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Hong Kong
SUSTAINABLE PEARLS FORUM
21th June 2014

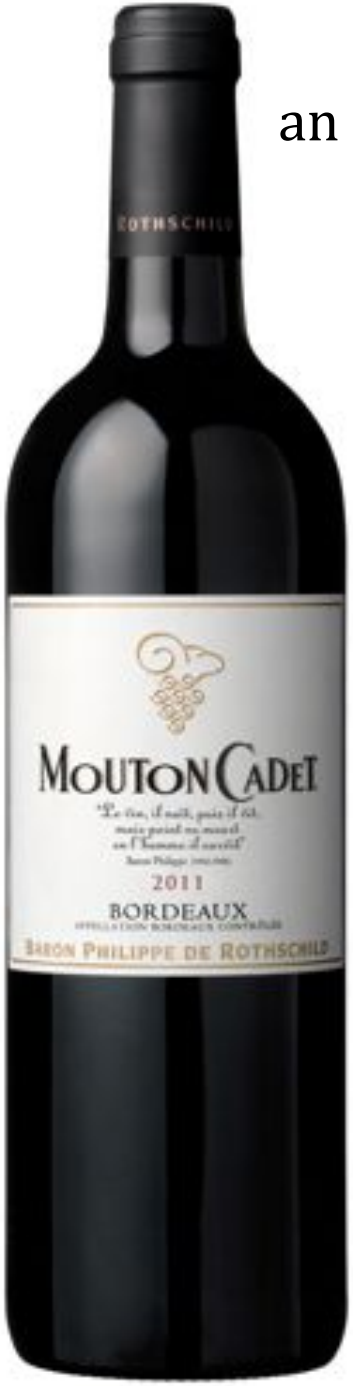
Tracing pearls through the supply chain

Dr. Michael S. Krzemnicki
Swiss Gemmological Institute SSEF
www.ssef.ch

Traceability…

Does this pearl come from the coast of this remote island ??

Traceability is
an issue for consumers
for many products...



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The colour spectrum of corundum

Finding traceability solutions....

For the Public

„branding“

- by technology
- by a certification scheme

- create transparency for consumer
- add further „emotions” to pearls
- create added value

For the Laboratory

Developing detection method

For both, cultured or natural pearls

- create transparency for consumer
- confirm the provenance of a pearl
- detect „forgeries“

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Constraints

For the Public

- easy branding process
- forgery-proof label
- not affecting the beauty of the pearl
- easy to read label at selling point (e.g. retailer)

For the Laboratory

- (quasi) non-destructive method
- distinct discrimination possible
- low costs and fast

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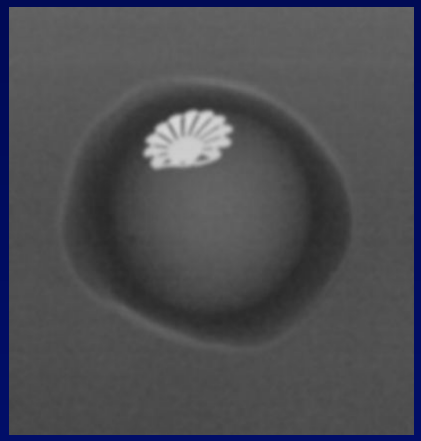
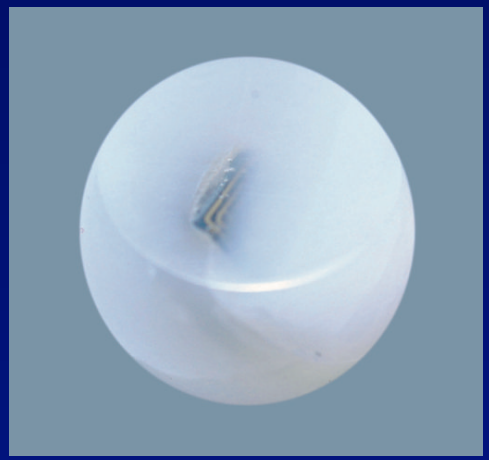
Methods for „branding“

Possibilites:

- Identity chips
- Micro-sized engraving



Metallic label of pearl farm attached to bead before grafting and radiography of cultured pearl with such a metallic label.



Radio-frequency ID-chip in an assembled shell nucleus and reader for RF ID-chips (by Fukui Shell Nucleus Factory, Hong Kong).

Methods for „branding“

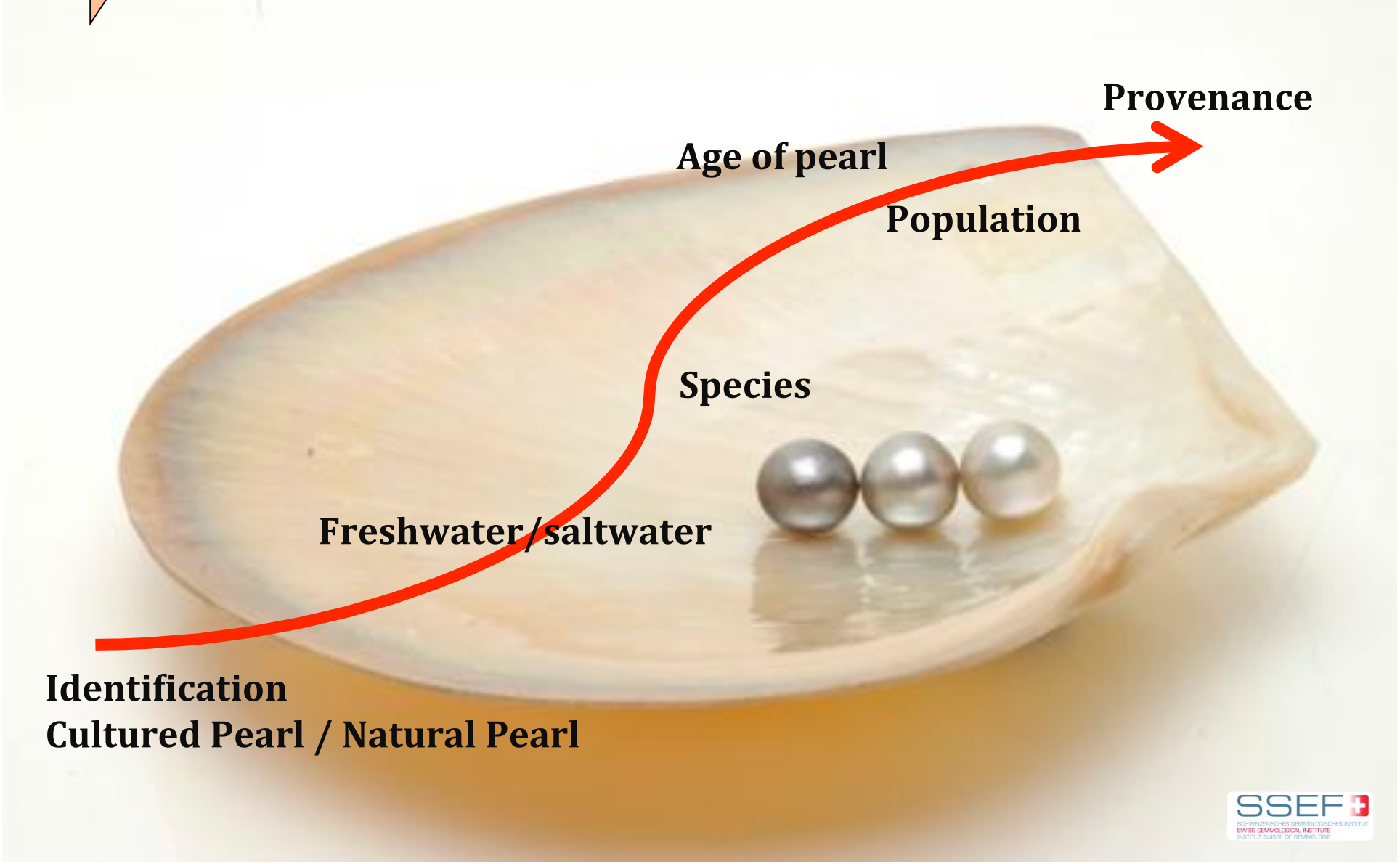
Possibilites:

- Chemical markers

Dyed Akoya cultured pearl with distinct colour concentration around drill hole.

Instead of colour, any liquid chemical or biological marker could be used.

Analytical steps in a laboratory



Identification of natural pearls and cultured pearls

Scanco µCT 40 Scanner at SSEF

Natural pearl (P. radiata)

Photo © S. Hänsel, SSEF

e.g. by using X-ray micro tomography to visualize internal structures of pearls in 3 dimensions.

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Separation of freshwater pearls from saltwater pearls

ThermoScientific Quant'X EDXRF at SSEF

e.g. by using trace element analysis

Analysis report chemistry (EDXRF)

klace_19, SSEF

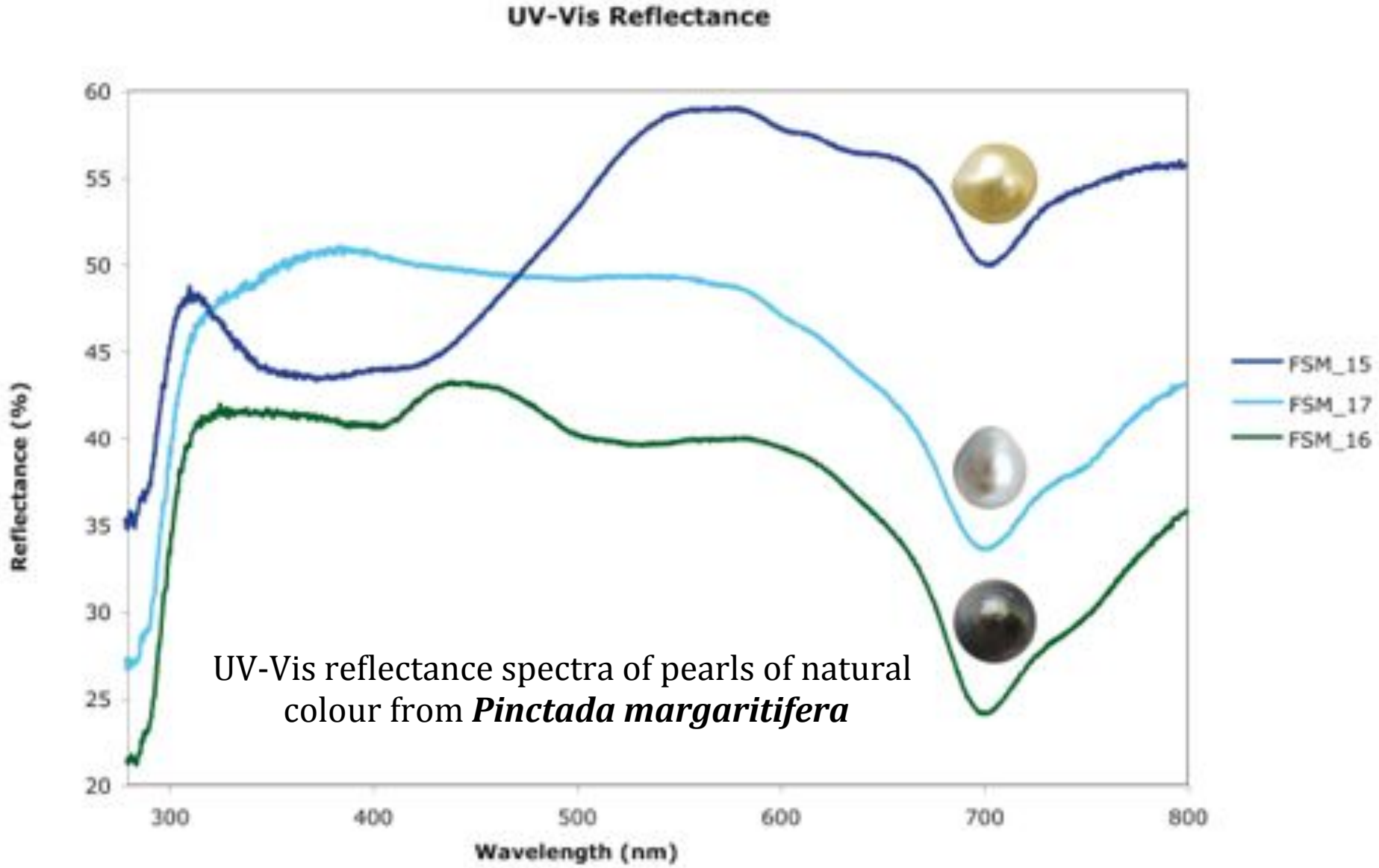
analysis:

Element	Concentration	Std. Dev.
freshwaterpearl_19		
CaCO3	99.66 %	0.19
Mn	1984 ppm	55
Fe	20.8 ppm	9.5
SrCO3	0.1060 %	0.0016
Ag	[6.2] ppm	5.4
I	0.00 ppm	0.0
Ba	137 ppm	45

Photo © S. Hänsel, SSEF

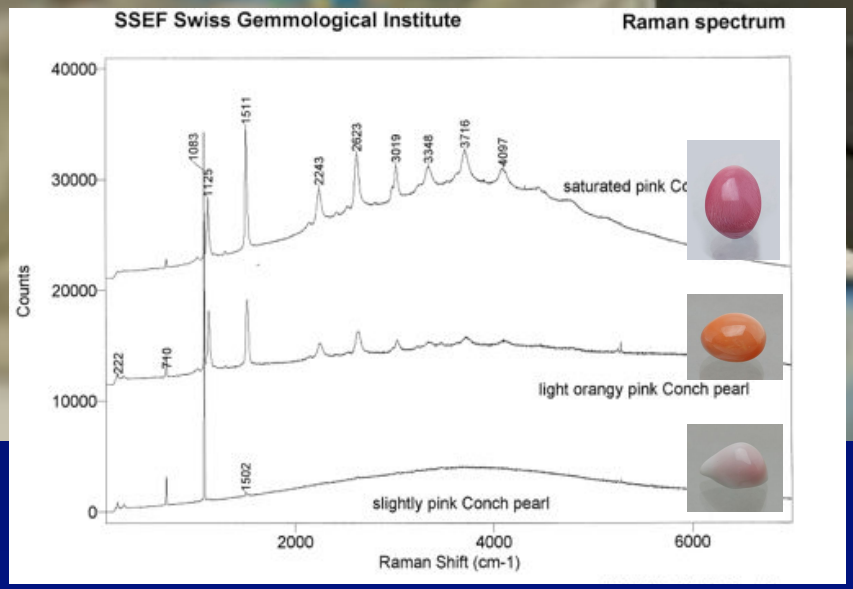
Which species ?

Species identification with UV-Vis reflectometry



UV-Vis reflectance spectra of pearls of natural colour from ***Pinctada margaritifera***

Species identification with Raman microspectrometry



Raman spectra of Conch pearls *(Strombus gigas)* of different colour and saturation.

Research breakthrough: DNA analysis of pearls

OPEN ACCESS Freely available online

PLOS ONE

DNA Fingerprinting of Pearls to Determine Their Origins

Joana B. Meyer[1,2]*, Laurent E. Cartier[2,3]*, Eric A. Pinto-Figueroa[4], Michael S. Krzemnicki[2], Henry A. Hänni[5], Bruce A. McDonald[1]

1 Department of Environmental System Science, Swiss Federal Institute of Technology, Zurich, Switzerland, **2** Swiss Gemmological Institute SSEF, Basel, Switzerland, **3** Department of Environmental Sciences, University of Basel, Basel, Switzerland, **4** Department of Ecology and Evolution, University of Lausanne, Lausanne, Switzerland, **5** GemExpert, Basel, Switzerland

Abstract

We report the first successful extraction of oyster DNA from a pearl and use it to identify the source oyster species for the three major pearl-producing oyster species *Pinctada margaritifera*, *P. maxima* and *P. radiata*. Both mitochondrial and nuclear gene fragments could be PCR-amplified and sequenced. A polymerase chain reaction-restriction fragment length polymorphism (PCR-RFLP) assay in the internal transcribed spacer (ITS) region was developed and used to identify 18 pearls of unknown origin. A micro-drilling technique was developed to obtain small amounts of DNA while maintaining the commercial value of the pearls. This DNA fingerprinting method could be used to document the source of historic pearls and will provide more transparency for traders and consumers within the pearl industry.

Citation: Meyer JB, Cartier LE, Pinto-Figueroa EA, Krzemnicki MS, Hänni HA, et al. (2013) DNA Fingerprinting of Pearls to Determine Their Origins. PLoS ONE 8(10): e75606. doi:10.1371/journal.pone.0075606

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* E-mail: joana.meyer82@gmail.com (JBM); gemlab@ssef.ch (LEC)

Introduction

Pearls produced by oysters of the Pteriidae family are among the most valuable and oldest gems. Oyster shells and pearls have been used for human adornment since antiquity [1], [2], [3], [4], [5], [6]. Today pearls are cultured in domesticated saltwater oysters and freshwater mussels and have become a billion dollar industry [7]. Whereas a natural pearl forms without any human intervention in a wild oyster, a cultured pearl is the result of a human-induced injury. The value assigned to a pearl depends largely on its quality, rarity, and whether it originated naturally or through culture [8]. Thus there is significant interest in being able to scientifically document the provenance of both historic natural pearls [8], [9] and modern cultured pearls. This is rarely possible for the most valuable white to slightly cream-colored pearls using are found in Australia, Burma, Indonesia and the Philippines [6], [7], [18]. Pearls from *P. margaritifera* are called black cultured pearls (or Tahitian cultured pearls) and are now produced mainly in French Polynesia, Fiji, Cook Islands and Micronesia [7], [19], [20], [21]. Akoya cultured pearls are produced mainly in China, Japan and Vietnam [6], [7]. Pearls from *P. radiata* are cultured exclusively in the Arabian/Persian Gulf. The majority of natural pearls come from *P. radiata* oysters, due to a long history of pearl fisheries in the Arabian/Persian Gulf [22]. Although they play a smaller role in the natural pearl trade, *P. maxima* and *P. margaritifera* oysters have produced many natural pearls of considerable size over the last centuries [4], [23], [24]. Natural pearls have a very small niche market and remain very rare because of extremely limited production in recent decades [8].

A cultured pearl consists of nacreous aragonite (calcium

published October 2013, PLOS One

Dr. Joana Meyer, Research Associate of SSEF preparing samples for DNA analysis made from drilling powder of pearl nacre.

Movie excerpt from
BBC News: Science and environment
http://www.bbc.com/news/science-environment-27314703

Camera/editing: Richard Duebel. Producer: Sylvia Smith

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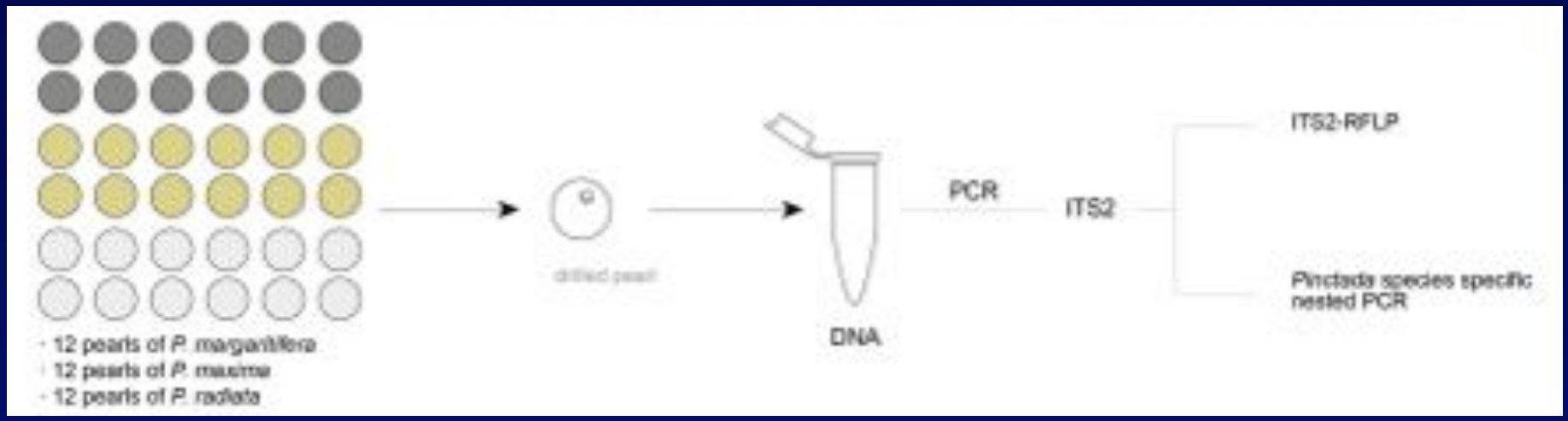
„quasi“ non-destructive sampling by using powder from drill-hole



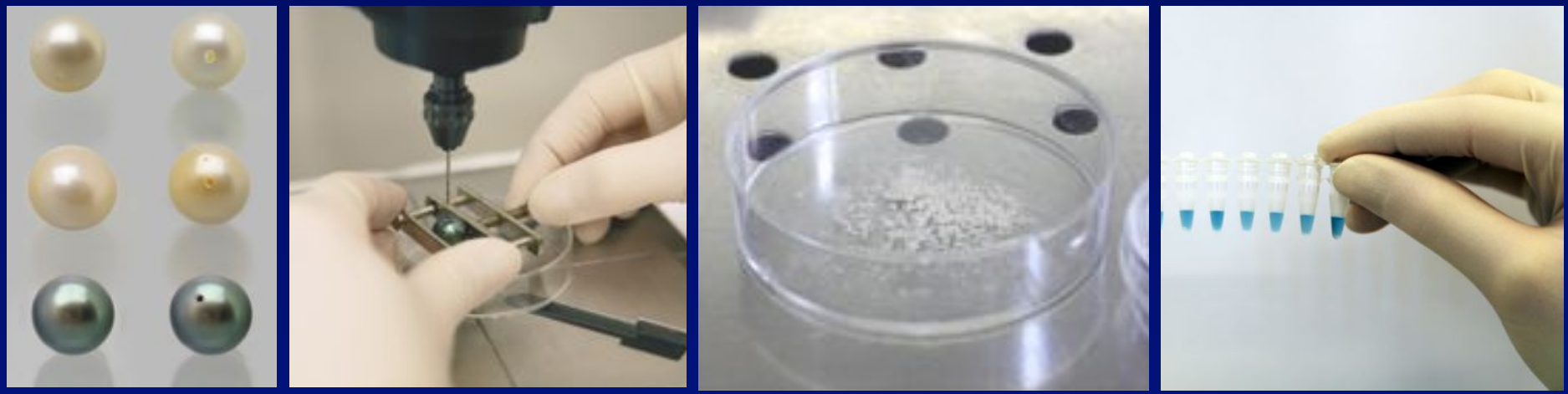
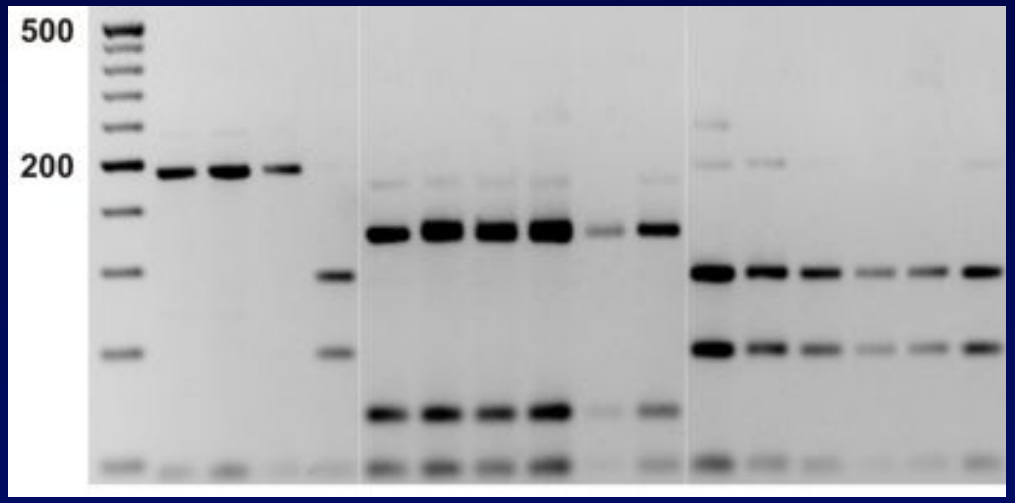


Figure and photos from Meyer et al. 2013



Our study has shown that **species identification** is possible based on DNA from pearls.

Table 2. Sequencing success rate associated with different molecular markers from pearl DNA extracts of *Pinctada margaritifera*, *P. maxima* and *P. radiata* using methods A, B and C (Fig. 2).

Method A[a]	16S rRNA	*cox1*	ITS1	ITS2	Total % of successfully identified pearls
P. margaritifera	86% (6/7)[b, c]	71% (5/7)	43% (3/7)	100% (7/7)	100% (7/7)[c]
P. maxima	60% (3/5)[c]	20% (1/5)	0% (0/5)	60% (3/5)	60% (3/5)[c]
P. radiata	83% (5/6)	67% (4/6)	50% (3/6)	100% (6/6)	100% (6/6)
Total % of successfully sequenced markers	78% (14/18)	56% (10/18)	33% (6/18)	89% (16/18)	89% (16/18)

Methods A, B and C[a]	Method A[a]	Method B[a]	Methods A+B[a]	Method C[a] practically "non-destructive"
	ITS2	ITS2	ITS2	ITS2
P. margaritifera	100% (7/7)[b, c]	100% (7/7)[c]	100% (14/14)[c]	92% (11/12)
P. maxima	60% (3/5)[c]	80% (4/5)[c]	70% (7/10)[c]	58% (7/12)
P. radiata	100% (6/6)	100% (6/6)	100% (12/12)	92% (11/12)
Total % of successfully sequenced markers	89% (16/18)	94% (17/18)	92% (33/36)	81% (29/36)

[a]in methods A and B the pearls were broken open using forceps to expose the inner material used to extract DNA. In method C the powder used for DNA extraction was obtained by drilling a 1-mm diameter hole in the pearls and the hole was enlarged internally using a 0.9 mm drill head.
[b]percentage (%) of successfully identified pearls (identified pearls/total pearls tested).
[c]from a total of twelve *P. maxima* and *P. margaritifera* samples analyzed in method A or in method B, one pearl that was predicted to belong to *P. maxima* based morphological criteria was identified as *P. margaritifera* according to the DNA fingerprint.
doi:10.1371/journal.pone.0075606.t002

Figure and table from Meyer et al. 2013

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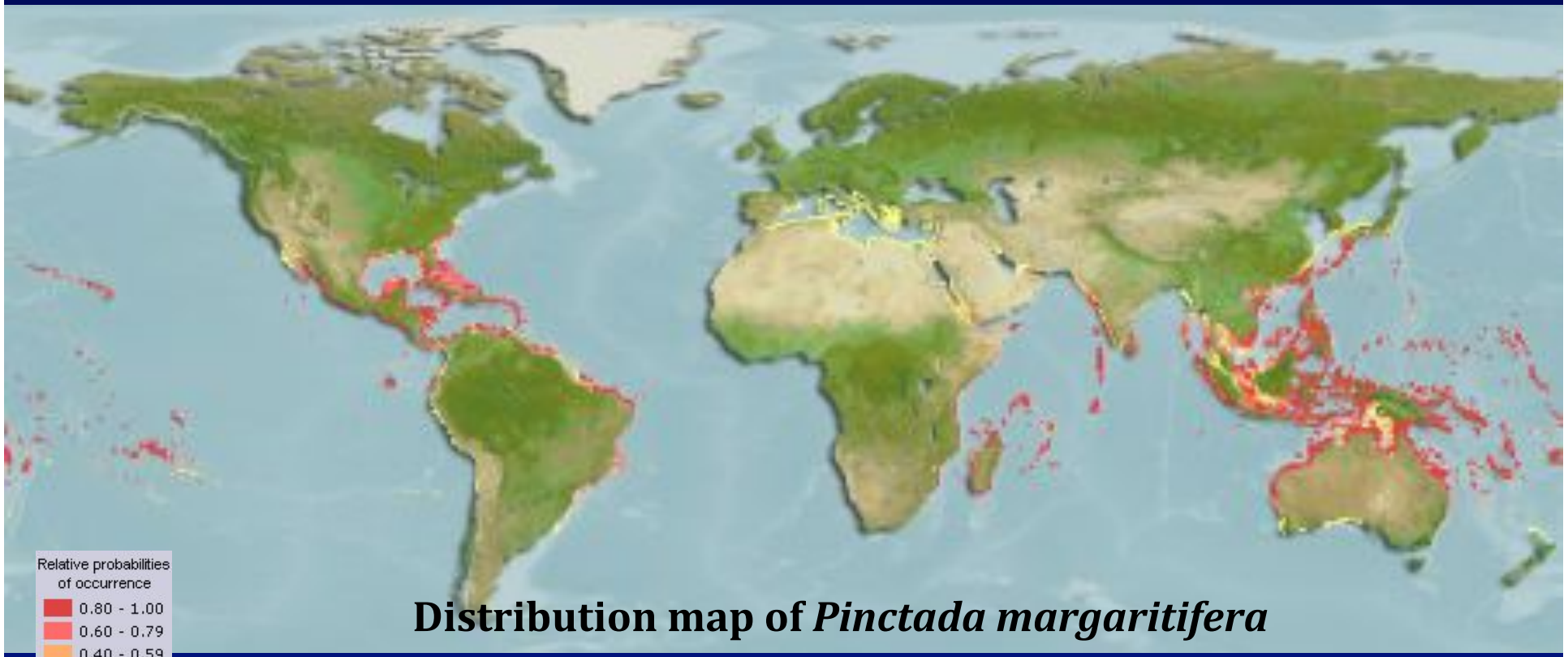
DNA research outlook:

We are currently starting DNA analysis for discrimination of populations within same species. The aim is to find genetic markers which enable to determine the geographical zone where the pearl has formed !



Distribution map of *Pinctada margaritifera*

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Age of pearl ?

…to support the documented historical provenance of a pearl

The principle of radiocarbon ^{14}C age dating

AGE DETERMINATION OF PEARLS: A NEW APPROACH FOR PEARL TESTING AND IDENTIFICATION

Michael S Krzemnicki

Swiss Gemmological Institute SSEF, Falknerstrasse 9, 4001 Basel, Switzerland. Email: gemlab@ssef.ch.

Irka Hajdas

Laboratory of Ion Beam Physics, ETH Zurich, Schafmattstr. 20, 8093 Zurich, Switzerland. Email: hajdas@phys.ethz.ch.

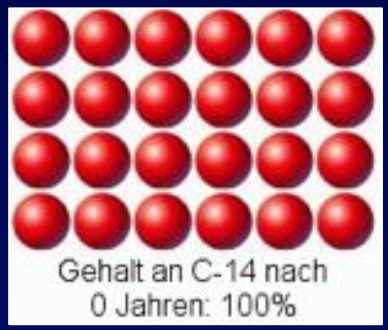
ABSTRACT. For this radiocarbon study, 7 saltwater pearls and 3 shells from pearl oysters have been analyzed. The declared ages of the samples range from the mid-19th century to very recent formations. The analyzed data show the potential of the bomb peak time marker to provide additional information when testing pearls. The analyzed pearls could be distinctly separated in pearls of pre- and post-bomb peak ages, in agreement with the distinction based on the declared ages. The analyzed data further reveals the potential of this method to provide supporting evidence for the historic provenience of a pearl or as an indication of a natural or cultured formation of a pearl.

INTRODUCTION

Due to their beauty, pearls have been used for adornment since prehistoric times and are among the most prized jewels, as they connote not only beauty and rarity, but also status and have thus been used as means of representation in many cultures since ancient times (Kunz 1908). Famous historic jewels and ornaments with pearls are known from the treasures of the royal courts in Europe, Russia, the Middle East, India, and China (Bennett and Mascetti 2007; Scarisbrick 2008).

With the development of pearl cultivation in the beginning of the 20th century, pearls have gained a much-increased accessibility and popularity when compared to previous ages. Now the pearl trade is a multibillion share of the worldwide jewelry market. Its products range from low-quality and inexpensive freshwater cultured pearls to rare and highly sought after natural pearls of historic provenance, such as the La Peregrina pearl (Figure 1). This natural pearl was sold in December 2011 for 11 million US dollars at auction (Christie's 2011), the highest price ever paid so far for any pearl. The price for this pearl is mostly linked to its historic provenance, being documented and depicted in paintings since the 16th century (Hans Eworth 1554, in Cooper 2008; Diego Velazquez 1634, in Lopez-Rey 1996; Finlay 2007).

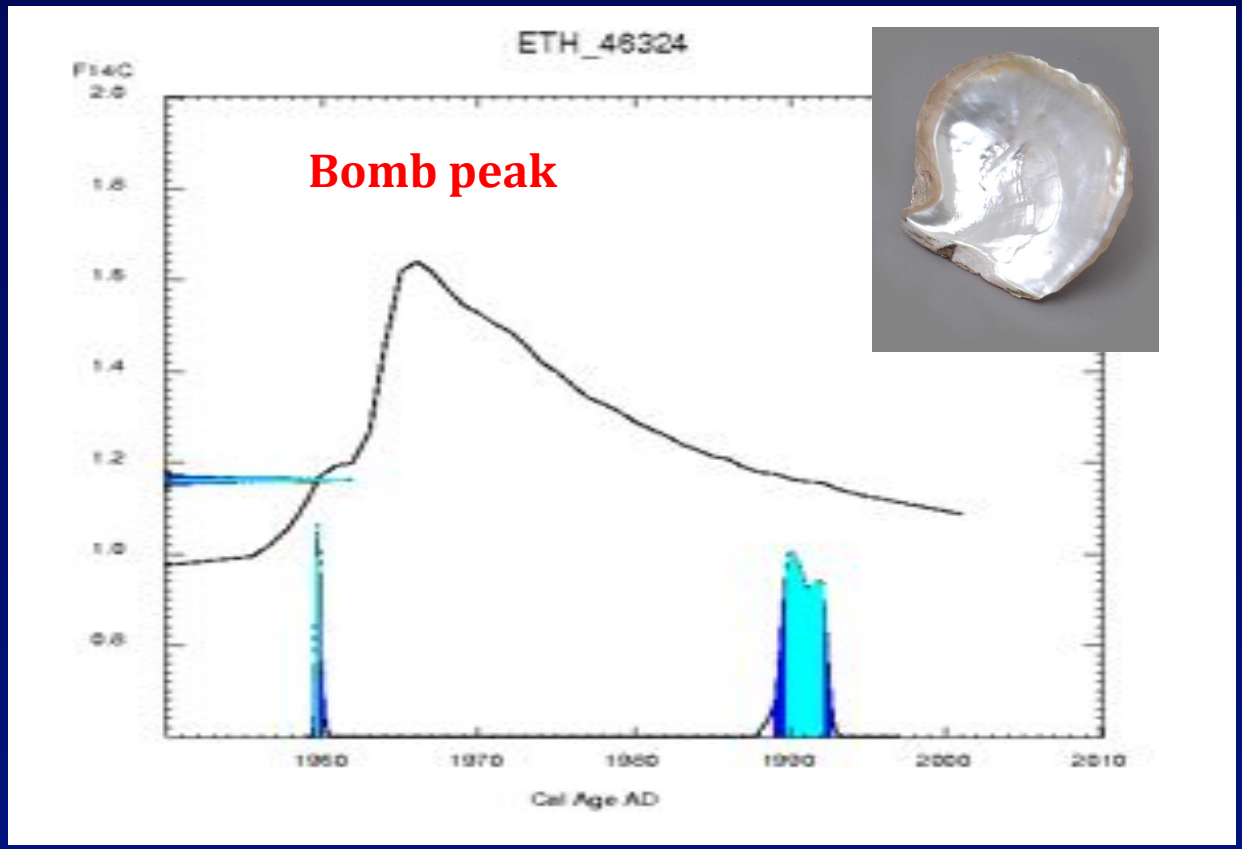
Published July 2013 in the Journal Radiocarbon



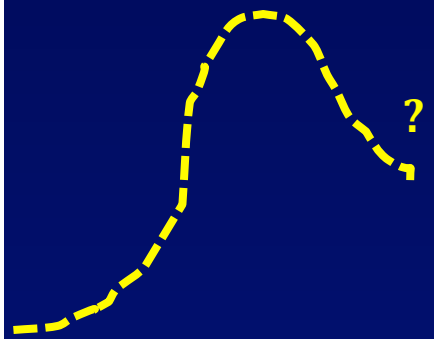
By measuring the ^{14}C / ^{12}C ratio, we get access to the age of organisms.

Radiocarbon dating of recent pearls:

Shell from *Pinctada maxima (Silverlip pearl oyster)* from the Philippines, collected 1990 (pers. comm. H.A. Hänni)



Kim Jong Boom ??



Ongoing research project with pearls from ca. 1950 -2012 in collaboration with Paspaley.

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Radiocarbon dating of historic pearls:

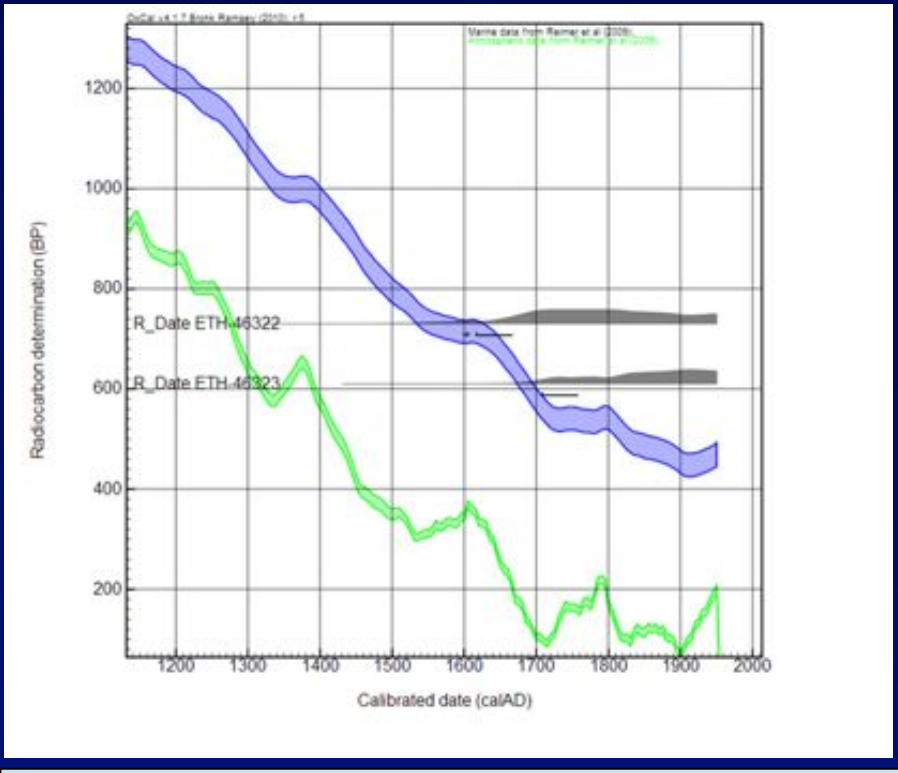

Figure 4. Calibrated of ages of two historic pearls ETH-46322 and ETH-46323 that were formed before the bomb peak. Both pearls originate from the Arabian Gulf, and were calibrated using marine calibration curve INTCAL09 (Reimer et al. 2009) and ΔR=190±180 yrs.

Ongoing research projects with antique pearls from ca. 900 AD, and pearls from 17th and 18th century.

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Conclusions:

- For consumers (in developed markets), the traceability of products they buy is getting more important.
- Thus “branding” of pearls may be valuable for producers to market their product better and for a better price.
- Several strategies for branding are currently being tested, but none is used on a large scale so far.
- Analytical methods to independently determine the most common pearl species are accessible for well-equipped labs.
- DNA and radiocarbon age dating open up new possibilities to support the traceability of pearls throughout the supply channel in the future.

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Thank you for your attention

Photos © Luc Phan, SSEF

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