Australian Government

Australian Centre for International Agricultural Research

Final report

Small research and development activity

project	**Investigating the Long-line nursery system for Giant Clam (Tridacdna sp.) farming in Savusavu Bay, Fiji**
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Contents

1 Acknowledgments

We thank Joji Vuakaca, Principal Fisheries officer (PFO), Department of Fisheries (DOF) of Northern Region for his part in granting permission to J. Hunter Pearls Limited to source from Tikina Na Savusavu waters (Traditional Fishing Right grounds) for collection of giant clam brood stock, *Tridacdna noae* (T. noae) in close proximity of the hatchery. We acknowledge the Department of Fisheries for allowing the use of T.derasa brood stocks from the Fisheries Research Station at the Makogai facility for use in the hatchery breeding. Similar expression of gratitude is expressed to Ratu Jone Maivilli who has a pearl farm in the Tikina Wailevu Province for being supportive to the project by allowing their private water front area to be used for safe keeping of T. noae brood stock as well as agreeing to use his collection of T. gigas brooders. We also express gratitude to Bart Simpson, General Manager of Jean Michelle Cousteau Resort for allowing the use of T. derasa brood stock originally obtained from the Department of Fisheries Makogai research facility. Bart Simpson showed a keen interest in the mariculture of giant clams and has been very supportive to the project by allowing collection of brood stock from the reef adjoining the resort.

We particularly thank J. Hunter Pearls Limited hatchery technicians, Sachin Deo and Atish Kumar for demonstrating professionalism and a high degree of competence through the course of the hatchery runs. Their generous friendship and communications for exchange of knowledge of blacklip oyster and giant clam culture is highly appreciated and valued.

2 Executive summary

The J. Hunter Pearls (Fiji) Limited, has been in the Pearl industry since year 2000. The high demand for giant clam products in the Marine Aquarium Ornamental Trade and International Sea food Market has prompted J. Hunter Pearls Ltd to expand its operations and diversify into giant clam mariculture to contribute to the development of the commercialization of the Giant Clam industry. Depending on the giant clam species it takes three years or more to reach food market size. This project, FIS/2015/028, set out to investigate the long – line nursery system for Giant Clam (Tridacdna sp.) farming in Savusavu Bay, Fiji. The selection of the long - line method is based on the French Polynesia experience of giant clam spat fall on pearl collectors and pearling floats. The company intends to thoroughly investigate and trial a proposed hatchery and nursery phase using a number of various substrate materials and timelines in order to establish a commercially viable practice using the long - line nursery system currently employed for the black lipped Pearl Oyster.

The upgrading of the hatchery facility was completed with establishment of two raceways now operating as the land - based settlement raceways each with base area of 15m^2. Seven different types of substrate materials were used to entice juvenile larvae to settle in the raceways. These materials were Oyster spat collectors, Christmas tree collectors, Concrete slabs, Organic copra bag, blacklip pearl shells and artificial turf materials with long and short bristles.

Giant clam brood stock, Tridacdna noae (T. noae) were collected from Tikina Na Savusavu reef waters adjacent to the J. Hunter Pearls hatchery. The brood stocks were adapted to the hatchery and spawned in August and December 2015 respectively. The larval rearing method used was a modified version from the methods described in the giant clam culture manuals by Heslinga et al 1990, Braley, R.D. ed., 1992, combining it with the methodologies applied at the J. Hunter Pearls hatchery for blacklip oyster larval rearing protocols in the Savusavu facility. Larvae from these spawning were reared in the hatchery and enabled trials to be conducted on the settlement of larvae on different substrate types and growout on the long - line system.

Mortalities of giant clam brood stocks in captive tanks posed challenges for seed production. Managing feeding regime, types of food provided and frequencies of providing supplementary feed were measures taken to control and reduce brood stock mortality in the tanks. In the hatchery improving symbiosis relationship between zooxanthellae and larvae is still a major challenge since low percentages of larvae are taking up zooxanthellae.

The observation of the first trial on the settlement of juvenile clams on different substrate types after three months of grow out showed that in the land base raceways three types of the substrate failed to attract larval recruitment. Four other substrate types presented varying degrees of settlement recruitment with short bristles artificial turf showing the highest rate. The Ocean nursery long - line showed similar result as in the raceways. Turf substrates showed better results than the rest of the other substrate types. Copra sacks showed the poorest result since they disintegrated. In December 2015, the second trial of an estimate of 9.5 million larvae was settled to carry out further investigations for other objectives.

The investigations in relation to the use of different substrate types to attract recruitment demonstrated that giant clam juveniles have potential to settle on certain substrates. Further experimentation is required to elucidate substrate types that provide high survival and fast growth rates of giant clams.

Unfortunately all trials were abruptly terminated by cyclone Winston therefore definitive conclusions could not be reached on most of the objectives we set out to achieve. Cyclone Winston impacted the project enormously. The J. Hunter Pearls hatchery building and its contents were destroyed to irreparable state especially the larval rearing tanks. The land base tanks where newly settled juvenile giant clams were raised had been washed away by strong waves. Giant clam brood stocks maintained in tanks were also washed away.

3 Introduction

Giant clams of the family Tridacnidae are one of the most comprehensively studied marine organisms attracting enormous attention from researchers, conservationists and mariculturists because of its thought - provoking biology, high value in the sea food market and shell trade especially in the Asian markets. For a long period, giant clams have been recognised as one of the marine resources commodity that can provide and supplement livelihoods and food security for the people in the Pacific Islands Countries (PIC's). Initial mariculture of giant clams has concentrated on growing adductor muscles for the food market favouring culture of larger species, T. gigas and T. derasa, Timothy P. Foyle et al 1996. The culture of giant clams for the food market never motivated the private sector for the commercialisation of the research results because it was not economically feasible to invest in an operation to wait for five to seven years to achieve the size of adductor muscle required to supply the market. However, interest in the marine aquarium trade has proven the culture of giant clams can be beneficial to rural communities of the Pacific Island Countries since the Tridacna products can be sold at a much smaller size. These stimulated the culture of T. maxima, T. crocea and T. squamosa. The iridescent colours and spectacular patterns of the mantle found in the smaller species are desired characteristics in the aquarium trade while restaurants in Asia treat giant clams as a delicacy, Miguel et al 2012, Anthony M. Hart et al 1998. Early studies showed good results of high survival and fast growth rates of giant clams when transferred to ocean nurseries (Saqauata, 1994; Foyle et al 1995), to date the mariculture of giant clams have failed to produce sufficient quantities of giant clams to supply the demand of the International sea food market.

This SRA supported J. Hunter Pearls Ltd to address and fine tune important issues surrounding the development of giant clams for high survival and growth rates at various culture stages by using a number of different grow-out methodologies. The survival rates of giant clams starting from hatchery through to land - based nursery and up to the Ocean nursery fluctuates with changing environment factors and between species. In particular the Ocean nursery culture of giant clam is tested to apply different approaches including Long-line, Sea bed enclosures, Seed floats, Floating nursery and Trestle systems. Such approach to giant clam culture is essential to transfer juveniles from land - based raceways as early as possible to increase quantity and improve quality of the products to meet the demand of the international market.

The J. Hunter Pearls Ltd identified a new avenue with a high demand for giant clam products in the lucrative international seafood market. The company has the potential to enter the growing market through innovative approaches to farming and marketing strategies.

In this SRA, the Department of Fisheries of the Ministry of Fisheries and Forestry is the collaborating partner to create new industries in the Fijian economy that will enter potential niche markets in the aquarium, ornamental and food trades. It is envisaged that through this collaborative work J. Hunter Pearls Ltd will enter into different facets of giant clam mariculture. That is to support communities to participate in giant clam conservation through restocking of reefs. Looking beyond Fiji, J. Hunter Pearls Ltd envisage supplying juvenile giant clams to Pacific Island Countries in order to support conservation efforts. At the same time J. Hunter Pearls Ltd will accumulate brood stock of various species of giant clams to preserve genetic pool.

When this SRA was still progressing there were confirmed reports that tonnes of giant clam shells from the wild harvest were bought for international export from a nearby town, Labasa, Fiji. This action by oversea buyer(s) is renewed assurance that there still exists a high demand for giant clam shells in the international shell trade.

4 Objectives and deliverables

This SRA addressed hatchery and nursery phases both in the Land - based and Ocean nurseries of the giant clam culture aimed at establishing a viable commercial system that will work at optimum levels at the current location in Savusavu bay. This work was founded on the investigation features as follows:

1. Conduct a scoping exercise to refit and setup with the assistance from Cletus Oengpepa, the current hatchery with the relevant equipment (i.e., raceways, water systems etc.).
2. Investigate and compare settling rates of Giant Clams on various substrate types
3. Conduct and compare hatchery runs using raceway systems vs ocean-based nursery systems at varying timelines.
4. Investigate the growth rates of juvenile clams using the ocean-based long - line method vs the land-based raceways.
5. To establish a commercially viable nursery system.

See Appendix 2: Activity summary

4.11 Scoping Study for FIS/2015/028

Through collaborative team effort and networking between the Director of the J. Hunter Pearls Ltd and Mr. Cletus P Oengpepa the design of raceways, water reticulation and aeration systems were accomplished and two concrete raceways were built. The J. Hunter Pearls hatchery is located at 16°48’33.77”S and 179°26’24.91”E. The hatchery required two raceways to operate as the land - based settlement raceways with base areas of 15m^2 each. The raceways were fitted with overhead sea water reticulation system connecting to the main hatchery pump supplying filtered sea water. Similarly air supply to the raceways was connected to the main aeration pump to provide air. A shade cloth with 75% shading factor was used to cover the roof of the raceways to provide shading to reduce heat from the sun. Mr. Cletus Oengpepa made two trips to Savusavu, Fiji, in August and December 2015 where the J. Hunter Pearls hatchery is located.

See Appendix 3, Itinerary for Cletus Pita Oengpepa to travel to Savusavu to attend to SRA activities.

Fig 1: Newly built raceways at J. Hunter Pearls Hatchery

4.12 Investigate and compare settling rates of Giant Clams on various substrate types

One of the constraining factors in the giant clam culture is the retention period of six to eight months (in some settings it can be as long as one to three years) of larvae culture in the land - based nursery. It is acknowledged that depending on the species of the giant clam the shell length achieved during the land - based nursery ranged between 18mm to 25mm during this period. In terms of production cycle such a long waiting period limits the number of runs that can be achieved in one year. When land - based nursery operations are maintained for a longer period tanks or raceways maintenance become critical as fouling algae begin to establish. Subsequently survival and growth of the clams is affected leading to low survival and slow growth rates. Therefore it does not favor giant clam culture as an economically viable operation. This section of the giant clam operation is also the most expensive since machineries are applied and maintained for twenty-four hours to supply sea water and aeration for the duration of the nursery period.

To improve the land - based nursery retention period the J. Hunter Pearls operation endeavored to investigate employing different substrates as an alternative method to attract settlement of juvenile giant clams with the intention to transfer them to the Ocean nursery as early as possible. The seven substrates used include; Blacklip oyster shells, Oyster spat collectors, Christmas tree collectors, Concrete slabs, Organic copra bag, and artificial turf materials.

At the J. Hunter Pearl hatchery in August of 2015, an estimated 1.2 million juvenile T. noae giant clams at Day 10 were transferred to the raceways containing different substrates to induce them to settle. Two weeks after half of the substrates were transferred to long-lines in the pearl farm site while the other half was maintained at the raceways. After three months of submersion on the long - line, the panels were brought back to land - based for observation of the settlement. Again in December 2015 two cohorts of 8.2 million and 1.2 million juvenile T. noae giant clams were transferred to settlement raceways.

Fig 2: Samples of Substrates for attracting larval settlement, A=Christmas tree, B=Copra Sack, C=Artificial Turf, D= Blacklip oyster spat collector

4.13 Comparison of Hatchery runs at raceways vs Ocean–based nursery systems

To compare the hatchery runs at raceways and the ocean nursery systems two methodological approaches were considered. In the first approach juvenile giant clam larvae that were settled in different substrates as described in section 4.12 were transferred directly to the long-line grow-out system. These substrates were maintained in the long-line system for three months. In the second approach, the nursery grow-out was designed to have 33% of the juvenile larvae settled in different substrates to go through an intermediate grow-out stage through application of Seed float (Fig. 5) while the other 33% to go directly to the long - line grow-out in the pearl farm and the final 33% to be maintained in the land - based raceways.

Fig 3: Seed float for intermediate grow-out for juvenile larvae

4.14 Investigate the growth rates of juvenile clams using the ocean-based long - line method vs the land-based raceways

To investigate the performance of juvenile giant clams cultivated at the ocean nursery long–line system and land base nursery raceway system in relation to survival and growth rate, juvenile giant clams were attracted to settle on seven different substrates. The thirty-two substrates were divided into two groups with 50% deployed in the long-line system while the other 50% were retained in the raceway at the land - based nursery. After three months of grow-out (September to December) substrates from the long-line grow-out site were brought back to the land – based for observation. At this age giant clam juveniles were beginning to become visible but then again quantitative assessment of growth require further two months period of grow-out.

4.15 To establish a commercially viable nursery system

The strategical approach to establish a commercially viable system is to: (1) apply the results of the investigations that show best grow-out methods with high survival and growth rates. Depending on the environmental conditions different sites will utilise the best suitable grow-out method. (2) Following on the investigations Google earth mapping system will be applied to identify all possible suitable sites around and near Savusavu. (3) A physical survey will be conducted for sites identified by Google earth map to assess environmental parameters such as current flow, temperature, salinity, wave actions, tidal variations, corals status and farmers accessibility to the sites. At the same time the concept of giant clam farming to the communities close to the suitable sites introduced. When juvenile giant clams of T. noae reach the shell size range of 18mm-25mm, they are robust enough to go into different grow-out nurseries in the communities. (4) The giant clam grow-out will continue on the long-line while work to enter the community farming system begins. The community giant clam farming system will involve training on farming husbandry, methods of grow-out comprising of long-line, seed floats, benthic enclosures, trestles and construction of farming implements for the ocean nursery.

Fig 4: Substrates in the raceway prepared for the transfer of T. noae larvae from the hatchery.

5 Brood stock Collection, Conditioning, Spawning and Larval Rearing

5.11 Brood stock Collection

Giant clam brood stock, Tridacna noae (T. noae) used for spawning during the period August 2015 were collected from Tikina Na Savusavu waters (Traditional Fishing Right grounds) fringing coral reef in front of J. Hunter Pearls hatchery. Thirty - two T. noae brood stocks were collected for this particular hatchery run. For the December 2015 giant clam hatchery run, more than sixty T. noae brood stocks were collected from the same Tikina Na Savusavu reef. Twelve T. derasa brood stocks were also brought from the Department of Fisheries Research station at Makogai Island. T. derasa brood stock from the Jean Michelle Cousteau resort originally obtained from the Department of Fisheries Makogai research facility were also brought to the hatchery. Sixteen *T. squamosa* brood stocks were collected from the barrier reef at Jean Michelle Cousteau resort and were taken to the resort for safe keeping. *T. Squamosa* were not spawned but considered for future activities.

The intention of J. Hunter Pearls hatchery to start accumulating giant clam brood stocks in one central place holds many advantages. It would allow the development of better brood stock management and create a brood stock pool to supply giant clam larvae through out Fiji and the neighbouring Pacific Island Countries for restocking and conservation purposes.

Fig 5: *T. noae* brood stock and Tikina Na Savusavu water area of brood stock collection

5.12 Brood stock Preparation, Conditioning and Spawning

Brood stock flutes were cleaved off using metal tools such as hammer and chisel and cleaned using pressurized sea water to remove fouling bio-growth on the shells. The spawning attempts were conducted applying the thermal stress method. The thermal stress process involved dry stressing the brood stock by placing them on their side for 20-30 minutes on the concrete slab but away from the direct sun light. The process was followed by submerging the clams in the tub or bucket of sea water while slowly elevating the temperature of sea water to achieve a temperature difference of 2˚C to 5˚C from ambient temperature. This process was repeated until the brood stock started to release gametes. In the December 2015 spawning, thermal stress were conducted by dropping the ambient temperature using ice cubes to achieve a difference of 2˚C to 5˚C. In both spawning occasions (August and December 2015) gonad extract was also used in combination with the thermal stress to stimulate release of gametes. Individual spawning sperm are allowed to release gamete in containers to stimulate other brooders. When eggs are released, individual clams are placed in separate buckets for fertilization of eggs with sperm.

Parental brood stocks were kept in the tanks supplied with seawater and aeration. Each morning and afternoon brood stocks were fed with mixture of algae that were identified and grown for pearl oyster needs.

5.13 Larval Rearing and Settlement

The giant clam larval rearing protocol used in the hatchery run was slightly modified from the methods described in the giant clam culture manuals by Heslinga et al 1990, Braley, R.D. ed., 1992) applying with the methodologies developed by private sector hatcheries in bivalve molluscs. Counted fertilized eggs were stocked in the incubation and hatching tank prepared a day ahead of conducting spawning. After the fertilised eggs hatched, culture tanks are drained periodically to maintain the water quality. On each draining period counted larvae were stocked back into the tanks that were prepared a day ahead for stocking. In the August 2015 hatchery run, larvae were reared on algal diets developed by the J Hunter Pearl hatchery for pearl oyster larvae (JHP has asked that exact techniques etc. be kept confidential.) When majority (60%-80%) of larvae had metamorphosed to pediveligers (swimming and crawling larvae) symbiont zooxanthellae was inoculated into the culture tank for larvae to commence absorbing zooxanthellae to establish the symbiosis relationship. In giant clams zooxanthellae are not passed on to the larvae but introduced to larvae to promote rapid changes to a new stage, (Ambariyanto 2002) and for production of food. . Takeo K et al, 2012, mentioned that understanding mechanisms that control increase symbiotic relations between clams and zooxanthellae will lead to better survival of giant clam at the juvenile stage while according to Beckvar, 1981, Mies et al 2012, survival of juvenile clams is often as low as 1% from eggs to juveniles.

The zooxanthellae extracts were collected from sacrificing a parental brood stock. Between 60%-80% of larvae showing development changes to juvenile were then transferred to land - based raceways.

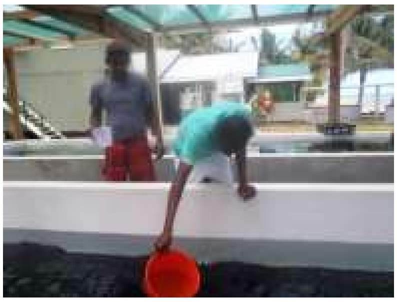

Fig 6: Stocking juvenile T. noae larvae in the raceway

6 Results

Brood stocks of T. noae were collected from Tikina Na Savusavu waters and T. derasa were collected from the Department of Fisheries Research station, Makogai. They were maintained in the hatchery holding tanks, conditioned and induced to spawn through application of thermal variation techniques in combination with gonad stimulation. Eggs collected were successfully fertilized and larvae were reared up to the juvenile stage in the hatchery. Better larval up take of zooxanthellae was witnessed when zooxanthellae were applied in a controlled manner in buckets. This method created an improved environment to enhance symbiotic relations between juvenile giant clams. Application of zooxanthellae was conducted when majority (60%-80%) of larvae had metamorphosed to pediveligers.

The successful hatchery runs enabled the initial trials on settlement to be conducted. After three months (September – December) of growout in raceways and long-line systems observations made confirmed that: in the land - based raceways, three types (43%) of substrates confirmed poor settlement. They are copra sacks; mesh coated with cement and blacklip oyster shells. The results of the other four types of substrates, short bristles artificial turf showed the highest settlement of juvenile giant clams (Fig 7). Pamela et al, 2014 claimed that giant clam larvae prefer to settle on substrates which offer shelter in the form of groves and cervices. In the long-line trials similar results were observed. The four types (57%) of the substrates presented varying degrees of settlement with short bristles artificial turf showing the highest settlement rate. This was followed by the Christmas tree collector and artificial turf with long bristles. However in the entire long – line substrates fouling oyster *Pinctada maculata*, crabs, and predator gastropods like cymatium settled abundantly. The *P. maculata* showed the highest recruitment of all fouling organisms.

Fig 7: Artificial short turf bristles with settlement of clams and other fouling marine organisms

7 Conclusions and recommendations

7.1 Conclusions

Encouraging results for the initial settlement trials was observed. That is four out of seven different substrate types demonstrated to have potential to attract settlement of juvenile giant clams. Further investigation is required to elucidate the substrate type that can support high survival and fast grow rates.

It was unfortunate that all trials were abruptly terminated by Cyclone Winston in February 2016. Therefore, definitive conclusions could not be reached for most of the objectives we set out to achieve.

Cyclone Winston impacted this SRA in a major way. The J. Hunter Pearls hatchery in Savusavu was one of the best hatcheries in the Pacific region with appropriate technology (i.e. microalgae culture room, water systems, aeration system and laboratory bench apparatus etc.), dedicated staff, and well-developed protocols and management. The addition of raceway facilities allowed investigations into giant clam mariculture activities with a view to introducing commercial farming targeting the Marine Aquarium ornamental trade and international sea food market. Unfortunately, the J. Hunter Pearls hatchery building sustained extensive damage. Its' front wing housing the larval rearing tanks was totally ripped off. (Annex 9.4). The building contents including larval rearing tanks, pumping and sea water filtration, black lip larvae collectors, algal laboratory and cooling system machines, laboratory equipment, to mention a few, were severely damaged to an irreparable state. Brood stocks collected for this project's activities and accumulated for the establishment of brood stock pool have all been killed. Regrettably, all trials that were set out for investigating other objectives were destroyed, both in the land base raceways and long - line grow out sites. Due to these losses, no conclusive results were reached for most of the objectives; hence no definitive conclusions can be affirmed.

7.2 Recommendations

For ACIAR

- ***Recommendation 1*: That ACIAR considers providing one year (12 months) extension funding to the project for the re-investigation of the objectives:**
  Investigate and compare settling rates of Giant Clams on various substrate types
  Conduct and compare post-hatchery runs using raceway systems vs ocean-based nursery system at varying timelines.
  Investigate the growth rates of juvenile clams using ocean-based long - line method vs the land-based raceways.
  To establish a commercially viable nursery system

  The implementation of the project has been successful with investigations uncovering critical areas in the hatchery and land - based nursery of the giant clam culture requiring urgent attention to improve survival of juveniles. Unfortunately, cyclone Winston on the 20th February 2016 decided to demonstrate its fierce strength claiming destruction of the hatchery building, raceways and the project materials.

  Recommendation 2: That ACIAR continues to engage and work with private sector, hatcheries (such as J Hunter), where research can merge and work with established hatchery techniques, protocols, and staff that have already been developed / trained for commercial Fiji pearl oyster production.

- ***Recommendation 3: That ACIAR supports the review of the Giant Clam Hatchery larval rearing protocol with the view of producing a commercial giant clam hatchery larval rearing protocol.***
  The early development, survival and growth rate of giant clam larvae especially between Day 6 to Day 10 require further investigation to identify mechanisms controlling larval survival through zooxanthellae application in the culture tanks. Therefore it is imperative to investigate possible mechanisms that encourage increase in the symbiosis rate. There had been significant advances towards developing further methods and techniques to address these issues by J Hunter hatchery staff. Hatchery staff and management are confident that this could be addressed.

- ***Recommendation 4: That ACIAR supports the Research to investigate and establish the influence of applying chemical inducers and identify possible mechanisms to shorten the swimming period of pediveliger larvae to settle on substrate in the land - based nursery.***

  In the natural environment there are cues that encourage rapid changes and settlement of giant clam larvae on the substrates in the coral reef. There are known chemicals that have the capacity to influence larval development to settle on the substrates faster. They should be trialled.

8 References

8.1 References cited in report

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8.2 List of publications produced by project

No Publications

9 Appendixes

9.1 Appendix 1: Acronyms and abbreviations

DOF	Department of Fisheries
PFO	Principal Fisheries Officer
PIN	Pacific Island Nations
SRA	Small research and development Activity
T. crocea	*Tridacdna crocea*
T. derasa	*Tridacdna derasa*
T. gigas	*Tridacdna gigas*
T. maxima	*Tridacdna maxima*
T. noae	*Tridacdna noae*
T. squamosa	*Tridacdna squamosa*

9.2 Appendix 2: Project Activity outline Summary

The outline summary of SRA activities at the J. Hunter Pearls Ltd hatchery

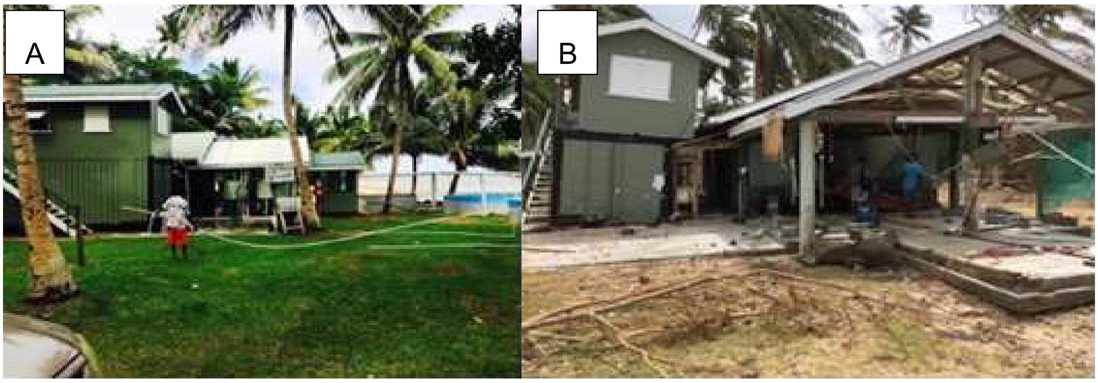
Date	**Activity**
July 2015	• Construction of the two raceways completed in late July 2015 • system tested and finalisation of water reticulation and aeration • Construction of substrates
August 2015	• Mr. Cletus Oengpepa, two weeks trip to Savusavu 15th August 2015 purposely to conduct spawning and larval run training with J. Hunter Limited Hatchery technicians • Completion of substrates, stocking in the raceways, soaking in flowing sea water • Hatchery preparation and T. noae for spawning • Collection of additional parental brood stock of T. noae at Tikina Na Savusavu waters, preparation, cleaning and conditioning of brood stock for spawning. • Conduct spawning of the brood stock • Hatchery larval run

	• Stocking of giant clam larvae in the two raceways
September 2015	• Substrates transferred to long-line growout nursery after four weeks at the J. Hunter Pearl limited Land - based nursery to pearl farm in Savusavu bay
November 2015	• Collection of T. noae brood stock from Tikina Na Savusavu waters • Collection of T. derasa brood stock from Fisheries Research Facility Makogai
December 2015	• Substrates from the long-line taken to land - based raceways for observation of settlement of giant clams after three months • Spawning of T. noae and T. derasa • Construction of Seed Float completed and ready for trial • Stocking of T. noae larvae on the substrates in the raceways

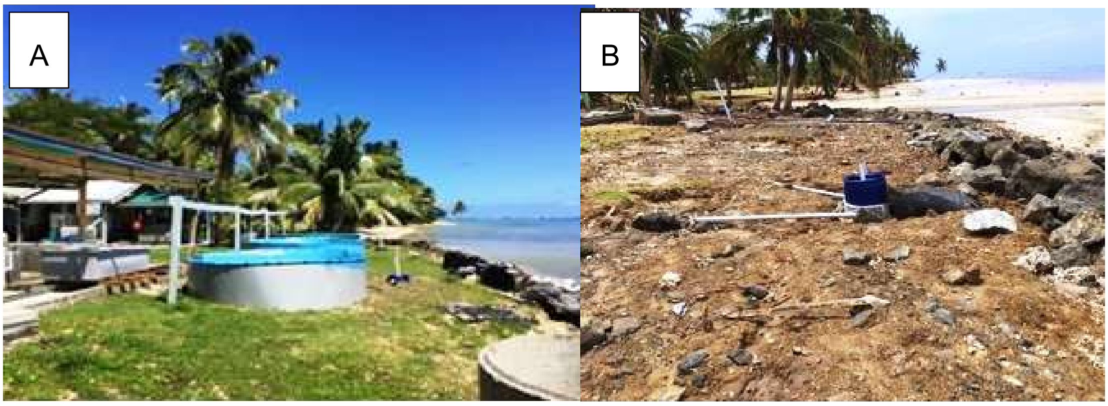
9.3 Appendix 3: Itinerary for Cletus Pita Oengpepa to travel to Savusavu to attend to SRA Activities

Date	Flight	sector	Departure	arrival
August 15th	IE801	Gizo Nusatupe/Honiara INTL	0925	1050
August 15th	FJ260	Honiara INTL/Nadi INTL	1630	2030
August 16th	FJ109	Nadi INTL/Savusavu	1430	1540
August 30th	FJ110	Savusavu/Nadi INTL	1610	1720
September 1st	FJ261	Nadi INTL/Honiara INTL	1225	1605
September 2nd	IE802	Honiara INTL/Gizo Nusatupe	1515	1640
November 28th	IE801 FJ268	Gizo/Nusatupe Honiara INTL/Nadi INTL	0925 1530	1050 2030
November 29th	FJ103	Nadi INTL/ Savusavu	0740	0850
December 29th	FJ198	Savusavu/Nadi INTL	1630	1740
December 29th	FJ261	Nadi INTL/ Honiara INTL	1225	1505
December 30th	IE800	Honiara INTL/Gizo Nusatupe	0930	1035

Appendix 9.4: Images of J. Hunter Pearl Hatchery Limited before and after cyclone Winston



A= before cyclone Winston, B= after cyclone Winston



A= before cyclone Winston, B= after cyclone Winston