Presentation of the collaborative network ADEQUA aiming at the improvement of pearl quality in French Polynesia


¹ Present address : Ifremer – Centre de Nantes – BP 21105 – 44311 Nantes
² Service de la Perliculture - BP 9047 Motu Uta- 98715 Tahiti
³ Ifremer – Centre Océanologique du Pacifique (COP) – BP 7004 98719 Taravao – Tahiti
⁴ UMR 5119 « Ecosystèmes Lagunaires » Ifremer-CNRS-Université de Montpellier II - Place E. Bataillon, CC80 - 34095 Montpellier Cedex 5
⁵ CRIOBE UMS 2978 CNRS – EPHE – BP 1013 Papetoai, Moorea
⁶ UMR 5561CNRS –Université de Bourgogne « Biogéosciences » 6 bd Gabriel - 21000 Dijon
⁷ UMR IFREMER-Université de Caen-Basse Normandie "Physiologie et Écophysiologie des Mollusques Marins" - IBFA – 14032 Caen Cedex
⁸ UMR IDES 8148 - Bat. 504 - Université Paris XI-Orsay - 91405 Orsay cedex
⁹ Société Texinfine - 60 Rue Duguesclin - BP 7114 - 69006 Lyon
¹⁰ Université de la Polynésie française - BP 6570 - 98702 Faa’a - Tahiti
¹¹ Skuld-tech - 134, rue du Curat - 34090 Montpellier

e-mail adress : nathalie.cochennec@ifremer.fr
cedrik.lo@perli.gov.pf

Keywords
Pinctada margaritifera, pearls, quality, mineralization processes

1. INTRODUCTION
Pearl farming industry as the first exporting sector is critical for the French Polynesian economy. It plays an essential role for regional development, employs about 5000 people and contributes both to land management and to the reversal of migration from the atolls to Tahiti. However, the liberalization of pearl farm concessions at the beginning of the 90s, followed by the grafting act popularization, concurred to the uncontrolled development of the industry and of the pearl production. The crisis was alimented by the continuous increase of the number of defective pearls on the market. Consequently, the farm profits decreased as evidenced by the drastic fall of the average pearl gram price observed since 2001.
Additionally, other countries like Australia, China, Indonesia and the Cook Islands entered the market, with the advantage of lower production costs. This strengthening of international trade led Polynesia to increase the number of poor quality pearl arrival onto the market. The quality of a pearl is mainly defined by the quality of its surface: its lustre and shininess, and whether it has any surface imperfections. The “Service de la perliculture” (Government service department for pearl culture) has instated a classification system to define the quality of pearls for exportations. Pearls are classified according to a number of different criteria: size, shape, surface quality, and a minimum thickness of 0.8 mm of nacre around the nucleus. On average, only 5 % of pearls in a first harvest are of very high quality. An increase in the number of perfect pearls would therefore be a considerable advantage for the industry.

Understanding the importance of pearl culture for the Polynesian economy, the “Service de la Perliculture” conducted several research projects on this activity. Collaboration agreements were made with Ifremer (French Research Institute for Exploitation of the Sea), starting in 2003, to define new research actions to optimise grafting and pearl quality in the pearl oyster, Pinctada margaritifera. Preliminary research examined the causes of nucleus rejection, revealing multi-factorial factors acting in cascade and demonstrating the complexity of grafting and post-operative processes that lead to pearl formation. It was quickly established that dynamic research and collaboration were necessary to examine these topics thoroughly.
In that context, the Ifremer laboratory of Tahiti together with the “Service de la perliculture” has organized in 2008 a scientific collaborative network aiming at the "improvement of pearl quality in French Polynesia" (acronym ADEQUA). This research project (2008-2012) gathering 11 partner laboratories from French Polynesia and France, applies an integrated and multidisciplinary approach to provide a precise description of the biological mechanisms of the pearl graft and the processes underlying pearl mineralization or its failure. This project aims to be both comprehensive and applied in approach. Its originality lies in the fact that it combines...
complementary studies in the specialised fields of the participating laboratories. It associates the specific techniques of pearl farming with innovative research methods as genomics, transcriptomics, proteomics, genetics, crystallography and Raman spectroscopy.

2. SCIENTIFIC OBJECTIVES

The overall approach takes into account all the stages of pearl farming, from graft surgery up to harvest, followed by the study of the pearl deposits (figure 1). It will make it possible, for the first time, to have common analyses and data, of known traceability, on the complete pearl formation processes.

2.1. Analysis of the main external factors known to play a role in determining the success of grafting and pearl quality

Studies by the “Service de la Perliculture” have shown for example that the regular cleaning of grafted pearl oysters and the choice of harvesting period influence both pearl growth and quality. These results are still patchy though and require completion. The experimental facilities at Ifremer will also allow us to verify the effects of temperature and/or nutritional status of grafted oysters on pearl characteristics (growth rate and surface quality) under controlled conditions. Apart from biotic and abiotic factors, the grafting operation is decisive for further success and the quality of the pearls harvested. It therefore seems important to compile a systematic record of different techniques, working together with the industry.

2.2. The improvement of nucleus quality to enhance grafting success and pearl quality

Preliminary results have demonstrated that the use of nuclei made of nacre from Pinctada species significantly increases the percentage of good quality pearls. A comparison of nuclei between Tridacna sp, Pinctada sp and Amblema sp. will aim to detect their organic matrix proteins composition in order to explain this difference. Additionally, newly available molecules (notably antibacterial bio-compounds or mineralization activators) will be tested to optimise the biological activities of nuclei coverings to replace those presently in use, which probably are suspected to contain conventional chemical antibiotics unauthorised in aquaculture.

2.3. The detailed description and dynamics of biological mechanisms of the graft process

The detailed description and dynamics of biological mechanisms of the graft process will be studied by (1) a sequential analysis of graft mineralization processes (from genes to proteins) with supposedly different mineralization properties and their evolution into pearl sacs. Complementary approaches of genomics and proteomics will be used to identify and characterise genes and proteins specifically involved in the formation of the organic layers that control and compose the mineral deposits of the pearl. (2) A description will be made of the first organo-mineral layers on the nucleus, analysing the secretary activities of the pearl sac around the nucleus. (3) The precise structural analysis of the mineral of the harvested pearls will be examined. The morphological (form, dimension and defects) and physical characters (colour, mass, volume and density) of the pearls will be described. The pearls will be cut in order to observe the development of the different layers starting from nucleus, deviations from uniform roundness, cavities, and the defects of stratification and pigmentation.

These approaches will allow us to look for correlations between graft mineralization properties, dynamics of pearl sac development and function, and the characteristics of the pearls produced (nature and structure of pearls obtained, growth rate, presence or absence of surface defects, quality of lustre). Disruptions that potentially occur over time in the pearl sac and that are supposed to be the reason for defects, could thus be better described and evaluated. Until now, the pearl quality and the presence of flaws have mainly been characterised by external description after harvest. This analysis cannot represent the formation of the pearl over time.

2.4. The characteristics of shell and pearl colour

The characteristics of shell and pearl colour will be studied by a combination of analyses on spectral qualities, pigmentation and genetics. These data will first be used to identify oyster populations with the most unusual colouration characteristics. These will then be used to try to understand the transmission of colour of selected batches to their descendants. Finally, the oysters produced and characterised in this way will be selected (1) for experimental grafts to test the relationship between the colour of donor oysters and that of pearls produced, and (2) to serve as genitors in a breeding design to evaluate the heritability of these characters.
3. EXPECTED OUTCOMES
This collaborative project will produce a large amount of both pure and applied data. It is essential to go through a fundamental stage that will allow the cellular and molecular processes involved in the grafting process to be better understood in order to then develop solid applications for the industry. Important advances will therefore be made from the increased knowledge of biological mechanisms of grafting and in the understanding of the pearl mineralization process. Complementary approaches that evaluate the impact of the choice of the graft and of the nature of the pearl sac on the quality of pearls will provide numerous data about the genes and the proteins involved in mineralization. “Biomarkers” of mineralization properties can therefore be developed that will allow us to explore and measure the biological activities of the different compartments of the graft (graft tissue, pearl sac), as well as the regulatory processes involved.

Many applications will be usable by those working in the industry, in order to:

Select graft donor oysters (colour and pearl growth). Biomarkers of mineralization and colour could serve as selection markers for graft donors with “high mineralization capacity” and/or as tools for predicting colours with high added value. These markers will be directly used in a genetic improvement program on graft donor oysters that could be produced by the hatchery run by the “Service de la Perliculture” on Rangiroa island (French Polynesia).

Have a supply of high quality nuclei. Newly identified molecules could be used to develop new coatings for nuclei for replacing conventional antibiotics presently sold in Polynesia and the use of which in aquaculture will be submitted to international regulation. This will promote the manufacture of local Polynesian nuclei, with controlled and homogeneous quality, and environmentally friendly coating. Such a form of diversification will allow pearl farmers to become independent from foreign sources of nuclei, that present variabilities in terms of quality and origin.

Decrease the incidence of flaws (blemishes and rings). The aim of studies is to identify and explain the causes for malformations and surface defects (hygiene, graft method, husbandry etc.). Potential solutions will be suggested to pearl farmers for reducing their frequency and increasing the overall pearl quality.

Increasing the value of Polynesian pearls. Methods developed to characterise pearl colours could be used to build an “identity card” for Polynesian pearls, with the idea of detecting fake colours (creation of a Polynesian quality label).

Training of grafters and Polynesian pearl farmers. Improvements in husbandry techniques could be offered directly to pearl farmers in order to optimise grafting, harvest timing, etc. Results of scientific comparison of the grafting techniques (operating technique, graft hygiene, nucleus choice, selection of graft donor oysters etc.) will be given to the “ (Polynesian Grafting school) on Rangiroa under the form of handbook; technical notes or courses will also be made available for pearl farmers (training already started by the European Development Fund 9th FED).

This Research Group will enable Polynesia to make innovative advances in pearl quality improvement by increasing the percentage of high quality pearls and by selecting oysters. For the pearl industry, where product excellence can only be maintained by the continual pursuit of maximum quality, the advances achieved in this project will maintain the superiority of French Polynesia in terms of technology and will ensure the future of this sector.

4. ACKNOWLEDGMENTS
This research is financially supported by the “Service de la Perliculture” and Ifremer.