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STUDY ON THE POTENTIAL OF FISH FARMING IN THE CARIBBEAN

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Study on the Potential of Fish Farming in the Caribbean

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Contents

Glossary of Acronyms

CARICOM – Caribbean Community

CARIFORUM - Caribbean Forum of African, Caribbean and Pacific States

CBOs – Community Based Organizations

CRFM – Caribbean Regional Fisheries Mechanism

EU – European Union

FAO – Food and Agriculture Organization

HACCP – Hazard Analysis Critical Control Point

ISO - International Organization for Standardization

IRA – Import Risk Analysis

MDGs – Millennium Development Goals

NGOs – Non Government Organizations

OHS – Occupational Health Safety

PUD – Peeled Un-deveined

R&D – Research and Development

US – United States of America

Glossary of Terms

Ancillary Infrastructure - means all the infrastructure and equipment associated with the husbandry operations from larval production to marketing.

Aquaculture - the farming of aquatic organisms in inland and coastal areas, involving intervention in the rearing process to enhance production and the individual or corporate ownership of the stock being cultivated.

Broodstock - specimen or species, either as eggs, juveniles, or adults, from which a first or subsequent generation may be produced in captivity, whether for growing as aquaculture or for release to the wild for stock enhancement.

Cage - rearing facility enclosed on the bottom as well as on the sides by wooden, mesh or net screens. It allows natural water exchange through the lateral sides and in most cases below the cage.

Eutrophication: is the response of an ecosystem to the addition of artificial or natural substances, such as nitrates and phosphates, through fertilizers or sewage, to an aquatic system

Extensive culture - production system characterized by (i) a low degree of control (e.g. of environment, nutrition, predators, competitors, disease agents); (ii) low initial costs, low-level technology, and low production efficiency (yielding no more than 500 kg/ha/yr); (iii) high dependence on local climate and water quality; use of natural water bodies (e.g. lagoons, bays, embayments) and of natural often unspecified food organisms.

Fingerling - related to any fish from advanced fry to the age of one year from date of hatching regardless of size; the term is, however, not rigidly defined.

Husbandry – management of captive animals to enhance reproduction, growth and health.

Hyper-intensive - system of culture characterized by a production averaging more than 200 tonnes/ha/yr, by the use of a complete (processed) fully formulated feed to meet all diet requirements of the species, stocking with hatchery-reared fry, no fertilisers used, full predator and anti-theft precautions taken, highly co-ordinated and controlled regimes, usually pumped or gravity supplied water or cage-based, full use of water exchange and aeration with increasing levels of control over supply and quality, usually in flowing water ponds, cage systems, or tanks and raceways.

Intensive - system of culture characterized by (i) a production of up to 200 tonnes/ha/yr; (ii) a high degree of control; (iii) high initial costs, high-level technology, and high production efficiency; (iv) tendency towards increased independence of local climate and water quality; (v) use of man-made culture systems.

Mycotoxin - a toxic substance produced by a fungus and especially a mold.

Ocean ranching - ranching carried out in the ocean.

Pathogen - any organism, which in living on or within another organism (the host) causes disease in the host.

Raft - a floating structure built of wood or bamboo, equipped with floats if necessary and safely anchored in a protected coastal area; may be used for the suspended culture of mussels or oysters.

Ranching - commercial raising of animals, mainly for human consumption, under extensive production systems, within controlled boundaries and paddocks (e.g. in agriculture), or in open space (oceans, lakes) where they grow using natural food supplies. In fisheries: stocking usually of juvenile finfish, crustaceans or molluscs from culture facilities for growth to market size or to maturity in the natural environment.

Recirculation System – system designed for the reuse of water within an aquaculture facility.

Rope Culture - type of mollusc suspended culture in which the cultured species are grown on hanging ropes.

Semi intensive - systems of culture characterized by a production of 2 to 20 tonnes/ha/yr, which are dependent largely on natural food, which is augmented by fertilization or complemented by use of supplementary feed, stocking with hatchery-reared fry, regular use of fertilisers, some water exchange or aeration, often pumped or gravity supplied water, and normally in improved ponds, some enclosures, or simple cage systems.

Sustainable - of, relating to, or being a method of harvesting or using a resource so that the resource is not depleted or permanently damaged

Sustainable Development - Development that meets the needs of the present without compromising the ability of future generations to meet their own needs

EXECUTIVE SUMMARY

Background:

The Caribbean, for the purposes of this study is a geopolitical construct that refers to CARICOM/CARIFORUM Group of Countries, which comprises most of the former British Colonies and current dependencies, as well as the former French and Spanish protectorates of Haiti and the Dominican Republic, and the former Dutch Colony of Suriname. The former British Colonies and dependencies include: Barbados, Belize, Dominica, Grenada, Guyana, Jamaica, St. Lucia, St. Kitts Nevis and Trinidad and Tobago.

The Caribbean Sea itself covers over 2.6 million km2. The geographical extent of the seas and the diversity and abundance of fishlife residing therein has provided the peoples and nations of the CARICOM and CARIFORUM Caribbean with opportunities for employment, food and nutritional security, income generation, trade and in general social and economic development. The association of the peoples of the CARICOM and CARIFORUM Grouping of Countries with fish production from the sea has been a well-established and long-standing tradition.

There has been a definitive commitment by a number of Governments in the Caribbean since the late 1970's and early 1980's to extend fish production from Capture Fishery based sources to aquaculture or fish-farming. This includes efforts by the Bahamas, Belize, Dominican Republic, Guyana, Jamaica, Haiti, St. Lucia, Suriname, and Trinidad and Tobago.

The countries in the CARICOM/CARIFORUM Region are also at differing stages of development. The most advanced countries in terms of aquaculture development have been characterized as being at the 'Commercial' Phase of Development - these are Belize and Jamaica (See Table 8). The countries at the intermediate stage of growth have been characterized as being at the 'Developing' Phase of Development - these are: the Dominican Republic, Guyana, Haiti and Suriname (See Table 8). The countries that are at the initial stage of growth have been characterized as being at the 'Experimental' Phase of Development – these are the remaining countries where some aquaculture activities have taken place and include: the Bahamas, Barbados, Dominica, Grenada, St. Lucia, St. Vincent, St. Kitts and Nevis, and Trinidad and Tobago.

Although the potentials for aquaculture development in the CARICOM/CARIFORUM Region have not been systematically and comprehensively assessed, it has been surmised that the scope for development is tremendous. This is based in large measure on the primary resource assets of the region. The CARICOM/CARIFORUM is richly endowed with the full suite of primary natural resources that would allow for the culturing of a range of species in a diverse array of husbandry infrastructure, to suit the multiplicity of the culture environments.

Contribution of Sustainable Fish Farming to Food and Nutrition Security:

Aquaculture has been one of the fastest growing food production sectors globally. This trend is expected to continue and even increase through to the year 2050. Between the current time and 2050, aquaculture is expected to fill the deficit in demand for fish for human consumption. This situation has arisen as a function of two (2) primary drivers: In the **first** instance the demand for fish will continue to expand as a function of population growth and improvement in the standard of living, especially for the working class citizenry – in the **second** instance production from capture fisheries or traditional fishing has peaked with only limited scope for expansion while the potential for the growth in aquaculture is great. It has been envisioned that expansion of aquaculture production can play a significant role in increasing overall fish and seafood supply in the CARICOM/CARIFORUM region.

Any future growth in aquaculture in the Caribbean however will need to be considered within the broader context of sustainability in all its dimensions, viz: the environmental, social and economic components. This will entail the building of human capacity and institutions, the generation of an

overarching governance structure, sustaining political commitment and in general the wise stewardship of the primary and secondary resources and services upon which the industry depends. This will of course entail the building of useful and constructive partnerships.

The purpose of this initiative is to seek to further the cause of sustainable aquaculture development within the context of the 'Fish-farming and the Blue Economy'. Apart from focusing on the status and potentials for aquaculture development in the Caribbean, this effort will also result in an articulation of the drivers that would be necessary for moving the region forward in its commitment to develop aquaculture.

Contribution of Sustainable Fish Farming to Socio-Economic Development:

The overall Fisheries Sector provided direct employment for 182,000 people in the CARIFORUM Region in 2010 As a general note the husbandry aspects of aquaculture are less labour intensive than for crop or livestock agriculture for a given quantum of biomass produced.

Apart from the immediate husbandry aspects of aquaculture, there is significant labour associated with the processing aspects of aquaculture.

In the CARICOM/CARIFORUM Caribbean where populations are generally youthful and where unemployment is a major challenge, the opportunities created by aquaculture could be meaningful, especially given that much of the demand would be for 'skilled labour'.

The employment of women and youth in aquaculture is reflective of the general structure of the population. The majority of the population in the Caribbean is under fifty (50) years of age. In Belize, Haiti and Guyana where much of the commercial aquaculture activity takes place inhabitants under fifteen (15) years of age ranges from 31 to 36% of the population.

There is generally the greater recruitment of men in commercial aquaculture enterprises at the hands-on and semi-skilled levels. This includes: the feeding, harvesting, repair and maintenance work on the farm.

Women dominate the processing aspects of aquaculture. The experience in commercial aquaculture in the region is that the employment of women in these areas has been significant in relation to the issue of income generation and poverty reduction.

In general, there are no elements of discrimination or institutional barriers which place women and youths at a disadvantage in the Caribbean. The region as a general rule is largely compliant with international instruments such as the Millennium Development Goals that speaks to these issues.

The small-scale participation in aquaculture in the region in regards to food production is related mainly to subsistence and experimental aquaculture (See Tables 1A and 1B). Small scale aquaculture in the Caribbean is faced with a number of challenges. The challenges range from technical and husbandry-related issues to marketing and quality assurance concerns.

Addressing the Long-term Sustainability of the Sector

The sustainable development of aquaculture requires an approach which recognizes the three (3) pillars of sustainability and the constraints and challenges associated therewith. It also requires an elucidation of the responses that would be necessary to resolve and ameliorate the challenges associated with these constraints and challenges.

Effective responses to address the ecological challenges of sustainability at the broad sector and national levels include:

- Increasing investment in technological innovation and transfer in the areas of breeding and genetics, disease control and feed and nutrition
- Use of Spatial Planning and Zoning to guide aquaculture development at the landscape and seascape levels
- Shifting Development Incentives to reward improvements in productivity and environmental performance

Effective responses in relation to social aspects of sustainability include:

- Implementation of pilot scale project based on viable economic models
- Use alternate energy sources such as wind, hydro and solar
- Capacity building in the areas of governance and policy development, technical husbandry processes and procedures and extension methodologies

Responses in relation to the economical aspects of aquaculture include:

- Determination of total cost of development which needs to be incorporated into the transactional costs of the sector
- Acquisition of stock insurance against diseases and natural disasters
- Development of risk assessments and traceability protocols and regulations

Areas where support would be needed over the next five years

The areas of support identified over the next 5 years include the:

- Strengthening of governance frameworks
- Building of capacity at various levels across a range of stakeholder groups
- Strengthening of data gathering and information exchange in regards to the performance of the sector

- Assisting aquaculture suitability surveys
- Strengthening credit regimes to assist small and medium-scale producers
- Improving regional production and access to lower cost, good quality feeds
- Reducing energy cost, cost of land and access to land for aquaculture
- Improving marketing including access to regional and international markets
- Improving fish health and food safety systems

This is to be accomplished through greater involvement of the private sector, strengthened partnerships and cooperation between the CARIFORUM Member States and its international development partners, as well as improved inter-regional cooperation among ACP regions. . The CARIFORUM Governments are to provide in-country logistical support and personnel presence while the international partners are to provide technical and capital assistance.

The proposed programme areas identified for external participation and support have been premised on the assumption the various nation states are at varying levels of development and the selection of any given state to participate is based on identified needs.

1. BACKGROUND

The Caribbean as a geopolitical construct refers to a relative expansive sea space interspersed and bounded by insular states and continental countries. The ocean space of the Caribbean covers 2.6 million km2.

The insular states are distributed as an island arc system in the south-eastern and eastern reaches of the ocean environment and are dispersed irregularly in the north-eastern margins of the area. The south-eastern islands of the island arc are referred to as the Windward Islands and those distributed in the eastern reaches of the area are referred to as the Leeward Islands (See Annex II, Fig. 1). The islands in the north-eastern quadrat of the Caribbean comprises the Bahamas and the Turks and Caicos Islands (See Annex II, Fig. 1).

The islands of the Caribbean are also subdivided into the Lesser Antilles and the Greater Antilles. This division is done on the basis of size or landmass. The Greater Antilles is comprised of Cuba, Jamaica, Hispaniola (Haiti and the Dominican Republic) and Puerto Rico (See Annex II, Fig. 1).

The western and south-western margins of the Caribbean are bounded by the continental countries of the Central American land bridge and the nations of north-eastern South America. The latter is comprised of Suriname, Guyana and Venezuela (See Fig. 1). Belize, Honduras and Nicaragua form the portion of the continental landmass that delimits the north-western Caribbean Sea (See Annex II, Fig. 1).

The Caribbean is further subdivided along historical, cultural and political lines into CARICOM and CARIFORUM Caribbean. The CARICOM grouping is comprised of 15 Full Member States, 5 Associate Members and 7 observers. Full membership in CARICOM comprises: Antigua and Barbuda, the Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, Montserrat, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname and Trinidad and Tobago (See Annex II, Fig. 2). The Associate Members of CARICOM are: Anguilla, Bermuda, the British Virgin Islands, the Cayman Islands, and the Turks and Caicos Islands (See Annex II, Fig. 2). The CARIFORUM Member States are Antigua and Barbuda, the Bahamas, Barbados, Belize, Dominica, Dominican Republic, Grenada, Guyana, Haiti, Jamaica, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname and Trinidad and Tobago. (See Annex II, Fig. 1).

The geographical extent of the seas and the diversity and abundance of fishlife residing therein has provided the peoples and nations of the CARICOM and CARIFORUM Caribbean with opportunities for employment, food and nutritional security, income generation, trade and in general social and economic development. The association of the peoples of the CARICOM and CARIFORUM Grouping of Countries with fish production from the seas and to a lesser extent inland water bodies have been significant in scope and long-standing in historical terms. Since the late 1970's and early 1980's there has been a definitive commitment and industry in extending fish production from Capture Fishery based circumstances to husbandry or aquaculture situations. This interest in farmed fish production has been broad in geographic scope and diverse in terms of the commodities or species being farmed: Organized and purpose-driven aquaculture has only been attempted in a few t of the States and territories of the Caribbean. These range from established operations in Belize, Jamaica, Haiti and Dominican Republic to smaller initiatives in St. Kitts and Nevis, St. Lucia and Suriname (See Annex II, Tables 1A & 1B).

Efforts in aquaculture development in the CARICOM/CARIFORUM Caribbean have been punctuated by political commitment and support at both the national levels and collectively at the regional level. At the national level political commitment and support is reflected in the articulation and implementation of policy, development plans, legislation projects and support services such as extension, education and outreach, as well as inspection and permitting functions. At the regional level the CARICOM Member States have developed and adopted a 'Common Fisheries Policy' which pronounces in its mission statement'…the sustainable development of fishing and aquaculture…'

Provisions have also been made at regional level in the CRFM Strategic Plan 2013 - 2021 for the development of aquaculture. Objective D focuses on aquaculture development as a means to increase fish supplies.

The purpose of this initiative is to seek to further the cause of sustainable aquaculture development within the context of the 'Fish-farming and the Blue Economy'. Apart from focusing on the status and potential for aquaculture development in the Caribbean, this effort will also address the drivers that would be necessary for moving the region forward in its commitment to develop aquaculture and realize social and economic benefits to be derived therefrom.

The structure and content of this report is guided by the TOR outlined in Annex I. The outline adopted has allowed for a comprehensive and informed treatment of the potential of aquaculture in the Caribbean. The methodology adopted entailed a literature review and synthesis supplemented by information from the States requested by the CRFM Secretariat (See Annex III).

2. SIGNIFICANCE OF FISH-FARMING SECTOR IN THE CARIBBEAN

The issue of 'Governance' is one of the recurrent issues raised at various fora in regards to the development of the aquaculture industry. The implied lack of regulatory leadership of the industry infers not only the political commitment that would be necessary, but also the policy direction and planning and legislation as well as the financial and material resource commitment from the public sector.

In terms of political commitment, this has been made at both the aggregate regional level of the CARICOM/CARIFORUM Grouping of countries, as well as at the level of various nation states within the region. At the regional level apart from the Common Fisheries Policy endorsed by the Ministerial Council of CRFM Member States in 2011, aquaculture development has also been a stated goal in the Second CRFM Strategic Plan 2013 – 2021.

In the Second CRFM Strategic Plan aquaculture development is to be realized through:

- Adopting an ecosystems approach to development
- Establishing a Regional Working Group
- Adopting an enabling policy and legal framework
- Developing and implementing voluntary guidelines and best management practices

At the national level most of the Governments have made some decisions related to the governance of the sector. This is in the form of either a stated policy, strategy or sector development plan, as well as in regard to enactment of legislation (See Annex II Table 9). Administrative support in terms of permitting functions and advisory service are also a subset of the Public Sector response. Generally however only a few of the National Governments had a specific, purpose-driven policy, strategy or development plan and legislation for the industry.

The Governments with official politically endorsed national policies included: Dominica, Dominica Republic, Grenada, Guyana, Jamaica, St. Vincent and Trinidad and Tobago (See Annex II Table 9). The Government with the most comprehensive and integrated National Development Plan for the aquaculture industry is St. Lucia (See Annex II Table 9). The structure and content of this Development Plan would make it an effective model for the region.

Although the various elements of public governance exists throughout the various states and territories in the region, they are in many cases not integrated or singularly identified with the development of the sector: The responses are also lacking in the depth and content that would be necessary or relevant to the development of the sector. The classical response would generally relate to some general provisions in the Fisheries Act authorizing the relevant Minister to enact Regulations relating to the industry.

Some of the other responses relevant to the governance of the industry included the granting of licenses for the operation of aquaculture facilities (See Annex II Table 9). Governments are generally involved with the issuance of permits for the importation of aquaculture stocks. This, for the most part, relates to broodstocks and seedstocks. Follow-up inspections have also been a part of the response in a few cases.

Governments throughout the CARICOM/CARIFORUM are also generally charged with offering extension services and in general technical advisory support (See Annex II Table 9).

Aquaculture in terms of public governance is generally treated as a sub-set of Fisheries Administrations. As a function of this arrangement, legislation and policies are usually subsumed under the jurisdiction of Chief Fisheries Officers or their equivalents.

2.1 Trends in production and trade

2.1.a Main Farmed Species

The species being farmed throughout the CARICOM/CARIFORUM Caribbean can be subdivided into three (3) main groups, viz, those that are the focus of:

- fully developed commercial enterprise or that are indeed in the process of being 'pilot tested' for full commercial scale operations;
- rural development and poverty alleviation initiatives, and;
- informal diversification schemes of farmers willing to venture into alternate agro-production activities.

The species that have been deployed in industrial oriented aquaculture operations are those that are fairly ubiquitous to culture situations across the tropics and sub-tropics. In the Caribbean these have been limited to the Whiteleg Shrimp (*Litopenaeus vannamei*), and the Nile Tilapia (*Oreochromis niloticus*) [See Annex II Tables 2 and 10]. The occurrence of these species under culture conditions relates to Belize, Jamaica, Dominican Republic, Guyana and Suriname (See Annex II Table 2).

Those species that are under commercial experimentation in the region include: the Cobia (*Rachycentron canadum*), the Pompano (*Trachionotus carolinus*), the Dolphinfish (*Coryphaenea hippurus*) and the Red Drum (*Sciaenops ocellatus*) [See Annex II Table 10]. These species relate to operations in Belize and the Dominican Republic (See Annex II Table 2).

Those species that have been deployed in projects connected with rural development and poverty alleviation includes the Mangrove Oyster (*Crassostrea rhizophorea*), Sea Moss (*Gracilaria spp.*) and the Baysnook (*Petenia splendida*) [See Annex II Table 10].

Those species associated farmers who are willing to venture into informal agriculture or fisheries diversification schemes are largely related to indigenous and locally occuring species. These include the Tambaqui (*Colossoma macroporum*), the Bashaw (*Micropogonias furnieri*), the Lukanani (C*hicla ocellaris*) and the Cascadura (*Hoplosternum littorale*) [See Annex II Table 10].

The locally occurring Caribbean White Shrimp (*Penaeus schmitti*) and the Mexican Brown Shrimp (*Penaeus aztecus*) are also a part of the species assemblage associated with informal agriculture diversification (See Annex II Tables 2 & 10).

A number of the species outlined in Table 10 (Annex II), transcend two (2) or more categories. These include for example the Nile Tilapia (*Oreochromis niloticus*) and the Baysnook (*Petenia splendida*). The Nile Tilapia (*Oreochromis niloticus*) has been both a candidate for fully developed commercial operations as well as a candidate for informal diversification schemes. In like manner the Baysnook (*Petenia splendida*) is both a candidate for rural development and poverty alleviation, as well as informal agro-production diversification scheme.

Table 10 represents the full portfolio of species being currently cultured or alternately most recently farmed in the CARICOM/CARIFORUM Caribbean. It should be noted from Table 10 (Annex II), which is a synthesis based on the value judgement of the author, that not all the species being cultured are at the same level of readiness for successful commercial culture. This is particularly relevant to those species that are locally occurring which have largely been the focus of informal diversification schemes. These efforts have been equally characterized as 'backyard aquaculture', which infers that they are on a subsistence scale and that they are not driven by science. The species of relevance include the Tambaqui (*Colossoma macroporum*), the Bashaw (*Micropogonias furnieri*), the Lukanani (C*hicla ocellaris*), the Cascadura (*Hoplosternum littorale*) and the bay Snook (*Petenia splendida*) [See Annex II Table 10].

2.1.b Main Producing Countries

There has been a great diversity of experiences in the CARICOM/CARIFORUM Region when it comes to the stage of succession or development of the aquaculture industry. Much of the attempts have been characterized as 'experimental' and 'subsistence' (See Annex II Tables 1A & 1B) and a number of these initiatives have met with failure and currently no longer exist.

The countries associated with the production of aquaculture commodities in any significant quantum are those that have been categorized as either being at the 'Commercial' Stage of Development or at the 'Experimental' Stage of Development (See Table 8). These countries are in general either producing that quantum of the particular commodity for a relatively large domestic market and/or for intra-regional trade, or for exportation outside of the CARICOM/CARIFORUM Region. The countries of relevance in declining order of magnitude are: Belize, Jamaica, Guyana, Haiti, the Dominican Republic and Suriname (See Annex II Table 5 and Fig. 4). The main commodities that are produced and traded in significant quantities are the Whiteleg Shrimp (*Litopenaeus vannamei*) and the Nile Tilapia (*Oreochromis niloticus*).

There has also been appreciable variation in the CARICOM/CARIFORUM Region in terms of the culture technology and environment. Much of the industrial or commercial scale activities have been in regards to semi-intensive and intensive husbandry regimes (See Annex II Table 3). This has been the case for both Marine Shrimp Farming and Tilapia Culture. In Belize, production trends have mirrored global experiences where there has been an increasing intensification of culture within both the semi-intensive and intensive regimes in recent times. In this regard production practices in a number of instances have succeeded from intensive culture to hyper-intensive production regimes (See Annex II Table 3). The production infrastructure has shifted from relatively large levied earthen ponds (20 – 25 acres) to polymer-lined aeration assisted recirculation systems (See Annex II Table 3).

The production trends in Jamaica have been noticeably different from those in Belize. In Jamaica the production of Tilapia has declined over the last seven (7) years from 5,000 MT per annum to 500 MT (Pers. Comm. A. Smikel). This has been as a result of the contraction in prices on the international market brought about by the most recent global recession, difficulty meeting export market standards and the lack of competitiveness on the produce in said market-place (Pers. Comm. A. Smikel). The latter is a function of high energy costs and to a lesser extent cost and quality of feed (Pers. Comm. A. Smikle). The cost of imported inputs has been exacerbated by the declining value of the Jamaican dollar against the US dollar (Pers. Comm. A. Smikel). There was a gradual concentration of aquaculture production and marketing in one company in Jamaica over the past 20 years. In 2009 approximately 120 of the estimated 200 fish farms in Jamaica were contracted by this single farm, Aquaculture Jamaica Limited, a subsidiary of the Jamaica Broiler Group of Companies (Jamaica Trade and Invest, 2009). The decision of this company to terminate its aquaculture operation has contributed significantly to the observed sharp decline in the industry in Jamaica.

In terms of the diversity of technology and culture environment, there have been significant efforts in the cage culture of Cobia (See Annex II Table 2) in Belize between 2004 – 2009. There have also been similar experiences with the species in the Dominican Republic in recent times (See Annex II Table 2).

There have also been research efforts in the past in marine cage culture technology with the Mutton Snapper in Martinique by the French Research Institute for Exploitation of the Sea (IFREMER).

The raft culture of the Mangrove Oyster (*Crassostrea rhizophorea*) has been practiced on a limited experimental scale in Jamaica. The long-line or rope culture of Sea Moss (*Gracilaria spp.*) has also been practiced on a limited commercial basis in St. Lucia (See Annex II Tables 2).

The Extensive Culture of a number of native fin-fish stocks has also been practiced in Guyana for some time now. This has succeeded into the present. The practice is based on the breaching of the sea defenses and the flooding of channels and agriculture fields on the in-coming tide. The practice focuses on a number of indigenous and locally occurring finfish and marine shrimp species such as Hassar (*Micropogonias furnieri)* and Lukanani (*Chicla ocellaris*), Cascadura (*Hoplosternum littorale*) the Gray Mullet (*Mugil cephalus*), the Caribbean White Shrimp (*Penaeus schmitti*) and the Mexican Brown Shrimp (*Penaeus aztecus*) [See Annex II Tables 2 & 10].

The diversity or mixed experience in aquaculture development is perhaps most significantly reflected in the different stages of development or succession realized by the various countries. The countries where aquaculture is most developed are Belize and Jamaica. These two (2) countries have been categorized as realizing full commercial development (See Annex II Table 8). This is reflected in the aquaculture product succession cycle and the volume of production over time. The main farmed commodity in Belize progressed through the 'introductory', 'growth' phase and 'maturity' stage, and is now at the point of 'stabilization' of the industry (See Annex II Fig. 5 & Table 8).

As suggested by the growth curve, the shrimp farming industry in Belize has experienced some contractions between 2005 – 2010 as a consequence of pathogenic disease problems, low price regimes on the export market and high input costs, especially energy and feed costs. The industry is now in full recovery in Belize with the rebound in demand and prices on the international market.

The experience in Jamaica for Tilapia shares many commonalities to that for shrimp farming in Belize. The primary drivers for the contraction in the industry in Jamaica have been high energy costs and feed prices as well as competition on the domestic market from cheap imports from Asia. This is mainly in the form of 'basa' or *Pangasius spp.* fillets from Vietnam.

As previously mentioned the advanced stage of succession in aquaculture for Belize and Jamaica is also indicated from annual production volumes. Between 2000 and 2011 the cumulative production volume from aquaculture was 71,044 MT for Belize while that for Jamaica was 52,123 MT (See Annex II Fig. 4). The next largest aquaculture production was 17,089 MT by the Dominican Republic (See Annex II Fig. 4).

In 2011 aquaculture production in Belize amounted to 5,290 MT while that in Jamaica was 5,141 MT (See Annex II Table 5). Those countries in which aquaculture development is progressing at an appreciable rate have been categorized as being at the 'Developing' Stage (See Annex II Table 8). These countries include: the Dominican Republic, Guyana, Haiti and Suriname (See Annex II Table 8). At this stage of development there is a dedicated focus to promote private investment, and to develop the supporting services and infrastructure and legislation (See Annex II Table 8). At this stage there is also an upswing in production. This is seen for the cumulative production of aquaculture in the Dominican Republic between 2000 – 2011 that amounted to 17089 MT (See Annex II Fig. 4). Aquaculture production peaked at 1,097 MT in 2004 but declined sharply in 2009 to 240 MT due mainly to a decline in marine shrimp production (CONAPROPE e IDIAF, 2010),

Significant production was also realized for Haiti and Guyana for 2011 which amounted to 511 MT and 400 MT respectively (See Annex II Table 5).

Smallscale, family oriented commecially viable aquaponics operations have been established in a number of countries including, Guyana, Belize, Trinidad and Tobago, The Bahamas, Barbados and the United States Virgin Islands. These farms typically integrate the farming of tilapia with the growing of vegetables

using waste from the fish as fertilizer and are particularly suitable in areas where land space and fresh water resources are limited. The University of the Virgin Islands has been doing research and teaching in aquaponic for several years, and runs a training course in Tilapia and vegetable aquaponics.

All of the other countries in the CARICOM/CARIFORUM Grouping that have been classified at the 'Experimental' stage of development are in the Lesser Antilles (See Annex II Table 8 and Fig. 1). The exception would be the Turks and Caicos Islands where the farming of the Queen Conch (*Strombus gigas*) at a commercial scale was fully developed. However, this farm closed in 2012.

The annual production for aquaculture in the CARICOM/CARIFORUM Region was 11,000 MT for 2011 (See Annex II Table 6).

The primary drivers of production in these countries are related to the macro-economic goals of: foreign exchange earnings, employment and income generation. These goals are either stated or implied across the region.

2.1.c Main Markets and Quality and Food Safety Standards

Although significant portions of the aquaculture commodities produced within the CARICOM/CARIFORUM Region are consumed intra-regionally, the majority is exported out of the region. The main commodities produced are marine shrimp and Tilapia: The main markets for marine shrimp in declining order of magnitude are the United States, Mexico and the European Union. Most of the farmed shrimps destined for the US Market and Mexico originated from Belize, the prime producer of this commodity in the region.

Farmed shrimp production going into the EU Market from the region originated from Belize and Suriname, however, the latter has not been a factor in recent times with the quality assurance challenges associated with the produce from that destination and the subsequent commercial failure of the major producers in the country.

The intra-regional trade associated with farmed shrimp (*Litopenaeus vannamei*) relate to exports from Belize to Jamaica.

Farmed shrimps going into the US Market from the region is in the form of Fresh-frozen 'Heads-off' IQF commodity. The product form going into the Mexican Market is freshly harvested and iced whole shrimps. The farmed shrimp going into the EU from the region is destined mainly for the French Market : The product form for this destination is fresh-frozen 'Heads-on' or whole shrimps.

The main producer of Tilapia in the region is Jamaica. Much of this production was exported to the EU and the USA, but since about 2005 has been marketed and consumed locally. This is exclusively in the form of fresh-frozen fillets.

Although the quality assurance and food safety concerns for aquaculture produce going into the US and Mexican Markets is not a problem, there have been challenges associated with produce going into the EU Market from time to time. This is generally related to the more stringent requirement for human health and safety associated with the produce.

The challenge facing both producers at the individual level, as well as regulators at the national level, is their lack of familiarity with the fish health, quality assurance and food safety requirements of the EU Market. This relates to ISO and CODEX Regulations. This is especially relevant because these regulations are not only rigorous in relation to bacteriological standards associated with the handling processing and packaging of the final product, but also chemical standards which inherently include issues of traceability along the entire value chain of the produce.

The producing countries of the Caribbean are not all at the stage of development as it relates to the capacity to comply with the fish health, quality assurance and food safety requirements of the export market. There are a number of shrimp farms in Belize that have been Certified by the National Competent Authority to export shrimp to the EU. This has been done on the basis of these farms meeting the regulatory requirements as it relates to product standards to ship into the EU. On the other hand there have been challenges to meet the EU Standards by operations in Suriname. There are deficits both at the level of the farm to meet the quality assurance requirement, as well as at the levels of the regulatory author to inspect, test and certify the shipments of shrimps.

Although the other countries that have been categorized in the experimental stage of development have not been exporting aquaculture produce to the EU, there is a need for some capacity building in these countries that would be focused on raising awareness in regards to the full range of quality assurance requirements for aquaculture produce going into the EU from the region.

One of the more significant issues facing the region is dated and obsolete legislation relating to food safety and human health. A number of legislation dates back to colonial times. There is an urgent need to revise and update this legislation to reflect emerging challenges of the global marketplace. This is especially relevant to the issue of traceability. Given the importance of feed in aquaculture and the potential for contamination from various sources that may enter the 'food chain' and impact the quality of the carcass of the stocks being farmed, there is the need to focus attention on the requisite legislation and material resources necessary for the testing and inspection of the produce as well as the production process. The impact from feed on farmed stocks may come from mycotoxins, disease treatment chemical residue, heavy metal and mineral salts, persistent organic pollution, etc.

There are larger aquaculture feed manufacturing facilities in at least two (2) of the producing countries of the CARICOM/CARIFORUM Region as well as a number of smaller facilities for aquaculture, notwithstanding that here are feed producing facilities that service both the livestock and the aquaculture sectors. There is a need to build in the necessary safeguards to ensure that feed ingredients are not contaminated, or indeed that the feed is not tainted or compromised during the manufacturing, storage or delivery processes. Thus there is the need for capacity building in risk analysis at the level of the farmers, feed ingredient produces and the regulatory institutions of government.

There is also the need to focus on the issue of best practices and voluntary certification schemes for producers. Environmental Certification schemes such as those promulgated by the Global Aquaculture Allaince (GAA) can be hugh dividents for aquaculture in the CARICOM/CARIFOUM Caribbean where water quality is generally near-pristine and where 'Clean Production Systems' are realizable within the production practice regime and withing the context of the skill set employed in the industry in both the shrimp farming and Tipalia culture sub-sectors.

Producers also need to be made aware that apart from the technical issues associated with the global marketplace, consumers will become increasing discerning in the future, and policies related to child labour, gender equity and the employment of youth will become increasing relevant. And in that context the capacity building response will also need to take note of the familiarity of stakeholders with instruments such as the FAO Code of Conduct for Responsible Fisheries1, the Millennium Development Goals (MGDs) and initiatives of the Blue Economy such as the Carbon Footprint associated with particular producers and the production process.

The prognosis for aquaculture production and trade for the CARICOM/CARIFORUM Region in the short to medium term future will depend largely on the fortunes of the industry in Belize,Jamaica, Guyana, Haiti and the Dominican Republic. In Belize the prognosis is for moderate growth. There has been a moderate and consistent rebound in yields and production volume in Belize with the recovery in prices on the international market. This has been especially relevant for the US Market.

1 which includes aquaculture

The increase in production in Belize is driven by the expansion of production acreages on the farms that sustained through the contraction of prices on the market between 2005/09 as well as in regards to the recommissioning of a number of the operations that went into receivership with the said down-turn in market prices. This optimistic forecast is predicated in large measure on the assumption that the industry will not be impacted by some catastrophic pathogenic disease events that have been the 'Achilles Heel' and a recurrent challenge to the industry globally.

The prediction for growth in shrimp farming in Belize for the industry going forward is also predicated on the assumption that there would be no significant increase(s) in input costs – especially in regards to feed and energy.

The prognosis for growth in the aquaculture industry in Jamaica is less clear than that in Belize. If the aforementioned decline in Tilapia farming industry is to be stemmed by initiatives such as the 'Aquaculture Park' planned for the industry, there should be some recovery and modest growth relative to the past seven (7) years. The 'Aquaculture Parks' are in principle 'Oasis' of development where basic infrastructure such as water delivery structures, roads and processing plants are installed by the Government to induce investments in fish farming by the private sector (Pers. Comm. A. Smikel).

The recovery and growth of the Tilapia farming in Jamaica in the short to medium-term will also be dependent on the policy reforms and support to the sector, including in the form of proper regulation of imported 'Basa' fillets and the down-ward rescheduling of duties on imported inputs such as feeds and equipment.

The prognosis for production trends for the Haiti, Guyana, the Dominican Republic, Suriname and those other producers that have been categorized in the 'Experimental Stage' of Development is even more guarded and tentative than the case for Jamaica for the short to medium-term. One of the primary drivers for these producers will be the quantum and likelihood of private sector investment in the industry. This is largely a question of 'investor confidence'. For those species such as Tilapia and Paneid Shrimps, where the technology is known and the product tested on the international marketplace, there should be a reasonable likelihood that investors will venture into these areas, once there are no critical technical or institutional challenges. Thus it may be reasonable to expect that once access to credit, access to affordable good quality feed, and the quality assurance and food safety challenges associated with access to external markets such as the EU Market for farmed shrimp are resolved, the Dominican Republic, Haiti, Suriname and Guyana may become significant producers in the region.

In regard to those species that are being 'commercially tested' such as the Cobia (*Rachycentron canadum*), the Pompano (*Trachionotus carolinus*) and the Red Drum (*Sciaenops ocellatus*), recruiting the financial resources to transition to full commercial scale operation is a major challenge. Thus it would not be feasible or constructive at this juncture to speculate on the likelihood that these species will be put into commercial production in the short-term future and that they would indeed have an impact on the volume and value of aquaculture commodities produced in the region.

In relation to those locally occurring and sub-regional species such as the Bashaw (*Micropogonias furnieri*), the Lukanani (C*icla ocellaris*) and Cascadura ((*Hoplosternum littorale*) - the economic impact would at best be moderate over the medium to long term. This would be related to the fact that, firstly, these species are no yet viable candidate for commercial culture given the gaps in knowledge in regards to a range of issues including their reproductive biology, growth performance and dietary requirements (See Table 9) - and secondly, even if and when the science and technology questions are resolved in favor of commercial culture, the consumer base for these species would be relatively narrow and limited to those areas where the species are known. Thus in principle, these species are not expected to impact either the intra-regional market, or the international market in any significant way in the near future.

In the case of Suriname and Guyana where much of these species are found – their development as candidates for aquaculture should be encouraged and supported and the approach to furthering enterprise in this area would need to be strategic. It has been reported that the Univeristy of the West

Indies (UWI) has done a fair amount of work on Cascadura (*Hoplosternum littorale*), including its reproductive biology (Pers.comm. J. White).

2.1.d Main Actors in the Chain

Although the value chain for those commodities marketed within the various countries would have some commonalities with those destined for the export market, there would be important dirrenence. This would be both in relation to both product inspection and certification issues, as well as the complexity of the chain moving from the producers to the end-product consumers. There are also differences in the value chain for commodities destined for internal market by industrial scale producers and small-scale subsistence operators. In the case of the latter it has been shown in Belize for example that the production of farm-raised Tilapia (*Oreochromis niloticus*) by subsistence producers was marketed freshly iced on a door-to-door basis to rural households within a radius of 30 miles of the farming operations (Pers. Comm. G. Perrera). The marketing was done by a wholesaler servicing five (5) small farms (pers. Comm. G. Perrera). The product was marketed as gutted and scaled whole fish (Pers. Comm. G. Perrera).

On the other hand the marketing of Tilapia from an industrial scale producer in Belize entailed direct wholesaling from the producer to supermarkets that in turn retailed the produce to consumers. The marketing of marine farmed shrimp in Belize embraced this strategy along with farm gate purchasing and subsequent wholesaling to supermarkets and small-scale retail outlets. The product for both the Tilapia and farmed shrimp were fresh frozen commodities: In the case of Tilapia the product from was frozen fillets and in the case of shrimps it was IQF Heads-off 5 pounds mini-cartons.

The marketing of produce for the export market was complex, especially as it related to the amount of tiers in the value chain. In Belize it has been shown that there are three (3) market options for shrimps exported to the United States. In the first scenario shrimp is exported from Belize directly to an International Marketing Company or Retailer which then sold the commodity directly to retailers (See Annex II Fig. 6, 'Main Market 1'). In the second scenario, the produce is exported from Belize to an Importer/Whole Saler who then sells to retailers who in turn sells to consumers (See Annex II Fig. 6. 'Main Market 2').

In the third instance the farmed shrimp is exported from Belize to an International Marketing Company which in turn sold the produce to a processor who processed and package the product before selling it to a mid-level Whole Saler who subsequently sells to the consumer (See Annex II Fig. 6, 'Main Market 3'). This model related to whole shrimps being exported to the United States in the early days of the industry. This model is now being utilized by Mexican Importers.

The market model with the greatest potential leakage for the exporting country is Scenario #3. Producers will in principle be offered the lowest prices for their produce. Generally the purchaser or importer would have the greatest scope for 'Value Adding' and profitability.

The market model with the least leakage is Scenario #1 (See Annex II Fig. 6, 'Main Market 1'). At least one (1) of the shrimp farming enterprises in Belize have established marketing companies within the United States over the last 10 years to import and retail the farmed shrimp produced by their operations in Belize.

The goal to retain as much of the proceeds of the farmed commodity within the producers entity should be a public policy issue given its implications for revenue generation, employment and foreign exchange earnings. These have been stated goals for the shrimp farming industry in Belize. They should be of equal relevance to Jamaica where there are parallels with Tilapia production, as well as in other political jurisdictions throughout the region.

Apart from the farms and importing entities for exported aquaculture produce from the CARICOM/CARIFORUM Region other parties in the 'Value Chain' include: brokers, truckers, shipping

companies and air-freighters. In certain circumstances where there is no vertical integration of production, processing and marketing, processors and marketers would need to be considered separately from the farming entities.

The regulatory arm of the industry would also need to be considered as a part of the 'Value Chain'. This would include quality assurance and inspection services, diagnostic services for safety and traceability issues,

The advantages of defining the 'Value Chain' for the Industry are that it provides opportunities for indentifying opportunities and constraints and homing in on strictures and challenges. A recurrent challenge for commodities from the region on the export market is the issue of "comparative cost of production" and hence the competitiveness of the commodity The major challenge facing both exported farmed shrimp from Belize and Tilapia from Jamaica and other exporting countries is the input costs of feed and energy. In anaylsing the value chain for feed it has been surmised that unit costs can be decreased by the In-Country production of the carbohydrae and plant protein source of the feed. It has been asserted that for every 1,000 acres of semi-intensive shrimp pond in Belize, there is the need for 3,000 acres of cultivated soy beans (Pers. Comm. J.V. Hyde). This has positive implications for grain crop producers in Belize.

The intervention of the In-Country production of soy beans and its integration into milled and compound aquaculture feed in Belize would bring with it the need for the engagement of other relevant parties in the 'Value Chain' such as local grain producers, feed manufacturer, credit institutions, government agronomists and analytical laboratory services.

The response of at least one of the major industrial orientated Tilapia farms in Jamaican to high feed cost was to redouble their efforts to source imported fish meal at a cheaper and more affordable price (Pers. Comm. Brown 2010). The response to high feed cost by the only industrial scale Tilapia operation in 2010 was the unified bulk purchasing of feed with other producers in Honduras to obtain a more favorable unit price (Pers. Comm. E. Mena).

2.2 New opportunities in market development

It has been surmised that the primary drivers of aquaculture production globally in the medium-, to long-term future will be the increase in per capita consumption of fish, the rise of a more discerning class of consumers and an increasing variety of species and product forms.

The increase in per capita consumption will be driven by:

- the general increase in human population and urbanization
- health concerns
- the general increase in living standards and consequently more disposable income
- the increasing trend of eating out at restaurants and in general fast food outlets
- the greater availability of pre-cooked and easy to cook fishery products
- the overall decline in prices as aquaculture production and the range of aquaculture produce increases.

These developments would have implications for production targeted at the domestic, intraregional and extra-regional global marketplace. There will be the scope for the expansion and commercialization of those species with relatively narrow natural distribution that are currently being grown on a subsistence basis or that are a part of small-scale rural development and poverty alleviation schemes. These may include the Bashaw (*Micropogonias furnieri*), the Lukanani (C*hicla ocellaris*) and the Cascadura (*Hoplosternum littorale*) in Guyana, Trinidad and Suriname, and the Bay Snook (*Petenia splendida*) in Belize. The existence of these species on the market from aquaculture sources would be premised on the assumption that they would have proven to be viable aquaculture candidates with the requisite R&D to

close the knowledge gap in regards to the various unanswered questions in relation to their biology and performance under conditions of captive culture.

The overall increase in the per capita consumption of fish going forward to 2050 has enormous positive implications for those producers at both the 'Commercial' and 'Experimental' Stages of development. In the first instance the scope for growth in production of the currently successful species could lead to significant increases in production biomass and profitability of the particular operation. This has immediate relevance to shrimp farmers in Belize and Suriname, as well as Tilapia Farmers in Jamaica. In the second instance, it would be reasonable to assume that some of those species that are one or two steps from full commercialization will break through. This may well be the case for Cobia (*Rachycentron canadum*) and Redfish (*Sciaenops ocellatus*).

The rise of a more discerning consumer will bring in its wake a greater focus on issues of traceability and environmental certification, child labour, gender equity, and environmental health. The latter in particular may prove to be a 'forcing function' that would direct the course of the industry globally for a greater inclusion of those species that would be of low trophic status such as the primary producers and primary consumers. This would include species such as Sea Moss (*Gracilaria spp.*), the Mangrove Oyster (*Crassostrea rhizophorea*), the Queen Conch (*Strombus gigas*) and the Mexican Sea Cucumber (*Holothuria mexicana*). This has positive implications for both industrial scale producers as well as small and medium size producers associated with rural development and poverty alleviation schemes.

Environmental Certification and the adoption of Voluntary Standards for Best Practices are becoming increasingly popular among Shrimp Farmers in Latin America. A number of shrimp farmers in Belize are also following suit. It would be expected that other farmers from those jurisdictions identified as being at the 'Commercial' and 'Experimental' Stages of Development would see the wisdom of subscribing to these efforts.

The traceability issue is one of major concern on two (2) fronts, firstly there is a knowledge gap in relation to the familiarity of producers and regulators with the various legal instruments and protocols associated with the issue and secondly there is a material resource and technology constraint. Farmers in the Small Island Developing States identified the gap in knowledge in regards to the lack of familiarity with CODEX and ISO in 2002 as one of the challenges for the development of the aquaculture sector. This included representation from both the Lesser and Greater Antilles with an interest in Aquaculture.

The traceability issues in regards to the possible tainting of farmed stocks through feed sources remains a pertinent and relevant concern. The production and importation of grains as feed ingredients poses a risk. Although there has been some initial sensitization efforts at the regional level in regards to risk management, this has not matured into any definitive policy, legislation or established protocol in the CARICOM/CARIFORUM Caribbean. The industry will need to constructively address this issue if aquaculture is to realize its fullest potentials in the region.

The increasing variety of aquaculture produce on the market has positive implications for aquaculture development in the CARICOM/CARIFORUM Region. It is envisioned that much of the possibilities in the market in regards to the diversity in product form would relate to the same species and their strains.. Farmers will routinely vary the length of their crops to select for a particular size class that would be driven by the demands of the marketplace. One of the possibilities that have been applied on a limited basis is for the selection of the larger size classes of farmed shrimp for the tourism market. At least one farm in Belize has shifted from semi-intensive production regime, to extensive production practice entailing lower stocking densities and a crop length of 9 months, as opposed to the 4 – 6 months crop cycle (Pers. Comm. L. Cardelli).

Apart from size classes, possibilities on the farmed shrimp market extend to value added processing. This includes: Peeled Un-deveined Shrimp (PUD), butterfly shrimp and whole cooked shrimp. This has implications for shrimp producers in Belize, Suriname and Jamaica.

Diversity in product form on the market would create possibilities for similar species to be stocked on a year-round basis to cope with seasonal temperature changes. This response would also entail genetic strains or variations within the same species. The latter infers efforts in genetic selection as well as hybridization. Shrimp farms in Belize and Latin America have included in their production strategy the shift from the Pacific White Shrimp (*Penaeus vannamei*) to the Pacific Blue Shrimp (*Penaeus stylirostris*) during the cooler months of the year.

A diversified market will also absorb different color morphs. This is seen especially within the different intra-specific hybrids of Tilapia. There is a preference on the whole fish market in the Caribbean for Red Hybrid Tilapia. This is also seen in the Asian Markets for fish on the north-east and west coasts of the United States. This has positive implications for Tilapia farmers in Jamaica and the continental states of Belize, Guyana and Suriname where available land, and abundant sources of water exists.

3. CONTRIBUTION OF SUSTAINABLE FISH FARMING TO FOOD AND NUTRITION SECURITY

The Capture Fishery and Aquaculture Sub-Sectors are important to the social and economic development of the CARICOM/CARIFORUM Caribbean. These are in relation to employment, income generation, foreign exchange earnings, food and nutritional security and poverty alleviation.

The Fisheries Sector in the CARICOM/CARIFORUM Region provided direct employment for 182,000 persons in 2010. Total fish production for the region also for 2010 was 176,213 MT (Haughton 2014) [See Annex II Table 6].

The CARICOM/CARIFORUM Region however continues to be a net importer of fish and fishery products. In 2010 the region exported 61,000 MT of fishery products and imported 117,000 MT (See Annex II Table 7). The deficit was also reflected in the value of the product where export earnings from the commodity was US$250 million and the imports were valued at US$343 million (See Annex II Table 7).

It is conceivable that contributions from aquaculture can significantly close and eliminate the trade gap in the medium to long term from aquaculture sources. This would be in terms of both production biomass as well as financial value.

The contribution of aquaculture to fisheries production is small but growing. In 2010 the total annual production from aquaculture was 11,000 MT – This amounted to only 6.2% of the total fishery production for the region (See Annex II Table 6).

The production from capture fishery sources is much like that of the global scenario where there is limited scope for expansion or increase in production. Much of the marine fishery stocks are fully exploited with a number showing signs of overfishing. Thus any significant increases in fishery production for the region would need to come from aquaculture sources.

3.1 Integrated agriculture and fish farming systems

There are only a few known examples of the integration of aquaculture and agriculture in the CARICOM/CARIFORUM Region – these are located in Belize, Guyana, Jamaica and Haiti. The Guyana experience relates to the extensive culture of a number of native finfish species in the drainage channels of rice fields. The production from this activity however is not of a quantum that would have any significant impacts on food and nutritional security, employment or trade.

In Belize there is a project based on the aquaponics of lettuce and Tilapia. There is no declared intention to expand this enterprise (pers.comm. Jimmy Jones).

While projects in the region, that are planned for the integrated farming of aquaculture and agriculture, are limited, there are a few cases ongoing, for example fish and livestock in Jamaica; and chicken production incorporated with fish production.

3.2 Contribution of mariculture

In the region, mariculture activities include the farming of marine shrimp and conch farming as well as the culture of for Oysters (*Crassostrea rhizophorea*), Sea Moss (*Gracilaria spp.*), Cobia (*Rachycentron canadum*), Pompano (*Trachinotus carolinus*) and Red Drum (*Sciaenops ocellatus*) referred to in Table 2.

3.3 Contribution to employment

In the CARICOM/CARIFORUM Caribbean populations are generally youthful and where unemployment is a major challenge. Unemployment rates have increased significantly in recent years due to the global economic crisis and disasters which resulted in zero to negative economic growth in most States. According to the most recent available data unemployment is considerably higher among females and youth than among males in most countries (Parra-Torrado, 2014). The overall Fisheries Sector provided direct employment for 182,000 people in 2010 (Haughton 2014). It has also been estimated that an additional 951 were directly employed in aquaculture (CRFM 2013 Statistics report). As a general observation - the husbandry aspects of aquaculture are less labour intensive than crop or livestock agriculture for a given biomass of production. The opportunities created by aquaculture could be meaningful, especially given that much of the demand would be for 'skilled labour'.

3.4 Recognition of the Role and Opportunities for Women and Youth in Aquaculture

The employment of women and youth in aquaculture is reflective of the general structure of the population. The majority of the population in the Caribbean is under fifty (50) years of age. In Belize, Haiti and Guyana where much of the commercial aquaculture activity takes place inhabitants under fifteen (15) years of age ranges from 31 to 36% of the population.

Employment in both the skilled and semi-skilled areas reflects the age structure of the population. The skilled area in aquaculture relates mainly to the upper and mid-management levels of enterprise. The representation of genders in these areas is largely reflective of the enrollment ratio of the genders in tertiary level institutions. It has been postulated that there is a direct relationship between the trained manpower and the development of aquaculture in the region, especially at the senior technical and management levels (Pers. Comm. R. Pretto).

There is generally a greater recruitment of men in commercial aquaculture enterprises at the hands-on and semi-skilled levels. This includes: the feeding, seeding, harvesting, repair and maintenance work on the farm.

Women dominate the processing aspects of aquaculture. Women have also been found to be quite adempt in the hatchery operations in the region. The experience in commercial aquaculture in the region is that the employment of women in these areas has been significant and provides a great reprive in relation to the issue of income generation and poverty reduction.
Increased participation of women and youth in aquaculture in the region will require further investments in skills training in different areas of aquculture targeted at the needs of these vulnerable groups.

In general, there are no elements of discrimination or institutional barriers which places women and/or youths at a disadvantage in the Caribbean. The region as a general rule is largely compliant with international instruments such as MDGs.

3.5 Benefits for Small-scale Producers

The participation of small and medium size enterprises in the CARICOM/CARIFORUM Region entails the engagement of both the ornamental fish production subsector as well as the food production subsector. Ornamental fish production from aquaculture is limited only to the culturing of fresh water stocks. Currently there are a number of operations Jamaica, St. Lucia, St. Vincent and the Grenadines, D.R., Hiati and Trinidad and Tobago.

The scope for ornamental fish production from aquaculture in the Caribbean is great. Given the relatively small sizes of these operations geographically and the limited primary resource demands in terms of land and fresh water, these operations can be located throughout the Lesser Antilles as well as the Greater Antilles and the continental CARICOM/CARIFORUM Countries in Central America and South America. The rural development and poverty alleviation strategies of the various countries in the regions can thus be realized in part through said freshwater ornamental fish culture.

The participation of small and medium size enterprises in aquaculture in the region in regards to food production is related to commercial, subsistence and experimental aquaculture (See Annex II Tables 1A and 1B). Small and medium scale aquaculture in the Caribbean is faced with a number of challenges.. The challenges range from inadequate access to technical and husbandry related knowledge and expertise, to poor business management and marketing, inadequate institutional support, and limited access to financing.

On the technical front, species selection has been a major impediment. In a number of instances the species chosen are not viable candidates for aquaculture. In other instances site selection has been a major challenge. There are instances where production ponds have been sited in low-lying swampy areas that are prone to flooding. In other instances, ponds were located on high grounds in limestone and sandy soils where seepage renders these projects unviable.

In regards to the issue of inadequate institutional support, the lack of basic training and capacity of the farmers and Government Aquaculture Extension Staff who should provide the necessary technical advice has been mentioned as one of the major impediments to the development of small-scale aquaculture.
Also in relation to institutional support the lack of credit to assist small and medium enterprises has been mentioned as one of the major limitations in small-scale fish farming. Most small and medium size enterprises lack the asset based to access credit from Commercial Banks and other traditional lending institutions. A related constraint in regards to the financing is the high interest rates that can generally be afforded by the merchant community and large scale producers but is out of the reach of small and medium size operators. This has been the experience in throughout the region.

Another major impediment to small and medium size enterprise is the high input cost of supplies going into the production process. The cost of feed has been most frequently cited cost factor for suchproducers. This has been the experience for small scale tilapia farmers in Guyana, Dominican Republic, Haiti, Suriname, St. Lucia, Dominica, St/ Kitts and Nevis, Jamaica and Belize.

The limitations of clearly defined markets also pose a major challenge to the development of small and medium size aquaculture in the region. Most small scale farming operations do not take this into account. In a number of instances there is the need for market surveys to define the structure and capacity of the market to absorb the production from these aquaculture operations.

4. ADDRESSING THE LONG-TERM SUSTAINABILITY OF THE SECTOR

The need for sustainable aquaculture development is predicated on the fact that the primary resources inputs such as land and freshwater are finite over time and space and that the aquaculture production activities itself generates negative impacts that can and has compromised the integrity of these resources upon which the long-term success of the industry depends. The maintenance of a viable environment in

terms of the quality aspects of the primary resources has been the most fundamental challenge to the sustainable development of the industry.

The global experience in aquaculture has been one in which there is an appreciable level of failures of commercial enterprises (GESAMP No. 68). The reasons for this contraction in the industry ranges from pollution and environmental management challenges, to inadequate experimentation and pilot testing of species and production systems, as well as a lack of political commitment and advisory support. The high costs of material inputs and low market price shave also been significant challenges to the success of the industry.

The experience in the CARICOM/CARIFORUM Region is reflective of the global experience where there has been a notable contraction in aquaculture at all levels of industry (GESAMP No. 68). The areas that have seen the most significant contractions are 'subsistence' and 'start-up commercial' aquaculture enterprises (See Annex II Tables 1A & 1B). This experience is relevant to the continental countries and the Greater Antilles (See Table 1A) as well as the Lesser Antilles (See Table 1B).

Various challenges impact on the sustainability of 'experimental' and 'subsistence' aquaculture. These as noted above, range from husbandry-related procedures and technology transfer, to governance and resource allocation, as well as market access and quality assurance issues. Some of the details of these are as follows:

- Technical and husbandry-related issues include:
  - Insufficiency in the availability of high quality broodstock, appropriate feed, fingerling and equipment
  - Inadequate planning of the production process
  - Inadequate knowledge about species being cultured, including reproductive biology and feed and nutritional requirement
  - High cost of inputs, especially feed
  - Limited amount of aquaculture staff available from Fisheries Government institutions to lend advisory support
- Technology transfer
  - Lack of information and training in relation to technology in question
  - Cessation of material and advisory support as foreign assisted bilateral missions have come unexpected and unplanned conclusion
  - Lack of proper feasibility studies, including market analysis
  - Limited private sector involvement
  - Lack of proper documentation of information, preservation and dissemination
- Governance Issues
  - Aquaculture not considered a priority by national government
  - No aquaculture policy or plans to direct course of development of the industry
  - Institutional capacity to develop aquaculture plans and policy not available
  - Existing Fisheries Legislation includes only limited references to aquaculture
  - Laws related to access rights for water non existent
  - Limited consultation between Government Agency with leadership mandate for aquaculture development and farmers and other stakeholders
  - Poor business management
  - High security costs
- Resource Allocation
  - Competition for limited financial resources in Government such as Tourism and traditional agriculture
  - Competing uses for limited land space and suitable seafloor areas reflected in speculative and inflated land cost

- Fisheries Departments underfunded and cannot provide requisite support and services to farmers
- Limited availability of equipment and transportation

- Market Access and Quality Assurance Issues
  - Weak linkages and lack of organization among farmers
  - Limited market studies especially for locally occurring species
  - Inadequate familiarity with regulations relating to food safety and human health
  - Paucity of information on best practices and certification programmes.

4.1 Policy processes and regulatory frameworks in support of aquaculture

Sustainable aquaculture development can be greatly assisted by adopting a planned approach to development. The states and Territories in the CARICOM/CARIFORUM Region are at different levels of accomplishment as it relates to this issue. The response to this issue is most constructively attended when states and territories develop a national development plan for the sector. Related responses include the development of policy as well as the development of strategy and supporting legislation.

It needs to be kept in mind that planned development is a hierarchical process with definitive linkages between policy, strategy and plan, and supporting legislation.

- Policy: is a broad vision for the sector reflecting its direction priorities and development goals.
- Strategy: a roadmap for the implementation of a policy and contains specific objectives, targets and instruments to address issues that might stimulate or impeded the comparative advantage of the sector and obstruct its development.
- Plan: a roadmap for the implementation of a strategy, that is, to achieve its objectives and implement strategy instruments. It is time-bound, contains specific programmes and activities and details the resources required to achieve them.
- Legislation: consisting of primary statutes and secondary legislations such as regulations, orders, directives, and rules. Legislation provides legal certainty regarding the principles, standards and procedures to be followed and the legal consequences that will flow from breaching the rules. Legal certainty is internationally recognised as a central requirement for the rule of law and enables those subject to the law to regulate their conduct with certainty and to protect them from arbitrary use of state power.

The States within the region that are most accomplished in terms of defining a clear mission and vision for the development of the sector include: St. Kitts/Nevis, St. Lucia, Dominican Republic, Dominica, Guyana, Jamaica, Grenada, St. Vincent and the Grenadines, Trinidad & Tobago, and Belize. St. Kitts/Nevis has a definitive development strategy for the sector. St. Lucia has declared the development of a national plan for the sector, however, this is functionally a national strategy since the document lacks time targets and the definition of resources to accomplish various activities (See Annex II Table 9).

Suriname has drafted a policy, development strategy and legislation for the sector that is pending political endorsement by parlaiment.

Belize also has a draft development policy for the sector (See Annex II Table 9). This however, has not been officially legislated.

Most of the countries within the region have some administrative instrument to guide the development of the sector. This includes: legislation and permitting functions as well as advisory support (See Annex II Table 9).

The response to the governance of the sector by the states and territories of the region is generally not comprehensive enough in scope to realize the full development of the sector.

4.2 Aquaculture Nutrition

Feeding and nutrition is arguably the most fundamental input to the production process of fed-aquaculture systems. There are two (2) major concerns in terms of maintaining the integrity of the husbandry environment and surrounding areas. In the first instance there is a need to ensuring that the feed being administered is stable enough to stay intact and not break apart and leech into the water column of the culture environment. This could among other challenges lead to the enrichment of the production environment in a process generally referred to as eutrophication.

The other issue related to feed and the integrity of the environment is excess feed and the breakdown of feces from the farmed stocks which also leads to eutrophication.

There has been a major focus among producers in the region on feed quality. This focus is primarily driven by growth performance and economic considerations. Farmers have focused greatly on diets with low food conversion ratios or high efficiencies in terms of digestibility and incorporation into biomass of growth. This co-incidentally also has positive implications for the environment in terms of decreased eutrophic effects.

The use of high digestible low pollution diets are more environment friendly than classically formulated diets. Low pollution diets however, are generally more expensive than classical formulations and have not been in demand by either shrimp growers or tilapia farmers in the region

One of the more global and strategic concerns in relation to feed and nutrition in aquaculture is the use of fishmeal in compound diets. There are two (2) major issues associated with this: firstly, fishmeal is derived from low trophic level finfish species. These are usually anchovies which are heavily fished at or near maximum sustainable yields. The second concern is that fishmeal is expensive and varies in abundance over time. Its availability greatly influences the price of feed for aquaculture. There is an urgent need to find a replacement for fishmeal that is more available and which is cheaper. There are major efforts to identify fishmeal replacements from terrestrial sources of protein.

There are opportunities within the region for commercial experimentation in the farming operations in respect of replacement feed. It is envisioned that this could be an effort between academia and producers. The more pertinent areas are in relation to the incorporation of locally produced ingredients into feed formulation, as well as in relation to disease management and waste loading on the environment.

The National FAO Office in Guyana is developing a project of feed formulation for aquaculture using locally available feed material. The findings of this effort will need to be communicated to the other CARICOM/CARIFORUM Countries. There would also be the need to replicate said feed formulation trials using locally available materials that would be accessible in the other states in the region.

The synergies between livestock and aquaculture feed will also need to be systematically assessed. On the one hand the formulation of livestock feeds has significant commonalities with aquaculture feeds and would need to be adjusted to accommodate the production of the latter. The wastes from livestock processing operations such as bone and feather meals will need to be considered in terms of its incorporation into the formulation of aquaculture meals.

4.3 Feeds Risk Analysis and Health Management

A well balanced diet with requisite nutritional components is important in aquaculture. Good quality feed formulation and manufacturing is important in providing the physical form in which the feed is to be delivered and providing to the animal a formulation with the required nutritional components. To

accomplish this there is usually the need for feed manufacturers to work with producers to not only enhance production of improve yields, but also for millers to understand what a well manufactured feed needs to be under operation conditions in the ponds and other engineering containment structures.

Poor feed quality can greatly impact water quality and the health of the stocks being husbanded. One of the most effective tools to assure good feed quality is risk analysis. Risk analysis in the context of feed and feeding in aquaculture, provides decision-makers with an objective method for assessing the risk posed by particular feed formulations and feed sources.

The major areas of concern in relation to feed for aquaculture are eutrophication, chemical pollution, occupational risk and import risks:

- Euthropication as pointed out earlier is related to the liberation of nutrients into the water column from uneaten feeds and faeces from the farm stocks.
- Chemical pollution is related to the release of toxins and bioactive compounds in the production system from feeds. These includes mycotoxins, antibiotics, persistent organic pollutants, heavy metals (mercury, lead, cadmium) and excess mineral salts (hexavalent chromium, arsenic, selenium, florine)
- Occupational risks is associated with workers being exposed to physical harm and hazard or alternately to pathogenic micro-biota and parasites, as well as deleterious chemicals associated with the culture environment and/or the material inputs and services to support the aquaculture production process
- Import risks relate to exposure in regards to the inputs and services to assist the aquaculture production process – this includes exposure to imported feeds, seedstocks and broodstocks, etc.

There are over 100 types of mycotoxins. These are usually derived from molds associated with feed ingredients. They may also be associated with the manufacturing or alternately during the storage of feeds after the manufacturing process. These mycotoxins are detrimental to the cultured stocks at concentrations as low as a few parts per billion.

Pesticides in feed ingredients also have similar effects, including at low concentrations. Apart from immediate toxic effects pesticides bio-accumulates which may make particular aquaculture commodity unmarketable. Pesticide residues are usually regulated by standards and once certain thresholds are surpassed they pose a risk to human health and safety and will not be accepted on the market.

The prophylactic use of antibiotics has been a major problem in aquaculture globally. This is done largely through incorporating antibiotics into feeds as ‘medicated feeds. Pathogenic microbes develop resistance to various drugs.

Feeds with heavy metals and toxic compounds have caused much mortality and loss in aquaculture. Although the possibility of the occurrence of such events cannot be ruled out, there is no known or documented incidents of mass mortality in production systems or the financial costs associated therewith. The risk that feed contaminants can be passed along the food chain exists, however there is no know occurrence of this in the in aquaculture situations in the Caribbean.

The occupational risks associated feeds relate to both the feed manufacturing process as well as on-farm contact with feed materials. In feed manufacturing the feed ingredients may be tainted with mycotoxins, heavy metals, antibiotics and parasites which may be a source of allergens or may interact with workers causing immediately debilitating reactions or more long-term chronic effects. The dust and particulates from the handling of ingredients, the storage of the finished product and the actual manufacturing process creates a challenged for many workers afflicted with respiratory conditions such as asthma and allergies.

In farm-based situations, farm workers are also exposed to the various hazards, including exposure to Salmonella and a range of parasites associated with the feed and the fishstocks being husbanded.

There is the need for policy and legislation dealing with occupational health. In Belize there is the Occupational Health and Safety Bill (OHS) Bill before Parliament for deliberation and passage into law. Because no aquaculture specific projects or programmes are in place in the Caribbean, there is no regional scale initiative to monitor and report on incidents associated with risks and hazards of feeds and aquaculture in general.

The cirtical needs for Import Risk Analysis (IRA) include the development of policy and legislation to regulate the importation of livestock as well as finished product. The need for the inspection and permitting in regard to livestock being imported for the aquaculture production process is related to the impact of pathogenic diseases. Pathogenic diseases caused by viruses and bacteria on shrimp seedstocks has been one of the major threats marine shrimp farming in Belize and other political jurisdictions in Central America

The issue of risks and traceability becomes more highly relevant when produce is exported outside of the region, especially to the EU and the US to a lesser extent where quality control issue are more rigorous.

Appropriate responses to risks and hazards in the region includes:
- Acquire stock insurance against diseases and natural disasters
- Improve access to investment and credit
- Increase incentives for farm improvement

Response by countries in the region include:
- Generally call under Climate Change driven disaster risk mitigation for establishment of Regional Insurance Fund at level of CARICOM Heads of Government
- Currently asset base not substantial enough to generate critical mass for the establishment of such as scheme. International facilities such as Lloyds of London exist, however cost of coverage would be a major cost
- Currently financial incentives for aquaculture are not performance based

4.4 Environmental Sustainability

Environmental Sustainability in aquaculture in reference to the above captioned heading would perhaps be better served by the term ecological sustainability since that would be the scope of this chapter of the presentation. Environmental Sustainability connotes the broadest definition of the term environment which has indeed social, economic and ecological dimensions. For the purpose of this discussion any reference to the term environment or environmental will be used inter-changeably with the term ecology or ecological.

The ecological/environmental sustainability of aquaculture is related to three (3) main variables, namely:
- Consumption of resources (land, water, feed, wild seedstocks, energy)
- Transformational processes including the impact of invasive species
- Output of wastes (water pollution, fish disease, escapes)

The consumption of natural resources in this context includes both the extractive and non-extractive uses. The primary resources deployed in aquaculture includes land, freshwater, energy, feed and species. The

latter relates mainly to animal and plant species that are used for seedstock broodstock and in general experimentation on the suitablity of these species for aquaculture.

The deployment of the primary resources in the aquaculture production process results in transformational changes at various scales. These changes may be at the species level, the community level, the habitat level or the landscape level. The transformational changes are brought about by a range of of impacts which affects biodiversity.

The ecological impacts of aquaculture derive from four (4) main sources, viz :

- Waste and nutrient loading
- Resources depletion and change in quality
- Escape stocks including the impact of invasive species
- Predation by feral species

Waste loading on the environment derives mainly from :

- Sedimentation and turbidity influences
- Macro-nutrients: nitrates and phosphates
- Vitamins, mineral
- Chemicals and antibiotics
- Feces, exudae and other oxygen depletion substances

Resource depletion relates in large part to the depletion of freshwater. This in many instances is from groundwater source.

The main risks of escaped stocks from farming facilities includes competition with wild stocks, genetic interactions with wild populations and disease transmission with wild stocks

Although pollution remains a risk in aquaculture, there are no known reported incidents where Public Sector regulators intervened to suspend or closed down any operation. Although this may be the case, there is the need for improvement in environmental stewardship for the sector. This is especially so given the scope for expansion in production going forward to 2050 where aquaculture production is expected to increase significantly, relative to 2010 production levels.

It also needs to be recalled that the aquaculture production process has negative consequences on biodiversity and the abundance and geographic extent of resources. The negative impacts include :

- Eutrophication
- Chemical contaminants (anti-fouling heavy metals, antibiotics, disease treatment chemicals)
- Oxygen depletion for organic wastes (dead fish, feces, uneaten feeds)
- Genetic interaction between farmed stocks and wildstocks

The full extent of this suite of environmental impacts has not been assessed in any Caribbean country.

There are a number of interventions that may be brought to bear to ameliorate or circumvent these impacts, which include:

- Precautionary approach
- Good governance
- ICZM
- Site selection
- EIA requirements

Effective responses to improving environmental stewardship include the following:

1) *Increase investment in technological innovation and transfer -.* This relates to technological advances in four interrelated areas, viz:
   - Breeding and Genetics: Establish or expand selective breeding efforts for those countries in the 'Commercial' and 'Experimental' Phases of Development with expanding production and good prospects for growth and which are committed to capitalizing on the expanding global market for aquaculture commodities;

   - Disease Control: Combine new technologies (e.g., diagnostic technologies, vaccines) and wider application of best management practices to combat disease problems. This is especially relevant to shrimp producers where mass mortality pathogenic disease events are a regular experience in the industry. This is highly applicable to shrimp farming which is invariably impacted on an episodic basis by mass mortality pathogenic disease events;

   - Nutrition, Feeds, and Management of Feeding**:** Minimize farmers' costs and aquaculture waste by increasing feeding efficiencies, and continue to develop alternatives to fish oil in aquaculture feeds. One of the recurrent focus of shrimp farmers in Belize and the regional countries of Latin America has been to access feeds with high quality. As shrimp farming spreads through the region, it is envisioned that focus on good feed quality will expand.

   - Low-impact Production Systems: Recirculating aquaculture systems, biofloc technology, and integrated systems perform well across most indicators of productivity and environmental performance. With additional R&D and awareness building, these systems may be well suited to the Lesser Antilles where land and freshwwater resources tend to be in short supply.

2) *Use of Spatial Planning and Zoning to Guide Aquaculture Growth at the Landscape and Seascape Level:* If conducted in a participatory way, these approaches can lessen the inevitable conflicts between a growing aquaculture industry and other economic sectors, reduce cumulative impacts caused by many farmers operating in the same area, and help minimize the risk associated with climate change.

   In at least one of the Countries in the Region, there has been the development of an Integrated Coastal Zone Management Plan, which has positive implications for other countries subscribing to spatial planning initiatives for the industry.

3) *Shift incentives to reward improvements in productivity and environmental performance:* Government initiatives (e.g., regulations, standards, taxation and subsidy policies, market-based mechanisms) and private initiatives (e.g., certification, purchasing standards) can complement landscape-level planning to realign incentives to encourage and reward sustainable production systems. These incentives should help the aquaculture industry reduce the environmental impacts of its most widely used production systems, and stimulate investment in and deployment of low-impact production systems.

4) *Leverage the Latest Information Technology to Drive Gains in Productivity and Environmental Performance:* Advances in satellite technology, digital mapping technology, ecological modeling, open data, and connectivity mean that global-level monitoring and planning systems that encourage and support sustainable forms of aquaculture development may now be possible. A platform integrating these technologies could help the governments in the region to improve spatial planning and monitoring, help the industry plan for and demonstrate sustainability of operations, and help civil society report success stories and hold industry and government accountable.

5) *Shift Fish Consumption Toward Low Trophic Level Farmed Species:* Increasing demand for low-trophic farmed fish species (e.g., tilapia, catfish, carp, bivalve mollusks) relative to "business as usual" growth in fish consumption would lead to more efficient use of scarce wild fish resources and could ease fishing pressure on marine and freshwater ecosystems. Changing public food procurement policies to

favor low-trophic farmed species, and selling the benefits of these species—such as affordability and taste—can all help to alter consumption patterns.

4.5 Economic Sustainability including Trade Related issues

In the fish production process linked with aquaculture, environmental and social sustainability is necessary over time, however these elements of sustainability are not sufficient to ensure economic sustainability. Aquaculture must also be a viable business with long-term prospects for wealth creation and growth. The economic sustainability of Caribbean aquaculture, that is, the long term economic viability of the sector, will depend on several factors. These include production costs, access to and use of knowledge and technology, marketing strategy and market development, supply chain, demand and supply characteristics, market price fluctuations, research, innovation and product development, and international competitiveness of the local product. Long term economic viability will also depend upon the impact of the governance arrangements, the legal and regulatory systems and government policies, on the profitability and growth of the sector.

Aquaculture faces competition in the market place at both input and output ends of the enterprise. The economic sustainability of aquaculture is founded on the principle that there is the need for the allocation of scarce resources in such a way that it it leads to the optimization returns in terms of financial profits, and knowledge and technology that could benefit future generations with the capacity to at least realize the same quality of life as the current generation.

For economic sustainability of the sector to be realized, the total cost of development must be accounted for and incorporated into the transactional costs of the sector. This includes all direct costs as well as indirect costs or externalities. Thus in functional terms economically sustainable development means development that meet needs of both current and future generations for food, pharmaceuticals, recreation and other ecosystems services, which is realized by maximizing profits and net benefits to society when all costs and benefits of aquaculture are considered.

If society is to maximize the net benefits of aquaculture, there must be a full accounting of both the costs and benefits of alternative aquaculture practices and such an accounting must become the basis of policy, ethics and actions.

For growth and development to take place there must be adequate investments in knowledge, physical capital and technology. This would of necessity include the profits generated from the industry. In this context there is the need to consider the current status of aquaculture in the region, the growth prospects for the industry, the adverse effects it is having, as well as the positive impacts and the policy and institutional framework that would be necessary to realize an economically viable and sustainable industry going forward.

An economic sustainability strategy for aquaculture development in the region needs to encompass the ecosystems approach to management, the role of aquaculture in terms of the provision of goods and services, and the use of resources deployed in the production process.

It needs to be recognized and recalled that aquaculture provides goods and services such as food, pharmacueticals, clean water, opportunities for recreation and financial profit to affect economic prosperity and human wellbeing. These outputs and outcomes of the development of the sector require the utilization of resources including land, water, seedstock, broodstock and energy.

Promoting long-term economic sustainability will require research to better understand the various factors at play influencing the long-term viability of the sector based on actual experience of aquaculture enterprises in the region and to facilitate the development of appropriate policy responses to address the evolving needs of the sector.

As the contribution of fish from aquaculture production sources on the international market grows, it is increasingly subject to safety mechanisms and protocols such as HACCP and ISO 9000 Quality Assurance Regimes from importing countries and regions such as the US, the EU and Canadian Markets.

Also as Safety and Trade Regulations are being harmonized at the international levels, risk assessments and traceability will become an increasing part of the regulatory landscape for the CARICOM Region.

The prognosis for the aquaculture industry into the foreseeable future is that it will be market driven: This will be in response to consumer preference and values and developing countries that are producing will need to adapt to the changing legislative regimes of the importing developed countries.

Important externalities will affect the Productive Sector, these include:

- Sustainability
- Traceability
- Gender issues
- Social inclusion

Caribbean countries will need to rise to the challenge of the evolving and increasingly stringent regulatory landscape of importing countries. This will in principle require changes in legislation, training, investments in testing facilities, good feed manufacturing practices, and environmental certification, and the adoption of best practices in the husbandry and processing aspects of aquaculture

4.6 Training and capacity development needs and provision of technical support

As aquaculture enterprise and production expands to meet the demand for seafood and other fishery products, there is the need to build human capacity across the various sectors and subsector at varying levels of competence in the relevant institutions. There are currently very few persons within the private or public sector in the region with either significant practical field experience, basic skills training or formal tertiary level training in aquaculture. Jamaica, Trinidad and Tobago and to a lesser extent Belize are the exceptions. Future training should entail both the public and private sectors including the NGO Community and academia and should focus on:

- Primary producers or farmers
- Ancillary staff (processors, hatchery managers and technicians, veterinary service, millers and feed importers)
- Government:
  - Extension and technical advisory staff
  - Phytosanitary Inspector
  - Surveillance and enforcement
  - Quarantine and Custom Officers
- Academia

Capacity building cannot be considered in isolation, it needs to be reflective of the needs and vision for the development of the industry going forward. Thus the scope and specificity of the human resources needs of the industry and indeed the particular areas where capacity development is needed should be a function of a comprehensive development plan for the sector. Areas of focus should also be defined and or inferred for development strategies or policies that have been articulated for the industry.

It should be discernible from the preceding discussion that the areas of focus and indeed the segment of the industry concerned vary greatly. The scope and depth of capacity building interventions would also vary greatly.

To deal with the issue of capacity building for the industry, there is the need for a census of the skill set currently engaged in the industry. There is also a need to census the institutions in the region that would

be relevant in offering training, and indeed the nature of the intervention that these institutions would be capable of making.

The broad focal areas for capacity building include:

- Governance and policy development
- Technical husbandry processes and procedures
- Trade and economical aspects
- Extension methodologies
- Quality assurance and food safety issues
- Disease management and “health controls”
- Feed and nutrition
- Feed manufacture
- Research and development
- Information and communication
- Business management and marketing including trade related issues

There will be the need for short-term sensitization seminars and workshops, as well as short-, to medium-term institutional interventions, as well as long-term in-depth training. This would be in terms of academic accreditations including certification at the diploma level, as well, as at the PhD level. Basic skills training in aquaculture should also be targeted at youth using online platforms and building on the curricula of existing skills training institutions in the region such as the Guyana School or Agriculture, the Institute of Technical and Vocational Education and Training (ITVET) in Belize, and Sir Arthur Lewis Community College in St. Lucia.

5.0 EXPERIENCES IN FISH-FARMING AND OPPORTUNITIES FOR AQUACULTURE DEVELOPMENT

5.1 Opportunities for aquaculture development across the Caribbean

Aquaculture has been one of the fastest growing food production sectors globally. This trend is expected to continue and even increasing through to the year 2050. In between the current time and 2050 aquaculture is expected to fill the deficit in food fish production. This situation has arisen as a function of two (2) primary drivers: In the **first** instance the demand for fish will continue to expand as a function of population growth, increase in urbanization and improvement in the standard of living, especially for the working class citizenry – in the **second** instance global production from Capture Fisheries or traditional fishing has peaked with little or no scope for expansion. This is a function of the fact that much of the highly targeted and familiar fishstocks are either fully exploited or in decline

Total world fish production for 2008 was 142.6 million MT – contributions from aquaculture accounted for 52.5 million MT: This contribution from aquaculture accounted for 45.6% of global food supply from fish. Between 2006 – 2011 fish production from Capture Fishery sources has varied from 88.6 million MT to 90.4 million MT: During this same time contributions from aquaculture have grown steadily from 47.3 million MT to 63.6 million MT.

The stabilization in production from Capture Fishery sources is expected to continue to the extent that little or no growth is expected in the medium to long-term future, while appreciable growth in aquaculture is expected to continue through to 2050 when production from the sub-sector is expected to reach 140 million MT. Thus in that context it is envisioned that the CARICOM/CARIFORUM Caribbean can play a significant role in contributing to this growth in aquaculture.

Although the potentials for aquaculture development in the CARICOM/CARIFORUM Region have not been systematically and comprehensively assessed, there is the general view that the scope for

aquaculture development is great. This is based in large measure on the primary resource assets of the region.

The CARICOM/CARIFORUM Region is equipped with the full range of natural resources assets that would allow for the culturing of a range of species in a diverse array of husbandry infrastructure to suit diversity of culture environments. There are in principle opportunities for the culturing of stocks in the Caribbean from the full range of species groups being cultured globally. These include: finfishes, crustaceans, molluscs and aquatic plants.

The CARICOM/CARIFORUM Region at the macro-scale provides opportunities for a range of culture systems. The environments of the continents/island shelves and inshore waters, bays, coastal lagoon, rivers and other lotic inland waterways, as well as upland lakes and other lentic water freshwater bodies presents a range of possibilities for culture. These include open ocean ranching releases and restocking scenarios, pen culture, tank culture, raft culture, long-line culture and pond culture (See Annex II Table 2).

Notwithstanding the above, the various sub-regions in the Caribbean present different possibilities for fish farming. The Lesser Antilles is constrained by geography, population and developmental pressures, competition for limited space particularly from tourism related activities, and limitations in surface water availability as well as soil suitability. Thus extensive and semi-intensive earthen pond culture on a commercially viable scale would generally be infeasible from both a technical and economic perspective. Where possibilities exist, they would most likely be limited in aerial extent and marginally feasible in terms of economic returns.

The possibilities for land-based culture in the Lesser Antilles exist in principle and in practice. Polymer-lined ponds, raceways and concrete tanks are technically feasible in this environment for both marine and freshwater driven aquaculture. The high capital costs and inputs costs, particularly for energy and feed for fed aquaculture species diminishes the economic feasibility and competiveness for this type of aquaculture.

The Lesser Antilles are, in principle, more suitable for ocean culture. This could relate to cage culture for Cobia (*Rachycentron canadum*), Pompano (*Trachionotus carolinus*), Dolphinfish (*Coryphaenea hippurus*) and Red Drum (*Sciaenops ocellatus*) which have either been historically tried in the region or is in the process of being currently cultured (See Annex II Tables 1A & 1B and 2). There are also possibilities for the long-line and rope culture of Sea Moss (*Gracilaria spp.*) as well as the raft culture of oysters which are being successfully reared in at least one political jurisdiction in the Caribbean (Jamaica) [See Annex II Table 2]. Aquaponics systems where fish is grown in combination with vegetables is also a possibility in the region particularly in the smaller Caribbean Islands with limited space and natural resources for more extensive operations.

The Greater Antilles and Continental Countries in principle have a greater scope for aquaculture development by virtue of the greater abundance and extent of primary resource assets as well as a function of lower population densities and development pressures. The greater landmass of the Greater Antilles, relative to the Lesser Antilles, makes them more abundant in inland freshwater resources. Thus for example Jamaica and Haiti have a greater range and areal extent of rivers and lakes than Barbados, St. Vincent or Grenada. This combined with the requisite topographical features and soil conditions, makes for the greater possibility of inland pond-based Tilapia Farming in Jamaica and Haiti, relative to Barbados, St. Vincent and Grenada.

The greater expanse of the submarine shelf area of the Greater Antilles, relative to the Lesser Antilles, provides for a greater range of possibilities for sub-tidal culture. This would include possibilities in cage culture, sea-floor or bed culture, pen culture and rope and long-line culture (See Annex II Table 2).

The continental countries are even more richly invested with primary resource assets than the Greater Antilles. Thus for example Belize, Guyana and Suriname as continental states are invested with extensive coastal plains with the requisite clay content in the soil to make for the possibilities of pond based shrimp mariculture and Tilapia farming.

The continental countries, by virtue of their land-mass effect have a greater diversity and aerial extent of rivers, lakes and other inland waterways. Apart from the greater quantum of suitable land for aquaculture, there are a greater diversity and abundance of indigenous and locally occurring finfish and macro-invertebrate species that may have some aquaculture potential.

Thus in summary, in as far as the possibilities for aquaculture in the CARICOM/CARIFORUM Caribbean goes, there is a direct relationship in regard to the scope and extent of aquaculture development and the landmass of the various territories: Generally the larger the landmass the greater the possibilities for aquaculture development. However, small and medium size farming, aquaponic and mariculture in the coastal waters may be feasible in all countries.

Any future growth in aquaculture in the Caribbean will need to be considered within the broader context of sustainability in all its dimensions, viz: the environmental, social and economic components. Much effort and investment will need to be injected into resolving the challenges and capitalizing on the opportunities presented in the region. This will entail the building of human capacity and institutions, the generation of an overarching governance structure, sustaining political commitment and in general the wise stewardship of the primary and secondary resources and services upon which the industry depends. This will of course entail the building of useful and constructive partnerships.

5.1.a Financial Sustainability

In the context of the current undertaking, financial sustainability infers the availability of financial resources to initiate development and maintain and expand said enterprises over time. It also infers the need for competitiveness in terms of market prices for the end output. This in turn has implications for the efficiency of resource use and the quality of the outputs produced. Financial performance and viability of the farming operation will depend on factors such as local conditions, location, type of culture, size of operation, use of technology and competition from alternatives products. These factors affect the cost of production and market prices.

Hanley (2004) reported that tilapia farming in Jamaica is affected by the volume of production. He found that small farms with low production tend to have higher proportional costs for feed than medium farms, but less than large farms which feed more intensively. Likewise, fingerling costs are higher on small and medium farms than on large farms because the latter tend to produce their own fingerlings and sell the surplus, offsetting costs. Large farms have higher utility and fuel costs because they operate vehicles and aerators in addition to the pumps operated by small and medium farms. The cost components for small. Medium and large tilapia farms in Jamaica in 1999 are presented below (Hanley 2004).

Item	Small farm (1 -4 ha)	Medium Farm (5 – 20 ha)	Large Farm (21-45 ha)
Feed	42	33	57
Fingerlings	30	40	9
Labor	3	3	3
Utilities, fuel, supplies, equipment	8	5	16
Transport	4	2	2
Bank, Administration, Management	13	17	13

The availability of affordable credit to assist private sector development has been repeatedly flagged as one of the more salient elements constraining the development of the sector. This is relevant to both small-scale producers as well as industrial scale operators. The experience in the region has been to an appreciable extent that the development to assist industrial scale aquaculture has been sourced outside of the region and has in principle been independent of the domestic financial institutions within the various countries of the region. This is usually on the basis of two (2) main considerations. In the first instance the development of aquaculture enterprises is capital intensive and the relatively large quantum of funds necessary to assist

the overall development of the sector cannot be generated from the financial markets within any of the particular countries in the region, with few exceptions, In the second instance the interest rates, collateral requirements and loan maturity periods and other lending stipulations are not attractive to investors, whom for the most part has been almost exclusively foreign investors. This has been the case especially for shrimp farming in Belize and to a lesser extent Tilapia farming in Jamaica.

It must be pointed out that the development of the industrial sector is not totally independent of the domestic lending institutions. These have been accessed by investors for targeted initiative such as the repair and maintenance of refrigeration systems, the improvements to processing plants and the expansion of production acreage.

Access to credit or indeed the lack thereof has been much more crucial to the development of small and medium size aquaculture enterprises in the region. This has been due in large measure to the lack of asset base for such borrowers and the limited knowledge and understanding and low level of confidence of traditional lending institutions in the sector. This is due mainly to a lack of information on the part of lending institutions in regards to the performance and potentials of the small-farming sub-sector. This has been the experience of fish-farmers in Belize, Jamaica, Suriname, Haiti, Dominican Republic and Guyana where much of the small and medium size enterprise activities have been attempted.

One of the other considerations that would impede the development of small and medium size farmers in aquaculture is that the financial institutions that would traditionally support small project may not be in a position to assist the critical mass of small farmers that would make an impact on the socio-economic fabric at the district or national level for the various nation states of the region. As previously mentioned, aquaculture is capital intensive relative to traditional crop and livestock agriculture and institutions such as Credit Unions and Small Farmers Banks that would normally on-lend to small stakeholder would not in the normal course of their operations have the Capital Base to afford lending on a broad scale that would be required for the development of the sub-sector.

One of the ways of addressing the challenge of small and medium size farmers accessing credit is to assist with the development of specific projects within Credit Unions and Small Farmers Banks for on-lending to small-scale aquaculture farmers. The capital might be sourced through projectized submissions to institutions such as the World Bank or programmatic institutions within the EU.

Break-even estimates for semi-intensive shrimp farming in Belize in 1990 was 40 acres of production ponds. The capital and operational costs for these facilities was US $350,000.

These small farmers credit assisted initiatives may be further enhanced by providing advisory support to individual farmers on the establishment of cooperatives and other partnership schemes to pool resources and access the requisite credit facilities.

Another response in terms of assisting small farmers is to develop pilot testing schemes in polyculture systems, where they would be capitalizing on more trophic niches within the pond systems with the consequence of optimizing production biomass per unit feed and energy input.

One of the major challenges that would be faced by the industry across the region will be the modality of interventions that would be needed to transition farmers from subsistence and small-scale experimentation schemes to medium-level commercial enterprises that would be based on sound principles of business management. The development of a project based on viable economic models such as a 50 acre semi-intensive shrimp farm, or a 20 acre semi-intensive Tilapia farming operation that could be assisted by a ‘Development Partner’ would be a much needed intervention. A project such as this can be configured to assist 15 – 20 farmers in 2 – 3 countries in the region.

Apart from the issue of access to credit, the issue of addressing the high input cost for producers needs to be attended. For industrial scale producers, the following responses have worked in some countries and may have relevant applications in the wider region:

- Bulk purchasing/importation of feed through cooperation and partnerships

- In-Country manufacturing and production of carbohydrate and protein inputs (Soy beans, corn, rice)
- Networking among farmers to access good quality feed at more favourable prices either from local millers or from imported sources
- Assisting research efforts on fish meal substitutes for manufactured feed through:
  - On-farm feed trials and experimentation in coordination with academia or feed manufacturers
  - Networking and sharing information on effectiveness and growth performance
  - Engagement of local grain growers such as soy bean and sorghum farmers for the in-country production of carbohydrate and plant protein sources

The high input cost for feed for small and medium size farmers requires responses that are different from those for industrial scale farmers. Since small farmers find it difficult to cope with the unit cost of feeds utilized by large farmers, the recommended strategy is for feed to be milled locally on a smaller scale to specifically suit the needs of small farmers. This would entail some additional R&D trials using local carbohydrate and protein sources. There would also be the need for the participation from the small-scale farmers by way of hosting the trials at their facilities. The farmers can also benefit by providing some if not most of the local raw material or feed ingredients. This initiative can be projectized to include the purchasing of a small feed mill to manufactured feed specifically for said small farmers.

Another critical challenge facing small and medium size farmers is the lack of a business approach to development. Many farmers will enter into the business of aquaculture without a business plan and without the benefit of analysing the various feasibility aspects of the development. The latter includes the financial aspects of the project, including profitability and return on investment, and market analysis. To address this issue, farmers should be encouraged to be engaged in:

- Pilot scale project based on viable economic models,
- Training of small farmers in basic business development, including records keeping, accounting and marketing,
- Use alternate energy sources such as wind, hydro and solar

5.1.b Gains for the local value chain

In principle for those countries in the region with the greatest level of aquaculture development would benefit from gains to the value chain by internalizing and consolidating most of the material inputs and supporting services to the industry. This would be premised on the assumption that there would either be some cost advantage from the In-Country control and execution of a particular production or delivery of service or alternately there would be some strategic advantage in having stewardship over the quality control of the inputs to the production process. The latter is applicable especially to seedstock production and the production of feed ingredients given the potential risks and hazards associated with these inputs. This echoes the scenario in Belize where it can be seen from Fig. 6 that the inputs that are derived from outside of the borders of the Country are feed ingredient, manufactured feed, technology/know-how and equipment supplies.

One of the most significant gains to the value chain would be for all the aquaculture feed used in the industry to be manufactured in In-Country. This would create immediate economic benefits for farmers whom would respond to the demand for soy bean and other plant sources of carbohydrate and proteins.

There would also be opportunities for Miller or Feed Manufacturer in Belize. A significant portion of the feed used in the industry is imported. If a policy decision is made to discontinue the importation of feed the local Mill will have an opportunity to fill the gap created by the ban on imports.

Additional opportunities from internalizing functions of the value chain are in relation to technology and know-how. Much of the disease diagnostics is outsourced to the United States at significant costs. This is one area that would need to be internalized over the long term. This would entail capacity building at the MSc and PhD levels as well as significant investment in testing and laboratory facilities. This should be an

investment that would be justified given the macroscopic geographic extent of the CARICOM/CARIFORUM Region and its tremendous scope for aquaculture development.

Also on the technology/know-how front, there are opportunities in R&D for on-farm trials in relation to feed formulation using locally sourced material inputs – this is relevant to the needs of small farm operations: There are also opportunities for experimentation with fish meal substitutes for the bigger industrial scale operations.

There are also synergies in the value chain for the consolidation of inputs in regard to seedstocks. Most of the farms are vertically integrated with on-growing production infrastructure. A number of these hatcheries are underutilized with production only a couple months. There are opportunities for coordination and cooperation in terms of unifying fingerling production.

There are also opportunities in the marketing and distribution sector. Some of the shrimp farms rely on brokers outside of Belize to market their produce. This aspect of the operation could be internalized in country.

There should be parallels to the Belize Shrimp Farming in the Value Chain in Jamaica in regards to the Tilapia farming Industry. High imported feed ingredient costs are a common factor in both countries. The risks associated with the importation of broodstocks and seedsctocks as well as said feed ingredients are also common to both countries. The potential synergies that would be created from internalizing some of the production and service functions are also a parallel consideration for both countries. This would again include the in-country production of grain sources for carbohydrate and protein that would be integrated into manufactured feeds, as well as the production of broodstocks and diseases diagnostic services.

There would also be the scope for innovations in husbandry procedures and technology that would be a function of R & D. This would create opportunities in Jamaica for collaboration in applied research between the Tilapia farmers and institutions such as the University of the West Indies (UWI).

The case presented for Belize and Jamaica in regards to the opportunities for aquaculture development are in large measure for illustrative purposes in as much as they would provide information in regards to the pertinent challenges and opportunities that would be relevant to those countries that are at the 'Commercial Stage' of development (See Annex II Table 8). The other countries that are at the 'Developing' Stage of development such as the Dominican Republic, Guyana, Suriname and Haiti (See Annex II Table 8) would have commonalities in their value chains in regards to aquaculture development. There would per force be some common challenges and responses experienced by both sets of countries, including in regards to the marketing of the exported products.

Although the definition of a 'Value Chain' for aquaculture might not be at an appreciable stage of succession, the opportunities for optimizing benefits and realizing synergies in the industry through application of the value chain approach is relevant throughout much of the region. This would be especially pertinent to those countries that have been characterized as being either at the 'Commercial Stage' of development or 'Experimental Stage' of development. This would relate to a number of pilot testing projects, small start-up commercial oriented projects, as well as poverty alleviation and rural development driven subsistence initiatives. There would also be opportunities for the full-scale development of ornamental fish rearing projects. This is particularly relevant to smaller island states of the region.

It needs to be pointed out that although much of the insular states of the CARICOM/CARIFORUM Region have been grouped into the same 'Experimental' status category (See Annex II Table 8), there are within that grouping differing degrees of development among the countries. Thus for example St. Lucia has made appreciable progress in aquaculture, especially in Sea Moss (*Gracilaria spp.*) cultivation. The experience in fish farming in St. Vincent has been extremely limited.

5.2 Areas Where Support would be needed Over the Next Five Years

The areas identified for support over the next 5 years would need to be informed by strategic development consideration for the sector. These areas would put the CARICOM/CARIFORUM Region in a position where it would be poised to make a 'great leap forward' in realizing the fullest potentials of the aquaculture industry.

Although the various countries in the region have varying potentials for aquaculture development and although they are at varying stages of aquaculture development, the interventions identified to assist the sector should philosophically provide 'the rising tide to raise all ships': This means that all the countries in the region with the political will and commitment and potential for aquaculture development should be positively impacted by the programme areas identified for implementation.

The interventions that have been identified for implementation over the next 5 years should increase the competitive position of existing aquaculture producing countries such as Belize, Jamaica, Guyana, Haiti, Dominican Republic, on the international market and resolve the most critical technical challenges for the culturing of marine shrimps and Tilapia in these countries. These countries are at a crucial juncture where there is the need to increase their presence on the export market through a fairly rapid and sustained expansion in domestic aquaculture production of the two (2) species mentioned.

The 5 year interventions identified should also place Belize and Jamaica in a position where issues of compliance with especially EU market Standards are resolved and where these countries are in an advantageous position to take advantage of emerging market niches. This would include the diversification of product forms and consumer choices that are made on the basis of product traceability. This would bring in its wake strategies that would embrace voluntary certification and ethical issues such as gender equity and the employment of youths.

The identification of Belize and Jamaica for the interventions mentioned above is guided by their status of aquaculture development which has been characterized as being at the 'Commercial Stage' of development (See Annex II Table 8).

The interventions that have been identified are designed to move those countries that have been categorized as being at the 'Developing Stage' of development, closer to, or into the category of 'Commercial Stage' of development (See Annex II Table 8). This would in part entail improving the infrastructure and services to transition those operations that are at the experimental and pilot testing phase to fully commercial realm. The intervention would also entail consolidating and expanding those operations that are already commercially established

The countries in question are the Dominican Republic, Haiti, Guyana and Suriname (See Appendix II Table 8). The intervention to assist these countries also focuses on improvements in governance structures, technical suitability surveys and the stimulation of private sector investment.

The 5 year intervention that has been identified to advance aquaculture development in the region is in principle providing and enabling pathway to move those countries that have been categorised as being at the 'Experimental Stage' of development to the next succeeding stage, which is the 'Developing Stage' of development. This includes the Bahamas, Barbados, Dominica, Grenada, St. Lucia, St. Vincent, Trinidad and Tobago and St. Kitts and Nevis.

The programmatic areas of intervention focuses on consolidating political and by strengthening governance frameworks; providing material and financial support; training and capacity building; data and information management and sharing, and the systematic assessment of the various states and territories for aquaculture development. The intervention also focuses on improving access to credit arrangements; to strengthen experimentation and poverty alleviation and rural development support that would be based on aquaculture.

The intervention is reflective of a number of cross-cutting issues which transcends the varied levels of aquaculture development across the region. The areas of interventions have been grouped under 7 thematic areas, namely:

- Governance framework
- Capacity building
- Aquaculture statistical and information management and sharing systems
- Aquaculture suitability surveys
- Market studies
- Research and development including access to lower cost, good quality feeds and reducing energy cost in fish farming
- Climate Change and disaster risk management
- Improving fish health and food safety systems

A major focus of the efforts to assist aquaculture development over the next 5 years will be the strengthening of governance frameworks. This includes the definition of national policies and development plans (See Annex II Table 11), and the strengthening of legislation and regulations for the sector. This would include those areas that are relevant to quality assurance and risk management as well as those relating to development incentives and the licensing.

The strengthening of governance builds on the strengths and accomplishments of the various states and territories. In this context those countries that would have pre-existing development policies of strategies will be assisted with the articulation of development plans and legislation (See Annex II Table 11). Strengthening governance arrangements will also include strengthening the participation of stakeholders in policy development and implementation. The various interventions are to be staggered over the 5 years time-frame (See Annex II Table 11).

The capacity building response is to be reflective of the full suite of development concerns articulated in the various sections of the document. The capacity building initiatives will vary from brief seminars and workshops, to short-term and medium-term training opportunities as well as more extended engagements. The latter is to involve educational opportunities at the MSc and PhD levels as well as more basic skills training levels (See Annex II Table 11). It is envisioned that these opportunities could be taken up regionally at UWI, as well as extra-regionally at the United Nations University in Iceland and perhaps in the UK, the US or Canada. Basic skills training in aquaculture could be provided through local vocational training institutes such as ITVET in Belize, Guyana School of Agriculture in Guyana, Sir Arthur Lewis Community College in St. Lucia and Community Colleges in various other countries. This training would be targeted at youth using online platforms and building on existing curricula of these institutions.
Training will also be facilitated by the production of series of key (training and lessons learning) videos related to Caribbean specific aquaculture. These videos will be placed online and made available via the CRFM's Knowledge Platform including via social media tools. The videos will address: Key Species Tilapia - site selection, pond construction, marketing, feed and feeding, hatchery production, raceways, tilapia processing and value addition, brackish water cage tilapia production. The videos will also showcase successful small and medium size enterprises and aquaponics in the region.

It is envisioned that the short and medium-term training opportunities might also be taken up regionally or extra regionally depending on pre-existing content area and or the capacity and willingness of the particular educational institution to develop and implement the requisite training programme.

There is a critical shortage of data and information on the performance of the aquaculture industry across the region. One activity will be focused on improving basic understanding of the structure and performance of the sector through adoption of a value chain approach, as well as improving the availability of basic data on various aspects of the industry (See Annex II Table 11). This would include information on biomass production, revenues, market destination, export and domestic market prices, yields, species in culture, disease events, labour force, etc.

The true potentials of aquaculture can only be fully realized if the suitability of the particular state or local area for aquaculture development has been determined. Thus a critical response is to focus on a systematic aquaculture suitability survey for the various territorities. The beneficiaries have been identified as those countries that have been characterized as being at the 'Developing Phase' of

development (See Annex II Table 8) or alternately those countries at the 'Experimental Stage' of development in which there is some appreciable developmental activity in aquaculture (See Annex II Tables 8 & 11).

One of the most critical items for the sustainable development of aquaculture is the availability of credit and development financing (See Annex II Table 11). This is especially pertinent to the participation of small-scale and medium enterprise stakeholders in the industry. The project has two (2) components which are based on the:

- establishment of ten 50 acre semi-intensive shrimp farms and ten 20 acre semi-intensive Tilapia operations to assist medium-scale stakeholders with start-up operations, or alternately those who may be transitioning from small-scale subsistence or experimental operations to commercial scale ventures (See Annex II Table 11). It is envisioned that the funding for this initiative would come from sources such as the World Bank or Kuwaiti Development Fund.
- establishment of a credit line of US $10 million to assist the development of twenty 10 acre plots of production ponds (See Annex II Table 11). This would be part of a rural development or alternatively poverty alleviation scheme. This would be especially relevant to small farmers with low asset base who are working with local species with definitive consumer acceptability and technical potentials such as the Cascadura and the Baysnook.

The countries that would benefit from the US $25 million shrimp farming and Tilapia rearing projects are those in which these activities already exists and in which there is a need to expand the benefits of the sector to small-scale stakeholders These project should renew confidence in the sector and catalyse further investment in the industry by the private sector.

The funds for this project should be administered through a Small Farmers Bank or equivalent in the various countries

The US $10 million initiative to support the culturing of indigenous and locally occurring stocks is to be administered through Credit Unions in the various countries and is to specifically accommodate those farmers with low asset base that would not qualify for credit in the commercial banking institutions. The beneficiaries to this project are in equal measure the insular states and the continental countries.

The market studies to identify the demand for indigenous and locally occurring stocks are a crucial pre-requisite to expanded investment and development of the sector (See Annex II Table 11).

The market studies in relation to ornamental fish farming are highly relevant in the region, especially in the smaller island states of the Caribbean where land and freshwater resources are scarce. Again this should be a part of a poverty alleviation or rural development scheme (See Annex II Table11).

Research and Development is crucial to the development of the industry. The priority issues range from the subject of substitutes for fish meal inorder to reduce the high cost and dependence on imported high cost feed as well as ensure the availability of high quality affordable feeds, to determination of the reproductive biology of indigenous stocks and the husbandry performance of low trophic level species, as well as alternative sources of energy including the use of solar and wind energy in aquaculture operations(See Annex II Table 11).

The focus on responding to the effects of Climate Change and Climate Variability is highly relevant in a region that is greatly impacted by hurricanes and tropical storms as well as flooding events.

It needs to be noted that the partnership between the CARICOM/CARIFORUM Region and it Development Partner, in the context of the foregoing initiative, is one in which the Caribbean Partner of responsible for the logistical arrangement and implementation arrangements while the foreign partner is responsible for technical advisory support and the provision of financial resources to support the various

activities. It also needs to be noted that activities are staggered over the entire 5 year project period to assist the smooth implementation of the various activities.

6.0 THE WAY FORWARD: KEY DRIVERS OF SUCCESSES AND LESSONS FOR SCALING UP

One of the lessons learned in the region in terms of the aquaculture sector is that development doesn't happen by chance but is the outcome of a process with a particular architecture. This entails the development of political will that would bring in its wake the enabling governance structure and material and financial support from Governments to direct and support the course of development for private sector participation.

Another valuable lesson learned is that development proceeds in stages and these stages cannot be avoided. It is also recognized that the importance of human resource and indeed the building of capacity cannot be overemphasized, especially within the Small Island Developing States of the Caribbean.

The importance of credit and in general affordable sources of funding is critical to the success of the industry. It is also recognized that the development of the industry must be market-driven.

It is also recognized that aquaculture needs certain natural resources for its development, however, the production process itself has consequence in terms of polluting influences which depreciates and compromises the quality and status of these resources to the extent where they may compromise and erode the viability of the aquaculture enterprise itself over the course of time. Thus the issue of sustainability in all its dimensions becomes highly pertinent to the development of the sector. Successful aquaculture requires striking the right balance between the environmental/ecological pillar of sustainability and the economic as well as the social pillars of sustainability.

Partnerships are a critical component of aquaculture development. This is relevant across the industry and at various levels of the organizational framework, including at the level of states and development partners.

The drivers of success are:

- political support
- regulatory framework
- input costs
- credit and development finances
- market forces and fish production trends
- science and technological innovation
- private sector confidence and investment in the sector

Political support is of paramount importance in advancing the cause of aquaculture. It is a precursor to requisite public policy and material and financial support. The lack of political support has been one of the drivers of the development process that has been cited as one of the major impediments to the development of the sector.

The orientation and magnitude of input costs is also another major determinant of the probability for success of aquaculture expansion and sustainable development in the region. The cost of feed and energy has been one of the major factors in determining the success of aquaculture enterprises across the region. If the industry is to progress on a viable and sustainable path the cost of both feed and energy will need to decrease. The major element of feed cost is fish meal. There is an urgent need to find a replacement for fishmeal, especially from terrestrial sources of protein. If the cost of energy is to be reduced alternative and renewable sources of energy will need to be integrated into the production process.

The high cost and availability of credit is a major impediment to the sustainable development of the sector. This is especially relevant to small-, and medium-scale producers in the industry. Access to both

the quantum of finances and the lending rate are a challenge. Definitive strategies will need to be defined and employed to resolve this issue.

The diverse range of aquaculture commodities and the decreased prices for these commodities on the market in the medium to long-term future will be significant drivers that will govern whom the successful producers in the industry will be. The diversity in product form will include the availability of closely related species, different color morphs of the same species, different body forms of the same species, pre-cooked and easy to prepare meals.

The evolution and functional radiation of the market will be buoyed by technological innovations and improvements in efficiencies to increase yields and in effect improve production biomass for a given quantim of production output. Market forces will also engender year-round production of stocks and new and innovative culture practices.

The co-requisites of R&D will yield innovations in technology and production practices that will largely define the path of aquaculture development. Technological innovations will continue to be a major part of the landscape in breeding, feed and nutrition, the production infrastructure, disease control and management, and environmental management.

These technological improvements are expected to yield:
- improvements in survival rate
- increased feed conversion efficiencies and consequently lower feed use
- early use of artificial diets
- improved environmental tolerance
- increased disease resistance
- better engineered production systems
- sterile progenies
- offsprings with delayed maturation

The development of aquaculture will continue to be investment driven. In democratic societies, which characterize the CARICOM/CARIFORUM Region, this is the exclusive domain of the private sector. As technology improves and aquaculture and markets expand the profit and development motive is expected to reinforce private sector confidence in aquaculture with the consequence of expanded participation of the private sector in investment in the various avenues of the sector. This should range from investments in the primary production infrastructure, to investments in the supporting services of feed manufacturing, processing, seedstock production, disease diagnostics and R&D in species technology and husbandry practices.

6.1 A work plan for aquaculture development

There are eight major areas (see Table 11) identified for moving the aquaculture agenda of CARIFORUM Member States forward over the next five years:

- Strengthening governance frameworks
- Capacity building
- Strengthening data and information management systems for aquaculture, including carrying out surveys on the suitability of aquaculture at the national level
- Strengthening access to affordable credit particularly, small and medium size enterprises
- Market studies including characterization of demand for indigenous and locally occurring species
- Research and Development on alternative feeds, energy, bio-technical and economical aspects of aquaculture
- Adaptation to climate change and climate variability

The activities include but are not limited to: syntheses of development policies, strategies and plans ; workshops and seminars on topics such as quality assurance, financial management, accounting, and aquaculture husbandry practices; National surveys to assess viability of aquaculture development ;

market feasibility studies for indigenous and locally occurring species ; research into feed material substitution and alternative energy sources; and, preparation of of climate change and disaster risk management plans for the aquaculture (sub-)sector.

This direction is in keeping with the CARICOM Strategic Plan (2015-2019) and the*approved Caribbean Community Common Fisheries Policy*, which is aimed at establishing a cooperative platform for the transformation of the fisheries and aquaculture sector; to create new opportunities for economic growth and prosperity, and to bring greater security and hope to the present and future generations of people who depend upon the region's living aquatic resources for their livelihoods.

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ANNEXES

Annex I - Study on the Potential of Aquaculture in the Caribbean countries: Terms of reference

1. Context

The Brussels Briefing n. 32 on Fish-farming: the new driver of the blue economy? co-organised by the CTA, DG DEVCO from the European Commission, the ACP Secretariat and Concord as part of the bimonthly briefings on key issues and challenges for rural development in the context of ACP-EU cooperation, generated a lot of interest from the audience.
Following the presentations by the experts from the regional organisations in the ACP (NEPAD, CRFM and SPC) the ACP Group of ambassadors recommended a follow-up on defining specific needs for support for the ACP group to be presented at the 11th EDF.

CTA is supporting the regions to build evidence on the aquaculture sector by commissioning a global study and three regional studies to each of the ACP regions.
The results will be presented in regions as well as in Brussels to the WG on Fisheries and the sub-committee on sustainable development.

2. Objectives of the Caribbean study

The study will focus on the opportunities for aquaculture development for the ACP regions and the drivers for success. It will highlight needed interventions to succeed.
While each region has its priorities, many issues are similar and there is scope for sharing experiences and expertise across the ACP.

Therefore specific interventions could be defined in a 5 year time frame to develop the sector, strengthen current positive experiences and upscale successes.

This study will be carried out by CRFM, NEPAD and SPC who will bring regional perspectives, especially on the identification of support needed.

The main findings of the study will be presented at the ACP and EU groups in Brussels.

3. Assignment

See below the content to be developed for the Caribbean regional study.

4. Deliverables

- Regional study: preliminary version for 15th June. Final document for 15th July.
- Regional workshop to be organized between mid June and mid July (exact date tbc)
- Presentation of the results of the study in Brussels – 3rd week of July (tbc)

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      b. Main producing countries
      c. Main markets and quality and food safety standards
      d. Main actors in the chain

   2.2. New opportunities in market development

3. Contribution of sustainable fish farming to food and nutrition security
   a. Integrated agriculture and fish farming systems
   b. Contribution to employment
   c. Recognition of the role and opportunities for women and youth in aquaculture
   d. Benefits for small-scale producers

4. Addressing the long-term sustainability of the sector
   a. Policy processes and regulatory frameworks in support of aquaculture
   b. Aquaculture nutrition
   c. Feeds risk analysis and health management
   d. Environmental sustainability
   e. Economic sustainability including trade related issues
   f. Training and capacity development needs and provision of technical support

5. **Proven successes in fish farming and opportunities for sustainable aquaculture development**
   a. Opportunities for aquaculture development across the Caribbean
      - Financial sustainability
      - Gains for the local value chain
   b. Areas where support would be needed over the next five years

6. The way forward: Key drivers of successes and lessons for scaling up

Annex II - Tables and Figures

Table 1A: Aquaculture in the Continental Caribbean and Greater Antilles

Country	**Species Group**								**Aquaculture Development**
	Finfishes			**Crustaceans**			**Other**		
	Tilapia	**Marine Species**	**FW Indgn Species**	**Marine Shrimps**	**Macbrn Spp.**	**Spiny Lobster**	**Oyster & Conch**	**Sea Moss**	
Belize	XRH	XRH		XC					Cm Crl
		XC			XLH	XRH	XLH	XC	Expt
	XC		XRH						SubSn
Dominican Republic	XC								Cm Crl
		XLH	XLH						Expt
									SubSn
Guyana	XC		XC						Cm Crl
									Expt
		XC		XC					SubSn
Haiti	XC								Cm Crl
	XC								Expt
									SubSn
Jamaica	XC			XC			XC		Cm Crl
		XLH						XLH	Expt
					XC				SubSn
Suriname	XRH		XLH	`XC					Cm Crl
									Expt
									SubSn

Key: Cm Crl = Commercial Culture Expt = Experimental Culture SubSn = Subsistence Culture
FW Indgn = Freshwater Indigenous Species Macbn Spp = Macrobrachium Species
C = Current LH = Longterm Historical (≥ 10 YRS) RH = Recent History (≤ 10 YRS)

Table 1B: Aquaculture development in the Lesser Antilles

Country	Species Group								Aquaculture Development
	Finfishes			Crustaceans			Other		
	Tilapia	Marine Species	FW Indgn Species	Marine Shrimp	Macbrn Spp.	Spiny Lobster	Oyster and Conch	Sea Moss	
Bahamas	XLH								Cm Crl
				XRH					Expt
									SubSn
Barbados									Cm Crl
	XLH	XLH							Expt
									SubSn
Dominica	XLH								Cm Crl
					XC				Expt
								XC	SubSn
Grenada									Cm Crl
	XLH								Expt
								XC	SubSn
St. Lucia	XC							XC	Cm Crl
					XLH				Expt
									SubSn
St. Kitts-Nevis									Cm Crl
	XC				XLH				Expt
									SubSn
Trinidad and Tobago	XC								Cm Crl
					XLH				Expt
			XLH						SubSn

Key: Cm Crl = Commercial Culture Expt = Experimental Culture SubSn = Subsistence Culture
FW Indgn = Freshwater Indigenous Species Macbn Spp = Macrobrachium Species
C = Current LH = Longterm Historical (≥ 10 YRS) RH = Recent History (≤ 10 YRS)

Table 2: Diversity of aquaculture production globally and their applicability to current commercial scale culture practices in the Caribbean

System and Culture Environment		**Applicability to the Caribbean**	**Species**	**Countries**
Environment	**System** (Growout production)			
Land-Based	Lagoons	-	-	-
	Flooded Agriculture Fields and Channels	√	Native finfish Hassar (*Micropogonias furnieri)* and Lukanani (*Chicla ocellaris*), mullet (*Mugil cephalus*), marine shrimps (*Penaeus schmitti*) and (*Penaeus aztecus*)	Guyana
	Ponds	√	Marine Shrimp (*Penaeus vannamei*), Tilapia hybrids (*Oreochromis niloticus*), Bay Snook (*Petenia splendida*) Colossoma, Freshwater Shrimp (*Macrobrachium spp.*), Cascadura (*Hoplosternum littorale*)	Bahamas, Belize, Dominican Republic, Haiti, Jamaica, Suriname
	Tanks	√	Tilapia	Jamaica
	Raceways	-	-	-
Water-Based	Open Release	-	-	=
	Beds	-	-	-
	Raft, Long-line	√	Oysters (*Crassostrea rhizophorea*), Sea Moss (*Gracilaria spp.*)	Belize, Jamaica, St. Lucia, Antigua and Barbuda
	Enclosures (pens)	-	-	-
	Cages	√	Cobia (*Rachycentron canadum*), Pompano (*Trachinotus carolinus*), Red Drum (*Sciaenops ocellatus*)	Belize, Dominican Republic, Martinique

Table 3: Aquaculture systems intensity and yields

Intensity	Yields	Feeding Practices	Husbandry Practice
Extensive	0.05 – 0.5 MT/Ha/Yr	No feeding	Stocking with wild-caught fry, fertilizers may be used
Semi-extensive	0.5 – 5.0 MT/Ha/Yr	Possibly supplemental feeding with low-grade feed	Stocking with wild-caught or hatchery-reared fry…Regular use of organic or inorganic fertilizers
Semi-intensive	2.0 – 20 MT/Ha/Yr	Regular use of formulated supplemental feed	Stocking of hatchery-reared fry, regular use of fertilizers
Intensive	20 – 200 MT/Ha/Yr	Complete artificial diet, fully formulated to meet all dietary requirements of species	Stocking with hatchery-reared fry, no fertilizers…Full predator and anti-theft precautions taken
Hyper-intensive	≥ 200 MT/Ha/Yr	Complete artificial diet, fully formulated to meet all dietary requirements of species	Stocking with hatchery-reared fry, no fertilizers…Full predator and anti-theft precautions taken...Highly coordinated and controlled production regime

Table 4: Relative aquaculture production biomass in the Caribbean - by declining order of magnitude

Country/Group of Countries	Percentage production – 2011
Belize	68.83%
Jamaica	16.49%
Haiti	8.6%
Guyana	3.77%
Suriname	1.38%
Dominica	0.5%
St. Lucia	0.17%
Barbados	0.16%
Trinidad and Tobago	0.09%
St. Kitts Nevis	0.01%
Anguilla, Antigua and Barbuda, Bahamas, Grenada, Montserrat, St. Vincent and the Grenadines, Turks and Caicos	< 0.01%

Table 5: Production main aquaculture producers in the Caribbean 2011 – In declining order of magnitude

Country	Aquaculture Production (MT)
Belize	5,290
Jamaica	5,141
Guyana	511
Haiti	400
Dominican Republic	240
Suriname	41

Table 6: Fisheries and aquaculture production in the Caribbean for 2010

Variable	**Source**		**Total Production** (MT)
	Capture Fishery	Aquaculture	
Production (MT)	165,213	11,000	176,213
Percentage Contribution (%)	93.8%	6.2%	!00%

Table 7: Balance of Trade for fisheries commodities in the Caribbean for 2010

Function	**Export**	**Import**	**Ratio** Export to Import
Production (MT)	61,000 MT	117,000 MT	1:2
Value (US$)	$250 million	$343 million	3:4

Table 8: Development stages of the industry and pre-requisites for progress for aquaculture in the Caribbean

Development Stage	Countries	Pre-requisites for Progress	Constraints	National Response Needed	Focus of International Assistance
'Experimental'	Bahamas, Barbados, Dominica, Grenada, St. Lucia, St. Vincent, Trinidad and Tobago	Political will and commitment Viable primary resource assets to support commercial culture Market demand exists for cultured species	❖ No aquaculture policies and plans available to incorporate into larger national development plans ❖ Aquaculture not considered priority by national governments ❖ Culture of insufficient planning for development of sectors ❖ Inadequate support systems for aquaculture development	❖ Availability of primary resource assets (land, seabed, clean water, viable species for broodstocks and seedstocks) ❖ Also development of secondary resources or infrastructure such as roads, bridges, ports, airports ❖ Market surveys to assist small stakeholders especially in relation to species acceptable on local market	Technical assistance and grant support to develop physical markets, processing facilities, feed mills for small stakeholders Technical advisory support and grant funding to assist aquaculture suitability surveys in various countries

Development Stage	Countries	Pre-requisites for Progress	Constraints	National Response Needed	Focus of International Assistance
'Developing'	Dominican Republic, Guyana, Haiti, Suriname	Functional infrastructure Technology developed and experimented under local conditions Critical mass of technically trained and competent persons Determination of full development potentials of industry Political awareness and material support	❖ Lack of or inadequate resources for aquaculture development ❖ Insufficient planning involved in technology transfer ❖ Ineffective human resource management to make pilot projects a success ❖ Poor strategic and human resources planning	❖ Flexible and willing public structure ❖ Securing extra budget support from annual budgets of Governments to develop infrastructure and support services for development of sector ❖ Generation and implementation of demonstration and pilot projects to stimulate and sustain aquaculture among small farmers ❖ Development of aquaculture woven into national development goals	Assistance in investment opportunities and external funding sources

Development Stage	Countries	Pre-requisites for Progress	Constraints	National Response Needed	Focus of International Assistance
'Commercial'	Belize, Jamaica	Sector Policy	❖ No clearly defined or specific policies on aquaculture ❖ Limited local expertise to guide policy formulation	❖ Generation and adoption of national policies, strategies and plans on a recurrent and episodic basis to guide long-term and sustainable development of sector ❖ Development of incentives and credit institutions and mechanisms to stimulate private investment in the sector	Securing advisory and technical support for establishing and maintaining marketing information hub at regional level within the CRFM
		Legal and Institutional framework	❖ Lack of financial resources for development of the sector ❖ Lack of knowledge on standards for food safety and human health (HACCP, CODEX, ISO etc.) ❖ Lack of understanding of	❖ Create, strengthen and reconfigure institution within public sector for regulatory leadership of the industry ❖ Develop, amend and strengthen legislative and regulatory environment to improve advisory	Securing donor support for repository and access of technical, scientific, economic , trade and marketing information to support aquaculture development at regional level
		Availability of financing to develop sector			Assist in building network and partnership to strengthen R & D efforts at both the national and wider regional levels

		Aware of quality assurance requirements to access foreign markets	implications of not adhering to CCRF	services, permitting and information to developers ❖ Availability of support services ❖ Capacity building in risk analysis and quality assurance requirement of export market	Assist in the organization and sponsoring of workshop and short-term training in the husbandry, marketing, economic and human resource aspects
'Commercial' (stage cont'd)		Familiar with primary drivers of sustainable aquaculture development	❖ Weak linkages between public and private sector aquaculture stakeholders ❖ High input costs especially feed and energy ❖ More discerning consumers, increase in production volume, greater diversity of product and lower product cost	❖ Legislative changes in inspection and quarantine protocol, as well as traceability and other regulatory issues related to product quality on the export market ❖ Research efforts in fishmeal substitutes especially from terrestrial protein sources ❖ Incorporating production from local agriculture sources in terms of primary produce and wastes and by-products	Acquiring technical experts to advise on issues of quality assurance requirements, marketing and trade including non-tariff barriers

				❖ Alternate and cheaper sources of energy than fossil fuel to assist aquaculture development	Assisting with forging of strategic partnerships to assist applied research in fish meal substitutes and alternate sources of energy

Table 9: Aquaculture Governance in the Caribbean

State/Group		Policy & Planning			Legislation		Admin. Support		
Country Group	**Country**	**Policy**	**Strategy**	**Nat. Dev. Plan**	**Fsh Act Provsn**	**Aqua. Spcf. Act/Regs.**	**Import Permit**	**Licensing Facilities**	**Extension Adv. Sup**
Continental Countries and Greater Antilles	Belize		XD		X	XD	x	X	X
	Dominican Republic								
	Guyana								X
	Haiti								
	Jamaica			X					X
	Suriname								
Lesser Antilles	Bahamas					XD			
	Barbados								
	Dominica	X			X				
	Grenada	X			X				
	St. Kitts Nevis		X						
	St. Lucia			X					
	St. Vincent	X							
	Trinidad and Tobago	X							x

Key: Nat. Dev. Plan = National Development Plan Fsh. Act Provsn = Fisheries Act Provision
Aqua. Spcf. Act/Regs. = Aquaculture Specific Act and/or Regulations Adv. Sup. = Advisory Support
D = Draft

Table 10: Suitability assessment for species that are either currently cultured in the region, or that were cultured in the recent past

Species/Group	Control of Breeding	High Fecundity	Short Larval Cycle	Rapid Growth	Simple Technology	Compound Diet Available	Fingerling Availability	Market Potential
Freshwater Species : Indegenous Stocks								
Bay Snook (*Petenia splendida*)	x	xx	xxx	x	xxx	x	x	xx
Tambaqui (*Colossoma macroporum*)	xxx	xxx	xxx(?)	xxx	xxx	x	xx	xx
Hassar or Bashaw (*Micropogonias furnieri*)	x	x (?)	xx?	x(?)	x ?	x	x	x
Lukanani (C*hicla ocellaris*)	x	x(?)	xx	x	xxx	x	x	xx
Grey Mullet (*Mugil cephalus*)	x	xx(?)	X(?)	x(?)	x(?)	x	x	xxx
Tilapia (*Orecchromis nilotocus*)	xxx	xxxx	xxx	xxxx	xxxx	x	x	xx
Cascadura or Kwiekwie (*Hoplosternum littorale*)	x	x(?)	x(?)	x(?)	xx(?)	x	x	xx
Eel (*Anguilla rostrata*)	xxx	xxxx	xx	xx(?)	xxx	xxx	x	xxx
Giant Freshwater Prawn (*Macrobrachium rosenbergii*)	xxx	xxx	xx	xxx	xx	xxxx	xx	xx
Freshwater Lobster (*Macrobrachium acanthurus*)	x	x(?)	xx	xx	xx(?)	x(?)	xx(?)	x(?)
Species/Group	**Control of**	**High**	**Short Larval**	**Rapid**	**Simple**	**Compound Diet**	**Fingerling**	**Market**

	Breeding	Fecundity	Cycle	Growth	Technology	Available	Availability	Potential
Marine Species								
Red Drum (*Sciaenops ocellatus*)	xxx	xxx	Xxx	xxx	xx	xxx	x	xxx
Dolphin Fish (*Coryphaena hippurus*)	xx	xxx	X	x(?)	x(?)	xx(?)	x	xxxx
Cobia (*Rachycentron canadum*)	xx	xxxx	Xxx	xxxx	xx	xxxx	x	xx
Pompano (*Trachionotus carolinus*)	x	xxx	Xxx	xx	xx	xx	x	xxx
Pacific White Shrimp (*Penaeus vannamei*)	xxxx	xxxx	Xxx	xxxx	xx	xxxx	x	xxxx
Caribbean White Shrimp (*Penaeus schmitti)*	xx	xxxx	Xxx	xx	xx	xxx	xx	xx
Mexican Brown Shrimp (*Penaeus aztecus*)	x	xx(?)	xx(?)	xx(?)	xx(?)	xx(?)	x	xx
Australian Freshwater Lobster (*Cherax quadricarinatus*)	xxx	xx	Xxx	xx	xx	xxx	x	x
Grass Shrimp (*Penaeus monodon*)	xxx	xxx	Xxx	xxxx	xx	xxx	x	xx
Spiny Lobster (*Panulirus argus*)	x	xxx	X	x	x	x	x	xxxx
Mangrove Oyster (*Crassostrea rhizophorea*)	xx(?)	xxxx	xx	x	xxx	-	x(?)	x
Species/Group	**Control of Breeding**	**High Fecundity**	**Short Larval Cycle**	**Rapid Growth**	**Simple Technology**	**Compound Diet Available**	**Fingerling Availability**	**Market Potential**
Queen Conch (*Strombus gigas*)	xx	xxx	Xx	x	xx	xx	x	xxxx

Sea Moss (*Gracilaria spp.*)	xx	-	-	xxxx	xxxx	-	xxx	xxx

Key:
xxxx = best case x = worst case. x (?) = worst case and insufficient information unavailable.

Table 11: Five year Work Plan for aquaculture development in the Caribbean

Objective/ Thematic Area	Activities	CARICOM Contribution	Development Partner Contribution	Beneficiaries	Time-line				
					Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
Strengthening governance frameworks	Preparation or Revision of national aquaculture plans and policies for up to 4 countries where required	In-Country staff and logistic support	Advisory support from United Nations University in Iceland	Bz, Jam, Haiti, Surin, Dom, Bah	X				
	Revision of preparation of National Legislation for up to 4 countries where needed	In-Country staff and logistic support	Advisory support from United Nations University in Iceland	Jam., DR., Guy., Sur, Haiti		X			
Capacity Building	Short training seminars and Workshops on (i) Policy Development, (ii) risk analysis, (iii) quality assurance, value chain approach, (iv) fish farming as a business, (v) aquaculture extension, (vi) Recirc System /aquaponics short course in Univ of Virgin Isles	Selection of candidates from private and public sector and sustaining in-country salary	Programme developed and implemented in collaboration with private sector partners and developmet partners such as United Nations University in Iceland, IFREMER, Univ of Wageningen, Univ of Ghent, Univ of Stirling, UWI, Univ of the Virgin Islands (aquaponics)	ANU, Bah, Bz., Jam., Dom, DR, Guy., T&T, Sur, St Lucia, SKN, Grn, SVG, Haiti, BDOS,	X	X	X	X	
	1 mth Intensive Training Programme in Husbandry Practices of tropical aquaculture species.	Selection of Candidates and sustaining in-Countyr salaries	Programme developed and implemented by Stirling University in Scotland	Bz, Jam, DR, Sur., Guy, St. Lucia, St. Kitts-Nevis, Dominica, Haiti	X			X	
	1) 1 – 2 yrs MSc Aqua Programmes (6 candidated from the Caribbean). 2) 3 Year Ph D Programme in aquaculture (1-2 candidates from the	Recruited from Government Services the private sector and/or regional institutions including national Universities (Univ Belize, Univ Guyana etc)	Aquaculture Programme at Wageningen Univ,, Univ of Ghent Univ of Stirling, or University in another ACP regionoffering Masters or PhD in aquaculture	Bz, Jam. Guy, Haiti, Suriname, Dominican Republic,	X	X	X	X	X

Objective/ Thematic Area	Activities	CARICOM Contribution	Development Partner Contribution	Beneficiaries	Time-line				
					Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
	region)								
	Production of a series of key (training and lessons learning) videos related to Caribbean specific aquaculture placed on online platform.	CRFM will provide personnel to set up, edit and produce videos	3 X 5 minute videos to be produced each year over 5 years	All	X	X	X	X	X
	Inter and intra regional working internship programme for both private and public sector participants	Support from member countries to offer relevant internships to both inside and outside	Funding and facilitation	All states	X	X	X	X	X
	Development of curriculum for basic skills training in aquaculture targeting youth and piloting in 4 countries	CRFM will coordinate development and recruitment of suitable skill training institutions	Funding. To be done in collaboration with UNU-FTP Iceland and Stirling Univ	Belize, Jamaica, St. Lucia, Dominica		X	X	X	X
Strengthening Data Mgmt and knowledge Sharing Systems for Aquaculture (build on existing regional knowledge platform)	Equipting Fisheries Departments & fish farmers associations and selected SME with Computer Facilities for collection, processing, storage and retrieval of data	Provide building and staffing and facilities	Funding support to purchase equipment – private sector people could get some assistance for start ups and piloting data collection and sharing schemes.	Bz, Jam., DR, Guy., Sur, Haiti, St. Lucia.	X	X	X	X	
	Caribbean Aquaculture Conference and Trade Fair to promote knowledge exchange and opportunities int he region and Europe - Involving Caribbean and key European input e.g. (i) feed manufacturers &	Provide venue but also as output to this produce Caribbean wide Aquaculture Suppliers Trade Directory – avaialble in hard copy also online	Support for conference speakers and participants from private and public sector	All countries		X			

Objective/ Thematic Area	Activities	CARICOM Contribution	Development Partner Contribution	Beneficiaries	Time-line				
					Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
	suppliers, (ii) General equipment - pumps, hapas hatchery etc (iii) Cage culture technology, & (iv)tropical aquaculture research including health management								
Aquaculture Suitability Surveys. (1 Site suitability surveys including GIS; and Production of portfolio of 5 economic viability studies for different prod systems	National GIS based surveys of biophysical, infrastructural and institutional factors to assess aquaculture potentials of country or region within country	Provide staff and lend in-Country logistic support	Funding and technical assistsance of EU Partner institutions as part of adacemic training for students at partner institutions such as IFREMER, Stirling Uni,University of Gent, as part of MSc or PhD Thesis requirement	Bz, Haiti, Guy., St. Lucia, DR, T&T, Suriname	X	X			
Strengthen Credit regimes	Access US$10 million soft loan to Credit Unions to on-lend to l farmers This is best done as a revolving credit fund to targeting small to medium scale fish farmers with low interest rates	Identify suitable Credit Institution such as Credit Union or Development Bank and structure agreement	Assist with mobilization of funds from potential funding sources and to be overseen by EU organisation with Microcredit Expertise	Bz., Jam., DR, Haiti, Guy., , T&T		X	X	X	X
	Access US$25 million soft loan to on-lend to farmers to start-up fish farms	Identify Agriculture Development Bank and structure agreement	Assist with mobilization of funds from potential funding sources	Bz., Jam. Guy., DR		X	X	X	X
Market Support	Market feasibility studies for indigenous and locally producedspecies	Logistic support including government counterpart	Funding support for regional and EU organisations with specialist skills such as	Bz, Guy, Sur, T&T			X	X	

Objective/ Thematic Area	Activities	CARICOM Contribution	Development Partner Contribution	Beneficiaries	Time-line				
					Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
			Stirling Univ, Newcastle Univ , Univ of sussex, Univ of Wageningen , Imperial College Univ of London , Stockholm Institute as well as Independent consultant from EU working with local counterparts						
	Market and Technical feasibility assessments of Ornamental Fish Culture	Logistic support including Government counterpart	Funding support for regional and EU organisations with specialist skills such as Stirling Univ, Newcastle Univ , Univ of sussex, Univ of Wageningen , Imperial College Univ of London , Stockholm Institute as well as Independent consultant from EU working with local counterparts	Dom., St. Kitts/Nevis, Grenada, St. Lucia, St. Vincent		X	X		
R&D	Industry research local feed material substitution small scale fish farming	Identify local farmer(s) to conduct feed trials	University of Stirling Institute of Aquaculture to lead research efforts. Also promote and establish linkage with European Feed Companies such as Skretting, Biomar , Coppens , Legouessant			X	X	X	
	Institutional research reproductive biology	Logistic support and coord with research	University of Stirling Institute of	Bz, Guy, T&T			X	X	X

Objective/ Thematic Area	Activities	CARICOM Contribution	Development Partner Contribution	Beneficiaries	Time-line				
					Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
	indigenous and local species (2-3 species)	institution	Aquaculture, IFREMER and UWI to lead research efforts						
	Institutional Research Low trophic level species (sea urchin, sea cucumber, blue land crab)	Logistic support and coord with research institution	University of Stirling Institute of Aquaculture and IFREMER to lead research efforts in collaboration with local institutions and farmers	St. Lucia, St. Kitts/ Nevis, Dom. Jam, Bze,				X	X
	Preliminary scoping study and pilot project in 2 countries on renewable energy development in Caribbean aquaculture. The focus would be primarily be on solar but others included	Logistic support and coord with research institution	Support for input from European Institutions and/ or private sector companies with expertise in this area		X	X	X		
Adaptation to Climate Change	Preparation and implementation of climate change adaptation and disaster preparedness plan for sector	Logistic support	Independent consultancy supported by Carbbbean Climate Change Center,	Bz, Jam. DR, Haiti, Guyana, Suriname, Gernada		X	X	X	
	Feasibility study on crop insurance for sector	Logistic support	Funding Support and study to be carried out by Aquaculture Insurance specialists such as Sunderland Marine Insurance of the UK	Bz, Jam. DR, Haiti, Guyana				X	X

Source: Map Resources. Adapted by CRS.

Fig. 1: Map of the Caribbean

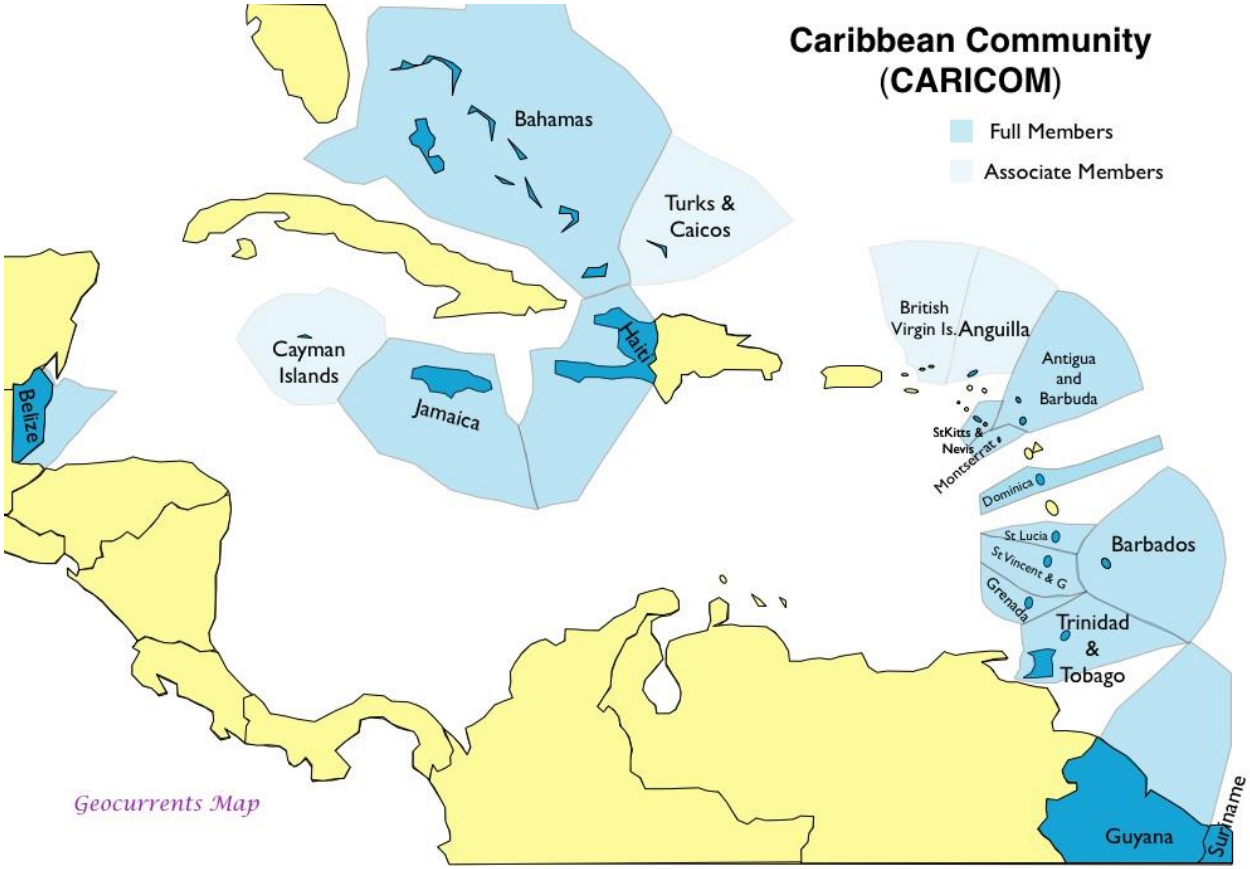


Fig. 2: CARICOM Member and Associate States
(Note : The maritime boundaries shown in this figure are indicative only, and are with out prejudice to any future boundary delimitations processes in which States may be involved)

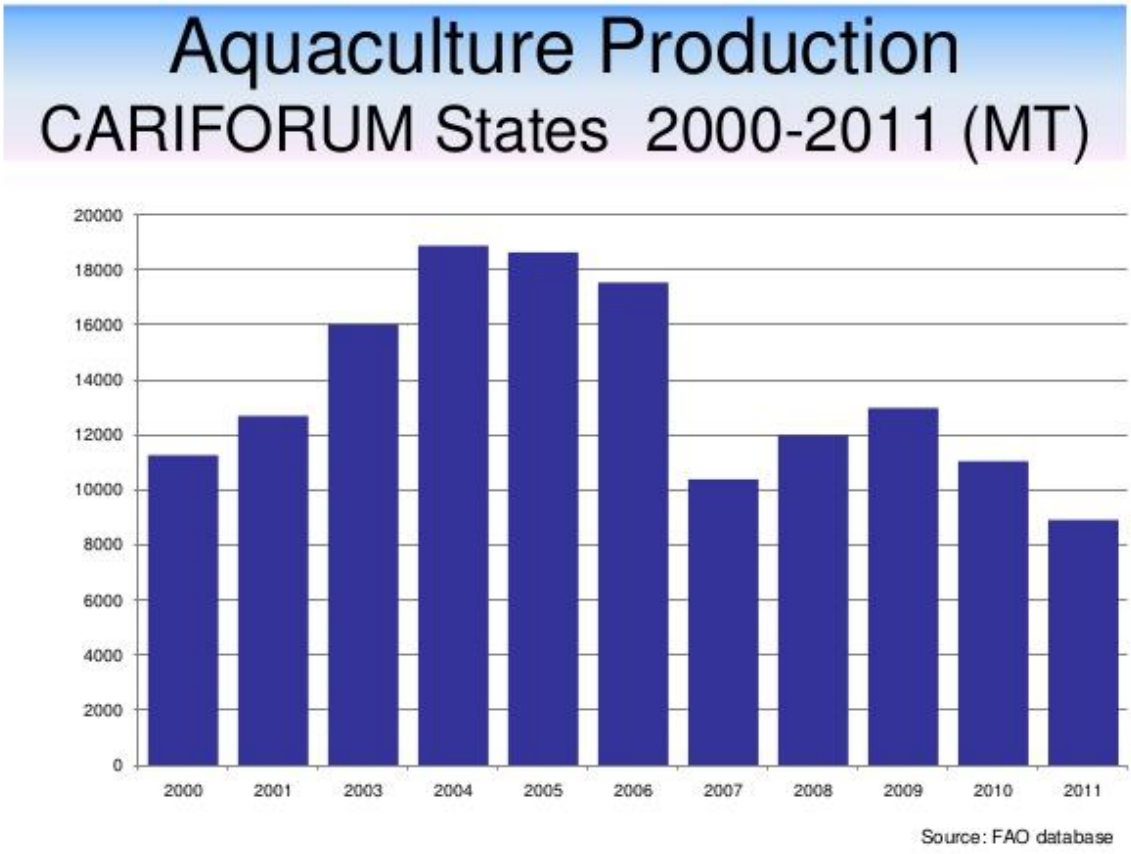


Fig. 3: Aquaculture production in CARIFORUM States

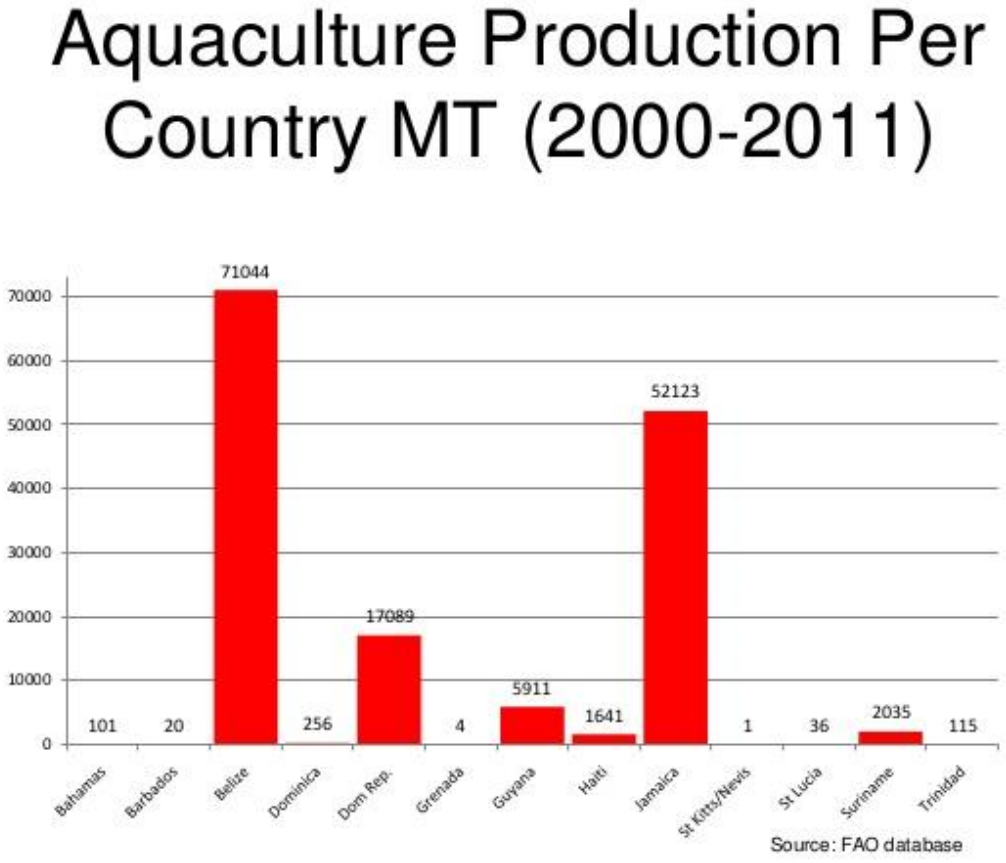


Fig. 4: Cumulative aquaculture production in the Caribbean by country 2000 - 2011

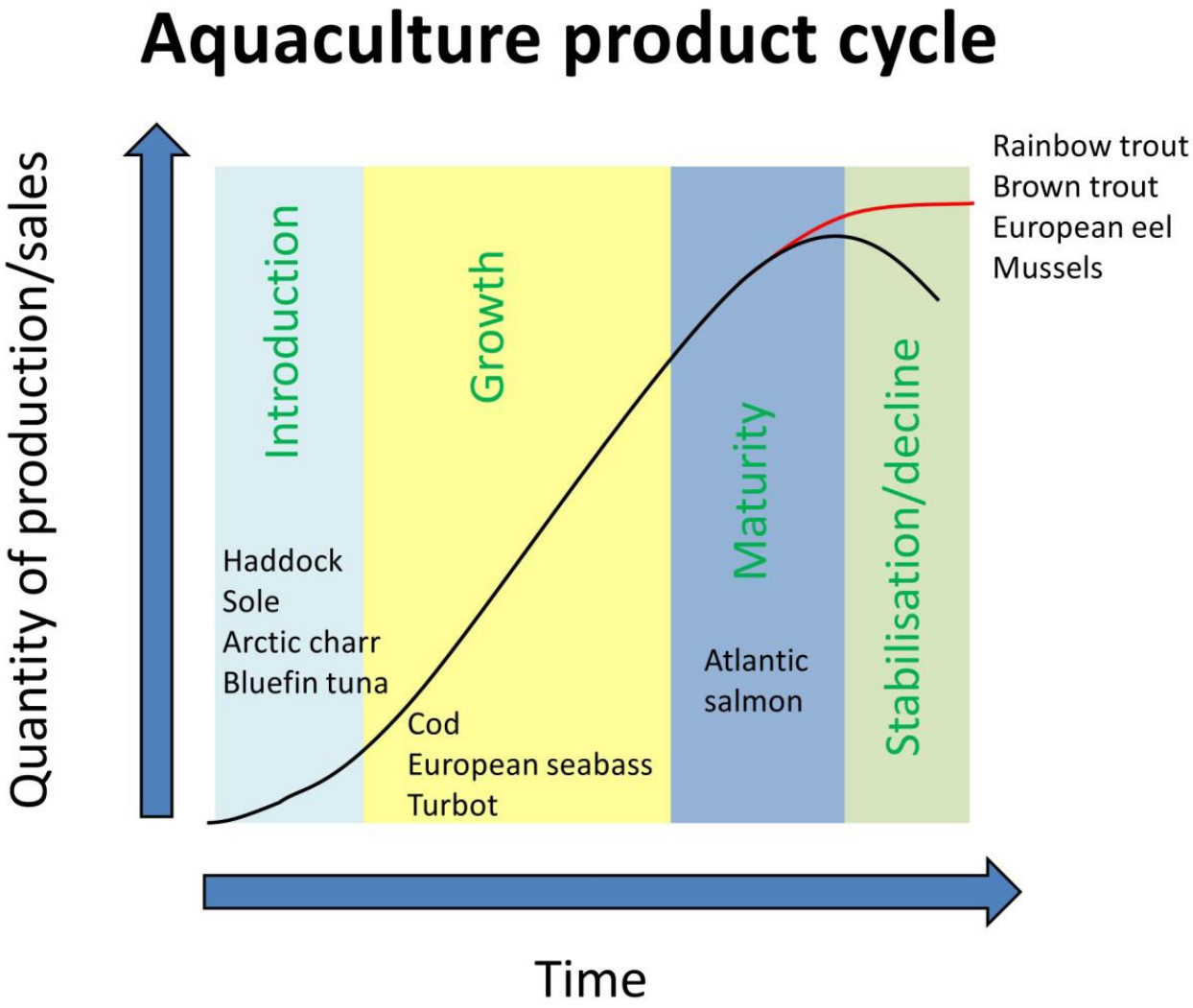
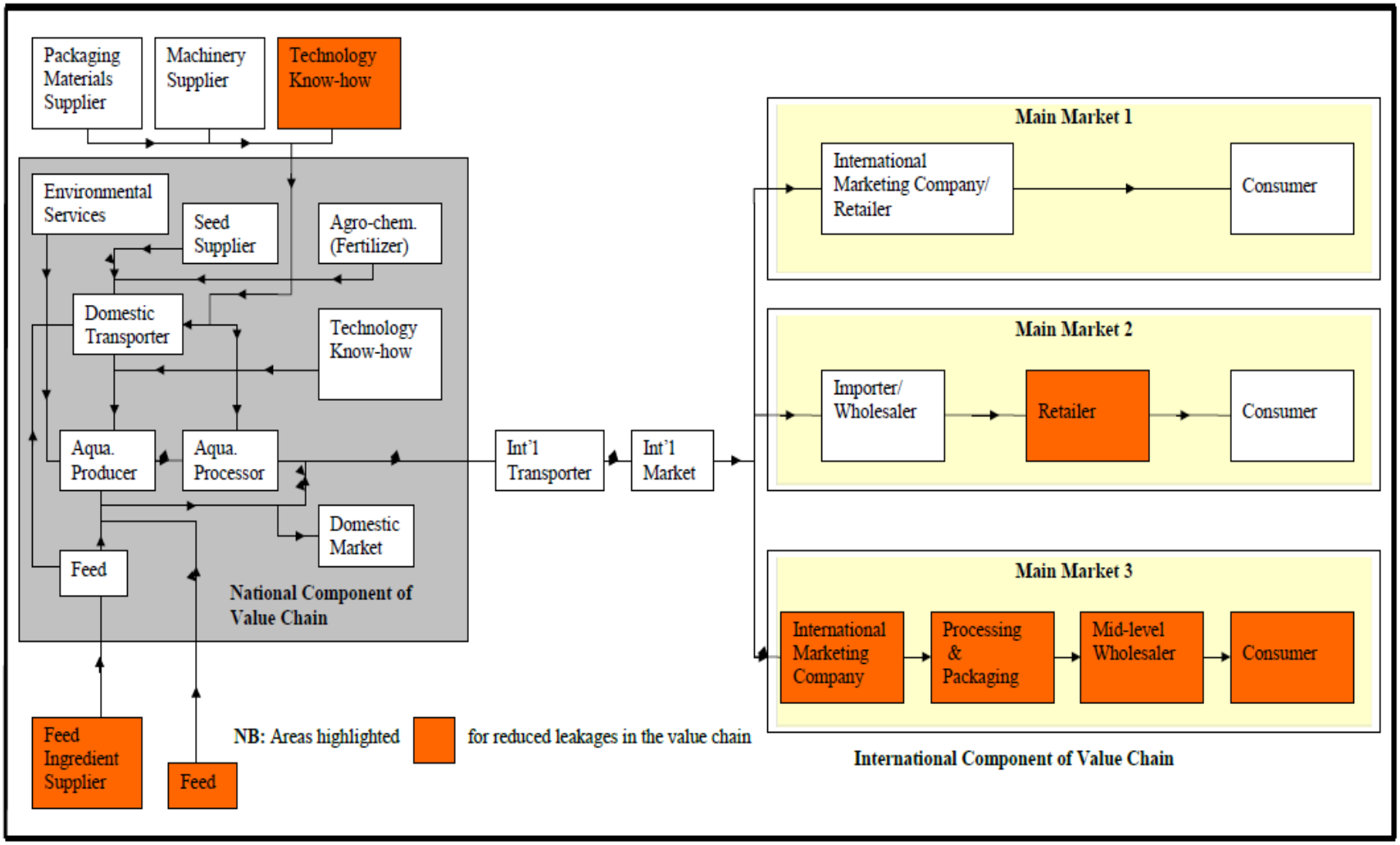


Fig .5: Aquaculture product cycle

- **Foot Note:** At the Introduction phase, new techniques are being developed and the market needs to be established. During the Growth phase, the techniques are established and the market is growing. During the Maturity phase, the industry is well established and the market fully exploited (e.g. Atlantic salmon in Europe). After this point, the industry may fall into decline due to excessive competition and oversupply or it may reach a steady-state and stabilise.

Fig. 6: Current Value Chain Analysis for the Aquaculture Sector



Annex III - Methodology and Approach

The current report captioned: 'Scope and Requirments for Sustainable Aquaculture Development in the Caribbean' is an output informed by a literature review and synthesis complimenetd by the results of a questionnaire sent to Member States from the CRFM Secretariat.

The literature search accompanying the process was broad in scope and encompassed material from the CRFM and CARICOM information stores, as well as the FAO electronic library and hard copies in the possession of the Belize Fisheries Department, as well as a range of literature from other sources, including unpublished reports and notes from various and sundry academic engagements.

There was a pausity of information in regards to the feedback from the various Member States. This may well have been a function of late notice and rapid response that was required. This affecetd the currency of the information especially as it related to production, yield, husbandry and developmental issues – thus the information provided in the reported was somewhat dated in part. This issue was partially recitfied through the efforts of the Regional Working Group on Aquaculture that reviewed the document.

Much of the Tables synthesized in the report are original in concept and have been constructed on the basis of information gleaned from the various literature and data sources.