5. The St. Kitts and Nevis "aquaculture model" making use of the competitive edge

A short recap of the situation is that SKN has pristine tropical, oceanic water conditions – but according to standard perception it is refrained from using it because of being situated in the hurricane belt. The hurricane season is up to 6 months (from June to November inclusive), but of course this does not mean having a hurricane every month. A hurricane of smallest category 1 is calculated to hit SKN directly once in 10 years, but every year there will be many hurricanes or storms with a track nearby which also can cause quite severe impact by wind, waves and especially rain.

SKN though has relatively ample sea areas in leeward of the islands (in lee from 100% of the normal wind direction) and of 20-30m depths – as such perfect for cage farming.

SKN has relatively ample, available land resources close to the coast which has been in idle use since the days of sugar cane farming. However SKN does not have freshwater resources and soil texture making it possible for development of traditional freshwater fish farming in ponds.

5.1 The business strategy of the SKN aquaculture model

But having these natural resources – the pristine oceanic water, the perfect sea sites for cages and the land area available close to the sea – it is suggested to develop a seasonal seawater farming model combining the two area resources – farming in sea cages outside the hurricane season and land based fish farming pumping in seawater in tanks during the hurricane season.

Traditionally tropical aquaculture is considered all year farming and thus the potential of SKN has not been appreciated fully by any international organisation because of the hurricanes, and land based seawater farming has for some reason never been considered. But there are many case stories in other (temperate) zones which have to use seasonal farming approach due to freezing weather and risk of ice formation.

It is suggested that in the simple form the land based phase is primarily used for juvenile production to have large stocking material to put into the cages in December when the hurricane season is over. Depending on fish species and market demand some has a production cycle as short as 6 months – others need up to 11-12 months from hatching.

Thus there are many strategies which can be applied – it could be possible to produce several batches of juveniles and stock the cages at different times thus to spread the harvesting period from the cages to avoid dumping the market – or it can be "all-in-all-out" – with a production targeting processing and distribution from cold storage – or any solution in between – that will be up to the business concept of the farmer or company.

The advantage of combining the land based farming with grow out in cages is that the grow-out phase is handling large quantities of fish and therefore also feed which would need a lot of water (for diluting the waste/nutrient load) and to bring in oxygen. If this water is to originate from pumping in seawater it would likely be a costly operation or investment per tons fish produced. Then better to do this in the sea where water is supplied free of charge.

After stocking the sea cages the land based facility could either lay idle or some minor volume fish could be kept for on growing also in the tanks – for ad hoc farm gate sales. Later when harvesting fish from the cages they could also be brought back to the tanks to have a "live fish storage", because when fully grown to market size they do not need to be fed much (or anything if only few days) – again to have a buffer for "fresh fish" for sales – such as e.g. if preparing the sales of 3,000 freshly harvested fish for the next cruise boat arriving.

There are endless combinations and specialisations, which could be applied depending on the species and market focus and the personality and competitive edge of the farmer/investor.

One final specialisation to mention is that the land based farm could also be operated as a quarantine unit – i.e. importing newly weaned fish fry – or even newly hatched fish larvae – and then grow them for sales to other farmers. This is a very high valued product – very high profit margins - but of course would need very skilful technical management – and it would need the market (the other farmers).

As this is a very important strategic facility for the development of the sector - to be in control of the quality of the juveniles for stocking - it could in the start be operated as a fully governmental facility or a PPP which eventually could be fully privatised (when the market has developed).

Eventually SKN should develop at least one 'all inclusive' hatchery. Again – the pristine oceanic water surrounding SKN and far away from marine fish farming would be a strong competitive edge in producing high quality marine fish juveniles for the whole Caribbean region. The Taiwanese would claim that the water is too clean – and does not have enough nutrients for the SE Asian extensive hatchery model – but if necessary this can be added. Most importantly there is no pollution and disease germs, which the Taiwanese have as a constraint in their preferred setting.

If thinking ahead in the sector development the hatchery should be situated on the Atlantic Ocean side of the islands as the main Caribbean current comes from the East-Southeast – and the future cage farming will take place in the Caribbean Ocean.

5.2 The technical setup of the SKN aquaculture model

A rule of thumb for a newcomer in aquaculture is to use PROVEN technology. Don't be a "guinea pig" for some equipment company.

This is why it is NOT suggested to start with submersible cages for all-year-production in the sea. Even some structures are claimed to have survived hurricanes it is an unnecessary risk to take when there are already proven technologies available – but only managed in a different manner than normal. The submersible cage solutions are apart from expensive equipment solutions also expensive in operation. Many procedures have to be carried out by divers – and the service boats have to be of a certain large size.

5.2.1 Land based facility

To start with the land based facility – which is illustrated in a generalised model in Figure 32.

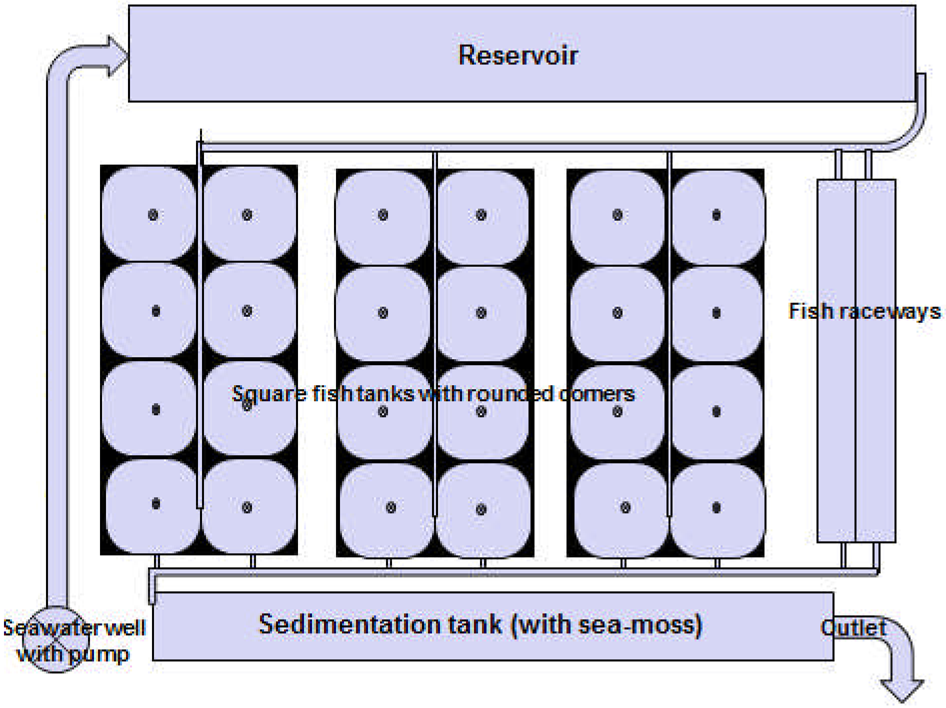

Figure 32: Flow chart of a land based fish farm

Firstly the site should be close to the sea but appreciating the setback distances and minimum required level over sea surface to make it safe against possible surge during a hurricane. The slope/inclination should not be too large – to save levelling work. To save pumping costs the overall height of area over the sea level should as a rule of thumb preferable be less than 10m – but this has to be calculated by an engineer based on the water inlet and pumping design (and energy supply/costs).

The water inlet can be constructed in several ways and this should be designed by a competent engineer based on the local conditions. The most difficult to construct is to make a pipe into the sea on an open sandy beach. This has to be anchored very well. A description of such a work can be seen on the website of a water supply company http://www.tsgwater.com/client_6.htm which made the water system for the desalination plant of Marriott hotel. The pipe was put 100m off shore and in addition to special water intake screens the pipe was anchored by 12 reinforced concrete saddles each 1 tons and 8 sand screws 5 m long and 9 cm diameter.

The better is if there is a rocky/large boulder coast/seafloor to which the pipe can be anchored directly to.

The pipe should drain into a 'well' made on the beach and with a depth below sea surface ideally to have water entering without the use of a pump.

Alternative models can be to dig down a drain system in the beach (parallel to the sea) which drains into the well. This model would need some test drillings to be made to find the depth of the seawater intrusion as there typically would be a freshwater (groundwater) layer on top.

One can also make a deeper bore further away from the beach which also penetrates into the seawater intrusion. The advantage of these models is that the seawater has been filtered and there will not be any fouling in the pipes as well as there will not be any risks of introducing parasites or germs from the sea. However sometimes there can be problems with hydrogen sulphide or others from the ground.

The pumping can be one of the major operational costs (in addition to feed) and therefore it is suggested that SKN makes use of competitive edge it has – which is the constant trade winds from easterly directions. They are in average over the year between 9 – 14 knots (4.59 – 7.20m/s), which is similar to a moderate breeze. It is suggested to use this directly for pumping water into a large reservoir. This reservoir could be compared with the same function as a battery has if producing electricity and that is to store the energy if the wind is too weak or if some maintenance is done. Most windmills are of course used for pumping freshwater so they would need to be adapted for seawater. There are however also windmill models which are moving water by an air pump. On e.g. the website internet www.ironmanwindmill.com pumps as are quoted to have capacity of pumping more than 1.3 m^3/minute (Figure 33). That would of course depend on the head that the water is to be moved.

Figure 33: Windmills are first of all being used for pumping of water. Picture is showing an Ironman windmill from USA

If to use a windmill for pumping seawater the best conditions are likely found if having the farm on the Atlantic Coast of the islands.

Due to nature of the soil, “traditional” earthen ponds are not feasible and instead tanks have to be constructed either by GRP, concrete or plastic liner.

The only aquaculture farm on SKN – the SNAPPER tilapia farm – is using plastic liner and raceways.

However it is suggested to use circular tanks as they have several advantages because of better hydraulics i.e. circular water flow pattern concentrating dirt in the middle due to slowest current.

- Significant better water quality (O_2 and CO_2) in the whole volume of the tank giving an even distribution of fish and thus ability for higher stocking density per cubic unit
- High self-cleaning effect of the tank floor (of faeces) even at low biomass and water flow
- Easier to install automatic harvesting (i.e. secured for future)
- For construction purpose the tanks can be modified into square tanks but with round inner corners, thus the tanks have some shared walls (like raceways)which make them cheaper in construction and less area demanding – but still keeping the hydraulic benefits
- If having sloping land area which is not feasible to level the circular tanks can easily be constructed at different levels, while raceways would need larger level area.

Irrespective of tank shape aeration is compulsory. Air also can be delivered in the tanks by windmill but in this case there will be a need for a backup system with a blower powered by electricity (and backup generator) in case no wind and no electricity.

The stocking density of fish or maximum biomass per cubic unit depends especially on water flow and minimum oxygen level but also to a certain degree on species and the individual size of the fish. Thus no generalised figures will be given apart from the juveniles cannot be stock at the same density as grownups.

The water is drained from the circular tanks through a central screen with a standpipe (on the side) thus insuring that faeces and feed pellets are removed from the tank. The effluent water is collected in a larger sedimentation tank where the speed of the current is small enough to start sedimentation. In the same tank hanging cultures of sea moss (seaweed) can be grown making use of the soluble nutrients.

The outlet/effluent from the system can be directly into the sea making sure that the intake and effluent water are not mixed. This can be done by having them at different distance from the beach as there typically is a current parallel to the beach.

As the oceanic water of SKN is very poor in nutrients the effluent water is not expected to have any negative impact – likely on the contrary. However the effluent could also be drained into the sand dunes and thus filtered. However in this case it the ground water levels and seawater intrusions should be known to avoid any damage of freshwater resources.

If using the land based system as a quarantine system for imported fish fry the effluent water should be treated by ozone, which would not be a larger task as the water volume would be minor.

5.2.2 Sea based facility

As mentioned - it is suggested to use proven technology, such as the circular HDPE cages with the appropriate seasonal strategy. The cage design was launched commercially in 1974 and copied around the world and today at least 70,000 units have been installed (Figure 34). 'New' submersible cages were launched in 2000 and likely around 100 units of different models have been installed. They receive a lot of media attention, but they are not for newcomers due to the investments and as many of them are still under development.

Figure 34: Traditional 60m circumference/19m diameter HDPE cage at a cobia farm in Vietnam. Net change can be done manually without need of hydraulic crane. If the net is 9 m deep each cage is able to hold up

It has already been mentioned several times regarding the site requirements as for recommended biotope. The depth is recommended to be between 15 to 30 m (optimal is 25m). The maximum is due the operation such as diving, inspection and detachment/reattachment of cages to the anchor mooring, while the minimum depth is to have enough water below the net bag, which should be from 5-9m deep (plus the central bottom of the net bag will hang down as a cone).

The site should be selected e.g. according to the standards developed in Norway – the home of the modern cage farming (Figure 35)

The Caribbean coast of the islands is protected from the trade winds and thus will fulfill the optimal wave requirements, while the current is not known to the consultant apart from the Caribbean current is in the range of about 40cm which should be optimal. There is hardly any tidal current. In shallow coastal areas local topography can influence currents a lot and therefore it cannot be recommended too strongly to make current measurements – like at least for 2 weeks around a full moon phase with readings at least every hour – speed and direction.

Significant wave height
i.e. the average height of the tallest 33% of the waves.

- A Hs <0.5m
- B 0.5m < Hs < 1.0m
- C 1.0m < Hs < 3.0m
- D Hs > 3.0m

Current velocities

- a u<0.25m/s
- b 0.25m/s < u <0.5m/s
- c 0.5m/s < u < 1.0m/s
- d u>1.0m/s

Figure 35: Norwegian standards for wave and current selection criteria for traditional plastic cage farming, green colour shows optimal conditions while red is prohibitive

The information about current is necessary for the dimensioning of the mooring as well as the design of cage (net) such as the use of sinker tube or not to keep the shape of the net bag in case of strong current. Strong current may also stress the fish – they will use a lot of energy (feed) for physical activity. On the other hand if too little current it will impact the maximum recommended biomass – i.e. the productivity of a cage because then there will not be optimal oxygen level inside the cage.

If having a site with 20-30 m depth the so-called “individual mooring system” is recommended Figure 36.

Figure 36: "Individual mooring" system using reinforced concrete anchors of 4 tons. Cheap and suitable solution for shallow mooring less than 30-40m

It can be seen that each anchor normally would only ‘hold’ 1 cage+ which is important for the dimensioning of anchor and rope.

The other mooring system often used is the frame mooring (Figure 37), which has advantages especially if mooring in deeper water. Because the anchor rope should be ‘3 times’ the water depth – and if in deep water the individual mooring would be costly because using a lot of mooring rope – as well as the area occupied would become relatively large. Then the frame mooring has an advantage. It however has many metal components, swivels, causes and shackles in addition to the large steel shovel anchors, each which has to be dimensioned to hold many cages. If buying a turnkey cage system the equipment producer/trader always suggests using frame mooring irrespective of the depth – because it adds volume (costs) to the order. But a frame mooring has many components which have to be inspected at a regular basis – so the risk element sometimes also becomes larger.

Figure 37: Frame or grid mooring using shovel anchors. Expensive design but feasible on deeper sites saving mooring rope

The idea of recommending using maximum 30m depths is to make things 'simple and less risky' and also because of the suggested seasonal model, which will involve some diving activity in the start and the end of the cage season. The concrete anchors are put on the site 'once and for all' and each anchor site is registered with GPS. When getting close to the hurricane season the cages are harvested and the nets brought to the shore base/storage. Then the cages are detached leaving a 3-4 m piece of the mooring rope at the anchor to be used for reinstallation of the cages after the hurricane season. The detached cages are towed to a storage area on the shore – the stanchions/uprights and hand rail are dismantled from brackets on the main pipes which then can be stocked on top of each other on the beach.

In the cages the maximum recommended biomass is up to 15kg/m^3. The fish most likely can be harvested partially i.e. when there are fish more than 500g (1¼ pound) ready to be sold. Thus actually the production over 'one season' may likely be more than 15kg/m^3.

After the hurricane season the mooring from the cages is reinstalled to the anchors which can be found either by their GPS location or by simple trolling with a leaded line between two boats. The mooring ropes are reinstalled to the rope at the anchors by diving.

If using cages of maximum 50 to 60m circumference (diameter 16 and 19m) the net bags can still be handled manually if not too heavy fouled and if not deeper than 9 m. Larger cages (and net bags) would need the use of hydraulic crane and thus a large vessel to be able to operate.

Being a full oceanic environment the cages will need to be protected with predator netting – around the net bags against barracuda and sharks (and possibly others) and a top bird net against frigate birds, brown pelicans, gannets, sea gulls, herons and the odd sea eagle or osprey.

Due to the low eutrophication level of the tropical oceanic water the environmental impact of the cage farming would likely be very small apart from a possible direct impact under a cage. The most likely impact seen will be stock enhancement around the cages.

Of course the cage farming would have to follow Better Management Practises (BMP), but actually the SKN aquaculture model already has several of the BMP elements inside it such as:

- Keeping the generations separated to avoid that one old generation from previous year cross contaminate the newly stocked juveniles especially with parasites – this is automatically implemented due to the seasonal farming
- After each production cycle it is in general recommended to fallow the site before it is stocked again. In the tropics a fallowing period of 3 months has been estimated sufficient in Australia. Using the seasonal farming, the farming site will be left idle for 6 months!!

When having a cage site a little far from the coast it will also be necessary to have a work platform (or moored boat) for storing feed and equipment – in addition to serve for the housing of the (night) guard. Each cage can hold potentially 38 tons of fish which alone in production costs will represent a value of USD 100,000+, which of course if left unattended may attract thieves.

On the shore it is necessary to have a shore base, which has road access and at least a slipway or a pier for the boat. The shore base should have workshop, ventilated storage facilities for feed and nets (both has to be rat proof and without sun access) and a net cleaning and repair area. In addition to the shore base it will be necessary to have access to a beach area where the cages can be stored on top of each other during hurricane season.

5.3 Potential farming stakeholders

Who will be the stakeholders involved directly in farming?

Even the Draft St. Kitts and Nevis Aquaculture Policy (2011) states the following criteria for engaging in aquaculture within the Federation:

> Applicants must reside in the Federation for ten (10) years prior to application.

It is likely that a foreign investor would find a local 'go between' to bypass such a rule. Thus it is envisaged that there will be 4 potential stakeholder groups:

- those interesting in developing their own livelihood;
- the local corporate investors
- the foreign corporate investors, and
- the SKN government!

5.3.1 The cluster farmer – the modern 'small-scale' farmer!

When using the term small-scale in the present report it does not refer to the traditional small-scale farmer of SE Asia – it simply means a personally/privately/family **owned and operated** farming activity as opposed to a corporate/investor owned only using hired in staff. It does not mean low tech but maybe low mechanisation because of lower investment.

A 'modern' small-scale farm seeks to achieve 'efficiency of scale' like the large-volume corporate farms, through linking into clusters. The cluster is different from a cooperative, because the cluster farmer owns his/her own farming activity.

There are several advantages in clustering. It means you can share the costs or access of some common infrastructure such as water inlet, reservoir, sedimentation tank and outlet of a land based facility – and for the cage farming some structure like shore base, mooring, work platform and/or night guarding. The other advantage of clustering is that the farm unit has better access to extension services and application of technology in the production. In the market they can have common sales meaning they can offer the customer volume and consistency – which otherwise is a competitive edge of the large-volume farm. Being in a cluster also makes it possible to share the costs of entering a certification scheme – the costs which otherwise could be prohibitive to the individual farmer. Farmers in a cluster of course have to follow a common approaches such as using traceable, quality (disease screened) juveniles, using BMP etc. etc.

Which are the advantages and disadvantages of cluster farmers in the context of development of the sector?

Advantages:

- The livelihood (needs or opportunity) is the driving force, rapid implementation when seeing local market and how to do. People are entrepreneurs and if only small investments they move fast in decision procedure.
- They are open, like agriculture farmers to share experience and thus rapid multiplication effect (on numbers of farmers – and production volume) through copying.
- Entry point also for fishermen (or their children) and the land based farming is gender equal.
- Target the domestic market. When production volume increases and the 'immediate market ceiling' is reached prices will fall dramatically, but if having common sales through the cluster they have better ability to enter new markets (regional) as well as doing generic market development like "eat more local fish instead of imported chicken broiler".
- Can be difficult to manage or control by authorities like enforcing environmental precautions, disease prevention measurements etc. but possible if located in clusters and aquaculture zones.

Main disadvantage:

- Lack of financial strength – government role?

5.3.2 The local corporate investor

The market volume of additional seafood from aquaculture in SKN likely would be in the range between 500-1,000 tons. This market may be very interesting and sufficient to the cluster farmers but if just 2 or 3 local corporate company investors enter the sector the market target need to be larger – such as additional looking into the regional (Caribbean) market. A corporate farm likely should target volumes at least between 200-500 tons before it will achieve the competitive 'efficiency of scale' which can bring in the profit margin of interest to an investor.

A larger production is more likely able to provide the cruise liner companies sufficient guarantees that the company has the logistics in place to supply the necessary volumes of fish when a cruise ship docks in Basseterre. One ship would likely order 2000 portion sized fish i.e. 1 tons at least every week, but still these are not large volumes for a corporate farm. If they have the whole cruise ship market it would be between 200,000 – 300,000 passengers a year i.e. 100-150 tons if all had a fish for one meal delivered from SKN. The ultimate aim should then be that the cruise ships buy more fish than just for one meal.

Which are the advantages and disadvantages of large-volume investors in the context of development of the sector?

Advantages:

- Corporate approach can make a large impact, already e.g. 2 medium farms would produce 1,000 tons/year.
- Because being investment intensive the risk reduction includes a vertically integrated business structure from 'egg to shelve'. I.e. hatchery and processing typically included in the setup – which can benefit the sector development

- Target regional fresh, frozen white fish market segment through 'efficiency of scale', volume and consistency in production

Disadvantages:

- Investors do not like taking the risk of being a pioneer. They like to see success of others before entering. They have lengthy planning and decision making procedure, thus slow to implement.
- Investment can sometimes be volatile because of investor decisions if sector is not a core business area or if company depends on foreign financing (impacted by outside factors).
- Large farms often tend to keep technology and operational management as company secrets, because they have invested in bringing in this competence or technology transfer from abroad.

The cluster and corporate approach can also form 'hybrids' such as arranging buy back arrangements where the corporate provides the juveniles, the feed and the market – while the cluster farmer takes some production risk but also larger profit if successful.

5.3.3 The foreign corporate investor

The author shares the intension expressed in the Draft St. Kitts and Nevis Aquaculture Policy (2011) that "Applicants must reside in the Federation for ten (10) years prior to application", because SKN is the smallest federation in the Americas and has limited natural resources. These limited natural resources should benefit local inhabitants – providing food security, livelihood and investment options.

However if a foreign investor develops a project proposal which does not impact the available **optimal** areas for aquaculture as described in the present report, but will make use of different ?submersible cage technology in fully exposed areas they should be welcomed as this will not restrict the local productions or opportunities.

However – like with foreign investments in e.g. Vietnam – the investor has to state exactly how many foreigners will be employed and how many locals, and foreigner staff should only be permitted if they will occupy key management positions. This will ensure local job creation.

5.3.4 Government

The role of the government is to initiate and achieve the goal: Increased seafood production through aquaculture to improve food security and quality of nutrition.

As may have been appreciated from the above it can be a lengthy process to wait for a local corporate investor to enter the sector and therefore it could be the role of the government to pave the road for the cluster farmers, which can act fast, provided some initial support is given from government.

This is mainly in providing the technical knowledge of how to farm fish and make it easy to enter the sector (cutting lengthy bureaucracy).

It is appreciated that many of below issues are part of the strategy and will be repeated in the dedicated strategy document, but it will be easier to understand if presented in a complete context.

- Identify 2 land based areas – government owned – and 2 sea areas in St Kitts and in Nevis to dedicate into aquaculture zones
- Perform all footwork - including:
  - calculate carrying capacity
  - environmental impact assessment at different degrees of production – and
  - develop better management procedures which have to be complied to.

- Establish Government Aquaculture Zone Companies (GAZC) with a management and management board making the regulations for the tenants (cluster farmers) in the zones
- GAZC will invest and operate pilot farms in the aquaculture zones to be used for:
  - demonstration
  - training and extension
  - testing/trialling
  - incubator arrangement (where a potential farmer can perform without having invested)
- GAZC will make common infrastructure for the cluster farmers – i.e. the tenants –
  - For the land based facility: water inlet and pumping, reservoir, fish tanks and sedimentation tank and water outlet.
  - For the sea based facility: shore base, pier or slipway, cage storage area, permanent mooring, working/guarding platform, area marker buoys
  - The tenants of the GAZC can pay a rent according to number of tanks used/water consumption and number of cage sites used
- GAZC will make common purchases and imports
  - of fish juveniles ensuring quality and traceability and sell to the farmers after having passed a quarantine nursery.
  - of feed to assure quality and quantum price.
  - of cages or pipes for local construction
  - of ready sown nets imported from ?India

If making the development through GAZC it will not be necessary to develop the full legislation and directives for operating an aquaculture farm as this can be made as the bylaws of the aquaculture zones – and then developed as and when needed. SKN is too small to follow all the guidelines made by FAO of what should be in place when developing the sector. Also there is the simple issue that so far there are no aquaculture sector and thus it would be wasted resources to make the legal framework even before it is seen that the sector will develop.

At this moment the regulations maybe should concentrate on who can do aquaculture, conditions for leasing area such as timespan and possible incentives. The author also supports the Draft St. Kitts and Nevis Aquaculture Policy (2011) which does not promise incentives in cash but more incentives based on investment (no import tax) and production achievement (no profit tax).

However for supporting cluster farmers an initial support could be given in kind – such as a grace period for paying rent for facilities; free delivery (or credit) of juvenile and feed for 1st production cycle.

If a corporate investor wants to apply it is suggested to have direct negotiations on conditions – simply because it is not anticipated that there will be a larger number than a handful investors over time – due to the small area resources and small local market. Investors likely would be attracted to other geographical areas which have better competitive edges than SKN as for transport and vicinity to larger markets. To make a legal framework for few companies would be too resources demanding – but of course it could be financed if putting a license fee on the corporate companies which then can be used to hire in legal expertise from e.g. FAO to draft the law and directives.

5.4 Potential for freshwater aquaculture:

Already arguments have been given on why SKN government should not give too much attention to freshwater farming. Other Caribbean countries have large freshwater sector but they also have the natural resources. E.g. while SKN has 0 km^2 of freshwater/inland water surface, Puerto Rico has 4,921 km^2, the Bahamas 3,870 km^2; Cuba 1,040 km^2; Dominican Rep 350 km^2; Haiti 190 km^2 and Jamaica 160 km^2 (World Factbook 2012 https://www.cia.gov/library/publications/the-world-factbook/index.html).

Let those countries farm freshwater fish or let Vietnam and China and import from them. Because only if very cheap there may be a local demand (in catering sector).

On Martinique there is a 40 tons production of freshwater prawn (*Macrobrachium rosenberghii*), which could be a candidate to stock in some rainwater reservoirs as they do in India, but relatively the price of spiny lobster is surprisingly low in SKN which would make consumers prefer the marine spiny lobster instead. So it is possible but there is not competitive edge.

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http://www.fao.org/fishery/culturedspecies/Rachycentron_canadum/en (overview of farming of cobia)

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Annex 9: Technical report 2: Aquaculture development strategy (2013-2023) for St. Kitts and Nevis

ELABORATION OF AN AQUACULTURE DEVELOPMENT STRATEGY FOR ST. KITTS AND NEVIS

Aquaculture Development Strategy 2013-2023

by Niels Svennevig



Draft

October 2012

DRAFT COVER PAGE TO BE ADJUSTED WITH THE DEPARTMENT OF MARINE RESOURCES

SOFRECO

ACP Fish II

Table of Contents

Executive summary 3

List of Acronyms and Abbreviations 5

1. Overall objective of the development strategy 6

2. Development Strategy 2013-2023 7

2.1 Phase 1 (2013-2016): Preparation and introduction to aquaculture 7
1.1. Providing an enabling environment for the economic and social development of the aquaculture sector 7
1.2 Ensuring that the necessary regulatory framework is maintained to encourage and protect investments in the aquaculture sector 10
1.3 Supporting training, extension and R&D for the advancement of the industry 11
1.4 Other supporting incentives for local farmers 12

2.2 Phase 2 (2017-2020): Production volume development in the aquaculture zones and the first corporate investors 14
2.1 Providing an enabling environment for the economic and social development of the aquaculture sector 14
2.2 Ensuring that the necessary regulatory framework is maintained and improved to encourage and protect investments in the aquaculture sector 14
2.3 Supporting training, extension and R&D for the advancement of the industry 15
2.4 Other supporting incentives for local farmers 15

2.3 Phase 3 (2021-): Consolidation Phase, satiation of local market demand 16

2.4 Financing 16

2.5 Role of private sector stakeholders 17
2.5.1 Local corporate investors 17
2.5.2 Foreign corporate investors 17

2.6 The role of fishermen in SKN aquaculture development after 10 years 18

2.7 Strategy monitoring 18

Annex: Action Plan 19

Executive summary

Due to high demand for seafood in St. Kitts and Nevis (SKN), leading to substantial imports of seafood as a result of stagnant output from capture fisheries, the Federal Department of Marine Resources of St. Kitts and Nevis (DMR) initiated the 'Elaboration of an Aquaculture Development Strategy for St. Kitts and Nevis' study. This study is designed to (i) reveal the potential for introducing aquaculture to the islands in order to improve food security and nutrition, and to (ii) develop a related implementation strategy.

The aforementioned study, supported by the European Union through the ACP FISH II programme, was performed from July to August 2012, with a validation workshop held at the start of September. The first report produced, initially envisaged to be a brief working document, was expanded to present a detailed appraisal, entitled 'Situation Appraisal for St. Kitts and Nevis – Demand for and Potential of Aquaculture'.

The present document sets out the 'Aquaculture Development Strategy for St. Kitts and Nevis'. It is recommended that the first working document, 'Situation Appraisal for St. Kitts and Nevis – Demand for and Potential of Aquaculture', be studied beforehand as it contains the analyses that led to the strategies developed and recommended in this document.

SKN, the smallest federation in the Americas, has limited natural resources, small islands and is situated in the Caribbean hurricane belt. These conditions have led international agencies to officially state that 'in the foreseeable future, aquaculture will not be able to develop on the small islands of the Lesser Antilles' (FAO, *Aquaculture development in the Caribbean*, *Mission to the Caribbean,* 1981).

The present report elaborates on a strategy for SKN to develop an aquaculture sector that capitalises on its competitive edges, especially its pristine, tropical, oceanic water and the availability of significant amounts of government-owned land resulting from abandoned sugar cane farming. An innovative seasonal farming approach, the 'SKN aquaculture farming model', is suggested, which combines the production of juvenile marine fish in land-based facilities during the hurricane season with grow-out farming in the sea in traditional, circular plastic cages during the calm season.

The strategy covers the period from 2013 to 2023. The first phase, covering four years, will be especially intensive and to a certain extent financially demanding, particularly due to the construction of pilot farms and farming infrastructure to be rented to cluster farmers, as well as human resource development (through overseas training).

Due to the limited human resources of the islands' administrations, the strategy suggests the establishment of four aquaculture zones - two land-based and two sea-based, with one of each on each island. These would be developed and matured for the purposes of aquaculture, with all necessary analyses being carried out for these selected areas only.

It is suggested that the zones be managed by Government Aquaculture Zone Companies, which should develop good farming management practises that must be complied with by the zones' tenants. This would avoid the resource-consuming development of a full body of aquaculture legislation when it is not actually known if the sector will be developed.

It is suggested that farmers in the zones be organised into clusters to capitalise on (i) large-volume production advantages or efficiencies of scale in purchases and sales, (ii) technology transfers to the farmers, and (iii) possibly certification schemes.

Finally, once the sector is sufficiently developed in terms of food security and livelihood opportunities for SKN communities, the role of foreign investors in the sector's development may be discussed. However, it is suggested that they be invited only after completion of the first phase to ensure good control of the resources' development and utilisation.

List of Acronyms and Abbreviations

CARICOM	Caribbean Community common market
DF	Department of Fisheries, Nevis Administration
DMR	(The Federal) Department of Marine Resources (St Kitts and Nevis)
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
AZC	Aquaculture Zone Companies
PPP	Public Private Partnership
R&D	Research and development
SKN	Federation of Saint Kitts and Nevis

1. Overall objective of the development strategy

Due to high demand for seafood in St. Kitts and Nevis, leading to substantial imports of seafood as a result of stagnant output from capture fisheries, the Federal Department of Marine Resources of St Kitts and Nevis (DMR) initiated the 'Elaboration of an Aquaculture Development Strategy for St. Kitts and Nevis' study. This study is designed to reveal the potential for introducing aquaculture to the islands to increase the local production of seafood, and to develop a related implementation strategy.

The 'Elaboration of an aquaculture development strategy for St. Kitts and Nevis' study, supported by the European Union through the ACP FISH II programme[1], was performed from July to August 2012, with a validation workshop in early September. The study produced two working documents: firstly, the 'Situation Appraisal for St. Kitts and Nevis – Demand for and Potential of Aquaculture', and secondly, a zoning and mapping report of suitable areas for aquaculture. The present 'Aquaculture Development Strategy for St Kitts and Nevis' was drafted based on the findings of these two documents.

The strategic document produced by the Ministry of Sustainable Development of the Government of St. Kitts and Nevis in 2006, *Adaptation Strategy in Response to the New EU Sugar Regime 2006-2013*, already mentioned 'Evaluating the potential for aquaculture and request[ing] technical assistance for the establishment of a demonstration and training unit'.

Domestic seafood production originating from capture fisheries currently stands at approximately 450 tons/year, and has remained stable for several years. A further 850 tons are imported every year, contributing to a large trade balance deficit of USD 3 million per year. Although aquaculture cannot directly replace these imports, it is clear that there is an unfilled demand for fresh, quality marine fish from the islands' residents.

In addition to improving food security and nutrition, it is is envisaged that the development of an aquaculture sector would provide new, valuable jobs and investment opportunities for the islanders, as well as leading to the sustainable use of the Federation's vastest natural resource - the ocean - for food production.

As natural resources are limited, the development strategy should carefully consider how the Federation and its people will benefit in terms of social development and food security, and when to allow foreign investment companies access to these limited natural resources.

A special **SKN Aquaculture Model** is suggested to capitalise on the natural resources, namely the pristine oceanic water, perfect sea sites for cages and available land area close to the sea. However, as the Federation is situated inside the hurricane belt, it is suggested to develop a seasonal seawater farming model combining land and sea area resources, i.e. farming in sea cages outside the hurricane season with land-based fish farming pumping seawater into tanks during the hurricane season.

The land-based phase would primarily be used for juvenile production to have large volumes of stocking material to put into the cages in December when the hurricane season is over. Depending on the fish species and marketable size, the total production cycle would vary from 6 to 11-12 months from hatching.

[1]The ACP Fish II programme is a four and a half year, EUR 30 million programme funded by the European Union through the EDF. It has been formulated to strengthen fisheries management, improve food security and alleviate poverty in 78 African, Caribbean and Pacific (ACP) states.

2. Development Strategy 2013-2023

2.1 Phase 1 (2013-2016): Preparation and introduction to aquaculture

As a Federation of only 50,000 inhabitants, the limited number of staff in marine resources and fisheries (DMR/DF) must be underlined. Governance ambitions in the aquaculture sector's initial development phase should reflect this and be realistic.

Many of the all-inclusive recommendations in the numerous, dedicated FAO technical papers and guidelines for aquaculture regulations, management and practises have been written for countries with greater administrative human resources, and, importantly, countries that are already involved in the aquaculture sector. Consequently, many of these recommendations are not relevant to SKN at this pre-development stage and should only be adopted or included in the legislation when the sector has eventually developed and the specific (FAO) recommendations actually prove relevant.

At this stage of development, the Department of Marine Resource's (DMR) limited human resources could be much better used if they are focused on how to stimulate development rather than how to regulate a sector which has not yet materialised.

However, a minimum of regulations and procedures should nonetheless be developed over the first years, especially those needed for the farmers and investors to feel that their activities, companies or investments are protected by law. Similarly, rules and regulations pertaining to the application procedures should be set out to ensure that the process is transparent.

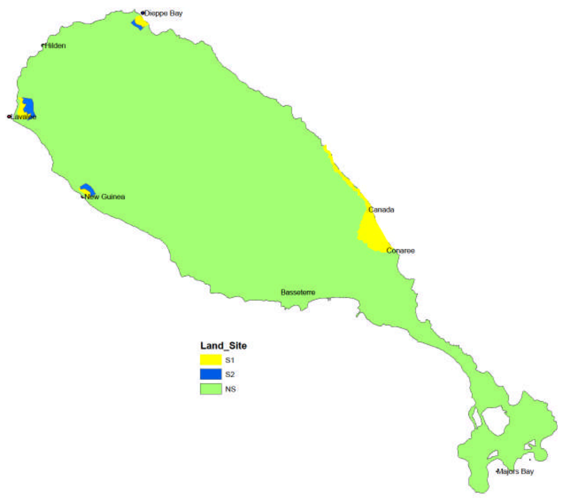
A number of strategic recommendations for Phase 1, i.e. the first four years (2013-2016), are set out hereunder.

1.1. Providing an enabling environment for the economic and social development of the aquaculture sector

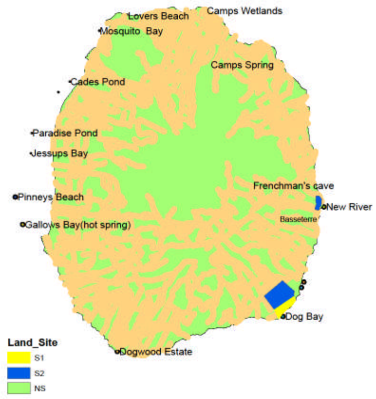
- 1.1.1 Develop a streamlined application procedure for granting aquaculture farming licenses.
  - Establish a 'one-stop-shop' entry point for the application procedure, where applicants present their application to only one office, such as the line/resort department (DMR/DF). This department would then be responsible for arranging a 'star hearing' with all relevant departments and organisations, i.e. coordinating and communicating all comments to the applicant.
  - The DMR would provide a detailed description of the information to be included in applications to make them transparent.
  - The two islands' administrations should harmonise the procedures and regulations for land-based farming (sea-based farming is already governed by the federal DMR).

- 1.1.2 The zoning plan for the coastal sea area proposed by DMR as part of an Ecosystem Approach to Fisheries includes Marine Management Areas, i.e. provides the possibility to approve sea-based aquaculture activities within this framework.
- 1.1.3 Establish **aquaculture zones (AZs)** on each island.
  - Two land-based AZs and two sea-based AZs, in areas that have been pre-approved as suitable for aquaculture up to a certain total fish production volume and using certain technologies.

    Potential areas for establishment of such zones are identified in the maps below:



Map 1* :Suitable zones for coastal aquaculture in St Kitts



Map 2* : Suitable zones for Costal aquaculture in Nevis

  - The land-based AZs should preferably be established close to fish landing places to be more attractive to fisherfolk.

    Comment: For biosecurity reasons, the land-based AZs, which will primarily be used for juvenile production, should be on the East/Atlantic Coast, as the Caribbean current has a west/northwest direction meaning that any diseases (or parasites) in the grow-out would not affect the juvenile production by sharing the same water. In addition, the Atlantic Coast is generally less developed in terms of real estate and tourism. The cage farming sites should be in the Caribbean Sea i.e. to the west of the islands, as it is better protected from trade winds and would be downstream from juvenile production. The transport of juveniles by truck or boat would be for small distances only (a few hours maximum).
  - The maximum carrying (production) capacity of a zone needs to be documented by carrying out capacity analyses and environmental impact assessments prepared under the responsibility of the DMR/DF. When the potential production capacity of the zones has been fulfilled by the 'tenants', further zone areas could be identified if market demand (including export) is present.
  - The AZs would be managed by **two Aquaculture Zone Companies (AZCs)** – one on each island, and could be publicly owned or part of a public-private partnership (PPP).

* Output from the GIS work done under the study detailed in the standalone working document

Comment: The Aquaculture Zone Companies could eventually have a large 'product' portfolio (see bullet below), requiring them to be economically strong and operating on business principles. However, due to their social responsibility, development agenda and some of the exclusivities that they would be granted, it is suggested they be launched as purely public companies. Nevertheless, if a suitable private partner (or partners) was (or were) present, a PPP arrangement could also be envisaged, especially during Phase 2 when the share owned by the Federation would be reduced as the sector would have achieved a certain development level, and when the AZCs' national development task would thus have been achieved.

- Detailed business plans would be developed for the AZCs, including their objectives, the financial resources needed, their legal status (part of the DMR, public or PPP), a product portfolio (renting out land, facilities, selling quarantined fish juveniles, feed, training courses, consultancy/extension service, etc.). The business plans should also include an approach for obtaining external financial and technical support, and an implementation schedule.
- The AZCs should develop AZ management rules/bylaws with which AZ farmers, as tenants, would have to comply.

Comment: The AZ management rules/bylaws would be a timesaving alternative to developing a full body of legislation. In addition to purely administrative issues, the management rules could include farming practices such as which quality of feed to use, the quality of fish juveniles (health certificates) to stock and biosecurity measurements to be observed, etc. They could be updated as appropriate, and later (during Phase 2) form the foundations, based on experience, for developing comprehensive/full regulations dedicated to aquaculture management.

- 1.1.4 To ensure the social development of SKN, applicants must reside in the Federation for minimum 10 years prior to application.

Comment: It is common practise in many countries for no foreign investors to be authorised to have (majority) ownership in the primary production sector (agriculture, forestry, fisheries and aquaculture). This can mean that foreign investors are not entitled to any shares whatsoever or that their shares cannot exceed 50%. However, it is also known that foreign investors sometimes use proxies to bypass such regulations. It is suggested that the current 'Applicants must reside in the Federation for ten (10) years prior to application' be maintained in the Draft St. Kitts and Nevis Aquaculture Policy, 2011, to discourage foreign investors at a time when SKN is trying to develop the sector itself. A number of strategic observations are made regarding foreign investment in the aquaculture sector during Phase 2 (ref 2.5.2) when SKN is in a better position to evaluate its pros and cons.

- 1.1.5 Develop human resources to ensure the presence of sufficient, qualified staff in the relevant public bodies.
  - Identify or recruit two members of staff at the DMR/DF to be trained in aquaculture governance and production.
  - Recruit three persons for each pilot farm: a pilot farm manager, a land-based production manager and a sea-based production manager, all of whom should be assigned to both production and extension work.
  - Arrange an aquaculture study tour for permanent secretaries, directors of the DMR/DF and above mentioned two members of staff at the DMR/DF to observe best practices in relevant countries in relation to both livelihood and corporate farming.

- 1.1.6 Under the lead of the DMR, carry out a baseline survey in 2013 to assess mullet juvenile stock in brackish water ponds and ghauts[2], and estimate the carrying capacity for the regulated harvest of juveniles for fish farmers (please refer to 1.4.5. bullet point 8 below). Developments in numbers of mullet juveniles should be monitored over consecutive years as well as any impacts on mullet output from capture fisheries.
  - In the above management of mullet juveniles, all natural fish nurseries (i.e. pond and ghaut habitats) should be preserved from filling, damming and logging, and water exchange with the ocean should be improved if necessary to offset sand deposits resulting from constructions, piers, breakwaters, etc. Monitoring and enforcement of conservation should be in place.

1.2 Ensuring that the necessary regulatory framework is maintained to encourage and protect investments in the aquaculture sector

- 1.2.1 Granting farming approvals for local residents following classification into two types of project/application:
  - **Type I**: Approval of farming licenses inside pre-approved AZs

    The advantage for SKN administration of having farmers in the pre-approved AZs, is that governance would be much less demanding in terms of human resources, and if there was a need to change the 'regulations', this could be implemented and enforced by merely amending the bylaws of the zones.

    Therefore this type of license should be encouraged to be used for any applicant by making the application procedure short and simple, needing to be evaluated only by the DMR or a designated Aquaculture Zone Board. This would be possible as the AZs would already have been cleared or approved by other relevant departments and organisations to be used for aquaculture.

    Successful applicants would have to follow the operational management practises or bylaws of the zones, and would therefore have to present a brief feasibility study describing their business idea, the technologies to be used, species to be farmed, juvenile source and quality, production development or implementation schedule, maximum quantity of feed or production volume (i.e. an indicator of potential pollution), and finally, their economic information.
  - **Type II**: Approval of farming licenses outside the pre-approved AZs, whether on private or public land

    In this case, the investors would have to submit a more detailed feasibility study including the above topics, documented qualifications and the training of management and staff, and an environmental impact assessment (EIA) detailing the production practises and potential impacts on the site, and suggesting mitigation measures.

    The EIA would have to be performed by a DMR/DF-approved agency at the applicant's cost.

    Should the application involve plans for large-volume production (>500 tons), or if the farm was planned in a vulnerable biotope (as judged by the DMR), capacity analyses could be requested.

    If the DMR was not in a position to appraise an application due to suggestions for either new technology or new species, it could abstain from approval or alternatively, request that the applicant cover the costs of having an independent, external expert perform the appraisal.

[2] A more or less temporary water course draining rainwater from the hills to the ocean.

The reason for requesting these different studies is to ensure that the applicant has sufficient background knowledge and finances, leading to a better success rate and avoiding damage to the sector's image (which is of federal importance).

- 1.2.2 Granting farming licenses in public areas, whether inside or outside pre-approved AZs:
  - The farming license should include a clause that the area has to be used according to the implementation schedule (described in the approved application).

    If a site lies idle for two production seasons it could be revoked without compensation, unless such a situation had been approved in advance.
  - Solid constructions would have to be approved.

    If deemed necessary, a bank guarantee could be requested to cover clearance costs in case of bankruptcy or should the project be abandoned.
  - Farming licenses would be given for a limited period of 15 years.

    Licenses could be renewed for sites documented to be used according to the stated purpose.
  - Farmers or companies could have to pay an administrative (lease) fee according to the size of land or sea area leased.

1.3 Supporting training, extension and R&D for the advancement of the industry

- 1.3.1 Arrange a basic aquaculture training course sponsored by the DMR introducing best management practises and SKN's legislative framework for aquaculture. This course should be attended by all approved applicants, including the production management of corporate investors.
- 1.3.2 Provide free technical assistance and extension services to stakeholders via the Department of Marine Resources.
- 1.3.3 Initiate (under the DMR's lead) the development of a dedicated aquaculture organisation or aquaculture technology forum/platform to promote and facilitate information exchanges. Membership of this organisation should be open to any interested persons, and should be compulsory for aquaculture farmers.
- 1.3.4 In the first aquaculture zones, establish two demonstration, training and test (pilot) farms – one on each island, managed by public or PPP AZCs, including land- and sea-based activities. The purpose of the pilot farms would be to:
  - Demonstrate and document the feasibility of the **SKN Aquaculture Model** for marine fish farming.
    - Develop business plans (models) indicating the proposed minimum production for different levels of stakeholders, including whether focusing only on land- or sea-based farming.
    - Organise open visits to the pilot farms for stakeholders on regular basis.
    - The land-based part of the pilot farms should preferably be established on an AZ close to a fish landing site to achieve maximum exposure to the main potential stakeholders.
  - Deliver, through the development of extension departments on the pilot farms:
    - On-demand training courses for new stakeholders (see action 1.3.1 of this chapter).
    - Pilot farm extension courses for existing farmers introducing new approaches, findings or equipment.
    - Free ad-hoc advisory services to aquaculture farmers on their farm site.
  - Test species and feeds, documenting feasibility levels.
  - Test, adapt and document new technical solutions.

- Incubator arrangement. Some parts of the pilot farm should be allocated to potential newcomers (farmers or small businesses) desirous to acquire supervised, hands-on knowledge before starting out themselves.

  Comment: The pilot farms would have to be operated as public entities (like the AZCs) as this is the only way to ensure that knowledge and technology is shared and disseminated. If operated as private companies, the operational management would be considered as in-house competence, which would slow down the sector's overall development. Furthermore, food security, social development and the Federation could become vulnerable to decisions made by a handful of persons with private interests. It is therefore considered that a broader cluster farming approach (in conjunction with corporate development) would be likely to lead to more sustainable sector development for SKN. When the AZCs eventually become privatised (ref 1.3.4.), it is recommended that the pilots be transferred directly under the DMR, and thus maintained as public entities.

1.4 Other supporting incentives for local farmers

Incentives may include:

- 1.4.1 Grace periods for area leases.
- 1.4.2 Duty free and VAT exemptions on imported equipment, boats, engines, trucks, juveniles and feed.
- 1.4.3 No sale or profit tax on businesses' earnings.

  Comment: It is important for incentives to be related to production activities and achieved production rather than granting direct loans based on 'plans'. Several countries have suggested favourable loan conditions to spur development, but this has proven to be risky as such loans can be used for purposes other than those they were given for, or can lead to the development of a project rather than to actual production. Decisions on incentives need to be carefully considered as it is difficult to subsequently supress them without causing political unrest/pressure. One strategy to avoid this would be to introduce incentives for a limited period of time. This would serve a dual purpose: 1) it would encourage recruitment into aquaculture 'now', and 2) if the sector did not developed according to plan, the extension of the incentive for a further limited period of time could be considered.

- 1.4.5 Providing support for aquaculture development along the value chain. In addition to their services as pilot farm operators, the Aquaculture Zone Companies (please see actions 1.3.4 and 1.3.5) will play an important role in SKN's aquaculture sector development by:

  - Organising the AZ tenants, i.e. the modern 'small-scale' farmers, into clusters. In this way the farmers will be able to achieve efficiencies of scale as though they were operating as a large-volume, corporate farm.

    Comment: The term 'cluster farmer' refers to modern 'small-scale' farmers running privately-, family-owned and operated farming activities as opposed to corporate, investor-owned farms operating through hired-in staff. A 'modern', small-scale farm seeks to achieve efficiencies of scale like large-volume, corporate farms by forming clusters. Clusters are different from cooperatives as cluster farmers own their own farming activity. The advantages of clustering can include: sharing common infrastructure costs, better access to bulk prices for feed, better access to extension services, better market access through consolidated volume and consistency; sharing the costs of certification schemes, etc. (please see 'Working

Document 1, Appraisal for St. Kitts and Nevis – Demand for and Potential of Aquaculture', for further details).

- Building common farming infrastructure in the AZs to be leased by cluster farmers or others, for example, AZ tenants. Common facilities may include:
  - o For land-based farms: water inlet, reservoirs, fish tanks, sedimentation tanks, water outlets, etc.
  - o For sea-based farms: shore bases, piers, slipways, cage storage areas, permanent mooring at the sea site, working/guard platforms, area marker buoys, etc.
- Charging a lease fee from cluster farmers according to, for example, the number of tanks used/water consumption, number of cage sites used, etc.
- Providing credit arrangements for cluster farmers for renting AZ infrastructure.
- Providing common purchase and import services for cluster farmers to ensure quality and bulk prices for:
  - o Fish juveniles, ensuring health quality and traceability for cluster farmers (after having passed through a quarantine facility).
  - o Feed.
  - o Cages or pipes for local assembly.
  - o Ready-made net bags (possibly imported from India).
- Providing storage facilities for imported goods through an obsolete sugar store at the deep water harbour, which can be modified for storage (rat proofed).
- Providing credit arrangements for cluster farmers to purchase juveniles and feed for their first production cycle, if purchased through AZCs.

  Comment: If the AZCs are eventually fully privatised, the above-mentioned credit arrangements (for juveniles, feed and infrastructure) could be expanded into a 'buy-back' arrangement between the AZCs and cluster farmers. There would be pros and cons to this for both parties, but the immediate benefit would be that the cluster farmer would not have to finance the production. This, of course, would lead to a lower profit margin to the farmer, but this share of the profit margin could otherwise have been taken by the bank. The benefit to the AZCs would be that they only have to pay for the actual achieved production and thus would minize their risk taking. The 'buy-back' arrangement could also be developed by any corporate entity with sufficient financial strength and market access.
- Developing a harvesting protocol for mullet juveniles from brackish water ponds/ghauts based on international experience in terms of sizes and numbers.

  The AZCs should – on exclusive terms (to facilitate monitoring by the DMR), harvest and supply the mullet juveniles to cluster farmers through a not-for-profit approach, covering only the costs incurred.

  The ACZs should also develop a distribution schedule if the supply of mullet juveniles is lower than the demand.
- Establishing a quarantine unit for imported marine fish juveniles to verify their disease-free status before they are released for sale and stocking to cluster farmers.
- Establishing a Southeast Asian-style, extensive, multispecies marine fish hatchery to produce fish species according to farmers' demands with a yearly capacity of a minimum of 1.25 million fish juveniles. This would be the basis for 500 tons of production.

  Comment: With reference to 1.1.3, the hatchery should be situated on the Atlantic Coast for biosecurity reasons, to avoid risk of using the same water as the grow-out facilities/operations (sea cages) that are in the Caribbean Sea, i.e. 'downstream'.

2.2 Phase 2 (2017-2020): Production volume development in the aquaculture zones and the first corporate investors

If Phase 1 is supported in a timely manner with sufficient, appropriate funding, all of the outputs could be achieved by the end of year 4. However, it is possible that the reality could be different.

Phase 2 of the strategy describes the actions to be undertaken once aquaculture production has already been launched, mainly by new cluster farmers using AZCs' common farming infrastructure facilities and services.

If Phase 2 is successful, aquaculture development would have taken up and expansion of the facilities would continue in the AZ.

During this phase, local corporate investors would be provided with sufficient documentation on the aquaculture business plans and models developed to enter into the sector by capitalising on their competitive edge (finance) for large-volume production.

Sector governance, including monitoring, should be fully developed in this phase, assuming that the sector has developed successfully.

2.1 Providing an enabling environment for the economic and social development of the aquaculture sector

- 2.1.1 Transform the **Aquaculture Zone Companies (AZCs)** established on both islands to manage the **aquaculture zones (AZs)** into PPPs or fully privatized companies.

  Comment: The AZCs should have developed/set up a large range of facilities and a broad service/product portfolio for the aquaculture sector, and should operate on the basis of business principles. During Phase 2, the share owned by the Federation will be reduced as the sector will have achieved a certain development level, thus reducing the AZCs' national development obligation.

- 2.1.2 Ensure the continuation of the operations of the quarantine unit for imported marine fish juveniles (established by an AZC) as long as imported juveniles are the main stocking resource. The quarantine unit will be continuously operated by the ACZ based on cost recovery principles and monitored by the DMR.
- 2.1.3 Upgrade the Southeast Asian-style, extensive, multispecies marine fish hatchery operated by an AZC, to include more intensive (western) hatchery production methods, thus improving biosecurity and production planning in particular.

2.2 Ensuring that the necessary regulatory framework is maintained and improved to encourage and protect investments in the aquaculture sector

- 2.2.1 Develop dedicated aquaculture legislation with directives.

  Comment: When the sector is seen to be developing, AZ management rules/bylaws should be used as the basis for drafting federal aquaculture legislation. Assistance from the FAO could possibly be requested to formalise the laws according to international best practise.

- 2.2.2 Discuss the possibility of granting foreign investors access to the sector, after having assessed the aquaculture sector's development in SKN, including the impacts on social and food security development. Take decisions on modalities for foreign investment in the sector.

  Comment: It is common practise in many countries for no foreign investors to be authorised permitted to have ownership in the primary production sector (agriculture, forestry, fisheries and aquaculture), as these sectors are considered to be of national, strategic importance. If foreign investments are authorised, it should be decided whether they are allowed as majority or minority shares only (see explanatory remarks regarding corporate investors in section 2.5.1 below).

2.3 Supporting training, extension and R&D for the advancement of the industry

- 2.3.1 Provide free technical assistance and extension service to stakeholders via the Department of Marine Resources through the pilot farms.
- 2.3.2 Transfer the pilot farms developed during Phase 1 from the AZCs to the DMR, as the AZCs become PPPs or private entities. The pilot farms will continue to serve the interests of the sector's development in the Federation through:
  - Continued development and fine tuning of the SKN Aquaculture Model for marine fish farming.
  - Continued incubator arrangements (on pilot farm training) for potential newcomers (farmers or small businesses) desireous to acquire supervised, hands-on knowledge before investing themselves.
  - Continued, free extension services including advice to newcomers.
  - Ad hoc advisory services for aquaculture farmers with more than one year's experience. Advisory fees may be charged.
  - Taking over the harvesting of mullet juveniles from the AZCs as the latter become increasingly privatised.
  - Achieving the status of '**aquaculture sector research institute**', which would facilitate the development of their regional research networking.
- 2.3.3 Identify at least 1-2 candidates from SKN to be sent abroad to begin MSc education in aquaculture or related topics during this phase.
- 2.3.4 Develop course modules on aquaculture sector services in the Ross University School of Veterinary Medicine and the Clarence Fitzroy Bryant College (CFBC) of St Kitts.

  Comment: Aquatic health management is obviously a very important risk mitigation action. The CFBC has already begun an agribusiness course leading to an associate degree, which addresses agriculture management in terms of crops and livestock. This programme could eventually be expanded to include aquaculture. Students graduating from such courses could enter large fish farms at production management levels and also governance, i.e. the DMR.
- 2.3.5 Initiate a dedicated Caribbean Aquaculture Counselling Group.

  Comment: A weakness of many Caribbean countries is their limited human resources, as many of them are too small to hold key expertise in all relevant fields. By creating a counselling group, local institutions/centres/projects would be recognised for their individual expertise and become centres of excellence to be used in the regional group for sharing knowledge and advice in the face of constraints.
- 2.3.6 Empower the aquaculture organisation or aquaculture technology forum/platform initiated by the DMR during Phase 1, by issuing bylaws to represent SKN aquaculture farmers' interests in local political debates as well as in regional, Caribbean organisations.

2.4 Other supporting incentives for local farmers

- 2.4.1 Continue the provision of some incentives for all farmers:
  - Duty free and VAT exemptions on imported equipment, boats, engines, trucks, juveniles and feed.
  - No sale or profit tax on business earnings.

- 2.4.2 Make changes to other incentives from Phase 1 to focus efforts on assisting only the first year of operations of newcomers, such as:
  - Grace periods for area leases.
  - The AZCs could still offer credit arrangements to new cluster farmers renting farming infrastructure or purchasing juveniles and feed through the AZCs.

  Comment: As the AZCs become fully privatised, the credit arrangements could be developed into 'buy-back' arrangements where the cluster farmers would benefit from credit arrangements for feed and juveniles against the delivery of their production to the AZCs.

2.3 Phase 3 (2021-): Consolidation Phase, satiation of local market demand

If SKN is successful in developing the sector, production should exceed 1,000 tons after the initial eight years of development, leading to saturation of the domestic and extended domestic market (the cruise liners).

This phase, during which there may be an expansion into exports, is where corporate investors may experience some competitive advantages, unless the cluster farmers have also appreciated the market challenges. Going into export means being able to deliver predictable, consistent production, which can be achieved through large-volume farming approaches including vertical integration as a major risk reducing factor. Vertical integration includes control from hatching, farming and processing through to direct marketing to major distributors. Quality assurance and certification schemes also need to be developed and monitored according to US FDA or EU standards, or possibly CARICOM standards which may be developed.

During this phase, the presence of a sector institute will become essential as the farming challenges will not always be able to be addressed by good management practices and solid experience, as is possible during the start-up/initial phases. Some challenges may require research to find solutions, and this is where having transformed the pilot farms into an aquaculture sector institute may prove to be extremely valuable.

2.4 Financing

If donors appreciate the potential importance of aquaculture to SKN, they could finance many of the activities, as the government itself is not in a strong position.

However, government support or credit lines could be made available by allocating public land, for instance, or possibly by issuing loan guarantees for infrastructure constructions to the AZCs.

The tenants/cluster farmers would have to contribute to repaying such loans (credit facility) through their lease fees to the AZCs.

SKN's public assets, such as natural resources, can already be leased to companies, for resort development in the tourism industry, for example. In return for a concession, foreign investors in particular should be encouraged to support corporate social responsibility projects for the benefit of local society under their operating license requirements. Aquaculture development, including the development of pilot farms and human resources, could be targeted through inclusion in a prioritised list by the government. This is common practise in many countries where larger investors are given access to public natural resources.

2.5 Role of private sector stakeholders

2.5.1 Local corporate investors

During Phase 2, it is anticipated that 1-2 local corporate investors will apply for a farming license for a large-volume farm, having observed the sector's development and seen that the SKN Aquaculture Model works. A potential market of 50,000 people cannot consume the production from one large-volume farm (500-1,000 tons), so such investors would have to focus on production for export.

It is expected that the production efficiency of the cluster farmers, with a good training background could compete with that of large-volume farms, particularly as cluster farmers obtain their whole salary or income directly from selling their production, unlike corporate investors who need to make an income to pay staff salaries and to see a profit on the investment itself. It is therefore expected that the cluster farmers will be more competitive in supplying local demand than the large-volume farms as they will probably produce several species of fish, while the large-volume farms will specialize in single species production to achieve the highest efficiencies of scale. On the export market, the large-volume farmers will probably be the most competitive.

It is possible that during Phase 1, a handful of small, locally invested 'corporate' farms (50-100 tons) become established within the AZs, in coexistence with the cluster farmers. They would possibly target slighly larger production volumes than the cluster farmers, and not depend on the credit lines provided by the AZCs.

2.5.2 Foreign corporate investors

Foreign investors might only be attracted to SKN aquaculture for the purpose of obtaining farm sites in the sea, which is a scarce 'commodity' for project developers.

Neither the size of the domestic market nor the availability of skilled workers are competitive edges for SKN's aquaculture sector. However, marine farm sites using 'traditional cage' technology will probably become a constraint for future aquaculture development in the tropical Americas, and this could be a reason to look into SKN sites, once investors have understood the seasonal sea cage farming concept.

It is difficult to anticipate when serious, foreign investors will look towards SKN. However, in the present context, it is assumed that this will not be before 2014.

Several approaches have already been put forward by investors, but they seem not to have shown a serious production purpose as they have not addressed the specific challenges of farming in SKN. This would seem to indicate a high risk that such investment projects are designed by a 'developers' for the purpose of attracting venture capital based on unrealistic market projections rather than situation analyses and proposals that can be implemented.

There should be two separate approval procedures for foreign investment applications in SKN: one for granting investment licenses and one for farming licenses. The coordination of farming license applications should be monitored by the line department (DMR).

As its natural resources are very limited, the Federation should firstly carefully consider the social development of its own people and their food security.

If a foreign investor develops a project proposal which is not located in the identified optimal areas for aquaculture as described in the Situation Appraisal Report, but make use of different submersible cage technology in fully exposed offshore areas, the approach should be welcomed as it would not restrict production or opportunities for local farmers.

SKN should, like in other countries such as Vietnam, welcome foreign investment but request that such investors state exactly how many foreigners and how many locals would be employed in the business application.

SKN should only grant permits for foreign staff if they are to occupy key management positions. Other staff should be from SKN and should be trained by the company. This would ensure local job creation.

Both local and foreign corporate investors are anticipated to be in very low number, and thus it is questionable whether SKN should develop dedicated legislation covering corporate investors, or instead hold direct negotiations on the terms and conditions that can be offered. If experienced, foreign, corporate investors are looking for optimal farming sites in the Caribbean they would probably be attracted to other geographical areas that have better competitive edges than SKN such as transport and proximity to larger markets.

2.6 The role of fishermen in SKN aquaculture development after 10 years

Before embarking on the development of the aquaculture sector, it must be ensured that it would not damage the livelihood of fishermen.

Firstly, the development of the aquaculture sector has been fully open to fishermen and their children. Fishermen have a competitive edge in terms of their skills and prior investments (boats, etc.). However, fishing is a very traditional occupation or lifestyle, and the average age of fishermen is currently 50 years plus indicating that fishing is not attractive to the younger generation. Aquaculture however may show busines qualities which the next generation may be attracted by.

A higher domestic supply of seafood would obviously create competition. However, it is predicted that the consumption of seafood would increase with a higher quality supply of marine fish, and this could possibly push down prices of freshwater fish fillet imports, which could eventually lead to these fish fillets being more competitive against imported chicken broilers. Whether this will actually materialise or not remains to be seen. Nevertheless, fish is predicted/destined to become a more important (food security) protein source worldwide than currently because it can be produced more cheap than other animal proteins. The question however is rather when it will be sold at the same profit margins as chicken broiler.

With regard to marine fish, demersal trap fishermen supply some 20 species of coral reef fish species. In general, these are small or slow-growing fish, and consequently not adaptable for aquaculture production and consequently they will probably keep a premium in the local market.

2.7 Strategy monitoring

It is suggested that the Department of Marine Resources (St Kitts)/the Department of Fisheries (Nevis) will be responsible for the strategy's implementation.

They will have to provide the impetus by implementing the first steps defined in the strategy, notably by providing an enabling environment for the economic and social development of the aquaculture sector, especially through the creation of the aquaculture zones and Aquaculture Zone Companies, and a public R&D function.

This strategy provides orientations and actions that will need to be updated on a 2-3 year basis, and the action plan outlined here should be refined accordingly to develop a suitable monitoring and evaluation process. At this stage of the strategy development it is mainly focused on tangible activities for the first phase.

Annex: Action Plan

Strategy axes	Actions	Resources (Indicative Estimate)	Responsibility
Phase I			
1.1.3 Establish aquaculture zones (AZ) on each island.	a) Identify aquaculture zones and have them 'pre-approved' by relevant ministry departments and organisations. b) Perform carrying capacity analyses and environmental impact assessments for the AZs. c) Establish an AZ Management Board and AZ Companies. d) Develop management rules/bylaws for the AZs. e) Develop business plans for the AZCs.	*Consultancy EUR 50,000* *Consultancy EUR 15,000*	DMR/DF
1.1.5 Human resource development.	a) Recruit three persons to each pilot farm: a pilot farm manager, a land-based production manager and a sea-based production manager. All should contribute to production and extension. b) Send above six staff for overseas training in production and extension (three months). c) Identify or recruit two DMR/DF staff members to be trained in aquaculture governance and production (one+one months) d) Arrange a two-week aquaculture study tour for six persons: permanent secretaries, DMR/DF directors, and above two staff from DMR/DF to relevant countries to learn about livelihoods and corporate farming in aquaculture.	*Direct/reimbursable: EUR 120,000 including tickets, tuition fees and per diems* *Direct/reimbursable: EUR 30,000 including tickets, tuition fees and per diems* *Direct/reimbursable:EUR 42,000 including tickets and per diems*	DMR/DF
1.1.6 Assess mullet juvenile stock in brackish water ponds	a) Make estimate of maximum sustainable harvest of mullet juveniles in the brackish water ponds	*Consultancy: EUR 15,000*	DMR
1.2: Develop the necessary regulatory framework	a) Make procedures for applications within preapproved AZs and outside	Not assessed at this stage	DMR
1.3.4 Establish two demonstration, training and test (pilot) farms in the (first)	a) Design two pilot farms including land- and sea-based activities for both islands.	*Consultancy:* *EUR 100,000*	DMR/DF

Strategy axes	Actions	Resources (Indicative Estimate)	Responsibility
aquaculture zones.	b) Build (and commission) two pilot farms including land- and sea-based activities, with one pilot for each island.	*Construction incl. consultancy: EUR 1,000,000*	
1.4.5 Provide support for aquaculture development.	a) Design, build (and commission) a SE Asian-style, extensive, multi-fish species hatchery (brood stock, live food ponds/tanks, hatchery and nursery) including four months of on-site management/training. b) Establish a quarantaine unit for imported marine fish juveniles (in connection with land based pilots/AZs)	*Construction incl.consultancy:* *EUR 500,000* *Construction incl. consultancy:* *EUR 20,000*	AZC
Phase II :			
2.1.3 Modify the extensive fish hatchery to higher intensification to improve the biosecurity and production planning	a) Design, construction and and four months of onsite management/training.	*Budget:* *EUR 1,000,000*	AZC

Annex 10: Technical report 3: Supplemental GIS Mapping Report for Aquaculture Development Strategy 2013-2023

ELABORATION OF AN AQUACULTURE DEVELOPMENT STRATEGY FOR ST. KITTS AND NEVIS

Supplemental GIS Mapping Report

by Michelle Walters

Draft

October 2012

Table of Contents

1. Introduction 5

2. Analytical Method 5

2.1 Data Sources 5

2.2 Analysis 6

2.3 Approach.... 6

2.4 Coastal Land Aquaculture 7

2.5 Sea Aquaculture....7

2.5.1 Accessibility to roads and electricity....7

2.5.2 Proximity to Coast....10

2.5.3 Slope parameter 12

2.6 Suitability....13

2.7 Offshore Aquaculture 14

2.7.1 Assessing Cage Site Suitability 14

2.7.2 Winds and waves 15

2.7.3 Benthic Habitat 17

2.7.4 Bathymetry....19

2.7.5 Suitability....21

2.8 Data limitations 23

3. APPENDIX....24

3.1 APPENDIX 1 Benthic Habitat Suitability Considerations 24

3.2 APPENDIX 2 Vulnerability Map St Kitts and Nevis....25

3.3 APPENDIX 3 Slope Calculations....26
3.4 APPENDIX 4 Details on Collected Data....28
3.5 APPENDIX 5 Offshore Suitability Cage Farming....31
3.6 References....32

Summary

Geographical Information Systems (GIS) would appear to be an ideal tool for aquaculture installations. In this project it was planned to use GIS to assess large areas using nationally available data sets. Spatial data required were acquired from various Government agencies as there is no national spatial repository existing.

Marine aquaculture parameters were assessed based on wind, wave, bathymetry and benthic habitat. Very limited data was made available for land assessment as compared to the marine environment. Further analysis could be done once land cover data is complete and available.

Typical freshwater in St Kitts and Nevis are from wells and small springs which are mainly used for consumption and agriculture therefore was not included.

1 Introduction

As part of the ACP FISH II commitment to strengthening fisheries policy development and implementation, a GIS component was included as part of the Aquaculture Development Strategy for St Kitts and Nevis. Geographical information system (GIS) is an established powerful mapping tool for spatial analysis in assisting effective aquaculture management. These include the use of the physical and environmental characteristics. The output is intended to assist planning of aquaculture development. It is recommended that prior to establishment of any aquaculture operation a proper site assessment be conducted to evaluate suitability based on its environs.

2 Analytical Method implemented

2.1 Data Sources

Primary data were amassed from a variety of sources including the internet. Some data were made available whereas other data were either not made available or incomplete.

Geographical Information System using map data of various scales was used as base data. These were obtained from national agencies and appropriate government statistics. In some cases there was considerable delay or non provision of data from key sources, including government agencies.

Presently there is no National Spatial Repository. Spatial data and statistical data were obtained from the following agencies through requests from the DMR:

- Department of Physical Planning and Environment(DPPE) St Kitts
- Department of Physical Planning Natural Resource and Environment(DPPNRE) Nevis
- Department of Marine Resources (DMR) St Kitts
- Department of Fisheries (DoF) Nevis
- St Kitts Waters Services Department
- Nevis Water Department
- Public internet database PGDM

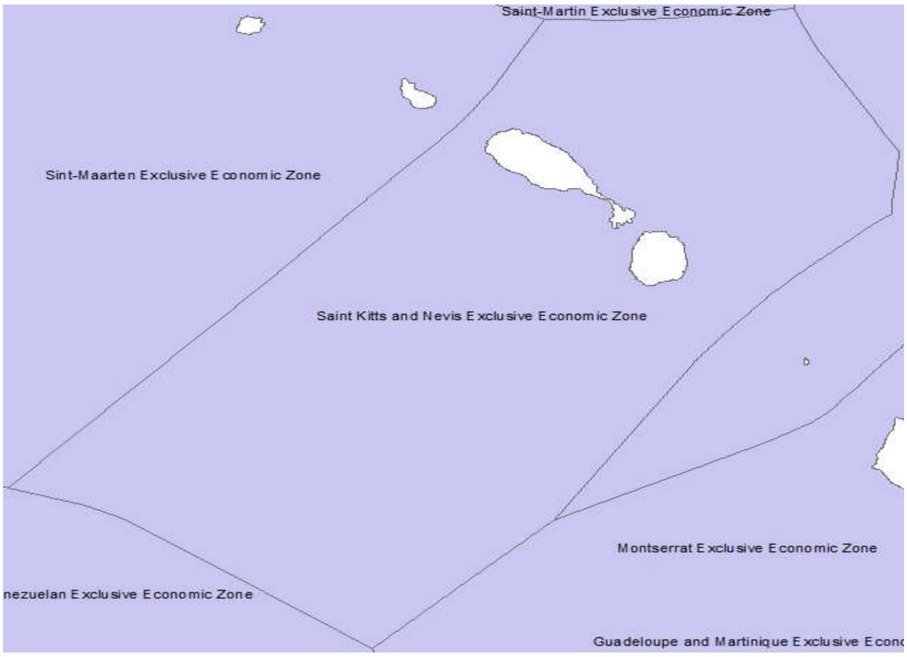
2.2 Analysis

In preserving the biodiversity on land and sea it was important to identify the ecologically sensitive habitats, both terrestrial and marine species. It was established by the aquaculture consultant that there was not an abundance of fresh water supply and existing wells and springs are for municipal consumption. Categories considered for potential aquaculture were:

1. Coastal Land aquaculture
2. Offshore marine Aquaculture

2.3 Approach

The project extents comprise the Exclusive Economic Zone (fig.1) within the Federation of St Kitts and Nevis.



Source: www.seaaroundus.org/eez/659.aspx

Map 1 Exclusive Economic Zone –St Kitts and Nevis

2.4 Coastal Land Aquaculture

Suitability grading is based on the following parameters:

1. Accessibility of road and power
2. Proximity to coast (constant water supply)
3. Slope

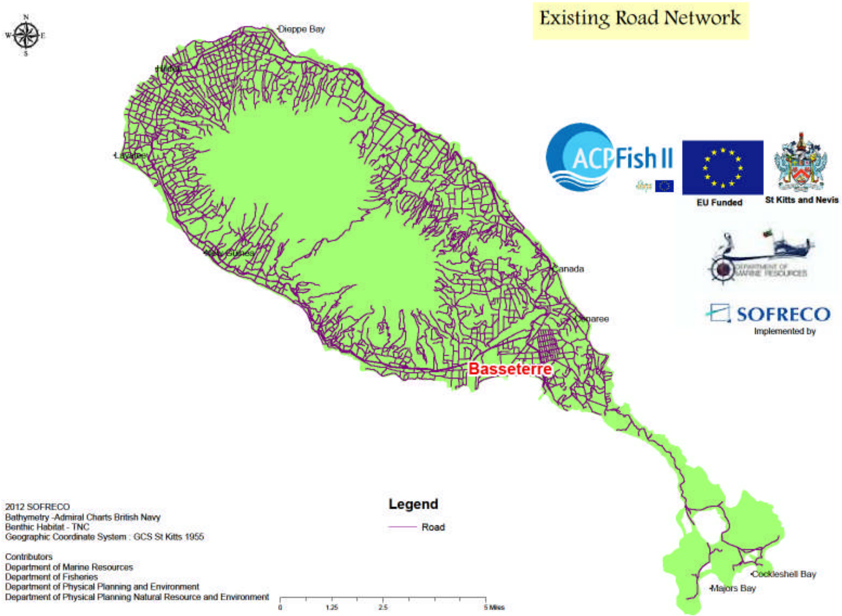
2.5 Coastal Sea Aquaculture

Suitability parameters, as determined by aquaculture consultant, are based on a sliding scale of investment. For sites reliant on access to seawater, these factors were included:

- Distance from seawater(pumping costs)
- Elevation above sea level(pumping costs)
- Site slope (site preparation costs)
- Distance to nearest road and power supply(site development costs)

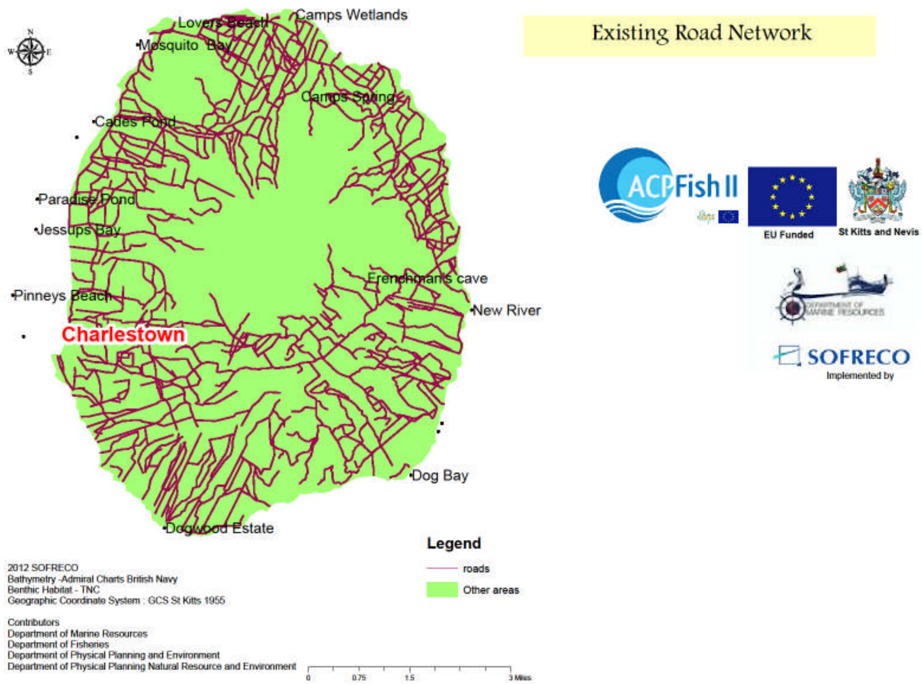
2.5.1 Accessibility to roads and electricity

A buffer rating of 1000 meters for vehicular access to the coast was established. This rating was considered for all aspect of transportation to and from coastal areas. In Map 3 and 5 brown areas show suitability and green areas along the coast require additional investment. Both islands have a well established road and electricity network for ease of transportation. Only the south east Peninsula of St Kitts has a single road as entry and exit.

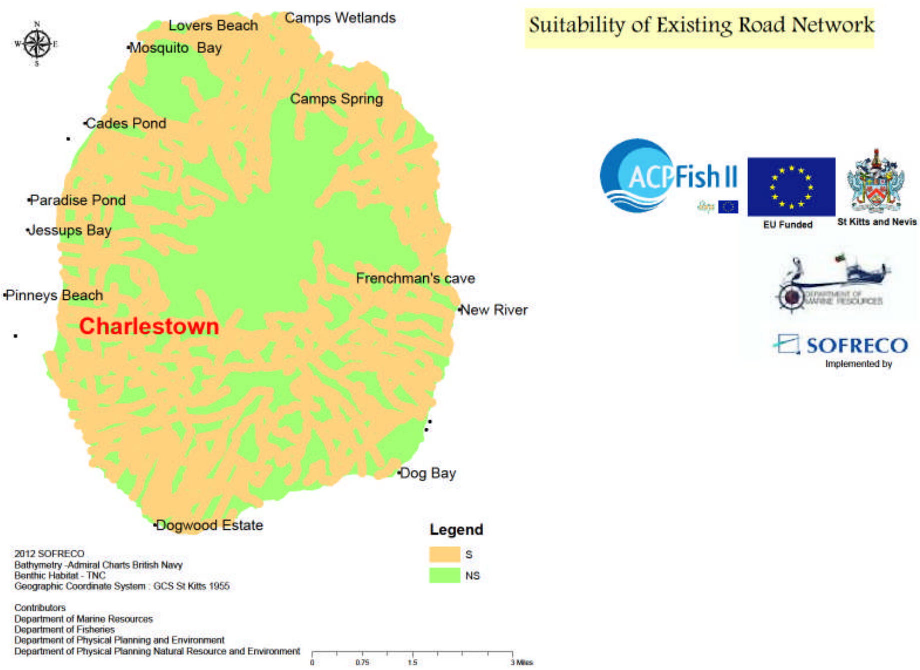


Map 2 :Existing road network in St Kitts

Map 3 Suitability for aquaculture based on Existing Roads in St Kitts



Map 4 Existing Road Network in Nevis



Map 5 Suitability for Aquaculture based on Existing Road Network in Nevis

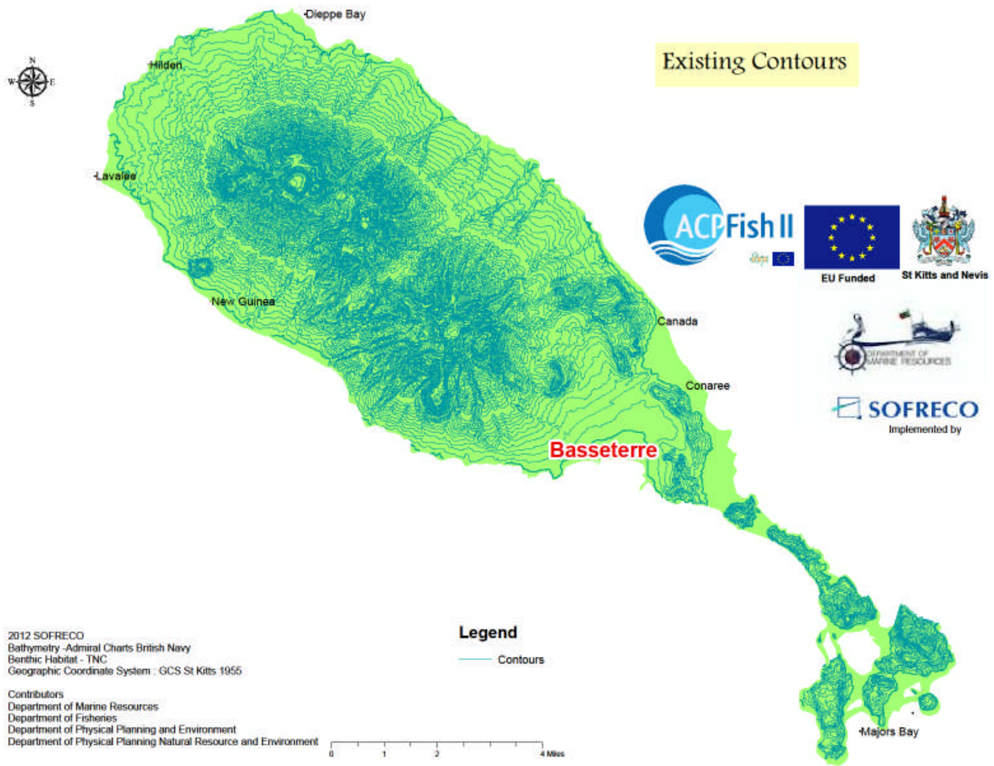
2.5.2 Proximity to Coast

Contours for St Kitts were available in 50ft interval and contours for Nevis were available in 10ft intervals. Due to water circulation, and site excavation expense, the selection by location was based on proximity to the coast and contour slope calculation as determined by aquaculture consultant. The closer the aquaculture pond is to the coast (source) the less force exerted and less distance water has to travel, therefore saving on electricity and excavation costs. Coastal suitability is considered based on the following criteria.

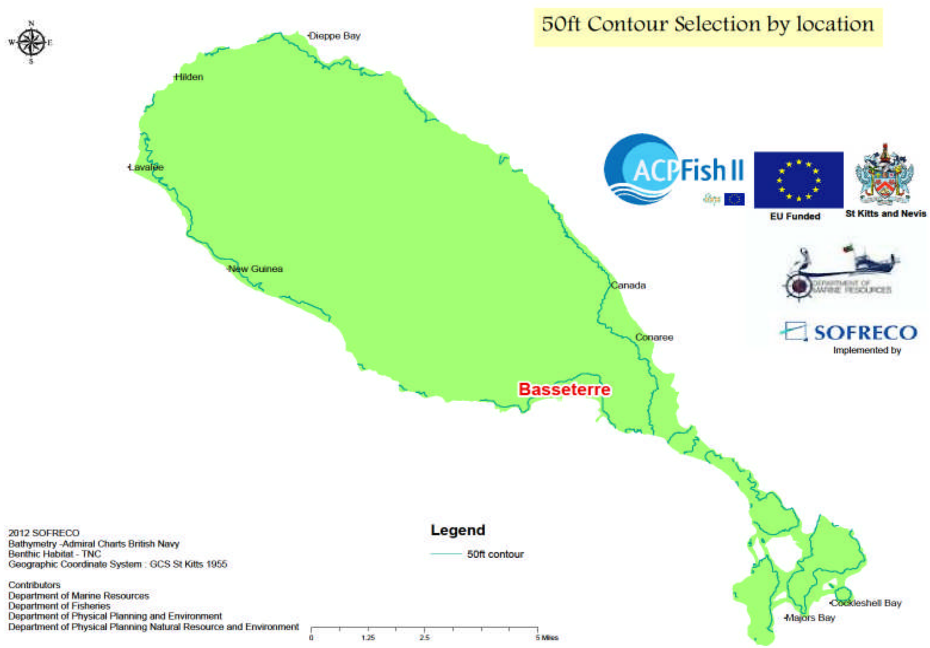
- S1 (Suitable) suitability based on regular investment for establishment of lined ponds
- S2 (Moderately Suitable) suitability based on additional investment such as excavation and additional pumping costs (larger pumps).
- Not Suitable(NS) – All other area not suitable (or with too expensive operation costs)

The buffered 50ft contour was isolated by selection by attribute as shown in Map 7. Verification of existing land cover was done by using satellite image and field verification.

Current Land use data was incomplete therefore not available for analysis. Settlements and developed areas that were stated to be in conflict with the selected contour were further eliminated.



Map 6 Existing Contours in St Kitts



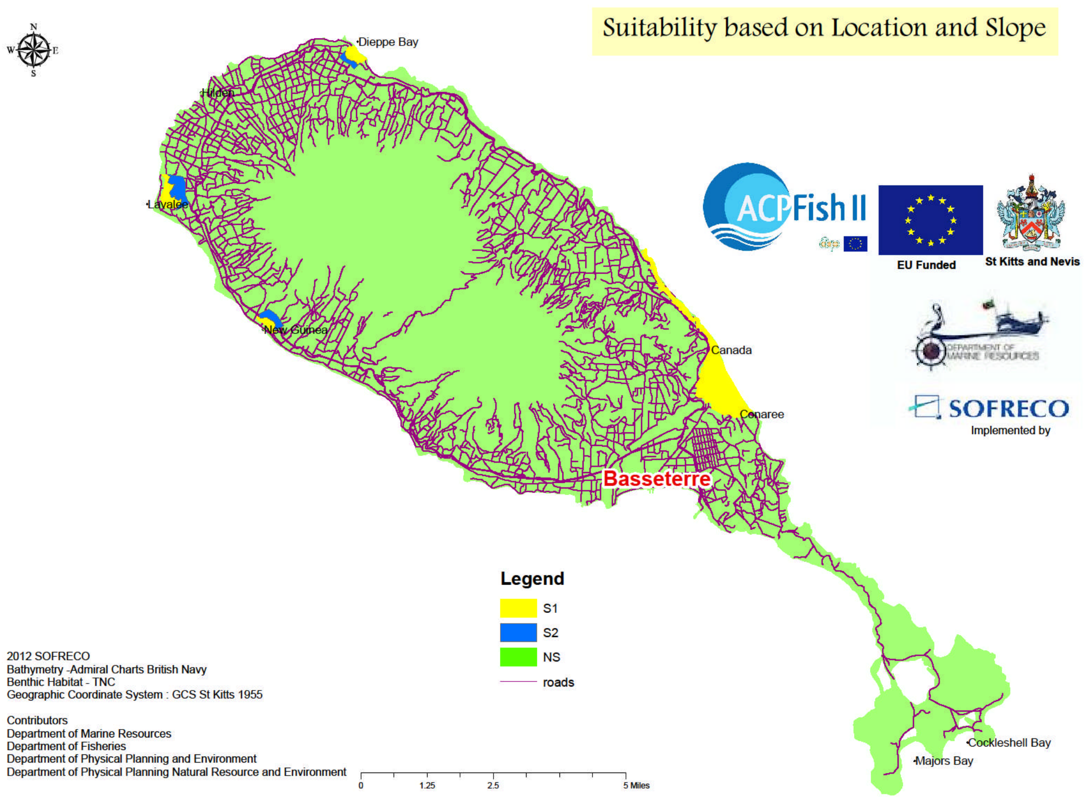
Map 7 : 50ft contour selection by location (St Kitts)

2.5.3 Slope parameter

Field measurements were done to verify slopes where coastal slope data was not available. Elevations were determined using an Automatic level on a tripod, vertical staff and measuring tape. The coastline was used as a bench mark of zero above sea level and measuring intervals of 20ft and recording the heights. Final slope calculations are shown in Table 1.

St KITTS	SLOPE (%)	Area(ha)
Conaree	2-2.94	25
Canada	2-3.12	34
Dieppe Bay	3.00	20
Lavalee	2.2	40
New Guinea	3.9	20
NEVIS	**SLOPE %**	**Area(ha)**
Indian Castle	2.00 -3.65	15
New River	4.56 -6	10

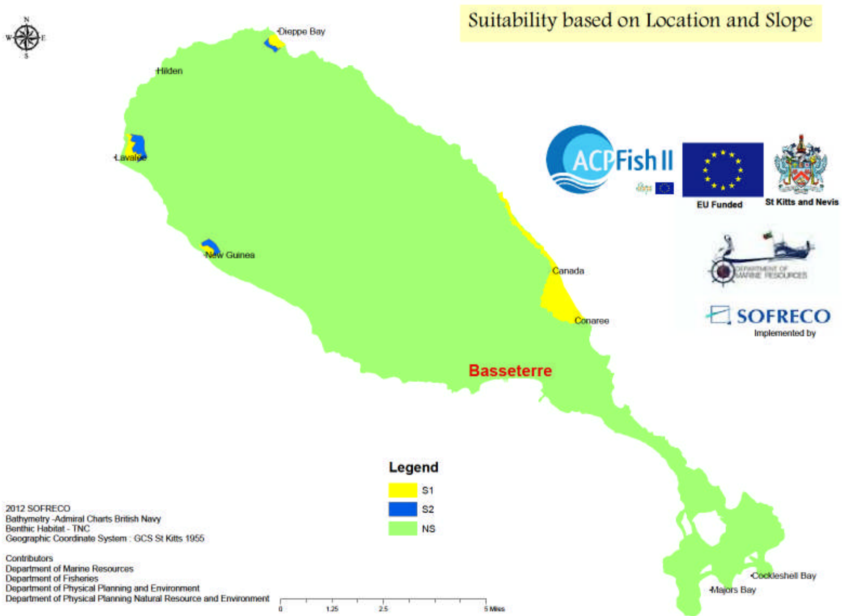
Table 1 : Potential Land Aquaculture Sites based on slope field calculations



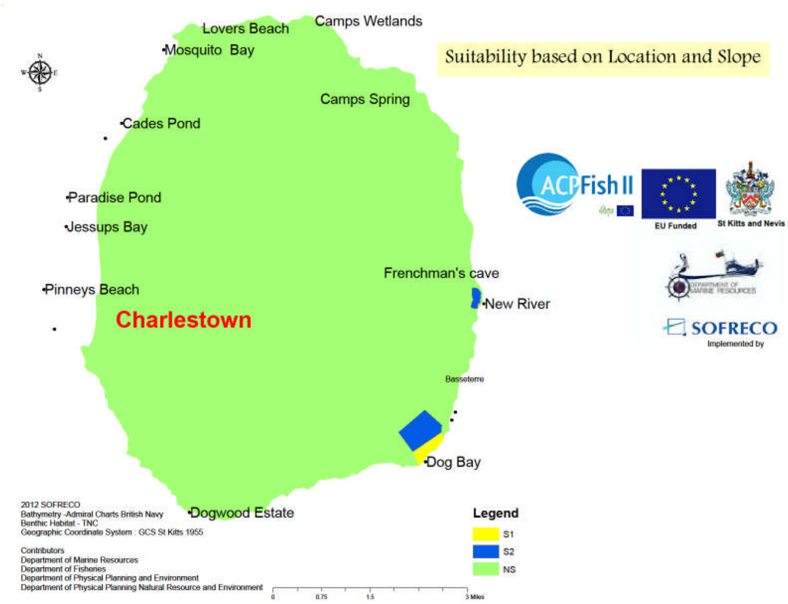
Map 8 : suitability based on location and slope

2.6 Suitability rating and mapping of potential coastal areas for aquaculture development

Potential areas shaded yellow in the below map 9 and 10 (suitability S1) requires less investment and maintenance as compared to areas shown in blue (suitability rate S2).



Map 9 Suitability based on location and slope (St Kitts)



Map 10 Suitability based on location and slope (Nevis)

2.7 Offshore Aquaculture

Assessing offshore suitability is based on physical environmental parameters in conjunction with engineering cage design (as determined by the aquaculture expert). Sites were categorized as suitable or not suitable.

2.7.1 Assessing Cage Site Suitability

- Exposure to wind - waves are small during farming season. This factor is extremely important as it can not only affect the productivity of a cage but it can also adversely affect the cage structure.
- Environment : Sites should not be directly in vulnerable ecological biotopes
- Bathymetry
- *Grade* 1 suitability (15-25m depth) - The depth of nets designed for these cages restricts their ability to be placed in shallower or deeper waters.
- *Grade 2* suitability between 50-60m depth (higher investment)

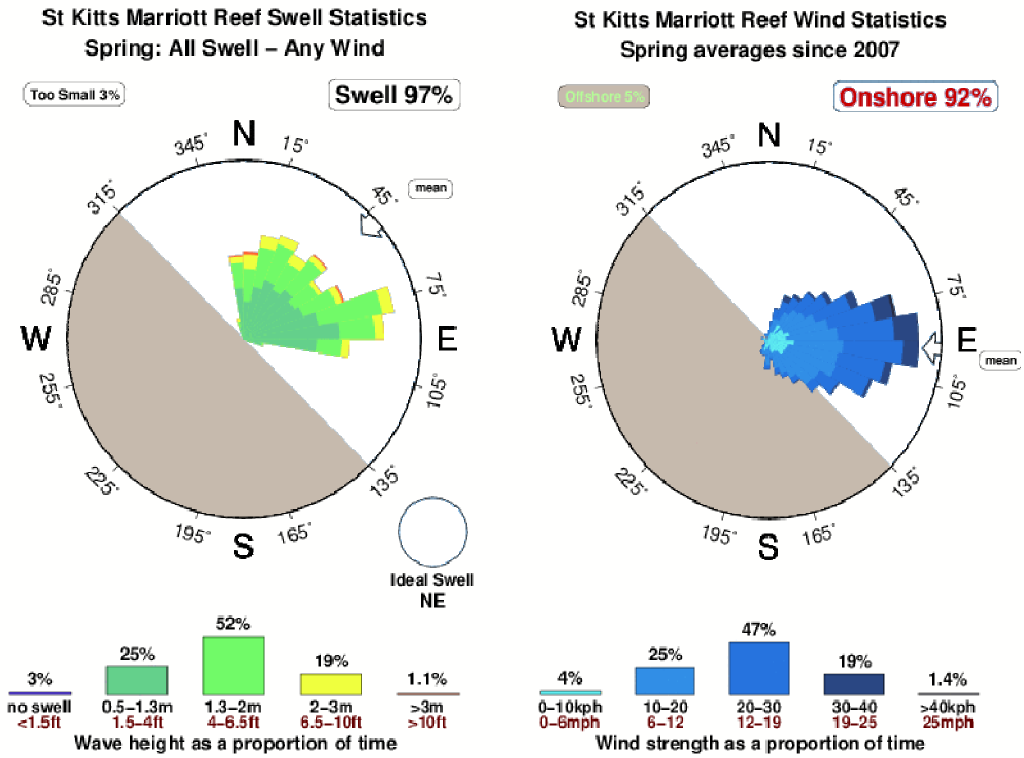
2.7.2 Winds and waves

Dominant Wind and wave currents are strongest at North East for St Kitts and East South East (ESE) for Nevis, thus the selection criteria would be where waves and winds are of less impact. According to the model of St Kitts Marriott Resort fig 2 the dominant wind and currents at St Kitts blows from the NE. Consequently wind rose pattern for Nevis shows a dominant ESE winds(fig3).

Map 11 shows areas semi sheltered from dominant winds and areas more exposed to prevailing winds yet away from dominant winds. Sheltered areas are less exposed therefore startup, maintenance and running operations are less costly as compared to exposed areas where equipment and management costs are much higher.

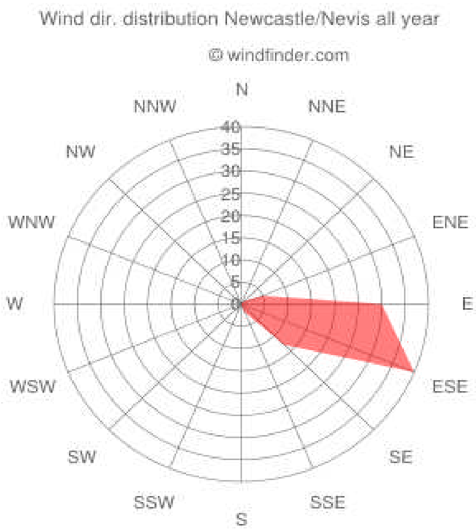
Criteria for site selection are;

- Bays or coves within grade 1 and grade 2 suitability depth
- Leeward away from dominant winds and swells –waves will be small during farming season



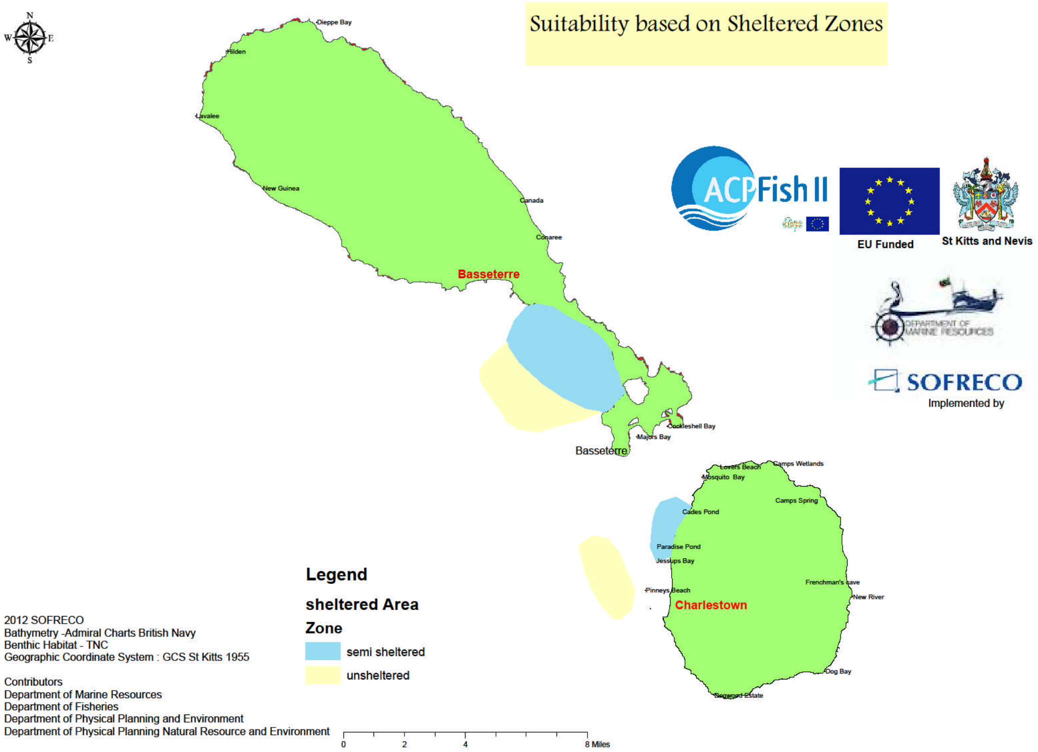
Source: www.surf-forecast.com/breaks/St-kitts-Marriott-Reef

Figure 1 : Wind and swells statistics from 2007-2012



Source: www.windfinder.com

Figure 2 Dominant Wind Direction - Nevis



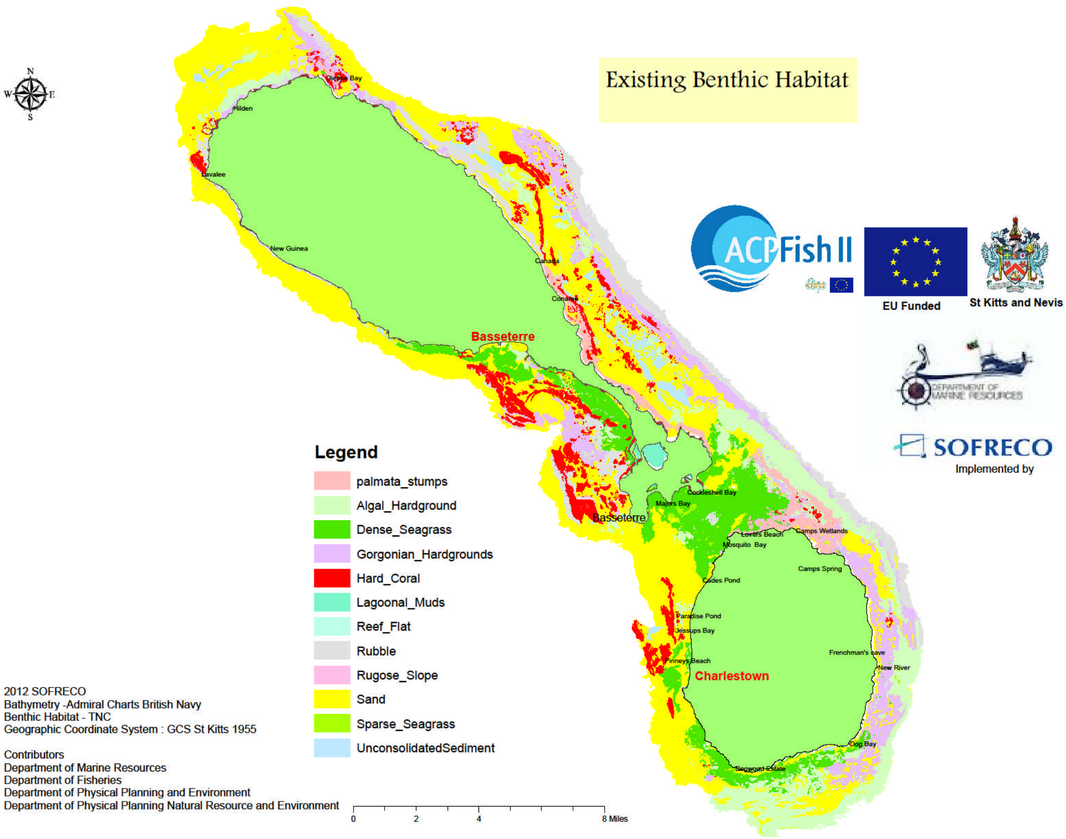
Map 11. Suitability based on Sheltered Zones

2.7.3 Benthic Habitat

Coral reefs are relatively small and of little variety throughout the federation, therefore protecting the oceans biodiversity was considered as a critical parameter for the analysis.

Important living benthic habitat such as dense seagrass, Acropora palmata stumps were classified as not suitable (NS). Other areas with no living organisms, such as bare sand, and consolidated rubble were considered as suitable(S) in Table 2 and Map 13.

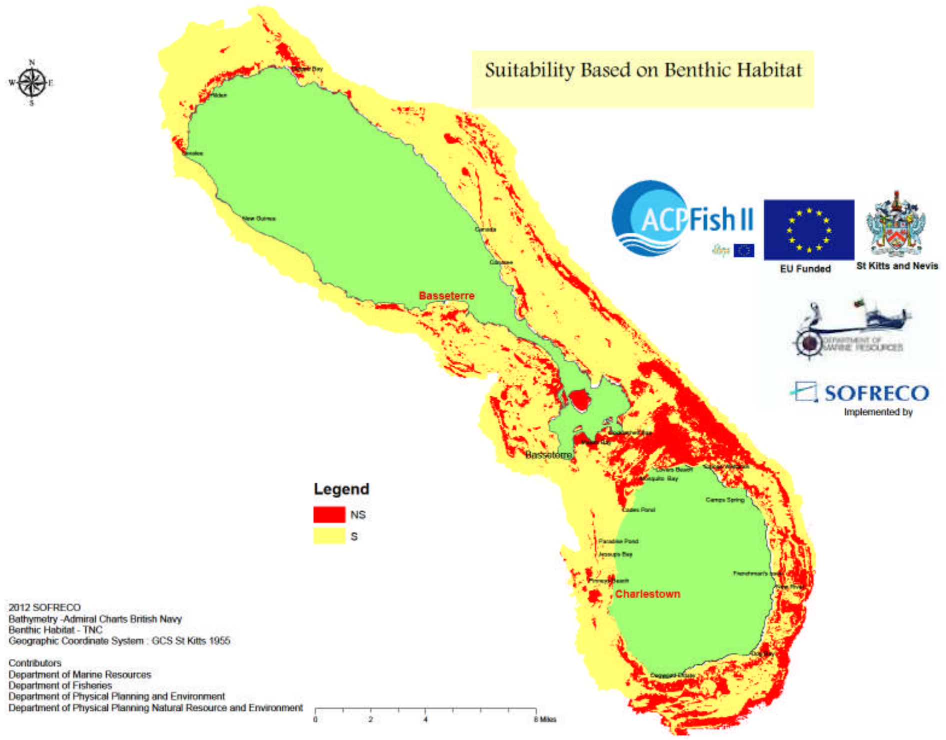
Each benthic characteristic were merged and reclassified as suitable(S) or not suitable (NS).



Map 12 **Existing Benthic Habitat**

BENTHIC HABITAT	SUITABILITY	
Unconsolidated Sand with Algae	S	
Sparse Seagrass area	S	
Bare Sand	S	
Rugose slope	NS	
Reef flat area	NS	
Lagoonal Muds	NS	
Hard Coral	NS	
Gorgonian hardgrounds	NS	
Dense seagrass	NS	
Algal Hardground	NS	
Acropora palmata stumps	NS	
Semi-Consolidated rubble	S	

Table 2 : Benthic Habitat suitability rating



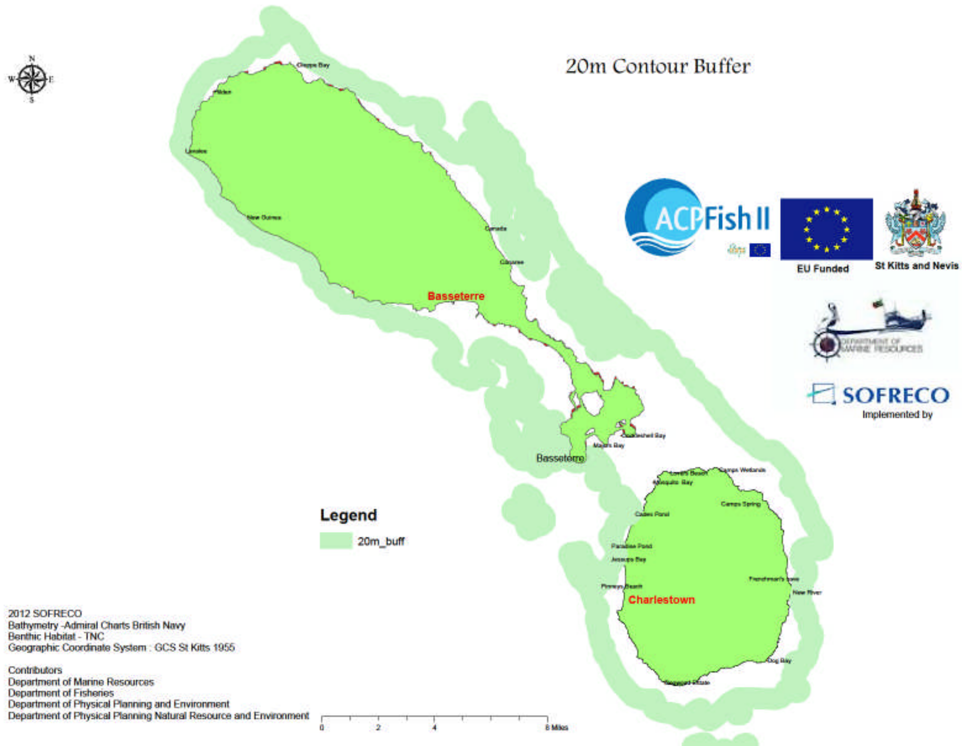
Map 13 Suitability for aquaculture based on Benthic Habitat

2.7.4 Bathymetry

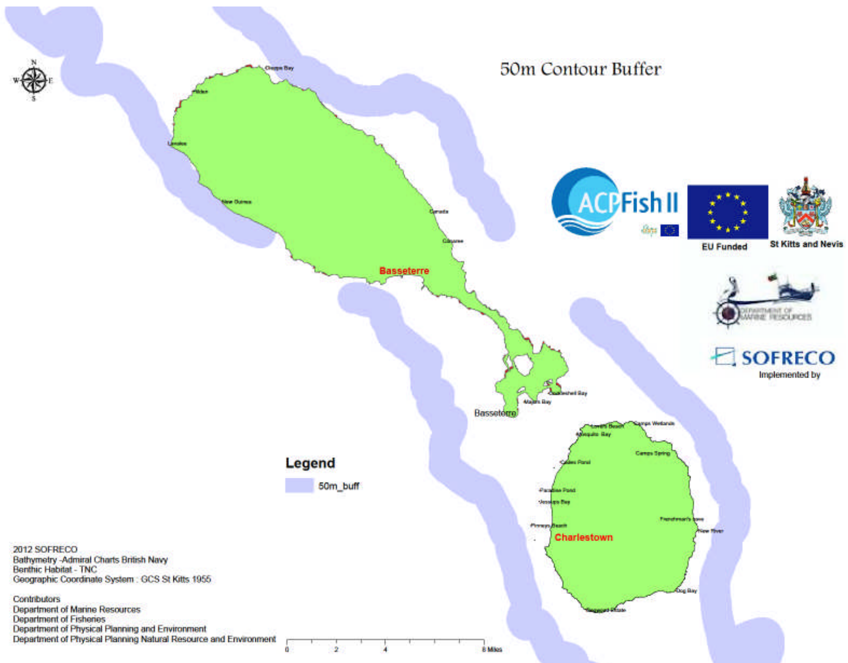
Bathymetry parameters were also analyzed prioritizing flat ocean floor with a maximum of 15-25m off shore for normal investment and 50-60m for higher investment (being ideal for laying and stabilizing cages).

Based on cage engineering, normal costs are for cages designed for semi sheltered areas, cages being located between 15-25m depth on leveled ground. Exposed cages are designed at higher cost and are located 50-60m in depth.

In Map 14 and 15 a maximum buffer distance of 1000m based on midway distance between contours was created along the 20m and 50m bathymetry contour separately to assess suitability.



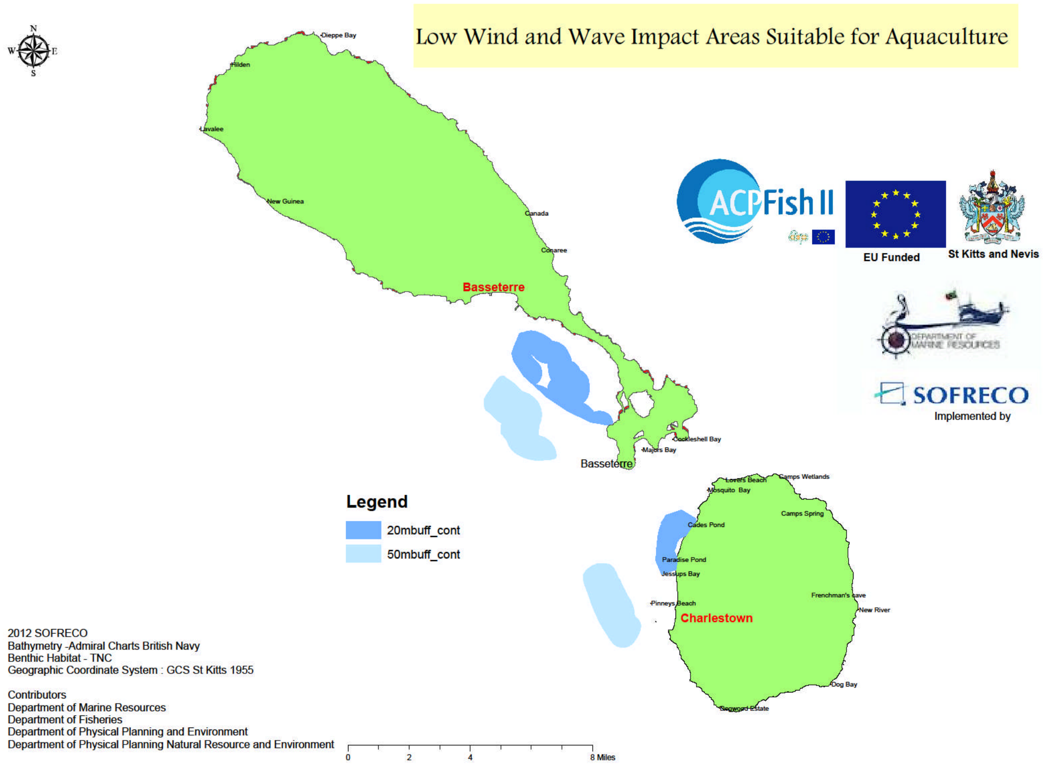
Map 14 Suitability with 20m buffer (Lower investment costs)



Map 15: Suitability with 50m buffer (higher investment costs)

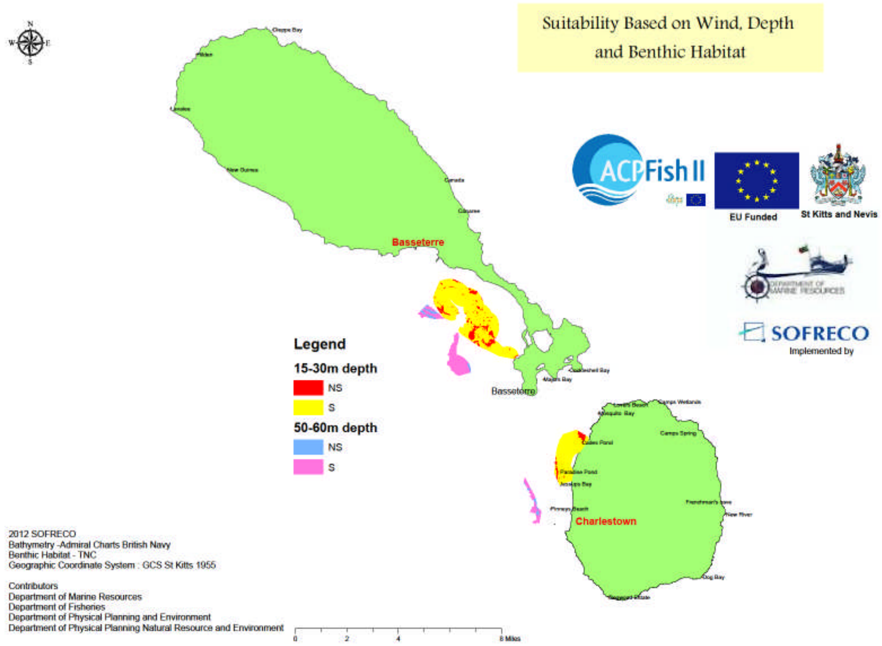
2.7.5 Suitability mapping for off shore aquaculture compiling different parameters

Further geo-processing resulted in Map 16 where buffered bathymetry contours (Map 14 and 15) were compiled with the sheltered areas layer (Map11). The zones created shows favorable areas for offshore aquaculture development where depth is convenient and wind and waves are of lower impact on cages and stock.

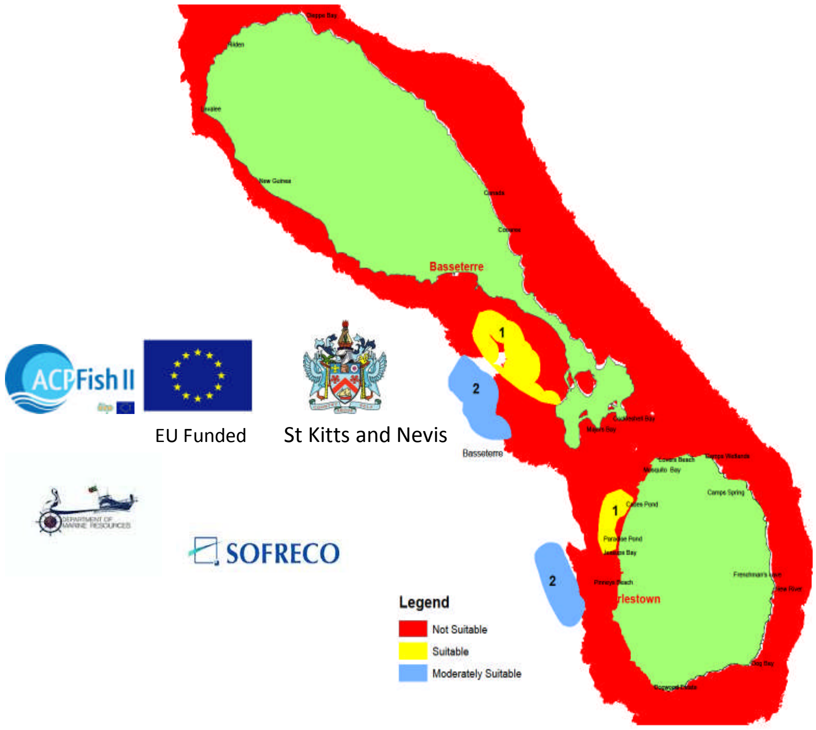


Map 16. Suitability for offshore aquaculture based on wind, wave and depth parameters

The final processing stage was to overlay low wind and wave impact areas to achieve the suitability within these areas based on benthic habitat (Map 17). Majority of the Benthic habitat data was not available for all areas for 50-60m depth therefore areas must be explored and approved before final approval of offshore cages.



Map 17 Suitability for offshore aquaculture based on wind, wave depth and benthic habitat



Map 18 Synthesis of Off-shore aquaculture Suitability

Approximate Coordinates for Offshore Potential Sites shown in Map18.

St Kitts – 1(15-30m) -2(50-60m)	*17°15'13.66" N* *17°14" 21.72N*	*62°40'41.68"W* *62° 42' 24.50"*	850ha 713ha
Nevis -1(15-30m) -2(50-60m)	*17°11'25.05"N* *17° 8' 51.92N*	*62°38'03.44"W* *62° 39'44.27"W*	309ha 674ha

Areas shown on suitability maps for aquaculture should be physically verified before anchor placement for development activities to avoid damaging important benthic habitat.

2.8 Data limitations

Acquired spatial data were generally not up to date.

Up-to-date land cover was said to be incomplete therefore was not available. Newly built establishments could be obviously located through field observation which was necessary for accurate positioning.

Some shapefiles acquired were captured with unknown geographic projection; therefore they could not be used due to consequential errors occurred when performing reclassification.

Shape files such as contours and coastal administration boundary were captured in different projections overlap. They produced errors because land contour should be totally contained within the administration boundary.

Rectification of such data could be performed if the projection is known. Ensuring all data acquired were created with the same or known spatial reference could alleviate such issues.

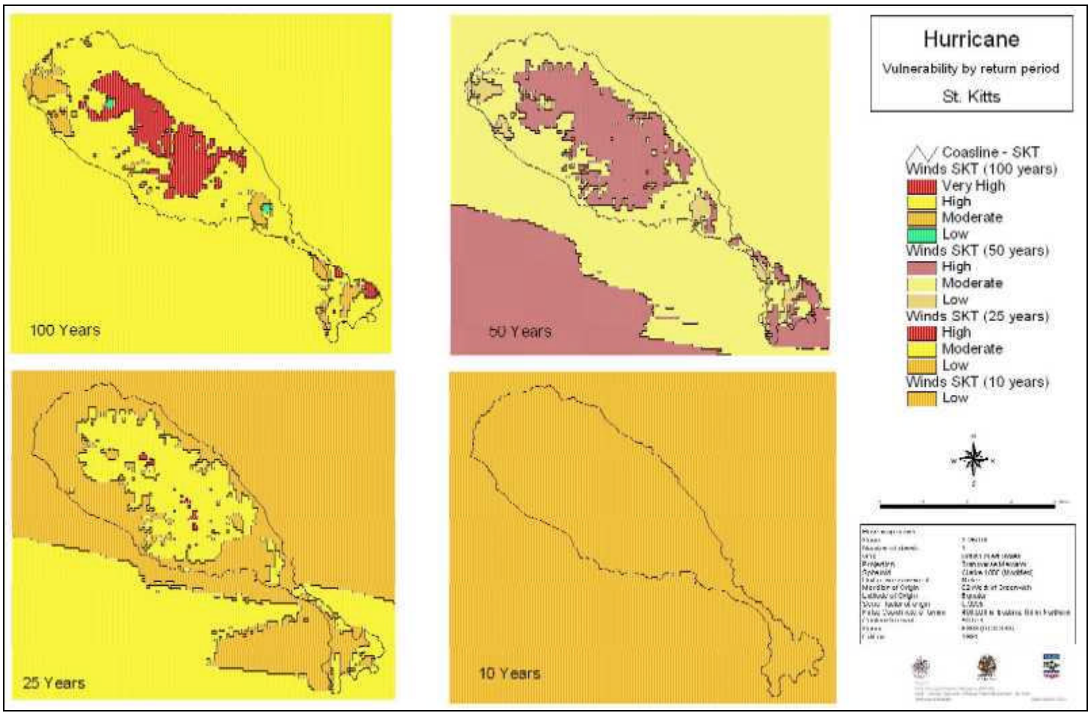
3 APPENDIX

APPENDIX 1 Benthic Habitat Suitability Considerations

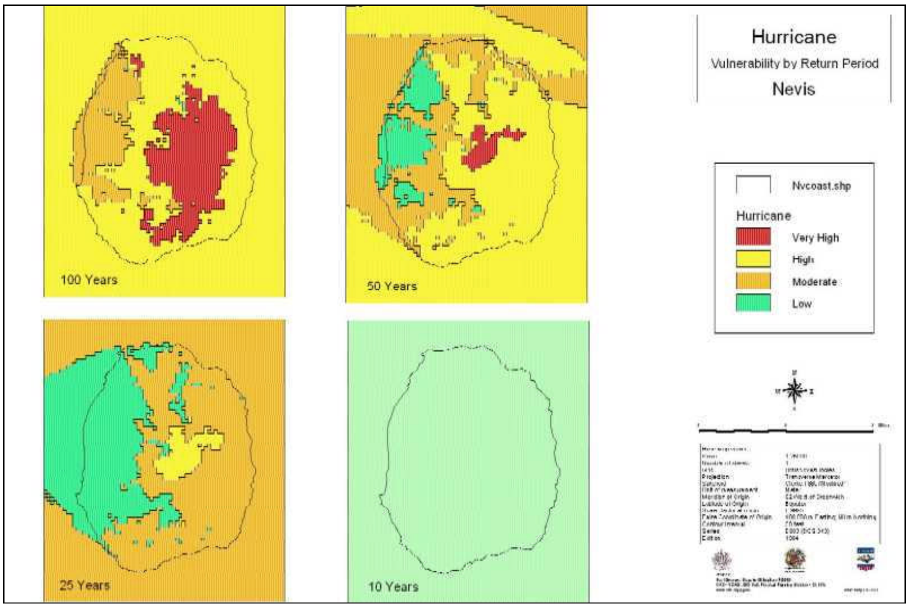
Benthic habitats suitable for laying cages

- Bare carbonate sand – Expansive sand sheets covering much of the benthic habitat particularly to the leeward side of the barrier reef system on the east coasts, and extending at least to 30 m depth on the west coasts.
- Unconsolidated sand with algae – Coarse, often rippled, sand sheets found in areas with higher energy flow along with small patches of *Halimeda* – a green calcareous seaweed .
- Sparse sea grass – Sand sheets with a sparse sea grass community (< 50% cover), dominated by turtle grass *Thallassia tesdudium*.
- Semi-consolidated rubble – Coral rubble originating from reef structures and bonded by coralline algae.

APPENDIX 2 Vulnerability Map St Kitts and Nevis



Source: Post Georges Mitigation Project(www.oas.org/pgdm/)



Source: Post Georges Mitigation Project(www.oas.org/pgdm/)

APPENDIX 3 Slope Calculations

Slope Site at Conaree , St. Kitts

Starting point elevation Bm at 6.00 ft

Each Station is @ 20 ft apart

Station	B.S. (+)	H.I.	F.S. (-)	Elevation (ft)	Distance (ft)	Ht Dif(in)	Slope
BM_1	6' 7.4"			6' 0"	(-)100		
Tp_1			6' 3.3"	6' 4"	(-)80	4	0.017
Tp_2			5' 9.1"	6' 10"	(-)60	6	0.025
Tp_3			5' 4.6"	7' 3"	(-)40	5	0.021
Tp_4			4' 10"	7' 9"	(-)20	6	0.025
Tp_5			3' 11"	8' 8"	(+)20	11	0.023
Tp_6			3' 3.1"	8' 10"	(+)40	8	0.033
Tp_7			2' 7"	9' 6	(+)60	8	0.033
					Average Slope		0.025298 2.53%

Terms

Bm - Bench mark

Bs- Back sight

Hi- Height ofinstrument

Fs- Foresight	B.S. (+)	H.I.	F.S. (-)	Elevation (ft)	Distance (ft)	Ht Dif(in)	Slope
BM_1	6' 9.2"			30' 0"	(-)100		
Tp_1			6' 5.8"	30' 5"	(-)80	5	0.021
Tp_2			5' 11.4"	30' 11"	(-)60	6	0.025
Tp_3			5' 8.0"	31' 2"	(-)40	3	0.013
Tp_4			5' 5.3"	31' 5"	(-)20	3	0.013
Tp_5			4' 4.2"	32' 6"	(+)20	13	0.027
Tp_6			3' 9.6"	33' 1"	(+)40	7	0.029

	Average Slope	0.021181 2.12%

Terms

Bm - Bench mark

Bs- Back sight
Hi- Height
of
instrument

Fs- Foresight	B.S. (+)	H.I.	F.S. (-)	Elevation (ft)	Distance (ft)	Ht Difference (in)	Slope
BM_1	9' 7.6"			26' 0"	100		
Tp_1			8' 9.3"	26' 10"	80	10	0.042
Tp_2			7' 9.4"	27' 10"	60	12	0.050
Tp_3			6' 10.6"	28' 9"	40	11	0.046
Tp_4			6' 1.0"	29' 6"	20	9	0.038
Tp_5			2' 11"	32' 8"	40	38	0.053
Tp_6			1' 01"	34' 6"	60	22	0.046
					Average Slope		0.045602 4.56%

Terms

Bm - Bench mark
Bs- Back sight
Hi- Height of instrument
Fs- Foresight

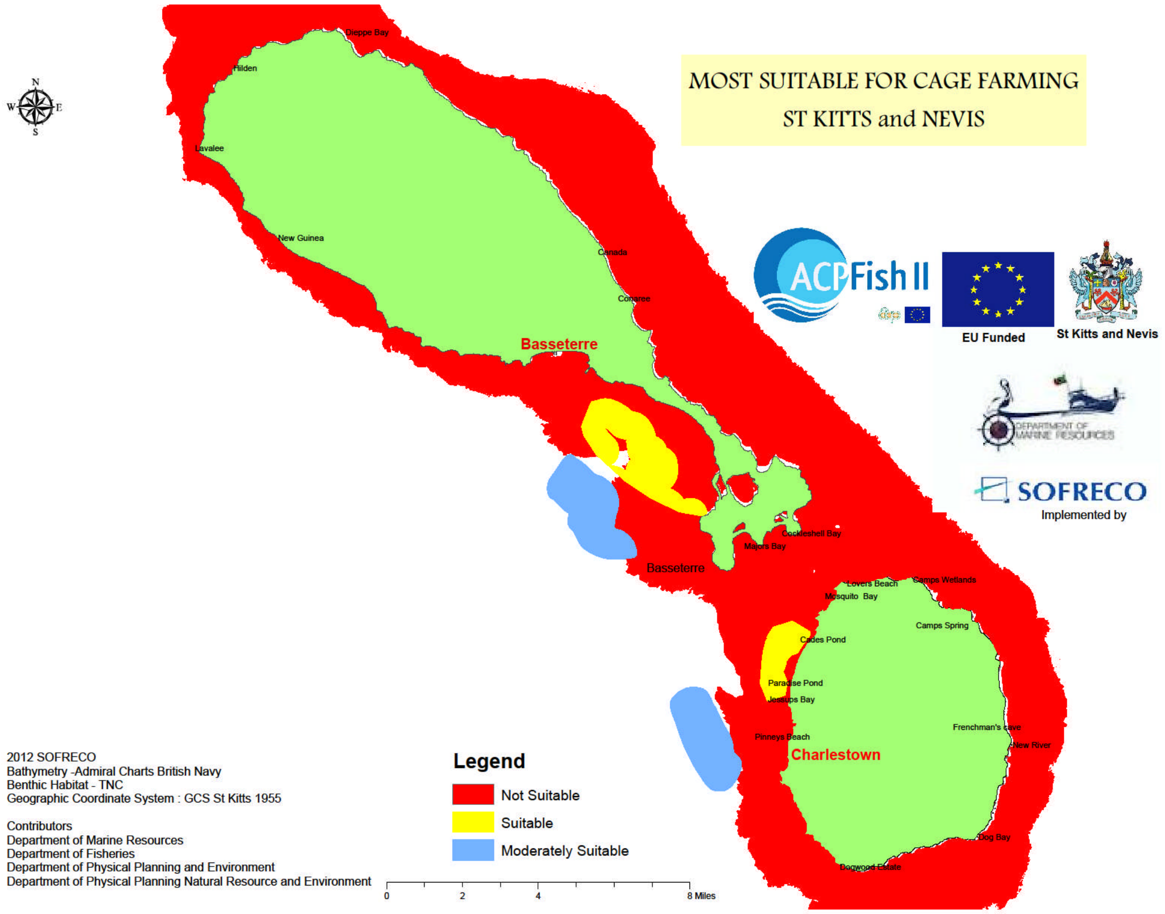
APPENDIX 4 Details on Collected Data

DATA SET	Filename	Data Provider	Coordinate	Data Source	Year
Benthic Habitat					
Unconsolidated Sand with Algae	skn_TaMa_benhab_UnconsolidatedSediment_NCRI.shp	Fisheries	WGS84	TNC	2010
Sparse Seagrass area	skn_TaMa_benhab_Sparse_Seagrass_NCRI.shp	Fisheries	WGS84	TNC	2010
Bare Sand	skn_TaMa_benhab_Sand_NCRI.shp	Fisheries	WGS84	TNC	2010
Rugose slope	skn_TaMa_benhab_Rugose_Slope_NCRI.shp	Fisheries	WGS84	TNC	2010
Reef flat area	skn_TaMa_benhab_Reef_Flat_NCRI.shp	Fisheries	WGS84	TNC	2010
Lagoonal Muds	skn_TaMa_benhab_Lagoonal_Muds_NCRI.shp	Fisheries	WGS84	TNC	2010
Hard Coral	skn_TaMa_benhab_Hard_Coral_NCRI.shp	Fisheries	WGS84	TNC	2010
Gorgonian hardgrounds	skn_TaMa_benhab_Gorgonian_Hardgrounds_NCRI.shp	Fisheries	WGS84	TNC	2010

Dense seagrass	skn_TaMa_benhab_Dense_Seagrass_NCRI.shp	Fisheries	WGS84	TNC	2010
Algal Hardground	skn_TaMa_benhab_Algal_Hardground_NCRI.shp	Fisheries	WGS84	TNC	2010
Acropora palmata stumps	skn_TaMa_benhab_Ac_palmata_stumps_NCRI.shp	Fisheries	WGS84	TNC	2010
Semi-Consolidated rubble	Skn_TaMa_benhab_semi_consol_rub_NRCI.shp	Fisheries	WGS84	TNC	2010
SATELITE IMAGE					2010
SKN_Landsat_24bit	SKN_Landsat_24bit.tif	Fisheries	WGS84	TNC	2005
Aerial Flyover		PPNRE	GCS 1984	Stewart Itl	2006
Other					
High Winds - 10 year	HVSKW10.shp	OAS	GCS 1984	PGDM	
High Winds - 25 year	HVSKW25.shp	OAS	GCS 1984	PGDM	
High Winds - 50 year	HVSKW50.shp	OAS	GCS 1984	PGDM	
High Waves - 10 year	HVSKWA10.shp	OAS	GCS 1984	PGDM	
High Waves - 25 year	HVSKWA25.shp	OAS	GCS 1984	PGDM	
High Waves - 50 year	HVSKWA50.SHP	OAS	GCS 1984	PGDM	
Storm Surge-10	HVSKST10.shp	OAS	GCS 1984	PGDM	
Storm Surge-25	HVSKST25.shp	OAS	GCS 1984	PGDM	

Storm Surge-50	HVSKST50.shp	OAS	GCS 1984	PGDM	
High Winds - 10 year	HVNVW10.shp	OAS	GCS 1984	PGDM	2000
High Winds - 25 year	HVNVW25.shp	OAS	GCS 1984	PGDM	2000
High Winds - 50 year	HVNVW50.shp	OAS	GCS 1984	PGDM	2000
High Waves - 10 year	HVNVWA10.shp	OAS	GCS 1984	PGDM	2000
High Waves - 25 year	HVNVWA25.shp	OAS	GCS 1984	PGDM	2000
High Waves - 50 year	HVNVWA50.shp	OAS	GCS 1984	PGDM	2000
Storm Surge-10	HVNVST10.shp	OAS	GCS 1984	PGDM	2000
Storm Surge-25	HVNVST25.shp	OAS	GCS 1984	PGDM	2000
Storm Surge-50	HVNVST50.shp	OAS	GCS 1984	PGDM	2000
Coast	Skcoast.shp	PPE	GCS 1984	PGDM	2000
Contour	Skconto3.shp	PPE	GCS 1984	PGDM	2000
Drainage	Skdrain.shp	PPE	GCS 1984	PGDM	2000
Roads	Sktrans.shp	PPE	GCS 1984	PGDM	2000
Coast	Nvcoast.shp	PPE	GCS 1984	PGDM	2000
Contour	nvctour.shp	PPE	GCS 1984	PGDM	2000
Landuse	NV__Landuse.shp	PPNRE	GCS 1984	PGDM	2000
Mangroves	Mangroves.lyr	PPE	-	-	-
Coastline	Skcoast.shp	PPE	-	-	-
Ports	Skports.shp	PPE	-	-	-
Wells	Water__wells	PPE	-	-	-

APPENDIX 5 Offshore Suitability for Cage Farming



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NASPA – Daily Wind forecast

Department of Marine Resources St Kitts

Department of Physical Planning and Environment St Kitts

Department of Fisheries Nevis

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