Environmental and biochemical research helps drive the resurging consumer demand for pearls

By Kenneth Scarratt, President
CIBJO Pearl Commission

The CIBJO Pearl Commission continues its work in updating and improving its Blue Book and guides, following the successful 2023 congress in Jaipur, India.

The Guide for Classifying Natural Pearls and Cultured Pearls, a 62-page illustrated document that provides an overarching view of natural and cultured pearls, is now available for free download from https://cibjo.org/pearl-guide/ in English (the official version), Japanese, Thai and French, with Italian coming to the website soon.

Following the 2024 congress in Shanghai, work will begin on updating the entire guide. The informative and well received document "The Environmental, Social and

Kenneth Scarratt, President of the CIBJO Pearl Commission.

Economic Impact of Natural and Cultured Pearls," agreed upon during the Jaipur congress, is now available at https://cibjo.org/the-environmental-social-and-economic-impact-of-natural-and-cultured-pearls/. Additionally, the Engish version of the CIBJO's Do's & Don'ts Guide has been updated at https://cibjo.org/dos-donts-guide/.

With regards the CIBJO Pearl Blue Book, in recent months the Pearl Commission Steering Committee, following a recommendation made during the Jaipur congress, reassessed the manner in which the bleaching[1] of pearls should be addressed. This has at its core an awareness that it is in the best interests of the trade for consumers to be fully informed with regards to all treatments applied to pearls, both natural and cultured.

In the past, a "grandfathered" exception has been made for the practice of bleaching that allowed for a non-specific (general) disclosure, but in the interests of protecting consumer confidence long-term, the Steering Committee will be suggesting during the Shanghai congress that the practice of bleaching shall henceforth be specifically declared for both natural and cultured pearls.

1 Bleaching (code B): Using a bleaching agent to remove or alter colour. This treatment may not be permanent regardless of special care requirements.

Microplastics and their potential impact on 'pearl oysters' – An update

In our 2023 Special Report we highlighted that potential impact of the presence of microplastics (MPs) in the marine environment where "pearl oysters" are present, both in the wild and in culturing farms. We reported that in the natural pearling beds of the UAE's northern shores, the Arabian and Andaman Sea, Southern Iran, the Argentinean estuaries, East China Sea, China, and India there is an abundance of microplastics, both in sediments and the oysters themselves. Additionally, we cited reports stating that, in culturing areas, important evidence has been collected that indicates that exposure to MPs may impact the appearance of biominerals and the expression of biomineralisation-related genes, posing a new potential threat to aquatic organisms.

Over the past year we have continued to monitor research reports concerning MPs within the pearling enviroments (Habib 2022) and note that considerable research is on-going and becoming more specific in its focus.

Lu et.al., in their paper "Effects of polyvinyl chloride microplastic on pearl oyster (*Pinctada fucata martensii*), (Lu 2024), observed that PVC-MPs had a negative effect in that exposure altered the immune, antioxidant and digestive systems, and that PVC-MPs caused oxidative stress, immune distortation and digestive impairment.

However, another study by Mkuys et.al., "The impacts of PVC microplastics on physiology and transcriptomic responses of pearl oyster *Pinctada fucata martensii*" (Mkuye 2024), reported that an examination of pearl retention rate and thickness revealed no significant differences across treatments. This indicated that short-term PVC MPs exposure did not notably affect pearl oysters' capability to retain the nucleus or form pearl layers, and highlighted *Pinctada fucata martensii*'s pearl retention and thickening resilient ability to PVC MPs.

There is still much to learn from the enormous body of work being published, but given the already significant pollution challenges within our oceans and waterways it might be prudent to continually monitor the presence of MP's within pearling waters and also report the disposal of fishing gear and plastics in general, from which the MP's originate.

An interesting insight gained from the current reported research is that 'bivalves can contribute to the removal and trapping of MPs" (Abdel Ghani 2023), although one has to wonder upon the eventual impact on this amazing marine life. For example, Abd-Elkader et.al., report that in the Red Sea "Bivalves [including the Pearl Oyster *P. radiata*] exhibited

Marine debris washed up on a beach at Sharm el-Naga, Egypt, not far from the Gimsha Bay, which has been a significant source for the pearl oyster Pinctada radiata (Yassien 2009). Image by Vberger (2010).

higher MPs abundances per gram of tissue wet weight compared to other groups."(Abd-Elkader 2023).

As stated in CIBJO's The Environmental, Social and Economic Impact of Natural and Cultured Pearls[2]. "Molluscs and pearl products generate value for communities (employment), impact climate (carbon capture and release), affect biodiversity (abundance and diversity), and mitigate pollution (water filtration)."

However, if MPs continue to polute our pearling grounds at an ever increasing rate, one might legitimately question the along term filtration capabilities of our precious bivalves.

2 https://cibjo.org/the-environmental-social-and-economic-impact-of-natural-and-cultured-pearls/

Current status of the Akoya pearl industry in Japan

CONTRIBUTION BY RYUICHORO MACHIZAWA

Japan's export and import performance in fiscal 2023 almost recovered to pre-pandemic levels, and in terms of value grew even larger.

One of the most remarkable results was the import value, which jumped 109.7 percent to 71.2 billion yen from 33.9 billion yen in the previous year (see Table 1, Page 4). Comparing long-term differences in exports and imports, the extent of the import surplus tended to lessen after the 2008 financial crisis (See Table 2, Page 4). However, the gap widened again, especially in terms of value, in fiscal 2023.

Historically, there used to be The Pearl Culture Industry Law in Japan. Under this law, the Japanese pearl industry maintained a policy of not disclosing its bead inserting technique. But, in the latter half of the 20th century, whereas Japan traditionally had been the dominant exporter of pearls, pearl cultivation began to flourish in many other parts of the world.

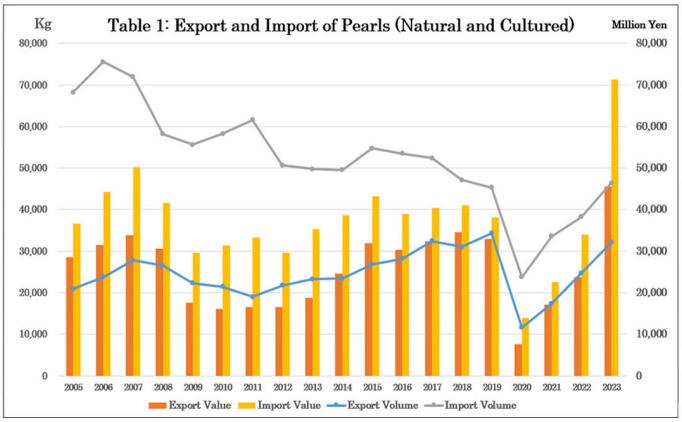
In fact, the import and export figures were reversed in terms of weight in 1998, when the Pearl Culture Industry Law was abolished, and in value five years later in 2003.

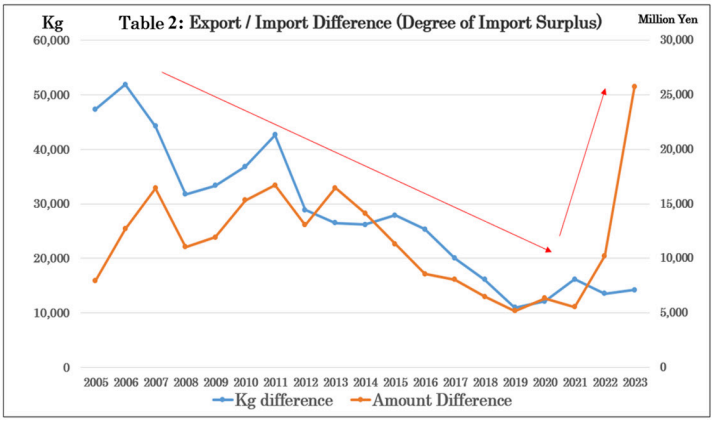
Since then, Japan has changed its position in the global market from a net exporter to a net importer of cultured pearls.

Considering the actual figures shown in the two tables,

Akoya Pearls.

JAPANESE PEARL IMPORTS AND EXPORTS





along with various factors such as the decrease in production of Akoya cultured pearls, the stagnation of the domestic market, and the demand to procure Akoya substitute goods against the backdrop of overseas demand, fiscal 2023 gave the impression that Japan once again is steering to be a net pearl importer.

Utilisation of pearl oyster genome knowledge for sustainable pearl production

CONTRIBUTION BY RYUICHORO MACHIZAWA

A research group of the Okinawa Institute of Science and Technology Graduate University (OIST) Marine Genomics Unit, the University of Tokyo, and K. Mikimoto & Co. Ltd., sequenced the entire genome of Akoya pearl oyster and published the results of the research in the online edition of the scientific journal DNA Research on February 7, 2012 (Takeshi and Hirotoshi 2012).

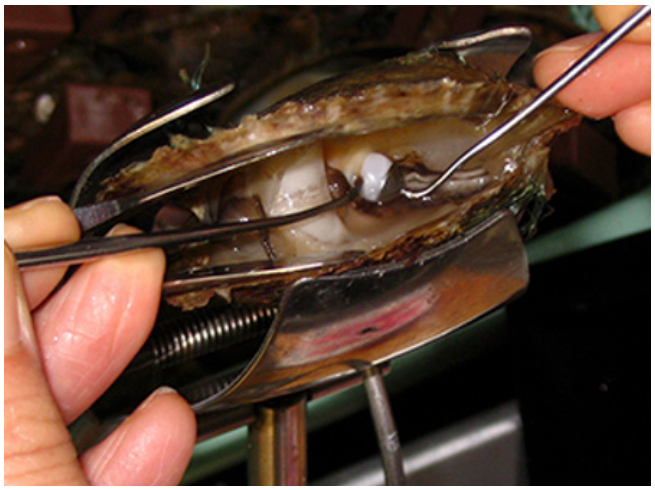
The Akoya pearl oyster is currently facing a mass mortality crisis due to the effects of the red tide dinoflagellate *Heterocapsa circularisquam*a, a new species of plankton that emerged in the 1990s, and red discoloration of the adductor muscle caused by bacterial infection (Fukuyo 2002; Yamaguchi 1997).

The sequencing of the Akoya pearl oyster genome makes it possible to study environmental changes in the ocean at the genetic level and protect the Akoya pearl oyster. In addition, future progress in experiments and analysis is expected to clarify the mechanism of producing pearls and apply it to quality control of Akoya oysters.

In addition, the Japan Pearl Promotion Society established

The Akoya pearl oyster.

a research center for the Akoya pearl oyster genome on April 1, 2024, in Shima City, Mie Prefecture (the Mikimoto satellite office of the Japan Pearl Promotion Society). It is equipped with advanced equipment for genome science and molecular biology research, and is working to realise sustainable pearl cultivation using the genome data collected.



Culturing Akoya pearls.

Update on the condition of the Bahrain pearl oyster beds

CONTRIBUTION BY DANAT

DANAT and Bahrain's Supreme Council for Environment and the Directorate of Fisheries conducted a research project to assess the status of the pearl oyster beds around Bahrain. This followed the launch of the National Plan to Revive the Pearl Sector in 2016.

The temporal comparison was based on data collected during three phases of the project, which extended from 2020 to 2023. It was compared to data collected from a similar study in 2012, and was conducted to assess pearl oyster beds (also known as "Hayr" in the loacal language), so as to compare them to other selected oyster bed areas in Bahrain over time.

As a result of the project, several objectives were achieved, including determining the density and abundance of pearl oysters, the size structure and distribution of pearl oyster populations, and natural pearl yield changes.

Compared to 2012, pearl oyster density increased at three sites (Hayr Bu Amamah, Hayr Bul Thamah, and the Buffer Zone) while the data for another site (Hayr Shtayyah) revealed a complex pattern that indicated a population decline. There also was a shift in the population size structure from the older to the younger generation. Northern Hayrat saw a slight increase in natural pearl yield.

However, when each oyster bed area was compared individually, there was a significant difference in pearl yield and a shift in yield between sites.

The results showed that there was no statistically significant difference since 2012 in pearl incidence. This temporal comparison provided critical insights into the *Pinctada sp*. population dynamics across various sites.

The study highlights the need for continued monitoring to support species conservation. DANAT aims to continue the project in collaboration with the pertinent government authorities.

A DANAT diver collecting research during the research project.

One of the oyster beds (Hayr) that was studied during the research project in Bahrain.

Paving the way from pearl impact to value through the Pearl Development Community

CONTRIBUTION BY PIERRE FALLOURD

On May 20, 2024, the Gems and Jewellery Trade Association of China held the 2024 Pearl Industry Development Symposium in Haikou. More than 50 representatives from leading pearl farming enterprises and related organisations from Australia, China, French Polynesia, Hong Kong SAR, Indonesia, Japan, Myanmar and Philippines participated in and supported the event.

The symposium provided an interpretation of the relevant tax policies of the Hainan Free Trade Port, exchanged views on the development status of the industry in eight global pearl production areas, and analysed and discussed the development prospects of the worldwide pearl market. Participants unanimously agreed that, despite the relative downturn in most jewellery markets in recent years, the pearls have shown remarkable growth and performance, yet there is still ample room for further development.

A key subject of discussion was the establishment of the Pearl Development Community, and the forum adopted a set of draft statutes for the new body and nominated a list of member organisations.

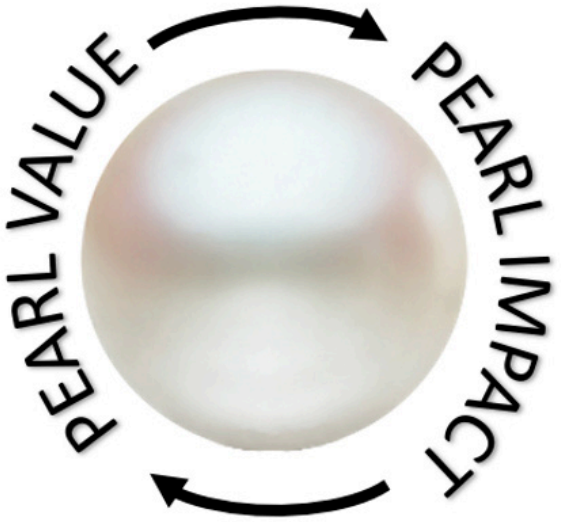
In establishing the Pearl Development Community, it was decided to follow the trend of global economic integration, promoting strong alliances, and resource and industrial integration in the global pearl industry. Its members pledged to work towards the "extensive consultation, joint construction and shared benefits in the supply chain, talent in workplace and innovation. Practical efforts will be made to strengthen international trade and exchanges, and to promoting the transformation and upgrading of the pearl industry, enhancing high-quality sustainable development and the worldwide influence of pearl brands.

To ensure a robust commencement for the Pearl Development Community, the following action plan was outlined:

- Actively pursuing favourable policies and efficient trading channels for the global pearl trade.
- Advocating for the development of global pearl quality grading standards.
- Proactively promoting pearl culture in the contemporary era.
- Organising timely pearl culture exchanges in key pearl-consuming nations and regions to bolster the overall image and impact of the industry.
- Conducting comprehensive research on the pearl industry, conducting statistical analysis of data, annually publishing reports on the development status of member bodies of the Pearl Development Community, actively providing consulting services and work recommendations, coordinating and resolving conflicts and issues, and promoting the sustainable high-quality development of the pearl industry.

Regenerative pearl farming

CONTRIBUTION BY PIERRE FALLOURD

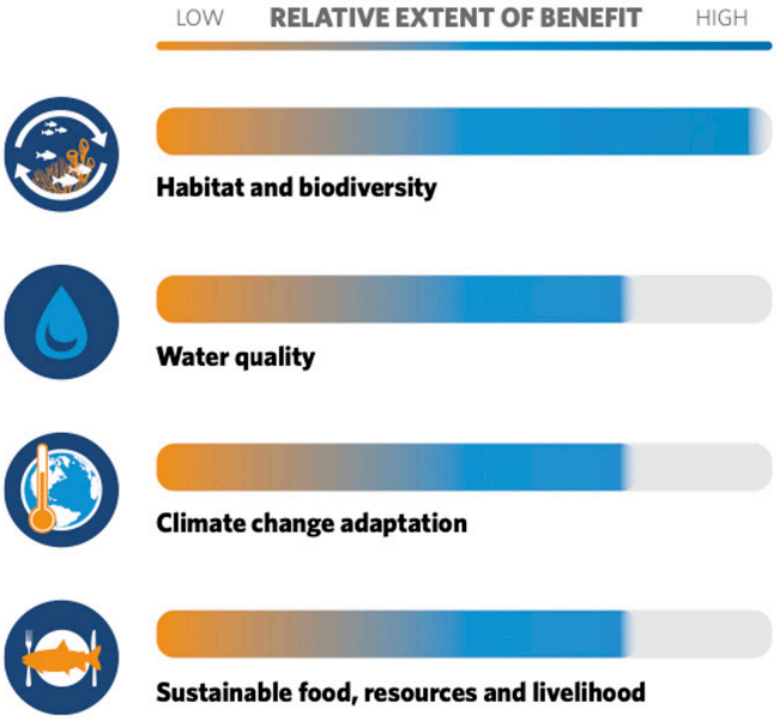


Marine pearl farming

The Nature Conservancy supported by the Gemological Institute of America published in January 2024 the first ever regenerative aquaculture potential assessment applied to pearl farming.

The climate impact of saltwater pearls ranges from a few grams to a few kilos of CO_2 equivalent (CO_2-eq) per pearl harvested, ranking it among the lowest of all gem materials.

The environmental impact of marine pearl farming varies greatly between species and locations, often as a result of farming operations. In the aquatic environment, the oysters farmed will also provide benefits to the ecosystems in which they grow, and these are values that can be included in studies of the impacts of the life cycle of production of a pearl.



Oysters cycle carbon dioxide, enhance water quality, and create thriving ecosystems. Additionally, crushed shells (and meat) can nurture soil, make cement and seed reefs, not to mention ornamental uses of nacre and the extraction of active ingredients for cosmetic and medical applications.

Intentionally applying best practices in marine pearl farming can:

- Reduce emissions, from a few kilos to a few grams of CO_2-eq per pearl.
- Increase nutrient bio-extraction, specifically phosphorus and nitrogen.
- Improve marine life abundance and diversity.
- Provide communities with alternative livelihood opportunities.

The assessment was published alongside a framework laying out the basis of a standard assessment tool, which will measure and monitor the actual impact of shellfish aquaculture.

Discussions started with various pearl producers setting up impact baseline measurement and monitoring protocols, to confirm and demonstrate the expected net positive impact of pearl farming on an on-going basis.

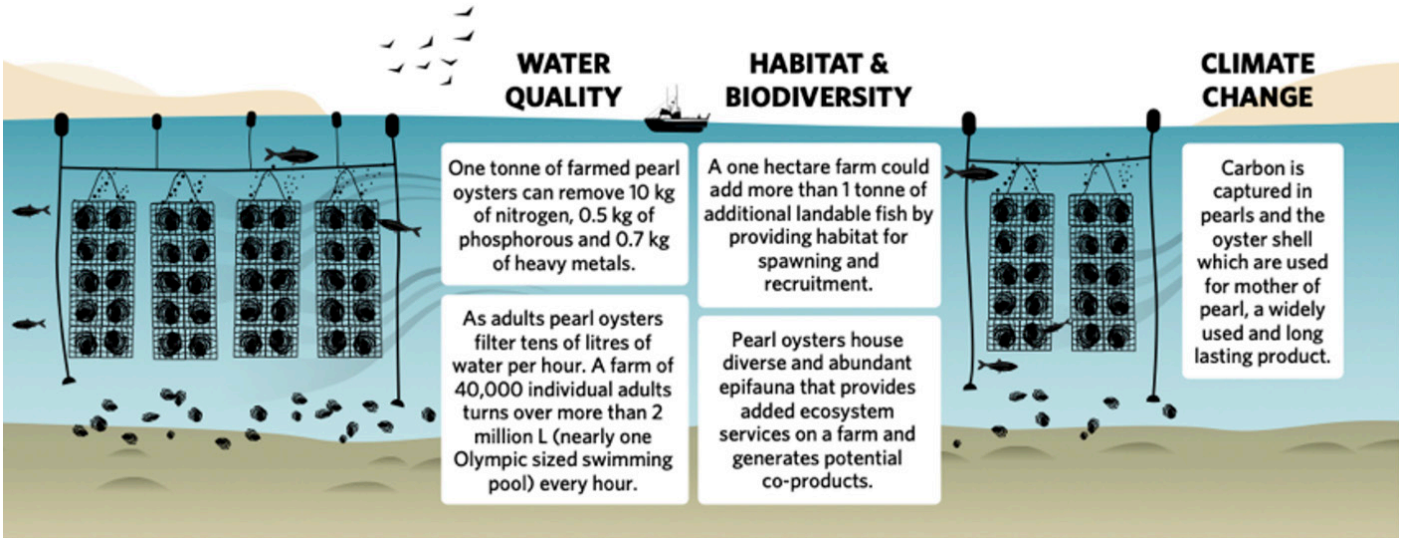


Image credits: The Nature Conservancy

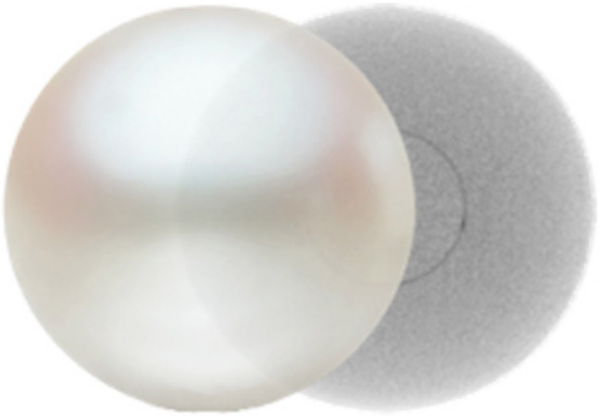
Freshwater pearl farming

The combined impact of pollution and climate change have severely affected the ability of producing quality freshwater and saltwater culture pearls alike.

Facing urgent ecological issues, the Chinese government took drastic measure as early as 2017 to halve production. This forced the industry to reinvent itself, and explore alternative production method that aim at quality rather than volume.

As a result, the range of freshwater pearls available is wider than ever, and their improved quality drove prices up,.

Large-scale programmes now aim at restoring urban waterways, turning mussels into bio extractors and fed aquaculture into potential nature-based solution to restore ecosystems.



Natural intelligence

Nacre is a core attribute to the value of a cultured pearl as its structure influences lustre, colour, shape, size and sometimes surface. Its relative thickness (typically proportionate to the nuclei size) and continuity (the absence of undersurface disruptions) are assessed to support pearls durability and rarity.

Nacre's unique structure – the foundation for all value factors – is strong (with extraordinary strength and toughness) but soft (low on Mohs) and sensitive to temperature, hygrometry and light. Individual nacre platelet thickness supports lustre and can trigger structural colour (overtone and orient). Long wave and short wave ultra-violet reliably identify treatments, which if excessive can negatively impact nacre.

Pearls reflect both the journey and the DNA heritage of the molluscs they grow within. Selective breeding and husbandry can influence cultured pearls physical attributes, but temperature, salinity and/or PH drive nutrients availability and aragonite crystals thickness, which impact colour and lustre for all pearls.

The Japan Pearl Standards 2020 (Japan-Pearl-Promotion-Society 2020) lists nacre thickness alongside shape, surface, colour and lustre as part of the beauty of pearls but also mention the structural soundness of its organic matrix (conchiolin) as a factor of durability.

It is common for pearl producers to refer to nacre thickness and/or structure. Autore and Paspaley have been rating a pearl's "grain" and nacre tightness and movement to value – what can be described as the canvas on which the other value factors anchor themselves.

The Gemological Institute of America (GIA) has been working on defining and classifying nacre continuity (in addition to thickness and condition) as part of its GIA 7 Pearl Value Factors™ classification system, whilst also supporting pearl impact assessment pilot projects. For Saltwater cultured pearls, GIA currently applies standards for structural integrity and minimum nacre thicknesses (according to type), resulting in a designation of "Acceptable" or "Unacceptable, "as well as offering an optional nacre thickness measurement service.

	Beauty	Durability	Rarity
Characteristics	Shape, nacre thickness flaws, color, luster	Nacre thickness, structural soundness of organic matrix (conchiolin)	Overall ratio of high to low quality pearls produced
Improvement measures	Production to enhance quality, orientation towards nacre thickness	Treatments, stability	Maintaining a sustainable production rate

Summary of "determining the jewel value of pearls" extracted from page 15 of the Japan Pearl Standards 2020.

"We recently updated our pearl reports to include Peacock and Hanadama (GIA 2023) comments (in addition to our existing Golden comment) to acknowledge and support important trade denomination," said Chunhui Zhu, head of GIA's Global Pearl Identification Division.

"We are currently finalizing the parameters of a scale for what GIA refers to as 'nacre continuity,' to classify the continuity of the concentric nacre layer deposition around a pearl nucleus. This scale will provide more specificity on nacre quality and complete GIA's pearl classification system in the near future," he added.

Nacre continuity reflects the quality of both the human care and natural environment in which pearls form.

An update on Australia

CONTRIBUTION BY PETER BRACHER

The Australian pearling industry uses predominantly wild-caught *Pinctada maxima* pearl oysters for South Sea pearl production. For the past 40 years, the number of pearl oysters collected each year has been regulated through a system of licenses and quota. Wild oysters are hand-collected by divers which prevents damage to the seabed and avoids collection of by-catch.

Wild oysters are larger in size and have greater hybrid vigour than hatchery-reared oysters. This means they have greater disease resistance and produce larger pearls. Another benefit of using wild oysters is that that the industry still finds important natural pearls.

The wild oyster population is assessed annually by the Western Australian Department of Fisheries, which sets a sustainable annual catch limit. The total allowable catch varies from year to year depending on variations in population of both juvenile and mature oysters on the pearl beds. These measures ensure this important natural resource is used in a sustainable way that assures its long-term health and viability.

In addition to regulation of the wild oyster fishery, Australian pearl farms are also regulated through a combination of Crown leases, licenses and a quote system that sets a maximum number of oysters that can be farmed and seeded each year.

The wild *Pinctada maxima* fishery has been certified as

Paspaley wild shell diving operations off the coast of Western Australia.

sustainable by the Marine Stwardship Council since 2018. It was re-certified in 2023 and this certification is valid to 2028. Paspaley's *P. maxima* pearl fishery certification process was independently evaluated by bio.inspecta and accredited by ASI under the ASI-ACC-041 voluntary sustainability standard.

In recent years, both the total allowable catch and the catch rate (the number of oysters that can be collected by a diver per hour) have been increasing. This is a strong indicator that the wild oyster population is in excellent condition.

Although the pearl trade is aware of the regulation of Australia's industry, there is a common misconception that production can be increased to meet demand when the market is strong. In reality, the annual catch rate is determined solely on the basis of sustainability and without regard to market conditions. Because of the long husbandry period of two to three years, production increases can only occur over an extended period. Paspaley expects production remain relatively stable for the foreseeable future.

Large freshwater cultured pearls with atypical bead nuclei

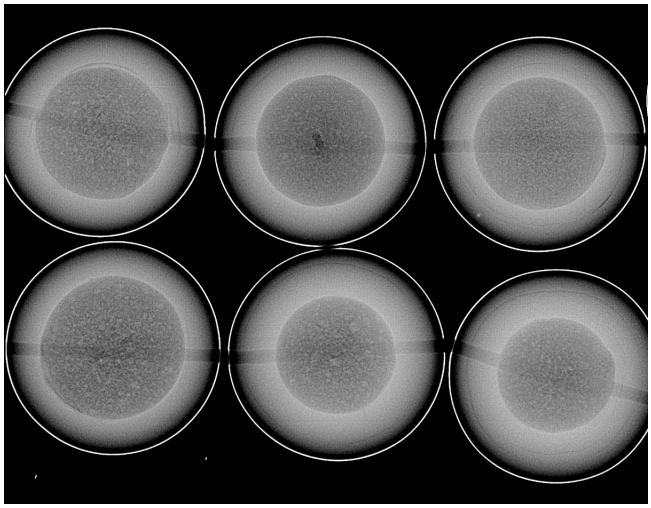
CONTRIBUTION BY GIA

GIA's New York laboratory recently examined two necklaces consisting of large pearls of mostly orangy pink to purplish pink colors, ranging in size from 15.40 to 17.42 × 16.70 millimetres and from 18.00 to 19.96 × 19.06 millimetres.

From the first impression, these pearls resembled the freshwater bead cultured pearls of large size, commonly known as "Edison" (C. Zhou, Ho, J.W.Y., Shih, S.C., Tsai, T., Sun, z., Persaud, S., Qi, L. 2021) pearls in the trade.

However, the pearls caught laboratory's attention with unusual internal growth features found under Xray-microradiography.

Real-time X-ray microradiography revealed that all the pearls were bead cultured, but not with the shell bead nuclei typically used for cultured pearls. Instead, a more X-ray transparent material with a distinct outline and near-round shape was found inside them. The material appeared porous and non-uniform, and did not resemble the "mud-like" material found in "soufflé" freshwater cultured pearls previously studied.



X-ray analysis of the neclaces revealed the near-round atypical bead nucleus used to culture each of the pearls. (Photo: GIA)

However, the exact nature of this material could not be determined. Energy-dispersive X-ray fluorescence analysis of their trace elemental concentrations of manganese and strontium confirmed that the pearls were grown in a freshwater environment. Furthermore, Raman spectroscopy using 514 nanometre laser excitation indicated that their

The two necklaces consisting of large freshwater cultured pearls that are displaying strong hues with orient. Photos: Sood Oil (Judy) Chia, GIA.

colors were natural, with two strong peaks around the 1125 and 1510 cm^{-1} associated with natural polyenic pigments.

Cultured freshwater pearls with large size, a near-round shape, and intense coloration are highly sought after and more valuable than traditional freshwater cultured pearls. These large freshwater cultured pearls are especially noteworthy because of the unique bead nuclei used during the culturing process, which suggests that culturing techniques are continuously evolving, resulting in higher-quality products. This finding was originally reported as a lab note in 2024 spring issue of *Gems & Gemology* (C. Zhou, Yazawa, E., Dragone, M. 2024)

Natural pearls from the Placunidae family (Windowpane Oysters)

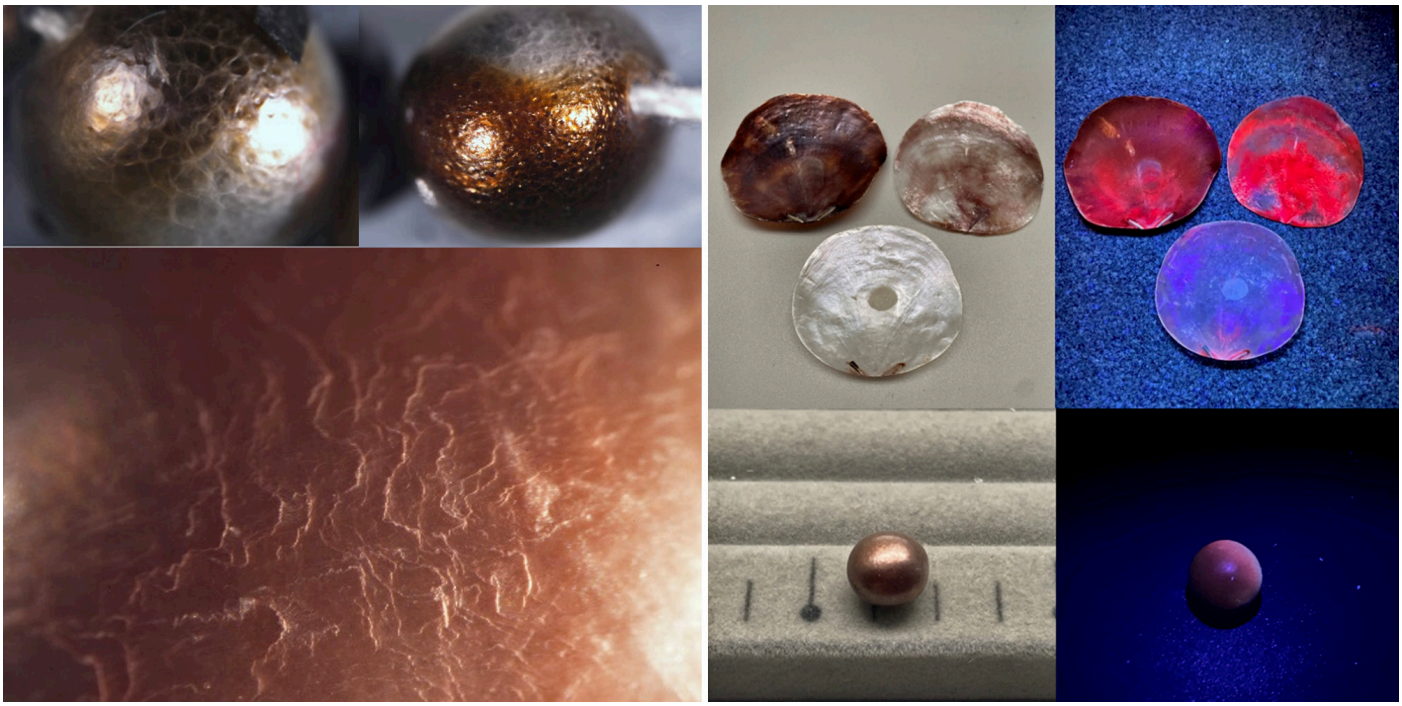
CONTRIBUTION BY GIA

GIA's Bangkok and New York laboratories recently reported unusual natural pearls produced by molluscs belonging to the *Placuna* genus in the *Placunidae* family, or commonly known as "windowpane oysters." They were variously shaped, measuring 3 to 8 millimetres. Their body colors ranged from silver to brown or gray, with varying degrees of tone and saturation.

Windowpane oysters are found along the coasts of India, Malaysia, China, and the Philippines. *Placuna* mollusks are widely valued for their thin, durable mica-like translucent flat shells, called capiz shells, which were once a popular alternative to glass and often used as windowpanes and decorations. Although the mollusks were also known to produce small pearls, these were not commercially available until recent decades.

Pearls produced by these unique mollusc species (Achuthankutty 1979) exhibit certain characteristics that can be identified using gemological and advanced instrumental techniques. Viewed under 40X magnification, they display diagnostic surface features of distinctive mosaic or botryoidal patterns, but could also show overlapping platelets typically found in nacreous pearls.

Two loose pearls from windowpane oysters submitted to the GIA Bangkok laboratory and a mixed strand containing mostly windowpane and Pteria species pearls submitted to the GIA New York laboratory. (Photo: Jian Xin (Jae) Liao, GIA)



LEFT: Characteristic surface features of mosaic pattern and botryoidal structure were observed from the windowpane pearls in the necklace, and the typical nacreous-looking surface of fingerprint-like platy structure was observed on a loose windowpane pearl. Field of view 7.19 millimetres, 9.61 millimetre and 2.90 millimetre respectively. (Photos: Joyce Wing Yan Ho (A, B) and Artitaya Homkrajae (C), GIA). RIGHT: Three variously coloured windowpane shells and a brown windowpane pearl, shown in daylight (left) and long-wave UV light (right). (Photos: Joyce Wing Yan Ho (top) and Kwanreun Lawanwong (bottom), GIA)

Under long-wave ultraviolet radiation, the pearls can display a striking reddish fluorescence, particularly in the darker areas, which is comparable to the reactions observed on the windowpane oyster shells.

Similar reddish fluorescence has been observed in dark pearls from the Pteria species. However, it is important to note that the composition of calcite in windowpane pearls and aragonite in Pteria pearls can be distinguished using Raman spectroscopy.

Additional analytical results such as UV-Vis reflectance features, Raman photoluminescence features, and their internal growth structures can also be used for identification purposes (Ho 2024).

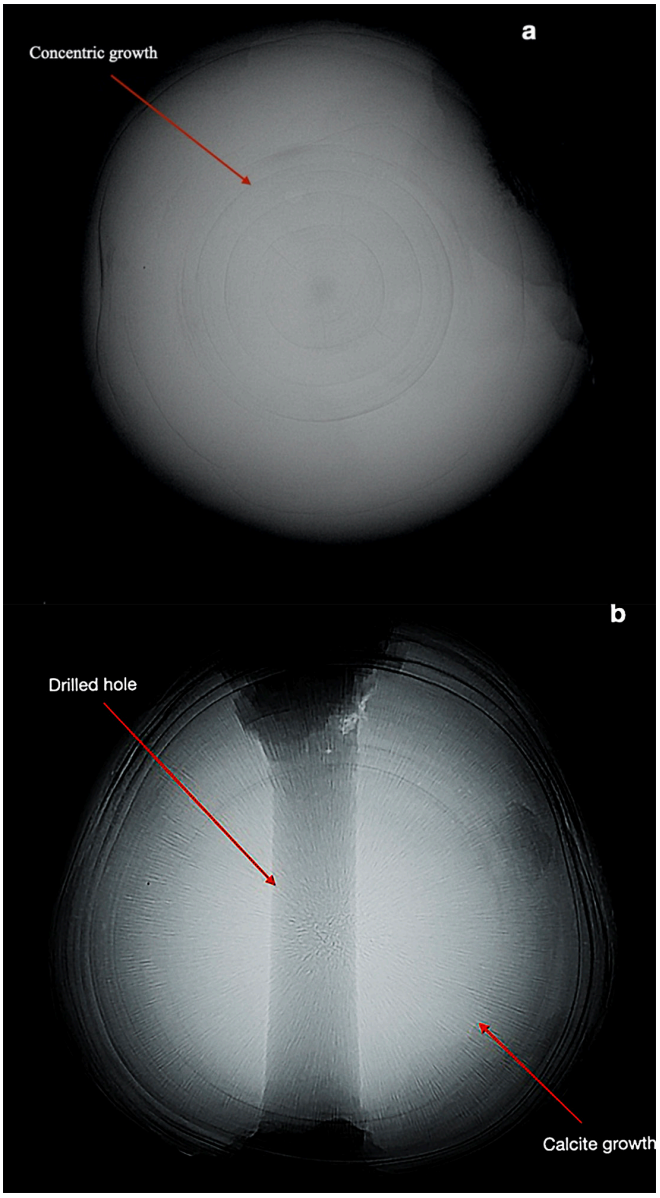
Ancient Pearls From Bahrain

CONTRIBUTION BY DANAT

Over the course of history, Bahrain has been referred to be the country of immortality. It is told that Gilgamish, the warrior, journeyed to Bahrain in search of the pearl oyster, which was believed to hold the secret to eternal life.

Ancient historians such as Pliny the Elder wrote about Tylos (an ancient name of Bahrain) and the abundance of natural pearls on its shores. Bahraini pearls were sought after by jewellers throughout history because they were renowned for their exquisite luster and shape.

Sample of three ancient pearls that have underwent testing by DANAT.



X-Ray microradiography images of two pearls, with (a) exhibiting a circular growth pattern, and (b) showing calcitic growth.

Although historians wrote about Bahrain and natural pearls, there were no analytical studies conducted on any ancient Bahraini pearls. This is the reason the Bahrain Institute for Pearls and Gemstones (DANAT), in collaboration with the Bahrain National Museum and the Massachusetts Institute of Technology (MIT), sought to study eight ancient pearls excavated in Bahrain at different archeological sites from the Dilmun, Tylos and Islamic periods.

By analyzing this information, it was hoped that might be possible to ascertain if the pearls originated from Bahrain or were imported from various sources, thereby mapping out the ancient trading routes.

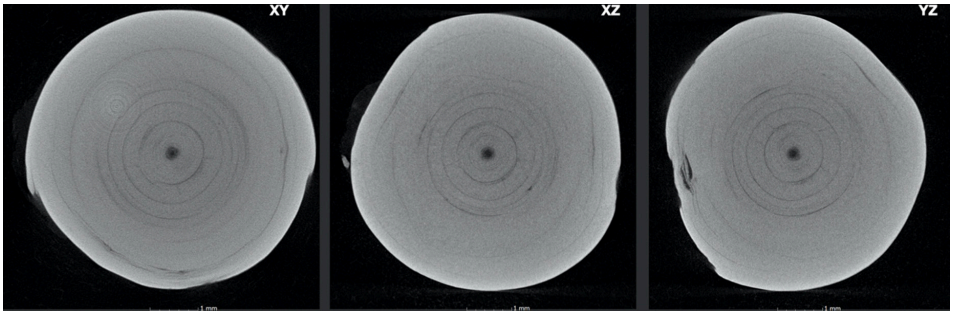
A total of eight pearls recovered from archaeological sites in Bahrain have been analyzed to determine their physical and chemical characteristics. The pearls had a weight range of 0.2 to 1.57 carats with near-round, button, and near-baroque shapes. The pearls exhibited colours from light cream to yellow, with certain specimens displaying hints of pinkish and purplish hues. The pearls were examined using different test methods that are typically used to identify pearls.

The examination of the surface characteristics of the pearls indicated that they had not undergone any form of treatment, regular cleaning or bleaching. They plainly exhibited signs of ageing and still retained traces of the dirt from which they were collected. Three out of eight pearls had been drilled, and it appeared that the drilling process was carried out using antiquated tools. The pearls exhibited several imperfections, including pits and scratches.

X-ray microradiography and x-ray microtomography (micro-CT) revealed natural growth structures, with some displaying the distinctive concentric pattern of natural pearls resembling a tree trunk cross-section. Additionally, there were pearls that included a prominent calcite core, while the remaining pearls exhibited faint features that are associated with their natural growth. The internal structures observed for pearls from the *Pinctada radiata* oyster found around Bahrain are quite comparable.

EDXRF analysis confirmed that all the pearls were derived from the shells of the *Pinctada* species in a saltwater environment. Additionally, no discernible pigment peaks or absorption were detected in the UV-vis and Raman spectra, which could aid in identifying the specific shell species.

DANAT will maintain its collaboration with the Bahrain National Museum to conduct additional investigations



X-Ray microradiography images of two pearls, with (a) exhibiting a circular growth pattern, and (b) showing calcitic growth.

utilizing advanced chemical analysis techniques such as LA-ICP-MS and DNA analysis. These methods will be employed to establish the provenance of the shell species, while Carbon-14 dating analyses will be employed to ascertain the age of pearl creation.

Traditional bleaching for natural pearls

CONTRIBUTION BY DANAT

Hydrogen peroxide (H_2O_2) is commonly employed as a bleaching chemical by pearl traders in Bahrain. The primary objectives are to cleanse the pearls and enhance the uniformity of their pearl collections.

To achieve this, a gentle bleaching procedure is employed to avoid any harm to the valuable natural pearls. A diluted solution of hydrogen peroxide is typically employed, often in conjunction with undisclosed chemical agents or/and elevated temperatures to expedite the process. The duration of the procedure typically spans a few days, however, in certain instances, it may extend beyond that time frame.

The outcome of this procedure yields natural pearls that are cleaner in appearance, exhibiting a consistent white to cream coloration.

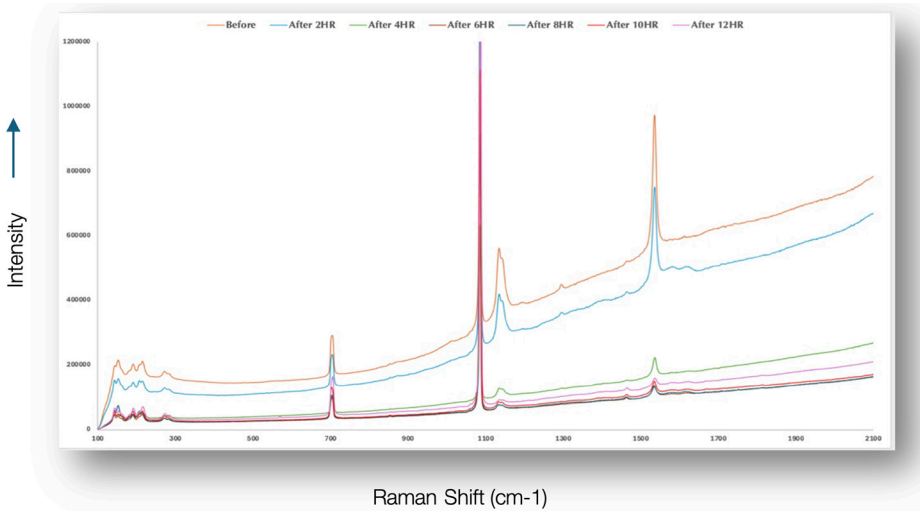
DANAT conducted an experiment to investigate detection methods for this type of treatment. It followed certain methods that had been disclosed by traders, with some alterations. The natural pearls used were from of the species *Pinctada radiata*, which were obtained from the northern region of the country.

Analytical techniques such as Raman spectroscopy, UV-vis spectroscopy, and fluorescence spectroscopy were used to analyse the pearls. In addition, high-resolution surface pictures were obtained using X-ray and X-ray tomography before the pearls underwent treatment. Data was consistently collected at 2-hour intervals for a total duration of 12 hours.

Upon analysis, it was evident that the pigments peaks shown in the Raman spectra had undergone a decrease in intensity over time. This can be attributed to the bleaching process, which gradually breaks down the chemical bonds of the pigment, resulting in a less pronounced appearance.

Prior to treatment, the fluorescence spectra exhibited a wide peak at 470 nanometres. However, throughout the treatment, this peak gradually changed to become the highest at 450 nanometres.

DANAT is continuing its investigation in order to provide a quick and straightforward approach for detecting any bleaching that has been done on natural pearls.



The Raman spectra oberved duringthe DANAT bleaching study demonstrated a decrease in the strength of the peaks, corresponding to polyenes as time increased.

Each pearl in the DANAT bleaching experiment was individually handled for the purpose of tracking.

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