

  - Infrastructure and Processing: Investment in processing and distribution infrastructure is needed to maintain product quality and safety, especially for exports.

- Competitive Imports: South Africa does import a significant number of fish and seafood products to meet local demand. Local producers must compete with imported products in terms of price and quality.

- Market Access: Access to certain international markets can be restricted due to trade barriers and regulations.

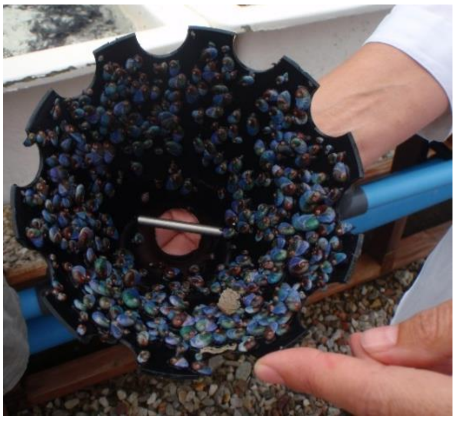
- Health and Safety Concerns: As with any food-related industry, maintaining high standards of hygiene and safety is crucial to building consumer trust.

- Consumer Trends:
Consumer preferences for sustainable, traceable, and ethically sourced products have been growing globally. These trends can influence purchasing decisions in the fish and seafood market as well.

Keep in mind that the situation may have evolved since my last update. To make informed decisions about investing in the fish and seafood market in South Africa, I recommend conducting thorough market research, seeking insights from industry experts, and staying updated on the latest trends and developments in the country's seafood industry.

Combining aquaculture with tourism on the West Coast of South Africa can create a unique and sustainable economic opportunity that leverages the region's natural resources, attracts visitors, and supports local communities. Here's a conceptual outline of how this integration could work:

- Aquaculture Farm Tours:
Set up guided tours of aquaculture farms along the West Coast. Visitors can learn about sustainable fish farming practices, the importance of marine conservation, and the role of aquaculture in food production. These tours can be educational and interactive, allowing tourists to see the entire process from hatcheries to harvesting.



Picture 3: Juvenile abalone spat to view during abalone farm tours, (Henk Stander).

- Agri-Tourism Experience:
  Develop agri-tourism experiences around aquaculture farms. Create opportunities for tourists to actively engage in tasks such as feeding the fish, monitoring water quality, and participating in basic farm maintenance. This hands-on approach can provide a deeper understanding of aquaculture and a connection to the local environment.

Picture 4: Welcome to Velddrif signboard, (Google Images).

- Seafood Culinary Experiences:
  Collaborate with local chefs and restaurants to offer seafood culinary experiences using the fresh products from the aquaculture farms. Visitors can enjoy a farm-to-table dining experience featuring locally sourced seafood prepared in innovative and traditional dishes.

Picture 5: West-coast rock lobster (crayfish/kreef) dish, (Google Images).

- Eco-Lodges and Accommodation:
  Build eco-friendly lodges or accommodations near aquaculture farms. These lodges can offer scenic views of the coastal landscape and provide tourists with a chance to stay close to the aquaculture operations. Interpretive signage and informative displays can educate guests about the ecological importance of the area.

Picture 6: Velddrif visitors accommodation, (Google Images).

- Fishing and Recreational Activities:
  Incorporate fishing and recreational activities such as kayaking, snorkelling, and bird watching. This would offer tourists diverse experiences that showcase the region's natural beauty, biodiversity, and the aquaculture activities happening in the waters.

Picture 7: Recreational fishing, (Google Images).

- Marine Education Centres:
  Establish marine education centres near aquaculture sites. These centres can include interactive exhibits, workshops, and presentations focused on marine life, conservation, and sustainable aquaculture practices. Schools, colleges, and local communities could benefit from educational programs.

Picture 8: SA Fisheries Museum, Velddrif, (Google Images)

- Environmental Conservation Initiatives:
  Promote environmental conservation and responsible tourism practices. Engage tourists in beach cleanups, marine habitat restoration, and awareness campaigns about preserving the delicate coastal ecosystem.

Picture 9: Counting and measuring crayfish, (Google Images).

- Community Involvement:
  Involve local communities in the tourism-aquaculture venture by offering employment opportunities, training programs, and partnerships. This integration can help boost the local economy while maintaining cultural authenticity.

Picture 10: Freshly caught crayfish, (Google Images).

- Marketing and Promotion:
  Market the aquaculture-tourism experience through various channels, including social media, travel agencies, and online platforms. Highlight the unique blend of aquaculture, sustainable practices, and authentic local experiences.

Picture 11: Laaiplek harbour festival advertisement, (Google Images).

Local festival events have the potential to make a huge economic injection in the local economy. In the past there was a Crayfish Festival or "Kreef Fees" which was unfortunately stopped because of the cancelation of commercial licenses and permits. It is recommended that the Municipality should consider establishing new festivals in the different towns. For instance, a "Bokkom and Wine" Festival in Velddrif, "Harvest Table" Festival in Piketberg and a "Blue-sky Paragliding" Festival in Porterville.

- Research and Innovation:
  Encourage collaboration between aquaculture farms, local universities, and research institutions. This can lead to advancements in aquaculture technology, improved sustainability practices, and a deeper understanding of the marine ecosystem in the coastal regions.

- Regulatory Compliance:
  Ensure that the combined venture adheres to environmental regulations, food safety standards, and ethical practices. Transparent communication about the sustainability efforts can build trust among visitors.

By combining aquaculture with tourism on the West Coast of South Africa, you can create a holistic experience that benefits the environment, the local economy, and the visitors seeking meaningful and educational travel experiences. It's important to conduct thorough feasibility studies, engage with stakeholders, and plan carefully to ensure the success and sustainability of such an integrated venture.

Financial Linkages – Information available on request.

Viability/Feasibility Argument – See section 5.4: Technical Analysis and section 7: Aquaculture Technologies.

7. Fish Farming Strategy:

Proper planning and site selection and institutional support by the creation of an enabling environment.

Aquaculture site selection is a critical process that involves choosing appropriate locations for the cultivation of aquatic organisms such as fish, shellfish, and aquatic plants. The success of an aquaculture operation depends heavily on the suitability of the chosen site. Here are some key criteria to consider when selecting an aquaculture site:

a) Water Quality:
   - Temperature: Water temperature should be within the suitable range for the target species.
   - Salinity: Salinity levels should match the species' requirements.
   - Dissolved Oxygen: Sufficient oxygen levels are essential for the health of aquatic organisms.
   - pH: The pH of the water should be within the acceptable range for the species.
   - Turbidity: Water clarity affects sunlight penetration and thus photosynthesis for aquatic plants.

b) Water Exchange and Flow:
   - Adequate water exchange prevents buildup of waste and helps maintain water quality.
   - Steady water flow can assist in waste removal and nutrient distribution.

c) Site Topography:
   - Water depth: Sufficient depth for the target species and farming method (e.g., cages, ponds).
   - Bottom substrate: Suitable substrate for attachment of organisms or anchoring of infrastructure.
   - Sheltered areas: Protection from strong currents, waves, and extreme weather events.

d) Environmental Impact:
   - Avoid sensitive habitats: Avoid areas with important ecological value, such as coral reefs, seagrass beds, and wetlands.
   - Minimize pollution: Prevent contamination of surrounding waters with excess feed, waste, and chemicals.

e) Nutrient Loading:
   - Avoid areas with high nutrient loads to prevent eutrophication and excessive algal growth.

f) Disease and Predators:
   - Minimize risk of disease outbreaks: Avoid areas with a history of disease outbreaks or proximity to infected wild populations.
   - Predator control: Choose sites with natural barriers to predators or implement protective measures.

g) Accessibility:
   - Proximity to markets: Convenient access to transportation and markets reduces logistical challenges.
   - Infrastructure: Availability of facilities like roads, electricity, and freshwater supply.

h) Legal and Regulatory Considerations:
   - Zoning and permits: Ensure compliance with local, state, and national regulations and obtain necessary permits.
   - Property rights: Clarify land and water rights before establishing operations.

i) Socioeconomic Factors:
   - Local communities: Consider the impact of the aquaculture operation on local economies and social structures.
   - Employment opportunities: Aquaculture can create jobs in rural areas.

j) Monitoring and Management:
   - Accessibility for monitoring: Choose sites that allow regular observation and data collection.
   - Emergency response: Plan for quick response to unforeseen events such as escapes or disease outbreaks.

k) Market Demand:
   - Align production with market demand for the chosen species and products.

l) Climate Resilience:
   - Consider the potential impacts of climate change, such as rising sea levels and changing weather patterns.

Site selection should be a comprehensive process that balances these criteria to ensure the sustainability and success of the aquaculture venture. It's often beneficial to conduct thorough site assessments, feasibility studies, and environmental impact assessments before making a final decision.

8. BUDGET:

#	Activity	Budget Amount	Actual Amount Spent	Balance
1	Consultation fees	R 77 500	R 77 500	R 0
2	Travel	R 5 800	R 5 800	R 0
3	Accommodation	R 11 500	R 11 500	R 0
4	Subsistence	R 3 700	R 3 700	R 0
5	Field Workers	R 0,00	R 0,00	R 0
6	Equipment	R 0,00	R 0,00	R 0
7	Stationary	R 1 500	R 1 500	R 0
8	Materials Supplied	R 0,00	R 0,00	R 0
9	Others	R 0,00	R 0,00	R 0
Total Amount:		R 100 000	R 100 000	R 0

9. PROPOSED AQUACULTURE PRODUCTION TECHNOLOGIES TO CONSIDER:

9.1 Aquaponics Systems (Freshwater and Marine)

The word “aquaponics” comes from two separate words, which are combined. The first word is “aqua”, which of course, means water, but in this case, the “aqua” is from another compound word “aquaculture” (the production or raising of fish as a livelihood). The second word is “ponics”, which is Latin for work, and comes from its use in “hydroponics” (working, at growing plants in water, hydro).

Aquaponics refers to any system that combines conventional aquaculture with hydroponics in a symbiotic environment. In normal aquaculture, excretions from the animals being raised can accumulate in the water, increasing toxicity. In an aquaponics system, water from an aquaculture system is fed to a hydroponic system where the by-products are broken down by nitrifying bacteria initially into nitrites and subsequently into nitrates that are utilized by the plants as nutrients. The water is then recirculated back to the aquaculture system.

Aquaponics systems are recirculating aquaculture systems that incorporate the production of plants without soil. Intensive recirculating systems are designed to raise large quantities of fish in relatively small volumes of water by treating the water to remove toxic waste products and then reusing it. In the process of reusing the water many times, non-toxic nutrients and organic matter accumulate. These metabolic byproducts need not to be wasted if they are channelled into secondary crops that have economic value or in some way benefit the primary fish production system. Systems that grow additional crops by utilizing by-products from the production of the primary species are referred to as integrated systems. If the secondary crops are aquatic or terrestrial plants grown in conjunction with fish, this integrated system is referred to as an aquaponics system.

Plants grow rapidly in response to dissolved nutrients that are excreted directly by the fish or generated from the microbial breakdown (mineralization) of fish wastes. In closed recirculation systems with very little daily water exchanges (less than 5%), dissolved nutrients accumulate and approach concentrations that are found in hydroponic nutrient solutions. Dissolved nitrogen, in particular, can occur at very high levels in recirculating systems. Fish excrete waste nitrogen directly into the water through their gills in the form of ammonia. Bacteria convert ammonia to nitrite and then to nitrate. Ammonia and nitrite are toxic to fish, but nitrate is relatively harmless and is the preferred form of nitrogen for growth of higher plants, such as fruiting vegetables. It is the symbiotic relationship between fish and plants that makes the consideration of an aquaponics system a reasonable system design criterion.

As existing hydroponic and aquaculture farming techniques from the basis for all aquaponics systems, the size, complexity, and types of foods grown in an aquaponics system can vary as much as any system found in either distinct farming discipline.

History of Aquaponics:
Aquaponics as a food growing technology has ancient roots, although there is some debate on its first application by humans. Aquaponics is nature at work. In nature, the fish eat whatever they can find for food, and their waste, is broken down by the bacteria in the water, creating nutrients for the plants. The plants then absorb these nutrients, and in doing so, they help clean the water for the fish.

The Aztec Indians of South America cultivated agricultural islands known as chinampas in a system considered by some to be the first form of aquaponics for agricultural use, where plants were raised on stationary (or sometimes movable) islands in lake shallows and waste materials dredged from the Chinampa canals and surrounding cities were used to manually irrigate the plants.
South China and the whole of Southeast Asia, where rice was cultivated and farmed in paddy fields in combination with fish, are cited as examples of early aquaponics systems, although the technology had been brought by Chinese settlers who had migrated from Yunnan around 5 Anno Domini (years before Christ). These polyculture-farming systems existed in many Far Eastern countries and raised fish such as the oriental loach, swamp eel, common carp, crucian carp as well as pond snails in the paddies.

The 13th century Chinese agricultural manual “Wang Zhen’s Book on Farming” described floating wooden rafts which were piled with mud and dirt, and which were used for growing rice, wild rice, and fodder. Such floating planters were employed in regions constituting the modern provinces of Jiangsu, Zhejiang, and Fujian. These floating planters are known as either jiatian or fengtian which translates to “framed paddy” and “brassica paddy”, respectively. The agricultural literature also references earlier Chinese texts, which indicated that floating raft rice cultivation was being used as early as the Tang Dynasty (6th century) and Northern Song Dynasty (8th century) periods of Chinese history.

The development of modern aquaponics is often attributed to the various works of the New Alchemy Institute and the works of Dr. Mark McMurtry et al. at the North Carolina State University in the USA. Inspired by the successes of the New Alchemy Institute and the reciprocating aquaponics techniques developed by Dr. Mark McMurtry et al., other institutes soon followed suit. Starting in 1979, Dr. James Rakocy and his colleagues at the University of the Virgin Islands researched and developed the use of deep-water culture hydroponic grow beds in a large-scale aquaponics system.

The first aquaponics research in Canada was a small system added onto existing aquaculture research at a research station in Lethbridge, Alberta. Canada saw a rise in aquaponics setups throughout the '90s, predominantly as commercial installations raising high-value crops such as trout and lettuce. A setup based on the deep-water system developed at the University of Virgin Islands was built in greenhouses at Brooks, Alberta where Dr. Nick Savidov and colleagues researched aquaponics from a background of plant science.

Relevance and advantages of Aquaponics:
Aquaponics as a technology offers an opportunity to produce food in a more economically and environmentally sustainable way with produce being grown using a low level of resource-input. Aquaponics could also help to reduce carbon emissions from food production, and through shortening of supply chains, could improve food security and food systems resilience.

Local economies could be further boosted through the use of aquaponics to reclaim some of the value of their outputs. This has been demonstrated recently by researchers who used domestic wastewater to grow tomato plants and found that harmful chemicals in the water, such as ammonium nitrate, were reduced to non-toxic levels so as to be useful in agricultural and industrial systems. Furthermore, an aquaponics system could significantly reduce the amount of water used for food production compared to existing methods of agriculture.

Aquaponics in Africa is only in its infancy. Production stats on aquaponics operations are almost non-existent due to so few systems. The systems that are known to exist are generally small-scale backyard systems and those designed to feed several families. Companies promoting aquaponics are active in Africa so there is an expectation that these systems will become more prominent over time. African countries where aquaponics is known to exist include South Africa, Botswana, Malawi, Kenya, Zambia, and Rwanda. Many of the initiatives are those by groups concerned about alleviating local poverty and nutritional deficiencies. The local Aquaponics industry in South Africa is quite well organized and the Aquaponics Association of Southern Africa (www.aquaponicssa.org/) was established in 2015.

Aquaponics systems offer several advantages:

- Fish provide most of the nutrients required by the plants
- Plants use the waste nutrients to produce a valuable by-product (second crop)
- The hydroponic component serves as a bio-filter
- Hydroponic plants extend water use and reduce discharge to the environment
- Integrated systems require less water quality monitoring than individual systems
- Profit potential increased due to free nutrients for plants, lower water requirement, elimination of separate bio-filter, less water quality monitoring and shared costs for operation and infrastructure (economic value).
- Can be built close to the market, limit transportation cost and supply fresher produce to the consumer

- Create jobs and can provide employment in areas with marginal agricultural soils
- Sustaining food security
- Producing fish and plants that are free of chemicals, pesticides, antibiotics, and growth hormones
- No pollution of any water sources
- Very energy efficient, only need to pump once depending on the design of the system.

There are, of course, disadvantages to aquaponics systems. The most obvious of these is the large ratio of plant growing area in comparison to the fish rearing surface area. A large ratio of plant surface to fish surface is needed to achieve a balanced system where nutrient levels stay relatively constant. Ratios vary from 2:1 to 10:1 or greater depending on the degree of solids removal, with larger ratios needed as solids removal efficiency decreases.

Understanding Aquaponics:
Plant growth in an aquaponics system is visually and systematically vastly different from a conventional growth, in farms and the likes, the same natural requirements are in place. And although the actual science of Aquaponics is still in the early stages of its development, the biochemical cycle within it, cycling within the system, is quite well understood. The most important is the nitrogen cycle, which in an aquaponics system is the key element cycle as it symbiotically provides fertility to plants as well as cleans the water for the fish, removing the toxicity they'd be subject to otherwise. The nitrogen cycle in this case occurs as the water flow through from the fish tanks to biological filters containing bacteria situated on submerged surface areas, to plants or a growbed and back again.

The major input into this nitrogen cycle – except for the electricity, which in this case is required for the pump to circulate the water, is fish food. The fish food can either be in the shape of an artificial fish feed or natural feed for instance aquatic plants, depending on the type of fish and plants in a given situation and the manner of intensification. After the fish eats and digest the food, they produce waste. This fish waste, as well as any uneaten fish food, starts to break down and, from this, the majority of the nitrogen content form ammonia (NH3). This ammonia is then, thereafter as it flows through the biological filter where Nitrosomonas bacteria is situated, converted to nitrite (NO_2) after which a second type of bacteria, Nitrobactor, converts nitrite into nitrate (NO_3). This nitrate then, as it flows through the growbed, serves as a fertilizer for the plants therein. As such the plants, in this hydroponic component of the system, take up the nitrate, that helps them grow by removing it from the water and as such purifies it as it circulates back to the fish tank returning clean, fresh water for the fish to thrive in.

In general, almost any freshwater fish and shellfish can be cultivated using aquaponics. Similarly, a wide range of plants can be grown in this kind of system. It is, however, easier to grow plants that do not have large roots that might cause them to rot, depending on what system-flow you utilize. More information about plant varieties will follow later in the course. Plants within a low to medium nutrient requirement tend to do best.

Picture 12: A commercial Aquaponics farm near Clanwilliam, (Henk Stander).

9.2 Bio-floc Production Systems (Tilapia, Prawns, Mullet, etc.)

Bio-floc systems were developed to improve environmental control over production. In places where water is scarce, or land is expensive, more intensive forms of aquaculture must be practiced for cost effective production. The sustainable approach of bio-floc systems is based on growth of microorganisms in the culture medium, benefited by the minimum or zero water exchange. These microorganisms (bio-floc) have two major roles: (a) maintenance of water quality, by the uptake of nitrogen compounds generating “in situ” microbial protein; and (b) nutrition, increasing culture feasibility by reducing feed conversion ratio and a decrease of feed costs. As long as there is sufficient mixing and aeration to maintain an active floc in suspension, water quality can be controlled. Managing bio-floc systems is not as straightforward as that, however, and some degree of technical sophistication is required for the system to be fully functional and most productive.

Bio-floc technology (BFT) developed as a consequence of the development of permanently mixed and aerated ponds, systems resembling biotechnological plants and maximizing the potential of microbial processes. BFT systems spread as a consequence of the restriction of water exchange due to costs and environmental regulation and as a means to provide bio secure systems to minimize disease, especially viral disease of shrimp. The basis of BFT systems are the bio-flocs. The bio-flocs are conglomerates of microbes, algae, protozoa, and others, together with detritus, dead organic particles. The bio-floc is a unique ecosystem of rich and potent particles suspended in relatively poor water. Bio-flocs found in ponds are porous, light and have a diameter of 0.1 to a few mm.

Advantages:
- Increased food and nitrogen conversion.
- Reduced water consumption, waste production and treatment.
- Simplification and cost reduction of facility design.
- Improved environmental control and pathogen bio security.

Disadvantages:
- Conditioning time for system starts up.
- Oxygen consumption of bio-floc.
- Energy requirements for maintaining bio-floc in suspension although low.

Picture 13: A commercial tilapia Bio-floc system in Mexico, (Sergio Simmerman).

9.3 Recirculation Aquaculture Production Systems (Atlantic Salmon and Marine Finfish)

Marine finfish recirculation aquaculture production systems, often referred to as marine RAS, are advanced aquaculture systems designed to cultivate marine fish species in a controlled environment. These systems aim to mimic the natural habitat of the fish while optimizing conditions for growth, health, and sustainability. Unlike traditional open-net pen systems, where fish are raised in natural bodies of water, recirculation aquaculture systems (RAS) minimize the impact on the environment by recycling water and treating waste.

Key components and features of marine finfish RAS include:

- Tank Systems: Marine RAS use specialized tanks that provide an environment suitable for the specific species being raised. The tanks are designed to maintain proper water quality, temperature, and oxygen levels.

- Water Filtration and Treatment: The heart of a recirculation system is its water treatment components. Mechanical filters remove solid waste, while biological filters house beneficial bacteria that break down harmful ammonia and nitrite into less toxic forms. Additional treatments like UV sterilization and ozonation can help control pathogens.

- Water Recirculation: The "recirculation" aspect refers to the fact that the water is continuously circulated through the system. This reduces water consumption compared to traditional aquaculture and helps maintain consistent water quality.

- Water Quality Monitoring and Control: Sensors and monitoring systems track parameters such as temperature, dissolved oxygen, ammonia, nitrite, pH, and more. These parameters are crucial for ensuring a healthy environment for the fish.

- Feeding and Nutrition: Marine finfish RAS systems provide precise control over feeding regimes to optimize growth and minimize waste. Proper nutrition is essential for the health and development of the fish.

- Biosecurity: RAS systems offer a higher level of biosecurity compared to open-net pen systems. By keeping fish in a controlled environment, the risk of disease transmission from wild fish or other sources is reduced.

- Stocking Density: The controlled environment of RAS systems allows for higher stocking densities compared to open systems, as long as water quality and other conditions are properly managed.

- Energy Efficiency: Marine RAS systems often utilize energy-efficient equipment and technologies to maintain optimal conditions while minimizing operational costs.

- Species Selection: Marine finfish RAS systems are suitable for a variety of species, including those that are sensitive to water temperature fluctuations or susceptible to diseases in open systems.

- Environmental Sustainability: RAS systems aim to reduce the environmental impact of aquaculture by minimizing water usage and waste discharge, as well as preventing the escape of non-native species.

- Challenges: Marine RAS systems are technically complex and require expertise in system design, operation, and maintenance. They also have high initial investment costs due to the advanced equipment and technology involved.

In summary, marine finfish recirculation aquaculture production systems offer a controlled and sustainable approach to raising marine fish species. They play a significant role in meeting the growing global demand for seafood while addressing environmental concerns associated with traditional aquaculture methods.

Planned land based Atlantic Salmon Recirculation Project:
Cape Nordic Corporation (Pty) Ltd (CNC) is currently developing a large-scale, land-based Recirculation Aquaculture System (RAS) for the production Atlantic Salmon (Salmo Salar). The facility will be located on the West Coast of South Africa.

The motivation for the project arose from the successful implementation of similar RAS units and hatchery/smolting facilities by the technology partners for this project. These technology partners have implemented successful RAS-based projects in Denmark, Norway, and Switzerland. The 4th generation RAS technology chosen for the project is the most suitable technology for the South African coastal and location conditions. Using this state-of-the-art European technology offers a large-scale potential to serve the South African domestic consumer market, as well as offering export opportunities to the middle east and Asia.

The project will be the first and largest land-based RAS facility of its kind on the African continent, with CNC utilising latest technology and innovative design to achieve maximum sustainability. Not only will the RAS system be a first for this region, but CNC will be supplementing and integrating the RAS facility with an Integrated Multitrophic Aquaculture System (IMTAS), which is on the cutting edge of global aquaculture developments and will provide for effective bio-mitigation of the fish farm effluent, while producing other commercially viable aquaculture species (such as oysters).

The farmland on which the proposed project will reside is located just north of Cape Town on the West Coast of South Africa between Elands Bay and Velddrif (approximately 20 km south of Elands Bay).

The size of the preferred property is 536 ha with a 1.2 km seafront. The RAS facility will be located at an approximate elevation of 10m above sea level.

The site location has been intentionally selected to be along the South African West Coast, where seawater temperatures are the coldest on the African continent because of the Benguela current bringing deep, nutrient-rich cold water up from the South Atlantic Ocean ((at temperatures of between 14 and 16°C). The availability of cold water is of course a critical factor for the survival and optimum growth of Atlantic Salmon, as per their natural environment.

Picture 14: Atlantic Salmon swimming in an RAS Aquaculture system (Cape Nordic).

9.4 Long Lines ((Mussels & Oysters):

Longline aquaculture is a method used for the production of various shellfish, including mussels and oysters. It involves suspending ropes or lines in the water, to which the shellfish are attached, allowing them to grow and develop in a controlled environment. Here’s how longlines are typically used in mussel and oyster production:

Mussel Longlines:

- Line Setup: Longline systems for mussel cultivation consist of horizontal ropes or lines that are anchored in place. These lines are usually made of durable material such as synthetic ropes or wires.

- Collecting Mussel Seed: Mussel farmers typically start by collecting mussel seed (young mussels) from the wild or from hatcheries. These mussel seedlings are then attached to the ropes.

- Attachment: The mussel seedlings are attached to the ropes using techniques like socking, where the mussels are placed into mesh tubes or netting that allows them to grow while remaining attached to the line.

- Growth and Maintenance: As the mussels grow, they filter nutrients from the water, which helps them develop and gain size. Mussel farmers need to regularly monitor and maintain the lines, ensuring they are not overgrown with fouling organisms or becoming too densely packed.

- Harvesting: Once the mussels reach a desirable size, they are harvested by pulling up the lines. The mussels are then detached from the ropes, cleaned, and prepared for market.

(See Blue Ocean Mussels Marketing Video)

Oyster Longlines:

- Line Setup: Oyster longlines are set up similarly to mussel longlines, with horizontal ropes or lines suspended in the water. These lines serve as the substrate to which oyster spat (young oysters) will attach.

- Collecting Oyster Spat: Oyster farmers can obtain oyster spat either from natural settlement in the wild or from hatcheries where oyster larvae have settled onto suitable substrates.

- Attachment: Oyster spat are allowed to settle and attach themselves to the lines. They secrete a substance that helps them adhere to the surface.

- Thinning and Sorting: As oysters grow, they can become overcrowded on the lines. Farmers may need to periodically thin out the population to ensure proper growth. Sorting may also be necessary to separate market-sized oysters from smaller ones.

- Growth and Maintenance: Oysters, like mussels, filter nutrients from the water to grow. Regular maintenance of the lines is essential to prevent fouling and to ensure optimal growing conditions.

- Harvesting: Once the oysters have reached the desired market size, they are harvested from the lines, cleaned, and prepared for sale.

Both mussel and oyster longline cultivation have the advantage of creating an environment where shellfish can grow in nutrient-rich waters while being protected from some natural predators. Additionally, this method reduces the need for bottom disturbance, minimizing potential negative environmental impacts compared to traditional bottom-culture practices.

9.5 Floating Raft Systems (Mussels, Oysters, Clams, Scallops):

A floating raft system for mussel and oyster production is a method of aquaculture that involves growing mussels and oysters on floating platforms or rafts in bodies of water like bays, estuaries, or even open ocean environments. This method offers several advantages for the cultivation of these shellfish:

- Water Access: Mussels and oysters are filter feeders, which means they extract nutrients and plankton from the surrounding water. Placing them in a floating raft system allows them direct access to nutrient-rich water currents, promoting their growth.

- Space Efficiency: Rafts can accommodate a high density of mussels and oysters in a relatively small area, optimizing the use of available space in the water body.

- Water Quality: The continuous movement of water around the rafts helps maintain good water quality, reducing the risk of disease and preventing the buildup of waste products.

- Protection from Predators: By elevating the mussels and oysters off the seabed, the floating rafts can offer some protection against predators that might be present in the water.

- Ease of Management: Raft-based systems can be easier to manage compared to traditional methods like bottom culture, as the shellfish are raised closer to the water's surface, making harvesting, maintenance, and monitoring more convenient.

- Reduced Environmental Impact: When properly managed, floating raft systems have the potential to cause less habitat disturbance and disruption to the seabed compared to traditional bottom culture methods.

Setting up a floating raft system for mussel and oyster production involves the following steps:

- Raft Construction: Design and construct rafts or floating platforms using suitable materials that can withstand the marine environment. These platforms can be made of wood, plastic, or other durable materials.

- Attachment: Secure the mussels and oysters to the rafts using ropes, nets, or other hanging systems. The shellfish should be able to dangle into the water below.

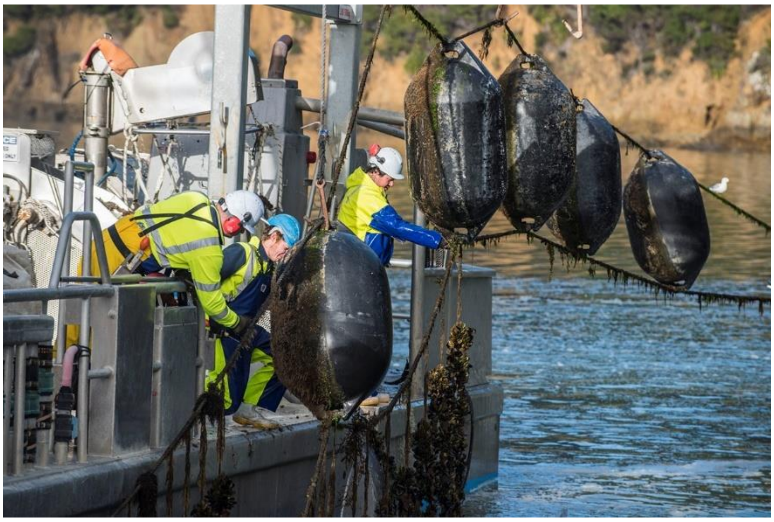
- Deployment: Place the rafts in suitable water bodies, taking into consideration factors like water quality, currents, and protection from extreme weather.

- Monitoring: Regularly monitor the health and growth of the mussels and oysters. Ensure that water quality parameters are within acceptable ranges and address any issues promptly.

- Harvesting: Once the shellfish have reached the desired size, they can be harvested by pulling up the ropes or nets and removing the mature mussels and oysters.

- Maintenance: Regularly clean and maintain the rafts to prevent fouling and ensure their structural integrity.

It's important to note that while the floating raft system offers numerous benefits, successful aquaculture requires proper planning, management, and consideration of local environmental regulations to ensure sustainable production and minimize negative impacts on the ecosystem.



Picture 15: Mussel Longline Production, (Google Images)

9.6 Offshore Floating Cages (Marine Finfish):

Offshore floating cages are a type of aquaculture system used for rearing marine finfish, such as salmon, sea bass, sea bream, and other species, in open water environments. These cages provide a controlled environment for fish farming while taking advantage of the natural marine conditions. They are typically located in sheltered coastal or offshore areas, allowing fish farmers to rear fish in deeper waters without the need for costly land-based facilities.

Key features of offshore floating cages for marine finfish include:

- **Structure**: Offshore cages are usually made of strong materials such as HDPE (high-density polyethylene) pipes or metal frames. These structures are designed to withstand the forces of currents, waves, and weather conditions.

- **Buoyancy**: The cages are equipped with buoyancy systems that keep them afloat on the water's surface. These buoyancy systems may consist of pontoons, floats, or other mechanisms that provide stability to the cage.

- **Netting**: The cage is enclosed by netting that serves as a barrier between the fish and the surrounding environment. The netting prevents fish from escaping and offers some protection against predators and debris.

- **Mooring Systems**: Offshore cages are anchored to the seabed using mooring systems. These systems keep the cages in position, preventing them from drifting away due to currents and waves.

- **Feeding and Monitoring**: Fish in the cages are typically fed with formulated diets. Automated feeding systems are often used to ensure the fish receive the appropriate amount of feed. Additionally, monitoring systems are used to track water quality parameters, fish health, and other important metrics.

- **Environmental Considerations**: Proper site selection is critical to minimize the environmental impact of offshore cages. Farms should be located in areas with suitable water quality, currents, and depth. Environmental assessments are often conducted to evaluate potential impacts on the surrounding ecosystem.

- **Harvesting**: Harvesting fish from offshore cages can be more challenging than traditional land-based aquaculture. Specialized equipment, such as harvest vessels, is often used to collect fish from the cages.

Benefits of offshore floating cages for marine finfish farming include:

a) **Higher Water Exchange**: Offshore locations often have better water exchange rates, leading to improved water quality and reduced disease risks.

b) **Reduced Environmental Impact**: Properly managed offshore cages can have a lower environmental impact compared to nearshore systems, as waste dispersion and nutrient distribution are more efficient in open water.

c) **Optimized Growth**: Fish can benefit from natural currents and a more natural environment, potentially leading to better growth rates.

d) **Less Competition for Space**: By moving farming operations offshore, it's possible to alleviate competition for coastal land space and reduce conflicts with other activities.

e) **Scalability**: Offshore farms can potentially be expanded more easily than land-based systems by using available open water space.

However, there are also challenges associated with offshore floating cages, including:

a) **Weather and Environmental Risks**: Cages are exposed to weather events such as storms, which can damage the infrastructure and harm the fish.

b) **Escape and Disease Management**: The risk of fish escaping from cages is higher in open water environments. Disease management can also be more challenging due to the exposure to wild fish populations.

c) **Logistics and Maintenance**: Operating and maintaining offshore cages require specialized equipment, vessels, and skilled personnel.

d) **Regulatory Hurdles**: Regulatory approvals and compliance may be complex due to concerns about environmental impact and interactions with other marine activities.

As with any aquaculture system, the success of offshore floating cages depends on careful planning, proper management practices, and adherence to environmental regulations.

Picture 16: Offshore Salmon Farm in Norway, (Google Images).

9.7 Integrated Multi-Trophic Aquaculture (IMTA) Systems:

Integrated Multi-Trophic Aquaculture (IMTA) is a sustainable aquaculture practice that involves cultivating multiple species from different trophic levels within the same farming system. The goal of IMTA is to mimic natural ecosystems by creating a more balanced and efficient nutrient cycling system, reducing waste, and minimizing environmental impacts.

In an IMTA system, different species are chosen based on their ecological interactions and nutritional requirements. These species are typically categorized into three trophic levels:

Primary Producers (Autotrophs): These are usually plants or algae that use sunlight to convert nutrients into organic matter through photosynthesis. They help in nutrient uptake, improving water quality by removing excess nutrients.

Primary Consumers (Herbivores): These are species that feed on primary producers. They help control the growth of algae and plants while providing a marketable product.

Secondary Consumers (Carnivores or Omnivores): These species feed on primary consumers and other available food sources. They are often the main focus of aquaculture for direct human consumption.

The main benefits of IMTA include:

a) Nutrient Cycling: IMTA systems capitalize on nutrient cycling. The waste produced by one species becomes a resource for another. For instance, the excretion of nitrogen and phosphorous from carnivorous fish can be used as nutrients for seaweed or filter-feeding shellfish, preventing water pollution.

b) Reduced Environmental Impact: By utilizing waste as a resource, IMTA reduces the release of excess nutrients into the surrounding environment. This helps mitigate problems such as eutrophication and water pollution.

c) Diversification of Income: Farmers can cultivate multiple species with varying market demands, reducing risks associated with relying on a single species.

d) Enhanced Resilience: IMTA systems tend to be more resilient to diseases and environmental changes. If one species faces challenges, the others can help maintain system stability.

e) Habitat Creation: IMTA systems can create complex habitats that offer refuge and food for various species, promoting biodiversity.

Common examples of IMTA systems include:

- Fish-Shrimp-Plankton System: Fish are the main species for human consumption, shrimp feed on planktonic organisms, and plankton help filter water and utilize excess nutrients.

- Seaweed-Shellfish-Finfish System: Seaweeds use dissolved nutrients, shellfish filter water and extract particulate matter, and finfish are the primary target for consumption.

- Seabass-Seabream-Bivalves System: Bivalves (like mussels or clams) filter the water and absorb excess nutrients, while seabass and seabream are carnivorous fish.

IMTA has the potential to contribute to sustainable food production and reduced environmental impact, but successful implementation requires careful consideration of species interactions, environmental conditions, and market demand.

Picture 17: Buffeljags IMTA Farm, South Africa. (Henk Stander)

9.8 Seaweed Production:

Seaweed farming, also known as mariculture or seaweed aquaculture, has been gaining attention worldwide as a sustainable and potentially lucrative form of aquaculture. Seaweed farming involves cultivating various types of seaweed in underwater environments, typically in coastal or marine waters. Seaweed farming has several potential benefits, including carbon sequestration, nutrient absorption, habitat creation, and the production of valuable products like food, cosmetics, and biofuels.

In the context of South Africa, the development of seaweed farming has not been explored due to the country's extensive coastline and diverse marine ecosystems. However, the extent and progress of seaweed farming in South Africa can change over time.

See addendum 9.2 and 9.6 for more detail information on the potential of seaweed production on the West Coast.

Picture 18: Seaweed Longline, (Google Images).

10. Conclusion:

South Africa has significant potential for aquaculture development due to its diverse marine and freshwater resources, favourable climate, and growing demand for seafood products. While the country's aquaculture industry is still in its early stages compared to some other nations, there are several factors that suggest positive prospects for its growth:

a) Abundant Water Resources: South Africa has an extensive coastline along the Atlantic and Indian Oceans, as well as numerous rivers, lakes, and dams. These water bodies provide ample opportunities for both marine and freshwater aquaculture.

b) Climate: The country's temperate and subtropical climate supports the cultivation of a wide range of aquaculture species. The moderate temperatures and suitable water conditions are conducive to the growth of various aquatic organisms.

c) Biodiversity: South Africa's marine environment is rich in biodiversity, which provides a platform for cultivating various species of fish, shellfish, and algae. This diversity can lead to a more resilient and adaptable aquaculture sector.

d) Economic Growth and Employment: Aquaculture development can contribute to economic growth and job creation, especially in rural and coastal areas. As the demand for seafood continues to rise globally, a well-established aquaculture industry could generate substantial revenue and employment opportunities.

e) Food Security: Aquaculture can help enhance South Africa's food security by providing a local and sustainable source of protein. Reducing reliance on imported seafood products could improve the country's self-sufficiency in meeting its nutritional needs.

f) Research and Innovation: South Africa has research institutions and universities with expertise in aquaculture, marine biology, and related fields. This knowledge base can drive innovation in aquaculture practices, technology, and sustainable methods.

g) Government Support: The South African government has shown interest in promoting aquaculture as a means of economic development and job creation. Policy frameworks and incentives are being developed to support the growth of the aquaculture sector.

h) Export Opportunities: The global demand for sustainable seafood products presents an opportunity for South Africa to enter international markets with high-quality aquaculture products.

However, there are also challenges that need to be addressed to fully realize the aquaculture potential in South Africa:

a) Regulations and Permitting: Navigating regulatory frameworks and obtaining necessary permits can be complex and time-consuming. Streamlining these processes can encourage investment and growth.

b) Infrastructure and Technology: Adequate infrastructure, such as hatcheries, processing facilities, and transportation networks, is crucial for the success of aquaculture. Access to modern technology and know-how is also important for efficient operations.

c) Environmental Considerations: Ensuring that aquaculture practices are environmentally sustainable is critical. Preventing pollution, managing waste, and avoiding negative impacts on local ecosystems are key concerns.

d) Skills and Training: Developing a skilled workforce with knowledge of aquaculture practices, research, and management is essential for the sector's growth.

e) Disease Management: Disease outbreaks can have devastating effects on aquaculture operations. Implementing effective disease management and biosecurity measures is essential to maintain the health of cultivated species.

In conclusion, South Africa (Bergriver Municipal area), has substantial potential for aquaculture development due to its abundant water resources, diverse climate, and increasing demand for seafood. By addressing challenges and leveraging its strengths, the country can work towards building a sustainable and thriving aquaculture industry that contributes to its economic development and food security goals.

Picture 19: Ocean conditions at Velddrift, (Henk Stander).

11. ADDENDUMS:

11.1 The Future of the Western Cape Agricultural Sector in the context of the 4th Industrial Revolution: Review Aquaculture.

11.2 Final Report: Pre-feasibility Study on the potential for commercial cultivation of African kelp along South Africa's West Coast.

11.3 Mussel farming on the West Coast.

11.4 Salmon Farming in South Africa

11.5 The Fish and Seafood Value Chain.

11.6 The Potential of Seaweed Culture in South Africa.

11.7 Draft Aquaculture Bill for SA.