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**WATER QUALITY ANNUAL DATA  
REPORT.**

**Penrhyn**

**January – December 2009**



**August 2010**

**Dorothy Solomona  
Teina Tuatai  
Tuaine Turua  
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**Annual Data Report 2009**

**INSHORE AND AQUACULTURE DIVISION**



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## 1. Introduction

Penrhyn also known as Tongareva is located at about 8.59°45' south latitude and 158.03° 33' west longitude and is a coral atoll with 3 main passages. It has the largest lagoon in the Cook Islands with an area of 208km<sup>2</sup> compared to a land area of 9.8km<sup>2</sup> with a surrounding reef of 1.1km<sup>2</sup>.

Previous water quality testing in Tongareva was undertaken because of environmental concerns raised by the Tongareva residents regarding protection and management of the lagoon. The primary objective at the time was to establish a pearl culture industry using sound management practices to prevent detrimental environmental effects. The following physical (Temperature, DO, pH and salinity), chemical (chlorophyll *a*, orthophosphate, silicates, nitrate/nitrite nitrogen, ammonia and total dissolved phosphorus) and biological information were collected.

The present water quality monitoring program was started in January 2008 to provide information for the pearl farmers on the potential for disease occurrences in the oysters and the general health of the lagoon. The measurement of nutrients (dissolved inorganic nitrogen and dissolved reactive phosphorus) chlorophyll *a* and bacteria (enterococci and *Vibrio* spp.) were undertaken as part of this water quality monitoring program.

All samples were processed in the Tongareva Marine Research Centre laboratory and temperature was measured in the field. The measurement of temperature is important for establishing long term trends and changes in the lagoon. Temperature influences aquatic plants, animals and water chemistry.

There are two distinct seasons in Tongareva which consist of a dry season beginning in May to November and the rainy season in November to April with January being the wettest month. Air temperature varies little throughout the year with December usually being the hottest month. The trade winds occur throughout the year but are particularly steady during May to November. The

prevailing winds are usually easterly, with occasional north and northwest winds between December and March.

Nutrients such as nitrate and phosphate which are naturally present in seawater are essential for the growth of phytoplankton and other algae which form the base of the food web. Elevated nutrients concentration can lead to an increase in algae and aquatic plants biomass which can have detrimental impacts on the coral reef health. The guidelines for nutrient concentrations for the protection of coral reef health are 14µg/L for dissolved inorganic nitrogen (DIN), which is made up of nitrate and ammonia (NO<sub>3</sub>-N + NH<sub>4</sub>-N), and 2.6µg/L for dissolved reactive phosphorus (DRP) (Bell 1992).

Chlorophyll *a* and total suspended solids measure phytoplankton biomass, inorganic and organic particulate material in the water respectively. Elevated concentrations of both have been shown to impact negatively on coral reef health above concentration of 0.5mg/L for chlorophyll *a* and 4-5 mg/L for total suspended solids Bell (1992).

Increased inorganic and organic materials entering lagoons is often associated with increases in bacteria numbers which can be disease causing organisms. Numbers of bacteria evaluated in the Tongareva lagoon were vibrio and enterococci. *Vibrio* spp. are a group of bacteria that naturally occur in seawater, survive well in warm water and are commonly found in bivalves, especially oysters and clams. *Vibrio* spp. infections of oysters have caused major disruptions to the pearl aquaculture production (Diggles and Hine 2001) in Manihiki, therefore monitoring this group of bacteria may provide an early warning of deteriorating water quality conditions for pearl aquaculture. There are no guidelines or standards for *Vibrio* spp. concentrations in relation to oyster health, however, *Vibrio* spp. can be broken down into glucose utilisers (yellow) and non-glucose utilisers (green) (Diggles and Maas 2003). The glucose utilisers include species such as *V. alginolyticus* and are not thought to be associated with disease outbreaks in aquaculture (Vandenberghe et al.,

1999; Gomez-Gil et al., 2002; Irianto and Austin, 2002). The non-glucose utilisers include *V. harveyi* have caused disease in the oysters in the past (Diggles and Hine 2001).

Enterococci bacteria are used to indicate the potential presence of human pathogens in marine and freshwater. Guidelines have been developed by the World Health Organisation (WHO) for contact recreation using Enterococci numbers (Table 1).

**Table 1: WHO Standards for Bathing Water Quality (WHO 2001).**

Category	Indicator Counts	Microbiological Assessment
A.	≤ 40 Enterococci / 100ml	Suitable for swimming
B.	≥ 41 to ≤ 200 Enterococci / 100ml	Suitable for swimming but requires surveillance
C.	≥ 201 to ≤ 500 Enterococci / 100ml	Not suitable for swimming, requires assessment
D.	≥ 500 Enterococci / 100ml	Not suitable for swimming, public warnings

This report is a Data Report of the water quality sampling program in 2009.

## 2. Methods

### 2.1 Sampling

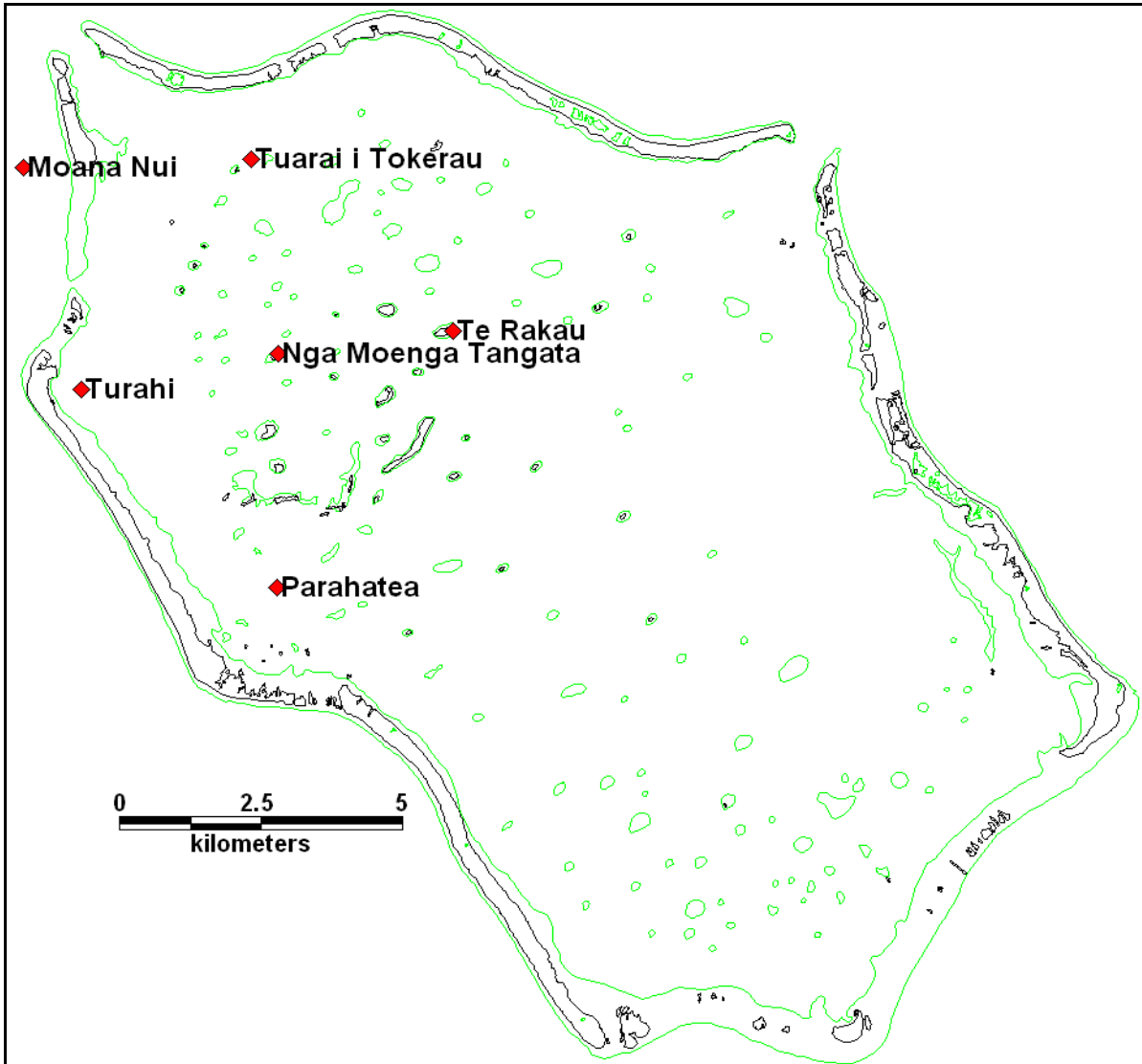
All the water quality parameters for the lagoon samples were measured fortnightly and samples were processed in the Tongareva Marine Research Centre laboratory (TMRC). Six marine sites were sampled (Table 2 and Figure 1). Water samples were collected 15-30cm below the surface of the lagoon, one 500ml bottle filled for microbiological analysis, one 2L bottle for other analyses and one 250ml nutrient bottle for total nitrogen and total phosphorus analysis (Hall et al., 2007), all samples were placed in a cool chilly bin and taken back to the laboratory for processing.

### 2.2 Penrhyn Marine Sampling Site and Map.

**Table 2. Penrhyn lagoon sampling sites.**

Location	Site Number	Latitude	Longitude
Paratea	1	S9° 0' 34.866	W201° 59' 8.106
Te Rakau	2	S8° 58' 3.2952	W202° 0' 50.2164
Nga Moenga Tangata	3	S8° 58' 16.6548	W201° 59' 8.4624
Turai I Tokerau	4	S8° 56' 21.5592	W201° 58' 52.7916
Moananui	5	S8° 56' 26.7504	W201° 56' 41.1432
Turahi	6	S8° 58' 37.5816	W201° 57' 14.4





**Figure 1: Penrhyn Lagoon Water Quality Sampling Sites.**

### **2.3 Physical Parameters**

At each site temperature (°C) was measured from the boat using a Eutech digital thermometer just below the surface of the sea. The Eutech thermometer was calibrated every 3 months in the TMRC laboratory (Hall et al., 2007).

### **2.4 Nutrient**

Total Nitrogen and Total Phosphorus samples were collected from the field, stored on ice in a chilli bin and then placed in a freezer upon return to the TMRC lab. All water samples for dissolved nutrient analysis were filtered through a Whatman GF/F glass fibre filter into a 250ml acid washed plastic bottle. These samples were stored frozen until they were shipped or air freighted on ice in chilly bins to Rarotonga and were then sent on to the National Institute of Water and Atmospheric Research Limited (NIWA) for analysis. All nutrient analysis was conducted using an Astoria Pacific autoanalyser 300 series with methods from the Astoria Pacific International Methods Manual (A 6/00). Nitrate was analysed by the cadmium column reduction method (Astoria 305-A177), DRP by the molybdenum blue method (Astoria 305-A204) and NH<sub>4</sub>-N by the indophenol blue method (Astoria 305-A026).

### **2.5 Chlorophyll *a* and Suspended Solids**

Samples for chlorophyll *a* and total suspended solids analysis of known volumes were filtered on to GF/F filters and both filters were frozen immediately in the TMRC laboratory. The frozen filters for chlorophyll *a* were shipped or air freighted on ice in chilly bins to Rarotonga and were then analyzed later by acetone extraction and fluorometry (APHA 1998) in the Ministry of Marine Resources (MMR) laboratory (Hall et al., 2007). Samples for total suspended solids analysis were shipped or air freighted to Rarotonga for analysis in the MMR laboratory, and were processed using methods outlined by Hall et al., (2007).

### **2.6 Bacteria**

Water samples collected for *Vibrio* spp. and Enterococci were analysed in duplicate. The Membrane Filtration Method was used to analyse samples for Enterococci and filters

were placed on Enterococci agar (Hall et al., 2007; Hall et al., 2007). The volumes filtered differed depending on how clean the sample water was and on previous results (Hall et al., 2007). *Vibrio* spp. were analysed using spread plating on TCBS agar (Oxoid). Three dilutions of each sample were used - direct sample (0.1ml),  $10^{-1}$  and  $10^{-3}$  and were plated in duplicate on TCBS (Oxoid). Both Enterococci and *Vibrio* spp. plates were incubated at 37°C for 24 hours (Hall et al., 2007; Hall et al., 2007).

## **2.7 Missing Data**

No bacteria samples were processed for January to March because agar was not available in the Tongareva laboratory. Total nitrate (TN) and Total phosphate (TP) were missing for the 29<sup>th</sup> April for Moana Nui and Turahi site. No data was collected from September to December due to lab technician absentees.

### **3. Acknowledgments**

We thank Drs Julie Hall and Els Maas for both technical advice and editorial comments and ongoing support, Mike Crump and his team at NIWA for their technical support, and the Inshore staff of the Ministry of Marine Resources for processing, editorial and the Tongareva Marine Research Centre staff also for collecting and processing the samples. Thanks also to the Cook Islands Meteorological Services for providing the weather and rainfall information. The Ministry of Marine Resources would also like to thank NZAid for all the funding support.

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## MMR Database

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## 5. Appendix

### 5.1 Penrhyn Lagoon Water Quality Data.

Location	Site Number	Date	Temperature (°C)	DRP (µg/L)	NH4-N (µg/L)	NO3-N (µg/L)	TN (µg/L)	TP (µg/L)	Chl a (µg/L) Extraction	TSS (mg/L)	VSS (mg/L)	Enterococci (Count/100ml)	Vibrio green (count/mL)	Vibrio yellow (count/mL)
Parahatea	1	20-Jan-09	28.8	4	1	1	85	10	0.81	1.3	1.3	-	-	-
Parahatea	1	17-Feb-09	28.4	3	0.5	0.5	96	9	0.99	1.2	1.6	-	-	-
Parahatea	1	31-Mar-09	28.6	6	3	6	87	10	0.40	0.8	0.3	-	-	-
Parahatea	1	29-Apr-09	28.4	7	5	6	93	9	0.93	0.3	0.3	0	0	0
Parahatea	1	26-May-09	28.6	8	4	2	69	15	1.13	0.3	0.3	0	0	0
Parahatea	1	23-Jun-09	28.8	11	4	20	111	12	0.35	0.3	0.1	1	5	5
Parahatea	1	21-Jul-09	27.7	8	3	2	102	17	2.45	0.3	0.5	0	0	10
Parahatea	1	18-Aug-09	27.8	12	3	20	126	16	0.72	0.7	0.5	0	0	5
Parahatea	1	Sep-09	*	*	*	*	*	*	*	*	*	*	*	*
Parahatea	1	Oct-09	*	*	*	*	*	*	*	*	*	*	*	*
Parahatea	1	Nov-09	*	*	*	*	*	*	*	*	*	*	*	*
Parahatea	1	Dec-09	*	*	*	*	*	*	*	*	*	*	*	*
Te Rakau	2	20-Jan-09	28.6	8	0.5	17	101	12	0.33	1.3	1.3	-	-	-
Te Rakau	2	17-Feb-09	28.2	0.5	0.5	0.5	88	8	0.39	0.9	0.1	-	-	-
Te Rakau	2	31-Mar-09	28.4	3	2	0.5	91	9	0.42	0.3	0.0	-	-	-
Te Rakau	2	29-Apr-09	28.4	5	3	1	115	9	0.45	0.4	0.1	0	0	0
Te Rakau	2	26-May-09	28.4	7	4	0.5	83	13	0.89	1.3	0.1	0	0	0
Te Rakau	2	23-Jun-09	28.8	7	2	0.5	110	11	0.80	0.6	0.4	1	10	5
Te Rakau	2	21-Jul-09	27.2	7	4	5	95	14	1.11	0.3	0.3	0	0	0

<sup>1</sup> No data (\*)

<sup>2</sup> No agar (-)

Location	Site Number	Date	Temperature (°C)	DRP (µg/L)	NH4-N (µg/L)	NO3-N (µg/L)	TN (µg/L)	TP (µg/L)	Chl a (µg/L) Extraction	TSS (mg/L)	VSS (mg/L)	Enterococci (Count/100ml)	Vibrio green (count/mL)	Vibrio yellow (count/mL)
Te Rakau	2	18-Aug-09	27.9	4	2	0.5	102	14	1.05	0.9	0.2	0	0	0
Te Rakau	2	Sep-09	*	*	*	*	*	*	*	*	*	*	*	*
Te Rakau	2	Oct-09	*	*	*	*	*	*	*	*	*	*	*	*
Te Rakau	2	Nov-09	*	*	*	*	*	*	*	*	*	*	*	*
Te Rakau	2	Dec-09	*	*	*	*	*	*	*	*	*	*	*	*
Nga Moenga Tangata	3	20-Jan-09	28.6	4	0.5	2	84	8	0.62	1.6	1.6	-	-	-
Nga Moenga Tangata	3	17-Feb-09	28.2	0.5	0.5	0.5	88	9	0.67	0.3	0.4	-	-	-
Nga Moenga Tangata	3	31-Mar-09	28.4	4	2	0.5	107	10	0.39	0.3	0.3	-	-	-
Nga Moenga Tangata	3	29-Apr-09	28.2	8	23	6	107	9	1.11	0.8	0.8	0	0	25
Nga Moenga Tangata	3	26-May-09	28.4	5	6	0.5	83	9	1.07	0.5	0.2	0	5	5
Nga Moenga Tangata	3	23-Jun-09	28.6	20	10	3	136	10	0.81	0.3	0.1	0	0	5
Nga Moenga Tangata	3	21-Jul-09	27.8	9	1	4	93	19	1.43	0.3	0.4	0	10	0
Nga Moenga Tangata	3	18-Aug-09	27.9	7	1	3	99	14	0.88	0.3	0.2	0	0	5

<sup>1</sup> No data (\*)

<sup>2</sup> No agar (-)



Location	Site Number	Date	Temperature (°C)	DRP (µg/L)	NH4-N (µg/L)	NO3-N (µg/L)	TN (µg/L)	TP (µg/L)	Chl a (µg/L) Extraction	TSS (mg/L)	VSS (mg/L)	Enterococci (Count/100ml)	Vibrio green (count/mL)	Vibrio yellow (count/mL)
Nga Moenga Tangata	3	Sep-09	*	*	*	*	*	*	*	*	*	*	*	*
Nga Moenga Tangata	3	Oct-09	*	*	*	*	*	*	*	*	*	*	*	*
Nga Moenga Tangata	3	Nov-09	*	*	*	*	*	*	*	*	*	*	*	*
Nga Moenga Tangata	3	Dec-09	*	*	*	*	*	*	*	*	*	*	*	*
Tuarai i Tokerau	4	20-Jan-09	28.8	8	2	20	100	11	0.47	1.5	0.0	-	-	-
Tuarai i Tokerau	4	17-Feb-09	28.4	2	0.5	0.5	84	11	1.04	0.3	0.4	-	-	-
Tuarai i Tokerau	4	31-Mar-09	28.4	4	3	0.5	131	10	0.81	0.3	0.3	-	-	-
Tuarai i Tokerau	4	29-Apr-09	28.2	8	6	5	104	8	0.27	0.5	0.5	0	0	5
Tuarai i Tokerau	4	26-May-09	28.4	5	4	0.5	86	9	0.25	0.7	0.3	0	20	0
Tuarai i Tokerau	4	23-Jun-09	28.6	26	12	1	100	11	0.47	0.4	0.2	0	0	0
Tuarai i Tokerau	4	21-Jul-09	27.6	7	2	1	93	13	1.17	0.3	0.4	0	0	10
Tuarai i Tokerau	4	18-Aug-09	28	6	2	0.5	96	14	1.22	0.5	0.1	0	0	0
Tuarai i Tokerau	4	Sep-09	*	*	*	*	*	*	*	*	*	*	*	*
Tuarai i Tokerau	4	Oct-09	*	*	*	*	*	*	*	*	*	*	*	*

<sup>1</sup> No data (\*)

<sup>2</sup> No agar (-)

Location	Site Number	Date	Temperature (°C)	DRP (µg/L)	NH4-N (µg/L)	NO3-N (µg/L)	TN (µg/L)	TP (µg/L)	Chl a (µg/L) Extraction	TSS (mg/L)	VSS (mg/L)	Enterococci (Count/100ml)	Vibrio green (count/mL)	Vibrio yellow (count/mL)
Tuarai i Tokerau	4	Nov-09	*	*	*	*	*	*	*	*	*	*	*	*
Tuarai i Tokerau	4	Dec-09	*	*	*	*	*	*	*	*	*	*	*	*
Moana Nui	5	20-Jan-09	28.2	11	0.5	36	118	15	0.07	1.6	1.6	-	-	-
Moana Nui	5	17-Feb-09	28	7	0.5	14	103	12	0.30	0.8	0.2	-	-	-
Moana Nui	5	31-Mar-09	28.2	3	3	0.5	137	14	0.35	0.7	0.7	-	-	-
Moana Nui	5	29-Apr-09	28	9	5	14			0.91	0.4	0.4	0	0	0
Moana Nui	5	26-May-09	28.4	10	5	19	113	14	0.21	0.3	0.2	0	0	0
Moana Nui	5	23-Jun-09	28.4	14	7	20	116	15	0.13	0.3	0.3	2	0	0
Moana Nui	5	21-Jul-09	28	13	3	29	142	15	0.15	0.3	0.3	0	0	0
Moana Nui	5	18-Aug-09	27.9	12	3	32	142	17	0.18	0.7	0.3	0	0	0
Moana Nui	5	Sep-09	*	*	*	*	*	*	*	*	*	*	*	*
Moana Nui	5	Oct-09	*	*	*	*	*	*	*	*	*	*	*	*
Moana Nui	5	Nov-09	*	*	*	*	*	*	*	*	*	*	*	*
Moana Nui	5	Dec-09	*	*	*	*	*	*	*	*	*	*	*	*
Turahi	6	20-Jan-09	28.8	10	5	28	121	12	0.26	0.5	0.5	-	-	-
Turahi	6	17-Feb-09	28.4	0.5	0.5	0.5	99	7	0.63	0.3	0.3	-	-	-
Turahi	6	31-Mar-09	28.4	11	4	17	91	8	0.15	0.3	3.1	-	-	-
Turahi	6	29-Apr-09	28.4	4	5	2			0.54	1.1	1.1	0	0	5
Turahi	6	26-May-09	28.6	6	6	5	90	9	0.67	0.3	0.2	0	0	0
Turahi	6	23-Jun-09	28.8	9	4	0.5	95	10	0.49	0.4	0.0	1	0	0
Turahi	6	21-Jul-09	27.8	6	3	0.5	126	14	2.45	0.8	0.5	0	10	10
Turahi	6	18-Aug-09	28.1	11	2	13	100	13	0.78	0.6	0.3	0	0	0
Turahi	6	Sep-09	*	*	*	*	*	*	*	*	*	*	*	*
Turahi	6	Oct-09	*	*	*	*	*	*	*	*	*	*	*	*
Turahi	6	Nov-09	*	*	*	*	*	*	*	*	*	*	*	*
Turahi	6	Dec-09	*	*	*	*	*	*	*	*	*	*	*	*

<sup>1</sup> No data (\*)

<sup>2</sup> No agar (-)