Giant Clam Project American Samoa

Report Prepared For
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Marine And Wildlife Resources
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PREFACE

The South Pacific Forum Fisheries Agency (FFA) was requested by the Department of Marine and Wildlife Resources, Government of American Samoa, for assistance in their Giant Clam Project. Specifically, the assistance sought was to perform the following:

1. update data analysis on giant clam growth, mortality and predator snail occurrences;
2. assess the progress of the giant clam project to date, both for the hatchery operation and grow-out phase;
3. assist in up-dating progress reports for the Project;
4. recommend areas of improvement in the hatchery system and protocol, data collection and compilation; and
5. recommend direction of management of Project including staff employment and level of employment.

This report forms most of the part for the tasks as stated above, and was prepared during and immediately after a 4.5-day visit to American Samoa in January 1993.

The period covered in this report is from 1990 to December 1992 and includes information from the hatchery and lagoon nurseries.

Funding for this work was provided by the Department of Marine and Wildlife Resources (DMWR), American Samoa Government. Assistance provided by Mr Ray Tulafono (Director), Mr Philip Langford (Deputy Director) and the Giant Clam Project staff of DMWR during the visit is greatly appreciated. Editing of this report was made by Mr Andrew Richards (FFA Research Coordinator), and is gratefully acknowledged.

The author assumes full responsibility for the contents of this report. Opinions, where expressed, are his alone and in no way reflect the policy of FFA, DMWR or the AS government.

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Summary of Project Results and Findings to Date

The `mild method' of inducing giant clams to spawn in the hatchery has been very successful. The method basically involves placing the breeders dry in the sun for 2 hours from 11 am to 1 pm, and the introduction of gonad solution when breeders open up after placing them in the spawning tank. Gonads of any giant clam species can be used for the gonad solution. The use of chemical stimuli to induce spawning, e.g. intragonadal injection of serotonin, is not necessary.

Spawning was found to be possible almost all year round in American Samoa.

The `intensive' culture of larvae, `indoors', for the first six days is necessary in order to avoid algae blooms. Algae blooms that occur in the stagnant culture water when the `extensive' method of culturing is employed lead to high larval mortalities. Addition of streptomycin to the culture water, at 1 g per 100 litres, prior to the introduction of fertilised eggs to the Larval Tanks on Day 0, improves water quality for the larvae. Complete culture water change every other day while larvae are in the Larval Tanks during the first 6 days, is necessary. It would be necessary to experiment whether addition of streptomycin is required for every change of culture water.

Introduction of zooxanthellae, extracted from a freshly sacrificed mature clam of the same species, to the culture water with larvae inside, on Day 5, worked well. In a few cases, it was necessary to add more zooxanthellae and retain larvae in Larval Tanks for an extra day after Day 6 before transferring to the outdoors Settling Tanks.

Provision of shade, through the use of a 50% shade-cloth, over the Settling Tanks when larvae are transferred outdoors, helps in controlling algal growth in these tanks, leading to an improved survival rate to the juvenile stage.

Addition of fresh 1-micron filtered sea-water, allowing overflowing, in Settling Tanks, was necessary on Day 10. However, the overflow was directed onto a 100-micron NITEX net placed under the over-flow pipe outside, to retain larvae that flow out. This was found to be necessary until after Day 17, for most batches.

Removal of algae, by a slow fanning motion of the hands, from the Settling Tanks floor, was necessary starting around Day 55.

Juvenile clams become visible at around Day 48 and can be harvested from the Settling Tanks at age 5 months.

No significant mortalities were experienced in Raceways, between harvesting from Settling Tanks and transfer to the lagoon.

Tank space at the hatchery can accommodate the production of 100,000 juvenile clams a year.

Site comparison growth trials, using *Tridacna derasa* from the same batch, in three different sites, Nuuuli, Alofau and Ofu indicate excellent and comparable growth rates in all sites for the first 18 months after planting. The clams planted in Nuuuli showed slightly faster growth.

However, clam mortality was very high at Ofu (61%), medium for Alofau (35%) and low at Nuuuli (3 & 13%). Most of the mortality recorded from Ofu was due to Hurricane Val and wave action. The highest number of predator snails, *Cymatium muricinum* was recorded from Nuuuli with only three in Ofu for the whole 18-month period.

Species comparison experiments using *T. derasa* and *Hippopus hippopus* on different sites indicate faster growth of *T. derasa* than *H. hippopus* in all three sites. Mortalities recorded for the different species within each particular site were not significantly different. However, comparison of sites combined mortalities, showed that Alofau had the highest mortalities (87% & 89%), followed by Ofu with 60% & 50%, and Nuuuli had the least with 10% and 8% for *T. deresa* and *H. hippopus* respectively. The experiment set at Nuuuli showed that a lot more (93%) *Cymatium* snails were found on *T. derasa* than on *H. hippopus* eventhough both species were mixed within all the trays.

The species yield comparison study, involving *T. derasa* and *T. gigas* culture in Nuuuli, has shown good growth rates for both species. However, for the first 18 months, *T. derasa* has shown faster growth than *T. gigas*. In addition, *T. derasa* has shown a much more uniform growth whereas *T. gigas* clam length range increases with time. A significant difference in mortality was recorded for both species during the same period. *T. derasa* had a total mortality of 110 (6%) while *T. gigas* had 333 (17%). Of the 1614 *Cymatium* collected from this experiment, 58% was from *T. gigas*. Additionally, a higher mortality, caused by *Cymatium*, on *T. gigas* (45) was recorded as compared to 19 on *T. derasa*. A plot of monthly combined mortality against total number of snails collected from these clams shows a close correlation between the two parameters in that they follow the same pattern However, mortality peaks decrease progressively towards December 1992 although they occur at the same time as those for *Cymatium* infestations. This is an indication of the success of snail patrols in removing snails leading to lower mortalities. The corresponding peaks of both at about the same time could indicate that a major portion of mortality recorded as Unknown and Unrecorded could be due to *Cymatium*.

No significant mortalities were recorded for the experimental use of racks for `off-the-bottom' clam culture, to minimize *Cymatium* infestations, as apposed to those directly placed on the bottom. However, total number of *Cymatium* collected from `On-the-Bottom' was higher (50) than from `Off-the-Bottom' (30), and that `On-the-Bottom' clams were affected by snails 3 months earlier.

Cymatium infestations at Nuuuli has peaks around August 1991, December 1991-January 1992 and July-August 1992.

A plot of total rainfall (*10) for the Territory against total number of *Cymatium* less than 20 mm from Nuuuli, from June 1991 to May 1992, seems to indicate that snail infestation occur 1-2 months after rainfall peaks.

Manual removal of the predator snail, *Cymatium*, during snail patrols have been very effective, especially in Nuuuli. This has resulted in minimum mortalities from the snail and thus forms an integral part to successful lagoon farming.

The type of area as that used for the Nuuuli nursery seems to be the most suitable kind for giant clam lagoon culture in American Samoa. It is mostly enclosed, relatively deep, free from significant fresh-water influxes and quite far from the barrier reef, thus it experiences minimum wave action and swift currents (also refer to recommendations).

1. INTRODUCTION

1.1 Aquaculture Surveys and Studies

The Territory of American Samoa was included in a survey conducted in 1972 by an FAO consultant looking at the potential for shellfish aquaculture in certain Pacific Islands. A bait-fish project, involving the culture of the Mexican molly, *Poecilia mexicana*, for the pole-and-line tuna fishery, was initiated in early 1970s. At the request of the Office of Marine Resources, American Samoa Government, an evaluation study was conducted in 1977 by the Oceanic Institute and Hawaii of Marine Biology, Hawaii, to assess aquaculture potential of the major inhabited islands in American Samoa. In 1985 meetings were held between the American Samoa Department of Marine and Wildlife Resources and the University of Hawaii Sea Grant Extension Service to initiate an aquaculture feasibility survey and extension program in the Territory.

This lead to yet another aquaculture site survey in 1986. These surveys identified limited land and water resources for large-scale extensive or semi-extensive fresh-water aquaculture operations and narrow reef flats and pollution for brackish and marine culture. However, small-scale or backyard aquaculture was quoted as having some potential, utilizing `farm parcels located near perennial streams using true eels, tilapia, grass carp, common carp, channel catfish and the Malaysian prawns' (Takata, 1986). For brackish-water and marine culture, species recommended by the reports included mullet, milkfish, mussel, clams, giant clams, marine shrimps and Trochus. Takata (1986) also listed potential sites for aquaculture in the Territory.

1.2 Species Introductions (other than giant clams)

Introduction of animals for aquaculture growth trials in American Samoa dates back to the late 50s or early 60s when a species of tilapia was introduced into the Aunuu brackish-water pond from Western Samoa (Van Pel, 1961). No details could be located on this but the species is suspected as *Oreochromis mossambica* (May et al. 1977). Further development of tilapia culture was discontinued.

Black tiger prawn, *Penaeus monodon*, post larvae were introduced from Tahiti in the late 70s and were cultured in pens either in the airport pond or Pala Lagoon or both. The preliminary culture results `showed potential promise for future culturing' (Bryan, undated). However, 8,000 post larvae in one of the holding pens disappeared four days after stocking. This was attributed to predation by the crescent perch, *Therapon jarbua*.

The bait-fish culture for the skipjack pole-and-line fishery, using *P. mexicana*, was initiated in the early '70s using broodstock imported from Western Samoa (Bryan, undated). This was the only aquaculture project that was pursued on a production level prior to the giant clam project. `A feasibility study conducted in 1983 showed that molly baitfish culture was not economically feasible for American Samoa' (Anonymous, undated) and was closed that year.

Grass carp, *Ctenopharyngodon idellus*, was introduced in 1987 and 1988, involving two separate shipments of fingerlings of about 1,000 each, from Hawaii. These were cultured in small tanks but were never released. Some of the fish were donated for the Community College which also

raised them in a tank. The fish were not distributed to the private sector as no one was interested (Gaisoa, 1992, personal communication).

1.3 Culture Trials of Local Species

Locally caught juveniles of rabbitfish, *Siganus argenteus*, were cultured in pens along with mollies and showed potential promise for culture (Bryan, undated). Additionally, mullet juveniles were also tried using the same method. However, poaching was problematic (Gaisoa, 1993, personal communication). The author was unable to locate results of these small experiments.

1.4 Giant Clams

`In an effort to develop and enhance local reef resources by supplementing the native giant clam populations (family Tridacnidae), yearlings of *T. derasa* were introduced from the Micronesian Mariculture Demonstration Centre (MMDC), Palau, in 1986, to initiate a small scale test project (Itano, et al. 1988). However, surveys conducted by the Department in 1986 indicated that the populations of the native giant clam species were very low and unlikely to have the capacity to re-establish naturally. With the recent and rapid development of giant clam mariculture in the Indo-Pacific Region, the Department of Marine and Wildlife Resources of the Government of American Samoa set the giant clam mariculture project at high priority.

Thus, in 1989, the `Commercial Feasibility of Giant Clam Mariculture in American Samoa' project was initiated with funds from the Centre for Tropical and Subtropical Aquaculture (CTSA). Included in the project is the setting up of a hatchery. This project has entered its fourth year (March 1992-February 1993) centring on giant clam species, *T. derasa*. A side project, funded under the Pacific Aquaculture Association (PAA) programs, was started in 1991 looking at *H. hippopus* as an additional/alternative culture species. In the same year, *T. gigas* was introduced into the Territory for comparative experiments with *T. derasa* under the PFDF/MMDC `Regional Yields of Commercial Species Project, Phase I.

With funds from the Pacific Island Network, Sea Grant Extension Service, Centre for Tropical and Subtropical Aquaculture and the American Samoa Government, an Aquaculture Specialist was contracted for two years from July 1990 to July 1992, to manage the project.

2. GIANT CLAM PROJECT IMPLEMENTATION (Method)

2.1 **Project Objectives**

The giant clam project in American Samoa has been operating two sub-projects, each funded by a different organization. In addition, American Samoa has been participating in the Phase 1 of the PFDF/MMDC `Regional Yields of Commercial Species', project which involves comparing yields of *T. derasa* and *T. gigas.*

2.1.1 CTSA Funded Sub-Project

Project Title: **Commercial Feasibility of Giant Clam Culture in American Samoa**.

Project Year: 1, March 1989-February 1990

Objectives:

1. To obtain training in the techniques of spawning and culture of giant clams for appropriate DMWR personnel.
2. To investigate domestic market potentials for giant clams produced in American Samoa.
3. To establish a demonstration giant clam culture station to be used for training, extension and economic feasibility studies.
4. To determine the optimum sites, species and conditions for giant clam culture in American Samoa.
5. To produce clam seed for sale to private sector individuals that have access to suitable sites for giant clam nurseries.
6. To obtain and compile current information on the economic viability of giant clam mariculture in American Samoa.

Project Year: 2, March 1990-February 1991

Objectives:

1. Operate a demonstration station for giant clam culture to be used for training, extension and economic feasibility studies.
2. Collect and analyze information on the economic viability of giant clam mariculture in American Samoa.

Project Year: 3, March 1991-February 1992

Objectives:

1. To maximize giant clam production from the hatchery to provide sufficient numbers of juveniles for extensive lagoon mariculture operations, with the view of providing background and extension training to potential operators.

2. To conduct and evaluate giant clam lagoon mariculture operations on different reef sites on the islands in conjunction with training potential farmers.
3. To assess, on a small scale, the viability of the `hanging technique' for giant clam lagoon ranching.
4. To establish an additional giant clam nursery for DMWR broodstock and seed clams.

Project Year: 4, March 1992-February 1993

Objectives:

1. Operate a demonstration station for giant clam culture to be used for training, extension and economic feasibility studies.
2. Collect and analyze current information on the economic viability of giant clam mariculture in American Samoa.

2.1.2 PAA Funded Sub-Project

Project Title: **Giant Clam (*Hippopus hippopus*) Culture in American Samoa**.

Project Year: 1, July 1991-July 1992

Objective:

1. To evaluate *H. hippopus* as an additional or alternative culture species to *T. derasa*.

Project Year: 2, July 1992-July 1993

Objectives:

1. To increase *H. hippopus* juvenile output from the Department's Giant Clam Hatchery.
2. To continue evaluation of *H. hippopus* as an additional or alternative culture species with the view of utilizing the extensive potential intertidal sites in the Territory.

2.2 Project Staff

In addition to the staff that were involved full-time on the giant clam project as listed below, assistance, in the form of labour, was rendered from other Divisions within the Department for construction work, lagoon cage placement, clam planting and sometimes, `snail patrols' and censuses.

Name	Position	Service Dates Start	End
Pio Gaisoa	Project Manager	Feb 1989	permanent
Bonnie Ponwith	Fishery Biologist	Oct 1989	Jul 1990
Bruce Tupuola	Technician	Feb 1990	permanent
Osa Fatuesi	Technician	Jul 1990	permanent
Lui Bell	Aquaculture Specialist	Jul 1990	Jul 1992
Dominique Gebauer	Biologist Trainee	Mar 1992	permanent

2.3 Training

Pi'o Gaisoa took the MMDC Giant Clam Farming Training, in June 1989, for three weeks.

2.4 Hatchery

The original design and goal of the hatchery was for the production of limited clam seeds as start-offs for interested farmers and to `serve as a demonstration for those interested in running their own hatchery' (Ponwith 1989). However, extra costs, the unwarranted option of having private and more than one hatchery as well as lack of qualified personnel to run hatcheries, prompted the Department to concentrate on setting up one that would produce enough giant clam yearlings for the Territory.

2.4.1 Facility

Originally, the hatchery plan called for the setting up of a series of splasher pools, raceways and a larval rearing tank. The use of splasher pools was eliminated as costs and lifespan were not comparable with concrete, in addition to the extra care needed when working with them.

Spawning Tank

One concrete tank was specifically constructed for spawning purposes. This is where the brooders are placed and induced to spawn. The tank measures 20' x 4' x 2' and can accommodate up to 50 *T. derasa* breeders at any one time.

Larval Rearing Tanks

Two 575 gallons round FRP tanks were installed and ready for use at the end of Year 3 of the CTSA funded project. Both tanks are placed indoors and are used for culturing larvae for the first 6-8 days after fertilization. Each tank can accommodate up to 45 million giant clam fertilised eggs at any one time.

Settling Tanks

Two concrete tanks, with a contiguous wall to minimize costs, have been constructed for rearing Day 6-Day 8 larvae to five months old juveniles. Each tank measures 30' x 8' x 2.6' and can

accommodate up to 13 million Day 8 larvae. Since each larvae batch takes a 5-month duration in one tank, each can only be used twice a year. Thus only four batches can be attained in one year using these two tanks. However, one of the raceways has been converted into a Settling/Raceway tank, thus increasing the number of possible batch runs to six per year.

Raceways

Six raceways have been constructed with two more to be built this year. All raceways are built in blocks of two, thus two tanks have one contiguous wall in the middle. Each raceway measures 30' x 8' x 2' and can accommodate up to one hundred and thirty two 1020 flats (plastic trays). At a density of 100 clams per flat, each raceway can accommodate 13,200 five-month old clams and 6,600 eight-month old clams at a density of 50 per flat. Thus, the eight raceways can take in 100,000 juvenile clams a year (2 cycles).

Aeration

Air for the larval tanks is supplied through 4-inch airstones using two small aquarium pumps, while aeration for concrete tanks and raceways is by a blower.

Pumping System

Due to the consistent rough seas and high wave action in the adjacent lagoon area, use of a large electric submersible pump is impossible. The choice was then made for the 3-inch and 4-inch intake Yanmar marine diesel. These have 5 hp generators and maximum pumping capacity of 300 gallons per minute.

2.4.2 Spawning Induction Methods

Induction using the mild method has been successfully used at the hatchery. This method involves putting the breeders, dry, in the sun for two hours prior to being moved to the Spawning Tank. When the breeders open up, after placing in the Spawning Tank, about 5 mls of gonad solution is squirted into the incurrent siphon of each clam, using a syringe. Gonad solution using gonads from *T. squamosa* and *T. maxima* has been used to induce *T. derasa* breeders, successfully.

2.4.3 Larvae and Post-Larvae Rearing Methods

The `extensive' method of rearing larvae to seed clams was used initially. This is the easiest and least expensive method, in which eggs are transferred directly to Settling Tanks after spawning and held there, in stagnant water, for the first 10 days. After Day 10, 1-micron filtered sea-water was added allowing overflowing. However, the over-flow was directed onto a 100-micron Nitex rested in a wash basin. This allows for the retrieval of any larvae that have not settled and come out in the over-flow water.

Due to algae blooms that normally start occurring on Day 2 and which intensified in the following days before the initiation of the over-flow at Day 10, the larval culture method used

was switched to the `indoors' intensive method. Two FRP 565 gal circular tanks were obtained from USA and are now in use. These tanks are housed within a separate building. When spawning occurs, eggs are counted and transferred into one of these tanks. However, prior to this transfer, the tank is thoroughly cleaned with sponge and liquid ivory soap or clorox and rinsed with fresh-water. One-micron filtered sea-water is added to the tank and filled up to the 1500 l mark. Fifteen grams of streptomycin is then added and aeration provided through two airstones fed by an aquarium pump. Larval tank and culture-water are changed every second day.

Changing the culture water is done by draining it onto a Nitex to retain the larvae. Prior to the start of the drain-down process, a piece of PVC pipe (control pipe) is secured perpendicularly onto the end of the drain pipe from the tank bottom using a PVC elbow. This piece should be long enough so that when held upwards and the stand pipe in the culture tank removed, water does not drain out. For sieving the larvae, a plastic mesh laundry basket is lined with the 60-micron mesh Nitex attached to the basket rim by laundry pegs. A 100-micron mesh Nitex is also attached to the basket in the same manner but rests midway between the 60-micron mesh and the rim of a washbasin in which the above nests. The washbasin makes sure there is always water for the larvae on the Nitex. The draining is initiated by removal of the stand pipe in the tank and replacing it with a 6-inch tall one. Then the `control' pipe is lowered towards one side and drained onto the Nitex. The flow rate is controlled by lowering the `control' pipe to the appropriate height. The bottom layer is sieved separately without disturbing the debris layer that sits on the tank floor. If larvae from this layer look healthy when examined under the microscope, they are combined with the rest. After taking samples for estimating the numbers, the larvae are transferred into the other cleaned tank.

On Day 5 (after fertilization), zooxanthellae is scraped from the mantle of a freshly sacrificed mature broodstock of the same species as the larvae, using a kitchen knife, and added to the culture water after passing through a 25-micron sieve. Prior to the final drain-down on Day 6, a sample of larvae are checked under the microscope whether they have taken in the zooxanthellae. If they have, the final drain-down is initiated and larvae transferred to the Settling Tank(s).

Addition of 1-micron filtered sea-water, allowing over-flow, in the Settling Tanks is started on Day 10. However, the over-flow water is directed onto 100-micron Nitex set under the Settling Tank drain pipe as in normal larvae draining and sieving. A sample of larvae caught on the Nitex is examined under the microscope and if alive and normal, all are returned to the Settling Tank. The use of the Nitex is discontinued when no more larvae come through. Juvenile clams are harvested from Settling Tanks when they are 5 months old.

Details of each successful spawning and corresponding batch are recorded on forms appended as Attachment 1(a). Daily observations and records of certain parameters when larvae are cultured in Settling Tanks are entered on forms as that appended as Attachment 1(b).

2.4.4 Juvenile Raceway Culture

Harvesting of 5-month old juvenile clams from Settling Tanks is accomplished by the same method as described by Heslinga et al, 1990. The average size is determined by measuring a

sample of 100-200 clams selected at random. The total number of clams is calculated after counting 100 clams into small plastic bags. Clams in one bag would be planted in a flat in the raceways.

When clams are 8 months old, they are thinned out at 50 per flat (tray). Sea-water added during the raceway phase is not filtered and that a few surgeon fish are put in to help control algae growth.

When juvenile clams are harvested from the Settling Tanks, details are recorded on forms appended as Attachment 2. Details of lagoon transfer are also recorded on the same form for ease reference of stock sources and history.

2.5 Lagoon Nurseries

2.5.1 Giant Clams Importations for the Project

Table 1 summarizes all the introductions and importations, to date, of giant clams into American Samoa for the project. All were from the Micronesian Mariculture Demonstration Centre (MMDC), Palau. A total of 65 brooders of two species were introduced in 1991 with *T. derasa* (6 years old) making 61.5 % and *H. hippopus* (3.5 years old) 38.5 %. Juvenile clams imported between November, 1986 and October, 1991, totalled to 11,000, involving 7 separate shipments. Of the 11,000 imported juvenile clams, 73 % were *T. derasa*, 18 % *T. gigas* and 9 % *H. hippopus*. Age at date of importation of these clams ranged from 12 to 21.5 months.

Table 1:

Date	Funds	Species	Number	Generation	Age	Source
Nov 26, 1986	DMWR	*T. derasa*	1000	F1	16 mos	MMDC, Palau
Nov 12, 1987	DMWR	*T. derasa*	1400	F1	18-21.5 mos	MMDC, Palau
Nov 17, 1987	DMWR	*T. derasa*	800	F1	21.5 mos	MMDC, Palau
Sep 12, 1990	CTSA	*T. derasa*	22	F2	6 yrs	MMDC, Palau
Jan 18, 1991	CTSA	*T. derasa* 18	F2	6 yrs	MMDC, Palau	
Feb 22, 1991	CTSA	*T. derasa*	1800	F2	15 mos	MMDC, Palau
Jun 20, 1991	PFDF/MMDC	*T. gigas* 2000	F1	14 mos	MMDC, Palau	
Jun 23, 1991	PFDF/MMDC	*T. derasa* 2000	F2	12 mos	MMDC, Palau	
Oct 29, 1991	PAA	*T. derasa* 1000	F2	12 mos	MMDC, Palau	
Oct 29, 1991	PAA	*H. hippopus* 1000	F2	16 mos	MMDC, Palau	
Oct 29, 1991	PAA	*H. hippopus* 25	F2	3.5 yr	MMDC, Palau	

2.5.2 Planned Giant Clam Importations

Date	Species	Age	Number	Possible Source
1993	*H. hippopus*	Yearlings	1500	MMDC
1993	*H. hippopus*	Broodstock	30	MMDC/Fiji/Marshall
1993	*T. gigas*	Yearlings	2000	MMDC/Marshall/Tonga
1993	*H. hippopus*	Yearlings	2000	MMDC

These will probably constitute the last importation of any clams for the project.

2.5.3 Sites

Three lagoon nursery sites have been established so far under the project. They are Nuuuli and Alofau on Tutuila Island, and Ofu on Manu'a. Nuuuli site harbours both the Department nursery as well as a family owned farm but on separate locations. The Ofu nursery is a village managed farm and Alofau is a family managed one.

The Department nursery constitutes clams of varying ages and different experiments set at different sea-water depths that range from 4-18 feet. The bottom is all sand. All three introduced species, *T. derasa*, *T. gigas*, and *H. hippopus* are being cultured here, with a few specimen of the native clam species, *T. maxima* and *T. squamosa*. The family owned farm in Nuuuli is at the shallower part of the lagoon at depth of 4 feet with sand/coral rubble bottom. Only *T. derasa* were given for the family, and the PAA funded *T. derasa* and *H. hippopus* experiment is in the same area (nursery). Both of these nurseries are within the lagoon area but quite far from the barrier reefs.

The site at Ofu is within the lagoon in an area where rocks have been cleared away and cages rested on sand and coral rubble. The mean water depth here is 3 feet and sometimes it gets strong wave action coming through. Both *T. derasa* and *H. hippopus* were introduced to this site. The site is very close to the barrier reef.

Alofau nursery is also within the lagoon area and has a sand/rubble bottom and mean depth of 6 feet. The site sometimes get influxes of fresh-water during heavy rain. Both *T. derasa* and *H. hippopus* have been introduced to this site.

2.5.4 Nursery Culture Method and Experiments

The method employed in the lagoon nursery phase is exactly that developed by MMDC, Palau. Cages (2 feet wide x 2 feet long x .5 feet high) are made from 14 gauge, PVC-coated wire that has a 1-inch mesh. Two `1020 nursery flats' fit into one cage. These are exclusively used regardless of the nature of the experiment, or species involved.

Several culture trials (experiments) have been initiated using different species as listed in Table 2 below:

Table 2:

Experiment	Site	Set-up		Depth (ft)	Start Date		Fund	Species	#Planted	Age (mos)	
1. Depth/Site		Nuuuli	Nuu_Deep		10	July 01, 91		CTSA	*T. derasa*	408	20
		Nuuuli*	Nuu_Shal		4	July 01, 91		CTSA	*T. derasa*	408	20
		Ofu*	Ofu_CTSA		3	June 14, 91	CTSA	*T. derasa*	371	19	
		Alofau*	Alo_CTSA		8	Nov 25, 91	CTSA	*T. derasa*	100	24	
2. Off-bottom		Nuuuli	Off-Bottom	14	Sept 13, 91	CTSA	*T. derasa*	112	22		
		Nuuuli	On-Bottom		16	Sept 13, 91	CTSA	*T. derasa*	112	22	
3. Derasa vs Hippopus		Ofu*	Ofu_PAA		3	Nov 12, 91	PAA	*T. derasa*	320	13	
									H. hippo	320	17
		Alofau*	Alo_PAA		8	Nov 25, 91	PAA	*T. derasa*	120	13	
									H. hippo	120	17

	Nuuuli	Nuu_PAA	4	Feb 28, 92	PAA	*T. derasa*	292	16	
						PAA	*H. hippo*	292	20
4. Derasa vs Gigas	Nuuuli	PFDF	11	June 28, 91	PFDF	*T. derasa*	1971	12	
							T. gigas	1929	14
5. Hatchery Produced	Nuuuli	FOGA#1	15	June 92			*T. derasa*	1980	15

*= Privately owned

All juvenile clams used in Experiments 1 & 2 originated from the same batch imported from MMDC. They were planted at the same density and are used to evaluate growth and survival of *T. derasa* at different sites and depths. Experiment 2 is an attempt at testing the effectiveness of culturing clams on racks, `Off-the-Bottom', in minimizing predator snail infestation. Seven cages of 16 clams each were positioned on racks constructed from PVC pipes. An identical set was deployed alongside, but placed `on-the-bottom'. For Experiment 3, *T. derasa* were all of the same batch, likewise *H. hippopus*, and both are of about the same age. Clams were planted at the same density at the different sites using different cells for each species. However, the set-up of Nuu-PAA was different in that the same number of each species were planted (mixed) in the same cage. This is a comparative study in which *H. hippopus* is evaluated against *T. derasa* as an additional or alternative subtidal culture species. Likewise, Experiment 4 is to compare yields from *T. derasa* and *T. gigas*. Both species are of about the same age and were planted in different cells for each species at the same density.

Data collected from all nurseries were recorded on forms and entered into databases under Lotus 1-2-3. The forms are appended as Attachment 3(a) and 3(b).

2.5.5 Broodstock

The *T. derasa* juvenile clams imported in 1986 were the only original breeders, but when it was confirmed, in 1990, that these had not reached their full sexual maturity when the hatchery became operational, a total of 40 mature (6-year old) *T. derasa* breeders were imported from MMDC in October 1990 and January 1991. These imported breeders are referred to as **PALAU** broodstock and those imported as juveniles in 1986 as, **LOCAL**, in this report. It has been confirmed from successful spawnings in 1992 that the **LOCAL** broodstock are reaching their full sexual maturity phase, thus bringing the number of available mature *T. derasa* spawners to more than 400. Twenty-five 3.5-year old *H. hippopus* broodstock were imported in October 1991.

2.5.6 Data Collection and Compilation

Snail patrols were conducted at least twice a week for all the nurseries at Nuuuli, while those on Ofu and at Alofau were visited by the Department once a month. Census are conducted once every three months. The form used for recording data from snail patrols for each nursery is shown in Attachment 4.

3. RESULTS AND DISCUSSION

3.1 Hatchery

3.1.1 Spawning

The use of the `mild' method to induce spawning (release of both sperm and eggs) in *T. derasa* has been successful and reliable. Intragonadal injection of serotonin solution has been tried. Although it worked well, it was discontinued because it was `too' effective, causing those clams that are not ready, to release non-viable eggs. Also the `mild' method was found to be reliable enough. Because there were only very few mature broodstock originally, spawning was very limited. But as more and more of the **LOCAL** broodstock became mature, it became almost possible to do a spawning, `on demand', towards the end of 1992.

Gonad solutions from *T. maxima* and *T. squamosa* were used to successfully induce spawning in *T. derasa*.

It has been possible to induce spawning in *T. derasa* in American Samoa almost throughout the year, even during the so called `winter' months. Table 3 records all the spawnings since the hatchery became operational and the method of larval culture employed and results for each batch.

Table 3:

Spawning #	Date	Species & Larvae Culture	Batch Fate
1.	Jan 30, 91	Td Extensive	No survival by Day 70
2.	Apr 02, 91	Td 1/2 Extensive, 1/2 Intensive	Harvested 4039 5-month old juveniles
3.	Jun 10, 91	Td Intensive (old tank)	Larvae complete loss by Day 8
4.	Aug 30, 91	Td Intensive	~100 survived to juveniles in ST after Val
5.	Nov 16, 91	Td Intensive	~60 survived to juveniles in ST after Val
6.	????	Td Intensive	Larvae complete loss by Day 6
7.	May 29, 92	Td Intensive (new LT)	Harvested 300 5-month old juveniles
8.	Jun 17, 92	Td Intensive	Harvested >25,000 5-month old juveniles
9.	Jul 09, 92	Hh brought up for school visit spawned on own-discarded on Day 3	
10.	Sep 15, 92	Hh Intensive	Larvae complete loss by Day 2

All of the successful spawnings in 1991 were from the 40 *T. derasa* **PALAU** broodstock except that one of the **LOCAL** *T. derasa* clams released mild amounts of eggs in the June 1991 spawning. However, the 1992 spawnings were from both the **PALAU** and **LOCAL** breeders. The June 1992 spawning was from all **LOCAL**. The increased number of available mature spawners now would make `spawning on demand' a reality. The 4.5 years old *H. hippopus* broodstock were successfully spawned twice in 1992. However, larval rearing were not successful.

3.1.2 Larval and Post-larval Rearings

Application of the `extensive' larvae culture method (direct transfer of eggs from a spawning into Settling Tanks) at the Department hatchery has been proven as unsuitable. This is due to massive and early algal blooms that occur within the first few days after fertilised eggs are introduced into Settling Tanks. Massive algal die-offs form slimy globules throughout the culture water. These entrap and choke swimming larvae and when they settle to the bottom they smother settling larvae.

The protocol developed for `indoor intensive' rearing of fertilised eggs to Day 6 larvae, has been successful, although to some degree, not perfected yet. Addition of zooxanthellae on Day 5 post-fertilization, while larvae are being cultured in Larval Tanks, has given excellent results. Examination of larvae on Day 6, indicate presence of zooxanthellae in more than 95% of the sample, in most cases. However, when a high percentage do not have zooxanthellae on examination, the larvae were retained in the Larval Tanks for an extra day and more zooxanthellae added.

Complete change of the culture water every second day while larvae are in the Larval Tanks has been found to be necessary to avoid bacterial infestation causing high mortality.

Most of the losses in larvae batches in Larval Tanks were due to technical errors, which can be attributed as a learning factor.

The use of the 50% shade cloth over the Settling Tanks has been effective in not only preventing high temperatures in these tanks but also delaying and minimizing algal blooms. Thus, holding larvae in stagnant water in the Settling Tanks from Day 6 to Day 10 poses no threat from blooms. However, it is necessary to initiate addition of 1-micron filtered sea-water, slowly at first, on Day 10. The use of a 100-micron Nitex to recover larvae that flow out with the over-flow water has been found to be necessary up to Day 17 post-fertilization.

With the use of the 50% shade cloth over the Settling Tanks, algal patches `hanging' from Settling Tanks walls start appearing at Day 25 and intensify in days that follow. Removal of these by a fine-mesh scoop net has been effective. It seems that a thin slimy algal layer appears around Day 35 but does not seem to get thicker. Formation of this layer was much sooner without the shade cloth.

Baby clams become visible around Day 48 if the tank bottom is examined carefully using a mask and snorkel.

Removal of algae from ST floor by medium strong fanning motion of the hands, starting around Day 55, has no ill effect on baby clams. The loose algae is siphoned out at the rear of the tank.

Of the total 10 spawnings, 5 were successfully reared to produce 5-months old juvenile clams, with yields from less than a hundred to about 30,000. Two of these batches were greatly affected during Hurricane Val as the seeds were smothered by dirt and leaves blown in the Settling Tanks. The greatest number of juveniles produced was obtained using the latest larval and post-larval rearing protocol described above utilizing the new indoors Larval Tanks, with the 50%

shade-cloth over the Settling Tanks.

3.1.3 Juvenile Harvest and Raceway Juvenile Rearing

The method employed for harvesting baby clams from the STs has been found to be effective and causing no mortality when properly executed.

Juvenile rearing in Raceways at densities mentioned earlier, resulted in good growth and negligible mortality.

3.2 Lagoon Nurseries

3.2.1 Giant Clam Growth

3.2.1.a *T. derasa* in Different Sites (CTSA funded)

Figure 1 shows growth of *T. derasa* from the same batch imported from MMDC in February 1991, under the **CTSA** funded project, and transplanted in different lagoon sites and used for `site' comparison trials and `off-the-bottom' experiment for *Cymatium* occurrence. It must be noted though that planting dates were different for most of the sites. Table 4(a) records overall growth rates for clams at each site from the date of planting to the latest date length measurement was taken. Table 4(b) records mean lengths for the same at 3 months interval. Clams planted at Nuuuli (Nuu_Deep and Nuu_Shallow) exhibited the highest overall growth rate from June 1991 to December 1992, followed by those at Ofu. The slowest growth rates were recorded at Alofau and the Off-the-Bottom experiment at Nuuuli. The Alofau experiment area is often affected by an influx of fresh-water while the area for the Nuuuli Off-the-Bottom experiment is in a narrow channel and is affected by siltation. These factors could have contributed to the slower growth rates. Clams planted at different depths in Nuuuli showed no significant difference in overall growth. Mean length data (Table 4(b)) for clams planted in Nuuuli indicated that the highest growth rates (5.3-6.0 mm/month) were obtained in the first six-month period after planting and progressively decreased in the following 6-month periods (~3.0 mm/month from age 31 to 37 months). Thus growth rates decrease as the clams get older. The same pattern of growth is also shown by the clams planted in the Ofu and Alofau lagoon nurseries.

Table 4(a):

Nursery Site	Set-up Name	Plant Date (mm/dd/yy)	Mean Length Plant Date	Date Last Measurement	Mean Length Last Date	Growth Rate (mm/mos)
Nuuuli	Nuu_Deep	07/01/01	91 mm	12/92	179	5.18
	Nuu_Shal	07/01/91	91 mm	12/92	179	5.18
	Off_Bott	09/13/91	114 mm	09/92	159	3.75
	On_Bott	09/13/91	112 mm	09/92	156	3.67
Ofu	Ofu_CTSA	06/13/91	92 mm	12/92	172	4.44
Alofau	Alo_CTSA	11/25/91	122 mm	12/92	169	3.62

3.2.1.b *T. derasa* vs *H. hippopus* in Different Sites (PAA funded)

Overall comparative growth of *T. derasa* and *H. hippopus* planted in different sites under the **PAA** funded sub-project is summarised in Table 5(a) for the whole period between planting date and the date of the latest census (December 1992). Three-monthly mean length data for these is recorded in Table 5(b). Each species is of the same batch and that both species are of almost the same age. *T. derasa* in all sites showed faster overall growth rates than *H. hippopus*, from planting dates to December 1992. Growth rates of both species are about the same for the three sites. The Alofau experiment has been affected by algal growth on the cages.

Table 5(a):

Nursery Site	Set-up Name	Species	Plant Date (mm/dd/yy)	Mean Length at Plant Date	Date Last Measurement	Mean Length at Last Date	Growth Rate (mm/mos)
Ofu	Ofu_PAA	*T. derasa*	11/12/91	58.5	12/92	140	6.27
		H. hippo	11/12/91	61.4	12/92	126	4.97
Alofau	Alo_PAA	*T. derasa*	11/25/91	60.1	12/92	134	5.69
		H. hippo	11/25/91	68.6	12/92	118	3.84
Nuuuli	Nuu_PAA	*T. derasa*	02/28/92	87.8	12/92	139	5.12
		H. hippo	02/28/92	97.1	12/92	139	4.19

3.2.1.c *T. derasa* vs *T. gigas* in the same Site-Nuuuli (PFDF/MMDC funded)

Overall comparative growth of *T. derasa* and *T.gigas* at Nuuuli, from the planting date (June 1991) to September 1992, a period of 14 months, is summarized in Table 6(a). Three-monthly length data is recorded in Table 6(b) and a plot of the same against the months is shown in Figure 2(a). This trial was mostly funded by PFDF/MMDC under a Regional Yield Culture Trials Project involving several Pacific Island States. For the first fourteen months after planting, *T. derasa* has exhibited a higher overall growth rate than *T. gigas*, and has attained a higher mean length even though they are younger. The mean growth rates for *T. derasa* and *T. gigas* for the whole period were 7.16 and 5.59 mm per month respectively. Progressive growth rates between each census date is shown in Figure 2(b). Both species showed high growth rates initially between June and September 1991, followed by lower rates between September 1991 and February 1992. *T. derasa* had a higher growth rate during that period.The steep rise in growth rate for *T. gigas* between January and February 1992 is probably due to bias in the data collection and represents a false rate. Growth rates started increasing again for both species after February 1992 with *T. derasa* exhibiting a higher one. The September 1992 data seems to indicate that *T derasa* clams continue to have an increase in growth rate more than *T. gigas*. However, a few *T. gigas* individual clams have attained larger sizes than all *T. derasa* in the experiment. During the whole culture period, *T. derasa* clams showed much more uniform growth than *T. gigas*.

Table 6(a):

Nursery Site	Set-up Name	Species	Plant Date (mm/dd/yy)	Mean Length at Plant Date	Date Last Measurement	Mean Length at Last Date	Growth Rate (mm/mos)
Nuuuli	PFDF	T. derasa	7/91	59.7	9/92	160	7.16

T. gigas	7/91	61.8	9/92	140	5.59

3.2.1.d `Off-the-Bottom' *T. derasa* Experiment at Nuuuli (CTSA funded)

Progressive length data for *T. derasa* used for the `Off-the-Bottom and `On-the-Bottom' experiment is recorded in Table 7. No significant difference in growth between the different sets was observed. However, comparison with growth obtained in other experiments within Nuuuli itself, where clams from the same batch as these were used, clams in this experiment exhibited slower growth. One possible factor for the slower growth is the high siltation experienced in this particular area.

3.2.1.e Fogagogo Hatchery Produced Clams

The first batch of *T. derasa* juveniles produced at the Project hatchery was transferred to the Nuuuli nursery in July 1992. This involved 1980, 15 months old clams with a mean length of 92 mm. These clams grew at a high rate 6.7 mm per month during the first three months after transplanting.

3.2.2 Mortality

The greatest combined loss from all lagoon nurseries at one particular time was due to Hurricane Val. The worst was experienced at the Ofu Nursery. The same site encountered clam losses from wave action a few months after the hurricane. An important factor in determining sites for lagoon nurseries is depths but especially its distance from the barrier reefs. The experiment placed in the shallow part of the Nuuuli nursery had insignificant loss from the hurricane as effects from wave action were less due to its distance from the barrier reefs. The Ofu nursery is only a few meters from the barrier reefs in that area.

3.2.2.a *T. derasa* in Different Sites (CTSA Funded)

Monthly mortality totals as well as Mortality Causes are recorded in Table 8 for the different sites in which *T. derasa* from the same batch were planted. The highest percent mortality from June 1991 to December 1992 (18 months) was recorded at Ofu, which was 61% (46.25% disregarding mortalities within the first 2 months which were due mainly by handling during transplanting). The lowest was at Nuuuli (Nuu_Deep), with a total mortality, during the same period, of 2.9%. Total mortality for Nuu_Shal, at Nuuuli, for the same period was 12.5% and that for Alofau from planting date (November 1991) to December 1992 was 35%.

At Ofu, 69% (168 clams) of the total morality was due to Hurricane Val and 24% (59 clams) to handling during the initial transplanting. No mortality was recorded as due to *Cymatium* but 7% (15 clams) was under unknown and unrecorded category, with 1% (2 clams) from poaching. The highest mortality cause recorded at Alofau was due to Hurricane Val (57% or 20 clams), followed by 26% (9 clams) by poaching, and 17% (6 clams) unknown. There was no mortality recorded due to *Cymatium*. Most of the mortality causes recorded for the trials at Nuuuli (Nuu_Deep and Nuu_Shal) were under the categories Unknown and Non-reported and represented 75% (9 clams) in Nuu_Deep and 88% (45 clams) in Nuu_Shal. Six percent was

recorded under poaching as well as *Cymatium* at Nuu_Shallow. No poaching occurred in Nuu_Deep except that 25% (3 clams) of its total mortality was by *Cymatium*. Mortalities by *Cymatium* are probably higher in both trials but were recorded under Unknown and Non-reported categories.

3.2.2.b *T. derasa* vs *H. hippopus* in Different Sites (PAA Funded)

Table 9 (a) records monthly mortality and *Cymatium* occurrences at the Alofau Nursery for the experiment comparing *T. derasa* and *H. hippopus* of approximately the same age. Total number of each species and planting density were the same. Total mortality for both species for the whole period from planting date to December 1992, were almost the same, *T. derasa* 87 and 89 for *H. hippopus*. Seventy percent of the total mortality recorded for *T. derasa* was from the Hurricane while 69% for *H. hippopus* was from smothering algae. (Mortalities from algae is an indication of the lack of maintenance by the operator). *H. hippopus* seemed to have been affected less by the cyclone than *T. derasa*. Four percent mortality for *T. derasa* was attributed to *Cymatium* and nil for *H. hippopus*.

There was also no significant difference in mortalities between *T. derasa* and *H. hippopus* planted at Nuuuli for the same comparison (Table 9 (b)). However, mortality causes for *H. hippopus* were recorded as unknown. Fifty four percent of the recorded total mortality for *T. derasa* was attributed to poaching, 39% as unknown and 4% each from *Cymatium* and non-reporting. There was no mortality by *Cymatium* reported for *H. hippopus*.

The major mortality cause recorded for the Ofu experiment was due to Hurricane Val, which accounted for 78% and 75% of the total mortalities for *T. derasa* and *H. hippopus* respectively (Table 9 (c)). Total mortalities for both species were above 50% of the number of clams planted for the culture period from November 1991 to December 1992. Fifteen percent of the total mortalities of each species was attributed to strong wave action a few months after the hurricane. No mortalities were attributed to *Cymatium* for both species on Ofu.

3.2.2.c *T. derasa* vs *T. gigas* in the same Site-Nuuuli (PFDF/MMDC funded)

There was a significant difference in total mortality between *T. derasa* and *T. gigas* planted in Nuuuli from the date of planting (June 1991) to December 1992 (18 months) as shown in Table 10. Total mortalities were 110 and 333 for *T. derasa* and *T. gigas*, which represent 6% and 17% of the total clams initially planted for each species, respectively. Seventy percent of the *T. gigas* total mortality was not known (not recorded) and 14% was attributed to *Cymatium* as compared to 67% and 17%, by the same causes respectively, in *T. derasa*. Using numbers only, more than twice the number *T. gigas* (45) were killed by *Cymatium* than *T. derasa*, as recorded. Most of the mortalities in both cases were either unknown or not recorded.

3.2.2.d `Off-the-Bottom' *T. derasa* Experiment at Nuuuli (CTSA funded)

Mortalities recorded from planting date (June 1991) to December 1992, a culture period of 18 months, were 8 and 9 for `Off-the-Bottom and `On-the-Bottom' respectively (Table 7). These represent 7% and 8% mortalities for each set,which are minimal. Mortality cause in both cases

were mostly unknown or unrecorded, except that 1 for `On-the-Bottom' was attributed to *Cymatium*. However, from *Cymatium* data recorded for each set, mortality caused by *Cymatium*, thus the overall mortality, for `On-the-Bottom' set could have been higher as the number of snails removed during `snail patrols' was almost twice those from `Off-the-Bottom'.

3.2.2.e Fogagogo Hatchery Produced Clams

For the first five months after planting to December 1992, mortality totalled 31, of which 17 (54%) was by the predator snail, *Cymatium*. The remaining mortality percentage was recorded as unknown and unrecorded.

3.2.3 Predator snail, *C. muricinum*, occurrences

3.2.3.a *T. derasa* in Different Sites (CTSA Funded)

Monthly *Cymatium* occurrences at each site of the Site Comparison experiment using *T. derasa* from the same batch are recorded on Table 8. Only 15 *Cymatium* snails were collected from Alofau for the 13-month period from December 1991 to December 1992. Only 3 were collected from Ofu for 18-month period from June 1991 to December 1992. A significantly higher number was collected at the 2 experiments set in Nuuuli during the same time period. Of the two in Nuuuli, the one set at the shallower area had more snails (total of 201) than that set in deeper waters (total of 91 snails). It must be noted though that the Nuuuli nursery was visited 2-3 times a week while visits to those in Ofu and Alofau were once a month. Even though a lot of the predator snails were collected in the Nuuuli trials, no significant mortality was attributed to snails. This is an indication of the effectiveness of `snail patrols'.

3.2.3.b *T. derasa* vs *H. hippopus* in Different Sites (PAA Funded)

No significant number (7 for the whole 11-month period) of the predator snail was recorded at the Alofau nursery (Table 9 (a)).

At the Nuuuli comparison trial, a total of 180 snails were collected within the 11-month period from February 1992 to December 1992, of which 93% were on *T. derasa* (Table 9(b). The highest infestation was between the months of August and November.

Only one *Cymatium* was recorded for this experiment in Ofu (Table 9(c)), which was on a *T. derasa*.

3.2.3.c *T. derasa* vs *T. gigas* in the same Site-Nuuuli (PFDF/MMDC funded)

Table 11 records total monthly number of *Cymatium* collected from cells containing *T. derasa* and *T. gigas*, separately. Compared to other experiments and nurseries, the greatest number of *Cymatium* collected was from this experiment. This experiment also had the greatest number of clams. From the planting date (June 1991) to December 1992 (18 months), a total of 1614 predator snails were collected of which 58% were collected from *T. gigas*. A plot of monthly *Cymatium* totals collected indicate infestation peaks around August, December and July (Figure

3). A plot of Total Monthly Mortality against Total Monthly number of *Cymatium* collected (Figure 4) showed a close correlation between the two parameters. High mortality (peaks) occurred during the same time high *Cymatium* infestation (peaks) were recorded. This could be an indication that a large proportion of mortality recorded as Unknown and Unrecorded could have been caused by *Cymatium*. It is noted that the mortality peaks progressively decreased except the December 1991-January 1992 period when the frequency of snail patrols was very low (due to electricity failure from the hurricane). Thus the filling of SCUBA tanks was not possible for several weeks). The progressive decrease in mortality peaks, relative to the number of *Cymatium* collected, could be due to the increase in the ability of the divers to collect (extract) predator snails and/or the clams becoming more resistant to snail attacks as they grow bigger.

3.2.3.d `Off-the-Bottom' *T. derasa* Experiment at Nuuuli (CTSA funded)

Table 7 records total monthly number of *Cymatium* recorded for each of the two sets for this experiment. The `On-the-Bottom' set was affected by *Cymatium* 3 months earlier than the `Off-the-Bottom' one. In addition, a total of 50 *Cymatium* snails were collected from the `On-the-Bottom' clams as compared to the 30 from the `On-the-Bottom' for the whole period from planting date to December 1992.

3.2.3.e Fogagogo Hatchery Produced Clams

Cymatium infestation started occurring in these cells on the first week after planting. This corresponded with the start of a major infestation in other experiments within the same nursery area, Nuuuli. From July to December 1992, a total of 458 *Cymatium* snails were collected (Table 12).

3.2.4 Rainfall and *Cymatium* Occurrence

In an attempt to examine whether rainfall triggers *Cymatium* spawning and thus settlement, total number of snails less than 20 mm from all of the experiments in Nuuuli were combined and plotted against total monthly rainfall (Figure 5). Snail infestations (peaks) seem to occur 1-2 months after heavy rainfall. Eventhough this indication seems to suggest a correlation between rainfall and *Cymatium* infestation in American Samoa, a more well planned and detail data collection, specifically for this purpose, is necessary.

3.2.5 Clam Tally

Table 13 records the total number, age and average length of all giant clams from the latest census date for each existing nursery. Attachments 5(a) and (b) constitute the lay-outs of all the existing nurseries and number of clams in each as of July 1992.

Table 13

Site	Nursery	Species	Census Date		Clams Age	Average Length (cm)	Total Number
Nuuuli	Nuu_Deep	*T derasa* Dec 92		37 mos	17.88	401	
	Nuu_Shal	*T derasa* Dec 92		37 mos	17.88	357	
	Off_Bott *T derasa*	Sep 92	34 mos	15.90		105	
	On_Bott	*T derasa* Sep 92		34 mos	15.60	103	
	PFDF	*T derasa* Sep 92		26 mos	15.98	1796	
		T gigas	Sep 92	28 mos	14.00		1539
	Td_Brood	*T derasa* Aug 92			30.30	415	
	Hh_Brood	*H hippopus*	Oct 92	56 mos	19.00		24
	Nuu_PAA	*T derasa* Aug 92			12.59	216	
		H hippopus	Jun 92			11.84	291
	Foga#1	*T derasa* Oct 92		18 mos	11.24	1949	
Ofu	Ofu_CTSA	*T derasa* Dec 92		36 mos	17.15	156	
	Ofu_PAA	*T derasa* Dec 92			14.00	215	
		H hippopus	Dec 92			12.60	259
Alofau	Alo_CTSA	*T derasa* Dec 92		48 mos	16.88	48	
	Alo_PAA	*T derasa* Dec 92			13.35	12	
		H hippopus	Dec 92			11.81	11

4 RECOMMENDATIONS

4.1 Hatchery

The use of gonad solution to induce giant clam breeders to spawn is currently in use and is very reliable. Effort should be made to avoid using the Department's limited broodstock for this purpose as gonads of any clam species can be used.

The latest protocol of larval and post-larval rearing, developed by previous aquaculture specialist, seems to be working well if followed properly. Provision of shade, using 50% shade-cloth, over settling tanks is a necessity, and should be used whenever larvae are transferred outdoors to the settling tanks. Six-month old juvenile clams harvested in January 1993 from the June 1992 spawning, yielded more than 25,000 clams. This is an excellent yield and also the highest from the hatchery so far. However, the protocol needs to be repeated several times in order to assess its reliability. It is also suggested that feeding of larvae while they are in the `indoors' Larval Tanks, be tried. This could mean a training attachment for one week for a project staff member at either ICLARM, Solomon Islands or at Fisheries, Fiji.

Only one spawning induction was attempted between July 1992 and December of the same year. In order to achieve maximum juvenile output from the hatchery, and the fact that spawnings have been possible almost all year round, spawning induction should be conducted whenever a Settling Tank is available, if weather permits.

On several occasions, broodstock induced during the day spawned after the staff had left at 5 pm. It is suggested that for future spawning induction, observation be continued after 5 pm for possible spawnings, to avoid eggs and developing embryo being left in the spawning tank for the whole night and part of the following morning. The risk of infestation by microorganisms in the spawning tank is very high, leading to the eventual possible total loss later on. It is probably better to handle fertilised eggs than developing embryo.

Two water pumps are urgently needed as there is only one currently working. More than 25,000 six-month old juveniles were harvested early January 1993 and if the current working pump breaks down, it could mean a total loss of juveniles. The importance of having a reliable pumping system (including back-up) can never be over-stressed.

The remaining juvenile clams (about 1,000 and 21 months old) from the first successful larval rearing presently being kept in raceways at the hatchery should be transplanted to the Nuuuli nursery. It is wasteful and expensive to keep them on land at this age.

4.2 Lagoon nursery

Most of the experiments, both at Nuuuli and Ofu, need thinning out as the clams in cages are becoming crowded. Overcrowding would result in stunted growth and misshapen shells. The thinning-out process should be done whenever the need arises. Removal of cage tops has been done and found safe when *T. derasa* are 30 months old.

The CTSA funded year 5 project (March 1993-February 1994) proposes the establishment of four new intertidal nurseries. In addition, under the PAA funded year 2 project (July 92-Jul 93), there are also another two intertidal nurseries being proposed. It is suggested that only two sites be developed for these intertidal trials to lessen the workload and make record keeping more manageable. For practical maintenance and proper record keeping and data collection, it is suggested that both sites be established on Tutuila Island in the Nuuuli-Fatumafuti stretch and that none for Ofu. The project staff should proceed now with earmarking these sites.

Participation by the `private owners' of the three clam farms established under the project, in maintenance etc, has been very minimal. For example, high clam mortality at Alofau was due to smothering by algae. This indicates the absence of any maintenance on the part of the owner. The other two, at Nuuuli and Ofu, have been fortunate that the Department staff undertakes maintenance there on a regular basis. It is suggested that the private owners be encouraged to increase their participation in the farm management as the Department gradually decrease its role in this area. It is also suggested that no more clams be given to these farms unless a vast improvement is made in maintenance participation.

The problem currently faced by the project staff in keeping up with consistent maintenance and data collection schedules for the lagoon nurseries could be an indication of over-load. If this is the case, then it is suggested that no more subtidal nurseries be established, whether it be for private or government. Instead, the Nuuuli nursery should be expanded using the remaining juvenile clams from the first successful batch presently kept in raceways at the hatchery.

Mortality and growth data suggest that the best sites for sub-tidal culture for American Samoa are those like the Nuuuli site. It is relatively deep (4-18 ft), situated far from the barrier reefs, and has insignificant fresh-water influx. This would minimize the effects of swift currents and wave action which have caused high mortality in other sites.

Manual removal of the predator snail, *Cymatium*, by snail patrols has been very successful, especially in Nuuuli. It has resulted in minimum mortalities from the predator snail and it thus forms an integral part for successful lagoon farming and should be conducted on a regular basis particularly in the infestation periods, July-November and January-March.

If the Department desires to establish additional lagoon nurseries, it should look for sites that are similar to Nuuuli.

It would probably be worth the effort to make another attempt for the possibility of experimental giant clam culture in the larger Airport Pond.

4.3 Data Collection and Compilation

Two current weaknesses in data collection are inconsistencies in following schedules (for census and snail patrols) and recording Mortality Causes. In order for the data to be used comparatively, some consistency in data collection is necessary. Data collectors should make an extra effort to record this while working at a nursery, even if the cause of mortality is unknown. The weekly data-base for each nursery has been modified for easier recording of mortality causes. However,

it is suggested that only weekly summaries should be entered into the data-base. A monthly summaries data-base, of almost the same format as the weekly one, has been created for each nursery for easier analysis for reports.

Often, the total mortality recorded by snail patrol divers and entered into the weekly data-base does not match with mortality calculated from 3-monthly census. If the count from the census is reliable, then the difference should be noted under a mortality cause column (e.g. Unr for unrecorded) on the census date. This would make part of the analysis easier.

Some information has not been filled in the weekly data-base, e.g. Header details. An effort should be made to update and correct all for each nursery.

4.4 Staff

Employment of a biologist, with experiences in giant clam culture (both hatchery and grow-out work), is very vital, and urgent, for the success of the project. The increasing work-load, the biological background requirement involved, as well as the increasing number of different culture trials using different techniques in different environment settings requires the skill of a qualified and experienced specialist. This should be priority for the project. If funding is not available locally for this position, assistance from the Pacific Island Network (PIN), Sea Grant (Honolulu) and Centre for Tropical and Subtropical Aquaculture could be sought.

There should be at least three properly qualified and competent SCUBA divers working for the project. Assistance should be available (and sought) from qualified divers working in other sectors of the Department when the need arises.

4.5 Fisheries Regulation

It will be necessary to modify part of the American Samoa Fisheries Regulations 1990 that deals with giant clams to accommodate the local sale of `cultured clams'.

4.6 Training

As stated under 4.1 above, the staff member responsible for carrying out the protocol for larvae rearing needs to undergo an attachment at one of the giant clam hatcheries currently involved in feeding larvae during the larval stages. This is also a good opportunity to observe other methods of rearing clams, especially the intensive larval culture methods.

It is strongly recommended that the data entry/computer files operator undergo training in basic-intermediate (then advanced later on) on DOS and LOTUS 123. Basic understanding of the workings of these is vital to keeping data and files properly managed and if the need arises, modify and upgrade the databases.

In addition, it is suggested that the biologist trainee should take a course in basic data analysis.

4.7 Economic Feasibility Analysis

The Economic Feasibility Analysis of culturing giant clams in American Samoa should be possible at the end of 1993. This work forms part of the CTSA funded project for the period March 1993-February 1994 (Year 5). At least 2 consultants (economist/marketing specialist and an aquaculturist) will be required for this work for a maximum period of one week.

4.8 Native Giant Clam Species

It would be desirable to conduct spawning and grow-out experiments in an effort to re-establish populations of the native giant clam species, *T. squamosa* and *T. max*ima since surveys conducted by the Department indicated very low populations and the likely inability of the remaining populations to recover naturally. The re-seeding programme could start with stocking marine reserves, e.g. Fagatele Sanctuary. The limited number of suitable subtidal areas in American Samoa for lagoon farming makes it realistic to initiate propagation on the native species for re-seeding purposes. *T. maxima* is abundant on Rose Atoll while *T. squamosa* can be collected from Manu'a or around Tutuila Island. Establishment of broodstock of both species, for spawning purposes, would probably involve a major undertaking by the Department. Since neighbouring countries are interested in re-seeding programmes involving the same species, the American Samoa hatchery can be the source of seeds for countries that do not operate giant clam hatcheries.