

**Ministry of Agriculture, Food Production,  
Fisheries and Rural Development  
Saint Lucia**

**FOLLOW-UP COOPERATION  
STUDY REPORT  
ON  
THE PROJECT FOR IMPROVEMENT  
OF  
FISHERY INFRASTRUCTURE  
IN  
ANSE LA RAYE, SAINT LUCIA**

**MARCH 2013**

**JAPAN INTERNATIONAL COOPERATION AGENCY**

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**ECOH CORPORATION**

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## **PREFACE**

Japan International Cooperation Agency (JICA) decided to conduct the follow-up cooperation study and entrust the study to ECOH CORPORATION.

The study team held a series of discussions with the officials concerned of the Government of Saint Lucia, and conducted a field investigations of damage, implementation of short-term countermeasure, study of coastal eroding mechanism in Anse La Raye Bay, clarification of problems to be solved of each facility on middle-term and long-term countermeasures, implementation of middle-term countermeasure and recommendation of long-term countermeasures, and as these results, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Saint Lucia for their close cooperation extended to the study team.

March, 2013

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## SUMMARY

Aiming the contribution to the improvement of operation efficiency of fisheries at Anse La Raye and local economy by synergy effect with tourism industry in Saint Lucia, the construction of fishery infrastructure consisted of jetty, Fisheries Complex building (including ice making machine, ice storage room, primary processing table and etc.), Fishing Gear Lockers, Vendors arcade and so forth on the beach located in Anse La Raye bay was commenced in December, 2008 and completed in February, 2010. These facilities after the completion have been well utilized by artisanal fishermen who are fishing variety of small pelagic fishes and coastal bottom fishes. As the result, they fulfill a function as the supply base of fisheries products to capital region since these facilities are located at a distance about 10 km by airline distance from the capital city, Castries or about 30 minutes by car. And, Vendors arcade for fresh fish and souvenir sales at the time of Fish Friday, foreshore of the arcade for landing place of fishing boats and Fisheries Complex installing primary processing table, ice making machine and ice storage room are adequately utilized as the core facilities to assume fisheries activities from fresh fish processing to cold storage and the accessibility.

However, after the hurricane "Thomas" hit in October, 2010, high waves which was higher than the average by November, 2010 have continued by anomalous climate and Fisheries Complex facility was influenced most of the shoreline recession being proceeded beyond the assumption at the time of May, 2011. Especially, Fisheries Complex has been affected most by shoreline recession out of the facilities.

The Government of St. Lucia has requested the items shown as A and B evaluation which has urgency considering damages by recessed shoreline concerning grant fisheries facilities shown in Table -1, the Follow -up cooperation was requested to JICA.

**Table -1 Summary of damages and urgency of measures of each fisheries facility**

Facility Name	Present Status	Damage Forecast	Urgency of Measures	Evaluation
Jetty & Accessories	•No damage	<ul style="list-style-type: none"> <li>•No recession damage at the base part of the jetty</li> <li>•Low possibility of damage at concrete foundation of the approach part</li> <li>•Possible damage in the long run</li> </ul>	<ul style="list-style-type: none"> <li>•There is no need to have short and middle term measures.</li> <li>• Countermeasure shall be necessary if wave comes over the concrete foundation of approach part in long run.</li> </ul>	C
Arcade	<ul style="list-style-type: none"> <li>•Subsidence at foreshore (1m)</li> <li>•Lost of backshore (10m)</li> </ul>	<ul style="list-style-type: none"> <li>•High possibility of damage due to the location at the severe retreating part</li> <li>•As it is mat foundation structure, it will be possibly declined if beach recession is proceeded.</li> </ul>	<ul style="list-style-type: none"> <li>•Urgent measure shall be necessary.</li> <li>•Stability measure of sand beach as middle term plan is necessary.</li> <li>•Stabilization measure of backshore as long term plan is necessary.</li> </ul>	A
Fisheries Complex	<ul style="list-style-type: none"> <li>•Subsidence at foreshore (1m)</li> <li>•Lost of backshore (10m)</li> </ul>	<ul style="list-style-type: none"> <li>•High possibility of damage due to the location at the severe retreating part</li> <li>•About only 1 m left to the bearing ground of continuous footing and the facility may be declined if the beach recession is proceeded.</li> </ul>	<ul style="list-style-type: none"> <li>•Urgent measure to protect scouring shall be necessary.</li> <li>•Beach stability measure is necessary as middle term plan.</li> <li>• Countermeasure for restoring sand beach and making it stable is necessary as long term plan.</li> </ul>	C
Fishing Gear Lockers I& II	•No damage	<ul style="list-style-type: none"> <li>•The location is at the place not to be influenced much</li> <li>•There will be possibly influenced if the retreat of total beach becomes apparent.</li> </ul>	<ul style="list-style-type: none"> <li>•Short and middle term measures shall not be necessary.</li> <li>•It is necessary to maintain backshore width and stabilize it.</li> </ul>	C
Workshop	•No damage	<ul style="list-style-type: none"> <li>•The location is at the place not to be influenced much</li> <li>• There will be possibly influenced if the width of sand beach is retreated.</li> </ul>	<ul style="list-style-type: none"> <li>•Short and middle term measures shall not be necessary.</li> <li>•It is necessary to maintain backshore width and stabilize it.</li> </ul>	B
Septic Tank	• No damage	•The location is at the place not to be influenced much	<ul style="list-style-type: none"> <li>•Short and middle term measures shall not be necessary.</li> <li>•It is necessary to maintain beach stability.</li> </ul>	C

(Source: Minutes of Discussion on the Follow-up Cooperation Study on the Project for Improvement of Fishery Infrastructure in Anse La Raye)

Saint Lucia has acknowledged some countermeasures however, expects a countermeasure so as not to change present shapes and landscapes of natural seashore as much as possible since this site is regarded as an important tourism resources.

With the above, the project target was set up “Safety of these facilities in Anse La Raye area shall be maintained and the facilities shall be utilized continuously”. The project outcome is follows;

- 1) These facilities shall be protected from the beach erosion generated at foreshore of these facilities by short term and middle term countermeasures,
- 2) Actual condition and tendency of the beach erosion generated at foreshore of these facilities can be comprehended, and.
- 3) Long term maintenance and management measures of these facilities shall be recommended.

The activities and input plan are as follows;

- 1) Short-term countermeasure  
Installation of rubble stones for the protection of scouring in front of Fisheries Complex and Arcade as the emergency measure
- 2) Middle-term countermeasure  
Execution of protection works to retreat and stabilize the foreshore in front of Fisheries Complex and other facilities as middle-term countermeasure
- 3) Recommendation for long-term countermeasure.  
Recommendation for protection measures to beach erosion of Anse La Ray Bay
- 4) Action Plan (confirmation, recommendation and advice of maintenance management plan of these facilities)

Basically it is very important of well understanding of the mechanism of coastal erosion process in Anse La Raye Bay. It is most important that the necessity and solved problems by the short-term and middle-term countermeasures are clarified. We could clarify the coastal process in Anse La Raye Bay as follows:

- 1) The Anse La Raye Beach is a pocket beach of about 300 meters long, which is formed by the sand supplied from the two rivers at the both ends of beach. A rate of sand supply from the river at the south end is larger than that of another one. Predominant sand supplies from the rivers occur when hillside landslides and floods take place due to the event of extremely heavy rain. The occurrence of big event is not in every year, but whimsicality. Its interval is usually more than 10 years. As sand supplies from the rivers are a little during a period of two big events, the shoreline recedes gradually until the time when a next big event occurs.
- 2) It is inferred that the last big event might occur in 1970s in Anse La Raye, which might supply a large amount of sand to the bay. Since then, a big event did not occurred, and shoreline receded with a constant speed of about 0.6 m/year during more than 30 years. Under this situation, the fishery facilities have been constructed at the place close to the beach. On the day of 30 October

2010, the beach was eroded by the waves due to the Hurricane Tomas, and was eroded further by large waves during about one successive month. As a result, the erosion reached up to the base of Fisheries Complex.

- 3) As a result of research, it is cleared that a large amount sand has been supplied to the bay two times when the large flood occurred in May 2009, and when the Hurricane Tomas attacked this site. In short, two big events occurred successively. A part of sand deposited on the sea bottom in front of the river mouth is transported gradually to the beach, and the shoreline advances gradually. According to the beach monitoring during a period from September 2011 to January 2012, there is a clear sign which show the beach recovery with the advance of shoreline.
  
- 4) By assuming that large hurricane does not come, the shoreline changes are predicted for 5 years in the future by the numerical simulation. The result of prediction shows that almost all area of the beach recovers gradually. However, it is hard to deny the possibility of the occurrence of large hurricane within 5 years. As the beach has been being continuously eroded in the past more than 30 years, it has not much endurance. If the large waves attack the beach under this situation, the abrupt erosion occurs temporarily. It reaches possibly to the fishery facilities, which themselves maybe are broken. Even if not so, the reflected waves by the facilities prevent the beach recovery. Then, it is necessary to take countermeasures against the attacks of large waves.

With the above reason the countermeasures are necessary to protect for the fisheries facilities. It is clarified the problems to be solved of middle-term countermeasure for each fishery facility. Table -2 shows the problems to be solved of each facility at the stages of middle and long-term countermeasures based on the basic policy of middle and long-term countermeasures.

**Table-2 Problems to be solved of each facility on middle & long-term countermeasures**

Facility	Problems to be solved of middle-term countermeasure	Problems to be solved of long-term countermeasure
Jetty and the ancillary facility	1) Countermeasure for exit of water drain	1) Location of rubble stones at the foundation of the jetty for securing beach in front of Vendors arcade
Arcade	1) Impact mitigation of run-up waves produced by swell of long-term period in winter season. 2) Security of backshore width for the function of hauling fishing boats. 3) Protection for scoring of arcade foundation at the time of run-up waves with a return period of 30 years. 4) Recovery of beach geometry	1) Retaining backshore width 2) Stability of foreshore 3) Mitigation of run-up height by waves with a return period of 30 years
Fisheries Complex	1) Impact mitigation of run-up waves produced by swell of long-term period in winter season. 2) Protection for scoring of foundation of Fisheries Complex at the time of run-up waves with a return period of 30 years. 3) Recovery of beach geometry 4) Retention of people's passage for north and south movement	1) Retention of backshore width 2) Stability of foreshore 3) Mitigation of run-up height by waves with a return period of 30 years
Fishing Gear Lockers I & II	1) Impact mitigation of run-up waves produced by swell of long-term period in winter season.	1) Retention of backshore width 2) Stability of foreshore 3) Mitigation of run-up height by waves with a return period of 30 years
Work Shop	1) Impact mitigation of run-up waves produced by swell of long-term period in winter season.	1) Retention of backshore width 2) Stability of foreshore 3) Mitigation of run-up height by waves with a return period of 30 years
Septic Tank	1) Impact mitigation of run-up waves produced by swell of long-term period in winter season.	1) Retention of backshore width 2) Stability of foreshore 3) Mitigation of run-up height by waves with a return period of 30 years

The construction works of middle-term countermeasure was implemented from 20th December 2012 to 21st March 2013 with the designated tender process by JICA Dominican Republic Office. Table-3 shows the problems to be solved and outcome of middle-term countermeasure for each facility. As well as reinforcing the protective measure for scouring and uneven subsidence of buildings of fisheries facilities at short-term countermeasure, the points that rubble stone works by short-term countermeasure disturb the north-south accessibility of fishermen and block the sandy beach landscape were solved as middle-term countermeasure in the main works of follow-up project. Therefore, “Partial recovery of sand geometry as well as repairing and reinforcing the result of short-term countermeasure and protect scouring and uneven subsidence of building foundations” which is the aim of study of middle-term countermeasure can be solved by the execution of main work of middle-term countermeasure. Thus, middle-term countermeasure can be judged as relevant.

However, the fear by anomalous weather like waves with a return period of 30 years cannot be solved only by middle-term countermeasure in case that beach in Anse La Raye Bay returns to its original feature “eroding beach”. The achievement of protective function and a partial recovery of beach geometry were made at middle-term countermeasure. As the environmental impact, it can be indicated that as there are exposed parts of the rubble stone works for the retention of protective function, the landscape becomes changed although the continuity of sandy beach landscape is kept. This is the impact on environmental aspect in middle-term countermeasure and the problems to be solved by long-term countermeasure.

It has been anxious about scouring and uneven subsidence of fisheries buildings by recessing beach more than the assumption at the time of May, 2011 with the fact that high waves generated continuously by abnormal weather exceeding the usual year up to November, 2010 after the hit of hurricane “Thomas” in October, 2010. St. Lucia understands that some countermeasure is necessary however they hoped to have countermeasure so as not to change current natural beach shape and landscape much since it was understood that the project site is important tourism resource.

This study solved the fear of scouring and uneven subsidence of fisheries buildings with short-term and middle-term countermeasures judging that expected functions of fisheries facilities at the time of Basic Design stage can be maintained by keeping the shoreline and backshore width at the time of Basic Design stage. And, it is relevant that long-term countermeasure are also recommended thinking of the situation after recovery of shoreline by sand brought by rivers due to the hurricane “Thomas” and this beach is originally eroding beach.



**Table-3 Problems to be solved and outcome of middle-term countermeasure for each facility**

Facility	Problems to be solved	Outcome
Jetty and Accessories	1) Countermeasure for the exit of water drain	1) Filling sand covers armor stones at the exit of water drain and the exposed situation can be solved
Arcade	1) Impact mitigation against run-up height by long term swell in winter season 2) Securement of backshore width for hauling function of fishing boats 3) Protection of scouring Arcade foundation at the time of waves with a return period of 30 years 4) Recovery of sand geometry	1) Mitigation can be made by creating backshore that is higher than the run-up wave height generating a few times in year 2) About 5 m backshore is to be secured by sand filling works 3) Scouring protection by armor stone installation 4) San beach is formed by sand filling works
Fisheries Complex	1) Impact mitigation against run-up height by long term swell in winter season 2) Protection of scoring foundation of Fisheries Complex at the time of waves with a return period of 30 years 3) Recovery of sand geometry 4) Securement of north-south accessibility	1) Mitigation by wave absorption function reinforcing the head par of armor stones 2) Protection by armor stones at foundation of building 3) Beach recovery by back filling 4) Securing accessibility by recovery of sand beach
Fishing Gear Lockers I&II	1) Impact mitigation against run-up height by long term swell in winter season	1) Protection for scouring and etc.by installing armor stones and sand filling in front of fence
Workshop	1) Impact mitigation against run-up height by long term swell in winter season	1) Protection for scouring and etc.by installing rubble stones and sand filling in front of fence
Septic Tank	1) Impact mitigation against run-up height by long term swell in winter season	1) Protection for scouring and etc.by installing rubble stones and sand filling in front of fence

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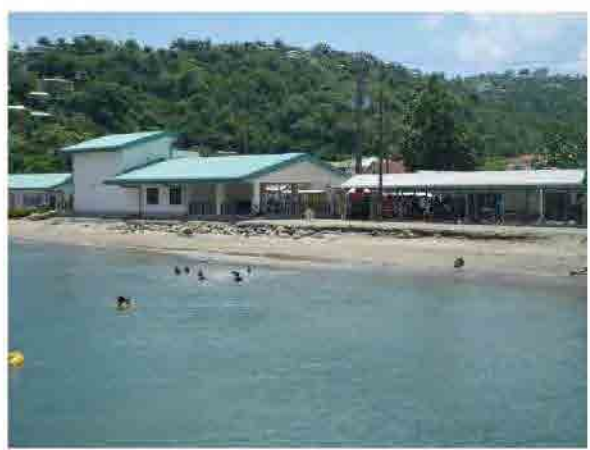


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## ABBREVIATIONS

ALR/CFCCS	Anse La Raye / Canaries Fisheries and Consumer Cooperative Society
ALRV	Anse La Raye Village Council
DCA	Development Control Authority
EIA	Environment Impact Assessment
EIS	Environment Impact Statement
E/N	Exchange of Notes
IICA	Inter-American Institute for Cooperation on Agriculture
NAFCO	National Association of Fisheries Cooperation
S/W	Scope of Works

# **Chapter 1 Background of the Project**

## **1-1 Background of Follow-Up Cooperation**

### **1-1-1 Background of Follow-Up Cooperation**

Aiming the contribution to the improvement of operation efficiency of fisheries at Anse La Raye and local economy by synergy effect with tourism industry in Saint Lucia, the construction of fishery infrastructure consisted of the jetty, fisheries complex building (including ice making machine, ice storage room, primary processing table and etc.), fishing gear lockers, Vendors arcade and so forth on the beach located in Anse La Raye bay was commenced in December, 2008 and completed in February, 2010. These facilities after the completion have been well utilized by artisanal fishermen who are fishing variety of small pelagic fishes and coastal bottom fishes. As the result, they fulfill a function as the supply base of fisheries products to capital region since these facilities are located at a distance about 10 km by airline distance from the capital city, Castries or about 30 minutes by car. And, Vendors arcade for fresh fish and souvenir sales at the time of Fish Friday, foreshore of the arcade for landing place of fishing boats and Fisheries Complex installing primary processing table, ice making machine and ice storage room are adequately utilized as the core facilities to assume fisheries activities from fresh fish processing to cold storage and the accessibility.

However, after the hurricane “Thomas” hit in October, 2010, high waves which was higher than the average by November, 2010 have continued by anomalous climate and Fisheries Complex facility was influenced most of the shoreline recession being proceeded beyond the assumption at the time of May, 2011. (Especially, Fisheries Complex has been affected most by shoreline recession out of the facilities) Saint Lucia has acknowledged some countermeasures however, expects a countermeasure so as not to change present shapes and landscapes of natural seashore as much as possible since this site is regarded as an important tourism resources. (It is considered to be difficult to take measures for shoreline recession only by self-help endeavor of execution agency considering the aspects of economic condition, personnel and technical level of execution agency and fisheries cooperative.)

With the above, for these facilities, Follow-Up Cooperation (F/U Study) is to be executed aiming the study to utilize these facilities continuously since the urgency and the relevancy of countermeasure for shoreline recession considering the points 1. These facilities are well utilized and produced an effect as fisheries facilities at present (future probability to be utilized as well) 2. It is considered to be difficult to take measures for shoreline recession only by self-help endeavor of execution agency considering the aspects of financial condition, organization system and technical level.

### **1-1-2 Requested content of Follow-Up Cooperation**

The Government of St. Lucia has requested the items shown as A and B evaluation which has urgency considering damages by recessed shoreline concerning grant fisheries facilities shown in Table 1-1-2-1, the Follow –Up Cooperation was requested to JICA.



**Table 1-1-2-1 Summary of damages and urgency of measures of each fisheries facility**

Facility Name	Present Status	Damage Forecast	Urgency of Measures	Evaluation
Jetty & Accessories	•No damage	<ul style="list-style-type: none"> <li>•No recession damage at the base part of the jetty</li> <li>•Low possibility of damage at concrete foundation of the approach part</li> <li>•Possible damage in the long run</li> </ul>	<ul style="list-style-type: none"> <li>•There is no need to have short and middle term measures.</li> <li>• Countermeasure shall be necessary if wave comes over the concrete foundation of approach part in long run.</li> </ul>	C
Arcade	<ul style="list-style-type: none"> <li>•Subsidence at foreshore (1m)</li> <li>•Lost of backshore (10m)</li> </ul>	<ul style="list-style-type: none"> <li>•High possibility of damage due to the location at the severe retreating part</li> <li>•As it is mat foundation structure, it will be possibly declined if beach recession is proceeded.</li> </ul>	<ul style="list-style-type: none"> <li>•Urgent measure shall be necessary.</li> <li>•Stability measure of sand beach as middle term plan is necessary.</li> <li>•Stabilization measure of backshore as long term plan is necessary.</li> </ul>	A
Fisheries Complex	<ul style="list-style-type: none"> <li>•Subsidence at foreshore (1m)</li> <li>•Lost of backshore (10m)</li> </ul>	<ul style="list-style-type: none"> <li>•High possibility of damage due to the location at the severe retreating part</li> <li>•About only 1 m left to the bearing ground of continuous footing and the facility may be declined if the beach recession is proceeded.</li> </ul>	<ul style="list-style-type: none"> <li>•Urgent measure to protect scouring shall be necessary.</li> <li>•Beach stability measure is necessary as middle term plan.</li> <li>• Countermeasure for restoring sand beach and making it stable is necessary as long term plan.</li> </ul>	C
Fishing Gear Lockers I& II	•No damage	<ul style="list-style-type: none"> <li>•The location is at the place not to be influenced much</li> <li>•There will be possibly influenced if the retreat of total beach becomes apparent.</li> </ul>	<ul style="list-style-type: none"> <li>•Short and middle term measures shall not be necessary.</li> <li>•It is necessary to maintain backshore width and stabilize it.</li> </ul>	C
Workshop	•No damage	<ul style="list-style-type: none"> <li>•The location is at the place not to be influenced much</li> <li>• There will be possibly influenced if the width of sand beach is retreated.</li> </ul>	<ul style="list-style-type: none"> <li>•Short and middle term measures shall not be necessary.</li> <li>•It is necessary to maintain backshore width and stabilize it.</li> </ul>	B
Septic Tank	• No damage	•The location is at the place not to be influenced much	<ul style="list-style-type: none"> <li>•Short and middle term measures shall not be necessary.</li> <li>•It is necessary to maintain beach stability.</li> </ul>	C

A: Most urgent, B: Higher urgency C. Urgency is low

(Source: Minutes of Discussion on the Follow-up Cooperation Study on the Project for Improvement of Fishery Infrastructure in Anse La Raye)

### **1-1-3 Summary of Follow-Up Cooperation Project.**

#### (1) National Target

Contribution to promotion of fisheries industry at Anse La Raye area

#### (2) Project Target

Safety of these facilities in Anse La Raye area shall be maintained and the facilities shall be utilized continuously

#### (3) Project Outcome

- 1) These facilities shall be protected from the beach erosion generated at foreshore of these facilities by short term and middle term countermeasures.
- 2) Actual condition and tendency of the beach erosion generated at foreshore of these facilities can be comprehended.
- 3) Long term maintenance and management measures of these facilities shall be recommended.

#### (4) Activities and Input Plan

- 1) Damage mitigation of the facilities by execution of short-term countermeasure (Volume of subsidence)
- 2) Stability of foreshore by the execution of middle-term countermeasure (width of backshore)
- 3) Possibility of maintenance management by the recommendation of long-term countermeasure (Construction cost and Maintenance cost)

#### (5) Activity and input plan

- 1) Short-term countermeasure

Installation of rubble stones for the protection of scouring in front of Fisheries Complex and Arcade as the emergency measure

- 2) Middle-term countermeasure

Execution of protection works to retreat and stabilize the foreshore in front of Fisheries Complex and other facilities as Middle-term countermeasure

- 3) Recommendation for long-term countermeasure.

Recommendation for protection measures to beach erosion of Anse La Raye Bay

- 4) Action Plan (confirmation, recommendation and advice of maintenance management plan of these facilities)

Confirmation of capability of execution for long-term countermeasure for beach erosion by St. Lucia and advice to JICA

#### (6) The area to be surveyed

Anse La Raye Bay in St. Lucia

(7) Beneficiary

1) Direct beneficiary

Fishermen in Anse La Raye (118 registered fishermen ) and fishermen surrounding this area and the related people like fish brokers

2) In direct beneficiary

Resident and inhabitant around urban area

(8) Organization of recipient country

Responsible organization: Ministry of Agriculture, Lands, Forestry and Fisheries

Implementation organization: Department of Fisheries, Ministry of Agriculture, Lands, Forestry and Fisheries

### **1-2 Fisheries Promotion Policy of Saint Lucia and National Plan**

”Toward An Integrated Economic Strategy Inaugural Report of National Economic Council April 2005 “ which was made out aiming sustainable development as National Plan is the current national policy. “ Short-term Remedial Growth Strategy” which is one of the development strategies setting up “improvement of fisheries infrastructures” becomes fundamental. This has no change from the Basic Design stage.

“Strategic Plan 2008-2013” does exist as the development plan of present Fisheries Sector. This plan prescribes a direction that Fisheries Sector should execute within 5 years. This plan shows the direction that the responsibility to enhance the self support power of fisheries industry aiming the sustainable development of fisheries industry under the circumstances with increase and decrease of world wide food prices;

- a) Direction 1 is to aim sustainable development of coast and marine resources which lead the impact to other sectors like tourism in the near future although the sustainable development has been focused once before and
- b) Direction 2 is to promote it together with other sectors like Tourism, Agriculture, Forestry, Education and etc. since it has a limitation of personnel.

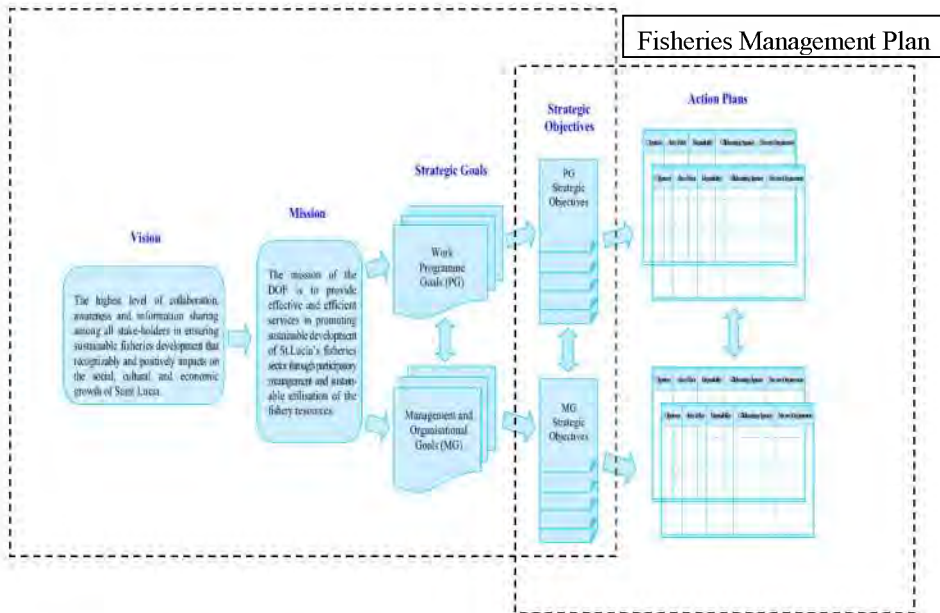
”Strategic Plan 2008-2013” is consisted of Working Program and Management Program clarifying Vision and Mission for their accomplishment. “Fisheries Management Plan (FMP)” was made up as the action plan to accomplish Strategic Objectives in each program and made action plans of short-term (1 -2 years) and middle-term (3-5 years). This plan has been progressed with checking and review in every 6 months and Working Program (PG) and Management Program(MG) are consisted of 3 programs each. In PG, it picks up Cultivation of Resources as PG-1, Promotion of Fishing Method and Fisheries Technology as PG-2 and Management and Development of Fisheries Resources based on the participation promotion by related agencies as PG-3. In MG, It picks up Cultivation of Human Resources as MG-1, Cultivation of Physical and Financial Resources as MG-2 and Promotion of Services to Consumers as MG-3.

PG-2 which relates to this study has 4 purposes and the purposes as PG-2.4 are described below:

- a) Continuously to support the development of fisheries infrastructures which is the base of Fisheries Development, and
- b) To intend the development and promotion of Fisheries Processing Techniques at SLFMC (Saint Lucia Fisheries Market Center), this is the implementation target for the promotion of fisheries processing technology.

PG-2.4 becomes the object for this study directly. And, as the budget is used for FMP every year, the annual budget plan is required.

Strategic Plan 2008-2013



Objectives	Action Point	Responsibility	Collaborators	Resource Requirements
PG 2.1 To enhance the skills of local fishers/ farmers in the use of more appropriate methods and technologies with a view to sustainably optimise catch	2.1.1 Assess the needs of the fishers 2.1.2 Identify appropriate methods and technologies 2.1.3 Develop and implement training programmes for fishers	Extension Unit of DOF	<b>Fishers/Farmers</b> (Other Units in DOF)	Financial and human resources
PG 2.2 To promote the use of more advanced and safer fishing vessels	2.2.1 Continue to identify/gather information on appropriate, more advanced and safer fishing vessels 2.2.2 Continue to evaluate cost and benefits of these more advanced and safer fishing vessels 2.2.3 Promote the use of appropriate fishing vessels	Extension Unit of DOF	Research Officers and Other Units in DOF <b>Fishers/Farmers</b>	Financial and human resources Technical assistance from regional and international partners
PG 2.3 To encourage navigation safety of domestic fishing vessels	2.3.1 Implement ongoing programmes to train fishers in methods related to <b>safety at sea</b> 2.3.2 Assess and develop new programmes to train fishers in methods related to <b>safety at sea</b>	Extension Unit of DOF	<b>Fishers/Farmers</b> Other Units in DOF	Financial and human resources Technical assistance from overseas partners
PG 2.4 To promote the improvement of fisheries-related processes and infrastructure within the sector	2.4.1 Continue to seek support for the development of fisheries infrastructure to foster development of the industry 2.4.2 Develop and implement a plan of action to foster growth of the processing industry, with an initial focus on the SLPMC	Extension Unit of DOF	<b>Fishers/Farmers</b> Other Units in DOF SLPMC	Financial and human resources

Figure 1-2-1 Working program of fisheries sector

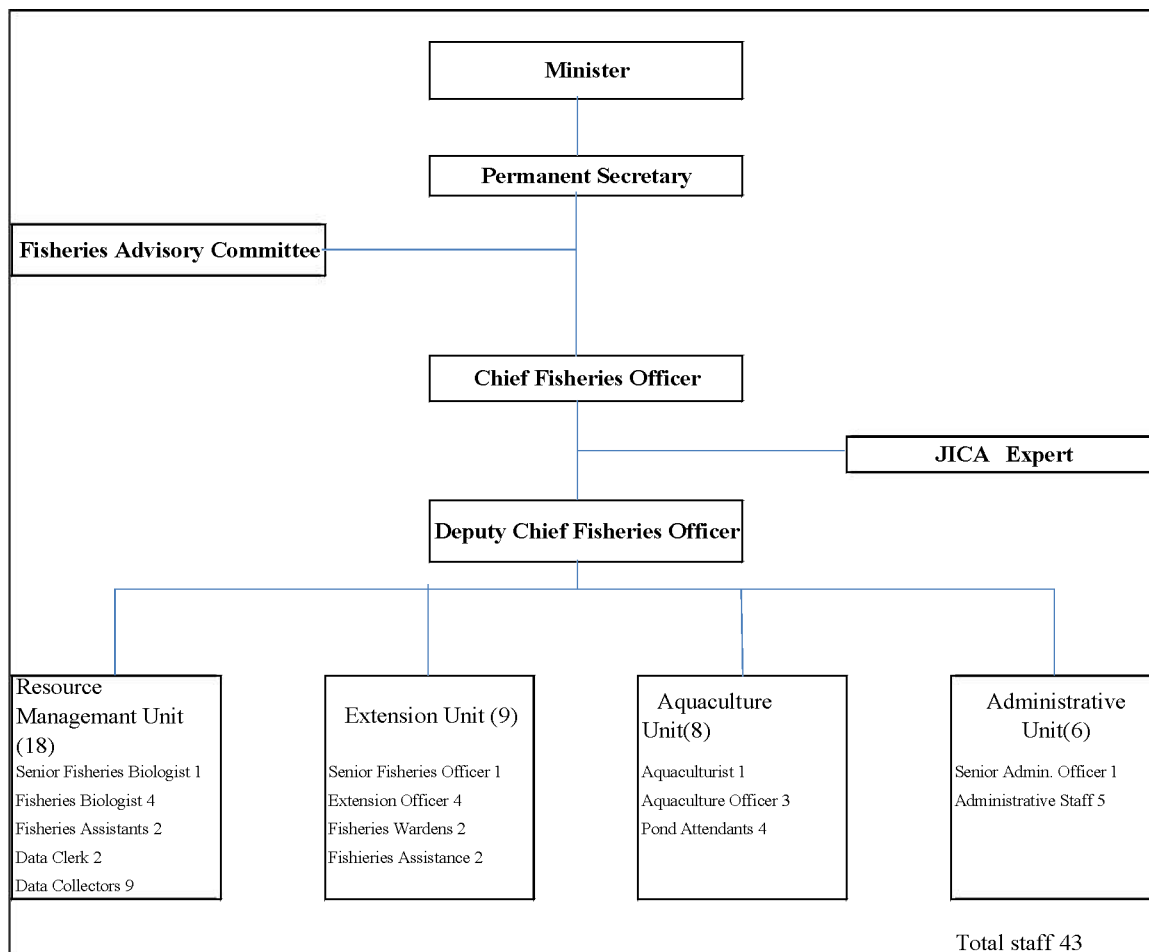
**1-3 Related organization system among responsible national organizations and implementation agency in Saint Lucia**

**1-3-1 Responsible national organization, implementation agency and etc. in Saint Lucia**

Responsible state organization for this plan is Ministry of Agriculture, Lands, Forestry and Fisheries and the implementation agency is the Department of Fisheries in the same Ministry. Ministry of Agriculture, Lands, Forestry and Fisheries is the organization for the policy planning and the implementation in the fields of Agriculture, Forest, Land and Fisheries and the Department of Fisheries is the implementation organization of the fisheries sector. Department of Fisheries is consisted of total 43 staff with Administrative Unit (6), Resource Management Unit (18), Aquaculture Unit(8) plus Chief Fisheries Officer(1) and Deputy Chief Fisheries Officer(1) as of September, 2011. The organization change was made from 4 Units under one Department with 43 staff at the time of Basic Design to 4 Units with 43 staff setting up new Fisheries Advisory Committee under Permanent Secretary.

**Table 1- 3-1-1 Confirmation of implementation organization**

1.Principal Ministry	Ministry of Agriculture, Lands, Forestry and Fisheries
2.Implementation Agency	Department of Fisheries, Ministry of Agriculture, Forestry and Fisheries
3.Project Site	Anse La Raye Area
4. Project Operation and Maintenance	Anse La Raye / Canaries Fisheries and Consumers Cooperatives Society



**Figure 1-3-1-1 Organization chart of Department of Fisheries**

### **1-3-2 Budget of Ministry of Agriculture, Lands, Forestry and Fisheries and Department of Fisheries**

Table 1-3-2-1 shows the budgets of the Government of Saint Lucia, Ministry of Agriculture, Lands, Forestry and Fisheries and Department of Fisheries at the time of budget plan in Basic Design stage in 2005/2006, facilities completion time (2009), one year after completion (2010) and Follow-UP Study (2011). The budget of Ministry of Agriculture, Lands, Forestry and Fisheries is 2% of total government budget and its Department of Fisheries is about 11% of the Ministry which budgets remain unchanged.

**Table 1-3-2-1 Budgets of Ministry of Agriculture, Lands, Forestry and Fisheries and Department of Fisheries (Unit: EC\$1,000)**

Organization	2005/2006	2008/2009	2009/2010	2010/2011
Government	618,480	816,460	771,412	844,284
Ministry	14,094	15,906	15,844	17,554
Department	1,979	1,872	1,694	1,904

Source: Estimates of Expenditure, Parliament Chambers Government of St. Lucia

### **1-3-3 Fisheries Cooperatives in St. Lucia and operation and maintenance organization for this project**

#### **(1) Fisheries Cooperatives in St. Lucia**

Strengthening of Fisheries and Agriculture Cooperatives 2006-2010 has been conducted at the time of Basic Design with the cooperation of IICA (Inter-American Institute for Cooperation on Agriculture) by Department of Cooperatives in Ministry of Labor Relations, Public Service & Cooperatives as the counterpart.

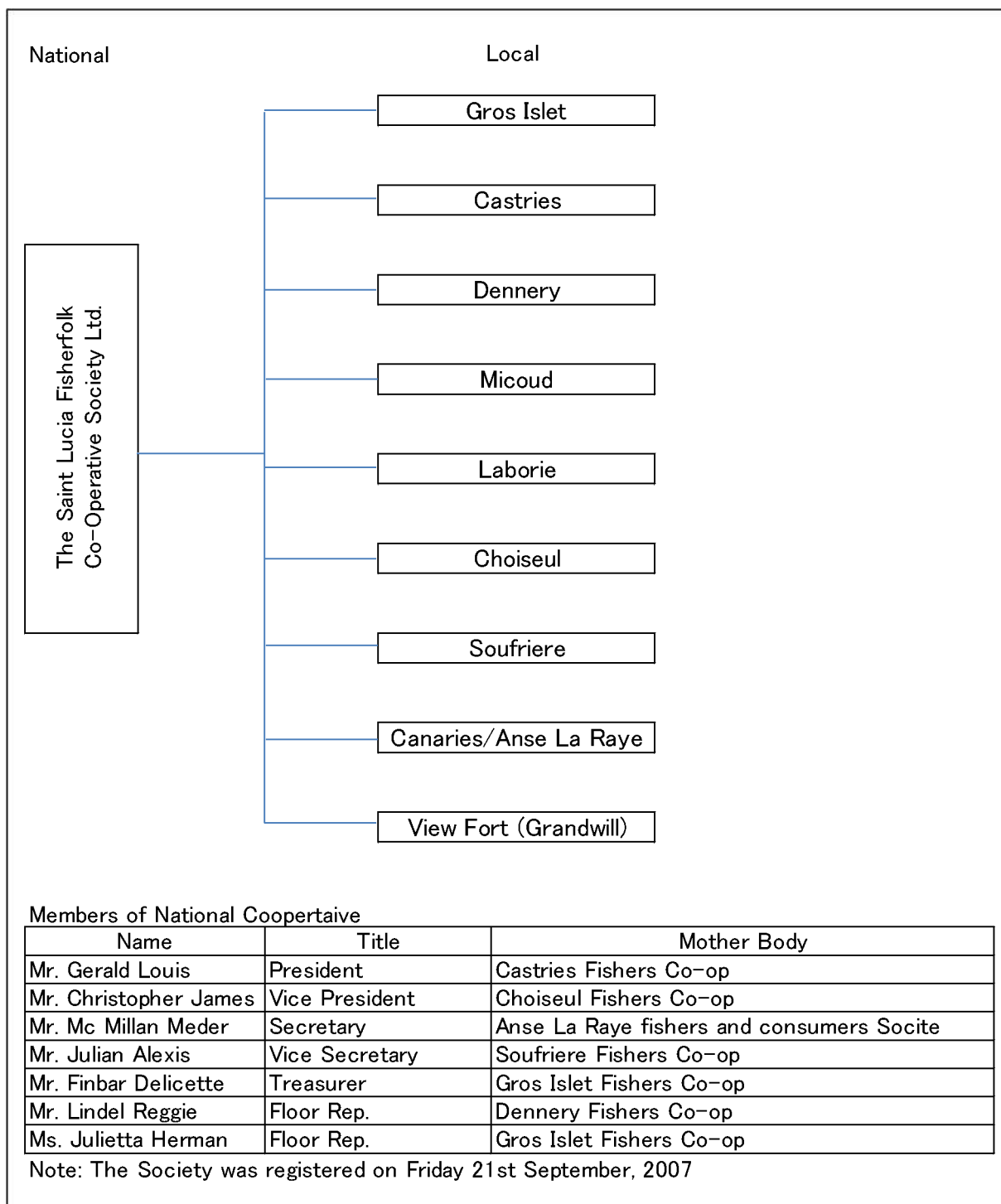
Although there was NAFCO (National Association of Fisheries Cooperation) in St. Lucia, it is not functioned now with various reasons. The Saint Lucia Fisher-folk Cooperatives Society Ltd. has been established in September, 2007 as the national wide cooperatives with the leadership of Department of Fisheries and under the said project and operate and maintain each fish landing site by the organization system as shown in Figure 1-3-3-1. Micoud is scheduled to be formally registered at the end of 2011 since unionization of fisheries cooperatives was occurred in 2009.

Nationwide cooperatives contributes to the organization to adjust conflicts among artisanal fishermen, fishing boat owners, related operators and etc. or to support the policy implementation of Department of Fisheries and tries to handle small amount of finance and insurance but the concrete activity was not commenced yet since it just started.

Local cooperatives of each landing site execute:

1. Bulk purchasing,
2. Retailing of Fishing Gear,
3. Retailing of Safety Equipment,
4. Fuel,
5. Education/Training, and
6. Life support for member of fishermen.

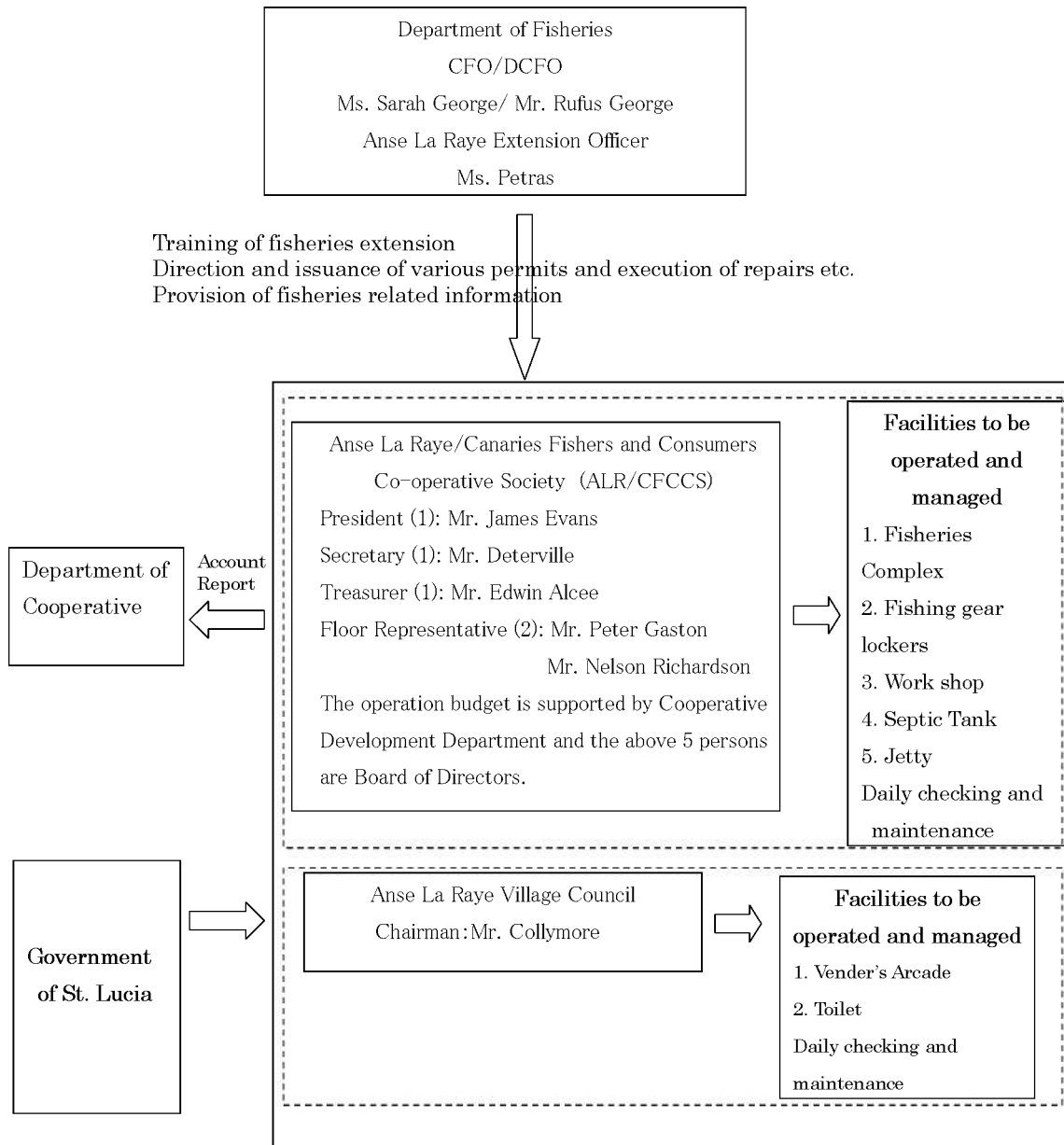




**Figure 1-3-3-1 Organization chart of Fisheries Cooperatives in St. Lucia**

**(2) Operation and maintenance organization for this project**

Fisheries facilities in this project have been operated and maintained by Anse La Raye/Canaries Fisheries and Consumers Cooperatives Society (hereunder called as ALR/CFCCS). Board meeting of this cooperative has been restructured in November, 2010 and it restarted as new cooperatives. The accounting report is not issued since the first fiscal year is not ended yet.



**Figure 1-3-3-2 Relationship between maintenance system of this project and Government organization and Village Council**

**(3) Organization of ALR/CFCCS**

1) Organization, personnel and budget

ALR/CFCCS is under the jurisdiction of Department of Cooperatives and obliged to submit an accounting report every year. The organization is the business corporation and operated with the capital and profit. ALRV operates Toilet and Vendors Arcade with the budget of Village Council and bears the toilet security person and the maintenance cost. Although Vendors Arcade is under the ALRV, the cost of maintenance is covered by its royalty of Vendors Arcade. Organization System of ALR/CFCCS and ALRV, facilities and the relationship among Government organization like Department of Fisheries and the number of staff are shown in Figure 3.3-1. Department of Fisheries works for the support of large scale repair of facilities, technical training and support to fisheries

activities and the management and publication for permits. For these works, extension officers are allocated.

**(4) Assignment of facilities management between Village Council and Department of Fisheries and the related matters in question**

As described previously, Department of Fisheries basically works for the support to large scale repair of fisheries facilities and the fisheries extension and Village Council works for operation and maintenance of Vendors Arcade and Toilet which are supporting facilities to tourism. At present, no remarkable matters are occurred for the assignment of facilities management.

**(5) Actual achievement and forecast of fish landing, ice sales, locker usage rate and etc.**

1) Landing record

As the landing record at Anse La Raye was not confirmed at the time of Basic Design stage due to the inclusion to “others”, it was forecasted based on the result of hearing survey to fishermen and the consumption volume at surrounding areas. The estimated landing volume at that time was 47.84 tons/year and anticipated that the catch volume by the concerned fishermen adding the landing volume to Castries was 83.49 tons/year.

At this study stage, it was found that the landing volume at Anse La Raye became clearly specified in statistic from 2009. Table 1-3-3-1 shows landing volume of total St. Lucia and Anse La Raye. There recorded 50.13 tons/year in 2009, 30.99 tons/year in 2010 which has decreased reflecting the bad weather in high fishing season. And, as this figure doe not include landing volume to Castries by the fishermen of Anse La Raye, the fish catch volume by Anse La Raye fishermen is deemed as 87.5 tons/year in 2009, 54.1 tons/year in 2010 considering landing ratio in Castries is 57.3% as estimated at the time of Basic Design. This figure is considered to be almost the same with the estimation at the time of Basic Design when the bad weather in high fishing season of 2010 is considered.

**Table 1-3-3-1 Landing volume of total St. Lucia and Anse La Raye**

Year		Total St. Lucia	Anse La Raye
2009	Volume (metric ton)	1,856.90	50.13
	Amount (EC\$)	24,062,280.71	451,477.21
2010	Volume (metric ton)	1,800.58	30.99
	Amount (EC\$)	24,297,764.77	451,477.21

Source: Summary of Estimated Fish Landing in 2009 and 2010, DOF

2) Registered number of fishermen and fishing boats

Registered number of fishermen and fishing boats in 2009 and 2010 in the total St. Lucia and Anse La Raye are shown in Table 1-3-3-2 and Table 1-3-3-3. Registered number of fishermen in 2010 was increased in comparison with 2009. It was also increased in the total St. Lucia. And, the registered number of fishing boats was also increased in whole country and Anse La Raye. Fishermen

and fishing boats in Canaries, Roseau, Marigot and Cul De Sac were within the plan at the time of Basic Design stage and planned 30 fishing gear lockers as describing later. As described previously, the cooperatives to consolidate Canaries and Anse La Raye was organized and the number of member of the Fisheries Cooperatives is 231 fishermen as of 2010 which is about 10% of the whole country and the number of fishing boats is 53 which is about 9 % of the whole country.

**Table 1-3-3-2 Registered number of fishermen**

Year	Landing site	Full Time	Part Time	Non-fisher	Total
2009	Whole country	1,361	880	188	2,429
	Anse La Raye	64	48	8	120
	Canaries	55	38	12	105
	Marigot	2		1	3
	Roseau	1	1		2
	Cul De Sac		1		1
2010	Whole country	1,366	895	197	2,458
	Anse La Raye	64	48	10	122
	Canaries	54	38	12	104
	Marigot	2		1	3
	Roseau	1	1		2
	Cul De Sac				0

**Table 1-3-3-3 Registered number of fishing boats**

Year	Landing site	Canoe	Pirogue	Transom	Shalooop	Whaler	Longliner	Others	Total
2009	Whole country	87	445	37	15	3	8	4	600
	Anse La Raye	4	14						18
	Canaries	10	13	3	1				27
	Marigot		2						2
	Roseau				1				1
	Cul De Sac								0
2010	Whole country	81	468	36	18	4	9	2	618
	Anse La Raye	4	16						20
	Canaries	10	11	3	2				26
	Marigot		3					1	4
	Roseau				1				1
	Cul De Sac		2						2

### 3) Ice

Ice making machine after it's completion was troubled on measurement apparatus(repair was done keeping production of ices but there was a period to stop ice making temporary) therefore, 100% operation started from June, 2010 While, as the re-forming of cooperatives, registration and permit was November, 2010, the data of production volume and sales volume could not be obtained. And so, hearing surveys to fishermen and venders were conducted.

a) Fishermen load 2 buckets (2.5 gallons = 11.365kg/1 bucket) in one voyage. As the loading ratio of total fishing boats is 40% (it was the same as BD study) and the rate of operation is 60% (it was 72 % at the BD study), the loading ice demand volume to fishing boat shall be 2 gallons/bucket x 2 buckets x 32 boats x 0.4 x 11.365kg x 0.6= 0.3 tons/day (fishing boats to load ice shall be 32 boats of PIROGUE). This figure is almost the same as the result of BD study stage which is 0.2 tons/day. Ice purchasing price for fishermen shall be 7EC\$ x 2 buckets x 32 boats x 0.4 x 0.6 = 107.5 EC\$ (which is 4,300 yen/day with the exchange rate of 40 yen/EC\$. It is necessary to increase ice loading rate by fishermen since it is 107.5 x 200 = 21,500 EC\$ ( 860,000 yen/year) if 200 days are operated in a year.

b) Venders are purchasing 10 buckets of ice which are 5 buckets more than the result of BD study in Fish Friday. However, as the first 2 buckets are free of charge, it is estimated that 11.365 kg/bucket x 8 buckets x 16 venders =1.45 tons/day if 16 venders purchase 10 buckets per a vender in average. In the same way, 7EC\$ x 8 buckets x 16 = 896 EC\$ which is 35,840 yen. At the BD study stage, the average number of purchasing was 5 buckets and the volume was 0.91 tons/day with 16 venders. It can be understood that the ice demand was increased in Fish Friday.

#### 4) Locker

The installed Fishing Gear Lockers were 30. At present, contracted lockers are 25 of which 2 lockers were occupied by the Cooperatives. Therefore, the usage rate is 76 % which is regarded as the proper use. As the usage fee per month is 30 EC\$, the income from Fishing Gear Lockers is 23 lockers x 30 EC\$/month x 12 months = 8,280 EC\$/year which is 331,200 yen/year. The payment method is basically by advance payment in every 3 months and there are a few fishermen who pay it lump sum in a year.

#### 5) Jetty

The jetty is managed by the Cooperatives and does not collect the usage fee for fishing boats. The Cooperatives is going to take off wooden parts of the jetty at the time of an emergency and the daily management and maintenance are executed by fishermen. Consumable like lighting is to get the supply upon application to Department of Fisheries from the Cooperatives and also Department of Fisheries executes large scale repair upon securing the budget.

## **Chapter 2 Status of Beach Erosion and Short-Term Countermeasure**

### **2-1 Status of beach erosion**

#### **2-1-1 Status of beach erosion before the Follow-Up Cooperation Study**

As it was described in Chapter 1, Project Background, it has been cleared that the beach in Anse La Raye Bay was already commenced to retreat of beach on July 23, 2010 that was 5 months later of project completion (February, 2010). Observation results at the time of defect inspection executed in February, 2011 are as follows,

#### **(1) Shape variation of total beach**

- 1) There is no big change of total beach shape (circular arc) through the Basic Design stage, (October, 2010) Completion Date stage (February, 2010) and Defect Inspection stage (February, 2011)
- 2) Backfilling the backshore portion about 10 m at the time of completion but backshore portion has been lost and there becomes foreshore beach only. This tendency is distinguished to become obvious toward south.

Beach situation in Anse La Raye ( North→South)



Subsidence and recession of shoreline in North side beach from the Jetty



Subsidence and recession of shoreline in front of Vendors Arcade



Subsidence and recession of shoreline between Fisheries Complex and the Jetty

**Photo 2-1-1-1 Beach situation at one year inspection**

**(2) Influence to facilities**

1) In the picture taking a picture of the area in front of Fisheries Complex on July 23, 2010 that is 5 months later than the completion (February, 2010), the width of backshore has been backfilled by rubble stones that were used for temporary revetment at the time of completion, waves have been run-up near the back-filling portion and the backshore width becomes about 5 m. The picture of front face of Fisheries Complex taken by General manager of JICA ST. Lucian office on September 28, 2010 shows the beach further retreated and becomes 2 to 3 meters if backshore width. There is no big difference with the picture that hurricane “Thomas” passed on October 30, 2010. However, at the time of Defects Inspection (February 8, 2011) the backshore in front of Fisheries Complex was lost and ground subsidence with about 1m was generated and exposed the

part of power cable of foundation portion of distribution box. This beach retreat phenomena has been reached to south side from Fisheries Complex, Vendors Arcade, Community Center, Warehouse to Laundry.



Oct. 20, 2006 at Basic Design stage



Oct. 20, 2006 at Basic Design stage

**Photo 2-1-1-2 Beach situation at Basic Design stage**



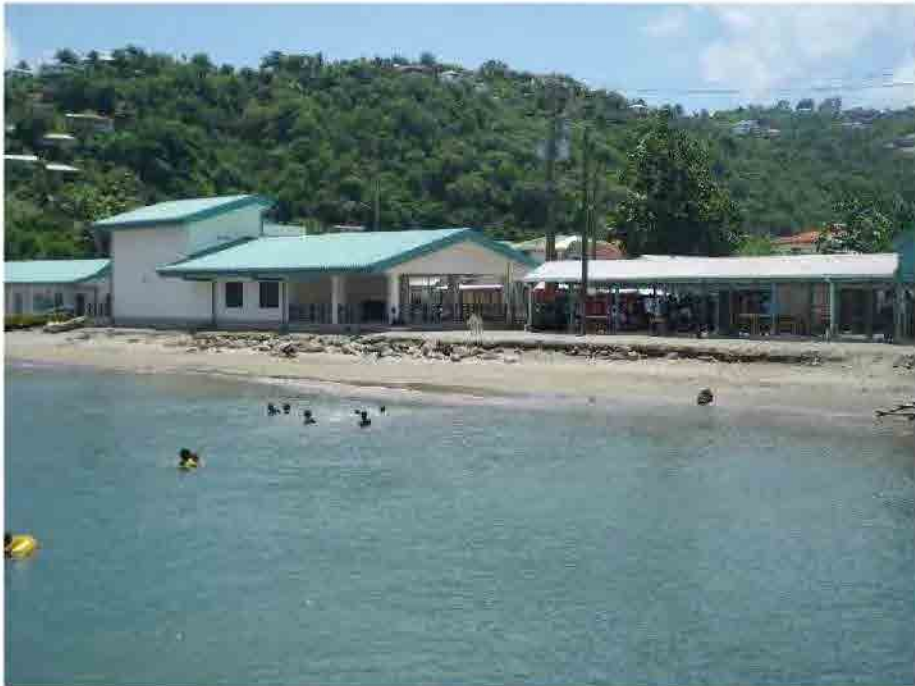


Feb. 19, 2010 at the completion of construction



Sept. 23, 2010 Photo by Mr. Adachi of ECOH CORPORATION

**Photo 2-1-1-3 Beach situation in front of Fisheries Complex before and after completion**



Sept. 23, 2010 Photo by Mr. Adachi of ECOH CORPORATION



Sept. 28, 2010 Photo by Director of JICA St. Lucia office

**Photo 2-1-1-4 Beach situation in front of Fisheries Complex after completion (1)**



Sept. 28, 2010 Photo by Director of JICA St. Lucia office



Nov. 02, 2010 After attacked Hurricane Tomas

**Photo 2-1-1-5 Beach situation in front of Fisheries Complex after completion (2)**



Feb. 08, 2011 at One year inspection



Feb. 08, 2011 at One year inspection

**Photo 2-1-1-6 Beach situation in front of Fisheries Complex at one year inspection**



Beach situation in front of Vendors Arcade at completion of construction; Feb. 19, 2010



Beach situation in front of Vendors Arcade at one year inspection; Feb. 08, 2011



**Photo 2-1-1-7 Beach situation in front of Vendors Arcade**

2) The backshore portion at the beach through Fishing Gear Lockers I, Toilet, Work Shop, Fishing Gear Lockers II where is in the north side of Fisheries Center becomes a little bit narrow, there are no beach recession nor subsidence generated. According to Department of Fisheries, it is seen that wave run-up with a degree to transport sand into the inside of Fishing Gear Lockers at the time of high waves.

**(3) Change of south side of beach**

1) The south side of beach where is out of project site, beach retreat and the subsidence are apparent. The deepest part of beach arc circular faces to Community Center (the office of Village Council has removed during construction period and this center is not in use now) and adjoining warehouse. The jetty is not affected the influence of beach retreat by foundation of foot protection with rubble stone.

2) The sea side of foundation portion of Community Center is exposed situation and the entrance at the seaside in adjoining warehouse has been widely falling. The boarder block wall of common laundry where is in south side has been leant to seaside. With these, there are an elementary school and a church grave yard, this vicinity is in the deposited tendency where is beach is advanced.



Beach situation in front of the Community Center at basic design stage; Oct. 19, 2010



Beach situation in front of the Community Center at one year inspection (subsidence of 1m); Feb. 08, 2011



Subsidence in front of the Community Center at one year inspection; Feb. 08, 2011



Old warehouse of the Fisheries Cooperative (partially collapse of building) at one year inspection; Feb. 08, 2011

**Photo 2-1-1-8 Beach situation in South side beach**

## 2-1-2 Status of beach erosion at the time of Follow-Up Cooperation study

Beach erosion status of Anse La Raye Bay from September, 2011 are explained as follows,

### (1) The situation of total beach

The following photos are total beach situation taken at the time of ebb tide in September, 2011. It is understood that pocket beach is formed but the run-up waves reached to facilities.



Planning site (North→South)



Planning site (South→North)

**Photo 2-1-2-1 Beach situation at Follow-up Study**

**(2) Each foreshore situation in front of fisheries facilities**

As shown in 2-1-1 beach has been recovered a little bit than the time of Defects Inspection (February, 2011). It is understood that foreshore slope becomes gradual although the backshore is lost.



Fisheries complex and Venders' arcade



Beach situation in front of Fishing gear lockers



Beach situation in front of Fisheries complex



Beach situation in front of Fisheries complex



Beach situation in front of Fisheries complex



Beach situation in front of Venders' arcade



Beach situation at south part of Jetty



Beach situation at south part of Jetty

**Photo 2-1-2-2 Foreshore situation in front of fisheries facilities**



**(3) Utilization status of each fisheries facility**

As shown in the following photos, fisheries facilities have been actively used.



Vendors' arcade



Fish Friday



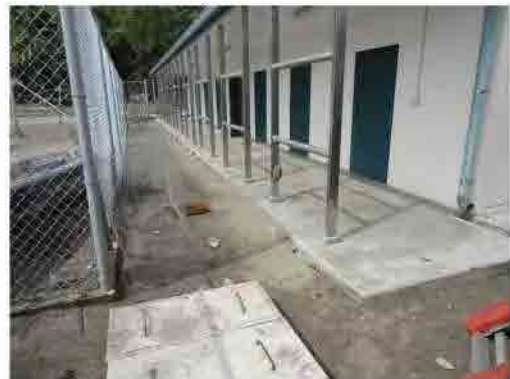
Fisheies complex



Ice strage room



Ice strage room



Fishing gear lockers



Fishing gear lockers



Fishing gear lockers

**Photo 2-1-2-3 Utilization status of each fisheries facility (1)**



Workshop



Workshop



Boat landing facility



Septic tank



Jetty



Jetty



North edge of Anse La Raye



North edge of Anse La Raye

Photo 2-1-2-4 Utilization status of each fisheries facility (2)

**(4) Grand subsidence situation of Fisheries Complex and Vendors Arcade**

The following photos shows the actual surveying of the foreshore situation in front of Fisheries Complex and Vendors Arcade where show the significant ground subsidence. According to these, it is understood that the backshore height has been recovered than that of subsidence at the time of Defects Inspection. The ground subsidence height as a whole is from 40 cm to 50 cm.

Fisheries complex(Sep. 23, 2011)



① Sea side 42cm



② 42cm



③ 46cm



④ 38cm

**Photo 2-1-2-5 Grand subsidence situation of Fisheries Complex (1)**



⑤ 32cm



⑥ 17cm



⑦ 16cm



⑧ 24cm

Venders' arcade (Sep. 23, 2011)



Photo 2-1-2-6 Grand subsidence situation of Fisheries Complex (2)



① 4.8m



① 4.8m



②0.9m



②0.9m



②0.2m



③ Edge situation

Photo 2-1-2-7 Grand subsidence situation of Vendors Arcade

## **2-2 Short-term countermeasure works**

### **2-2-1 Necessity and coverage of short-term countermeasure**

Table 1-1-2-1 shows the summary of damages and the urgency of countermeasure of each fisheries facility. According to this, foreshore recession and ground subsidence in front of Fisheries Complex and Vendors Arcade were generated and immediate measure shall be necessary. Therefore, the short-term countermeasure was executed during site survey stage of this study.

### **2-2-2 Content of short-term countermeasure and the execution**

The works of short-term countermeasure which was understood in previous 1-1-2 was executed by re-consignment to local contractor.

#### **(1) Consent to work execution**

The works of short-term countermeasure have been agreed in the Minutes concluded on September 7, 2011.

#### **(2) Work Permit**

The work permit has been issued on September 22, 2011 by DCA (Development Control Authority) upon the consent and the provision of collateral condition concerning the works by Ministry of Public Works through the submission of Site Management Plan and Traffic Management Plan for the works of short-term countermeasure and the work explanation at the site on September 16, 2011. (Permit was issued with the condition that the removal and restoration of rubble stones to be used for the short-term and middle-term countermeasure must be done if they will have a bad effect on the beach stability)

Incidentally, all who execute development works in St. Lucia are obliged to conduct EIA and submit the report by the Physical Planning and Development Act, 2001. The procedure is called as the procedure for Preliminary Planning Approval of Development Plan as shown in Table 2-2-2-1. The BD study for example, Department of Fisheries produced necessary documents and submit them to Development Control Authority after Detailed Design Documents were presented. Development Control Authority will show TOR of EIS/SIS to Department of Fisheries which will execute the assessment and submit the report. DCA will show additional TOR when necessary to Department of Fisheries which will correct the report through the inspection of DCA and the development permit will be usually given subject to the collateral condition. This period is needed about 4 weeks. And, in parallel with the above procedure, Full Planning Commission is going to be held and this is deemed to be an application for Building Certification in Japan. This inspection procedure is as shown in the lower part of Table 2-2-2-1, Detailed Design Drawings which the Consultant submitted are submitted to DCA by Department of Fisheries and the DCA will issue the work permit through the inspections of experts of related agents. Therefore, it takes usually about 4 weeks.

Concerning the development application and permit after November, 2011 in St. Lucia, all developers have to submit the plan to DCA with e-documents before submitting them to related agents

and DCA will ask opinions from the related agents and ask necessary additional data (EIS/SIS, Construction Management, Traffic Control and etc.) and issue the development permit upon discussions in the board meeting of DCA. Therefore, concerning the works of middle-term countermeasure, the preparation of documents for the adjustment and discussion at the board meeting of DCA shall be required.

Concerning the works of short-term countermeasure in this follow-up study, 1. Work Summary Plan, 2. Construction Supervision Plan and 3. Traffic Control Plan shown in Data-3 were submitted to DCA and Ministry of Public Utility rotated by Chief Consultant and Permanent Secretary of Ministry of Agriculture, Land, Forestry and Fisheries and get permit. In case of the works of middle-term countermeasure, as the scale of work is getting bigger in comparison with the work of short-term countermeasure, there is high possibility that design drawings at the detailed design stage are required. It is necessary to ask simple procedure like the same procedure at the stage of S/W.

**Table 2-2-2-1 Process of EIA and review of project detail plan (at the time of BD)**

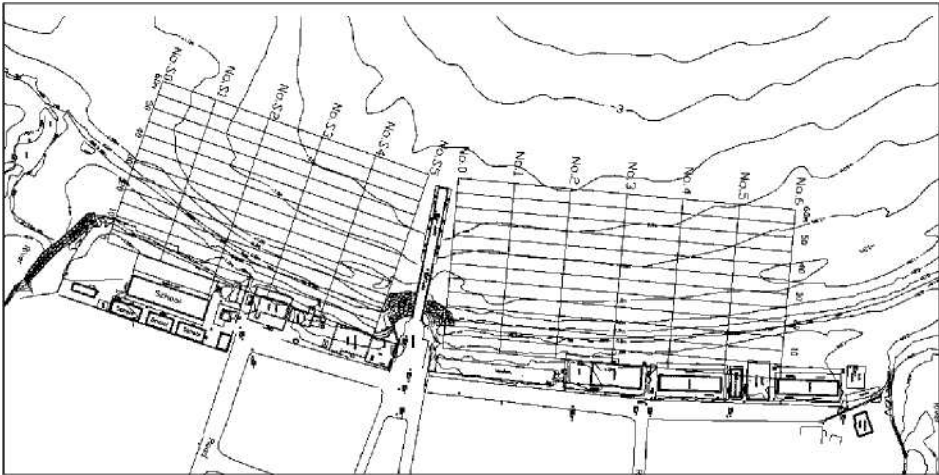
Preliminary Planning Approval	1st week	2nd week	3rd week	4th week	Application documents, etc.
1. Submission of Detailed Design Drawings to DOF	▽				*Detailed dsign drawings
2. Submission of Application to DCA by DOF					*3 copies of Project Proposal 1 copy of Facility Location Plan 10 copies of Conceptual Plan 1 copy of Survey Plan 1 copy of certificate of Land Ownership
3. Referral Agency make TOR of EIA to Applicant.					*TOR of EIS/SIS
4. Delivery of TOR to Applicant		▽			*TOR of EIS/SIS
5. Enforcement of EIA by Applicant			▽		*Report of EIA
6. Referral Agencies feedback additional TOR to Applicant.					*Additional TOR of EIA
7. Issue of Permission for construction works with commnets					*Permission with comments
Full Plannign Commission	1st week	2nd week	3rd week	4th week	Application documents, etc.
1. Submission of Detailed Design Drawings	▽				
2. Submission of D/D drawings to DCA	▽				*3 copies of Project Proposal 3 copies of Facility Location Plan 3 copies of Site Plan 3 copies of Building Drawings including Architectual, Structural, Electrical, Plumbing with septic tank&sewerage and Fire System
3. Screening of D/D drawings by Technical Committee of DCA			▽		*10 copies of Report of EIA
4. Issue of Approval of Construction Works by DCA				▽	*Approval of construction works

**(3) Selection of re-consignment of local contractor**

In accordance with the revised specification for the works of short-term countermeasure with the result of prompt report of natural condition survey, the cost and methodology of the works have been requested to 2 local companies in St. Lucia on September 19, 2011 and re-consignment contract was concluded with TAKAO & SONS ELECTRICAL-MECHANICAL AND ENGINEERING CONTRACTORS LTD. who proposed cheapest price on September 22, 2011.

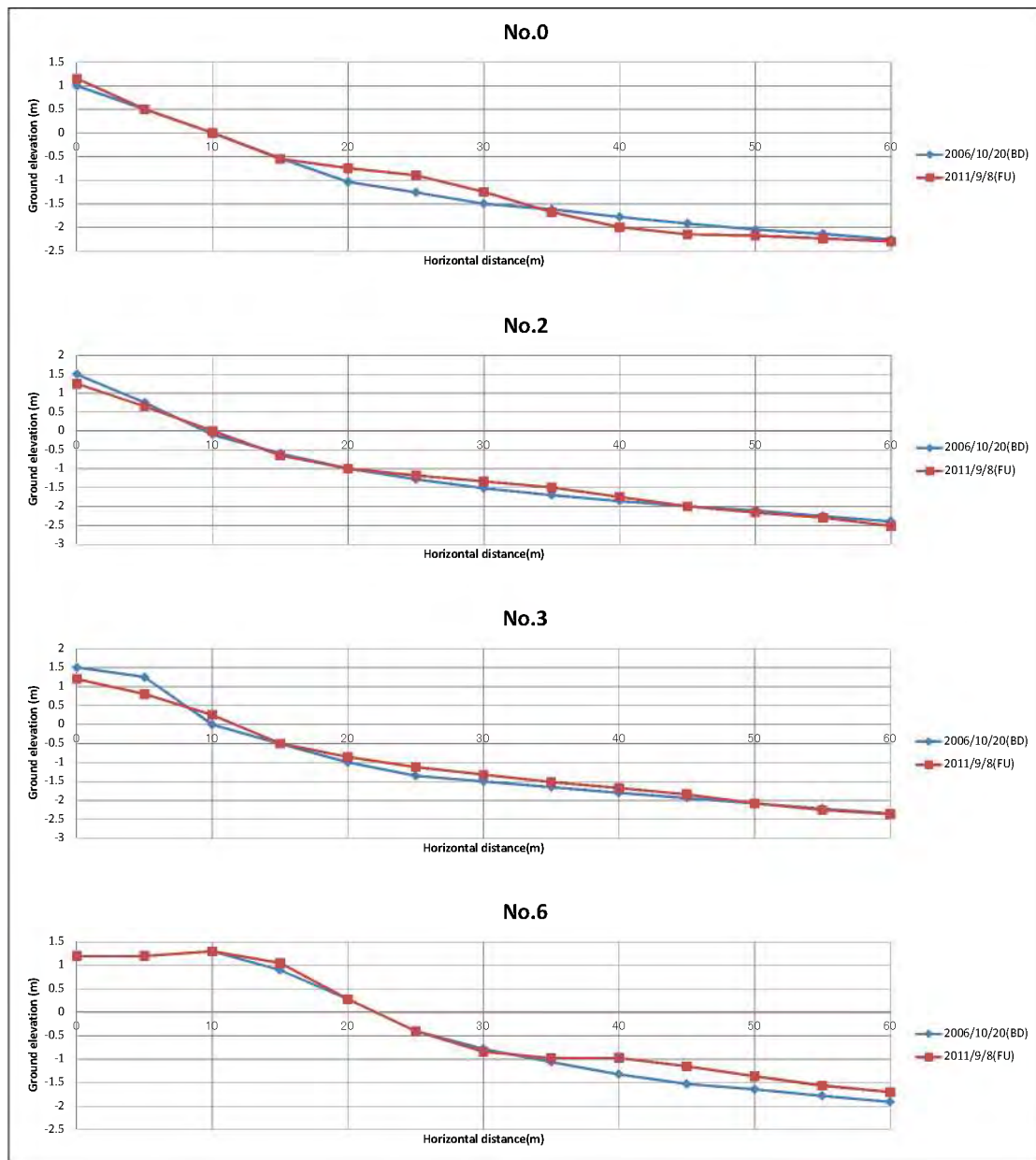
**(4) Work summary**

Figure 2-2-2-2 indicates the cross sections that are compared the survey result at the time and BD and on this follow-up study. The survey lines are indicated in Figure 2-2-2-1.



**Figure 2-2-2-1 Location of survey lines**





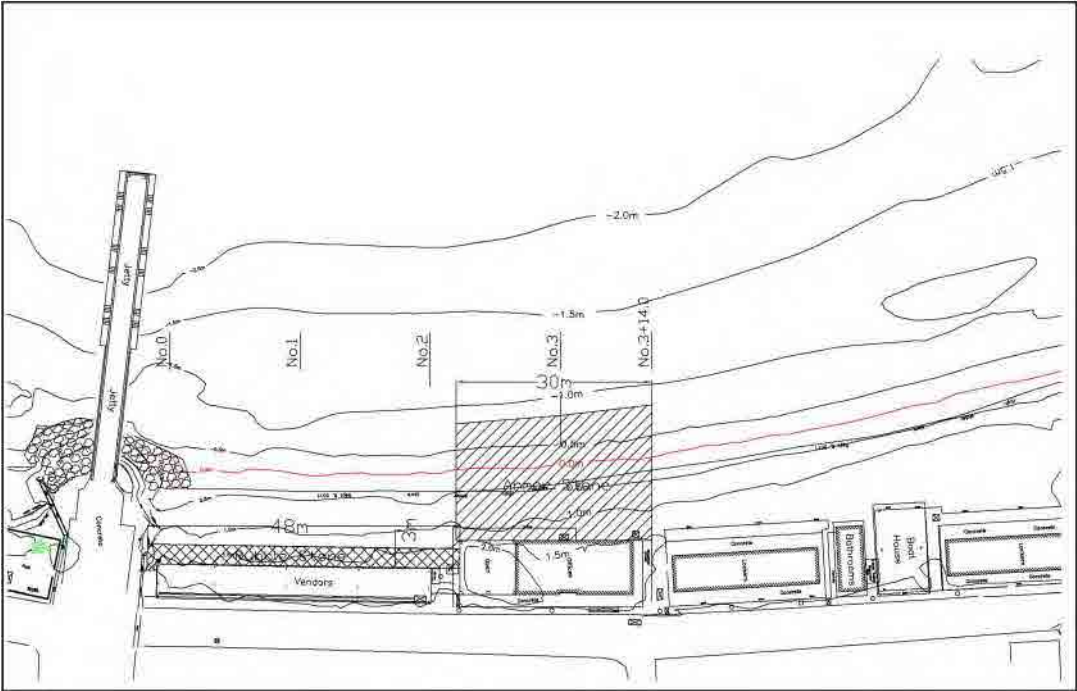
**Figure 2-2-2-2 Cross section comparison chart of representative survey lines**

In the cross section comparison on the north half side of Anse La Raye Bay beach, the beaches between the survey line 1 and the survey line 4 are sagged and the beach is gently sloped however, the area around 20-30m offshore has the tendency to be slightly deposited. The cross sectional changes are not generated at the beach and the offshore up to the survey line 5 and 6. The settlement measurement of beach between the survey line 1 and the survey line 4 was maximum about 1m at the time of one year inspection and it becomes gentle with maximum about 46 cm now. And also, the foreshore of Arcade at the survey line 0 to the survey line 2 is sagged as well as the foreshore of Fisheries Complex building and the width of backshore becomes narrower toward south side. The backshore of south end of Arcade was lost and the under part of floor concrete is scoured and the foundation is exposed.

There will be possible scouring of the foundation of facilities by further recession of shoreline if high wave is continued keeping the present situation. It is already in hurricane season therefore, the urgent countermeasure which is workable within short period is necessary. In order to prevent scouring at foreshore by wave run-up, the covering foreshore with rubble stones was made to execute within a period of this study. The construction area is in front of Fisheries Complex and Vendors Arcade. Floor Plan is shown in Figure 2-2-2-3 and the cross section is shown in Figure 2-2-2-4.



**Photo 2-2-2-1 Capstan line for hoisting fishing boats installed backshore (BD stage)**



**Figure 2-2-2-3 Floor plan**

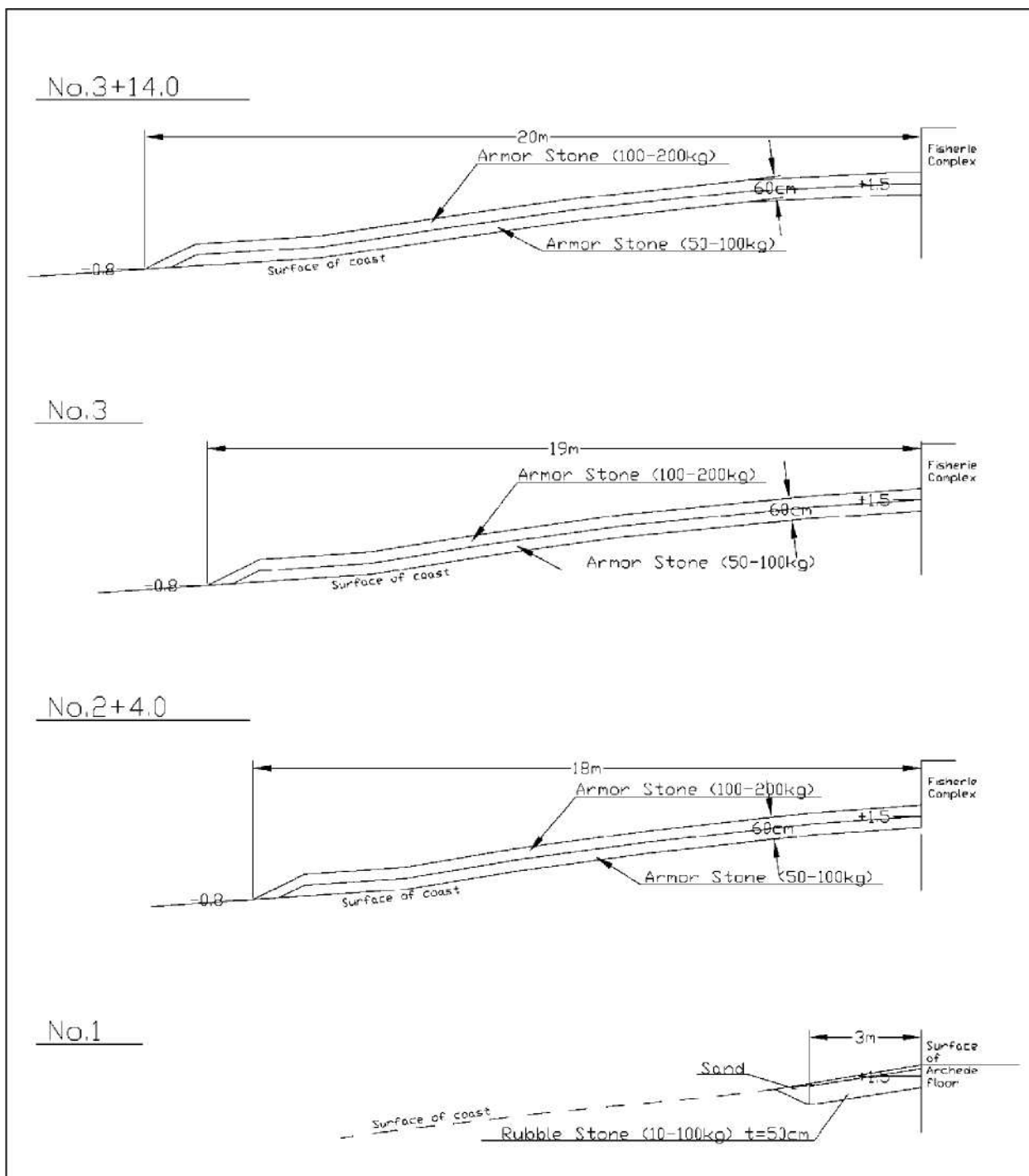


Figure 2-2-2-4 Cross section

**(5) Work execution**

Re-consignment contractor had a preparation on September 23, 2011 and has commenced the work from September 26, 2011. The execution plan was planned to be completed on October 17, 2011 with considering the influence to tourists and Fish Friday except possible delay by bad weather and force majeure. However, the works have been completed on October 11, 2011 due to the effective execution of the works and the good weather.

## **2-2-3 Effect of short-term countermeasure**

### **(1) Beach recovery status**

#### 1) Difference of recuperative power at north and south of the jetty

Photo 2-2-3-1 is a broad view from north side cliff toward south side. It can be understood that the area from river mouth of north side to Fishing Gear Lockers II area has been recovered. Photo 2-2-3-2 shows the site of short-term countermeasure works enlarged. With this, it is understood that the rubble stones in front of Fisheries Complex could have been worked for wave absorbing function. The recuperative power of foreshore in front of Vendors Arcade where forms pocket beach being wedged between these rubble stones and the one at the base part of the jetty is weak but it indicates stable foreshore slope.

Photo 2-2-3-3 is the picture of beach from view point on south side cliff. It is understood that the south side beach from the jetty has been greatly recovered and the backshore width considerably advanced. Photo 2-2-3-4 enlarged an area around the jetty. With this, it is understood that the backshore has been formed at south side of access portion of the jetty and the shoreline has been advanced. It is expected that sediment transport shall run over the rubble stones at the base of the jetty of access portion.



**Photo 2-2-3-1 Whole beach view from north side**



**Photo 2-2-3-2 Situation of short-term countermeasure works**



**Photo 2-2-3-3 Whole beach view from south side**



**Photo 2-2-3-4 Recovery status at south side of the jetty**

2) It takes longer time in north side of beach although the south side has been greatly recovered.

Photo 2-2-3-5 and Photo 2-2-3-6 show the comparison of before and after short-term countermeasure works. It is understood that south side beach has been apparently recovered. Photo 2-2-3-7 and Photo 2-2-3-8 show the comparison of foreshore in front of Community Center. The rubble stones at the jetty base part are exposed in Photo 2-2-3-7. However, it is understood that the exposed portion becomes apparently small and the backshore has been recovered in Photo 2-2-3-8. Therefore, it can be predicted that the recovery of north side beach from the jetty shall take longer time although the south side of beach from the jetty has been shown a tendency to recover greatly at the time of last additional study.



**Photo 2-2-3-5 Beach status before short-term countermeasure works**



**Photo 2-2-3-6 Beach status on January 19, 2012**



**Photo 2-2-3-7 Foreshore status before execution of short-term countermeasure works**



**Photo 2-2-3-8 Foreshore status in front of Community Center on January 19, 2012**

## **(2) Status of work site for short-term countermeasure**

### **1) Vendors Arcade**

Photo 2-2-3-9 shows the foreshore status in front of Vendors Arcade. This part forms pocket beach with the rubble stones at front face of Fisheries Center and the rubble stones at the base part of the jetty. It can be understood that the foreshore slope is going to be the same as slopes in surrounding area. There arises uneven part between head part of protective rubble stones and foreshore in front of Arcade. Photo 2-2-3-10 shows the wave run-up situation at the foreshore. With this, it can be understood that wave run-up is higher in comparison with the rubble stone part in front of Fisheries Complex but the foreshore slope becomes stable just like surrounding beach. Photo 2-2-3-11 shows the diffraction status of protective rubble stones of the jetty base part and the foreshore slope in this part becomes steeper comparing with the one surrounding this part but it is predicted that this part produces a large effect on the recovery of foreshore when littoral drift is in the situation to reach to foreshore in front of Arcade over the jetty.



**Photo 2-2-3-9 Foreshore situation in front of Vendors Arcade**





**Photo 2-2-3-10 Wave run-up situation at foreshore**



**Photo 2-2-3-11 Beach situation of rubble stones in base part of the jetty**

Photo 2-2-3-14 shows the rubble stones situation in front of Arcade. The rubble stones are installed on the level and the protective effect is worked but the head part is exposed and lead to uneven part with the foreshore. Photo 2-2-3-15 shows the exposed situation of rubble stones. Fishermen have indicated the possibility to make damage to boat bottom at the time of hauling them up.



**Photo 2-2-3-12 Armor stones situation in front of Arcade**



**Photo 2-2-3-13 Exposed situation of armor stones**

## 2) Foreshore in front of Fisheries Complex

Photo 2-2-3-14 shows armor stone part and foreshore slope in front of Fisheries Complex. With this, it is understood that this armor stone part becomes fit in the foreshore slope. Photo 2-2-3-15 shows wave absorbing situation at the head of armor stones. It can be understood that wave absorption effect is worked at assumed head part of armor stones. Photo 2-2-3-16 shows the head part of armor stones and it can be understood that they becomes stable not largely pulling out to offshore side although there seen subsidence a little bit.



**Photo 2-2-3-14 Armor stone part and foreshore slope in front of Fisheries Complex (1)**



**Photo 2-2-3-15 Armor stone part and foreshore slope in front of Fisheries Complex (2)**



**Photo 2-2-3-16 Situation at head of rubble stones**

Photo 2-2-3-17 shows deposited situation of foreshore at north side of rubble stones. It can be understood that sand is about to supply into the inside of armor stones. Photo 2-2-3-18 shows the backshore situation of north side of armor stone part. Like this, it can be understood that backshore is going to be formed. Photo 2-2-3-19 shows the foreshore side situation in front of Arcade at south side of armor stone part. It is understood that waves are diffracted at the head of armor stones and supply sand.



**Photo 2-2-3-17 Deposited situation of foreshore at north side of armor stones**



**Photo 2-2-3-18 Backshore situation at north side of armor stone part**



**Photo 2-2-3-19 Foreshore side situation in front of Arcade at south side of armor stone part**

### **(3) Front face of Fishing Gear lockers and Work Shop**

Photo 2-2-3-20 shows backshore situation in front of Work Shop from Fishing Gear Lockers. It can be understood that large scale backshore is formed from north side river mouth to Fishing Gear lockers. Photo 2-2-3-21 shows backshore and foreshore situation in front of Fishing Gear Lockers to Work Shop. Top height of backshore is not seen enough recovered yet but it can be confirmed that the backshore is apparently formed.



**Photo 2-2-3-20 Backshore situation in front of Fishing Gear Lockers to Work Shop**



**Photo 2-2-3-21 Backshore and foreshore situation in front of Fishing Gear Lockers to Work Shop**

Photo 2-2-3-22 shows the comparison with the situation before short-term countermeasure works. Photo was taken to meet the scale with a light green boat and compare two photos and it is understood that the shoreline apparently advanced and the backshore width is extended.



**Photo 2-2-3-22 Comparison with the situation before short-term countermeasure**

#### **2-2-4 Evaluation on short-term countermeasure**

##### **(1) Evaluation of the Government of St. Lucia**

Discussion was made on January 20, 2012 for the evaluation on short-term countermeasure of Department of Fisheries and the evaluation of the execution of short-term countermeasure were as follows,

- 1) St. Lucian side made evaluation on the effect of armor stones. However, it is indicated that the accessibility from south to north for fishermen is blocked by armor stones in front of Fisheries Complex.
- 2) Study request for the countermeasure to be able to transport between south and north with the idea like board-walk over the armor stone part was made from St. Lucia side.
- 3) It was indicated that the effect against incoming waves with a return period of 30 years could not confirm yet since there was no abnormal weather like hurricane generated after the execution of short-term countermeasure. In this point, the explanation was made that fatal damage shall not be received even if waves with a return period of 30 years hits.

##### **(2) Evaluation of fishermen in Anse La Raye**

Hearing survey from 4 fishermen who are in leadership position was made on January 21, 2012 witnessed by staff of Department of Fisheries concerning evaluation of short-term countermeasure works. Hearing questions are 1.Effect and issue on short-term countermeasure, 2.North-south accessibility by short-term countermeasure, 3. Finish in front of Fishing Gear Lockers 4.Opposing view against short-term countermeasure. Opinions from fishermen are as follows,

1) Evaluation of armor stones in front of Fisheries Complex

- a) Most of fishermen evaluated as effective
- b) Some fishermen directed the inconvenience for accessibility to Fishing Gear lockers
- c) There were opinions to have foot pass and there were opinions that it is improper to have board walk being slippery.

2) Evaluation of armor stones in front of Vendors Arcade

- a) Indication was made that exposed head of armor stones in front of Vendors Arcade damage boat bottom.
- b) Indication was made that it should be faired along with beach slope.
- c) Indication was made that armor stones at base of the jetty block sand accessibility returning (Sand trap effect shall be rather than more when sand will return crossing over the jetty. Therefore, present situation should be kept.)

3) Evaluation of armor stones at base of the jetty

- a) There was indication that drainage water becomes the trigger of sand scouring since drainage ditching of urban drainage were installed at both ends sides of the jetty although this is not the scope work of short-term countermeasure.
- b) This urban drainage becomes the trigger of odor and pollution of sand beach in front of Vendors Arcade.

4) Other opinions

- a) There was an opinion that beach shape and the beach itself are important and it is better to have protection by detached breakwater than that of armor stones.



# Chapter 3 Mechanism of Beach Erosion in the Anse La Raye Bay

## 3-1 Long-term changes of shoreline, based on aerial photographs

### 3-1-1 Analyses of shoreline changes by utilizing aerial photographs

Shoreline changes in the Anse La Raye Beach and the Roseau Beach, which locations are shown in Figure 3-1-1-1, are analyzed by utilizing aerial photographs. Figure 3-1-1-2(a) and (b) are aerial photographs of Anse La Raye Beach. By comparing the spaces of three roads running parallel to the beach and a distance from the sea-side road to the shoreline, the shoreline changes can be roughly understood. The distance from the road to the shoreline was nearly the same as the road space in 1977, while it became apparently shorter in 2007 and 2009.



Figure 3-1-1-1 Locations of the Anse La Raye Beach and Roseau Bay Beach



Figure 3-1-1-2(a) Aerial photographs of Anse La Raye

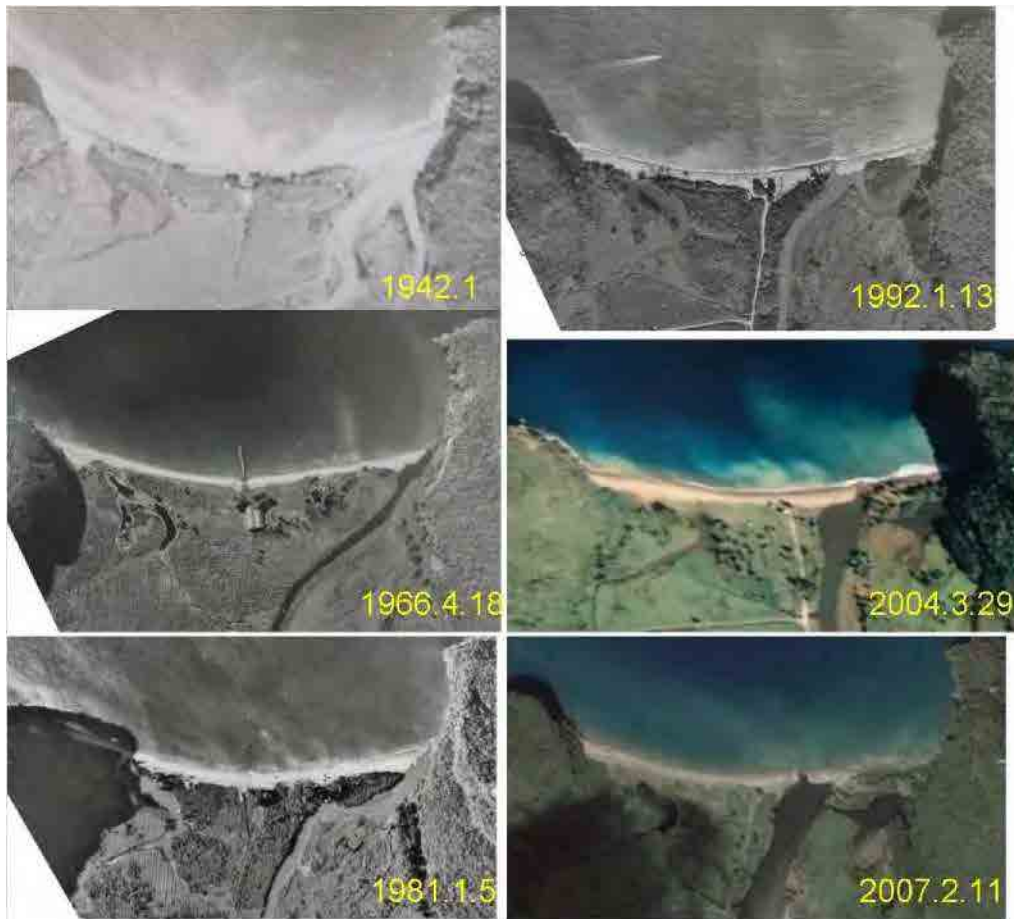


**Figure 3-1-1-2(b) Aerial photograph of Anse La Raye, taken in February 2009**

The locations of shoreline at the center of beach, which is just the north-side of the jetty, were read from the photographs in Figure 3-1-1-2(a) and (b). Furthermore, the shoreline locations were read also at the center of the Roseau Bay Beach from the aerial photographs in Figure 3-1-1-3. In table 3-1-1-1, the dates of taking photographs are listed. The shoreline positions are also listed in this table, with a seaward distance from a datum point which is the shoreline in 1942. A correction by tide level is not done. However, the tide level difference in Anse La Raye as shown in Figure 4-3-2-5, as they are 0.56m between NHHWL and NLLWL and 0.16m between HWOST and LWOST which tidal variations are small therefore, there will be no problem without adding a correction by tide level when the shoreline locations are read.

The shoreline position is shown in Figure 3-1-1-4. Before explaining Figure 3-1-1-4, following items should be confirmed.

- 1) Although the aerial photographs are old and a little bit indistinct as seen in Figure 3-1-1-2(a) and Figure 3-1-1-3, the shoreline position has been read somehow. An accuracy in reading shoreline position is worse than others.
- 2) The shoreline in the Roseau Bay advanced as passing phenomenon in 2007. By inspecting Figure 3-1-1-3 precisely, it is clear that the river mouth usually located at north-side of beach (or right-side in photograph) except in 2007. In 2007, it located to the center of beach, where the shoreline position has been read. The configuration of shoreline around the river mouth was slightly convex to the sea. The shoreline advance in 2007 is considered to be due to this phenomenon.



**Figure 3-1-1-3 Aerial photographs of the Roseau Bay**

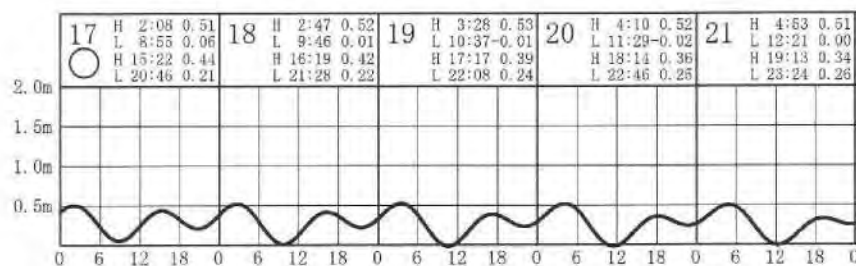
**Table 3-1-1-1 Shoreline position read from aerial photographs**

Photographing date	Shoreline position(m) (reference to 1942)	
	Anse La Raye	Roseau Bay
Jan/15/1942	0	0
Apr/18/1966	16	22
Mar/27/1977	13	
Jan/05/1981		25
Jan/13/1992	3	16
Mar/29/2004		7
Feb/11/2007	-1.5	17
Feb/15/2009	-6	7

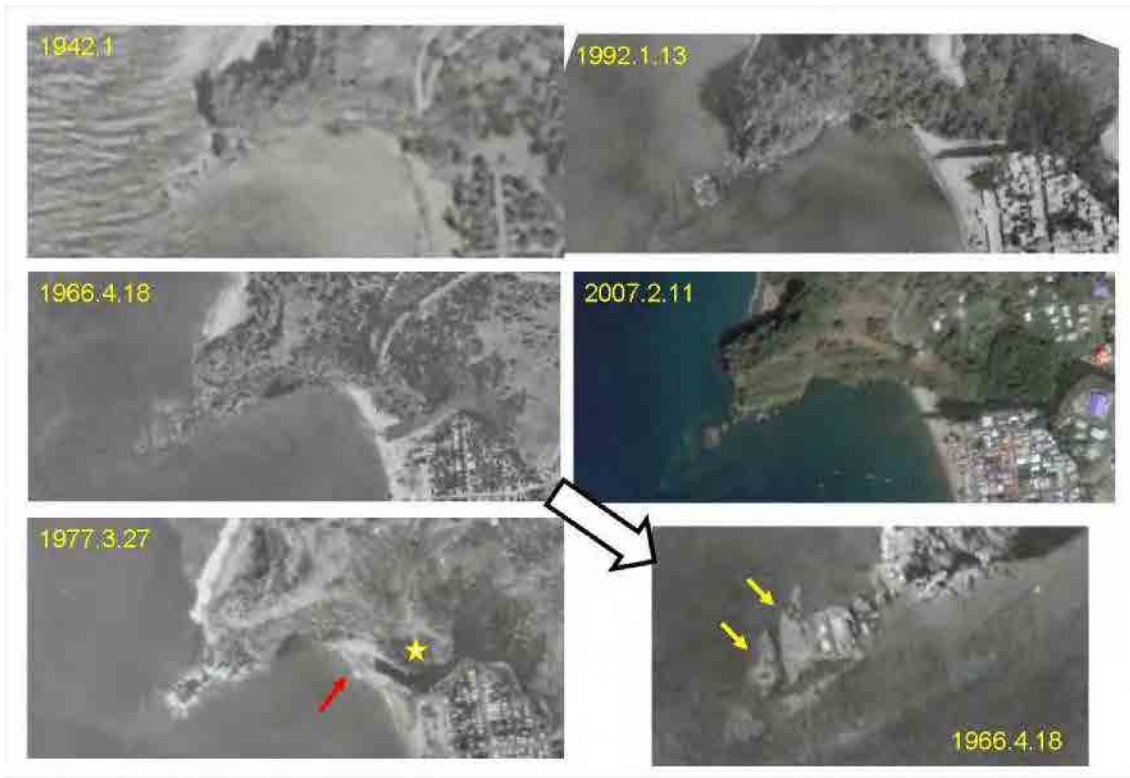


**Figure 3-1-1-4 Changes of shorelines**

3) The aerial photograph in 1966 was taken on 18th April. Figure 3-1-1-5 shows the tides at the Anse La Raye during a period from 17th to 21st April, 2011. It is a spring tide on the day of around 18th April every year, and the lower low tide takes place in the daytime at that. Then there is every possibility that this aerial photograph was taken at a time when the tide level was low. Furthermore, Figure 3-1-1-6 shows the headland located at the north end of Anse La Raye Beach, with the enlarged photograph of 1966 at the right-bottom corner. Two rocks can be clearly seen in the enlarged photograph, which are denoted by yellow arrows. That is to say, rock shoals emerged above the sea surface. In the other aerial photographs, by inspecting carefully, the same shape of rock shoals can be seen faintly in the sea. Therefore, as the aerial photograph of 1966 was taken when the tide level was low, it can be said that the effect of low tide level, s shoreline advance, is contained in the shoreline position read from the aerial photograph of 1966.



**Figure 3-1-1-5 Predicted tide from 17th to 21st April, 2011**



**Figure 3-1-1-6 Headland located at the north end of Anse La Raye Beach**

The interpretations of Figure 3-1-1-4 are as follows, being standing on the above items confirmed;

- a) The shoreline was receding in the Anse La Raye Beach since around 1977, with an almost constant speed of 0.59m/yr.
- b) Also in the Roseau Bay Beach, the shoreline recession occurred during the same period, with the nearly same speed as that in the Anse La Raye Beach.
- c) Since the similar shoreline recessions occurred in the different two beaches, it is inferred that the cause of recession is due to not the something related to the local and inherent in each beach, but the phenomena in wide area such as atmospheric and oceanographic ones.
- d) Although accuracy in reading shoreline position is worse in the aerial photograph of 1942, the recent shoreline positions in both beaches are located almost the same location as those in 1942.
- e) There are two possibilities of interpretation for shoreline changes shown in Figure 3-1-1-4.
  - \* The shoreline has been receding since the second half of 1970s.
  - \* In the first half of 1970s a large amount of sand was supplied temporarily to the beach for some reason, e.g. abnormal weather and record-breaking heavy rain, which advanced the shoreline abruptly. After that, the shoreline receded gradually to the original position of 1942.

### 3-1-2 Possibility of temporal supply of a large amount of sand to the beach

Possibility of temporal sand supply is examined. Figure 3-1-2-1 shows the coastal cliff at the north-side of the Anse La Raye Beach, which was taken from a tip of the jetty. Trees grew thick on both dates, at the base of coastal cliff. Why did the trees grow at such place near the sea surface?



**Figure 3-1-2-1 Coastal cliff, taken from a tip of the jetty**

Figure 3-1-2-2 shows a condition of coastal cliff which is located at the right-side of the trees. The cliff over-hangs slightly over the sea, and a notch is formed due to erosion by waves at the base. The coastal cliff is sedimentary soft rock containing gravels, which seems to be not so strong. Taking these conditions into account, it is inferred that the trees on the cliff dropped to the base with the landslide before 2006, and they took root there.



**Figure 3-1-2-2 Coastal cliff (8 September, 2011)**



**Figure 3-1-2-3 Enlarged photo of coastal cliff**

Checking the photos of cliff, taken from the sky, in chronological order (see Figure 3-1-1-6), the cliff configuration changed during a years from 1966 to 1977, that is a landslide. Furthermore, the shoreline in 1977, which is denoted by a red arrow, advanced remarkably in comparison with shorelines in other date. It is not contradictory to the landslide. There is a topography projected downward in 1977, which is denoted by a yellow star in Figure 3-1-1-6. As it disappeared in 1992, it is inferred that the landslide occurred also at this place after 1977.

According to the consideration done so far, it is considered that a large amount of sand was supplied temporally to the beach due to the landslides around 1977. Since the landslide occurs repeatedly owing to the heavy rain fall, it can be inferred that the amount of rain fall became abnormally large around 1977. As there is a large river in the Roseau Bay Beach, the sand supply from the river became large also in this beach. As a result, the shoreline changes in these two beaches strikingly similar each other. After all, between two interpretations for shoreline changes in figure 3-1-1-4, the latter one becomes more valid.

### 3-2 Main causes of beach change from October 2006 to September 2011

#### 3-2-1 Recent Beach Processes

Figure 3-2-1-1 shows the comparison of beach profiles between in October 2006 and in September 2011, which are measured before and after the project respectively. The reference line No.3 is a line passing a center of Fisheries Complex (see Figure 3-2-1-2), and an origin is set at the base of Fisheries Complex, being positive in the seaward direction, in Figure 3-2-1-1. In the area from 0m to about 8m, the beach eroded about 0.5m thick.

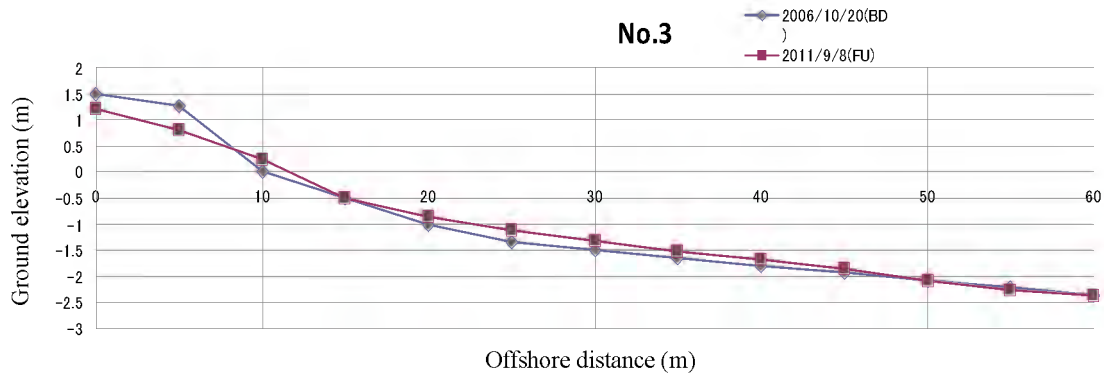


Figure 3-2-1-1 Comparison of beach profiles in front of Fisheries Complex (Reference line No.3)

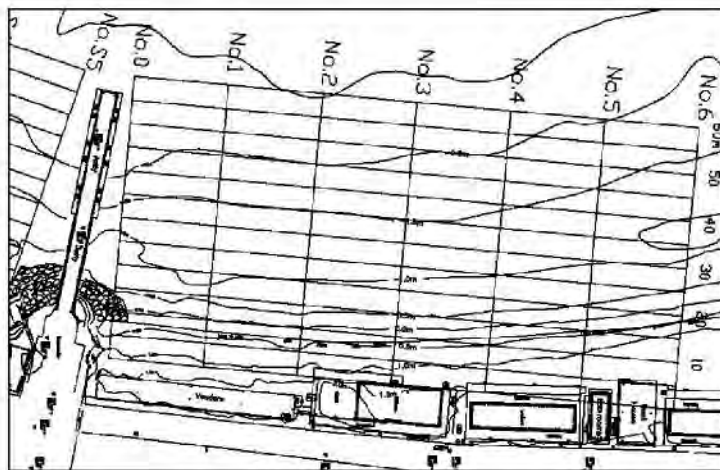


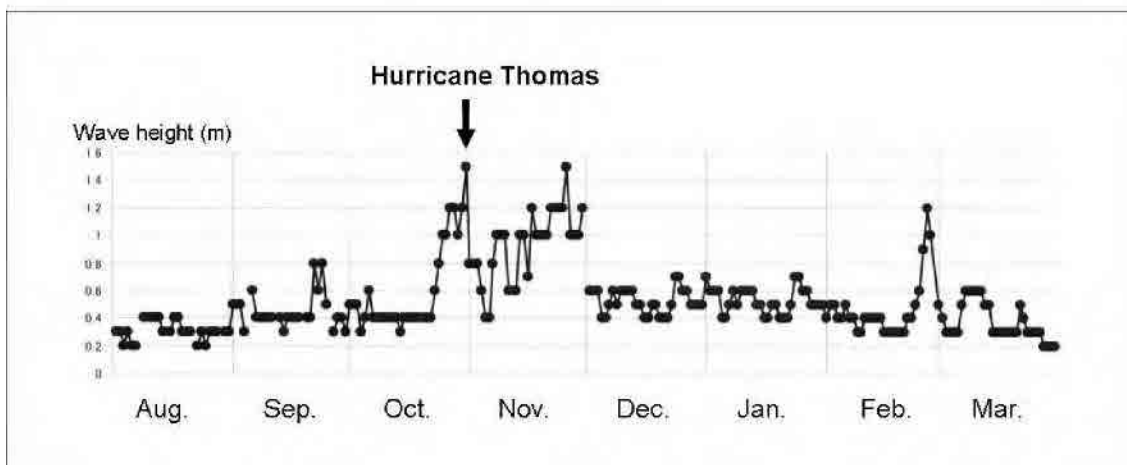
Figure 3-2-1-2 Reference lines

Figure 3-2-1-3 shows the beach topography in front of Fisheries Complex, one of which has been taken on the day just after the Hurricane Tomas(30 Oct., 2011) and another has been taken in about three months. Although the beach was eroded by the Hurricane Tomas, the erosion did not reach to the base of Fisheries Complex. The erosion reached up to the base by 8 Feb., 2011, and the power box was exposed. That is due to the duration of high wave conditions during about one month after the hurricane (see Figure 3-2-1-4).





**Figure 3-2-1-3 Comparison of beach topography in front of Fisheries Complex**



**Figure 3-2-1-4 Waves by eye-estimation in Gouyave, Grenada, from August 2010 to April 2011**

Figure 3-2-1-5 shows photos of beach in front of Fisheries Complex, taken on 8 Feb. and 5 Sep., 2011 respectively. Paying attention to rubble stones which are in existence at the place about 5 meters from the base, it is understood that the sand has accumulated there because the exposed part of stones became smaller on 5 Sep., 2011. Concerning to the area close to the base, the recovery of beach is not recognized because the distance from a handrail to the floor is nearly the same as that from the floor to the beach in both photos, which are enlarged in Figure 3-2-1-6.



**Figure 3-2-1-5 Conditions of beach in front of Fisheries Complex  
(taken on 8 Feb. and 5 Sep., 2011)**



**Figure 3-2-1-6 Enlarged photos (parts of Figure 3-2-1-5)**

Figure 3-2-1-7 shows the conditions of rubble stones in front of Fisheries Complex on the days of 5, 8,10, and 11 September, 2011. Judging from the exposed conditions of rubble stones, the changes of beach are as followings. The sand accumulated well on 5 September. The beach eroded slightly by the day of 8 September. The sand deposited a little on 10 September. The beach eroded slightly again on 11 September. That is to say, the place, which is about 5 meters apart from the base of Fisheries Complex, changes daily.

The above considerations can be summed up as followings; The beach in front of Fisheries Complex, within about 8 meters of the base, eroded about 0.5 meter thick between the profiles before and after the project. The erosion occurred due to the Hurricane Tomas on 30 October 2011 and following large waves continuing about one month. During a last half year, the erosion at the base of building does not develop further. At the place about 5 meters from the base, the sand have

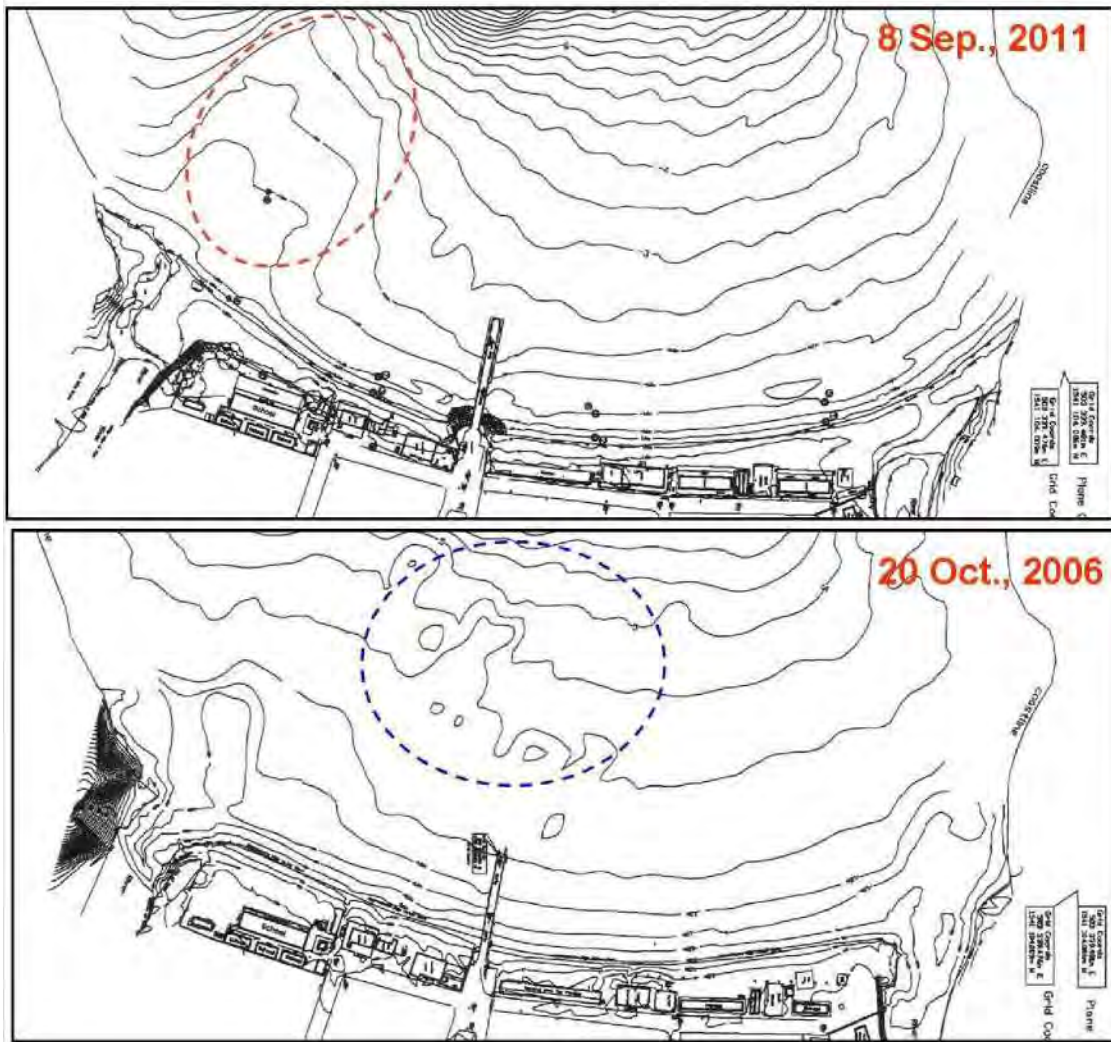
accumulated and the beach has been recovered a little, but the beach is not stable because erosion and deposition repeat daily.



Figure 3-2-1-7 Short-term changes of beach in front of Fisheries Complex

3-2-2 Change of sea bottom topography

Figure 3-2-2-1 shows the contour maps surveyed in 2006 and in 2011. Please take notice that an interval of contour lines is 1m in 2006, while it is 0.5m in 2011. The distinctive feature of topography in 2006 exists in the area surrounded by a dotted blue line, where the contour lines are disarranged. In the case that the sea bottom material is sand, the contour lines should be smooth curves. The disarrangement of contour lines suggests the existence of rock reefs on the bottom.



**Figure 3-2-2-1 Comparison the contour maps surveyed in October 2006 and September 2011**

Figure 3-2-2-2 is the aerial photograph taken in February 2009, of which contrast and the tone of color have been slightly adjusted. By inspecting this photo carefully, the color of sea bottom can be detected black in the area surrounded by a dotted blue line. Also from this evidence, it can be inferred that there exist the rock reefs.

In 2011 (Figure 3-2-2-1), the contour lines in the corresponding area are curved smoothly, and the rock reefs is considered to be disappeared. It is propriety to interpret that the sand accumulated on the rock reefs.



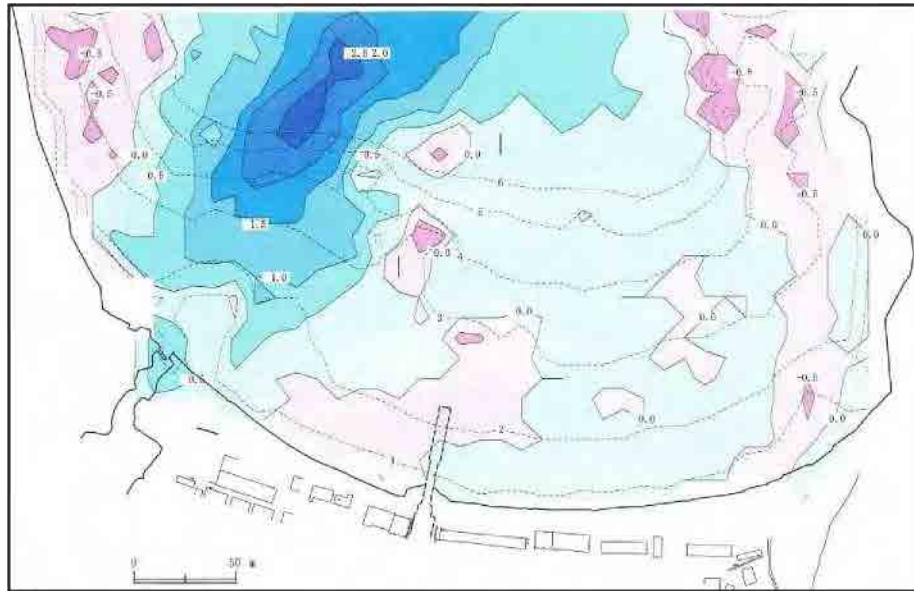
**Figure 3-2-2-2 Aerial photograph taken in February 2009**

The distinctive feature of topography in 2011 exists in the area surrounded by a dotted red line, where the contour lines project remarkably offshore-ward. This accreting topography, or shoal, can be seen in Figure 3-2-2-3 which was taken in the almost same time as surveying, on which the waves break. However, the shoal is not recognized in front of river mouth both in the aerial photograph in February 2009 (Figure 3-2-2-2) and in the contour map in 2006.



**Figure 3-2-2-3 Shoal in front of river mouth and breaking waves (4 Sep., 2011)**

Figure 3-2-2-4 shows the change of topography from 2006 to 2011. The area of deposition is long and narrow in the cross-shore direction in front of river mouth, being the maximum thickness of deposition is more than 2.5 meters. This deposition is inferred to occur during a period from February 2009 to September 2011, because the rock reefs is still seen on the bottom and the shoal was not formed yet in front of river mouth in the aerial photograph, Figure 3-2-2-2, taken in February 2009.



**Figure 3-2-2-4 Change of topography from 20 Oct. 2006 to 8 Sep. 2011**

### **3-2-3 Main causes of sea bottom change from February 2009 to September 2011**

Judging from the pattern of sand accumulation shown in Figure 3-2-2-4, it is reasonably inferred that the accumulated sand have been supplied from the river located at the south-end of the Anse La Raye Beach. There were following two events, or large floods, which transported sand to the sea during this period;

- 1) The large flood on 5 May, 2009, see Figure 21,
- 2) The Hurricane Tomas on 30 October, 2010.

Concerning to the flood 1), there are two pictures, Figure 3-2-3-1 and 3-2-3-2, which were taken by Mr. Adachi, a resident engineer. Figure 3-2-3-1 shows a condition of flood with muddy water and Figure 3-2-3-2 shows a inundated village of Anse La Raye. Except these two pictures, there is no more quantitative information such as precipitation, duration time of rain or river discharge. But, it is no doubt that the large flood occurred.



**Figure 3-2-3-1 Large flood on 5 May, 2009**



**Figure 3-2-3-2 Inundated village on 5 May, 2009**

Concerning to the event 2), quantitative information of natural conditions on Anse La Raye Beach is no obtained yet. However, from the following information, it is inferred that a large amount of sand was supplied to the sea.

[The return period of the rainfall was of the order of 180 years.]

The distinctive feature of Hurricane Tomas was a large quantity of rainfall and its return period was of the order of 180 years. Owing to this event, the river was considered to flood on an extensive scale.

[Cows were drowned in the hinterland of the Roseau Bay]

A person, who is an owner of banana farm in the hinterland of the Roseau Bay, said that the farm was completely submerged under the flood water and almost all cows were drowned when the Hurricane Tomas passed near the island.

[The hillside landslides occurred on a large scale]

Owing to a large quantity of rainfall, large and small scale hillside landslides took place all over Saint Lucia (see Figure 3-2-3-3). It is inferred that the earth and sand run into the river, which were transported to the river mouth by the flood.



**Figure 3-2-3-3 Large scale hillside landslides (Hurricane Tomas)**

It is considered that a large quantity of sand has been supply to the sea through rivers owing to these two big events, that is, the large flood in 2009 and the Hurricane Tomas in 2010. The contribution rate of each event to the sand deposition in front of river mouth is not estimated. At any rate, the sand accumulation shown in Figure 3-2-2-4 took place as the result of being piled up the effects of these events.

### **3-3 Possibility of beach processes in future**

#### **3-3-1 Sign of beach recovery observed in by field inspections and soundings**

The sand deposited in the deep area is not transported to the beach, while the sand deposited in the shallow area is transported to the beach by the incident waves. As the jetty is a permeable structure, the sand is also transported in the longshore direction to the beach in front of Fisheries Complex. Figure 3-3-1-1 shows the south-side beach of the jetty, which pictures were taken at approximately one month interval. The volume of sand seems to be increasing on the beach.

Figure 3-3-1-2 is the picture taken from opposite site, which shows that a mass of sand is running ashore to form the berm, also see the Reference figure. On the day of 30 November, it completely lands on the beach as seen in Figure 3-3-1-3.



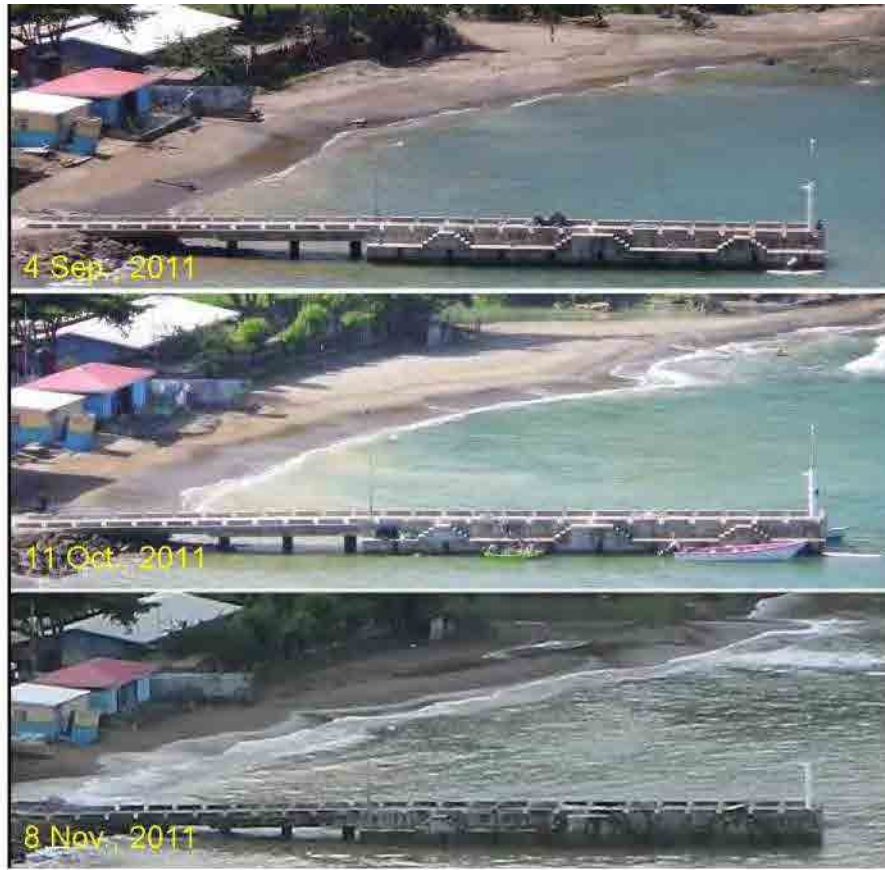


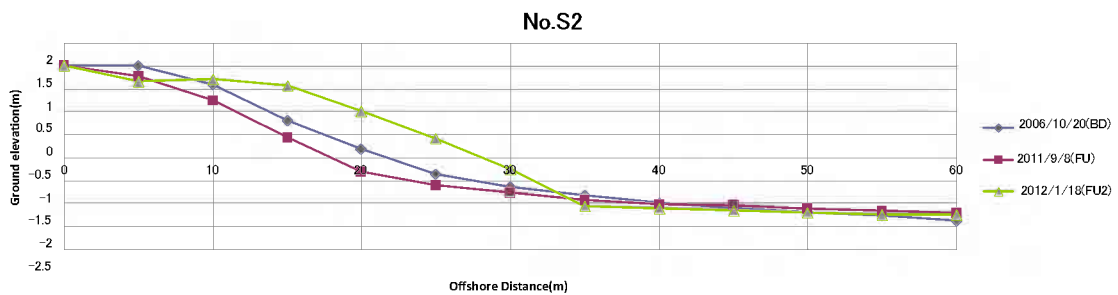
Figure 3-3-1-1 Changes of south-side beach of the jetty



Figure 3-3-1-2 Sand accumulation on beach, 8 Nov., 2011

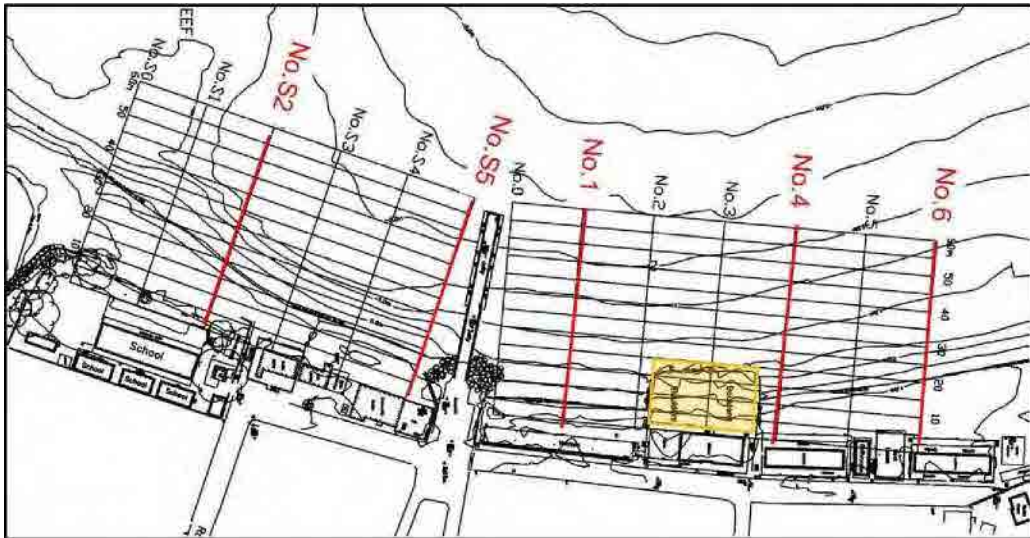


**Figure 3-3-1-3 Sand accumulation on beach, 30 Nov., 2011**



**Figure 3-3-1-4 Profile changes at reference line No.S2**

Figure 3-3-1-4 shows changes of profile at the reference line No.S2, which location is roughly corresponding to Figures 3-3-1-1 to 3-3-1-3. The precise location of the reference line is shown in Figure 3-3-1-5. Comparing with the profile in October, 2006, which is before the project, the area from the foreshore to the depth of 1.5 meters is slightly eroded in September 2011. However, as explained in Figures 3-3-1-1 to 3-3-1-3, the shoreline advances about 10 meters, and the sand accumulates about 1.5 meters thick around the shoreline.



**Figure 3-3-1-5 Locations of reference lines**

Figure 3-3-1-6 shows the beach in front of the washhouse. Paying attention to the concrete wall on the back shore, the sand accumulated about 0.5 meter during about two months from September to November, 2011, which is roughly estimated by comparing the height of person standing nearby. In short, the expected sand accumulation is now taking place on the south-side beach of the jetty.



**Figure 3-3-1-6 Beach in front of washhouse**

Next, let's confirm a beach recovery in front of the Community center, which is closed to the jetty. Figure 3-3-1-7 shows the situation on the day of 4 September, 2011, that is, the beach was eroded and concrete channel for drainage was exposed, which is denoted by a red arrow. The same situations are seen on 1st October in Figure 3-3-1-8 and 14 December, 2011 in Figure 3-3-1-9. Then

there was no beach recovery until the middle of December, 2011. Figure 3-3-1-10 shows a situation on the day of 19 January, 2012. The channel, which location is denoted by a red arrow, was completely buried under the recovered beach. The beach recovery in this area was delayed about two months compared with the areas in Figures 3-3-1-3 and 3-3-1-6.



Figure 3-3-1-7 Situation in front of Community Center, 4 Sep., 2011



Figure 3-3-1-8 Situation in front of Community Center, 1st Oct., 2011



Figure 3-3-1-9 Situation in front of Community Center, 14 Dec., 2011



**Figure 3-3-1-10 Situation in front of Community Center, 19 Jan., 2012**



**Figure 3-3-1-11 Recovery of beach in front of Community Center**

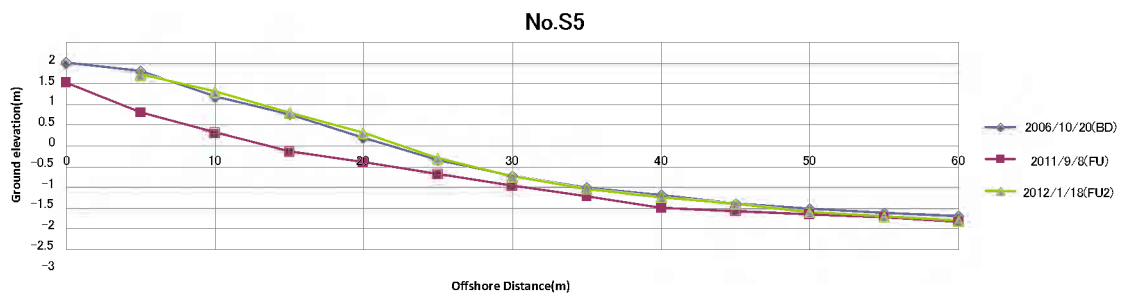
Figure 3-3-1-11 shows a comparison between the situations on 1st Oct, 2011 and on 19 January, 2012, in which we can clearly observe the shoreline advancement.



**Figure 3-3-1-12 Scour at the base of Community Center**

Figure 3-3-1-12 shows the base of Community Center. The base was scored and a stair was suspended on 4 September, 2011, while the sand has deposited in the scored area on 21 January, 2012 when the beach has been recovered.

Figure 3-3-1-13 shows changes of profile, which location is roughly corresponding to Figures 3-3-1-7 to -12, see Figure 3-3-1-5. The beach was greatly eroded during a period from October, 2006 to September, 2011. Since then, the sand has accumulated and the beach has been recovered to the original position.



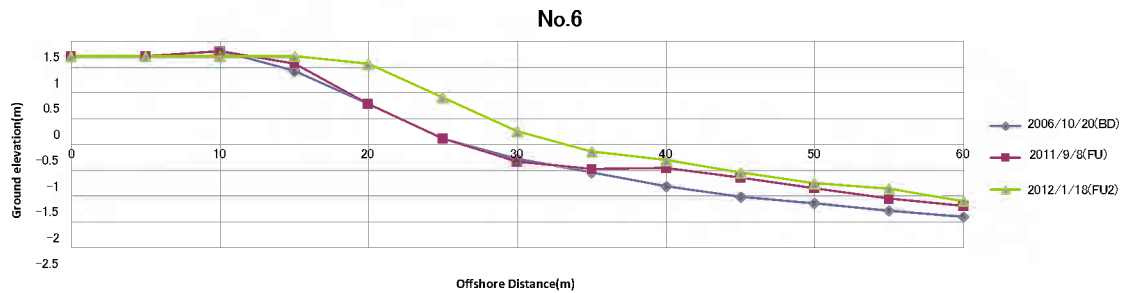
**Figure 3-3-1-13 Profile changes at reference line No.S5**



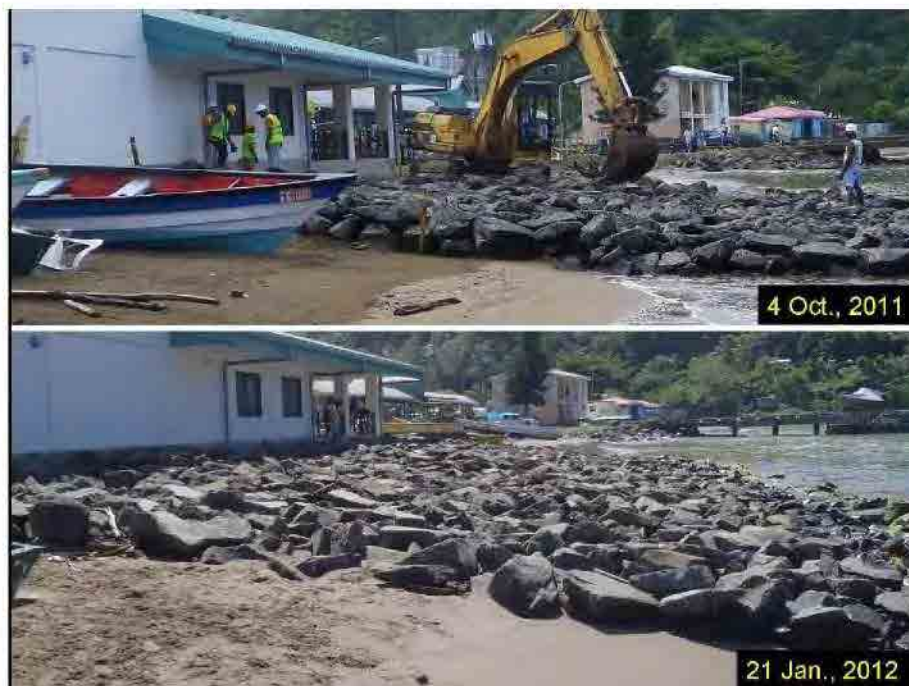
**Figure 3-3-1-14 Beach in front of Workshop**

Figure 3-3-1-14 shows the beach in front of Workshop on the days of 4 September, 2011, 12 October, 2011 and 21 January, 2012. In these pictures the small boat was set at the same place and in the same manner by chance. By referencing the boat, the scales of pictures have been adjusted. By comparing these pictures, it is understood that the shoreline, or the wet line, advanced with time.

Figure 3-3-1-15 shows the changes of profile at the reference line No.6, which location is roughly corresponding to the place where the boat was set, see Figure 3-3-1-5. The profile did not change during a period from October, 2006 to September, 2011. During a successive period up to January, 2012, the sand has accumulated about one meter thick at the elevation of zero meter, and the shoreline has advanced about 8 meters.



**Figure 3-3-1-15 Changes of profile at reference line No.6**

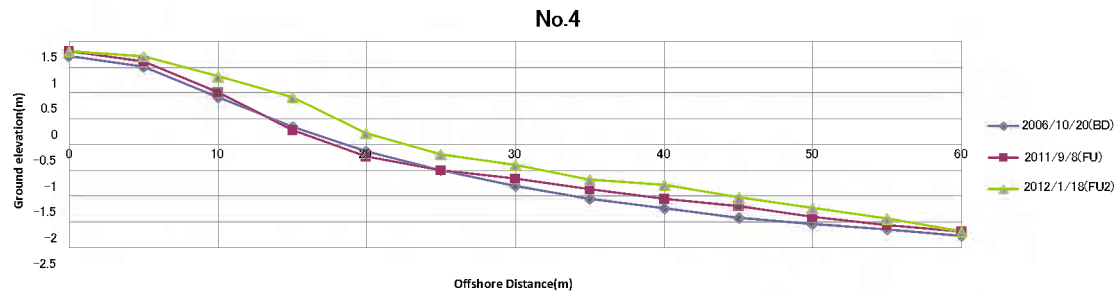


**Figure 3-3-1-16 Beach in the vicinity of the area armored with rubble stones**

Figure 3-3-1-16 shows the beach in the vicinity of the area armored with rubble stones, in front of Fisheries Complex. The upper picture was taken when the armoring works, which was 0.6 meter thick, was under construction on 4 October, 2011. In the lower picture, the thickness of armor layer became thin, being about half of initial one.

Figure 3-3-1-7 shows the changes of profile at the reference line No.4, which location is roughly corresponding to the beach in Figure 3-3-1-16, see Figure 3-3-1-5. The profile did not change during about five years from October, 2006 to September, 2011, while the sand accumulated on the beach during a successive period up to January, 2012. The extent of accumulation was about 0.3 meter thick at the offshore distance of 10 meters. Then, it can be considered that the decrease of thickness is not due to settlement of stones, but due to sand accumulation.





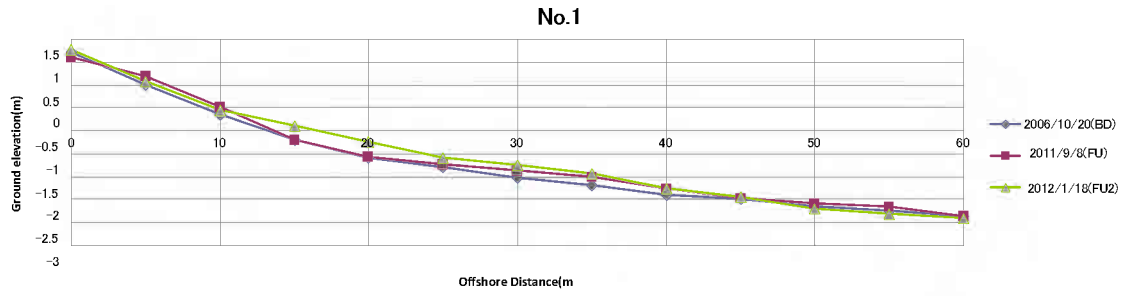
**Figure 3-3-1-17 Profile changes at reference line No.4**



**Figure 3-3-1-18 Beach condition on 21 January, 2012**

Figure 3-3-1-18 shows the wide area of beach on 21 January, 2012. As already explained, the sand accumulated on the beaches over the jetty, denoted by an arrow with A, and on this side of armored area, by an arrow with B. However, the center beach bounded by the jetty and the rubble stones' work, that is the beach in front of Vendors Arcade, was formed relatively land-side compared with the beaches of A and B. There was no sand accumulation yet when this picture was taken.

Figure 3-3-1-19 shows the changes of profile at the reference line No.1, which is located just in front of Vendors Arcade, see Figure 3-3-1-5. The profile did not change among the three times of surveying.

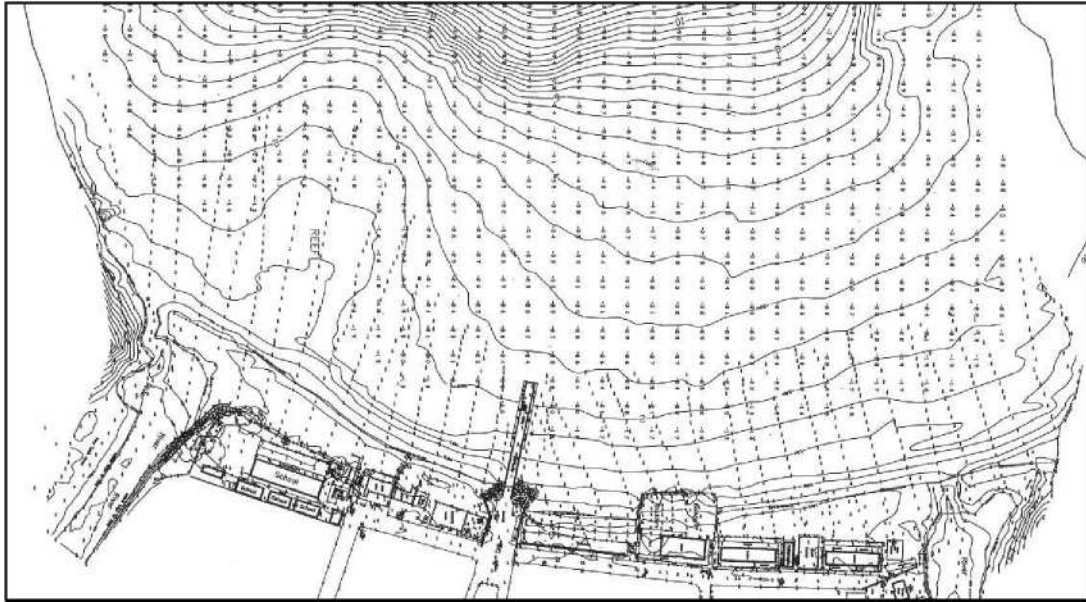


**Figure 3-3-1-19 Profile changes at reference line No.1**

Figure 3-3-1-20 shows the beach in front of Vendors Arcade on 21 January, 2012. Although the profile did not change, the rubble stones are exposed at the boundary between the foreshore and the backshore because the crown height of rubble stone laid under the beach is a little bit high. Anyway, as the exposed rubble stones make the people away from the beach, it is desirable to improve this situation.



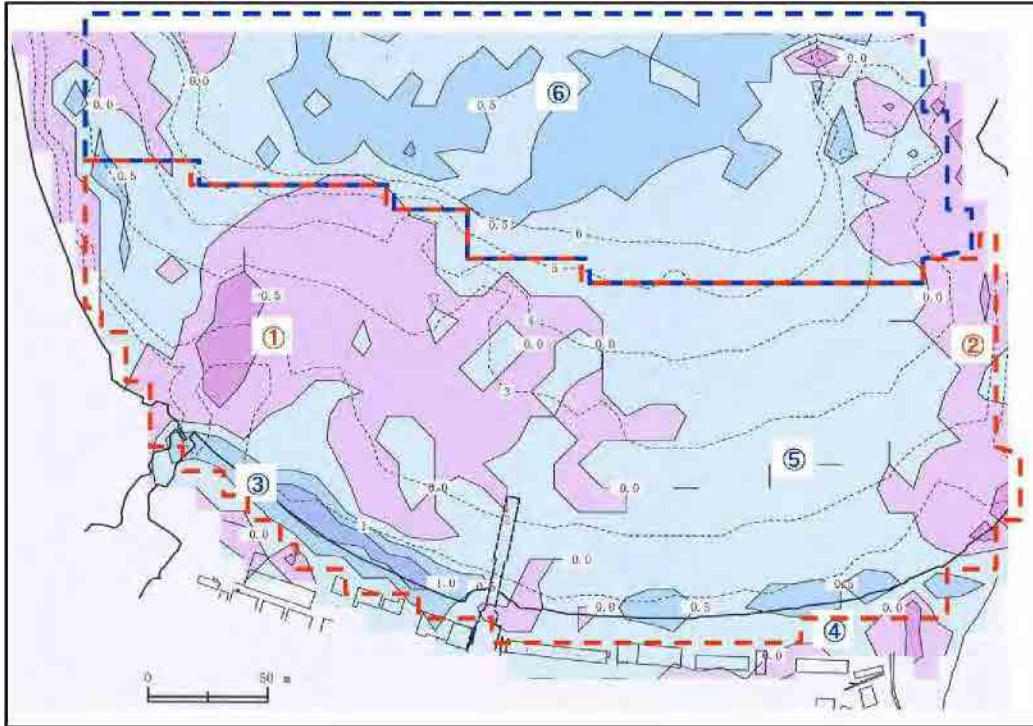
**Figure 3-3-1-20 Beach in front of Vendors Arcade**



**Figure 3-3-1-21 Contour map, 18 January, 2012**

Figure 3-3-1-21 shows the contour map, surveyed on 18 January, 2012. Figure 3-3-1-22 shows a topographic change from 8 September, 2011, which is shown in the upper figure in Figure 3-2-2-1, to 18 January, 2012. The contour lines are corresponding to the topography in October, 2006. Paying attention to the eroded area denoted in red, there are two large areas, that is to say, the area ① expanded from the river mouth to the jetty and the area ② close to the coastal cliff shown in Figure 3-1-2-4. The erosion occurred in the areas shallower than about 5 meters. In the area ①, the river mouth terrace, which was formed with the sand supplied by the floods, was scraped by the action of waves. It can be considered that the removed sand were transported both in the onshore direction to the area ③ and in the offshore direction to the area ⑥ and deposited in these areas. The sand deposited in the deeper area ⑥ will not be transported to the beach by the incident waves because the water is deep. In other words, the sand in the area ⑥ does not contribute to the recovery of beach. On the other hand, in the area ②, the erosion occurred also in another period from October, 2006 to September, 2011, see Figure 3-2-2-4. There may be a long-term trend of erosion in this area.

Next paying attention to the accumulated area in blue, the major accumulation is seen around the shoreline on the south-side beach of the jetty, which area is denoted by ③. It is inferred that the sand was transported to there from the area ① in front. The sand accumulation around the shoreline occurred also on the north-side beach of the jetty, denoted by ④, but the volume was less than in the area ③. It is very hard to guess where the sand was transported from. There are three possibilities, that is, the sand supplied from the smaller river located at the north-end of beach, from the eroded area ② or/and from the area ⑤ where the sand has deposited thinly but widely.



**Figure 3-3-1-22 Topographic change from 8 September, 2011 to 18 January, 2012**

Figure 3-3-1-23 shows the volumes of topographic changes in the area shallower than about 5 meters, which area is surrounded by a broken line in red in Figure 3-3-1-22, and in the deeper area surrounded by a broken line in blue. The volumes are expressed in values relative to the topography on 20 October, 2006. The volumes of sand accumulation up to September, 2011 were 13,000m<sup>3</sup> in the shallower area and 18,000m<sup>3</sup> in the deeper area, being 31,000m<sup>3</sup> in total. As already explained, these accumulations were due to the floods in May, 2009 and in October, 2010. The volumes of sand accumulation increased furthermore up to June, 2012. The increments during about four months from 8 September, 2011 to 18 January, 2012 were  $\Delta s = 5,000\text{m}^3$  in the shallower area and  $\Delta d = 11,000\text{m}^3$  in the deeper area, being  $\Delta T = 16,000\text{m}^3$  in total.

The reason why the sand increased in the recent period is because of sand supply from the river. Owing to a large quantity of rainfall due to the Hurricane Tomas, large and small scale hillside landslides took place all over Saint Lucia. At the time, large amount of sand was transported to the bay through the river by flood. However, it can be guessed that a large volume of sand is still remained in the upper reach of river. For example, Figure 3-3-1-24 shows the existence of sand on the bed in the river flowing into the bay at the south-end of the beach in the Anse La Raye. It is considered that such remaining sand was transported to the bay during the rainy season of four months from September, 2011 to January, 2012. It is expected that such remaining sand gradually transported to the bay from now on.

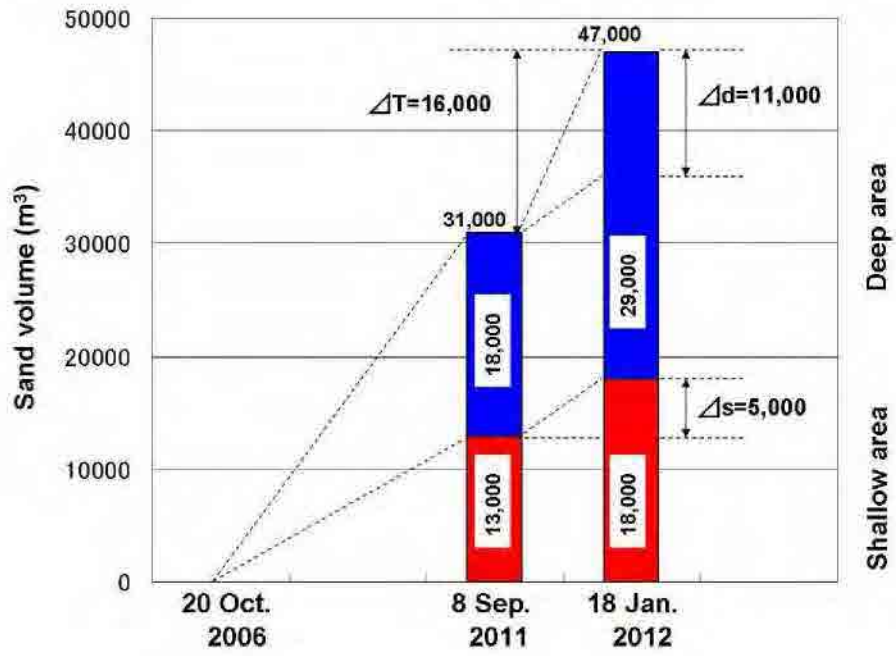


Figure 3-3-1-23 Volume of topographic changes in shallower and deeper areas

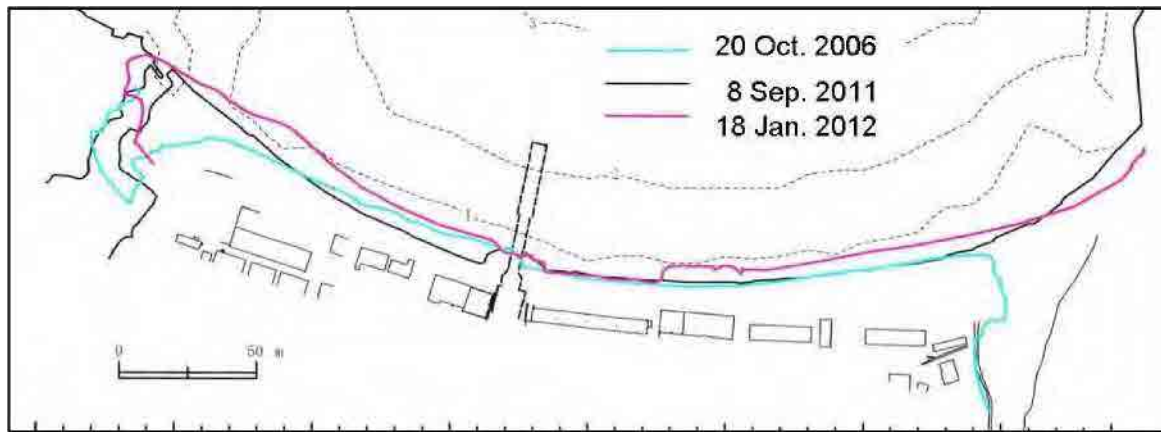


Figure 3-3-1-24 Deposition of sand in the river, 11 September, 2011

### 3-3-2 Prediction of shoreline changes by numerical simulation

Figure 3-3-2-1 shows the changes of shoreline based on the contour maps. The latest shoreline has advanced at the both sides of beach, while it has not changed at the beach in front of Vendors Arcade. The shoreline seems to have advanced at the place in front of Fisheries Complex. It do not, however, it is due to the construction of the rubble stones works.

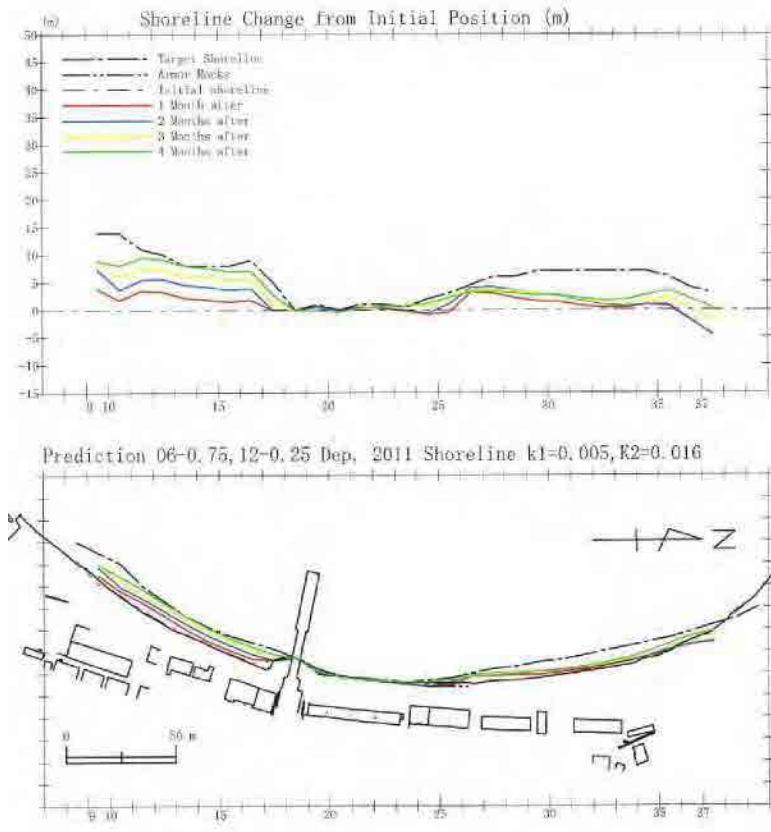
First of all, the shoreline change in four months from September, 2011 to January, 2012 is reproduced by a numerical simulation of a one-line theory. After confirming the reproducibility, the shoreline position is predicted for 5 years in the future, by setting the shoreline location on September, 2011 as an initial boundary condition.



**Figure 3-3-2-1 Actual shoreline changes**

Figure 3-3-2-2 shows the result of reproduction of shoreline change. A chain line in black is the shoreline in January, 2012, which is the target of reproduction. By inspecting rates of shoreline changes in the upper in Figure 3-3-2-2, it is known that the shoreline starts to advance from the beginning on the south-side beach of the jetty (X-axis: 10-17), and it reaches to the target shoreline position in four months. However, it starts to advance 2 to 3 months late at the place close to the jetty (X-axis: 17-18). These calculated changes are similar to the situations in the field which have been explained.

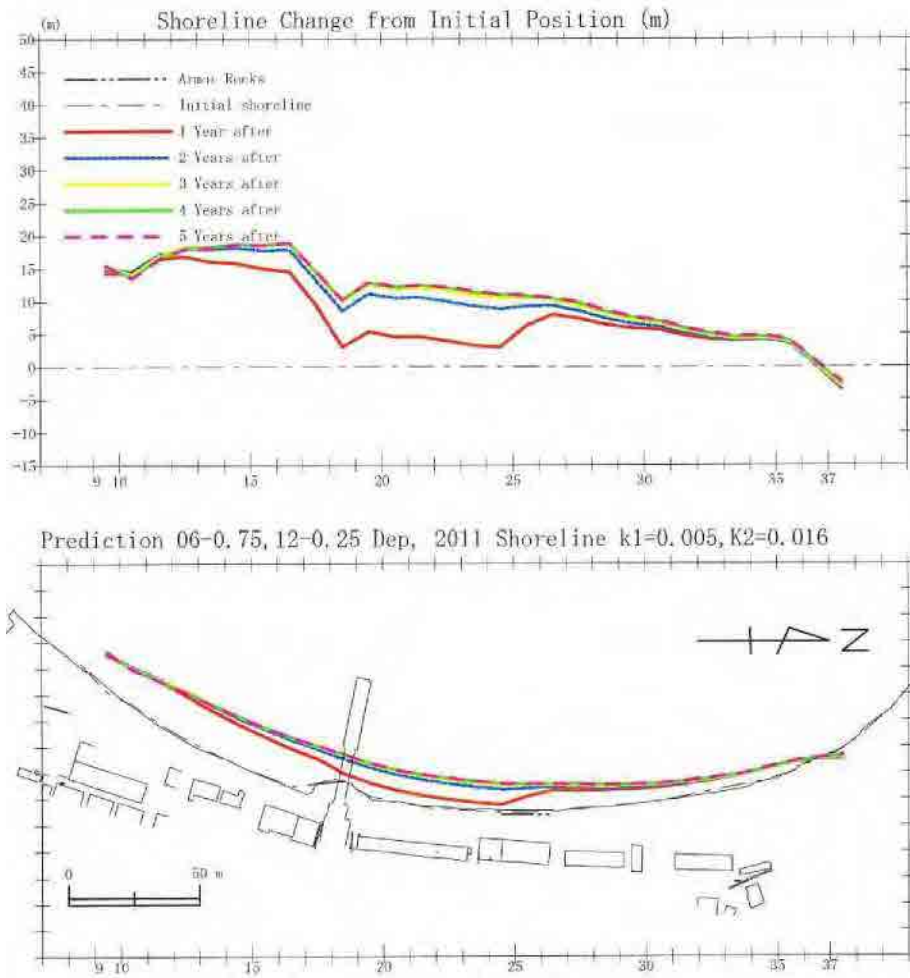
Furthermore, the shoreline does not change on the beach in front of Vendors Arcade, which is also similar to the situation in the field.



**Figure 3-3-2-2 Result of calculation for reproduction, for a period from September, 2011 to January, 2012**

Although the shoreline advanced more than 5 meters in the field on the north-side beach of the armored area (X-axis:28-35), a rate of shoreline advance is not enough in the calculation. Several means are possible to be applied only for increasing the reproducibility of shoreline change in this area. However, it is meaningless to do so without understanding where the sand comes here from, it is rather dangerous sometimes. Therefore, it should be interpreted that the precision of prediction for shoreline changes is not good in this numerical simulation, on the north-side beach of armored area.

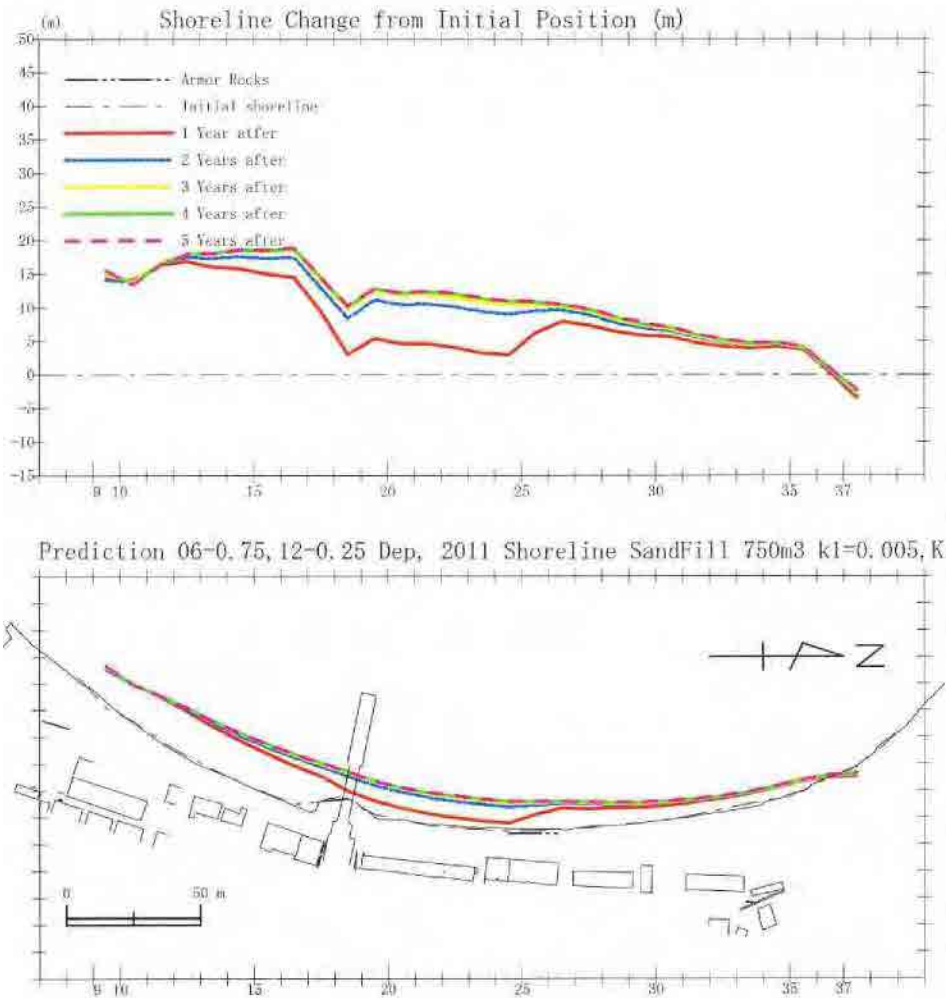
Figure 3-3-2-3 shows the predicted shoreline for 5 years in the future. It is assumed in the prediction that the sand volume supplied from the shallow area to the beach is largest in the first year, which decreases with year during 5 years, being 7000m<sup>3</sup> in total. The total volume of sand supplied to the beach is about 54 percent of sand accumulated in the area shallower than 5 meters, being 13,000m<sup>3</sup>, during a period from October, 2006 to September, 2011, see Figure 3-3-1-23. On the south-side beach of the jetty (X-axis:10–17) the shoreline advances about 18 meters in the end. Although the shoreline advance is very small in the first year, which is denoted by a line in red, on the beach in front of Vendors Arcade, it advances about 12 meters ultimately. As a result, the shoreline configuration is smoothly curved after 5 years as seen in the lower in Figure 3-3-2-3. As the beach in front of Vendors Arcade is well used by the residents and tourists although its width is very narrow, it is desirable to be recovered as early as possible. It can be recommended that the formation of wide beach is promoted by an artificial assistance from the view points of disaster prevention, utilization and environment.



**Figure 3-3-2-3 Result of prediction, in the present state with no sand-fill**

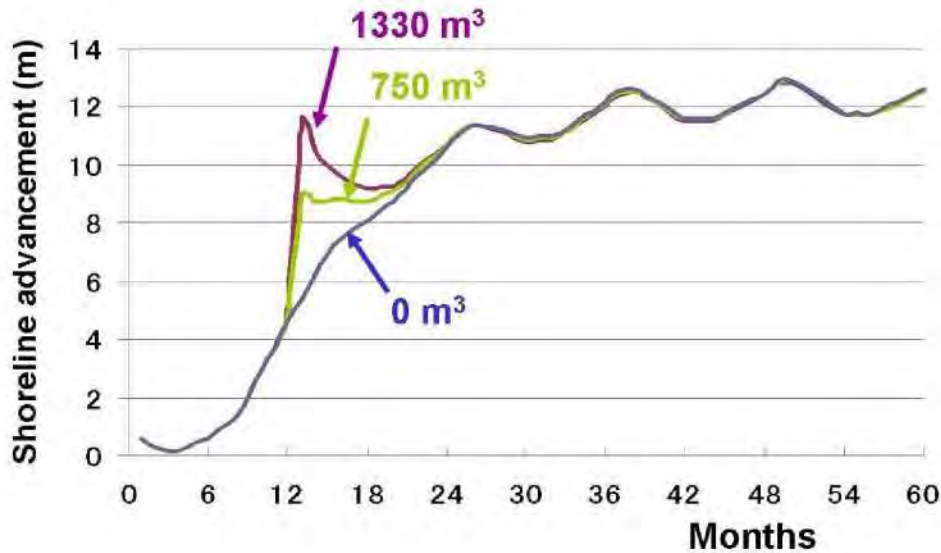
As one of artificial assistances, the sand of 750m<sup>3</sup> in volume is mined from the south-side beach (X-axis:10 and 11) and it is filled artificially on the beach in front of Vendors Arcade (X-axis:20-22), of which effect is examined by the numerical simulation. The sand-fill of 750m<sup>3</sup> in volume makes the shoreline advance about 4meters. A time of execution is in September 2012, which is one year after the start of simulation.





**Figure 3-3-2-4 Result of prediction, with sand fill of 750m3**

Figure 3-3-2-4 shows the predicted shoreline for 5 years in the future. By comparing it with Figure 3-3-2-3, it becomes very difficult to detect differences between these two predicted results at the places of sand-mining and sand-filling. Then, the shoreline changes at the beach in front of Vendors Arcade (X-axis: 21) are compared among three cases of sand-fill with 0m<sup>3</sup>, 750m<sup>3</sup> and 1330m<sup>3</sup> in Figure 3-3-2-5. After a lapse of 12 months, or one year, the sand is put on the beach, which makes the shoreline (green-line) advance about 4meters more. The resultant shoreline position is at 9 meters. The shoreline does not change, being stable for a while. After a lapse of another 12months, or 24 months in Figure 3-3-2-5, the shoreline with on sand-fill (blue-line) catches up with the shoreline of green-line. Since then, both shorelines advance together. In short, we can widen the beach at the early stage by a small amount of sand-fill. Although the sand-fill of 1330m<sup>3</sup> in volume makes the shoreline (red-line) advance up to 12meters temporarily as seen in Figure 3-3-2-5, the shoreline recedes gradually and reaches the same position as that of shoreline (green-line) with shad-fill of 750m<sup>3</sup> at the time of 24 months. In other words, a part of sand put on the beach is lost, which means that the excess volume of sand-fill is ineffective and uneconomical.



**Figure 3-3-2-5 Shoreline changes with the sand fill at the beach in front of Vendors Arcade**

Finally, a precision of numerical simulation carried out here is mentioned. As a precision of numerical simulation is generally judged based on a degree of reproducibility, it is a case-by-case. This time, the target of reproduction is the shoreline change in about 4 years, and prediction is done for 5 years in the future. In other words, a time scale of 4 months in the initial stage is extrapolated to a long term of 60 months. Although the reproducibility is good in 4 months, especially at the beaches of south-side and in front of Vendors Arcade, we cannot deny the possibility that a small difference is expanded in a process of extrapolation. Furthermore, there are several assumptions which may have effects on the rate of shoreline change in prediction, such as

- \* The sand transport rate from the shallow area to the beach is 7000m<sup>3</sup>, although its appropriateness is considered to be high,
- \* No abnormal meteorological phenomena such as Hurricanes occur during the term of prediction,
- \* The sea bottom topography does not change, that is to say an annual situation of wave incidence is repeated every year without changing, during five years.

Therefore, although the results of prediction are explained quantitatively in this report, for example that is “advance of 8 meters”, properly speaking the explanation must be done with a qualitative interpretation. If we continue to monitor the beach processes in situ up to 24 months for instance, by utilizing the data obtained we can check the result of prediction such as shown in Figure 3-3-2-5 and improve a precision of prediction. A continuous monitoring on beach processes is strongly desired.

### **3-4 Mechanism of beach erosion in the Anse La Raye Bay**

#### **3-4-1 Basic understanding of beach processes in the Anse La Raye Bay**

The Anse La Raye Beach is a pocket beach of about 300 meters long, which is formed by the sand supplied from the two rivers at the both ends of beach. A rate of sand supply from the river at the south end is larger than that of another one. Predominant sand supplies from the rivers occur when hillside landslides and floods take place due to the event of extremely heavy rain. The occurrence of big event is not in every year, but whimsicality. Its interval is usually more than 10 years. As sand supplies from the rivers are a little during a period of two big events, the shoreline recedes gradually until the time when a next big event occurs.

It is inferred that the last big event might occur in 1970s in Anse La Raye, which might supply a large amount of sand to the bay. Since then, a big event did not occurred, and shoreline receded with a constant speed of about 0.6 m/year during more than 30 years. Under this situation, the fishery facilities have been constructed at the place close to the beach. On the day of 30 October 2010, the beach was eroded by the waves due to the Hurricane Tomas, and was eroded further by large waves during about one successive month. As a result, the erosion reached up to the base of Fisheries Complex.

The erosion at the base of Fisheries Complex was considered to be very serious condition because there was a long-term trend of beach erosion. Then, the beach in front of Fisheries Complex has been armored with rubble stones as an urgent countermeasure in order to prevent further erosion. At the same time, the field research has been carried out to make a plan for a middle-term countermeasure.

As a result of research, it is cleared that a large amount sand has been supplied to the bay two times when the large flood occurred in May 2009, and when the Hurricane Tomas attacked this site. In short, two big events occurred successively. A part of sand deposited on the sea bottom in front of the river mouth is transported gradually to the beach, and the shoreline advances gradually. According to the beach monitoring during a period from September 2011 to January 2012, there is a clear sign which show the beach recovery with the advance of shoreline.

#### **3-4-2 Necessities of a middle-term and a long-term countermeasures and problems to be solved**

##### **(1) Necessity of middle-term countermeasures and the subjects to be solved**

By assuming that large hurricane does not come, the shoreline changes are predicted for 5 years in the future by the numerical simulation. The result of prediction shows that almost all area of the beach recovers gradually. However, it is hard to deny the possibility of the occurrence of large hurricane within 5 years. As the beach has been being continuously eroded in the past more than 30 years, it has not much endurance. If the large waves attack the beach under this situation, the abrupt erosion occurs temporarily. It reaches possibly to the fishery facilities, which themselves maybe are broken. Even if not so, the reflected waves by the facilities prevent the beach recovery. Then, it is necessary to take countermeasures against the attacks of large waves.

1) The subjects at the beach in front of Vendors Arcade

At present the width of beach is the narrowest, and the speed of recovery is the slowest in this beach. The sea water flowed over the concrete floor of Vendors Arcade several times when the large waves attacked this site, which did not damage the facilities so far because Vendors Arcade is the facility of very simple structure without walls. However, by accepting these facts of over flowing seriously, it is necessary to take countermeasures against the attacks of large waves especially due to a hurricane. The beach is utilized not only for keeping boats on it by fishermen but also for having a peace of mind by tourists. However, the buried stones are exposed partly at the backshore at present, see Figure 3-3-1-20, which reduces the beach qualities of utilization and spectacle. The countermeasures which include the consideration for all of these issues are required.

2) The subjects at the beach in front of Fisheries Complex

The crisis state has been improved by armoring the beach with the rubble stones in October 2011. This countermeasure has a function mainly for the prevention of disaster because it was an urgent requirement and the chronic beach erosion was considered to continue in the future. However, the field research conducted this time has revealed that the shoreline advances gradually from now on. Then, the countermeasures which include the consideration for all of these issues are required also at this beach.

3) The subjects at the beach in front of Fishing Gear Lockers and Workshop

Although the width of beach is relatively wide and the shoreline is advancing at present, it is unknown where the sand is transported from. The precision of numerical simulation is not good at this beach. The trend of shoreline advance is not to be accepted at its predicted value. Furthermore, now there is no facility for protecting the fishery facilities. Then, the countermeasure is required for the worst, so to speak a bulletproof jacket under a suit.

4) The subject at the south-side beach of the jetty

The shoreline has advanced more than 10 meters in January 2012, comparing with that of October 2006. It can be judged that the beach is wide enough against the attack of large waves. Now, there is no subject to be solved.

**(2) Necessity of long-term countermeasures and the subjects to be solved**

The beach is preserved by the big event which is a large amount of sand supply from the rivers due to the extremely heavy rain. If the big event occurs with a temperate interval, being 10 to 20 years for instance, the beach is continuously preserved. Without the big event for many years longer than temperate interval, the beach is eroded gradually. The actually recession of shoreline was 0.6m/year in the past more than 30 years. Unfortunately, the present technology cannot predict when a big event occurs.

Therefore, to monitor the beach process regularly is the most basic and important. Based on the result of monitoring, it is necessary to take a countermeasure ahead of time, by taking well into

account the national plans. According to the present national plans, it is necessary also in the future to work out a countermeasure against the disaster by considering the utilization, the spectacle and the environment of beach.