Sea cucumber aquaculture business potential in Middle East and South-East Asia - Pathways for ecological, social and economic sustainability

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Abstract

Sea cucumbers are delicacy and popular traditional food in South-East Asia especially China, Hong Kong, Singapore, Malaysia and Taiwan. They are also used in traditional Chinese medicine and regarded as a specialty product that falls within the same niche market as other high-value luxury seafood products, including shark fin, fish maw and abalone. Currently more than 50 species of these highly valued bioresources are sold as trepang or Bêche-de-mer, in Asian dried seafood markets. Sea cucumbers are commercially exploited worldwide and the production have expanded in catch and value worldwide during the recent decades.

In Middle East region, important sources of sea cucumber are: Egypt, Oman, Yemen, Iran, Saudi Arabia and Turkey while in South-East Asia, Philippines, Indonesia, Malaysia and Vietnam are the main producers with Hong Kong and Singapore being major export countries. Due to overfishing and unsustainable harvest, the supply of sea cucumber is declining throughout the world especially in Middle East and South-East Asia. The increasing demand for the product has kept prices at attractive levels. Aquaculture of sea cucumber is much needed to offset the rapidly declining source, conserve stocks biodiversity and sustain the ecological, social, and economic benefits of these high-valued marine bioresources.

Keywords: Sea cucumber Aquaculture, Bêche-de-mer, Middle-East, South-East Asia.

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Introduction

Mass exploitation and ill management of sea cucumber fisheries paved the way for loss of this naturally eco engineering resource round the globe. Tropical mari culture of Sea cucumber has promising economical returns and also equally contributing towards natural stock enhancement too. Sand fish (*Holothuria scabra*) exhibit an averaging growth rate 0.75 to 1.25 g per day with a survivability of 60-70% or more. Being detritivores, they inhabit shallow waters and soft sediment regions. Holothuroidea have been economically exploited for a millennium in Indian sub-continent and South East Asia (Indonesia, the Philippines, Conand, 2004), the Middle East was into pearling and shark fins alone with lesser focus upon sea cucumbers. South-East Asia has been the global hub of production of tropical sea cucumbers for Chinese markets. Early research into cultivation methods were notably in India, the Pacific region and China.

The potential for sustainable, profitable and socially equitable, innovative holothurian farming is unlimited in the Asiatic region (Daniel, 2015). Sea cucumbers have immense potential to diversify mariculture industries in the tropics and temperate and strongly mitigate the detrimental effects of mariculture on coastal ecosystems (Purcell *et al.*, 2012).

Sea cucumber fishery and over exploitation

A globally eminent fishery exists for sea cucumber, with a 60 plus species fished actively with major production areas in the north-west and south-west Pacific Ocean (Purcell *et al*., 2012). They are highly at the harsh mercies of local, regional, national, international and transcontinental overfishing with a cyclic boom and bust curves (Dalzell *et al*., 1996; Skewes *et al.,* 2000; Uthicke 2004; Kinch 2005; Toral-Granda 2005; Uthicke and Conand 2005).

Sea cucumber importance in inland coastal aquaculture

Sea cucumbers are the only natural solution for re-mineralizing the wild sediment characteristics and causing an inhibitor effect on aquaculture farm canal sediment re-suspension and assuredly maintaining water quality by filtering pollutants, excess nutrients and sediments through natural means. Sea cucumber as an eco-engineer cut shorts heavy input of externally drawn-in sediment loads. Thus, natural ecoengineering of silt load settling in the aquaculture farm water canals can be biologically controlled. As well known, the Arabian upwelling brings high nutrient seawater to the coastal regions and the wild ocean particulate and soluble P may sorb to suspended solids and settle and this. Mineralized sediment P may also be released to the overlying water. Area specific nutrient regeneration rates by holothurians are in the range of 0.52–5.35 mg m^{-2} day^{-1} N and 0.01–0.47 mg m^{-2} day^{-1} P. The benefits of the sea cucumber in any fluid canal bed zone are overall - Bottom bioturbation and regeneration; sediment re-mineralization; redistribution

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of sediments; boosting symbiotic associations of benthos; influencing healthy seawater chemistry and biotic interactions at sediment-water interface.

Sea cucumber farming potential

Regenerative ecological engineering processes of waterfront properties with Ocean grain digesters – literally referring to the sea cucumbers are highly waiting for a great renaissance in the new millennium. Eco centric marine agronomy with conscientious metrics of monitoring and system efficiency should be the top strategic priority for sea cucumber farmers. We do not need a sandfish food farm with a high dominion by towering corporate giants but a combination of societal traditions with innovations bearing interdisciplinary expertise is exigently sought for. As a new reckoning forward, we need judicious investments that would exclusively support marine agronomical food systems that healthily ensure crop availability, sensible access and crop stability with embedded sustainability all along its life cycle segments. The nexus between economic and environmental benefits demands rational apportioning for a balanced intertidal marine sediment inventory that pays back. “Food security exists when all people, at all times, have physical, [social] and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life” (FAO, 1996).

Sea cucumber aquaculture business – Investment and returns summary (Approximation-based)

The culture of sea cucumber is the best known eco-friendly and sustainable aquaculture in the world, as this aquaculture does not require artificial feeding. They are naturally grown at low density once they leave the hatchery as juveniles. This makes sea cucumber aquaculture more profitable and environmentally friendly. Sea cucumber Consultancy use clean and green Australian hatchery production and grow out technology to produce high grade safe seafood using best environmentally sustainable practice and the latest technology. The medium scale project requirement, profit and expense are summarized in following Table 1.

Sea cucumber Consultancy offers a Full Project Approach for the design, engineering, construction, and operation of advanced sea cucumber farming projects. We operate according to the highest international standards: environmental, health, security, and quality standards. We implement complete production line, from 'farm' to 'fork', adjusted to client-specific site, investment, and country conditions.

Integrated multi-trophic aquaculture – bioremediation

Rethinking Ecosystem Engineers, Nutrient recycling by sea cucumbers is a significant, recently discerned phenomenon, always considered eco-friendly only for the reefs with the conformity in thoughts scientifically that soluble nitrates and phosphates excreted

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by sea cucumbers into surrounding seawater can be absorbed by nearby corals, macroalgae, microalgae, and bacteria and in turn, the nutrient composition of the microalgae and bacteria is enriched, and they can be eaten by the sea cucumber and other deposit feeders, thus forming a recycling loop in the ecosystem (source: Purcell *et al.,* 2016).

Table 1: The medium scale project requirement, profit and expense

Parameters	Investment/ Profit
Project Investment	US$ 3.9 M
Land Requirement for Hatchery Complex	1 Ha seafront Site for the Hatchery Complex
Pond / Lagoon Requirement for Grow out	60 Ha pond area or 100 Ha sea lagoon
Sea cucumber production cost/Kg	US$ 35 - 50
Sea cucumber Wholesale export price/Kg	US$ 145/Kg
Net profit/ Kg	US$ 95/Kg
Average net Profit/Year (From Year 3)	About US$ 3 Million
Full Return of the Investment	Three years from Production
Main export Market	Mainland China, Hong Kong, Singapore, Malaysia
Market Areas	Sea Food, Nutraceutical, Pharmaceutical, Cosmeceuticals, Vaccines, Adjuvants & Immunoglobulins

The benefits from the renaissance and biological engineering-based water quality assurance would be viz., oxygen regenerative capacity of substrata; promotion of natural food web and utilization; bacterial balance of benthos; benthic water chemistry enhancement; shrimp crop calcification support; sediment dissolution absorption; facilitating photosynthesis of symbionts (like photosynthetic bacteria); enhancing naturally bioaugmented benthic community metabolism etc. henceforth, Sea cucumbers introduced into a virgin area and in bioturbation action as principal sediment resource managers form pathways of energy transfer in food chains and buffer acidification equations and reduce organic loading, in a nutshell.

Growing sea cucumbers in consonance with other communal species has drawn immense attention not only for the economic returns but for the environmental burden mitigative benefits as well and widely tested with many aquaculture species viz., bivalves (oysters, scallops, mussels, clams), gastropods (abalones, snails), crustaceans (shrimps, crabs, lobsters), several species of finfish, jellyfish, sea urchins and macroalgae. Henceforth, appropriate futuristic aquaculture engineering

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developmental process engineering knowledge production and sharing has thus proved more and more essential (Zamora *et al.,* 2018). Blanket ban on commercial exploitation helped little or nothing to improve the wild population (Giraspy *et al*., 2012).

All ecological indicators should be pre-conceived to resolve the loci-specific release strategies, survival probability assessment and monitoring. Local environment-dependent animal density requirement in both natural and enhanced systems and its effect on population regulation should then be computed. Carrying capacity assessment gains focus as carrying capacity varies depending on the quality of sediment and culture conditions. Development of appropriate site-specific release strategies need to be adopted. Parameterization for all local environmental processes and hydrodynamic properties for adoptability of culture and management systems then follows. Eco physiological behavior of cultured organisms needs to be duly logged in. Discerning the framework of influence of natural biogeochemical fluxes over time on the integrated nutritional pathways between IMTA clusters must also be accomplished. Local hydrodynamic process-watch on exchange rates dependent on advection by water currents or turbulent diffusion has to be prior-defined. Assessment of spare habitat capacities in the system must also be done in parallel for maximum fisheries enhancement in to-be-restored / rehabilitated habitats. Eco trophic efficiency assessment should also categorically follow.

As IMTA practices strive to facilitate nutrient recycling and optimize co-culture productivity through bioremediation, to achieve this, biomass stocking densities of the cultured sea cucumber species must be optimized with time progression by means of ecosystem models. The bio deposition rate of nutrients in the culture mesocosm and sediments should be tracked through periodical estimations. Roles of benthic microalgae, organic matter, microorganisms (e.g. bacteria), and sediment grain size and so on, ought to be examined. Protection from predators until the normal diel burrowing habit is established is highly put into functional effect. Stress watch must be performed on real-time basis as the factors for poor recovery of juveniles in sea-based mari culture may include predation, transport stress, freshwater inundation, being washed away by strong currents, escape from enclosures and/or extreme weather inputs.

Population modelling approaches also need to be performed to predict recapture rates and yields at different levels of releases and harvests. Self-replenishing population status check is consistently done with time. Predation-Immune zones (PIZs) are earmarked to protect the subsequently released animal batches until they and their progeny have replenished the target population. Immune-pockets modelling are also a practical way of identifying the invisible areas needed to protect further released sea cucumbers as they disperse throughout their life span. Site-specific knowledge of the key predators of cultured sea cucumbers would enable

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better mitigation strategies. The benefit of caging newly released juveniles may extend beyond simple predator exclusion if cages provide naïve, hatchery-produced juveniles a greater chance to acclimate to the wild and normalize behaviors such as seeking shelter, predator avoidance and feeding. Sea cucumbers in bioturbation action as sediment resource managers form pathways of energy transfer in food chains buffering acidification and reduced organic loading. Bio filming detritus and bioprotein particulate deposits from oysters prove to be extra nourishment for the sea cucumbers and projecting a confirmed integrative strategy for Holothurians under oyster grow out farms.

Biodiversity enrichment and ecological resilience to climate change

Potential influence of sea cucumbers on local water chemistry entails the atmospheric (atm) CO_2 dissolving in seawater (aq, aqueous), lowering pH, a process called ocean acidification, which also lowers the saturation stage of carbonate minerals (Kleypas *et al*., 1999, Branch *et al*., 2013). Carbonate sands ingested by sea cucumbers (e.g. *Stichopus herrmanni*) are partially dissolved in the gut and the animals also release ammonia, resulting in an increase in pH and total alkalinity of surrounding water (Schneider *et al*., 2011, 2013). Thus, the metabolic activity of sea cucumbers helps buffer the effects of ocean acidification at local scales and, along with providing nutrients to promote photosynthesis of numerous symbionts in nature (Purcell *et al*., 2016).

For an added enlightenment on the natural wild Ocean contextual setting, willful cultured release of Sea cucumbers into earmarked Marine Protected Areas (MPAs) have ensured reciprocal trophic relationships; added value to the benthic food chain ; being active mud-suspension feeders bioremediate the bottoms; general promotion of habitat health; amplifying biodiversity; supporting other productive food chains; nutrient recycling and sediment cleaning; ecosystem health and productivity; increased species richness (symbioses); assuring a carbonate-rich habitat balancing sand : detritus particles; reduction of marine stressor effects; serving as hosts to marine parasites; contributing food sources of benthic adult fishes.

Blue economy sustainability

A multi-faceted vision of sea cucumbers on multifarious lines are principally viz., commerce, educational programs, ecological restoration practices, bait utility in sport fishing, polyculture initiatives, effluent treatment exercises, derelict marshland Salinas rehabilitation, allelopathic induction and crustacean immunity control, ornamental objectives for marine vivarium, bioassay candidate organism in marine eco traceability research, ecological habitat health metrics validation, coral cover regeneration, shoreline marine sediment re-fertilization, abandoned rig platform bioaugmentation and natural reserve park formation for coral cover resumption and fish

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recruitment values, as bio reference for ocean stress physiology indices, for biologics enhancement for diseases of unknown etiology, as anti-ageing manna and elixir for the sick, infirm and convalescent etc. Sea cucumber farms can be diversified from small farmer to moderate farmer to community farmers to corporate farmers or to private sea-edge estates development for floating islands and leisure fishing, marine reserve farming under national interests or Environmental regulatory programs for an aqua greening natural stock enhancement.

Summary

We do not need killer-minded, hit-and-run farm operators for posterity. Looking beyond on the next three-decadal perspective, the futuristic policies should draw the growing environmental energy and drive of new and young entrepreneurs who can shape and influencing their destiny on a renewable approach through community farming and not on precision farming for the elite diner's plate at the cost of Planet-A (without a Planet-B option). International Wildlife agencies, Nature Conservancy organizations, regional Ocean health programs, multi-national research institutions, sub-Ocean regulatory bodies, environmental foundations should fund instruments that empower resource owners and virtually disarm the venture-capitalistic Lords. Governments should also continue officiating on their overall regulatory roles but equally vouching for incubation of private-public sector partnerships between coastal resource owners and businesses for harvesting the symbolic golden egg every day on healthy lines without disturbing natural ecological balancing powers. Continually assured sea cucumber stock stability over future timeline, insured societal access and slow-progressive utilization of resources is the need of this hour. The much-needed interfaces between seaweed farmers, oyster farmers and sea cucumber farmers sound imperative and are a wishful dreaming task beyond. Solicited contributions to the sustenance and fruition of sea cucumbers is both on regional, national and international focus by developing a holistic framework appreciating the multifaceted dimensions of coastal sustainability (be it environmental, economic, social or cultural) spawning the participation with a rational enjoyment of stakeholders at all levels from regulators, moderators, producers, investors, suppliers, processors, auditors, bench markers, vendors, scientists, educators, students and the consumers which is a distinct frontier ahead. Propping up a Coastal Health Authority (CHA) and providing the underpinning administrative and institutional federal support mechanisms to enrich the natural stocks of sea bed patrollers as real time 'sand inching agents' and as a proclaimed 'King of seabed ecosystem' are all within reach, and possible means ahead.

With our two foundational decades of pro commercial Holothurian experiences in Australia, Philippines, Maldives, Maldives, Saudi Arabia, Mexico, Ecuador and India, we as Sea cucumber Aquaculture consultancy, have been

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actively extending technical assistance at mega levels for an ecologically regenerative, natural forces-resilient, sustainable farming systems. Instead of blindly persisting on the current marine food web trajectories in the Arabian Gulf, before the storm of marine ecosystem problems get morphed into emergencies, it is good to propose and act fast on intelligent eco-bio-engineering of Arabian reef systems for more economic growth, more fish wealth extraction, more surveillance of the edge of the seas and more marine policy control through coordinated channeling of scientific / technological knowledge into Ocean stress physiology restoration mission-critical systems and operations. With the Arabian sea shelves in a fast decline process, a hurried lead grappling to balance efforts/ energy between Holothurian stock enhancement business and adapting to climate change is sure to save and nurture coral propagation in the natural seas beyond the timeline for posterity.

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