# Niue Giant Clam Re-Seeding
# Cost Comparison For Local Production (Hatchery) And Importation (Juveniles Or Larvae)

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## Introduction

In November 1992, the Department of Agriculture, Forestry and Fisheries, Government of Niue, expressed its desire to initiate a project targeting at re-seeding Niuean reefs with giant clams of the native species, *Tridacna maxima* and *T. squamosa*. Specifically, the request was to conduct a cost-comparison assessment of producing juvenile clams locally, by means of a hatchery, as opposed to importing juvenile clams from an existing hatchery in the South Pacific.

## Status of the Local Giant Clam Stocks

In 1990, through joint assistance from the South Pacific Commission and the FAO South Pacific Aquaculture Development Programme, a fisheries and marine resources survey was conducted in Niue. Part of this included an intensive stock survey of giant clam populations. The survey found only two species of giant clams, *T. squamosa* and *T. maxima* existing in Niue waters. Mean stock densities for both species were estimated to be 89.0 and 14.0 clams per hectare for *T. maxima* and *T. squamosa* respectively (Dalzell, et al 1991). Standing stocks were then estimated for the total Niue subtidal reef area (to 25m) as 24,252 *T. maxima* and 3,815 for *T. squamosa*. The *T. maxima* population density was considered low and thus the *T. squamosa* must be very low, but not quite `extremely low'.

Dalzell, et al (1991) considered that `the consumption rate of *T. maxima* in Niue is not high enough at present to seriously threaten resident stocks. However, the consumption rate of *T. squamosa* is high enough to suggest that there is a need for some form of conservative measures that will allow the natural populations to re-establish'. The report indicated that the lack of suitable safe protected areas for grow-out and the limited number of potential sites for a hatchery, as the main factors restricting the potential of culturing clams in Niue. However, it was suggested that `Niue fisheries do no more than obtain some cultured juvenile clams (from a neighbouring country hatchery) and proceed with small-scale experiments for the suitability of clam culture in subtidal protected areas'.

## Broodstock Enhancement

Long-term options that would serve in the process of re-establishment of native stocks of giant clams on over-harvested reefs include the establishment of reserves in areas where wild populations still exist, and the collection and creation of artificial clump populations (as practised with clam circles in Tonga) to enhance reproductive success. The `clumped' distribution is believed to be critical for the success of reproduction in giant clams (Braley, 1992). Evidence of the hypothesis of the critical mass required for reproductive success was documented by Braley (1984) on high density clam reefs. However, these would naturally take a long time before their impacts or benefits can be assessed or realized, provided too that the broodstock do not get stolen or die off. Braley (1992) noted that `scientific proof of this (recruitment success from clam circles) may take 5 yr+ but it is likely that a quantifiable effect will be observable in future if the broodstock in the circles survive poaching activity'. He regarded marine reserves as probably the best method for broodstock enhancement where there still remain sizeable giant clam populations and that the `reserves would be most successful if the protection encompassed all coral reef species in the reserve'. It was further noted that `it would be wise use of the reserve to establish artificial clumps (circles) of broodstock clam species which are rare in the reserve and adjacent areas'.

Creation of reserves in areas where clam populations still exist in good numbers and building up clam `clumps' remain the only sure safe and cheap way of enhancing local stocks.

However, the interest by Niue to either produce or import giant clam juveniles in an effort to re-seed its overfished reefs seems to be more immediate.

**Other Considerations**

The request by Niue to compare the cost of setting up a giant clam hatchery with importation of giant clam juveniles includes the assumption that juvenile clams can be reliably obtained by either importation or production. Consideration also needs to be made of the potential detrimental effects of introducing stocks from other regions. However, several other factors, apart from costs, need to be addressed in order to make a more practical and meaningful approach in finding the right direction to take.

1. <u>Level of Need and Long-term plan</u>

In order to make a meaningful evaluation on whether dependency on an outside supplier would be sufficient and reliable or setting up a hatchery is justifiable, some indication on the scale of operation (number of juveniles required per year and for how many years) is needed. This can also be worked out by the total number of juveniles required for the whole project. An important consideration here is to estimate the number that the local Fisheries Section staff can handle. Additionally, local lagoon (ocean) area available for this venture needs assessment.

The re-seeding plan, as submitted by the Niue Department of Agriculture, Forestry and Fisheries, would involve planting juvenile clams on twelve separate reefs at 2,000 clams per reef, per year, for 3-5 years, depending on results. This would then require 24,000 juvenile clams a year, 72,000 for three years and 120,000 for five years. Twenty-four thousand clams a year is a lot of clams to manage on a yearly basis, considering the number of Fisheries staff available, and possibly suitable subtidal areas available for ocean/lagoon/reef culture. (see note under 7 below).

For a more manageable project as well as the practicality of importing juvenile clams, it is proposed that the level as suggested by Niue be reduced by half. This would mean a need of 12,000 juvenile clams per year at 1000 clams per reef. Costings for imported juveniles are based on this figure in this report.

2. <u>Timing</u>

An important consideration involves the ease or difficulty in obtaining larvae/juveniles from other hatcheries as opposed to waiting for the construction work and eventual success or failure of the hatchery in producing juvenile clams. Some materials that are essential for the hatchery would have to be imported. This would probably take quite some time before ordered materials reach Niue.

Information from currently operating hatcheries in the region seems to indicate that juveniles are, and would be, readily available. Contracting one (or even two) of the hatcheries for the supply, of say 12,000 juveniles a year for a period of time, would be realistic. Setting up a local hatchery could take at least two years before consistent production is realized.

3. <u>Availability of Larvae/Juveniles of Preferred Species from Other Hatcheries</u>

Most of the hatcheries operating presently are targeting the fast growing species, *T. gigas* and *T. derasa* (plus, to a lesser extent *Hippopus hippopus*, *T. squamosa* and *T. maxima*). ICLARM's Coastal Aquaculture Centre (CAC) in the Solomon Islands is probably the only possible source of giant clam larvae for both species, at present. The Fiji giant clam hatchery is currently producing *T. squamosa* and *T. maxima* on a reliable basis. The Tonga Fisheries hatchery produces juveniles of *T. squamosa* but not *T. maxima*. The hatchery in American Samoa could produce juveniles of both *T. squamosa* and *T. maxima*, however, positive progress of the hatchery is questionable in addition to the absence of broodstocks of both species at the Department nursery.

4. <u>Transport Survival for Larvae/Juveniles</u>

Transportation of larvae from Honiara could be very risky because of the duration and handling involved which might lead to high mortality. Shipment would require at least two lay-overs (1 night in Tonga and several in American Samoa) and assistance in airplane transfers, re-oxygenation and/or release in larval tanks and re-packing in both countries during trans-shipment would be required. A successful shipment of *H. hippopus* larvae from CAC to Western Samoa took place in 1990, with high larvae survival on arrival (however, see 5 below). Fiji and Tonga hatcheries have not been involved in the export of giant clam larvae but they probably could if approached.

The three possible sources of juvenile clams are Fiji Fisheries, Tonga Fisheries and American Samoa Department of Marine and Wildlife Resources. Shipments from all three sources should not be problematic in terms of clam survival as the flights involved are fairly short ones. However, the cooperation and assistance of Fisheries from Tonga, Western Samoa and American Samoa for trans-shipments, are required.

5. <u>Settling Tank Survival for Larvae</u>

The only giant clam larvae shipment to the islands was from CAC, Honiara, to Western Samoa in 1990, involving *H. hippopus*. Larval survival on arrival was high, however, all died in the culture tanks because `culture procedures were not followed'. Thus, it can not be predicted that a certain number of larvae that survive transportation would make it to juvenile stage (5 months old). Handling larvae requires a lot more care than for yearlings or 6-month old juveniles.

6. <u>Hatchery Site and Success of Local Hatchery in Production</u>

Three areas were recommended and inspected as potential sites for a hatchery or land-based nursery. Details are as follows:

<u>Limu Sea Track near Manukula Village</u>

| | |
|---|---|
| Land owner: | Villagers |
| Elevation from Sea: | ~30 m above sea level |
| Nearby Sea Area: | both giant clam species found and trochus seeded |
| Other: | sheltered pools & developed as an attractive tourist area |
| Electricity: | supply at land level |
| Sea Track: | well constructed |

<u>Fakaleina near Alofi</u>

| | |
|---|---|
| Land owner: | Family |
| Elevation from sea: | ~10 m |
| Sea: | deep on one side and shallow on the other |
| Land: | broken coral (PWD bulldozer could level for $400-500) |
| Other: | not well protected as that at Limu. |
| Electricity: | close-by at gymnasium |
| Sea track: | cove nearby to the south has 2 sea tracks |

<u>Amanau near PWD Offices, soon to become DAFF Offices</u>

| | |
|---|---|
| Land owner: | Government |
| Elevation from sea: | ~40 m above sea level |
| Sea: | fairly shallow water on reef flat |
| Other: | not well protected |
| Electricity: | close by |
| Sea track: | open cove with sea track |

As far as choosing a site for the hatchery, the above information seems to indicate that the major concern is the ability to pump up sea-water reliably and the sustainability and maintenance of intake pipe lines. The distance from the in-takes to the land-based facility for all of the above sites is in the vicinity of 80-100 metres. This would require a very strong sea-water pump, especially when most of the pumping required is upwards. Even for the Fakaleina site, which is 10 m above sea-level, investment in the intake pumping system could be prohibitive.

Regardless of the means taken to obtain juvenile clams, construction of a land-based facility, equipped with a proper system to pump up sea-water, is necessary. Imported juveniles would need a 6-month quarantine period, for observation of any possible introduced diseases, in land-based raceways before transplanting into the ocean.

Setting up a hatchery is not a guarantee of obtaining juvenile clams, on time. It has taken quite a few years for some of the current operating hatcheries to develop to the stage they are at now. It requires well trained personnel, a fair number of broodstock and commitment of both workers and government, in addition to environmental requirements. In the possible event of producing excess juvenile clams that the Department or Niue can handle, avenues to distribute or sell these, to avoid waste and hatchery idleness, need to be addressed.

7. Ocean Nursery and Grow-out

To minimize and avoid unnecessary costs, juvenile clams would have to be transplanted to the sea at latest 1 year of age if produced locally. Protection from natural predators would be a necessity until about 3 years of age when transferred to the ocean nurseries. Survival of unprotected released clams in the wild after this age in not known. However, to maximize the possibility of reproduction and thus recruitment to the population, release in `clumps' is recommended. This however would mean an easier target for poachers.

Assuming that the clams will be transplanted to lagoon/reef at the age of approximately 12 months, protection from their natural predators would be required for approximately two more years (until they reach the 3-year old age) before they can be released (i.e. without protection). The area to be used should be large enough to accommodate clams from the thinning-out processes that would be required as the clams grow. The original number of cages deployed for a certain number of clams per area can be more than doubled for each successive year due to this. Alternatively, other suitable areas can be used to accommodate the thin-out clams. The area to be used for the lagoon/reef culture must be free from fresh-water influxes and high siltation. In addition, it must be flat and have sand or rubble bottom, and free of coral. Water currents and wave action effects should be minimal. The expanse of culture areas is often wrongly calculated by just looking at the area of the lagoon or reef alone. Suitability of the bottom floor for ease and safe deployment of cages is a major consideration.

8. Creation of Marine Reserve(s) or `out of bounds' zone(s)

Apart from protecting some of the areas where native giant clam populations still exist, areas where introduced/produced clams also need to be protected, allowing time for them to positively contribute to the resource.

9. Minimum size limit

An important consideration in efforts to manage the local giant clam resources is the introduction of regulations on minimum size limits for harvesting. There is enough literature for guidelines on these. Part of this should include limiting sales of clams to those with shells on, in order to practically monitor the regulation. If clam meat is presently being exported, action should be taken to limit or ban it. Enforcement of regulations then becomes a matter of primary importance.

10. Potential Biological Consequences

An essential consideration, as a determining factor in making the decision whether to import juvenile/larvae of giant clam species that are present on location, is the risk of introducing new predators and diseases and a different giant clam genetic pool. The risk of introducing `unwanted' organisms is least with importation of larvae and increases with the size of clams shipped. This is of such importance that it should form the basis for the direction to take as far as the giant clam project is concerned. Benzie (undated) wrote, `the source of material to be transferred to a location is now a critical issue if the aim is to enhance local stocks without endangering local genetic diversity. The risks and guidelines associated with the transfer of clams are contained in the attached SPC/Fisheries 17/WP.24.

**Operational Giant Clam Hatcheries - Possible Sources**

<u>MMDC Palau</u>
Shipment of clams from MMDC or Marshall Islands would require 2 lay-overs, 1 in Hawaii and 1 in American Samoa. In addition, arrangements would have to be made with Waikiki Aquarium and Department of Marine and Wildlife in Pago Pago for these. Each species would require a separate permit from the Quarantine Branch of the Department of Agriculture in Honolulu for the Hawaii lay-over prior to shipment. These permits are normally issued for multiple shipments for a one-year period. It may even require someone to be in Hawaii to make sure clams will be picked up, taken to Waikiki and then repacked and taken to the airport for the flight to American Samoa. (All clam shipments from MMDC for the American Samoa project involved one staff from Pago Pago flying over to Honolulu for the trans-shipment). MMDC, Palau and Marshall Islands are the most isolated giant clam hatcheries from Niue and it is possible that giant clams there would have a very significant genetic difference from those on Niue. For the above reasons MMDC and Marshall Islands are not considered as possible sources of juvenile clams or larvae.

<u>CAC (ICLARM) Solomon Islands</u>
The CAC giant clam hatchery is presently producing approximately 160,000 five-month old clam seeds of several species per year. Exportation for culture purposes is limited to the 25-day old or younger larvae (seeds). They have broodstock of *T. squamosa* and *T. maxima* and can reliably produce larvae for these species. However, exportation is very restrictive in that there is no shipment of clams (larvae or juveniles), for culture, to any country, of species that are present there (importing country). Exceptions are given in cases where a particular species has become locally extinct or becoming extinct. There is no exportation from CAC to any country of clam species that are not native to the receiving country. Someone from Niue would almost certainly be required to `hand-carry' the larvae for the first shipment.

Flight schedules
Hir/Tonga Friday afternoon, arriving Tonga Friday night.
Tonga/Pago HA Friday night, arriving Pago Friday morning
Pago/Niue, following week, PH Thursday night, arriving Niue Thursday night.
Layover : 7 days in Pago

<u>Costs per shipment</u>
Larvae cost : 0
Packaging Costs : 1 esky @ $50.00 each = **$50.00**
Shipment Costs
Hir/Ton : 20kg @~$1.00/kg + $5.00 for documentation = **$25.00**
Ton/Pago : 20 kg @ ~ $6.00/kg = **$120.00**
Pago/Niue : 20 kg @ ~ $1.80/kg = **$36.00**

Assuming there would be two shipments per year, **Total Costs per year = $462.00**

Fiji Fisheries

Fiji Fisheries giant clam hatchery at Makogai is currently producing 200,000 juvenile clams per year of mainly *T. derasa*, *T. squamosa* and *T. maxima*. They have signed an agreement with an American Company for the supply of 2,000 juvenile clams a week for export to the U.S. Availability of clams for other channels depends on excess from this undertaking.

Flight schedules

Suva/Nadi FJ Thursday morning.
Nadi/Apia FJ/PH Thursday noon, arriving Apia Wednesday noon.
Apia/Pago/Niue PH Thursday night, arriving Niue Thursday night.
Layover : 1 day in Apia[1].

Costs for Yearlings Importation per shipment

Yearling Costs : 2,000 clams @ 0.70 each = **$1400.00**
Packaging Costs : 10 styroform boxes @ $20 each = **$200.00**
Freight Costs : Suva/Nadi
: Nadi/Apia = 110 kg @ ~ $1.00/kg (F$1.29/kg) = **$110.00**
: Apia/Niue = 110 kg @ ~ $1.00/kg (WS$2.20/kg) = **$110.00**
Six trips to make up 12,000 clams per year, **Total Costs per Year = $10920.00**

Costs for 6-month old juveniles Importation per shipment

6 months old seeds : 2,000 clams @ 0.50 each = **$1000.00**
Packaging Costs : 5 styrofoam boxes @ $20 each = **$100.00**
Freight Costs : Nadi/Apia = 55 kg @ $1.00/kg = **$55.00**
: Apia/Niue = 55 kg @ $1.00/kg = **$55.00**
Six trips to make up 12,000 clams per year, **Total Costs per Year = $7260.00**

Tonga Fisheries

Hatchery production has been concentrating on the native *T. derasa* but recently has included *T. squamosa*. Spawnings were successful with both species in December, 1992. Juvenile clams of *T. squamosa* are available for export. Work on *T. maxima* is not planned due to lack of broodstock. Hatchery production is seasonal. Maximum order requirement is 10,000 yearlings (this figure is probably based on available juvenile clams at the time of this report preparation).

Flight schedules

Tonga/Apia PH Wednesday night, arriving Apia Tuesday night.
Apia/Niue PH Thursday night, arriving Niue Thursday night.
Layover : 1 1/2 days in Apia[2].

[1] If the Western Samoa Fisheries Division does not have the facilities for the lay-over, the clams can be shipped to American Samoa the same afternoon. American Samoa has an operational hatchery and a lot of tank space.

[2] If the Fisheries Division in Western Samoa does not have the facilities for the lay-over, the clams can be shipped to Pago Pago the following morning as they have an operational hatchery with a lot of tank space.

Costs for Yearlings Importation per shipment

Yearling Costs : 2,000 clams @ 0.70 each = **$1400.00**

Packaging Costs : 10 styrofoam boxes @ $20.00 each = **$200.00**

Freight costs : Ton/Apia, 110 kg @ ~ $ 1.00/kg = **$110.00**

: Apia/Niue, 110 kg @ ~ $1.00/kg = **$110.00**

Six shipments to make up 12,000 clams per year, **Total Costs per Year = $10920.00**

Costs for 6-month old Juveniles Importation per Shipment

6-month old clams : 2,000 clams @ 0.40 each = **$800.00**

Packaging costs : 5 styrofoam boxes @ $20.00 each = **$100.00**

Freight costs : Ton/Apia, 55 kg @ $1.00/kg = **$55.00**

: Apia/Niue, 55 kg @ $1.00/kg = **$55.00**

Six shipments to make up 12,000 clams per year, **Total Costs per Year = $6060.00**

American Samoa Department of Marine and Wildlife Resources (DMWR)

The American Samoa giant clam hatchery has to date been successful in producing juveniles of one species only, *T. derasa*. Spawning trials on *H. hippopus* have not been successful, probably due to immaturity of broodstock. They presently have a few *T. maxima* and *T. squamosa* but attempt at spawning have also been unsuccessful. A good number of broodstock of both *T. squamosa* and *T. maxima* can be obtained locally, but hatchery production is concentrated on the introduced exotic species. DMWR has plans to collect broodstocks for the production of juveniles of the native species for re-seeding purposes. Hatchery juvenile production is not consistent yet on the introduced species and it may take some time before work is initiated on the indigenous clam species. However, since their giant clam project is working out the commercial feasibility of culturing clams in the Territory, including the operation of a hatchery, American Samoa might be interested in producing larvae or juveniles of both species if contracted to provide the required numbers. American Samoa would be the most ideal place from which to import larvae/juveniles.

Flight schedules

Pago/Niue PH Thursday night, arriving Niue Thursday night.

Lay-over : 0

Costs for Yearlings

Yearling costs : 2,000 clams @ $1.00 each = $2000.00

Packaging : 10 styrofoam boxes @ $20.00 each = $200.00

Freight costs : 110 kg @ $1.80/kg = $198.00

Six shipments to make up 12,000 clams per year, **Total Costs per Year = $14388.00**

Costs for 6-month old juveniles

6-month old costs : 2,000 clams @ $0.50 each = $1000.00

Packaging : 5 styrofoam boxes @ $20.00 each = $100.00

Freight costs : 55 kg @ $1.80 each = $99.00

Six shipments to make up 12,000 clams per year, **Total Costs per Year = $7194.00**

**Juvenile Giant Clam Acquisition**

Obtaining giant clam seeds for reef re-seeding on Niue seems to fall under three general categories. These include (i) establishment of a local giant clam hatchery, (ii) importation of larvae, and (iii) importation of juveniles, (a) yearlings, (b) 6-month old. The two alternatives under importation of juvenile clams are importation of yearlings or importation of 6-month old seeds. The lower costs of shipping 6-month old juveniles over yearlings, makes it a potential mean of obtaining clams for culture.

1. Setting up a Local Giant Clam Hatchery

The major advantage of setting up a hatchery is that it avoids the importation of clams from other countries. Thus, the risk of introducing new predators, diseases and other unwanted organisms is eliminated. In addition, the local genetic pool is not `diluted'. Other benefits include the exclusion of relying on an outside supplier and avoiding the difficulties that are normally involved with shipments.

Apart from the high initial and recurrent costs involved, setting up and operating a giant clam hatchery requires that the operator has a good understanding of the processes involved in larvae culture and must possess the biological background which is so vital for the success of such an undertaking. Almost certainly, initiating a hatchery would require contracting an experienced and qualified aquaculturist/biologist. A very important consideration, which would be applicable to Niue, is the establishment of a suitable site where sea-water can be easily and reliably drawn up. The supply (including quality) of fresh sea-water is such an essential component of the hatchery that it is the basis for site suitability determination. Even if construction of the hatchery facility can be done quickly, establishing a suitable larval rearing protocol which would produce juveniles reliably for the particular site, might take some time. Ordering equipment from overseas is always a problem in the islands and can cause long delays in production.

2. Importation of Giant Clam Larvae

Giant clam larvae can be transported long distances without unreasonable mortalities. Larvae of both species are available from the Coastal Aquaculture Centre (CAC), ICLARM, Solomon Islands.

The major advantage of importation of newly settled larvae (Day 14-Day 28) is the elimination of having to handle eggs and the culturing of larvae in its early stage, which requires meticulous care and technology. The dependency on local successful spawning is also negated. Millions of larvae can be easily transported with minimal freight weight. Since the larvae are supplied by CAC at no cost, the only costs involved are those incurred in packaging and freight. Culturing imported larvae would not require the expertise that is needed for setting up and operating a hatchery and equipment costs are also lower.

The disadvantages of importing larvae include the possibility of introducing predators, diseases and unwanted organisms as well as the dilution of the local population genetic pool if stocks of those species still exist. It must be noted that CAC `would not allow exportation of larvae if local broodstock are available' (Gervis, fax dated 22 January 1993). Export of larvae is only possible `if local stocks are newly extinct or unsustainable locally'. Imported larvae would require a more sophisticated facility to receive them than would be required for imported juveniles. The connecting flights from Honiara to Niue make it impossible to avoid a 7-day layover enroute before the larvae get to Niue. Survival during such a journey could be disastrous as it would require larvae release into a tank and re-packaging either in Pago Pago or Tonga and Apia. Survival, of larvae that survive transportation, to 5-month old juveniles, in settling tanks, after arrival would not be predictable, but can be as low as 0%.

3. Importation of Giant Clam Juveniles

The nearest two possible sources of juvenile clams for Niue, from hatcheries that are currently dealing with *T. maxima* and/or *T. squamosa*, are Tonga and Fiji. Both hatcheries are in operation on a regualr basis. However, the Fiji Fisheries hatchery at Makogai is producing clams on a more consistent basis and can reliably supply juvenile clams of both species. Connecting flights from both sources to Niue are good with only 1-2 days layover in either Western Samoa or American Samoa. Thus mortality during transportation is expected to be very minimal. The giant clam hatchery in American Samoa is also a possibility but may take some time for them to establish broodstock of both species.

Importation of juvenile giant clams would eliminate both the construction of costly facilities and the expertise needed in culturing larvae. The biological background requirement for local staff would be very minimal. Mortality during juvenile rearing in raceways is expected to be insignificant. This could be the most reliable means of obtaining a certain number of clams on a timely basis.

The probability of accidental introduction of predators, diseases and unwanted organisms through the importation of juvenile clams is much higher than it is for larvae. In general, `*it is best to ship organisms at the smallest possible sizes in order to minimize the risk of introducing exotic pathogens*' (Munro, undated). As it is with the importation of larvae, importation of juveniles would eventually lead to the mixing of genetic stock from a different region into the indigenous stocks. Munro (undated) wrote ` *as a general case it is considered highly undesirable to indiscriminately mix genetic stocks of farmed or wild organisms because this can result in the loss of desirable characteristics which might be of considerable importance to the development of improved strains. In the case of marine organisms such as giant clams where the eggs are released into the plankton, the eventual intermixing of the stocks becomes unavoidable*'. `*If significant local populations occur, the introductions of material from elsewhere should not be encouraged*' (Benzie, undated). `*The source of material to be transferred to a location is now a critical issue if the aim is to enhance local stocks without endangering local genetic diversity*' (Benzie, undated2). As Tonga is the closest country to Niue and its giant clam populations would probably have insignificant genetic difference from those on Niue and because of their close proximity to each other, it is very likely that there is a genetic exchange already. Cumulative juvenile clams costs are high.

Six-month old juvenile clams are smaller animals, and the volume of water they carry would be less and the risk of `accidental introduction' of other potentially harmful organisms would be somewhat less than yearlings. The costs for handling, clams and freight, are expected to be approximately half those for importation of yearlings.

Since the importation of any clams, regardless of age, would require a quarantine period of six months in land-based tanks prior to transplanting into the lagoon/reef areas, less tank space would be needed for 6-month old juveniles than that required for yearlings. The quarantine period for the 6-month old juveniles also serves as the `waiting' period until the clams reach the age (12 months) preferred for lagoon transplant.

**Major Costs Involved for Each Method**

The major costs involved with each of the four means are itemized in Tables 1, 2, 3 and 4 below. There is, however, another cheaper but highly detrimental option under the importation of juveniles which would **not** be recommended for consideration. This involves direct transfer of imported juveniles to the ocean (lagoon) upon arrival. It would eliminate the need for any land-based facility but runs the very high risk of introducing diseases and harmful animals.

Each of the four methods would require construction of a land-based facility but of different levels. The lagoon/ocean phase would be the same for all using the same number of juvenile clams. This comparison then is limited to the land-based operation required for each means of obtaining/producing clams. The costs involved with juvenile shipment in Tables 3 & 4 are separated out as there are three separate sources with slightly different costs.

**Equipment and Material Costs**

Due to the nature of some information obtained, the costings for most of the equipment need some clarification.

All figures are estimated in US dollars, and depreciation on facility is not taken into account. Costs of material and equipment from other sources may differ from those used in this report. However, they should not vary much if used relatively, i.e. to compare relative costs of the different ways of obtaining clams. An effort was made to list materials and equipment that are essential to obtain clams in all methods. Expenses incurred durng trans-shipment process are not included.

The spawning tank, as costed in the Tables, is that of concrete and measures 20' x 4' x 2', as used in American Samoa. However, should the round fiberglass storage tanks, available in Niue, be suitable, the cost figure would be less.

Larval Tanks costs were estimated from those obtained by the American Samoa hatchery in 1992 from US. The 575-gallon tanks cost about US$500 each with a total freight cost of approximately US$1500. Thus the figure given also include the estimated freight costs. Again, if the fibreglass storage tanks available locally on Niue are suitable for larval rearing, then this item cost will be greatly reduced.

Settling Tanks are estimated from the AS costings for a 30' x 8' x 2.6' concrete tank, and 30' x 8' x 2' for raceways, also concrete.

Diesel pumps costs were estimates from Yanmar Japan in 1992 for the 3" version, including freight. However, since the intake line would be mostly up-hill and approximately 100 metres from the intake to the hatchery, larger and stronger pumps would be required. Thus the cost for this item could be much higher.

Most of the sea-water system material, including PE pipes, are estimated using prices prevailing in American Samoa as most are available there, whereas laboratory and hatchery equipment were estimated from US suppliers cost listings as purchased by the AS giant clam project.

**Summary**

The major advantage of setting up a giant clam rearing facility on Niue, to produce juveniles of one, or both, of the native giant clam species, *T. squamosa* and *T. maxima*, is the elimination of possible introduction of predators, diseases and other unwanted organisms. In addition, it avoids the mixing of genetic stock from a different region into the indigenous stocks. However, setting up a hatchery involves construction of costly facilities and employment of a qualified aquaculturist. The development of such an undertaking may take years before success is achieved. For a 5-year project, this option is estimated to be the second most costly method of obtaining giant clam juveniles, cumulatively.

Importation of 14-25 days old larvae is the least costly means of possibly obtaining juvenile clams for re-seeding reefs. Since CAC (ICLARM) Honiara is currently the only possible source, shipment routes to Niue are restrictive. In addition, CAC's stand on exporting juveniles and larvae to areas where native stocks of the same species still exist, prohibits this avenue. This source can only be possible if it can be proven that native giant clam species are becoming extinct locally. However, the possibility of importing larvae from Fiji, Tonga and American Samoa might be worth exploring as shipment of larvae is the least risky means as far as the introduction of diseases by importation is concerned. It is also the cheapest means for importation but has the high uncertainty of larval survival both during shipment and in settling tanks.

Due to cumulative clam and shipment costs, importation of yearlings is the most costly estimated means of obtaining juvenile clams for re-seeding for a 5-year period programme. The single major component is the juvenile costs. As expected, importation of younger juvenile clams, 6-month old, is cheaper and comparatively, it is the second least expensive option after larvae importaion. Juvenile clams are readily available from both the Fiji and Tonga Fisheries hatcheries. Connecting flights from these countries to Niue are excellent, involving only 1 or 2 days in Western Samoa. This would require assistance from the Apia Fisheries in the trans-shipment (lay-over). An alternative is a lay-over in American Samoa, which currently has proper facilities for that purpose. The giant clam hatchery in American Samoa is a possible source but it is currently concentrating on introduced species and may take some time before work on the native species materializes. However, this process can be accelerated if they can be contracted to supply clams of the native species for a few years since that project is specifically working on the economic feasibilty of producing giant clams in the Territory. Due to the limited subtidal areas suitable for clam farming in American Samoa any market avenue for clams/larvae produced would be to their advantage in order to avoid the hatchery being idle. The major disadvantages of importing juvenile clams include the possibility of introducing exotic pathogens and eventual mixing of genetic stocks of the imported clams with those of the indigenous ones, in addition to those listed in the attached SPC/Fisheries 17/WP.24. Where importation transfers occur, the above paper also gives guidelines to be considered. The decision concerning this would be up to the Niue Government. On a timely basis, importation would be mostly likely to materialize soonest.

One of the cheaper options involves importation of yearlings which are transferred directly to ocean nurseries on arrival. However, this is the most perilous means, as any other organism tranported, `accidentally', with the clams would be introduced to the marine environment and can become a threat to marine life. Other disadvantages mentioned under the importation of juvenile clams also apply here.

A major consideration for the Niue proposed giant clam project is locating a suitable site for the land-based facility where sea-water can be reliably pumped up and where sustainability and maintenance of the pumping system is not prohibitive. Additionally, suitable and large enough lagoon sites for the grow-out phase need to be established.

The establishment of reserves, in areas where native giant clam stocks still exist, and the collection and creation of clam clumps within the reserves, remains the only safe and cheap means in any effort to enhance native populations. Though it would naturally take time, the risk of introducing new diseases and genetic material that would be detrimental to local resources, is nil.

Introduction of Fisheries regulations for the management of the native giant clam stocks seems to be essential at this stage. Of primary importance is the ability to enforce these regulations consistently and effectively.

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Attachment 1

## COMPARATIVE LISTINGS OF EQUIPMENT, MATERIAL AND QUANTITY REQUIRED FOR ALL METHODS FOR THE FIRST YEAR

| | Hatchery | Larvae | Yearlings | 6-month old |
|---|---|---|---|---|
| Specialist | 1 | - | - | - |
| Training for Local Officer | 1 | ? | - | - |
| Spawning Tank | 1 | - | - | - |
| Larval Tank | 2 | - | - | - |
| Housing for Larval Tank | 1 | - | - | - |
| Settling Tank | 2 | 2 | - | - |
| Raceway | 4 | 4 | 4 | 3 |
| PVC Pipe | 8 | 6 | 4 | 4 |
| Water system fittings | *4,9,11,13,14,8 | *4,6,8,10,10,8 | *4,4,6,8,8,8 | *4,4,6,8,8,8 |
| Diesel Pump | 3 | 3 | 3 | 3 |
| Housing for Pumps | 1 | 1 | 1 | 1 |
| PE Pipe | 8 | 8 | 8 | 8 |
| Air Blower | 1 | 1 | 1 | 1 |
| Broodstock | 200 | - | - | - |
| Larvae (imported) | - | 2 million- | - | |
| Juveniles clams (imported) | - | - | 12,000 | 12,000 |
| Packing Cost | - | | | |
| Freight & Trans-shipment Cost | - | | | |
| Lab & Hatchery Equipment | | | | |
| Shade-cloth | 2 | 2 | - | - |
| Trays | | | | |
| Fuel | | | | |
| Sea-water requirement (# days pump operate) | 365 | 365 | 365 | 365 |

*PVC check-valves, PVC Tee joints, PVC elbows, PVC ball-valves, PVC couplings, brass couplings.