2021 2030 United Nations Decade of Ocean Science for Sustainable Development

AfriMAQUA
Nutrition sensitive Marine aquaculture in Africa

AfriMAQUA 2023 CONFERENCE

TOWARDS A MORE SUSTAINABLE AQUATIC FOOD SYSTEM: INTERDISCIPLINARY RESEARCH ON SUSTAINABLE MARINE AQUACULTURE IN AFRICA

BOOK OF ABSTRACTS

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23–28 OCTOBER 2023
MOMBASA, KENYA

KMFRI
Kenya Marine and Fisheries Research Institute

IRD Institut de Recherche pour le Développement FRANCE
French National Research Institute for Sustainable Development

AfriMAQUA 2023 Conference

Towards a more sustainable aquatic food system: Interdisciplinary research on sustainable marine aquaculture in Africa

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23-28 October 2023
Mombasa, Kenya

AfriMAQUA 2023 Conference
Towards a more sustainable aquatic food system: Interdisciplinary research on sustainable marine aquaculture in Africa
Book of Abstracts

October 2023

Editors: Maria J. Darias, David O. Mirera

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INTRODUCTION

Aquatic foods are a vital source of essential nutrients and contribute to food and nutrition security in many countries. By 2030, per capita fish consumption is expected to increase worldwide with the exception of Africa, due to population growth outpacing supply on this continent. Aquaculture has significantly expanded in Africa — mostly based on freshwater aquaculture —, but marine aquaculture production is one of the lowest in the world.

This conference, organised in the framework of the United Nations Ocean Decade Program AfriMAQUA (Nutrition-sensitive marine aquaculture in Africa), aims to bring together scientists from the South and the North from various disciplines to present their work on different aspects of the aquatic food system related to marine aquaculture in Africa. In addition, it will provide a platform for stakeholders with the mandate to contribute towards the development of Kenya's marine aquaculture, including academia, government, industry, and civil society, to discuss and craft future scenarios of marine aquaculture and capacity development in Kenya. Moreover, AfriMAQUA will organize a training course that will target young university students in marine aquaculture.

PROGRAMME

Monday, 23 October 2023

08:30 – 09:00 Arrival and registration

09:00 – 09:15 Welcome by the conference organizers
David O. Mirera, KMFRI, Kenya, & Maria J. Darias, IRD, France

09:15 – 09:30 Music interlude by traditional dancers

09:30 – 10:30 **Opening addresses**
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- Daniel Mungai, Director General, KeFS
- Hon. John Safari Mumba, Chairman Board of Directors, KMFRI
- Dr. Paul-André Calatayud, IRD Representative for East Africa
- HE. Abdulswamad Shariff Nassir, Governor, Mombasa County Government
- Ms Betsy Njagi, Principal Secretary, State Department for Blue Economy and Fisheries, Ministry of Mining, Blue Economy and Maritime Affairs
- Hon. Salim Mvurya, EGH, Cabinet Secretary, State Department for Blue Economy and Fisheries, Ministry of Mining, Blue Economy and Maritime Affairs

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12:30 – 12:50 Coral gardening as a mariculture concept for coral reef fishery restoration: the Kuruwitu experience for traditional in-situ passive coral restoration
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15:10 – 15:30 Growth performance and survival of four *Artemia franciscana* populations subjected to different temperatures
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15:30 – 15:50 Sea urchin aquaculture in South Africa: From research to commercial scale
Brett M. Macey, Bas de Vos, Mark D. Cyrus, Marissa Brink-Hull, John J. Bolton

15:50 – 16:10 Revival of seaweed farming in Mozambique
Henriques Bustani, Maira Adamo, Bruno Oliveira, Bernabe Donato

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11:40 – 13:00 **Lunch**

Optional: Field trip to Kibokoni Fish Farm and Dabaso Crab Shack

13:30 Departure to Kibokoni, Umoja Self Help Fish Farm
14:30 – 15:30 Arrival and tour of farm and engagement with farmers
15:30 Departure to Dabaso Crab Shack Mud Crab Farm and Eco-restaurant
16:30 – 17:30 Arrival at Crab Shack and engagement with Dabaso Conservation Group
17:30 – 18:30 Dinner at Crab Shack Restaurant
18:30 Departure from Dabaso

Thursday, 26 October 2023: Kenyan stakeholder workshop

08:30 – 09:00 Arrival and registration
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11:30 – 13:00 **Roundtable 2:** Implementing nutrition-sensitive strategies in Kenyan marine aquaculture
13:00 – 14:30 **Lunch**
14:30 – 16:00 **Roundtable 3:** Opportunities and challenges in small-scale marine aquaculture in Kenya
16:00 – 16:30 Closing remarks and conference closure

ABSTRACTS

ORAL PRESENTATIONS

The 'seaweed revolution' and the potential for an African contribution

John J. Bolton
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Global agriculture production is made up largely of plants, with only 3.6% by weight being animal production. If we are to feed 10 billion people on earth by 2050, we will need to make use of coastal seas to a much greater extent than currently. Over 50% of marine aquaculture production in the world is seaweeds and if there is to be a major impact on human food provision from marine habitats, in a sustainable manner, much of the production in the future will be seaweeds. Seaweed aquaculture is currently hugely skewed geographically, almost all taking place in East Asia. Of the small amount in the rest of the world, Africa is well represented although also geographically skewed, with 92% of African production being *Eucheuma/Kappaphycus* in Tanzania.
There are widespread predictions of a 'Seaweed Revolution' in the Western Hemisphere, and a recent World Bank report suggests potential for rapid increases in production in the short term for agricultural biostimulants and animal and pet feed, and in the medium term for nutriceuticals. The talk will summarise the major seaweed groups currently grown on a global scale, and briefly summarise the potential groups that may become increasingly important in an African context, including *Eucheuma/Kappaphycus*, *Ulva*, *Gracilaria*, *Caulerpa*, *Asparagopsis*, *Sargassum* and kelps.

This study received funding from the EU Horizon 2020 Research & Innovation Programme ASTRAL Project under Grant Agreement No. 863034.

Towards sustainable mariculture development in Kenya

James Mwaluma*, David O. Mirera, Morine M. Ngarari
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Kenya has a significant potential to be a major player in aquaculture and the Blue Economy due to diverse water resources in terms of brackish, fresh, and marine waters, which can be harnessed for mariculture and coastal aquaculture. The country has a 640 Km coastline, a territorial sea extending 12 nautical miles, and an exclusive economic (fishing) zone extending 350 nautical miles, offering significant opportunities for sustainable marine aquaculture to address food security, employment, wealth creation, and social welfare. For mariculture to develop in Kenya sustainably, the production of marine species for human consumption will depend primarily on the availability of good quality and ample broodstock and seed stocks. According to a mariculture baseline survey conducted along the coast, approximately 66 groups are currently engaged in mariculture, with an average of 50 members farming seaweeds, milkfish, prawns, mud crabs, *Artemia*, tilapia, and to a lesser extent, lobsters. This intervention has the potential to directly employ 3,300 individuals, and indirectly employ another 9,900 women and youth who trade in value-added products like dried fish, smoked fish, ice production etc. However, farmers rearing marine species depend entirely on seeds sourced from the wild and do not have the requisite training for production. The quantity of seed sourced from the wild is not sustainable to maintain mariculture even at its current subsistence levels. Current mariculture production is low, with about 4 mt for finfish and shellfish, and about 106 mt dry weight for seaweeds, yet the potential could be tenfold. This paper delves into the steps taken by KMFRI and other partners (National Research Fund and Kenya Marine Fisheries and Socioeconomic Development Project) in the journey towards establishing sustainable mariculture and the challenges faced therein, specifically addressing the issue of establishing a marine hatchery.

Multi-raft as deep-water seaweed farming method

Zakaria A. Khamis*, Yussuf B. Salim, Ali S. Ali, Masoud J. Ali, Abubakar T. Noman, Mwadini H. Vuai
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Deep water seaweed farming has emerged as a new practice introduced in several tropical regions, including Zanzibar, which provides new ground for farming seaweeds while increasing its productivity. This farming practice addresses the long-term challenges observed in shallow water seaweed farming; however, information regarding the potential technique for farming seaweed in deep water is currently limited. Multi-raft was used to study the growth rate of seaweed and observe the water quality parameters in the cultured area. The multi-raft was constructed by placing the four wooden poles standing at every corner of individual rafts. It had a height of 1.5 m with three individual rafts, each individual raft was made by connecting four wooden poles, each 3 m long, creating an area of 9 m^2. Seaweed seeds weighing around 50-75 g were tied to tie-tie ropes and attached to nylon ropes of 3 m length, where each single raft held ten nylon ropes. The results showed the growth of both seaweed species cultivated in individual rafts was increasing over time; cottonii 1 showed 2,500 g as the highest growth at week six, cotonii 2 had 2,800 g as the highest growth in week six, and spinosum had 3,500 g during week six. There was a slight difference in the water quality parameters, with water temperature ranging from 28.5 ºC to 25.47 ºC, salinity ranging from 25.47 to 30 ppt, dissolved oxygen varying from 7.8 mg l^{-1} to 8.2 mg l^{-1}, and pH varying from 6.5 to 7.8. Conclusively, the results from this study show that multi-rafts can be used to cultivate seaweeds in deep water to increase its production while addressing environmental challenges. However, more studies on deep water seaweed farming and on the suitable materials for constructing multi-rafts are needed.

Coral gardening as a mariculture concept for coral reef fishery restoration: the Kuruwitu experience for active coral restoration

Katana N. Hinzano[1,2*], Cameron T. J. Bowden[1], Remmy S. Shoka[1], John D. Balarin[1]

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Coral mariculture, also known as coral gardening (farming), is the cultivation of corals for commercial purposes, either as aquarium corals or for coral reef fishery restoration. Two such coral farming approaches are currently in use in Kenya, with this study focusing on active coral gardening to restore the reef fishery using in-situ nurseries. The Kuruwitu fishing community began active in-situ coral farming to restore their catches. The objective was to address the diminishing catch due to overfishing, reef destruction, and 50-90 % coral die-out resulting from climate-induced coral bleaching.

In early 2019, the fishing community in Kuruwitu village, Kilifi County, Kenya, assisted by Oceans Alive, started active coral farming. To date, 32 table nurseries are in operation with a maximum capacity to rear 15,000 juvenile corals per year. These are out-planted in degraded areas or on artificial reefs. Various methods are underway to simplify and make the technique more cost-effective within the economic and technical capacity of the fishing communities. Pilot trials at Kuruwitu have, to date, contributed to over 20,000 juvenile corals being out-planted and 300 artificial reefs being placed. These coral farming techniques have been documented in educational material and have been used in raising awareness among other fishing communities, schools, and international student programs. Active coral farming by fishing communities offers the opportunity for greater investment in fisheries restoration, with prospects for reducing wild collection of corals for the coral trade.

Coral gardening as a mariculture concept for coral reef fishery restoration: the Kuruwitu experience for traditional in-situ passive coral restoration

Dickson J. Gereza[1*], Cameron T. J. Bowden[2], Remmy S. Shoka[2], John D. Balarin[2]
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Coral mariculture, also known as coral gardening (farming), is the cultivation of corals for commercial purposes, either as aquarium corals or for coral reef fishery restoration. Two such coral farming approaches are currently in use in Kenya, with this describing a traditional in situ passive restoration technique. In early 2003, the fishing community in Kuruwitu village, Kilifi County, Kenya, realized that their catches were diminishing due to overfishing, reef destruction, and 50-90 % coral die-out resulting from climate induced coral bleaching. The village elders enacted traditional laws and established a 'Tengefu', a 30 ha Community Conservation Area (CCA). The community formed the Kuruwitu Conservation and Welfare Community Based Organization (KCW-CBO) to manage the area as a closed no-take zone. Supported by the Wildlife Conservation Society (WCS) and Oceans Alive (OA), this membership body has protected and managed the area for the past 20 years. This includes enforcing local by-laws, monitoring recovery, and generating income from ecotourism.

Over a 5-year period, this pilot exhibited a remarkable recovery with 400% increase in fish biomass, 30% reef recovery, and 17% sea grass regrowth (WCS data). The result contributed to a 15% increase in neighboring fish catches due to the fish 'spill-over effect'. This spectacle created by the biodiversity recovery offers a unique snorkeling experience, opening economic opportunities in 'aquatic safari' ecotourism and concessions. In addition, the site has become a living classroom for school and peer-to-peer knowledge sharing, benefiting both local and international communities, resulting in replication by at least 30 other fishing communities along the Kenyan coast.

The Tengefu concept aligns with the recent Beach Management Unit (BMU) Regulations and allows some of the 100 BMUs to replicate this technique to restore their inshore reef fishery through coral gardening in Co-managed Areas (CMA).

Use of under-utilised foods to increase micronutrient status of vulnerable groups: The case of fish

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Over 2 billion people worldwide are deficient for one of more micronutrients, thereby affecting health and development of individuals. Vulnerable groups for micronutrient deficiency include infants and young children, and women of reproductive age (WRA). Indeed, recent data suggest that globally >50% of children and >66% of WRA have micronutrient deficiencies. Interventions to improve micronutrient status of populations include supplementation (e.g. iron-folate acid supplements for pregnant women), fortification (e.g. salt iodisation) and dietary diversification. However, less attention has been given to food-to-food fortification, that is, the addition of specific foods to the diet with the purpose of increasing the micronutrient intake of populations. Certain locally available foods are rich in micronutrients but under-utilised. Including these foods, either processed or as integral part of the diet, could contribute to reducing the gap in micronutrient intakes.
One example of an under-utilised food is fish. Fish is rich in calcium and several micronutrients, but often not consumed on a regular basis, either due to lack of availability or cultural habits. For over a decade, we have been working on ways to introduce processed fish products to fight micronutrient malnutrition as a cost-effective and sustainable intervention. In Cambodia, fresh-water fish was incorporated into ready-to-use foods to treat acute malnutrition, replacing milk as protein source, but also providing essential fatty acids and micronutrients (iron, zinc). Fish-based products were at least as efficient in improving nutritional status as reference foods. Currently work in Indonesia and South-Africa is focusing on marine products to be used for women of reproductive age.

Commercial integrated aquaculture of abalone and the green seaweed *Ulva* in land-based systems in South Africa: an update

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The first commercial land-based system using abalone effluent to cultivate the green seaweed *Ulva* was built on an abalone farm in South Africa in 2002. Over 1000t fresh weight of *Ulva* was produced in South Africa in 2007, grown predominantly in abalone effluent, and the main reason for this seaweed production was as additional feed for the abalone, as well as a recently established innovation using the seaweed to provide bioremediation of the effluent to enable partial water recirculation on a section of a single farm. Bolton et al. (2009) carried out a SWOT analysis of the use of these abalone/*Ulva* IMTA systems. After a further 15 years, we will re-examine these findings in the light of the subsequent development of the industry. Currently ca. 2500t of *Ulva lacinulata* is produced, mostly on 5 farms, two of which use seaweed bioremediation to enable them to operate at 50% recirculation, saving up to 40% in pumping costs. Full (100%) recirculation is also possible in the latter systems for a few days, as a potential amelioration measure for Harmful Algal Bloom occurrence. The major threats to this commercial IMTA system remain the reluctance of some farmers to recirculate seaweed and water in their systems as a result of biosecurity concerns, despite only beneficial effects observed thus far, and economic pressure to utilise space to grow abalone rather than seaweed. This two-species combination of animal/seaweed in land-based IMTA systems has recently been implemented in a number of countries around the world, including *Ulva* also with fish and prawns.

This study received funding from the EU Horizon 2020 Research & Innovation Programme ASTRAL Project under Grant Agreement No. 863034

Growth performance and survival of four *Artemia franciscana* populations subjected to different temperatures

Morine M. Ngarari[1,2*], Betty M. Nyonje[1], Charles C. Ngugi[2], James M. Mwaluma[1]
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Artemia, a cosmopolitan organism, inhabits coastal lagoons, inland salt lakes etc., where there are few or no predators and competitors. Geographical isolation of *Artemia* biotopes has led to numerous geographical populations that have adapted to conditions that fluctuate widely with regard to temperature, salinity, and ionic composition of the biotope. *Artemia franciscana* endemic to America, is present in other continents due to its introduction for aquaculture purposes. *A. franciscana* from San Francisco Bay (SFB), USA was introduced in man-made saltworks in Kenya and Vietnam in the mid-80s. Despite Kenya and Vietnam having higher temperatures compared to SFB, *A. franciscana* adapted well. This study aims to establish how *A. franciscana* evolved from the original SFB population four decades after its introduction into new environments with different temperature regimes. For this study, two *A. franciscana* cyst samples from Kenya, one from Vietnam, and one from SFB were used. Cysts were hatched into nauplii using optimal hatching conditions. Three hundred nauplii were placed in 0.25 L culture volumes and cultured under temperature replicate treatments of 28.0, 32.0, and 36.0 °C ± 0.5 °C. A constant salinity of 80 ppt and aeration were maintained throughout the culture period. Nauplii were fed on *Dunaliella tertiolecta*. Length and survival data were measured on the fourth day after hatching and then repeated every four days. One-way ANOVA test was applied to all treatments to find the overall effect of treatment on length and survival. Tukey's pairwise multiple comparison was used to detect significant differences between the experimental sample means at a significance level of $p \leq 0.05$. Two-way ANOVA of length and survival data was used to detect significant interactions between population and temperature. Results indicate there are marked differences between similar *A. franciscana* populations due to their geographical distribution, since they are all subjected to different environmental conditions.

Sea urchin aquaculture in South Africa: From research to commercial scale

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Sea urchin gonad (uni) is regarded as a premium seafood product. High international demand for these products has led to the collapse of many global wild sea urchin stocks and extensive interest in echinoculture. Basket depth and stocking density are crucial and related factors for successful echinoculture, but these factors have not been definitively determined for production of *Tripneustes*. This study investigates the effects of varying basket depths (deep 35cm vs. shallow 10cm), stocking densities (4, 6 and 8 kg m^{-2} or 13, 19 and 24% coverage of available basket surface area) and husbandry practices (basket removal times) on urchin production (e.g., consumption, spine loss and growth). Literature suggests that production of various urchin species is reduced when cultivated in deeper baskets. The present study confirmed these findings, with deeper baskets resulting in significantly lower consumption of various feed types ($p<0.026$). This is likely the consequence of lower feed accessibility, which in turn causes the observed reduced yield. Shallow baskets are therefore recommended to enhance production of *Tripneustes*. Trials provided important management recommendations (e.g., removal of urchins from baskets for extended periods (>5 s) or feeding rigid feeds (*Ecklonia maxima*) increases spine loss ($p<0.0001$)). While higher stocking densities did significantly reduce mass SGR ($p<0.044$), mortality, cannibalism and gonad size/ quality were not influenced by stocking density. Difference in SGR are attributed to spine loss from negative behavioural interactions. From our data, the optimal stocking density for both grow-out and gonad enhancement of *Tripneustes* is ~20% coverage (surface area of urchins' tests by surface area of basket). The implications of this study for *Tripneustes* echinoculture development will be discussed, and additional key findings from on-going commercial-scale hatchery and grow-out trials at Buffeljags Abalone will be shared.

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Revival of seaweed farming in Mozambique

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Seaweed has been widely cultivated in many parts of the world due to its significant contribution to human nutrition and its role as a very important source of bioactive compounds, such as polysaccharides and pigments, which are extremely valuable to the pharmaceutical and food industries. In Africa, seaweed farming began in the Western Indian Ocean (WIO) region around the 1980s in Tanzania, specifically on the islands of Zanzibar and Pemba. In the mid-1990s, it was subsequently adopted in Madagascar and northern Mozambique, specifically in the provinces of Cabo Delegado and Nampula. Seaweed production in Mozambique ceased in the last years of the 2000s, when the lack of a market and the appearance of diseases were identified as the main causes for the abandonment of seaweed farming in the country.
Over time, with a new global dynamic for demand for seaweed, Mozambique is challenged to resume seaweed farming. Starting with experimental cultivation, algae from the genera *Eucheuma* and *Kappaphycus* are being tested to determine the potential ecological areas for cultivation, the relative growth of tested species, and the influence of physico-chemical factors on the development of seaweed farming in the region. In an experimental cultivation period of one year, two cultivation methods are being tested, namely, the tubular method and the tie-tie method along the intertidal zone. Preliminary results show that the tubular method is the most resilient in wind-exposed areas and that algae of the genus *Eucheuma* are more resistant to changes in physico-chemical factors than *Kappaphycus*.

Preliminary assessment of the occurrence of silver pompano (*Trachinotus blochii*) in three coastal counties of Kenya to inform mariculture development

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Silver pompano is a premium tropical fish that easily adapts to cultured environments, readily accepts formulated feed, and has a fast growth rate compared to other farmed species. It is highly preferred in high-end local and export markets, thus fetching a higher price. This makes it a promising species for mariculture practices especially in the Western Indian Ocean region. In the absence of a marine hatchery, fingerlings will need to be collected from the wild. The research sought to understand the occurrence and abundance of silver pompano fingerlings in three coastal counties to inform the culture of the species. The counties were selected based on previous experience in mariculture and proximity to the study site. Questionnaire surveys were conducted at the landing sites and at home using a clustered and randomized design. Based on the results, experimental fishing was conducted by fishers in Kilifi County. Results indicate that majority of fishers interviewed were above thirty-five years old and 45% had more than 10 years' experience in fishing. About 68% of the people interviewed had primary level education. The major fishing grounds for silver pompano are the open sea and coral reefs. During the Northeast monsoon season, a higher number of fishers (37%) landed 11-50 kg day^{-1}, while during the Southeast monsoon season, the highest percentage of fishers (51%) landed <5 kg day^{-1}. The main fishing method employed is seining, with a maximum of five crew members. Experimental fishing indicated that two fishers can obtain up to 8 fish fingerlings per hour in a good season and 4 fish fingerlings per hour in a bad season. This study provides an understanding of the occurrence of silver pompano in coastal areas to guide farming of this high-value species.

Tissue culture of *Gracilaria verrucosa* (Hudson) Papenfuss, 1950 for sustainable production of agar in Kenya

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The main objective of this study was to carry out tissue culture of the red seaweed *Gracilaria verrucosa* for production of adequate seedlings with desirable qualities for mass seaweed production that will sustain a viable agar industry in Kenya. Four tissue culture experiments were carried out during the present study period, with emphasis on regeneration, contamination and survival of cultured explants. Test explants were excised from native *G. verrucosa* samples collected from Kibuyuni study site in south coast Kenya and surfaced sterilized with 10% sodium hypochlorite solution before being cultured in Murashige and Skoog (MS) basal medium in combinations with varied plant growth regulators (PGRs) such as gibberelic acid (GA3) kinetin (6-furfurylamino) purine, 2,4-dicholorophenoxyacetic acid (2,4-D), and indole-3-acetic acid (IAA) in different concentration ranges of 0, 0.5, 1.0, and 1.5 mg L^{-1}. Culture medium without PGRs was used as the control.
The ensuing results are for the two remaining experiments; namely experiment 1 and 2 since two experiments were discontinued due to gross fungal/bacterial contamination. Experiment 1 was monitored over a period of 16 weeks, while experiment 2 was monitored over a period of 20 weeks. Regeneration of new shoots by cultured explants was noticed during the eighth week of culture period in all cases but only on explants cultured on medium with PGR enrichment, thus indicating the important role of plant growth regulators on initiation of regeneration process in seaweeds. Explants cultured in medium supplemented with IAA at 0.5 mg L^{-1} concentration level exhibited highest shoot regeneration efficiencies of 67, 100 and 67 % after 8, 12 and 16 weeks of culture period respectively in experiment 1, and shoot regeneration efficiencies of 0, 67, 100 and 100% after 8, 12, 16 and 20 weeks of culture periods respectively in experiment 2. Similarly, explants cultured on medium with GA3 enrichment at 1.5 mg L^{-1} concentration level in experiment 1 exhibited the highest shoot regeneration efficiencies of 100, 33 and 67 % during 8, 12 and 16 weeks of culture periods, and 100% shoot regeneration efficiency in all respective culture periods in experiment 2. The erratic contamination rates of explants probably due to ineffective surface sterilization of explants and /or external contamination were observed across the respective culture enrichments and periods. Basically, some of the explant cultures were either contaminated or bleached by the fourth week of culture period, thus, effectively limiting the regeneration process of the cultured explants. The overall mean survival rates of explant cultures in experiment 1 and 2 were 22% and 17 % respectively, thus indicating the failure of the culture process of in both experiments.

These findings indicate the complexities faced in first attempts in seaweed tissue culture studies as in other similar previous studies. The results suggest that tissue culture of *G. verrucosa* is possible if contamination of cultures can be minimized through frequent observation of the cultures, use of aseptic procedures and systematic housekeeping. Thus, there is need to conduct further studies in order to bridge the existing gaps.

Social acceptability and governance of aquaculture developments. Issues, challenges and recent experiences

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Marine aquaculture is facing a wide range of challenges, which threaten further development, competitiveness and sustainability. Because producers develop their activity within a complex regulatory, institutional and social framework, social constraints become major issue beyond of profitability and environmental ones. Understanding the social bottlenecks that lead to the stagnation of aquaculture development has been an area of study frequently overlooked. But beyond the classic approaches of spin-offs or jobs, which more often provide material for communication or promotion of a sector rather than questioning its sustainability, the social dimensions of aquaculture development can also be understood in its wider public dimension. The social acceptability as an understanding of the acceptability of aquaculture development by the society and not limited to its solely social dimension, allows for integrating ecological, economic and social dimensions of Aquaculture Development to re-drive this development to a more sustainable path. It allows to reposition governance at the core of sustainability and address the territorial dimension of aquaculture development by co-constructing the aquaculture vision of a territory before entering into sites selection and carrying capacity. It rather pledges for an integrated approach of the carrying capacity concept encompassing the ecological, the economic and the social carrying capacity.
Based on the institutional dimension and acceptability of aquaculture, the conditions for implementing such an approach to aquaculture development are under question and call for some recommendations: i) support countries in developing strategic aquaculture development plans and include provisions to improve the social acceptability; ii) the establishment and implementation of good governance mechanisms, iii) the fostering of the adoption of appropriate policy instruments and decision-making processes in order to enhance participatory approaches and open and broad dialogue with the industry, all aquaculture subsector and local communities; and improve general public knowledge and perceptions of aquaculture.

Seaweed production in Kenya amid environmental, market and COVID-19 pandemic challenges

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Despite being a widely accepted viable and sustainable livelihood for coastal communities in the Western Indian Ocean (WIO) region, seaweed farming in Kenya has faced several challenges, including environmental, marketing, limited space for expansion and, recently, the impact of the COVID-19 pandemic, among others. In the present study, we discuss the results of a survey conducted in April 2019 to assess the status of seaweed farms, seaweed biomass production, and the household economic status of a small-scale coastal seaweed farming village on the southern coast of Kenya upon the outbreak of the COVID-19 pandemic. The study established that the immediate containment measures imposed by the government to curb the spread of the COVID-19 pandemic had extremely negative impacts on the general performance of seaweed production strategies in Kenya. The smooth flow of farm management was interrupted, with 80% of the farms being in a dilapidated state and seed preservation structures in deep water collapsed. The year's total sales results showed a 6% decline in seaweed biomass in 2019 after losing approximately 135 tonnes (dwt) of seaweed worth approximately Ksh 3 million. The loss of this revenue coupled with the loss of clients for locally-made seaweed value-added products adversely affected the economic livelihood of seaweed farmers in Kibuyuni village. Based on the experience of COVID-19 impacts on seaweed farming in Kenya, a multidisciplinary approach composed of governments, development partners, donor agencies, researchers, and farmers has a substantial role in mitigating these challenges to ensure the sustainability and resilience of this important livelihood in the WIO region.

Importance of oysters in the local economy and the effects of oyster exploitation on populations' standard of living

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Oyster exploitation includes harvesting, rearing, processing and marketing. The aim of this study was to assess the evolution and economic and social importance of oyster production in Senegal. Field surveys were carried out using a questionnaire and an interview guide to gather all the information required for this study from 189 oyster operators in the Saloum Delta (Niodior, Dionewar, Falia, Diogane, Soucouta, Dassilamé Sérére, Sourou, Némaba, Bakadadji), in Casamance (Ziguinchor, Tobor, Niaguiss and Katakalousse), on the Petite Côte (Joal and Fadiouth), and in Dakar (Almadies, Marché Thiaroye, Marche Tiléne and Marché Castor). Our results show that oyster exploitation is a dynamic sector, mobilizing thousands of operators (more than 14,000 in total) and involving significant bartering. It provides operators with additional income, as well as important food and financial support. The oyster industry has enabled the emergence or development of other economic activities, such as pirogue rental, transport by pirogue and cart, the sale of perch to oyster farmers, the sale of petrol, and the financing of agricultural, beekeeping and commercial projects. However, its impact is rarely measured over time, despite its socio-economic importance. However, its impact is rarely measured over time, despite its socio-economic importance. The availability of recent data from this study has therefore enabled us to take stock of its current evolution, and to formulate recommendations and prospects for growth.

Socio-economic studies and economic feasibility analysis of *Artemia* (*Artemia franciscana*) culture in East Africa

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In Kenya, *Artemia* was introduced targeting the salt production process and is mostly found at the shoreline and in salt ponds. This study was undertaken to promote utilization of *Artemia* cysts and biomass in emerging local aquaculture activities for better growth performance, feed utilization, survival of fish and improving local livelihoods. The study was carried out at Kadzuhoni village in Kilifi County in the northern coast of Kenya. A socioeconomic survey was conducted using a questionnaire and focus group discussions. The economic feasibility of *Artemia* farming was determined through Payback Analysis, Return on Investment (ROI), and Net Present Value Analysis. Results indicated that Kadzuhoni village has over 300 dwelling units with approx. 4,000 people. The main livelihood sources were casual employment at the salt works and small-scale businesses, which included salt production. *Artemia* farmers have internalized *Artemia* culture technology, and 6 artisanal salt producers have been involved in *Artemia* farming on pilot scale, with ponds dedicated to *Artemia* farming. *Artemia* production is still low since it is carried out on pilot scale, though demand is high in the local market. On average, 11 kg of *Artemia* is produced per pond with prices ranging from Ksh.3500 per 0.5 kg (Decapsulated Artemia) to Ksh.14,000 per 0.5 kg (GSL). The Total Initial Investment for six ponds was estimated at KShs.744,003 in the first year. Payback analysis revealed that it takes one year 7 months and 9 months to recoup initial investment at a price of Ksh.3,500 per half kilogram of *Artemia* and Ksh.8,000 per half kilogram, respectively. ROI analysis revealed that there are higher prospects at higher prices (Ksh.8,000 to Ksh.14,000) of *Artemia.* Challenges included land ownership issues, inadequate technical know-how in processing of the *Artemia* biomass and cysts, inadequate capital for expansion and rainfall-induced mortality of *Artemia.* It was concluded that higher prices of KShs.8000 0.5 kg^{-1} and above result in a shorter payback period of < 1 year, while prices below KSh.4000 0.5 kg^{-1} are not favorable. There is need for continuous monitoring to ensure prompt corrective measures and strengthening the working relationship between artisanal *Artemia* farmers and commercial salt producers.

A critique of the institutional and legal policy framework on the management and conservation of fisheries and aquaculture resources in Kenya

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Fisheries and aquaculture resources play a key role in sustaining many households among the coastal communities, and aquaculture is ranked as one of the leading food-producing enterprises globally. In Kenya, the Blue Economy Concept (BEC) especially under fisheries and aquaculture has been given an upper hand by the government owing to its underlying opportunities towards poverty alleviation, job creation, increased incomes, and food security. Consequently, many projects within this context have been initiated by the government, private firms, and individuals, which if not guided by a relevant institutional and legal policy framework, will ultimately have adverse environmental effects and thus compromise the sustainability of the already existing fisheries and aquaculture resources. Capture fisheries has seen unprecedented rise in number of fishermen exerting increased pressure on the fisheries of different water bodies in the country. This has been catalyzed by unclear laws, policies, and regulations between the national and county governments, and the Beach Management Units (BMUs). On the other hand, aquaculture activities have increased ten-fold with pond aquaculture slowing down in favour of cage culture. This has seen serious investments in Lake Victoria, one of the world's important freshwater fishery accommodating over 6000 cages. Paradoxically, however, the venture has been marred by a myriad of challenges including massive fish kills, both in the wild and in cages, apart from regular conflicts among cage owners, fisheries managers, water users, navigators, and fishermen. As much as policy regulations have been drafted for adoption, it is still not clear whether such policies ought to be followed. This study, therefore, gives a detailed critique of the institutional and legal policy framework on the management and conservation of fisheries and aquaculture resources in Kenya, reviewing the available data and information while taking into account the existing challenges and opportunities for sustainable utilization.

Small-scale mud crab aquaculture: a model of bottom-up economic transformation agenda: the case of Dabaso Village, Kilifi County, Kenya

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The efforts toward economic transformation through small-scale mud crab farming are evident at Mida Creek in Dabaso village. The interest in conserving the mangrove ecosystem and its associated biodiversity led to the development of a mud crab farm, offering sustainable livelihoods to the community. Initially, the focus was solely on farming crabs for sale; however, this initiative has had far-reaching impacts. The community now hosts an international mangrove eco-restaurant called the "Crab Shack," which is locally run and has created substantial employment opportunities for the youth. This study assesses the economic impact of the mud crab farm and its multiplier effect, utilizing various methods, including desktop analysis, evaluation of production and sales records, focus group discussions, and key informant interviews conducted through the snowball method.
The findings reveal that mud crabs can generate 5-10 times more income through value addition in the restaurant compared to selling fresh whole mud crabs. In the market, a 500 g fresh crab can fetch between 1.0 – 1.3 $US, while value addition through the production of crab samosas results in two portions (2 pieces/portion) sold at 2.5 $US each, generating a 100% sales income. Furthermore, if the same crab is cooked and sold whole in the restaurant, it can fetch 10 $US, a significantly higher price than the export price for live mud crabs, estimated at 8 $US. According to expenditure and sales records of 2018, the mud crab enterprise yielded a profit margin of 18,600 $US. Overall, the mud crab farm and its associated enterprises have created direct employment for 45 community members, earning them a monthly salary ranging from 66 to 350 $US. This study serves as a case study of small-scale marine aquaculture driving significant economic transformation in a coastal rural village.

Finfish farming can diversify the Namibian mariculture industry: prospects of the as mariculture candidate species, Silver Kob, *Argyrosomus inodorus* (Griffiths & Heemstra, 1992)

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The Namibian aquaculture sector, more specifically the mariculture sector, has been solely concentrated on the shellfish farming (mussels, oysters, and abalone). There is a need to expand and include marine finfish that have shown to be in demand and of high value. It is also in the interest of the industry to diversify as it will enable the mariculture to be robust. One of the identified finfish species is the silver Kob, *Argyrosomus inodorus* (Griffits and Heemstra 1992) with farming potential, as some of its close relatives (*Argyrosomus japonicus*, *Sciaenops ocellatus*) it has shown good indicated rapid growth rate when held in seawater tanks or cages. The species (*A. inodorus*) is currently exploited by recreative and artisanal linefish anglers and commands relatively high value and strong market demand. The farming of any new fish species requires the development of appropriate husbandry systems that consider the nature of the species concerned, and its reproductive biology, feeding behaviour, growth, and survival. The current presentation investigates the ongoing work on controlled broodstock conditioning under manipulated captive conditions and parasite study of Silver Kob, *Argyrosomus inodorus* (Griffiths & Heemstra, 1992).

Characterizing the genetic structure of introduced Nile tilapia (*Oreochromis niloticus*) strains in Tanzania using double digest RAD sequencing

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Tilapia hatcheries in Tanzania rely heavily on importing germplasm. Nevertheless, the genetic structure of the imported stocks is poorly understood. In the current study, the level of genetic diversity and differentiation of eight populations of Nile tilapia (*Oreochromis niloticus*) strains imported in Tanzania was investigated. Four of the studied strains originated from Thailand, three from Uganda, and one from the Netherlands. Double-digest restriction site–associated DNA sequencing (ddRAD-seq) was applied to identify and genotype single nucleotide polymorphisms (SNPs). In total, 2214 SNPs passed all the quality control steps and were utilized for downstream analysis. Mean heterozygosity estimates were higher for the Thailand strains (Ho, 0.23) compared with the strains from Uganda (Ho, 0.12). Low genetic distance was observed amongst populations from the same geographic origin (Fst, 0.01–0.04). However, genetic distance between populations from different geographic origins was substantial (Fst, 0.24–0.44). Bayesian model–based clustering (STRUCTURE) and discriminant analysis of principal components (DAPC) grouped the studied animals into three distinct clusters. A cross-validation approach (where 25% of animals from each population were considered of unknown origin) was conducted in order to test the efficiency of the SNP dataset for identifying the population of origin. The cross-validation procedure was repeated 10 times resulting in approximately 97% of the tested animals being allocated to the correct geographic population of origin. The breeding history and hatchery practices used to manage these stocks prior and after import appear to be the main factors for the genetic diversity observed in this study. Our study will help inform hatchery stock management and future breeding program designs in Tanzania.

Effects of salinity on the reproductive characteristics of three *Artemia franciscana* populations in a laboratory set up

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Artemia franciscana originally from Francisco Bay has been introduced in various parts of the world with different climatic conditions from its native habitat. There are currently several populations of *Artemia franciscana* in different parts. This study determined the effect of salinity on the reproductive performance of three populations from Kenya (KEN), San Francisco Bay (SFB) and Great Salt Lake (GSL). Adult *A. franciscana* from each population were paired in falcon tubes with saline water at 35, 70, 105 and 140 g L^{-1}. *Tetraselmis* was fed once a day at 1.5×10^6 cells/animal/day. From the results, SFB had the longest reproductive period at 140 g L^{-1}, while for GSL and KEN, it was at 105 g L^{-1}. The number of broods was highest for SFB and KEN at 140 g L^{-1}, while for GSL it was at 105 g L^{-1}. The number of nauplii produced was highest at 105 g L^{-1} for KEN, 140 g L^{-1} for the SFB and 35 g L^{-1} for GSL. The number of cysts produced was highest at 105 g L^{-1} for the GSL and SFB, and 140 g L^{-1} for KEN. From the results, it was concluded that high salinity prolonged the reproductive period of the *Artemia* populations studied. Further, the three populations had different ideal salinity levels for optimal reproductive performance. A genetic study was recommended to determine whether the KEN was adapting to local conditions hence diverting from the parental inoculum, the SFB *Artemia*.

Feeding the future: the path towards nutrition-sensitive aquaculture

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Aquatic or blue foods, including a variety of fish, invertebrates, and algae, are pivotal for global food and nutritional security, contributing to 15% of animal and 7% of overall protein intake worldwide. Especially in lower-income nations, they form a significant portion of animal protein consumption. Despite their high nutritional value, including essential amino acids, fatty acids and micronutrients like iron, zinc, and vitamins, their importance is often overlooked in policy discussions and financial allocations, with less than 50% of national public health nutrition strategies and fisheries policies recognizing their significance. In many countries worldwide, the narrative has been primarily economy-centric, emphasizing high-value production for export over local food security and well-being.
Over the last three decades, aquaculture production has rapidly increased to fulfill the rising demand for aquatic foods, given the stagnation in capture fisheries. However, for it to effectively contribute to global food security and livelihoods, it must operate sustainably. Although there's a positive trend towards sustainability in aquaculture, challenges such as habitat degradation, disease management, and environmentally unfriendly feed production persist. The narrative is gradually shifting towards a nutrition-sensitive approach in aquaculture, focusing on producing a variety of affordable, nutritious, and culturally appropriate foods sustainably. This approach envisions aquaculture as a means to enhance well-being, taking into account socio-economic, environmental, and cultural factors. It advocates for diversified and sustainable aquaculture production, evaluating the nutritional composition of aquatic organisms, and promoting sustainable feeding practices. Such a paradigm shift, aligning with the United Nations Sustainable Development Goals, positions aquatic foods as a promising avenue to address both nutritional needs and environmental sustainability, paving the way toward a more balanced food system.

Effects of replacing the dietary fishmeal with black soldier fly larvae (*Hermetia illucens*) diet on rabbitfish (*Siganus sutor*) reared in intertidal brackish water earthen ponds

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The effects of replacing dietary fish meal and black soldier fly larvae (BSFL) on rabbitfish were evaluated for a period of 90 days in hapa cage nets of 1 m x 1 m x 1 m length, width, and depth respectively, with a mesh size of 1 mm. The four diet treatments used were: T1- 0% fish meal, T2 – 75% fish meal and 25% BSFL, T3 – 50% fish meal and 50% BSFL, T4 – control commercial feed. Stocking density was 15 fish m^{-3} and fish were fed twice daily at 5% of body weight. The initial mean weight and length of stocked fish were 11.64 ± 0.97 and 9.12 ± 0.14 respectively. The final mean weight gain varied between 32.3 ± 4.05g (T1) as the highest and 22.75 ± 3.89 (T2) as the lowest. Average daily length (ADL) increment was highest in T1 (0.068 ± 0.016 cm) and lowest in T2 (0.045 ± 0.002). The average daily growth (ADG) varied between 0.359 ± 0.05 (T1) and 0.253 ± 0.03 (T2). The feed conversion ratio (FCR) in all diets showed no significant difference, while survival (SR) was highest in T2 93.3 ± 4.73% and lowest in T1 171.1 ± 9.18%. Specific growth rate (SGR) was higher in T2 ($P<0.05$). There were no significant differences in water parameters across all treatments ($P>0.05$). This study suggests that it may be possible to farm rabbit fish in intertidal earthen ponds, and that using black soldier fly larvae as a replacement for fish meal is acceptable.

Fruits and vegetable scraps and kitchen wastes are suitable substrates for mass production of black soldier fly (*Hermetia illucens*) larvae

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The black soldier fly (*Hermetia illucens*) larvae (BSFL) are a promising alternative high-quality protein ingredient for fish feed production, replacing the expensive and limited availability of fishmeal. However, technology for mass production of BSFL is currently limited in most countries. This study assessed the appropriate organic substrates for attracting adult BSF for massive egg laying. Six replicates of attraction using fruits and vegetable scraps (FVS), kitchen waste (KW), fish offal (FO), and a mixture of the three substrates (FKF) were prepared to attract BSF adults to lay eggs for five weeks. The eggs hatched were monitored for growth performance, survival rate, and yield by using the same substrates. The results showed that FVS and KW substrates attracted a significantly larger mass of BSF adults to lay eggs compared to FKF and FO ($p < 0.05$). FKF and KW substrates supported significantly higher final weight and specific growth rate of larvae than FVS and FO ($p < 0.05$). Moreover, KW and FKF substrates had significantly higher BSFL survival rates than FVS and FO ($p < 0.05$). Furthermore, KW and FKF substrates had significantly higher BSFL yield than FVS and FO ($p < 0.05$). Taken together, FVS and KW are suitable substrates for attracting BSF adults for mass production of BSF eggs, while KW and FKF are suitable substrates for growth performance, survival rate, and yield. We recommend using FVS and KW for attracting adults for massive BSFL eggs production, and KW and FKF for BSFL growth and production.

Growth performance of rabbitfish (*Siganus sutor*) fed on formulated aquafeeds in different culture systems

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Rabbitfish is an important artisanal food fish consumed locally in the Western Indian Ocean region and is highly targeted by fishers. The fish is herbivorous, adapts well to formulated feeds in addition to feeding on algae, and has good growth and survival rates. The current study conducted an assessment of the growth performance of the species fed on macroalgae-based aquafeeds. A feed of 25% crude protein was formulated and used in the experiment. Feed A had only one seaweed type (*Chaertomorpha crassa*), while feed AB had two seaweed types (*Ulva fasciata* and *Chaertomorpha crassa*), each contributing 10% to the feed (total of 20%). Wild juvenile rabbitfish were collected and acclimatized in the cages for two weeks before use in the experiments. Fish were stocked at 0.5 fish m^{-2} in ponds and 25 fish m^{-3} in cages and were fed at 5% of body weight twice daily. Sampling was undertaken monthly to assess growth performance of the aquafeeds and water quality parameters were measured. The study established that growth rate in earthen ponds was significantly higher in treatments with a single macroalgae species (A: 0.31 g day^{-1}) compared to treatments with the two macroalgae species (AB: 0.13g day^{-1}). Similar observations were made in fish cultured in cages (A: 0.23 g day^{-1}; AB: 0.15 g day^{-1}). Overall grow rates were significantly higher in earthen ponds compared to cages for single macroalgae species, even though stocking densities were different. The observations indicate that macroalgae species in aquafeeds will influence growth trends in rabbitfish. More studies are needed to establish the proportions of macroalgae inclusion that can be made in aquafeeds and how this can influence feed costs.

Suitability of polychaete worms (*Marphysa mossambica*) as protein and lipids ingredients for the culture of Tiger prawn (*Penaeus monodon*) in hapa nets in tidal ponds of Mtwapa creek

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This study presents an evaluation of cultured polychaetes (*Marphysa mosambica*) as a suitable alternative protein and lipid source alternative to freshwater shrimp in the feed formulation of Tiger prawn (*Penaeus monodon*) juveniles. The study was conducted over a 94-day period using twelve hapa nets of $1m^3$ each installed in a tidal pond. Each hapa was stocked at a density of 20 juveniles m^{-3} of *P. monodon* collected from Mtwapa creek. The initial weight and length averaged 1.28 ± 0.84 g and 5.26 ± 0.68 cm, respectively. Cultured polychaete worms were used for the preparation of formulated feeds. Three polychaete substitution diets were formulated with varying contents of polychaetes as follows: Poly-30%, Poly-35%, and Poly-40%. The commercial shrimp meal with no polychaete added (0%) was used as a control diet. The four diets were administered to the juveniles at 3% body weight for the experiments: Control (poly 0%), Poly-30%, Poly-35%, and Poly-40%. The formulated and control diets were randomly allocated to 12 hapa nets. The shrimps were acclimatized for four (4) weeks and thereafter, length and weight sampling to monitor growth was conducted fortnightly. Results showed significant differences in growth rate among the treatments/diets (Weight (g), $F=10.23$, $P<0.05$, Specific growth rate (SGR), $F=11.99$, $P<0.05$), and exposure periods (Weight gain (WG), $F=34.17$; SGR, $F=122.49$). The highest weight gain (2.71 g) and SGRs (5.74 % day^{-1}) were recorded on Poly-40% and Poly-35% diet treatments, which were significantly higher than both the shrimp meal and poly-30% diets. The Poly-30% diet had a lower SGR (3.50% day^{-1}), but weight gain was comparable to the shrimp meal control diet treatment. Limited quantities of cultured polychaetas and drying methodology for the polychaetes limited 100% polychaete substitution. The results of this study provide a basis for the integration of *Marphysa mossambica* in the formulation of diets for Tiger prawn. Refining culture protocols for *Marphysa mossambica* require further investigation.

Harnessing the potential of restorative marine aquaculture for sustainable ocean ecosystems through Integrated Multi-Trophic Aquaculture in Mauritius

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Biodiversity is not just an important element of natural ecosystems, it is of overarching importance both scientifically and for society, being critical to the understanding of biogeographic patterns, evolutionary history, ecosystem functioning, and to ecosystem services and resources, which provide monetary, recreational or other values. Restorative marine aquaculture represents a paradigm shift in our approach to the oceans, emphasizing not only the sustainable production of seafood but also the revitalization of degraded marine ecosystems. As the world grapples with the dual challenges of overfishing and ecosystem degradation, restorative aquaculture emerges as a promising solution that can address both issues simultaneously. The data was collected by using advanced live monitoring cameras, Line Intercept Transects, quadrats, diving, and snorkeling surveys from 4 different stations, the only operational fish farm with 3500 tons yearly production at Pointe-aux-Feuilles, at a port area which is also a fisheries reserve site and two specific lagoons at Balaclava and Trou-aux-Biches. Diversity indices were calculated, and it was observed from the results that biodiversity was highest at the fish farm site, followed by the port area and lowest at the lagoons. The farming structures along with the concentration of fish and nutrients in the form of excess and uneaten feed, faeces or other forms of organic matter were the key attraction for other organisms. A total number of 39,109 of individuals belonging to 16 faunal groups and 839 species were found at four sites. The present operational fish farm has some key components of restorative marine aquaculture which includes the thriving of ecologically valuable species, the use of low-impact farming techniques, and the incorporation of scientific monitoring and adaptive management practices on the production system.

MarCOSIO: Remote sensing for aquaculture support in the Western Indian Ocean

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The Marine and Coastal Operations for Southern Africa and the Indian Ocean (MarCOSIO) project, one of two marine and coastal consortia under the Global Monitoring for Environment and Security and Africa (GMES & Africa) initiative, provides decision-making services to promote sustainable management of marine resources, improve marine governance and stimulate the growth of the blue economy in the Southern and Eastern African Regions. The MarCOSIO consortium is led by the Council for Scientific and Industrial Research (CSIR), and consists of partner institutions from industry, academia and government from Angola, Namibia, South Africa, Mozambique, Kenya, Tanzania, Madagascar, and Mauritius.
The MarCOSIO services are built on public platforms and freely available environmental satellite data from the European Union's Copernicus missions. Here we showcase the MarCOSIO services related to aquaculture, with near-real time and historical satellite-derived products and indicators for eutrophication, phytoplankton biomass, and sea surface temperature (anomalies, gradients, and marine heat-waves). We provide examples of operational support provided during harmful algal bloom events in South Africa, and during coral bleaching monitoring and preparation in the Western Indian Ocean. Our aim is to empower stakeholders and users in the public and private sectors with free satellite observations and information services across the marine thematic areas related to coastal monitoring, water quality, fisheries and aquaculture, supporting resource management and sustainable development in the process.

Potential interventions for protecting open aquaculture systems from piscivorous pest birds – lessons from freshwater finfish farms

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Piscivorous birds are among the most significant agents of loss to open aquaculture production systems worldwide through direct predation on cultured fish, thereby undermining food and nutrition security goals. Here we present results from an assessment of the role of the interplay between two key habitat variables, enhanced water fertilization, physical barrier types, and bird functional groupings on potential success in reducing predation pressure on open tilapia and catfish farms in western Kenya, and discuss how these results may be applicable for marine aquaculture systems. Birds were categorised into 4 functional groupings by feeding strategy, and observed once weekly for five months, with three observation sessions each day with 20-minute intervals to determine assemblages and fish capture rates across twelve pairs of ponds experimentally block-designed with or without enhanced fertilization, with wither coarse-grained of fine-grained wire barriers, or no treatment (unfertilized, no barrier). Average height of trees of pond-side grass thicknesses were also determined, and analyses conducted on how these factors, singly or in combination, influenced bird assemblage patters or contributed to reducing predation rate. Bird visitation was unaffected by pond-cover barrier type while enhanced fertilization and barrier presence corresponded to reduced overall predation rate. Predation also reduced when bird species richness was higher, and when ponds were located near taller trees but only for larger wading birds. While fertilization reduced predation by all large birds, even for open ponds, it was ineffective against small plunge-diving species which were deterred only by fine-net barriers. Thus, enhancing pond fertilization needs to be combined with specific habitat variables as well as consideration of piscivorous birds' functional attributes to maximize success in mitigating overall predation pressure. Given Kenya's national distribution of the piscivorous bird species examined in this study, these results are equally applicable for marine as well as freshwater open aquaculture systems.

Mariculture development in the Western Indian Ocean region: status, opportunities and challenges

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Whereas aquaculture production is increasing globally, there are large regional differences. In 2020, global aquaculture production reached 122.6 million tons with Asia accounting for 91.6% of the total production. In 2020 aquaculture production in Africa accounted for 2.57% of the world aquaculture production excluding algae. During this period, Egypt contributed 70.74% of the total aquaculture production in Africa, while Nigeria contributed 11.63% and the other areas of the continent contributed 17.63%. In the Western Indian Ocean region, inland freshwater aquaculture has progressed well compared to marine aquaculture. Over the last decades, marine aquaculture has depended on utilization of wild seed collections to support finfish and shellfish marine aquaculture farmers in addition to seaweed farming that is limited to a few species. However, in the recent past significant interest has been observed by regional governments leading to development of marine hatcheries and development of strategic documents to guide marine aquaculture development. The paper provides an overview of the development of marine aquaculture in the region, existing opportunities and challenges that will require to be addressed to enhance investment in the sub-sector.

Growth performance of five different strains of Nile tilapia (*Oreochromis niloticus*) introduced to Tanzania reared in fresh and brackish waters

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Five introduced strains of Nile tilapia (*Oreochromis niloticus*) were tested for growth performance both in fresh- and brackish-water (2 salinity units) environments for 56 days. The BIG NIN, GIFT, Chitralada, "Ruvu Farm" and Silver YY strains with initial mean average weight (± standard error) of 96.4 ± 6.90 g, 104.1 ± 7.19 g, 137.2 ± 7.21 g, 53.2 ± 6.98 g and 95.3 ± 7.11 g, respectively were used. Individuals were tagged and pooled in hapas (12 m × 8.5 m × 2 m each), aligned into different ponds (20 m × 20 m each). Stocking density of 5 fish m^{-2} and 350 g kg^{-1} crude protein diet were used. Overall, the average weight gain for GIFT strain was 7.5%, 32%, 45% and 86.5% higher than BIG NIN, Chitralada, "Ruvu Farm" and Silver YY strains, respectively, across both environments. All strains performed significantly better ($p < 0.05$) when reared in brackish water than their respective counterparts in freshwater, except for the BIG NIN strain. The morphometric correlations for all strains in both environments ranged from moderate (0.50) to strong positive (0.92). The GIFT strain demonstrated superior growth and genotype by environment interaction was weak and not important to be prioritized in breeding programs.

Fish cage site selection at Kibuyuni in Kwale County, Kenya: tidal variations, waves height, current speed and direction status

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The objective of the study was to select a suitable site for cage fish farming in the South Coast of Kenya at Kibuyuni, by investigating the status of tidal variation, wave height, and current speed and direction, which was done using the Acoustic Wave and Current Profiler (AWAC). The AWAC was deployed at 13.6 m depth. The study showed that the current speeds at Kibuyuni varied from the surface to the seabed: water surface, 0.8690 m s^{-1}; 6 m depth, 0.6090 m s^{-1}; 8.5 m depth, 0.5590 m s^{-1}. According to the Norwegian fish cage site classification, current speed should not exceed 1.5 m s^{-1} because this can cause the cage to move if not well fitted with heavy weights. Therefore, these current speeds indicate that the area is suitable for cage installation. The highest tide was 13.5680 m, while the lowest was 9.6840 m. The tidal fluctuation/difference is 3.8840 m, which is good for adequate water exchange that will enable the flow of nutrients through the cage. The significant wave height (Hs) was 0.36 m (Maximum wave height=Hs × 1.9), with a theoretical maximum wave height of 0.684 m. According to the Norwegian fish cage site classification, a maximum wave height between 0.5-1.0 m is considered moderate for fish cage sites. Therefore, this site is considered moderate for fish cage installation.

The bacterial benefits associated with integrated abalone-*Ulva* farming at different stages of production

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Buffeljags Abalone is a commercial abalone farm in South Africa that practices integrated multi-trophic aquaculture (IMTA) by growing the green seaweed *Ulva lacinulata* in D-shaped paddle-raceways receiving effluent water from adjacent *Haliotis midae* raceways. This practice allows for bioremediation of farm effluent, partial recirculation of water and the cultivation of *Ulva* as a supplementary feed. The microbiome of an IMTA farm and the associated species, is likely influenced by feeds, incoming seawater and environmental factors, but also by changing conditions from hatchery to grow-out. The aim of this study was to characterise the bacterial microbiome of hatchery-produced juvenile abalone (3 - 10 mm shell length (SL)) and the sources of bacterial introductions (feeds and seawater), and to compare this with the microbiome of adult abalone (± 70 mm SL) grown in an abalone-*Ulva* IMTA system. Results showed that *Ulva* modulates its surface microbiome and that of the abalone effluent, reducing the abundance of certain genera, including known opportunistic pathogens, without causing a collapse in bacterial diversity of the bioremediated seawater. In the hatchery, the bacterial community in the incoming seawater has a transient effect on that of the juvenile abalone, and the bacteria introduced through feeds shapes their gut microbiome to a larger extent, showing that there is potential for the effective use of functional feeds at this life stage. Juvenile abalone digestive tract bacteria were dominated by the genera *Formosa* (36%), *Psychrilyobacter* (11%), *Vibrio* (11%) and *Mycoplasma* (5%), all of which are known colonisers of adult abalone digestive systems. Over time, abalone digestive tracts and their associated microbiome become more specialised with *Psychrilyobacter* (47%), *Vibrio* (21%) and *Mycoplasma* (18%) forming the core bacterial community. These bacteria play important roles in digestive processes and in maintaining gut health. These data show that both abalone-*Ulva* IMTA and the inclusion of seaweeds in abalone diets have beneficial effects on the bacterial microbiome.

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Development of a method for the detection of important virulence factors of the shrimp pathogen *Vibrio parahaemolyticus*

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Acute hepatopancreatic necrosis disease (AHPND) is caused by toxin producing *Vibrio parahaemolyticus* strains. These strains have a pVA1 plasmid that encodes the binary toxins PirA^{vp} and PirB^{vp}. The disease has caused serious losses to the global shrimp industry. However, environmental manipulation such as fluid shear triggers production of a non-toxic Alkaline Phosphatase (PhoX^{VP}). The most commonly used diagnostic methods currently are PCR based methods that detect the presences of both PirA^{VP} and PirB^{VP} genes. However, due to mutations of the plasmid, bacterial strains containing the PirA^{VP} and PirB^{VP} genes do not always express the binary toxin. Therefore, an antibody based diagnostic tool to detect the presence of these binary toxins was developed in this study, to complement the present PCR based tools. In this context, PirA^{vp}, PirB^{vp} and PhoX^{VP} proteins were recombinantly produced and purified. PirAB^{VP} toxins were spiked in shrimp water and shrimp hepatopancreas tissue and the detection limit of the newly designed ELISA assay was determined. For the shrimp tissue test, two methods were employed:
1. In two hepatopancreas from post-larval (PL) shrimps, toxin PirA or PirB was injected.
2. In a third PL, homogenization was done first and homogenate spiked with the toxins.
Detection was done by a sandwich ELISA on His Tag antibody plates. The sandwich ELISA developed could detect PirA^{VP} and PirB^{VP} toxin as low as 0.037 µg ml^{-1} and 0.014 µg ml^{-1} in shrimp water respectively. In shrimp tissue, the detection limit for method one was lower than 1.875 µg ml^{-1} for PirA, and lower than 1.625 µg ml^{-1} for PirB. For method two, the detection limit is higher than 2 µg ml^{-1}.
To be able to further adapt and optimise the ELISA assay, polyclonal antibodies (pAbs) against PirA^{VP}, PirB^{VP} and PhoX^{VP} were produced. Rabbits were immunized with the purified recombinant PirAB^{vp} and PhoX^{VP}. Blood serum titers were analysed using indirect ELISA (iELISA). A high titer of pAbs in rabbit serum was observed after immunization and there was a steady increase of the titer during the immunization schedule. The pAbs specific to PirAB^{VP} and PhoX^{VP} produced in this study can be used to further optimise the ELISA test, which would help shrimp farmers do real-time diagnosis of AHPND in the farm.

Nutritional value and heavy metal content of farmed and candidate aquaculture seaweed species in South Africa

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In South Africa, seaweed aquaculture is presently limited to *Ulva lacinulata* and *Gracilaria gracilis*, which are used as feed for farmed abalone (*Haliotis midae*) and, in the case of the former, also for water bioremediation in integrated aquaculture systems. *Laminaria pallida*, *Ecklonia maxima* and *Macrocystis pyrifera* are additionally considered potential candidates for commercial kelp aquaculture. The present study aimed at analysing the nutritional value and heavy metal content of these species to assess their beneficial value for human consumption and for animal feeds. *Ulva lacinulata* and *G. gracilis* were sampled at an abalone farm and kelps were collected from natural stocks. All seaweeds contained similar levels of lipids (~3% dry matter-DM) and carbohydrates (~14% DM), while *U. lacinulata* and *G. gracilis* had a higher protein content (28% and 20% DM, respectively) than kelps (~14% DM). Both farmed species also contained higher levels of polyunsaturated fatty acids, with ω-6 and ω-3 being highest in *U. lacinulata* and *G. gracilis*, respectively. In terms of macrominerals, the highest levels of Ca, K and Mg were found in *U. lacinulata*, *M. pyrifera* and *G. gracilis*, respectively, while all kelps showed higher levels of Na and P than *U. lacinulata* and *G. gracilis*. Regarding trace elements, all seaweeds showed similar levels of Zn, while the farmed seaweed species contained higher Fe, Se, Cu, Mn and Cr levels than the kelps. For heavy metals, *U. lacinulata* and *G. gracilis* accumulated higher Al and Pb levels than kelps, whereas the opposite was found for Cd, Hg and As. *Laminaria pallida* and *E. maxima* also contained the highest levels of I. In conclusion, the studied seaweed species showed significant species-specific variations in their nutritional value and were particularly rich in minerals. Results will be discussed in relation to Recommended Nutrient Intake and known maximum limits for heavy metals.

Evidence on food loss and waste – a case of Kenya fish value chains

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Fish presents a valuable source of proteins and nutrients in the diet of many worldwide and its importance in contributing to food security in Kenya is rising. Kenya produced a total of 163,600 MT of fish in 2021, with total revenue of KES 30.4 billion (USD 250 Millions). The Kenyan fishery sector employees about 65,250 as fishermen or fish farmers and further supports about 1,2 million people along the value chain, with a contribution to the GDP of 0.7%. However, fisheries remain dominantly artisanal with poorly developed cold-chain-infrastructure. The study aimed at consolidating fish post-harvest management interventions in the country, as well as documenting the evidence on losses and wastes along the value chains. Prevailing literature, frame survey data, and information from the Kenya Marine and Fisheries Research Institute (KMFRI) and the Kenya State Department of Blue Economy and Fisheries was used. The study reviewed the contribution of post-harvest management interventions in reducing fish losses and wastes. The results depict the Kenyan fish market to have a structure that categorizes value chain actors focusing on the internal market and others dealing with the international market. There are abundant interventions in both handling and processing, but low utility (<40% of installed cold rooms, dryers and smoking kilns) and a multiplication by fishers and fish farmers. The main cause of losses included: poorly developed cold-chain-infrastructure (29%), inefficient marketing/Lack of buyers (22%), poor weather conditions/heavy rain (21%), lack of fish processing/preservation equipment (10%), and others. However, fish targeting export markets have well-organized structures, portraying a weak regulatory framework as a key constraint in addressing post-harvest management of fish intended for domestic market. Under-utilization of installed interventions results in continued fish waste and losses, thus contributing to food and nutritional insecurity.

Profiling the status of fish farmers, fishermen and fish traders as direct recipients of the climate-smart SolCoolDry system in Kwale County, Kenya, and their perspectives on fish preservation technologies

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Post-harvest losses in artisanal mariculture and capture fisheries value chains contribute significantly to enhanced livelihoods, food, and nutritional security of coastal communities in Kenya. The present study investigated the status of direct recipients of the SolCoolDry technology – a climate-smart system for chilling and drying aquatic and farm produce for sustainable reduction of post-harvest losses. Semi-structured questionnaires were administered to randomly sampled fish farmers, seaweed farmers, fishermen, traders, and processors from Mwazaro, Shimoni, Gazi, and Kibuyuni in Kwale County, Kenya. The findings revealed high illiteracy levels, with 75 % of respondents lacking exposure to formal education. The technology recipients were aggregated into groups sharing community-owned fishing grounds, drying racks, office space, processing areas, and storage facilities. The per-capita production capacity of fresh fish was reported to range between 25 kg to 1,500 kg depending on the season. More than 75 % of respondents reported having encountered losses. The loss-reduction methods employed by the actors included gutting, salting, chilling, freezing, salting, or drying. Fishermen and fish farmers reported not chilling or freezing harvested fish, while 78 % of fresh fish traders used ice blocks, flakes, or freezers for cold-chain preservation. Ice was purchased from ice dealers, Shimoni ice flake machine, and the SolCoolDry system in Mwazaro. Inadequate drying racks and inefficient drying during the wet season were reported to contribute to high losses in the dried fish value chain. Of the 80 % respondents who were aware of the SolCoolDry system, only 18 % reported having used the system. Most of the value-chain actors cited the comparatively higher melting rate of ice flakes compared to ice blocks and the perceived high cost of using the SolCoolDry system. There is an urgent need to increase the ice production and drying capacity of preservation systems for sustainable fish value chains.

POSTERS

Co-culture of Nile tilapia, sea cucumber, and oysters in an integrated multi-trophic aquaculture system using earthen tide fed ponds

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Acclimatized marine tilapia was used as the fed component in an Integrated Multitrophic Aquaculture (IMTA) system with different species combinations. The study was designed to have a monoculture of marine tilapia (*Oreochromis niloticus*) as the control (C), a combination of *Oreochromis niloticus* and *Holothuria scabra* as treatment 1 (T1), a combination of *Oreochromis niloticus*, *Holothuria scabra* and *Sacostrea cucullata* as T2, and a combination of *Oreochromis niloticus* and *Sacostrea cucullata* as T3. Stocking was done in replicate ponds at densities of 2 ind. m^{-2}, 1.9 ind. m^{-2} and 2.1 ind. m^{-2} for tilapia, sea cucumber and oysters respectively, in all treatments. All organisms exhibited weight gain over the study period (150 days), with *O. niloticus* displaying a significantly higher ($p < 0.05$) average body weight (ABW) in T2. Treatments that had *H. scabra* as one of the extractive species exhibited low survival rates, i.e. 53 % in T1 and 45 % in T2. Production was highest in T2 where all three species were integrated. Net income was US$ 77.5 in IMTA compared to US$ 1.0 for the control, while cost-benefit ratio (CBR) was ≈1.0 for IMTA and ≈0.4 for the control experiment. Incidences of tilapia predating on sea cucumbers observed during the study compromised its viability as a fed species in IMTA. Collectively, these experimental findings demonstrate the potential of IMTA as a more profitable mariculture practice compared to monoculture and therefore, is recommended for adoption to promote production in earthen pond mariculture systems in coastal Kenya.

The past and present initiatives on mariculture developments in the coastal waters of mainland Tanzania

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This study focuses on the sustainable utilization of marine coastal resources in Tanzania, which are vital for the country's economic development and the well-being of its coastal communities. The primary objectives are to assess the current status of mariculture activities and to provide insights into past experiences and future prospects. To achieve these objectives, a comprehensive survey was conducted across mainland coastal regions, coastal islands, and Zanzibar (Unguja and Pemba). The study aimed to gather data on existing mariculture practices, as well as reasons for discontinuation among former practitioners. Results reveal that coastal communities engage in a diverse range of activities, including subsistence farming, forestry, artisanal fishing, and seaweed farming, highlighting the multifaceted nature of their reliance on coastal and marine resources. Effective management of these resources is crucial for poverty alleviation and food security. In conclusion, this study underscores the importance of sustainable coastal resource management in improving the socio-economic conditions of coastal communities. By drawing from past experiences and current practices, Tanzania can chart a path toward a more prosperous future. Collaborative efforts among stakeholders are essential to enhance mariculture's sustainability and productivity. The findings of this study provide valuable insights into the past, present, and future of aquaculture development in Tanzania. They underscore the critical role of sound resource management in poverty reduction and food security for coastal communities. By leveraging accumulated knowledge, Tanzania can work towards a brighter and more food-secure future for its coastal regions.

On-farm assessment of different fingerling sizes of Nile tilapia (*Oreochromis niloticus*) on growth performance, survival and yield

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The rapidly increasing production of hatchery-raised Nile tilapia (*Oreochromis niloticus*) in most developing countries lacks informed recommendations regarding fingerling weight for stocking in semi-intensive grow-out ponds. The current study assessed the growth performance, survival, and productivity of all-male Nile tilapia fingerlings of 0.2 g, 1 g, and 5 g in an on-farm experiment. The final mean weight of the fingerlings stocked at size 5 g was significantly higher (113.80 ± 4.21 g) ($P< 0.05$) compared to the 0.2 g (36.99 ± 1.14 g) and 1g (91.93 ± 5.59 g) fingerling sizes. The mean daily weight gain was highest in the 5 g stocked fingerlings (0.91 ± 0.04 g day^{-1}), resulting in significant differences in the final mean weight. The coefficient of correlation between fish body length and weight was high and positive ranging ($R = 0.95 - 0.98$). A significantly lower percent survival was recorded in the 0.2 g stocked fingerlings (64.43 ± 1.93%). The net fish yield (NFY) and profit index (PI) were significantly lower at the 0.2 g. The highest NFY and PI were recorded in the 5 g stocked fingerlings (8.59 ± 0.09 tons ha^{-1} $year^{-1}$ and 6.6 ± 2.08, respectively). Thus, with an appropriate Nile tilapia fingerling weight at stocking, fish farmers can maximize fish growth, yield, and profits.

Optimize feeds and feeding regimes for full-life cycle grow-out of *Tripneustes gratilla* in Integrated Multitrophic aquaculture (IMTA)

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The collector sea urchin (*Tripneustes gratilla*) is an echinoderm whose gonads (roe) have high commercial value on Asian markets. Due to its fast growth rate, early maturation and high gonadal production, it has been proposed as a viable candidate for aquaculture/echinoculture. *Tripneustes* also develops well in co-culture with seaweed and can be grown in similar productions systems as abalone, which is the primary aquaculture crop in South Africa, making it a good candidate for IMTA. To facilitate development of *Tripneustes* aquaculture it is important to develop feeds and feeding regimes that promote rapid somatic and gonadal growth, with the resulting gonads meeting the quality criteria of the Asian markets in terms of weight, colour, texture and firmness. Therefore, the aim of this study was to identify feeds that would promote rapid somatic and gonad growth, particularly during early stages of production. Juvenile sea urchins (ca. 2mm test diameter) were obtained from a commercial hatchery (Buffeljags Abalone) and stocked into 4 baskets per treatment (n=20 individuals/basket). Three feeds were tested: fresh *Ulva lacinulata*, fresh kelp (*Ecklonia maxima*), and a formulated feed (20U) containing 20% dried *Ulva* (w/w). Each feed was provided ad libitum over the 17-week growth period. To measure somatic development, urchin weight and diameter was measured once every week. Towards the end of the somatic period (week 13), gonad development was evaluated by assessing 10 gonads per treatment group. Gonads were weighed and texture and firmness were rated visually, whereas colour was rated both visually and with a hand-held reflected-light fibre-optic spectrophotometer. There was a significant impact of feed on test diameter and gonad development/quality. Somatic development was better in sea urchins fed with *Ulva* and kelp by the end of the trial. The formulated feed produced larger gonads compared with the seaweed treatments, but these gonads did not meet the marketing criteria in terms of texture, firmness and colour. In contrast, the gonads obtained from the *Ulva* and kelp treatments were marketable and of high quality. These trials provided valuable information on the impacts of feed on early development of *Tripneustes gratilla* for commercial production.

Comparative growth performance of marine tilapia (*Oreochromis niloticus*, L.) cultured in hapa nets at different stocking densities using animal and plant protein diets

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Aquaculture as an enterprise is hampered by the high cost of fish-based protein diets which account for 30 - 70% of the production cost. Alternative plant-based protein diets are paramount in guiding fish farmers on feed efficacy and fish stocking densities. This study analyzed the growth performance of marine acclimatized Nile tilapia (*Oreochromis niloticus*) using fish meal (animal protein), soybean (plant protein) and wheat bran (control) formulated diets. Nile tilapia fingerlings weighing 13 - 17 g were cultured in hapa nets in three concrete-based ponds at stocking densities of 15 fish m^{-3}, 10 fish m^{-3} and 5 fish m^{-3} for each feed treatment. Monitoring of water quality parameters (temperature, dissolved oxygen (DO), and salinity), as well as the initial and final fish body length and weight, was done fortnightly during the experimental period. Two-way ANOVA was used to determine if stocking density and feed treatment(s) had a significant effect on fish growth performance. Weight gain was highest in fingerlings cultured using the soybean-formulated diet (10.28 ± 2.44 g). Marine acclimatized *O. niloticus* fingerlings had a high feed utilization for soybean meal. The stocking density of 5 fish m^{-3} recorded the highest percentage survival rate of 85.6% on wheat bran treatment. An optimal stocking density of 5 fish m^{-3} is therefore recommended to optimize and maximize fish production.

Effect of *Ulva* supplemented feeds, with and without probiotic (*Debaryomyces hansenii*) supplementation, on the growth, immunity, oxidative stress response and gut morphology/microbiome of the dusky kob *Argyrosomus japonicus*

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Globally, several seaweed species are reported to have great potential as functional ingredients in aquafeed for a variety of fish species, including *Solea senegalensis*, *Clarias gariepinus*, *Salmo salar* and *Oreochromis niloticus*. *Ulva* has been cultivated by the South African abalone industry in Integrated Multi-trophic Aquaculture (IMTA) systems for use as feedstock or crop-based dietary ingredients in formulated feeds for aquacultured abalone (*Haliotis midae*) for almost two decades, and more recently for sea urchins (*Tripneustes gratilla* and *Parechinus angulosus*). The current study aims to enhance the growth, immunity, oxidative stress, gut morphology and microbiome of *Argyrosomus japonicus* (dusky kob) through dietary supplementation with dried *Ulva lacinulata*. Dried *U. lacinulata* inclusion levels of 5, 10 and 15% (w/w) will be tested and compared with a non-supplemented (0% *Ulva*) control feed, totalling to four (4) dietary treatments- of 3 replicate tanks each. Data will be collected for (1) growth performance, and nutrient utilization: Weight gain, feed conversion ratio, specific growth rate, condition factor, hepatosomatic index, viscera-somatic index and survival rate; (2) Haematology: blood glucose, haematocrit and blood histology; (3) Immune response by assessing variation in the expression of relevant immune genes such as IL-1β, IL-10, TNF-α and IgM from selected tissue samples (liver, intestine, head kidney and spleen). This will be conducted using semi-quantitative Real-Time Polymerase Chain Reaction (RT-PCR); (4) Flesh proximate analysis; (5) Antioxidant indicators of serum and liver; (6) Histology of the intestine; (7) Microbiome associated with gut tissue. Results from this study will help inform the aquaculture industry about how dietary *Ulva*-supplementation can help improve the health and welfare of one of South Africa's promising aquacultured fish species, the dusky kob *A. japonicus*. The presentation will provide an overview of the work that is planned and currently underway.

Identification of green seaweeds (Caulerpaceae) from three sites on the Kenyan coastline with potential food use

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The objective of this study was to identify green seaweeds (Chlorophyta) of potential food value under the genus *Caulerpa* along the Kenyan coast. The study focused on identifying, utilising, and exploiting the phycological resources in the West Indian Ocean (WIO) region. The possibility of incorporating *Caulerpa* species in food security programs in Africa is significant, but there are no programs that promote cultivation and harvesting. While *Caulerpa* has not attracted extensive attention from researchers, biochemical extracts have been tested, and the therapeutic effects identified include antinociceptive, antiviral, antimicrobial, immunostimulatory, cardioprotective, and anti-obesity. The field survey targeted three rocky shores.: Mkomani English Point, Watamu Landing Site and Kibuyuni, suitable habitats for Caulerpaceae. Targeted searches were conducted to find representative members during low spring tides for access to intertidal areas. Six *Caulerpa* species were identified after field surveys (*Caulerpa scalpelliformis*, *Caulerpa sertularioides*, *Caulerpa lentillifera*, *Caulerpa zeyheri*, *Caulerpa taxifolia* and *Caulerpa racemosa*). Identification was based on morphology and does not account for variants within the same species. The six species of *Caulerpa* were not found on all three sites explored during the study. On the Mkomani English Point site, *Caulerpa scalpelliformis* were found in rocky pools while *Caulerpa sertularioides* were present on sandy substrate. Representative species of *Caulerpa lentillifera* and *Caulerpa taxifolia* were also identified. Watamu Landing Site provides a suitable habitat for sea grapes, i.e, *Caulerpa racemosa* and *Caulerpa lentillifera*. *Caulerpa zeyheri* was also identified. In Kibuyuni, only *Caulerpa lentillifera* was found. The sustainable exploitation of these resources will demand further research into the ecology of *Caulerpa* species and exploration of marine agronomy for long-term production.

Natural diet and feeding habits of fresh/brackish water prawns of the genus *Macrobrachium* (Family Palaemonidae) in Kenya

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The freshwater prawns of the genus *Macrobrachium* comprises 243 described species spanning the tropical and subtropical regions globally which include *M. rude*, *M. dolichodactylus*, *M. equidens*, *M. lepidactylus* and *M. niloticus*. In Kenya, *Macrobrachium* species are well recognized for their ecological role as well as a human food source. However, there is limited information on their natural diet and feeding habits in Kenya limiting the aquaculture potential of some of these prawns. Field sampling of prawn data was carried out in 7 selected sites along mid and downstream coastal estuaries and during the wet and dry seasons in Kenya. Laboratory work on stomach content analysis was carried out at both the Kenya Marine Fisheries and Research Institute laboratory at Gazi-Bay station and the National Museums of Kenya, and stomach content data was analyzed using the percent frequency of occurrence of food items. A total of 80 different types of food items were identified in the stomachs of three *Macrobrachium* species with *M. rude* recorded the highest number of food items (77), followed by *M. lepidactylus* (42), while *M. dolichodactylus* recorded the least (37). *M. rude* recorded the highest number of unique food items (28) dominated by the algal species *Coleochaete* sp, *Strichococcus* sp, *Synedra* sp and *Mougeotia* sp. *M. lepidactylus* recorded (8) unique species dominated by the algal species *Botrococcus* sp, *Ceratium* sp, *Microcystis* sp and *Daphnia* sp, while *M. dolichodactylus* recorded (7) unique species dominated by *Characium* sp. The results of this study suggest that the three *Macrobrachium* spp are omnivorous in nature with a preference of algal species. The nutritional information generated from this study on the prawn's diet will allow formulating recommendations for artificial feeding for Macrobrachium spp for the mass production in aquaculture to secure sustainable fishing and the success of aquaculture initiatives.

Growth and survival rate of catfish (*Clarias gariepinus*) fry fed on Kenyan produced and imported *Artemia* with subsequent weaning of dry feeds

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A 21-day experiment was conducted to evaluate the growth and survival rate of *Clarias gariepinus* fry fed on Kenyan produced and imported *Artemia* cysts. The experiment was conducted in twelve (12) glass aquaria (60 cm X 30 cm X 30 cm) filled to a capacity of 30 l and randomly placed at the hatchery. Four hundred and fifty *C. gariepinus* fry of approximately 0.02 g and 6 mm were counted randomly and introduced in each aquarium at a stocking density of 15 fry l^{-1}. The fry were fed exclusively on *Artemia* diet from day 2 to 8 of the experimental period. On day 9 to 11, the fry were co-fed on *Artemia* and dry feed in order to prepare them for the starter diet which was a dry feed. After the three days, the dry feed was introduced from the 12th day to the end of the experiment. The feeds were administered three times a day at a four-hour interval at 09.00, 13.00 and 17.00 hours. There were no significant differences in body length among treatments at the end of the experiment. However, there was a significant difference in body weight on day 7 among the treatments. A significantly higher survival rate ($p < 0.05$) was observed in larvae fed on the decapsulated Shell Free Artemia at 21 days compared to the other two encapsulated treatments. Growth parameters results demonstrate that 7 days of live feeding is sufficient for efficient rearing of catfish larvae. The decapsulated *Artemia* can be recommended for a higher survival rate of fish fry.

A contribution to the study of environmental constraints to oyster farming in Senegal

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Faced with the challenge of preserving fish stocks, threatened by global warming and overexploitation due to population growth, aquaculture is a means of meeting the demand for aquatic animal proteins. Although Africa is now the world's second most populous continent after Asia, it accounts for just 2.7% of global aquaculture production. This situation has given rise to considerable reflection aimed at promoting the development of African aquaculture, and oyster farming in particular.
The main objective of this study was to gain a better understanding of the environmental constraints of oyster farming in Senegal, in order to identify the necessary foundations for the emergence of the sector. To achieve this, a questionnaire and an interview guide were used to gather the necessary information from one hundred (100) oyster producers, selected using the snowball sampling method, in the Saloum Delta, Casamance and Petite Côte. Meetings with resource persons and field visits were also organized to obtain an overview of the oyster farming industry.
The results showed that oyster farmers' level of education is fairly low, and that women account for over 90% of those surveyed. It should be noted that the oyster farmers are all members of oyster farming groups responsible for supplying oyster farming equipment, training in oyster farming and marketing oysters. The choice of one of the three existing farming methods (suspension, table and estrien) was guided by the techniques acquired, to the detriment of the environment. The results also showed that among the environmental factors hindering oyster farming, bio-aggressors are the most influential, and their management remains problematic in all our study areas.

Water quality sustainability in the context of growing marine aquaculture industry in Mauritius

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Mauritius boasts its "paradise status" through its rich marine biodiversity and pristine clear blue lagoon. Marine aquaculture, a critical component of global food production, is intrinsically linked to water quality. The maintenance of suitable water conditions is imperative for the health and productivity of farmed species and the sustainability of aquaculture operations. The operational fish farm at Pointe-aux-Feuilles, Mauritius was assessed in terms of water quality and compared to various sites and control stations. Samples were taken around 25 ± 10 cm from the surface by opening sealed plastic bottles at the appropriate depth. Water parameters including temperature, pH, salinity, conductivity, dissolved oxygen, chemical oxygen demand, total suspended solids, nitrate, phosphate, ammonia, total coliform, feacal coliform and feacal *Streptococci* were assessed. Phytoplankton density and Chlorophyll-*a* were also assessed. Average physico-chemical and biological parameters were as follows: salinity 35.1 - 36.0 ‰; conductivity 38.3 - 51.9 MS cm^{-1}; dissolved oxygen 4.5 – 8.0 mg L^{-1}; total suspended solids 3.0 – 27.9 mg L^{-1}; chemical oxygen demand 0.6 – 4.7 mg L^{-1}; pH 7.9-8.1; nitrate nitrogen (NO3-N) 0.3-1.9 mg L^{-1}; phosphate phosphorus (PO4-P) 0.0 – 0.2 mg L^{-1}; ammonia 0.1 – 0.5 mg L^{-1}; total coliform counts (TCC) 0.9 – 43.7; feacal coliform counts (FCC) 0.0 – 44.4; feacal *Streptococci* (FS) 0.0 – 23.6. Environmental stewardship is paramount in the context of marine aquaculture, and regulatory frameworks must be in place to ensure responsible practices. Collaboration between the aquaculture industry, researchers, and policymakers is essential for the development and enforcement of guidelines that promote sustainable water quality management.

Does cage culture influence physico-chemical parameters and phytoplankton diversity? A case study on ecological impact of cages in Lake Victoria, Kenya

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This study was conducted to establish the factors that influence the phytoplankton diversity community structure in cages and their ecological implications on to human health. Sampling stations were selected in triplicates. Parameters determined included nutrients, phytoplankton chlorophyll and algal toxins. The phytoplankton diversity index was calculated using the Shannon-Wiener diversity index, and the phytoplankton richness calculated through the Simpson richness Index. Statistical significance was set at $p < 0.05$. Statistical analyses were performed using Minitab version 17 Inc. for Windows. There was a significant difference in chlorophyll a, temperature, dissolved oxygen, conductivity, pH and Secchi depth at Anyanga (ANOVA; $p<0.05$). However, no significant difference was observed in nutrients measured in Victory farm (ANOVA; $p>0.05$). Mean overall dissolved oxygen was 7.41 ± 1.39 mg l^{-1} and varied significantly between sampling stations ($p = 0.0491$). Mean conductivity levels were 142.39 ± 63.786 µS cm^{-1} but differed significantly between stations ($p = 0.0005$). The mean phosphorus level was 330.02 ± 311.9 mg l^{-1} but differed significantly between sampling sites ($p = 0.001$). The mean overall ammonium level was 319.29 ± 397.35 mg l^{-1}, varying significantly between sites ($p = 0.0008$). The mean overall Chlorophyll a level was 592.9 ± 604.38 mg l^{-1} at Mfangano cages. With 46%, diatoms were the most predominant phytoplankton family in the study. There were significant differences in phytoplankton families between stations ($p = 0.0001$). In addition, the results can be used to rank the cages with respect to levels of pollution. High turbidity negatively affects the lake ecosystem, hence the proliferation of Cyanobacteria is likely to occur in cages, both presently and in the future, with poor management practices.

Cage farming in the environmental mix of Lake Victoria: an analysis of its status, potential environmental and ecological effects, and a call for sustainability

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Lake Victoria has experienced an ecological shift resulting in dwindling fisheries and the extinction of about 200 fish species. This has been attributed to overfishing, eutrophication, introduction of exotic species, pollution, and climate change. To supplement capture fisheries from the lake, cage culture was introduced, but its sustainability and influence on the ecology of the lake are not well understood. In this study we examined the degradation of Lake Victoria and assessed the role of cage culture as a solution to the current situation and as a cause for concern. Data from grey and published literature was utilized. Degradation of the lake begun in the 1930s when the trophic status and ecology showed signs of anthropogenic influence. The Nile Perch was introduced in the early 1960s to replenish the fishery, but its ecological impacts were felt in the 1970s and 1980s when the native haplochromine species started to disappear from catches. Progressively, the ecological changes and management concerns in the lake have become a complex mix of exotic species introductions, eutrophication, and overfishing. Among these persistent ecological changes, the once thriving capture fisheries revolving around two exotic species (*L. niloticus* and *O. niloticus*) have significantly declined, threatening the livelihoods of millions of people. Cage culture was introduced in 2005 to meet the increasing fish demand. Over 70% of the cages have been installed in shallow areas, which goes against the guidelines on cage installation and operation. Regulations on cage farming were introduced after the activity had gained momentum in the lake. Limnological data has shown evidence of negative effects on water quality. This decline in water quality can be attributed to residual feeds used in cages, 50% of which are sinking types, and wastes from fish excretion and egestion. Although data are limited, the potential influence of cage farming on the already altered ecology and environment of Lake Victoria needs to be recognized and investigated. This study recommends research targeting cage operations in the lake, including a comprehensive environmental audit to assess their sustainability and inform relevant policy.

Effects of phytoplankton and water quality dynamics on Nile tilapia in earthen ponds at Nyaguta Fish farm in Kisii County

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Aquaculture is the future for bridging the gap created by the decline in capture fisheries. According to a recent overview survey, fish farming in Kenya is currently on the rise. In the effort to increase production in ponds, there was a need to investigate the water quality and algal biodiversity, since they play an important role in the aquatic food chain. This study, carried out from October 2015 to 2018, measured in-situ the physico-chemical parameters (turbidity, temperature, conductivity, alkalinity, dissolved and suspended solids, and dissolved oxygen concentration). Chlorophyll a and phytoplankton analyses were done using spectrophotometric and microscopy techniques, respectively. There were significant spatial differences in the dissolved oxygen concentrations ($p<0.0001$) within the ponds. These differences were pronounced at the Pond B, Pond E and Pond F. The differences were associated with the stocking density and feeding regimes. Chlorophyll a concentrations were found to be higher during the dry season compared to the rainy season. This could be attributed to high turbidity during the rainy season, which reduces light penetration into the water column. The diatom family was the most abundant group (60 %), followed by Chlorophyceae (28%), Euglenophytes (11%), Zygnemetaphaceae family (7 %), Euglenophyceae (4%) and Cyanophyceae. Among the diatoms, the most dominant species were *Amporas* sp., *Cyclotella* sp., *Synedra* sp and *Surillella* sp. Significant differences in distribution patterns in phytoplankton were observed between the Pond A and Pond F. Phytoplankton quotient (PQ) value was estimated at 4.1 ± 0.26, indicating that the ponds are highly eutrophic. These results are useful in formulating management advice for stakeholders.

Utilization of water quality index in the water analysis of Goreangab Dam to determine the suitability of a potential aquaculture site

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The aim of this study was to explore the utilization of the Water Quality Index (WQI) in analyzing the water quality of Goreangab Dam in Windhoek, Namibia. The WQI provides an overall assessment of water quality by integrating multiple parameters and assigning a single numerical value. The primary objective was to determine the suitability of a potential aquaculture site in the area of the dam based on water quality analysis. To achieve this objective, water samples were collected from two sampling locations (P1 and P9) within Goreangab Dam. These samples were analyzed for various physical, chemical, and biological parameters, including temperature, pH, dissolved oxygen, nutrients, and salinity using standard laboratory techniques. The collected data was then used to calculate the WQI for each sampling point using a software called "Know Your H2O." The results of the analysis showed that the water quality varied at the two sampling points. Samples collected on May 16, 2023, at point 1 had a WQI score of 37, indicating poor water quality, while point 9 had a WQI score of 60, indicating medium water quality. On August 24, 2023, both points (1 and 9) had a WQI score of 42, indicating bad water quality. Based on these findings, it can be concluded that the water in Goreangab Dam is not suitable for use in an aquaculture facility without proper treatment. The results highlight the importance of regular monitoring and mitigation measures to maintain suitable water quality for aquaculture practices. This study's findings have the potential to contribute to the development of sustainable aquaculture practices and the efficient utilization of water resources in the country.

Socio-economic importance and constraints of oyster exploitation in Senegal

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Oyster exploitation is an ancient activity practiced in various regions of Senegal, mainly by women. Today, this activity generates income that meets the most basic needs of the people involved in this sector. The main objective of this study was to assess the importance and socio-economic constraints of oyster farming in Senegal. The study consisted firstly in determining the socio-economic effects of oyster farming on household living conditions, secondly in identifying the sector's constraints, and thirdly in analyzing oyster exploitation methods. To do this, a multi-question questionnaire and an interview guide were used to gather all the necessary information from 173 stakeholders in the Saloum Delta, Casamance, Petite Côte (Joal-Fadiouth) and Dakar. The survey results show that oyster exploitation is expanding with new members, and that operators' income covers most of their needs. They also show that the oyster production sector is evolving with the adoption of new harvesting techniques such as oyster farming, in addition to the natural harvesting of oysters in mangroves. The organization of women into MSEs has lightened the workload and added value to the oysters. However, the sector is facing problems linked mainly to the effects of climate change, over-salination of water and bio-aggressors, which have a considerable impact on oyster quality. The customer base and access to outlets pose serious marketing problems and tend to influence oyster quality.

Juvenile fish recruitment and seed availability insights in the coastal habitats of Kijiweni, Kenya

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Marine and coastal habitats, such as mangroves, seagrasses, and coral reefs, are vital for the abundance and diversity of fish juveniles, which play a critical role in supporting future fish stocks and sustaining fisheries and aquaculture. With a majority of the population relying on subsistence fishing, declining catches due to overfishing have prompted a shift to small-scale aquaculture. Yet, the consistency of seed supplies remains a challenge for its long-term viability. This study aimed to investigate fish juvenile recruitment patterns in these critical habitats and explore solutions for enhancing coastal community welfare and marine resource sustainability. Monthly samplings were conducted in Kijiweni, Kwale County, from August 2021 to August 2022. A total of 244 fish species from 54 families were recorded, with a dominance of Pomacentridae, Sphyraenidae, Apogonidae, Hemiramphidae, and particularly Siganidae (rabbitfishes), a promising mariculture species in the Kenyan coast. Recruitment showed monthly variations, peaking in August 2021 and November 2021, while September 2021 and May 2022 had the lowest juveniles. Notably, the distribution of *Siganus* sp varied seasonally. Seagrass habitats emerged as the top recruitment zones for *Siganus* sp, followed by mangroves and coral reefs. Hydrographic parameters, including temperature and salinity, followed similar patterns to fish juvenile abundance, suggesting their potential influence on fish juvenile recruitment in coastal habitats. This study offers vital understanding of juvenile fish recruitment in key coastal areas, underlining the need for conservation for the sustainability of fisheries, and importantly gives essential advice to small-scale farmers depending on wild seeds about the best times for seed collection.

Public nuisance or latent problem: the human dimensions of harmful algal blooms (HABs) on cage fish farmers and small-scale fishing communities of Lake Victoria basin

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With approximately 40 million inhabitants living within the Lake Victoria Basin and depending on the lake's ecosystem goods and services, the emergence of Harmful Algal Blooms (HABs) portends significant socioeconomic and health challenges through agents such as lake-sourced fish, water and ambient air. While some impacts of HABs on water quality and safety of fisheries resources in the Lake have been documented, human exposure pathways and health risks associated with HABs have not been adequately communicated to primary resource users. Using a mixed methods approach that integrated existing literature with household interviews and a water testing assay, our study assessed the perception of households on HABs vis-a-vis the scientific reality of their presence. Results indicate that there is a dichotomy between indigenous knowledge systems and scientific findings on HABs. While 20% of household drinking water showed contamination at source, most (65%) households still perceived HABs as a public nuisance rather than a latent health problem, an opinion largely shaped by a complete reliance on traditional knowledge systems. Cage culture is still growing in HABs contaminated zones, and household consumption of lake-sourced fish is highest in the riparian communities. Many (70%) households also experienced respiratory illnesses which are related to health impacts of HABs. We recommend a science-based public education strategy for Lake Victoria resource users to mitigate the misconception of HABs created by over-reliance on indigenous knowledge systems.

The critically endangered Jipe tilapia (*Oreochromis jipe*), its hybridization potential under aquaculture conditions and implications for conservation

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Hybridization between introduced and native species can result in the loss of unique genetic resources and may accelerate the risk of extinction. In Kenya, the Nile tilapia (*Oreochromis niloticus*) has been widely introduced to non-native environments for aquaculture and the expansion of capture fisheries. This research seeks to show that the critically endangered *Oreochromis jipe*, found in the trans-boundary Lake Jipe, is under threat due to hybridization with the larger invasive Nile tilapia (*Oreochromis niloticus*) and *Oreochromis esculentus*. To demonstrate potential hybridization and growth in aquaculture conditions, we employed a combination of breeding techniques based on Mendelian principles. We also examined the use of morphometric and meristic characteristics to distinguish hybrids from the parental stock. In conclusion, we find that populations of *O. jipe* are at risk of hybridization with these two introduced species and recommend conservation measures, particularly in the context of aquaculture, to protect this fish species.


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