

Pearls of wisdom

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The largest ocean in the world, the Pacific, has a desperate need for effective marine management. Not only is the region home to many unique habitats, it is subject to frequent natural disasters, susceptible to climate variability and change, and has a high reliance on natural resources. PI-GOOS is the Pacific Islands' Global Ocean Observatory System (GOOS), which encourages collection of data imperative for sustainable management of ocean resources.

A case in point is the black pearl industry in Manihiki Lagoon, Cook Islands, which was virtually decimated by a disease outbreak in 2000. With government support and financial aid (see box), a team of scientists and an economist have established the underlying cause of the catastrophe and have helped the islands plan for a sustainable pearl industry based on sound science, good management and capacity building.

The island of pearls

Manihiki, “the island of pearls”, is an idyllic atoll remotely located among the Cook Islands in the Pacific Ocean. Comprising 40 tiny islets encircling a 4 km wide lagoon, this completely enclosed body of water is the source of the island's most valuable asset, the black pearl. Islanders have traditionally derived three products from the black-lipped pearl oyster (*Pinctada margaritifera*) that inhabits the lagoon, namely oyster meat, mother-of-pearl and black pearls.

While locals once dived for wild oysters, this subsistence-based activity transformed into a stalwart aquaculture industry throughout the 1980s and 1990s. From a modest start with a single farm in 1982, the number of farms increased exponentially to 205 in 2003, with an estimated total of one million cultured adult pearl oysters. In the 1990s, tourism was the only sector in the Cook Islands that surpassed the pearl industry in revenue. At its peak in 2000, the pearl industry earned USD18 million in export revenue, accounting for 20 per cent of Cook Islands' GDP.

Precipitous decline

This same year, however, the shine began to wear off the pearl oyster, as the industry in Manihiki lagoon was decimated by an outbreak of *Vibrio harveyi*, a marine bacterium that commonly infects cultured shellfish. Since the 1990s, there was growing concern that the lagoon would be struck by the disease, which had previously crippled pearl industries in French Polynesia, Indonesia, Myanmar and Australia. Together with low international prices, this led to a dramatic decline in pearl export revenue to NZD 2.8 million in 2005. In the year prior, French Polynesia, the majority supplier of black pearls globally, had rapidly increased the supply to the market, causing a fall in average prices. In Manihiki, the average price received per pearl dropped from USD 200 in the early 1990s to USD 20.00 in 2003.

Poor practice

Following the slump in export revenue, an investigation by the Island Council and Cook Islands Government found that poor farming practice was weakening and stressing oysters in the lagoon, leaving them susceptible to disease. Overstocking had become common practice under a system with regulations that were limited, unsystematic or not enforced. In the history of Manihiki pearl farming, not a single pearl farmer has been penalised for poor farming practices. In September and October 2000, windless and dry weather conditions reduced the amount of lagoon flushing, causing a rise in water temperature. At the same time, a massive spawning event caused high concentrations of *Vibrio* bacteria in the water. Together, these factors caused the oysters in Manihiki to be badly affected by the *Vibrio* outbreak.

A system of lagoon management regulating farm practices might have prevented the initial factors that led to the demise of the industry. To prevent a catastrophe of this magnitude from reoccurring, the Cook Islands Ministry of Marine Resources (MMR), with the assistance of supporting organisations

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such as NZAID, NIWA, SOPAC and SPC, implemented a series of projects to better understand the system and to achieve sustainable development of pearl oyster aquaculture in Manihiki.

Mapping Manihiki

The Manihiki lagoon covers an area of 10 by 7 km, with a maximum depth of 70 m. Pearls are farmed between 2 and 30 m. To best utilise this area without overstocking oysters, it was necessary to establish the actual placement of farms within the lagoon and their boundaries in relation to each other.

To achieve this, SOPAC carried out a bathymetric survey in 2002 to define the complex geometry of the lagoon and mapped the position of pearl farms within this area using a Differential Global Positioning System (GPS). Project Leader Robert Smith told The Marine Scientist that a RESON 8010 multibeam system was used for the bathymetric mapping and that IKONOS High-Resolution Satellite Imagery from RadarSat was used as additional data to complement the swath. Map-Info, a Geographical Information System (GIS), was used as a management tool to link the census data on the number and location of pearl farms to the bathymetry. The GIS made it possible to simultaneously view multiple layers of mapping data to get a holistic view of the lagoon and formed the basis of a pearl farm database developed by staff at the MMR. This continues to be maintained for lagoon management and both existing and new pearl farmers have been given a map of their licensed area, showing the farm boundaries and the depths of the lagoon within and around each farm. Mapping the lagoon in this way shows areas at future high-risk of disease outbreak as well as those suitable for farming. It also allows negotiation of boundaries to avoid conflicts.

Lagoon circulation

In addition to the distribution of farms within the lagoon, information on the carrying capacity and environmental conditions was needed to manage pearl farming in the area sustainably. Collection of baseline data on physical, chemical and biological lagoon parameters began initially in 1996 with the Lagoon Ecology Monitoring and Management Project (LEMMP). The LEMMP established the water quality and made recommendations on advisable oyster stocking densities, stocking rates and management options. This is still used as a reference database on the ecosystem.

To support this information, in 1996 SOPAC completed a lagoon circulation study to work out the properties and movement of water into, out of, and around the lagoon. Manihiki has a small tidal range

and is flushed principally by hydraulic pumping of waves. The study found there are slow rates of water exchange between the lagoon and the ocean, suggesting the lagoon takes a long time to “flush” itself with fresh oceanic waters, increasing the likely impacts of disease and pollution. In November 2000, SOPAC completed a further water quality study, using the baseline data from the 1996 lagoon circulation study as a comparison. Immediately following an outbreak, there were notably low levels of dissolved oxygen in the lagoon, indicating that overstocking and slow water exchange were critical factors.

Long-term monitoring

Following the 2000 study, the need for long-term monitoring of the lagoon was apparent, and yet LEMPP and subsequent studies were labour-intensive and time-consuming. In November 2003, the MMR, with the assistance of SOPAC, installed a Sound Ocean oceanographic monitoring buoy in Manihiki. This has several advantages as a system of data collection. The buoy is fitted with a range of sensors and automatically measures a variety of chemical and physical lagoon parameters every hour, including sea-surface temperature, salinity, air temperature, dissolved oxygen, chlorophyll levels (an indicator of phytoplankton concentration), solar radiation, barometric pressure, pH values, wind direction and speed. To sample areas not covered by the buoy, in 2003 the Ministry purchased a hand-held YSI probe capable of measuring a range of different lagoon parameters, including temperature, pH, salinity, dissolved oxygen and turbidity.

The monitoring system is still in place as part of PI-GOOS. Hourly data sampled by the buoy are sent to a base station on a daily basis using a data uplink to an Iridium satellite phone. These data are received, processed and archived online at the SOPAC website (<http://www.sopac.org>) where they can be downloaded. Currently, a report on the monitoring buoy data is compiled by SOPAC every month and disseminated to pearl farmers, fisheries and the Island Council. According to Smith, the buoys are currently undergoing maintenance and calibration. Due to the isolation of the area, calibrating the instruments and inserting new power sources for the units has been a huge challenge and has required bringing them to a central location for refitting. One will be deployed later this year in Manihiki and the other will be placed in Rakhanga, a lagoon some 30–40 miles NE of Manihiki.

Net benefits

The disease outbreak continues to have an impact on the pearl industry, with a significant proportion of oysters in Manihiki still affected by the disease.

The local community has responded to the crisis, however and is gradually getting back to where it was through a system of proper management. The information garnered from state-of-the-art monitoring technologies has a number of benefits. The oceanographic data act as an early warning system of environmental conditions, giving the farming community time to respond to events such as the 2000 outbreak. The projects have studied the response of the lagoon to intense mariculture and act as a baseline by which to assess the potential of other lagoons for pearl farming. In addition to bringing state-of-the-art technologies to Manihiki, SOPAC and other supporting organisations have empowered the local community to manage its resources. This has been achieved by capacity building through a series of training initiatives in GIS, pearl technician skills, oyster health surveys and buoy deployment.

Cost benefit

The Manihiki Island pearl industry has the potential to generate multimillion dollar net benefits for the Cook Islands, but this will only materialise in the presence of an effective management regime. In 2004, a cost-benefit analysis of the Manihiki projects

carried out by Emily McKenzie, the then Resource Economist at the SOPAC Secretariat, highlighted the economic benefits of implementing a management plan for the lagoon: the net present value of the industry in Manihiki for 15 years (2004–2019) is NZD 40 million, with additional indirect, secondary benefits when supported by a Pearl Farming Management Plan based on sound oceanographic mapping and monitoring. Without a Pearl Farming Management Plan, incentives remain for resource users to stock the lagoon at unsustainable oyster densities and employ poor farming practices. In this case, the net present value of the projects will be negative over this same time period, falling to NZD 2.8 million.

A Pearl Farming Management Plan has now been developed by the Cook Islands MMR and Manihiki pearl farmers, and according to the Secretary for Marine Resources, was being implemented at the end of March 2006. Based on the practical applications of innovative technologies in hydrography and operational oceanography, the management plan has the potential to change the practice of pearl farming in the region dramatically, helping to ensure its long-term sustainability as an industry.