

## **Proposal for Works - Clean-up of the Manihiki Lagoon**

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**Prepared By:**

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## RATIONALE

The Cook Islands black pearl industry was established in the 1980's and is one of the few income generating options for individuals living in the remote northern group of the country. For this reason, it is a priority sector for the Northern Cook Islands development from both economic and social perspectives. In recent years however, pearl farming numbers and overall export value have steadily declined from an industry peak of \$18 million in 2000 to less than \$400,000 in 2012. A number of factors led to this decline, but the primary cause is poor water quality making it difficult to maintain profitable pearl farms.

Because pearls are an immunological reaction in the soft-tissues of oysters - an attempt to rid themselves of indigestible irritations - it is critical to the pearl industry that oyster stocks are not stressed and have healthy immune systems. Any weakness of the individual pearl oyster: lack of food, oxygen or disease, will reduce the effectiveness of its immune system and thus the thickness and quality of nacre produced on a pearl. In the Manihiki lagoon, farmed *Pinctada margaritifera* (black-lipped pearl oyster) are competing not only with each-other for resources, but also with a wide variety of other naturally occurring organisms. In a study by Pouvreau et. al (2000) it was found that if there is a 10% reduction in available food in the area around a *P. margaritifera* oyster it results in a significant decline in both gamete and nacre production. Specifically, it took a 3 year old oyster 22 months rather than the standard 16 to produce 1mm of nacre on an implanted nucleus. *P. margaritifera* filter up to 1500 Litres of water per day, more than any other cultivated species of mollusc, and thus have considerable oxygen and food requirements in order to sustain growth. To further add to the difficulties of pearl farming, the water quality must be consistently excellent. It takes an average of four years from the time an oyster larvae settles on a spat collector for an individual to produce a single pearl, and any stress within that time period will decrease the quality of the pearl.

In Manihiki the decline of the black pearl industry began at the end of 2000 with a disease outbreak and mass mortality of *P. margaritifera* throughout the lagoon. An investigation of the event was conducted by NIWA (Client Report: WLG 01/5) and they were unable to pinpoint any singular cause. The final conclusion reached was that due to over-stocking of *P. margaritifera* overall lagoon water quality had declined to levels which the oysters found intensely stressful and rendered them vulnerable to infection by opportunistic bacteria. Following this mass mortality, many farmers decided to cut their losses and permanently left Manihiki. In most cases, after harvesting all seeded shells, the entire pearl farm and all associated infrastructure was completely abandoned. At this point in time, there are currently more than 610 hectares of previously permitted farming areas which are no longer active and likely contain abandoned farming equipment.

Given that there are two limiting factors which affect the capacity of the Manihiki Lagoon for farming: 1) the number of *P. margaritifera* stocked should not exceed the natural levels of food production and oxygen availability, and 2) the amount of appropriate space /depth strata available for farming is limited, it is critical that any farming infrastructure which is not actively being used is removed from the lagoon. However, at this point in time, abandoned farming equipment distributed throughout the lagoon is limiting the growth of the pearl industry in both respects. More than 610 hectares of farming area is currently unsuitable for use due to the presence of sunken lines which farmers are not properly trained or equipped to remove. Additionally, the abandoned equipment provides an un-natural substrate for settlement and growth of marine invertebrates which utilize similar resources to those required by *P. margaritifera* and thus limits the biological carrying capacity of the lagoon.

Given the importance and demonstrated potential of the black pearl industry the Cook Islands MMR, with assistance from New Zealand and Australia, is undertaking a clean-up project to remove all farming infrastructure from within the Manihiki lagoon which is not actively being utilized.

## **WORK PLAN**

The clean-up project will be divided into four stages. Stage 1 will be to conduct a Dive Safety and Commercial Diving Training course for all divers on Manihiki to ensure that the community is appropriately trained to maintain the Manihiki lagoon beyond the extent of the project. Stage 2 will be a comprehensive survey of the lagoon to locate and document farming infrastructure for removal. Stage 3 is an independent assessment of the clean-up work programme for feasibility and environmental impact. Stage 4 will commence the clean-up phase of the project, removing abandoned or downed farming infrastructure from the Manihiki lagoon in order of priority. Details of each stage are outlined below.

### Stage 1 – Dive Safety & Commercial Diving Training Course

Though SCUBA diving is required for the timely and efficient functioning of the Manihiki pearl farms, only minimal training has been obtained by the vast majority of divers. It is a requirement of the MMR that all individuals who have SCUBA cylinders filled must have a valid Open Water Diver certificate, but that is only the first certification level for recreational divers and very few individuals have exceeded this minimal requirement.

Given the remote location (flights to Rarotonga available only once every fortnight), and the lack of medical facilities (no doctor on the island), safe diving practices are critical. The purpose of this initiative is to bring the dive safety standards on Manihiki up to a level appropriate to the remoteness of the island and the type of work required to create and maintain well-functioning pearl farms.

In order to fulfil this requirement we will contract a SCUBA Instructor certified by an internationally recognized organization to run a tailor designed course to meet the unique needs of Manihiki pearl farmers. The course will cover diving safety and first-aid, search and rescue, preventative equipment maintenance and skills required for working while underwater.

This training will ensure that diving standards on the island are brought up to a level appropriate to the conditions and type of diving being undertaken by pearl farmers. It will also ensure that the pearl farmers are properly trained to remove un-wanted farming equipment beyond the duration of the project.

### Stage 2 – Documentation Survey

The Manihiki lagoon is 8.4 km wide by 9.5 km long and covers an underwater area of 4, 315 hectares. While it is well established that there are many abandoned farms throughout the Manihiki lagoon, the full extent and exact locations of such equipment have never been mapped. Prior to commencing a clean-up project it will be necessary to conduct a comprehensive survey of the lagoon to establish areas of focus and greatest need. This survey will photographically document and collect GPS coordinates of all farming infrastructure found which lies outside currently permitted areas or below 10m depth.

Given the susceptibility of the Manihiki lagoon to perturbation due to its 50 day flushing rate and the sensitivity of *P. margaritifera* to stress, we believe it is critical to consider the implications of equipment removal and approach each site independently with methods chosen to minimize disturbance of bottom sediments, reef structure and nearby farming areas. This information will also allow us to create a detailed timeline for the clean-up project, and will be provided to the contractor in Stage 3 to aid in the Independent Assessment of the Work Programme.

**Figure 1 – Map of areas most likely to contain abandoned farming infrastructure.**



Figure 1 (above) is a map of areas most likely to contain abandoned farming infrastructure based on current and historical permitting records. We overlapped the area boundaries of the permitted farms from the 1996-2000, 2006-2010 and 2011-2015 periods and selected all areas which were permitted in either 1996 or 2006, but which were not renewed in the most recent permitting cycle to be the focus of the survey.

Additionally as part of this survey, we will contact all currently permitted farmers and inquire about equipment requiring removal in their current working areas. Many of the current farmers have expanded into new areas which were previously permitted to other individuals and contain abandoned equipment which impedes expansion of their farms.

### Stage 3 – Independent Assessment of Work Programme

Given the importance of water quality to the health of *P. margaritifera* and the quality of pearls they produce, it is critical that a clean-up programme in the Manihiki lagoon be conducted so as to minimize any negative environmental impacts.

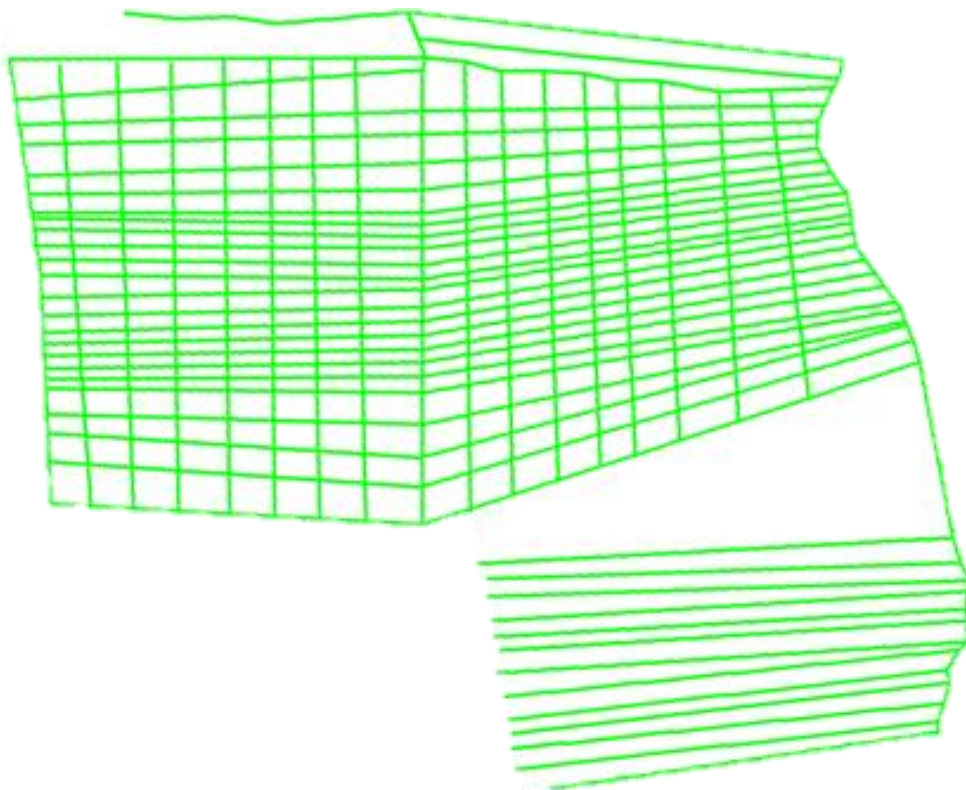
Upon completion of the survey of the Manihiki lagoon to locate and document abandoned infrastructure for removal, a contractor or company with both marine science and commercial diving knowledge will be commissioned to travel to Manihiki and perform an on-site Environmental Impact Assessment and Feasibility Study of the outlined work programme.

The contractors will visit the most significant sites requiring clean-up, spanning both currently farmed and un-farmed areas, and assess all aspects of the proposed work programme including clean-up methodology, waste disposal, safety and environmental impact. The results will be collated into a summary report which reviews every aspect of the work programme and in any cases where the outlined method appears potentially risky from any perspective, alternatives will be proposed with cost-benefit analyses provided for all options.

### Stage 4 – Removal of Abandoned Farming Equipment

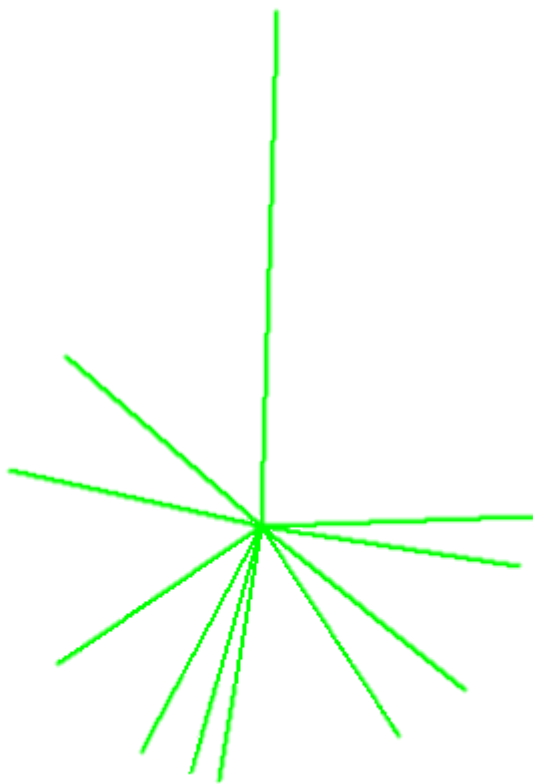
A pearl farm in Manihiki is fairly simple and consists of either polypropylene or nylon lines which are anchored to the reef or concrete blocks on the bottom. Plastic floats, barrels or drums are used to hold the lines aloft in the water column. Mainlines are usually either 110 or 220 metres long, from which either chaplets or spat collectors hang vertically. At the time of the mass mortality event in 2000 there were more than 1,500,000 farmed *P. margaritifera* in the Manihiki lagoon, and no guidelines or best practices for farmers to follow regarding farm layout or spacing. As such, many of the farmers at that time modelled their farms after those of Mr Yves Chenpan who introduced pearl farming to Manihiki (Figure 2).

**Figure 2 - Example of a 'net' layout following the design of Mr Yves Chenpan's farms. The lines running horizontally are 440 metres long; the lines running vertically are ~220 metres.**

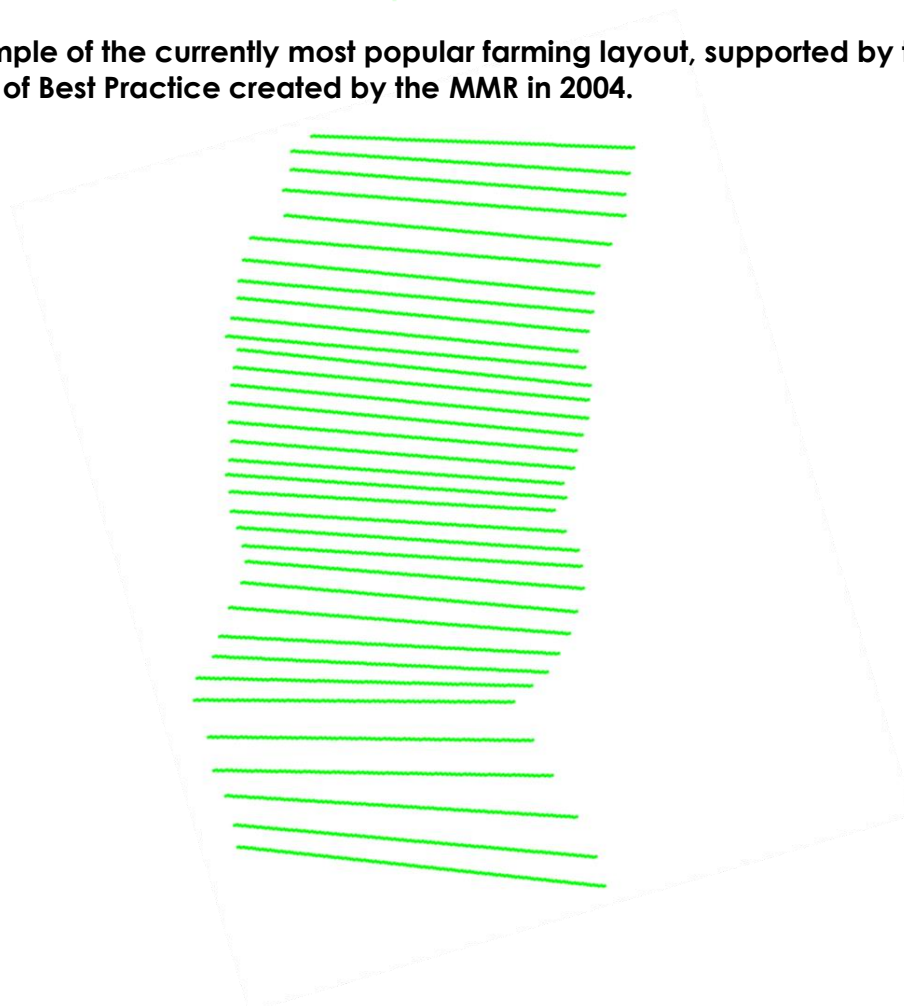


That said however, the layout of any particular farming area is left to the discretion and control of the individual farmer and as such span a wide variety in the Manihiki lagoon. Figures 3 & 4 are illustrations of other popular farm layouts in Manihiki.

**Figure 3 - Example of the 'web' layout. This design is utilized in the deeper regions of the lagoon in an attempt to maximize the available shallow space around coral bommies (kaoa).**



**Figure 4 – Example of the currently most popular farming layout, supported by the Manihiki Pearl Farming Code of Best Practice created by the MMR in 2004.**



It is because of this variety in farming layout that each location must be considered individually, with a clean-up plan specific to the requirements of the site. However, there are some general principles to the clean-up project which will be adhered to across all sites.

A) Prioritization – Using the information gathered in the survey during Stage 2 of the project, clean-up sites will be arranged in order of priority. Since the most important factor for *P. margaritifera* health is the local water quality, our first priority, and possibly the biggest challenge of the project, is to remove unwanted farming equipment from currently permitted farming areas. Many of the Manihiki pearl farmers have been forced to expand into previously occupied areas with old, abandoned farming equipment which not only adds difficulty to the establishment of new lines, but also reduces the local carrying capacity of the area. The two major challenges faced during this phase of the project are:

- 1) Because flow in the Manihiki lagoon is entirely dependent upon wave action, caution must be taken during the clean-up project to not over-burden any one site with contamination from bottom sediments or bio-fouling.
- 2) In many cases there will be active farming lines in the water column above the equipment to be removed, thus impeding the flexibility of the removal operation.

Following clean-up of all of the currently permitted areas, the remaining areas will be prioritized based on a number of criteria including the amount and density of abandoned equipment at the site, the proximity to current farming areas and the suitability of the location to be used for active farming.

B) Diving Safety – All workers on the project must be Open Water Diver certified by an internationally recognized SCUBA agency and will have to have successfully completed the Diving Safety & Commercial Diving Training course conducted at the beginning of the project. Emergency Oxygen supplies will be present on the boat at all times, and all in-water work will be performed by groups of no less than two divers. Dive plans will be shared among all workers prior to commencing underwater work and will be strictly adhered to. Additionally, all divers will wear diving computers during all underwater work with audible alarms which track decompression status and rate of ascent. All divers will also be required to carry a knife at all times.

C) Labour – The clean-up phase of the project will be overseen by two permanent project staff, a Project Manager and Dive Safety Officer. Both will be SCUBA Instructors certified by internationally recognized organizations. Additionally, the Project Manager will be required to have commercial diving and team management experience. The remainder of the team will be sourced from the local labour pool on Manihiki which we have been assured is readily available by the Mayor. The Local Labourers will be sourced from a rotating pool and paid at a rate of \$400/week, allowing for adjustment of the team size based on current workload, farming schedules and dispersion of job availability throughout the community.

When clearing currently permitted areas, the permit holder and/or their nominated staff will be required to assist the clean-up team. In this way the clean-up project will serve as an additional training tool to better prepare the Manihiki community to maintain a healthy, un-cluttered lagoon beyond the extent of the project.

D) Underwater Removal Methodologies – Where possible, main lines will be detached from their anchorage points and sent to the surface whole using lift bags. If chaplets or spat collectors are attached to the main line, they will be removed and sent to the surface in a basket attached to a lift bag. Once empty, the basket and lift bags will be dropped back down to the divers in order to minimize the amount of surfacing required by divers.

If the lines have become overgrown by reef, they will be cut around the reef and sent to the surface in segments in order to minimize the harm to the reef habitat. When lines have sunken to the bottom and become covered by sediments, attempts will be made to remove the majority of sediment near the bottom prior to being sent to the surface so as to minimize the amount of sediment introduced to the water column. If there are large areas where lines have become covered by sediment, a site specific removal plan will be created so as to stagger the disturbance to local water quality, taking into consideration the active farms in the area, the recent weather conditions and the other nearby sites requiring clearing.

- E) Waste Disposal – Whenever possible, all lines and floats recovered in the project will be taken back to shore and cleaned for re-use on farms. Given the synthetic nature and strength of the materials, it is expected that a significant portion of the equipment recovered will still be functional. In cases where the equipment is beyond repair and/or re-use it will be buried in a landfill using land and a digger arranged with the assistance of the Manihiki Island Council.
- F) *Pinctada margaritifera* stocks – Prior to abandoning farms, most farmers conducted kill harvests in which all seeded shells were removed from the lagoon, however untold kilometres of spat collector lines were left un-touched. If *P. margaritifera* are recovered in a currently permitted farming area they will be left with the permit holder to utilize as they wish. If *P. margaritifera* are recovered from spat collectors in areas which are not currently permitted, they will be placed on the reef to maintain broodstock and genetic diversity in the Manihiki population.
- G) Timing – The Manihiki lagoon is a virtually enclosed atoll with an unbroken rim of living coral growing above sea level. Because of this topography, circulation and flushing of the lagoon waters is controlled entirely by wave action. When swells are large enough to break over the reef and come into the lagoon, the lagoon is flushed. When conditions are calm and the swells are not large enough to break over the reef, the lagoon is stagnant and receives little refreshing water input. The flushing time of the lagoon, in average swell conditions, is 50 days. For this reason it is critical that the clean-up of the lagoon is conducted over an extended period of time so as to not cause a significant decline in the lagoon water quality. Following this plan, we will use a small, dedicated team of workers throughout a period of one year to conduct the clean-up operation. In this way, the lagoon will have time to flush bottom sediments or in-advertently introduced bio-fouling from the water column before any significant decline in water quality is created.
- H) Monitoring – The Ministry of Marine Resources currently conducts weekly water quality monitoring of six sites distributed throughout the Manihiki lagoon. For the duration of the clean-up project an additional site will be added in the centre of the current clean-up operations so that we can directly monitor any potential changes in water quality caused by the clean-up programme and mitigate any negative impacts to current pearl farming practice.

## **BENEFITS TO THE COMMUNITY**

Given the nature of remote, low-lying atolls almost every aspect of daily life revolves around the ocean and lagoon. A healthy lagoon supports not only successful pearl farms, but also a diverse fish and invertebrate community on which the local population relies for sustenance. The benefits of this project and improvement of the water quality in the Manihiki lagoon will be felt throughout the population in the form of long-term sustainability of lagoon resources and food availability.



Additionally the project will significantly benefit the pearls farmers, which consist of both men and women, in Manihiki several ways. The improved diving safety knowledge imparted during the project will reduce the number of diving related injuries which occur on the island, making the pearl farming industry more appealing to youth and minimizing the amount of chronic illness associated with the industry. The project will also not only improve the water quality in the lagoon, but it will also ensure that the knowledge and equipment needed to maintain a clean lagoon are transferred to the Manihiki community and that the work can be continued beyond the extent of the project. The improved water quality will result in healthier *P. margaritifera* stocks able to produce higher quality pearls with less frequent dissolved oxygen depletion and mortality events. Removal of unwanted equipment will allow current farmers to expand within their current areas and will also open up new areas of the lagoon which have been abandoned for years to pearl farming.

This proposal has been designed so that the maximum amount of resources are injected directly into the Manihiki economy and pearl industry. Upon completion of the project, all equipment purchased for the project will be left with the Manihiki Island Council to utilize as they find appropriate in order to best help the pearl farmers of Manihiki. Currently there is only a single air compressor in Tauhunu village which is operated by the MMR. When that compressor breaks down farming work in Manihiki is at a stand-still for weeks until replacement parts can be shipped from Rarotonga or New Zealand as required. The compressor outlined in this proposal is the same model as that currently operating in Manihiki, and will be operated by the MMR and stationed in Tukao village upon completion of the project leaving Manihiki with a back-up compressor in the event of mechanical issues and reducing the amount of fuel expended by farmers in filling their diving cylinders travelling between villages. The boat outlined for purchase is of ideal size and construction for work on pearl farms and will be made available for rent to pearl farmers who do not have their own boats or whose boats are experiencing mechanical problems. The diving equipment acquired for the project will be sold to farmers at minimal expense upon completion of the project, providing the island with the option of safe equipment which include alternate air sources, depth, and air pressure gauges for conducting the deep water work required when setting out new farming lines. The diving computers selected provide audible alarms which warn divers when they are being unsafe and reduce the necessity of the complicated calculations required when using dive tables, a task rarely completed by Manihiki divers.

Finally, the infusion of five job positions to the Manihiki labour pool will create a much needed opportunity for individuals who desire to set up or expand their farms but currently lack to capital to accrue funds. The wages proposed in this document are in the upper level of current pay rates in Manihiki and reflect the demanding nature of the work being conducted. Labourers for the project will be chosen from the individuals who complete the Stage 1 – Dive Safety Training course and will be rotated as necessary and fitting in order to divide the wages and experience gained while working on the project throughout the community.

## **COORDINATION**

The MMR will accept full responsibility for the organization and coordination of the works described in this proposal with additional input from MFEM and MFAT where appropriate. This includes acquisition and distribution of equipment to the Island Council upon completion of the project, as well as selection and contracting of necessary staff and consultants as outlined in the proposal.

## **GOVERNANCE**

There will be a locally based Project Coordination Team composed of representatives from the MMR, Manihiki Island Council, Manihiki Pearl Farmers Association and the Project Manager once recruited. The Project Coordination Team will report back the GFA members including the MMR, MFEM and MFAT.

## **CONSULTATION**

This proposal was drafted by Ms. Tina Weier, the MMR Pearl Biologist stationed in Manihiki. Ms. Weier has a Master of Science degree in Marine Environmental Biology from the University of Southern California as well as her Professional Association of Diving Instructors Divemaster certification and is an experienced diving professional.

In the drafting of this proposal Ms. Weier consulted with the Manihiki National Environment Service Officer, Mr. Nimeti Nimeti, the Mayor of Manihiki, Mrs. Ngamata Napara, the Chairman and Vice-Chairman of the Manihiki Pearl Farmers Association, Mr. Kora Kora and Mrs. Rangi Johnson (respectively), as well as the MMR Station Manager, Mr. Tangi Napara. Additionally Ms. Weier consulted with five different commercial and salvage diving experts regarding removal methods, two of which have been on-site in Manihiki.

Ms. Weier and Mr. Napara presented this proposal to the Manihiki Island Council on 5 December 2013. The Manihiki Island Council expressed satisfaction with the project as outlined and fully endorse the current proposal.

## **REFERENCES**

- Pouvreau, S., Bacher, C., and Heral, M. 2000. Ecophysiological model of growth and reproduction of the black pearl oyster, *Pinctada margaritifera*: potential applications for pearl farming in French Polynesia. *Aquaculture*, 186(1-2): 117-144.
- NIWA Client Report: WLG 01/5. 2001. Mortality of black-lip pearl oysters (*Pinctada margaritifera*) in Manihiki Lagoon.

## IDEAL BUDGET

EXPENSE	BUDGET (NZ\$)	TOTAL (NZ\$)
<b>Stage 1 - Dive Safety Training</b>		<b>\$27,000</b>
Airfare	\$2,700	
Food & Accommodation	\$4,200	
Contract Estimate	\$20,000	
<b>Stage 2 - Lagoon Survey</b>		<b>\$10,500</b>
Underwater Camera	\$500	
Labour	\$4,000	
Fuel	\$6,000	
<b>Stage 3 - Feasibility &amp; Environmental Impact Assessment</b>		<b>\$26,100</b>
Airfare (2 people)	\$11,400	
Food & Accommodation (2 people)	\$6,300	
Contract estimate (2 people)	\$8,400	
<b>Stage 4 - Removal of Abandoned Farming Equipment</b>		<b>\$636,400</b>
Lift Bags	\$700	
Cutting Implements	\$500	
Baskets	\$150	
Rope	\$100	
GPS	\$600	
Fuel	\$175,000	
Boat	\$40,000	
100 HP Yamaha 4-stroke engine	\$18,000	
Three-phase Air Compressor	\$27,000	
Commercial Shredder	\$100,000	
Surface Marker Buoys	\$400	
Dive Reels	\$400	
Dive Knives	\$500	
Diving Regulators	\$3,700	
Dive Computers	\$1,600	
Wet Suits	\$1,500	
Compressed Gas Cylinders	\$1,750	
Emergency Oxygen Kit	\$1,800	
First Aid Kit	\$700	
Mobile Phone	\$600	
Personnel	\$230,000	
Contingency	\$21,400	
Shipping	\$10,000	
<b>OVERALL PROJECT BUDGET</b>		<b>\$700,000</b>

## BARE MINIMUM BUDGET

The alterations from the ideal budget to reach this figure were the following:

- Labour was decreased from two workers down to one for the Lagoon Survey on the assumption that the MMR could provide workers for the project
- The amount allocated to fuel for Stage 4 of the project was decreased from \$175,000 to \$150,000, with the possible risk of not being able to remove all rubbish from the lagoon
- The commercial shredder was removed from the equipment, meaning that rubbish will have to be buried with minimal processing thereby increasing the time required for degradation and increasing the space requirements.
- There is no contingency included in this budget.
- Salary for one labourer was removed from Stage 4 of the project.

EXPENSE	BUDGET (NZ\$)	TOTAL (NZ\$)
<b>Stage 1 - Dive Safety Training</b>		<b>\$27,000</b>
Airfare	\$2,700	
Food & Accommodation	\$4,200	
Salary	\$20,000	
<b>Stage 2 - Lagoon Survey</b>		<b>\$8,500</b>
Underwater Camera	\$500	
Labour	\$2,000	
Fuel	\$6,000	
<b>Stage 3 - Feasibility &amp; Environmental Impact Assessment</b>		<b>\$26,100</b>
Airfare (2 people)	\$11,400	
Food & Accommodation (2 people)	\$6,300	
Salary (2 people)	\$8,400	
<b>Stage 4 - Removal of Abandoned Farming Equipment</b>		<b>\$448,400</b>
Lift Bags	\$700	
Cutting Implements	\$500	
Baskets	\$150	
Rope	\$100	
GPS	\$600	
Fuel	\$150,000	
Boat	\$40,000	
100 HP Yamaha 4-stroke engine	\$10,000	
Three-phase Air Compressor	\$20,000	
Surface Marker Buoys	\$400	
Dive Reels	\$400	
Dive Knives	\$500	
Diving Regulators	\$3,700	
Dive Computers	\$1,600	
Wet Suits	\$1,500	
Compressed Gas Cylinders	\$1,750	
Emergency Oxygen Kit	\$1,800	
First Aid Kit	\$700	
Mobile Phone	\$600	
Personnel	\$208,400	
Shipping	\$5,000	
<b>OVERALL PROJECT BUDGET</b>		<b>\$510,000</b>