POLYNESIAN BLACK PEARLS

By Marisa Goebel and Dona Mary Dirlam

Historically, natural black pearls have been one of the rarest and most exotic of gem materials. In the 1960s, however, a black-pearl culturing industry was initiated. Today, cultured black pearls play a prominent role throughout the international jewelry community. This article reviews the history of Polynesian black pearls, the development of culturing and the techniques involved, grading, treatments and identification, and the factors responsible for their growing popularity in the 1980s.

ABOUT THE AUTHORS

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The 1980s have seen an explosion of interest in the cultured black pearls of French Polynesia, five groups of island archipelagos in the South Pacific. Twenty years ago, black pearls were a mere curiosity appreciated by a handful of people. Today, cultured black pearls, often called Tahitian pearls or Tahitian cultured pearls, can be found in fine jewelry stores throughout the world.

The large black-lipped oyster that produces black pearls, *Pinctada margaritifera*, is found in the coastal waters of Peru, Baja California, Panama, Indonesia, Micronesia, the Red Sea, the Philippines, and Okinawa (a prefecture of Japan), as well as French Polynesia. Yet natural black pearls are extremely rare compared to their white counterparts. In the 1960s, however, with the aid of Japanese technicians, pearl farmers in French Polynesia mastered the culturing of black pearls. Like the natural black pearls, the Polynesian cultured pearls are large and often noted for their superb luster and orient, as well as for the unusual gray-to-black range of color (figure 1). To this day, the vast majority of black-pearl culturing is in Polynesia.

With the greater availability of black pearls has emerged a broader market in the jewelry industry, as is evidenced by their regular presence both in retail stores and at auction. Problems have also arisen, such as concern that the pearls might have been dyed or irradiated (Maitlins and Bonanno, 1987). To provide a better understanding of this exotic material, this article will review the history, biology, and culturing of black pearls. It will also describe grading parameters and how to detect treatments used on pearls from other mollusks to mimic the Polynesian blacks and, more recently, on some Polynesian cultured pearls as well.

THE SOURCE: FRENCH POLYNESIA

Midway between Australia and North America—at approximately 17° south latitude and 151° west longi-

Figure 1. This three-strand necklace illustrates some of the fine black cultured pearls that have been produced in French Polynesia in recent years. Note especially the superb luster and orient of these pearls, which range from 12 to 15 mm. Photo by Tino Hammid; courtesy of Christie's, New York.

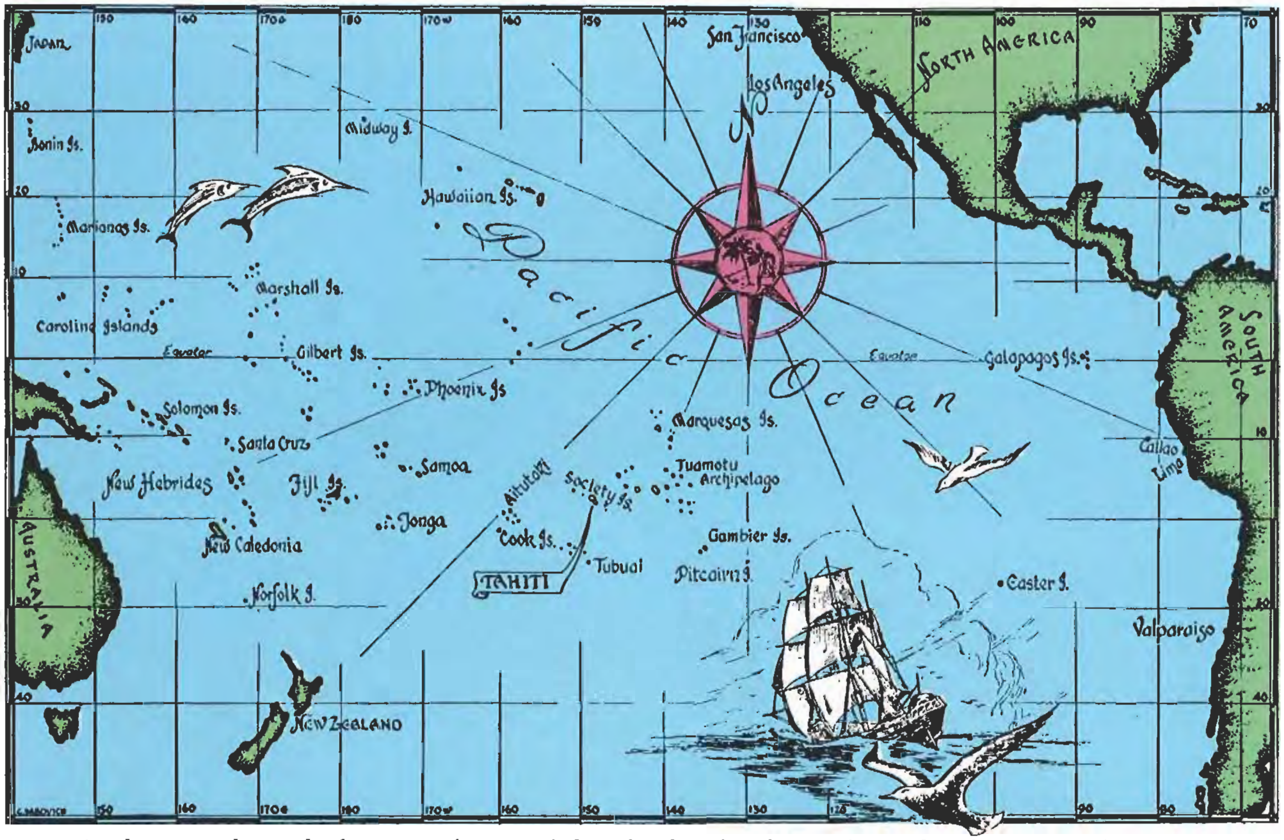


Figure 2. This map shows the location of some of the island archipelagos of French Polynesia, midway between South America and Australia. Adapted from Langdon (1975).

tude—is a group of 130 islands known as French Polynesia (see figure 2). This land mass of 1,550 square miles (9,600 km²) is divided into five archipelagos: the Society Islands, the Leeward Islands, the Tuamotu Archipelago, the Gambier Islands, and the Australes. The black pearls are cultivated primarily in the lagoons of the Tuamotu Archipelago (figure 3) and the Gambier Islands, the waters of which have been found to provide a perfect environment for *P. margaritifera* (Salomon and Roudnitska, 1986).

Figure 3. Black pearls are typically cultivated in lagoons such as this one on S. Marutea Island in the Tuamotu Archipelago. Photo © Fred Ward/Black Star.

HISTORICAL BACKGROUND

The shell of *P. margaritifera* was treasured by native Polynesians long before the European explorers arrived. According to Tahitian legends, black pearls were considered to be emanations from the gods. One important god, Oro, traveled to earth by means of his rainbow, which was believed to be the source of the iridescence in the pearl and its shell (Salomon and Roudnitska, 1986).

In September 1513, Spanish explorer Vasco Núñez de Balboa (1475–1519) first arrived in what is now French Polynesia and claimed the group of islands for Spain. Later, European sailors recounted in their logs and diaries the abundance of giant mollusks in the warm, shallow waters of the South Sea islands, and the ease with which they could be retrieved (Lintilhac, 1987). Unfortunately, little is known about how the pearls were used by native Polynesians or the early European visitors. The earliest record of shell jewelry dates from 1722, when Roggeveen, a Dutch navigator, noted that the people wore silver disks in their ears and pendants of mother-of-pearl (see figure 4). Some of the ceremonial uses included decorating robes with shells and filling eyes in sculpture with mother-of-pearl. Kunz and Stevenson (1908) describe how Tahiti's monarch Queen Pomare played marbles with black pearls in the early 1800s.

In 1842, Polynesia became a protectorate of France, ending over 300 years of conflict with other European countries. During the 19th century, navigators from France, England, the Netherlands, and elsewhere traded flour, cloth, nails, and alcohol to the divers for mother-of-pearl shells that they used in jewelry, as inlay in furniture, and as buttons. They also brought back pearls, some of which were undoubtedly incorporated into fine jewelry. A few historically important natural black-pearl pieces are known today, although the source of the pearls cannot always be established. In May 1989, for example, Christie's Geneva auction sold (for $104,310) a stunning fringe necklace of 35 graduated natural black, silver, and gray pearls that had belonged to the Spanish ambassador to Russia, the Duke of Osuna, in the 1850s.

Twining (1960) describes "The Azra" black pearl, part of a famous necklace in the Russian crown jewels that eventually came into the possession of the Youssoupoff family. Another black pearl on a diamond necklace that had once been owned by the Youssoupoff family was auctioned for $130,000 by Christie's in 1980. The April 1984 Christie's auction of jewels from the estate of Florence J. Gould featured a period piece with

Figure 4. The shell of P. margaritifera *has been treasured by native Polynesians for centuries; this crude necklace represents one example of early usage. Photo © Alain Durand; courtesy of the Museum of Tahiti and Its Islands.*

Figure 5. This brooch from the estate of Florence J. Gould, whose father-in-law was railroad magnate Jay Gould, is one of the few period pieces with natural black pearls known today. The pearls range from 13 to 19 mm and are set with old mine-cut diamonds. The piece sold at auction for $82,500 in April 1984. Photo courtesy of Christie's, New York.

natural gray pearls set in a dramatic diamond, platinum, and white gold brooch (figure 5).

The 1840s were marked by heavy harvesting of the black- lipped oyster. By 1850, reports indicated concern that the oysters were becoming scarce and had to be recovered from greater depths of water (Lintilhac, 1987). As the overharvesting progressed, the French government intervened by establishing seasonal diving periods.

By 1885, the French government realized that the pearling industry would not survive in the South Sea islands unless more dramatic steps were taken. The government then hired biologists to determine ways to replenish *P. margaritifera.* One of these biologists, Bouchon Brandely, suggested a strict prohibition on fishing in certain oyster-bearing lagoons. More importantly, he recommended collecting spats, or young oysters, and placing them in a protected area. The resulting concentration of oysters created an ideal environment for reproduction, so much so that even today, spat cultivating is the primary way of guaranteeing the oyster population.

At the time Bouchon Brandely suggested cultivating spats, the economic impetus was the demand for mother-of-pearl; any pearls found were simply by-products. Black pearls did not become more than an attractive oddity until culturing in *P. margaritifera* was achieved in the 1960s. Early in that decade, French veterinarian Jean Marie Domard began to study culturing; in 1962, he brought a Japanese specialist to Polynesia, who implanted 5,000 oysters. By 1965, they had obtained 1,000 gem-quality cultured black pearls (Lintilhac, 1987).

Figure 6. These baroque cultured black pearls (the largest is 16 × 8 mm) came from the first harvest of the Rosenthal farm on Manihi Atoll. Courtesy of John Latendresse; photo by Robert Weldon.

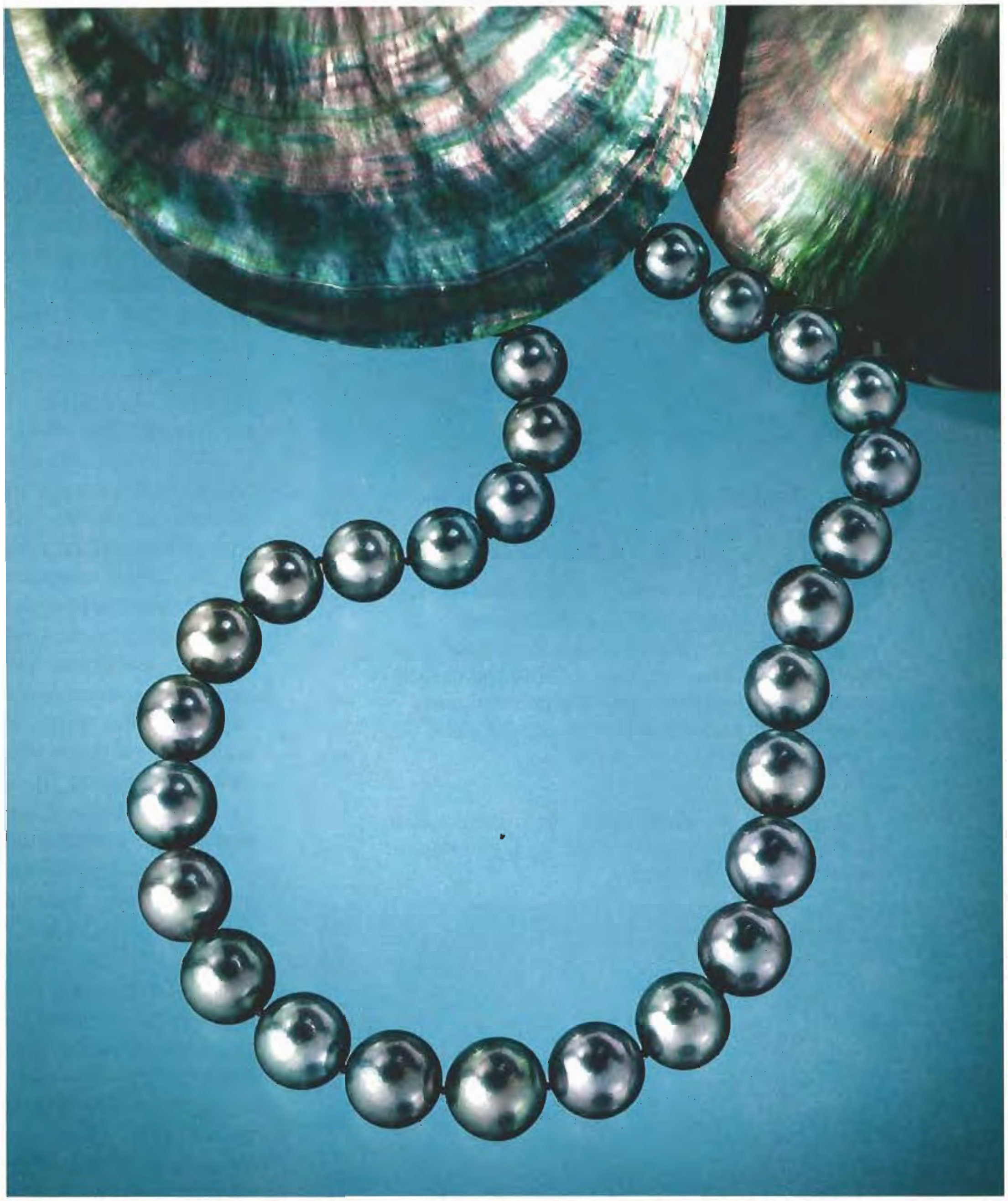
The first pearl farm in French Polynesia was started in 1966 on the Manihi Atoll in the Tuamotu Archipelago by Hubert and Jacques Rosenthal, grandsons of "pearl king" Leonard Rosenthal, author (1920) and scion of a French jewelry family known for their fabulous pearl jewels. The Tahitian government encouraged the Rosenthals to help develop the culturing industry in Polynesia. Through the efforts of Japanese specialist Renji Wada and site manager Koko Chaze, the farm was in full operation by 1968 (figure 6). It continues today, managed by Leonard's great grandson, Cyril Rosenthal. Over the course of the next 20 years, culturing developed into a viable export industry as the technical expertise evolved to produce large, fine-quality black pearls for the jewelry community (figure 7).

ANATOMY OF THE OYSTER AND COMPOSITION OF THE PEARLS

Of the more than 70 species of mollusks (from the phyllum Mollusca) that can produce pearls, the majority belong to the *Pinctada* family. *Pinctada maxima,* the white-lipped or gold-lipped oyster, is prized for both its shell and the large gold-colored and white pearls it produces. It lives in the South Seas, Burma, New Guinea, the Philippines, Australia, and Indonesia. *Pinctada fucata martensii,* commonly called Akoya, has a thin shell of no commercial importance but is valued for its small (usually less than 9 mm) white pearls, which are abundant on the world market today. These mollusks are found in China and Japan. *Pinctada margaritifera,* the black-lipped oyster, is prized for both its mother-of-pearl shell and its large gray to black pearls. Pearl-bearing *P. margaritifera* are found in Peru, Baja California, Panama, Indonesia, Micronesia, the Red Sea, the Philippines, and Okinawa, as well as French Polynesia.

Oysters, bivalve mollusks like the *Pinctada,* have two symmetrical shells hinged together by a ligament. The life span of *P. margaritifera* ranges up to 30 years; a single oyster can weigh up to 11 lbs. (about 5 kg) and reach a diameter of 12 in. (about 30 cm). A powerful adductor muscle holds the two shells together, leaving an indentation on the inner surface. One of the most distinctive characteristics of the black-lipped shell is the

Figure 7. Today, pearl farmers in French Polynesia are producing superb cultured pearls. This natural-color cultured pearl necklace contains 29 fine round pearls that range from 12.5 mm to 15 mm. Two polished P. margaritifera *shells accompany it. Necklace courtesy of Assael International; photo © Harold & Erica Van Pelt.*



greenish black color on its inside edges, which is duplicated in many of the fine pearls from this mollusk. The two most important organs in producing pearls are the mantle and the gonad (figure 8). Not only does the mantle form the shell, but each part of the mantle also secretes different layers of nacre. The gonad is the reproductive gland, a large whitish sack that holds the eggs or sperm. In the culturing process, the bead nucleus and a piece of mantle tissue are inserted into the gonad to produce a cultured pearl.

Nacre, the essential ingredient of all pearls, is composed of approximately 90% aragonite (orthorhombic calcium carbonate crystals) and 5% conchiolin (an organic protein that binds the aragonite crystals together), together with other organic material; the most abundant trace elements in *P. margaritifera* are magnesium, strontium, and sodium (Wada, 1981, p. 154). The nacre is secreted in concentric layers about a micron thick. Cultured pearls have a refractive index of 1.53–1.69 and a specific gravity range of 2.72–2.78. The average hardness is 3.5.

CULTURING

While natural black pearls are still found occasionally, nearly all the black pearls on the market today are cultured. Most natural black pearls have slightly less luster and tend to be larger than their cultured equivalents.

Figure 8. A 14-mm cultured black pearl emerges from the gonad of this P. margaritifera *grown in the Marutea lagoon. Note the mantle surrounding the pearl, and the characteristic black color on the inside edges of the shell. Photo © Fred Ward/Black Star.*

Figure 9. At one of the spat-cultivating areas, a diver checks the growth of the young mollusks. Photo by Cyril Rosenthal.

Culturing is essentially a two-part process: first, the cultivation of the oyster, *P. margaritifera*, and second, the growth of the pearl in this oyster. The technique is essentially the same one Mikimoto used to develop the Japanese pearl-culturing industry (Shirai, 1970). Mikimoto even did some culturing experiments with *P. margaritifera* in 1920, when he established an experimental station at Palau (Cahn, 1949; George, 1979).

The oysters used in the culturing process are still drawn from the limited resources in the water around the islands. Although some are retrieved by independent divers (who continue to be restricted by the Tahiti government to certain zones of the atolls), most are produced by spat cultivation. In a contemporary adaptation of Bouchon Brandely's original program, young oysters are placed in nurseries, suspended from metal nets by stainless steel or nylon wires, until they are old enough—at least two to three years old—to be used for pearl culturing (figure 9). Some farms are also experimenting with growing mollusks in tanks; positive results are anticipated.

Pearl culturing consists of inserting into the gonad of the oyster a bead made of freshwater mussel shell along with a graft of mantle tissue from another live black-lipped oyster. The nucleus is typically made from the mother-of-pearl of a Mississippi River (U.S.) mollusk. Once, only the pigtoe mussel was used; today, three species found in central and southern tributaries of the Mississippi River also provide good nuclei. The mantle-tissue graft is an essential component of the culturing process, both in terms of stimulating the secretion of nacre and in determining the color and other features of the finished pearl. The entire operation of inserting the bead and tissue takes one to two minutes and is usually done by Japanese, Australian, or Polynesian technicians. The technician chooses the appropriate nucleus size for the oyster being used, typically a bead 5–9 mm in diameter, and then makes a small incision in the gonad, into which the nucleus and mantle-tissue graft are placed (figure 10). The experience of the technician is invaluable in ensuring that the oyster used is healthy, that the largest bead possible is selected, and that the various components are not damaged in the course of the operation.

Once the procedure is completed, the oysters are attached to a nylon rope through holes drilled in the shells. In some farms, the oysters are placed individually in net bags, which catch any beads that are rejected. A diver then attaches the chain of oysters to an underwater platform (figure 11). The operation takes place typically between June and September, the winter months for this region, when the water is cooler and there is less risk of violent storms.

If an oyster rejects the bead, it will generally do so in the first two months following the surgery. Some well-equipped farms have been known to X-ray the oysters to see if the nucleus has been rejected or if it is in place properly, but this technique is used much less frequently today than it was in the past (R. Wan, pers. comm., 1989). Oysters that reject their beads can be re-operated on after a couple of months of rest. On some farms, these oysters are instead used to create mabes or assembled cultured blister pearls.

Approximately two years must pass before the success of this operation is known. At that time, a few mollusks are brought to the surface and checked to see if a pearl has formed and, if so, how thick the nacre is. With three or four layers of nacre deposited a day, a pearl cultured in *P. margaritifera* will develop a nacre thickness of 2 to 2.5 mm in two years, compared to 1 mm developed by an Akoya pearl over the same time span.

During the growth period, the oysters must be watched constantly. They are brought to the surface and the barnacles cleaned off several times a year. Predators, parasites, hurricanes, pollution, and piracy are a constant threat. In both 1983 and 1985, hurricanes did profound damage to oysters, equipment, and buildings in French Polynesia on farms in the Tuamotu Archipelago (Cohen, 1983; C. Rosenthal, pers. comm., 1989).

Currently the lagoons of two archipelagos—the Tuamotu Archipelago and the Gambier Islands—are used primarily for cultivating pearls and the mother-of-pearl shells that are now the by-product of this important industry in French Polynesia. Efforts are being made to find other suitable lagoons.

HARVESTING

If, at two years, all of the indications are good, the oysters are harvested. A number of farms now have two or more harvests a year. At this time, the oysters are brought to the installation or laboratory where the initial insertion took place and are opened by a technician who then examines the interior (figure 12).

If the operation is successful and a pearl is

Figure 10. An essential step in the culturing process is the insertion of the bead nucleus into the gonad. Photo © Fred Ward/Black Star.

Figure 11. Once the oysters have received their implantations, they are attached to a chain and taken to an underwater platform. Photo by Cyril Rosenthal.

Figure 12. A pearl can be seen lying within the gonad of this oyster, which has just been harvested. Photo by Marisa Goebel.

found, it is removed carefully. The harvested pearls are washed, dried, and lightly polished by rubbing in salt in preparation for sorting and grading. On a few of the farms, the oyster may be reoperated on after a period of rest (V. Dockendorf, pers. comm., 1989). On average, 55% of the oysters will accept the operation the first time. A return of 30% commercially acceptable pearls is considered a very good harvest (C. Rosenthal, pers. comm., 1989).

Figure 13. Polynesian cultured black pearls occur in a variety of colors. Photo © Fred Ward/ Black Star.

If the oyster has rejected the bead nucleus, the technician will check to see if a "keshi" (mantle tissue–nucleated pearl) has been created from the piece of mantle tissue that was inserted. In any case, if the mollusk that rejected the bead is deemed healthy, another implant may be attempted. Again, some farms will elect to make mabes at this stage rather than risk a second implant because of the high mortality rate for mollusks after the second insertion.

GRADING

Five factors are commonly used by the trade to grade Polynesian black pearls: color, luster, shape, size, and surface features.

Color and Orient. In the context of black pearls, one of the most important factors, "color," consists of two components: body color (the basic color presented by the pearl) and overtone (the hues seen superimposed on top of the body color). Body color can be subdivided into six groups: silver, silver blue, gold, brown-black, green-black, and black (figure 13). Overtone is typically a mixture of colors that is best observed as the pearl is rotated. Created by light passing through the layers of nacre, the overtone may be any combination of pink, lavender, blue, "peacock" blue, gold, green, or a reddish purple called *aubergine* (after the French word for eggplant). The color most characteristic of fine Polynesian black pearls is a greenish black (also referred to as "peacock") that sometimes has an *aubergine* overtone. Because other South Sea pearl-bearing oysters may also produce silver, silver-blue, and golden pearls, these latter colors are more plentiful in the market and therefore may command a lower price than the various combinations of black-colored pearls.

Also caused by the passage of white light through the many layers of nacre is the rainbow-like play of color that seems to *hover* about the surface of some pearls. Called orient, it is not always prominent in black pearls, although it is readily visible in the finer grades.

Luster. Luster is the quality of light reflections from the surface of the pearl. As taught in the current GIA pearl course, luster is considered high when reflections are bright and sharp, and low when they are weak and fuzzy. In black pearls, much of the light is reflected from the surface, thus producing excellent luster in most. In the trade, this brilliance is called *éclat*, from the French word for shiny.

Shape. Shape can be divided into three main categories: round or spherical, symmetrical, and baroque. The most highly prized is the perfectly round pearl that will roll in every direction when placed on a flat surface (Lintilhac, p. 70). Symmetrical pearls are pear-, egg-, or button-shaped; some are evenly elongated. The baroque-pearl category contains all the irregular shapes and is the most interesting to many pearl enthusiasts.

Currently, there is an abundance of baroque pearls from the South Seas (see figure 14). American pearl grower John Latendresse feels that the disproportionate number of baroques is due to the poor quality of bead that has been supplied to the Polynesian pearl farmers. His examination of black-pearl nuclei reveals that many are infested with parasites whose presence alters to bits of organic material on the surface of the beads (figure 15), referred to in the trade as *wax*. "Nacre won't adhere to the nucleus in places where there is wax," Latendresse explains. "As a result, you get baroque pearls" (Federman, 1985). The desire for improved quality and a steady supply has led black-pearl producers to find beads outside the traditional sources of supply in Japan (C. Rosenthal, pers. comm., 1989).

Figure 14. Cultured black pearls are also found in a broad assortment of shapes. Pearls courtesy of Ocean Gems; photo by Robert Weldon.

Size. Size is the most readily determined feature of a pearl. Pearl sieves, much like diamond sieves, with holes ranging from 9 mm to 13 mm, are used initially to separate pearls into batches. Polynesian black cultured pearls generally average between 9 mm and 12 mm. Since the diameter of the typical

Figure 15. These three beads were created from U.S. freshwater mollusks for use as nuclei in the culturing process. The imperfect surfaces may influence the final shape of the pearl. The furrow may produce rings, the fish-eye may produce a fish-eye effect, and the organic residue may result in a baroque-shape pearl. Beads courtesy of John Latendresse; photo by Robert Weldon.

Figure 16. At 20.8 mm, the center pearl is the largest known round cultured black pearl. For comparison, the pearl on the left is 12 mm and the one on the right is 14 mm. Pearls courtesy of Robert Wan; photo by Marisa Goebel.

nucleus is 5–9 mm, the pearl's final size depends on the amount of nacre secreted by the oyster. Prior to sale, the pearls are then measured more precisely using a millimeter gauge (Lintilhac, p. 70).

Figure 17. This colorful strand contains 41 ringed Polynesian cultured pearls of greenish blue body color with aubergine *overtones. The two round pearls in the center measure 12.4 mm and 11.9 mm. Pearls courtesy of Ocean Gems; photo © Tino Hammid.*

The largest round cultured black pearl on record is 20.8 mm (figure 16).

Surface. As is the case with all pearls, surface imperfections such as pits, bumps, ridges, cracks, and spots lower the grade on a Polynesian black pearl. Rings, actually parallel furrows that encircle the pearl, represent an unusual though often attractive surface feature (figure 17). Most rings, according to Latendresse (pers. comm., 1989), result from the pearl being nucleated near the hinge of the two shells. In a cultured black pearl, a line on the surface of the nucleus bead may produce rings (again, see figure 15).

Pearl Grading System. Systems used in the trade to grade black pearls typically consist of a series of letters that indicate shape and surface features. Lintilhac (1987) describes one such system:

Shape

R = Round
D = Drop or pear
Brq = Baroque
But = Button
Circ = Circled (Ringed)

Surface and Luster (figure 18)

A = Pearls with a flawless skin and high brilliance with one pit or pinprick
B = Pearls that are less brilliant and have two or three surface blemishes
C = Pearls that are somewhat dull or have four or more surface blemishes
D = Pearls that are definitely dull or marred by deeper flaws

A similar system used by Assael International is outlined by Federman (1987).

CAUSE OF COLOR

As discussed above, color in pearls is a mixture of body color and overtones. The body color is determined by a combination of factors, including the biology of the mollusk (specifically the mantle tissue), the composition of the mother-of-pearl shell, and trace elements present in the water environment. Japanese researchers have investigated the body color in pearls extensively for over 50 years (Fox, 1979). They cite the presence of porphyrins (a group of water-soluble, nitrogenous

16-member ring organic compounds) in the shell of the mollusk as a primary cause of color in colored oyster pearls. In mollusks, the porphyrins combine with metals such as lead and zinc to form metalloporphyrins. These same porphyrins produce a red fluorescence that is useful in identifying natural color in black cultured pearls. Miyoshi et al. (1987) illustrate the diagnostic spectra produced by porphyrins present in the nacre.

Also contributing to the color of most black pearls is the presence of brownish organic substances that exist between the translucent porphyrin-containing nacre and the bead nucleus (Miyoshi et al., 1987; P. Galenon, pers. comm., 1989). This substance is thought to be conchiolin, but research to date has not been conclusive.

Fritsch and Rossman (1988) describe the cause of the "high order" interference colors—overtone and orient—seen in black pearls as "light passing through and reflected back by alternating layers of aragonite [in the nacre] and conchiolin." The finer the layers of nacre are, the more orient a pearl has (R. Wan, pers. comm., 1989).

COLOR TREATMENTS

In a 1971 article, C. Denis George lamented his unsuccessful search for even one natural-color black pearl in visits to Mexico City, New York, and Paris. He was routinely offered treated black pearls that were represented to be natural color, and he railed against the "unscrupulous suppliers" who were perpetrating this "miserable and fraudulent" situation.

In fact, from 1900 to 1978 (when cultured black pearls first began to appear in quantity), there were far more treated than natural-color black pearls on the market. One result of the overharvesting of *P. margaritifera* in the 19th century was that by 1900 there was a shortage of natural-color black pearls. To fill this void, people began to use silver nitrate solutions to dye the smaller Akoya pearls common to Japan (figure 19). Even today, silver nitrate and other silver salts are probably the most common form of treatment to turn white and off-color Akoya pearls black (Komatsu and Akamatsu, 1978; Taburiaux, 1985).

Although pearl treaters are among the most secretive in the gem industry, we do know that the basic procedure involves soaking the pearls in a weak solution of silver nitrate and dilute ammonia and then exposing them to light or hydrogen sulfide gas. This produces a change of color in the conchiolin that makes the pearl appear black in reflected light. The resulting color is stable to light and heat (Nassau, 1984). Because the hues of brown-black, green-black, and black are similar to natural colors, it is virtually impossible to distinguish them by visual observation alone (Taburiaux, 1985).

Figure 18. This selection of six pearls shows the range of surface and luster quality seen in round cultured Polynesian black pearls. Beginning in the upper left-hand corner and moving from left to right and top to bottom, the grades would range from A to D on the system described by Lintillac (1987). Pearls courtesy of South Sea Pearls, Inc.; photo by Robert Weldon.

Another, reportedly organic, dyeing technique was commonly practiced from approximately 1915 through the 1920s. Called the French Method, it was used by a few treaters in Paris on off-color natural pearls. Although little is recorded about the actual procedure, we do know that it can be detected with a microscope when dye concentrations are present. Pearls were shipped from Japan to Paris for treatment and then back to Japan for sale (R. Crowningshield, pers. comm., 1989). In 1920, Rosenthal cautioned jewelers to be aware of pearls treated by this process.

Although historically treatment has involved Akoya cultured pearls, it was inevitable that attempts would be made to enhance light-color *P.*

Figure 19. The black pearls in this fine necklace, signed by David Webb, are typical of the treated pearls commonly seen in the trade. Interestingly, the baroque pearls in the earrings and ring have also been treated. Photo by Tino Hammid; courtesy of Christie's, New York.

maxima and *P. margaritifera* cultured pearls as well. In 1987, Fryer et al. reported seeing a strand of 11- to 14-mm black cultured pearls that showed evidence of silver nitrate dye. More recently, in September 1989, the GIA Gem Trade Laboratory in New York examined two 12-mm black cultured pearls that showed evidence that they might have been dyed. The laboratory staff subsequently received confirmation from the trade that some South Sea pearls were being treated to darken the color (D. Hargett, pers. comm., 1989).

One of the more recent treatments used on *P. fucata martensii* (Akoyas) in an effort to darken mediocre-color cultured pearls is irradiation, specifically with a cobalt gamma source. According to Matsuda and Miyoshi (1988), gamma-ray irradiation can change off-color cultured Akoya pearls to an attractive bluish gray. These authors report that irradiation of Akoya pearls began in the 1950s with the "Atoms-for-Peace Program" and resulted in irradiated cultured pearls first appearing on the market in the 1960s.

Ken Tang Chow's patent on irradiating pearls, filed in 1960 and granted in 1963, sheds some light on the procedure used. The technique he patented involves exposure of the pearl to cobalt-60 with an intensity of 1,000 curies of gamma rays at a distance of 1 cm from the source for about 20 minutes at room temperature. Chow found that longer periods of irradiation did not produce any appreciable change in color. He also reported that the irradiated pearls were stable to light and heat.

Scientists have often noted that the color of freshwater shells and pearls can be changed by irradiation more easily than that of saltwater oysters. They attribute this to a change of manganese compounds ($MnCO_3 \rightarrow MnO$) which are more abundant in freshwater mollusks (Wada, 1981).

Irradiating Akoyas produces a darkening of color because the freshwater bead nucleus darkens and influences the body color. In *P. margaritifera*, the much thicker nacre would not allow the color shift of the nucleus to be visible (R. Crowningshield and D. Hargett, pers. comm., 1989). Dr. George Rossman, of the California Institute of Technology, recently experimented with the irradiation of three Polynesian black pearls following the procedure outlined in Chow's patent, but left them in the reactor for slightly longer than 24 hours. No appreciable change was observed in these pearls compared to their control samples, although a color shift was observed in the freshwater pearls irradiated at the same time (pers. comm., 1989).

Modern Pearl Identification. In 1920, Rosenthal recommended a relatively simple method for identifying dyed pearls: "When a [natural] black pearl is scraped, the powder is white, but in the case of an artificially colored pearl, the powder is black." While this procedure is accurate for some dyed pearls, it is also destructive. Similarly, successful experiments in the 1970s with a Vickers hardness machine (Komatsu and Akamatsu, 1978) were never adapted for routine testing because of their destructive nature. Today, because of the sophisticated equipment and experience needed to identify treatment, definitive pearl testing requires the resources of a well-equipped gemological or pearl-testing laboratory. Currently, gemologists at most Western gemological laboratories commonly use long-wave U.V. fluorescence, X-ray fluorescence, X-radiographs, visual observation, and microscopic examination to separate treated from natural-color pearls. These tests are often used in conjunction with other procedures to determine first whether the pearl is natural or cultured (figure 20). Our primary concern in the following discussion, however, is their application in separating natural-color from treated black pearls.

U.V. fluorescence can be diagnostic in this separation. For example, the fluorescence of natural-color black pearls commonly varies from bright red (pearls from Baja California) to dull reddish brown (Tahiti pearls) when exposed to long-wave U.V. radiation, while dyed pearls are usually inert or fluoresce a dull green (Benson, 1960; Crowningshield, 1970; Fryer et al., 1987; R. Crowningshield, pers. comm., 1989).

X-ray fluorescence spectral analysis involves exposing the sample to X-rays and measuring the wavelengths emitted with a spectrometer (Komatsu and Akamatsu, 1978). Silver used in the various silver salt treatments will be detected. This test must be performed carefully, by an experienced technician, since the sample pearls have been known to turn brown-black if exposed to the x-rays in a wave-length dispersive x-ray fluorescence unit. Therefore, most gem-testing laboratories use an energy-disersive XRF unit (as described in Liddicoat, 1987).

X-radiography, a technique developed in the 1920s to separate natural from cultured pearls, has been discussed in detail in the standard gemology

Figure 20. Some of the methods used by pearl testers to determine type and composition of the pearl are also used to separate natural- from treated-color pearls. Here, from top to bottom: X-ray fluorescence (to separate saltwater from freshwater pearls, as well as silver-treated from natural color), candling (to see thickness of nacre), Lauégram (to identify presence of nucleus in a cultured pearl), X-radiograph (to show presence of nucleus and evidence of silver treatment in some pearls), and a microsection (to examine the structural profile of a cultured pearl). All lead to a cultured South Sea pearl at the front. Photo © Michael Freeman.

texts (see, e.g., Webster, 1983; Liddicoat, 1987). The method works on the principle that different materials such as nacre, conchiolin, and silver vary in their degree of transparency to X-radiation (Brown, 1979). Cultured pearls usually show high relief between the nucleus, with its dark ring of conchiolin, and the nacre. In a silver-treated pearl, the silver tends to concentrate in the area of the conchiolin. Because silver is opaque to X-rays, this area commonly appears white on the X-radiograph. The white ring or area around the nucleus of a treated black pearl is sometimes called a reversal ring (Fryer et al., 1986, pp. 173 and 174).

Also used in pearl identification is visual observation supplemented by microscopic observation. To the unaided eye, dyed materials will sometimes show an unusually even distribution of color throughout the pearl and in some cases throughout an entire strand of pearls. With magnification, dye can be seen concentrated around the drill hole and even extending out into the pearl in a vein-like fashion (as illustrated in Fryer et al., 1984, p. 230).

Figure 21. Mantle tissue–nucleated "keshi" pearls are an interesting by-product of the culturing operation. This necklace shows the variety of shapes and colors in which black "keshis" can occur. The drop is the only pearl on this necklace that is bead nucleated and, therefore, not considered a "keshi." Photo by J. C. Bosmel; courtesy of Michel Fouchard.

In some instances, dye can be detected by using a cotton swab dipped in a *weak* (e.g., 2%) solution of nitric acid on an inconspicuous area of the pearl. This is, however, another destructive test (Fryer et al., 1984, p. 229).

Visual examination is also useful in identifying irradiation in the smaller Akoya pearls. Irradiation will darken freshwater pearls and shells, but not saltwater pearls. Therefore, since cultured pearls use freshwater-shell nuclei almost exclusively, the dark bead nucleus of an irradiated pearl is easily seen through the drill hole of the pearl. The color of the nacre is unchanged (Fryer et al., 1986, p. 173, and 1988, p. 244, figure 11). One must be careful, however, to make several tests on each pearl, since while irradiation changes the *color* of the bead, it does not change the reaction of the pearl to long-wave U.V. radiation (Matsuda and Miyoshi, 1988).

Even undrilled pearls can provide clues to the experienced pearl scientist by virtue of their visual appearance. The intense color and metallic luster have been cited as indications of treatment (see, e.g., Fryer et al., 1985).

It should be noted that size can be another important indicator of treatment. Small, rounded pearls 8 mm or less with very black, gray, green, or blue-green hues are generally treated pearls—that is, smaller Akoya pearls that have been dyed or irradiated—since the pearls grown in *P. margaritifera* are seldom smaller than 9 mm. Again, though, it is important to test pearls carefully, because some localities such as Baja California produce a lustrous black pearl of natural color in small sizes. Black "keshi" pearls can also occur in small sizes.

In recent years, Japanese scientists have led the way in pearl research. In 1978, Komatsu and Akamatsu reported the success of their experiments with infrared film to separate natural-color from dyed black pearls. Akamatsu (pers. comm., 1989) reports that the Mikimoto Research Laboratory now finds spectrometry to be an even more efficient method to make the separation between natural-color and silver-treated blacks. Pearls from *P. margaritifera* have a specific absorption at 700 nm that is caused by the black pigment and can be easily measured by a spectrophotometer.

The team of T. Miyoshi, Y. Matsuda, and H. Komatsu has focused on methods for determining the parentage of cultured pearls using laser-induced fluorescence measured by a spectrofluorophotometer. In their 1987 paper, they reported their observation of two fluorescence peaks—at 450 nm and 620 nm—in *P. margaritifera*. The 620 peak was not observed in *P. maxima* or *P. fucata martensi*, because the shells of these oysters do not contain porphyrins. This makes it possible to separate *P. margaritifera* pearls from those produced by these two subgroups. Research such as this will provide the basis for more definitive pearl testing in the future.

DISTRIBUTION

Currently, culturing in Polynesia is carried out on privately owned pearl farms like the Rosenthals' or on pearl cooperatives. While there are many farms that produce less than 200 pearls annually, 24 farms have an annual production of over 5,000 cultured pearls. The farms tend to be more successful than the cooperatives because of the financial resources with which they are backed. The cooperatives were established in 1971 by the Department of Fisheries with loans from the Société de Crédit d'Océanie (SOCREDO) so that each atoll would have its own pearl-culturing industry. In 1988, there were approximately 40 cooperatives with 1,145 members. These cooperatives were reorganized in 1989 into 157 smaller family groups in an effort to improve production (M. Coeroli, pers. comm., 1989).

The cultured pearls are sold either through private sales or auctions. Most of the material produced on the farms is sold privately to pearl wholesalers and major jewelry companies. However, approximately 40% of the total production each year is sold at auction.

Auctions are usually held once a year, in October. They are coordinated by EVAAM and GIE Poe Rava Nui, the two government agencies that oversee the pearl-culturing cooperatives (M. Coeroli, pers. comm., 1989). These pearl auctions give the cooperatives the opportunity to help repay their government loans. They have also been important in making the international public and jewelry community more aware of Polynesian cultured black pearls.

The auctions are held in private, by invitation only, in Papeete, Tahiti. At the 1988 auction, 107 participants (co-ops and independent farms) presented their goods to an invited audience. The pearls were divided into lots of different pearl sizes and quantities. After examining the various pearls in a lot, buyers make specific offers for the particular lots in which they are interested. At the 1988 sale, approximately 70 lots were offered, with total sales exceeding $2 million (almost 10 times the total amount exported the first year the auction was held, 1981). In addition, 515 kg of "keshi" pearls, a by-product of culturing (figure 21), were sold (Cazassus, 1989).

TABLE 1. Exportation of black cultured pearls from French Polynesia 1972–1988[a].

Year	Weight (in grams)	Value (in US $)
1972	1,563	3,609
1973	800	23,528
1974	3,891	166,337
1975	15,631	100,918
1976	6,111	163,206
1977	6,128	213,184
1978	49,982	1,693,496
1979	86,092	2,162,821
1980	28,779	1,038,483
1981	86,527	3,873,993
1982	32,310	807,534
1983	139,888	4,689,822
1984	112,183	2,530,535
1985	206,463	10,201,822
1986	104,114	8,606,441
1987	407,620	22,937,512
1988	446,827	22,810,618

[a]*Translated from Ministère de la Mer (1989), with dollar amounts converted from Pacific French francs.*

In 1984, the principal buyers at auction were Japanese, 30%; U.S., 30%; and Swiss, 30%; with France and other countries, 10%. By 1988, the market was such that 84% of the production sold at auction went to Japanese buyers, with the remainder sold primarily to Tahitian jewelers (Cazassus, 1989).

It is important to remember that natural-color cultured black pearls have been commercially available for less than 20 years. Production has risen rapidly during this period (table 1), yet it appears that demand still exceeds supply. In Japan, in particular, demand increased sharply in the second half of 1988 and continues to rise (Chun, 1989).

MARKETING

The great popularity of black pearls today can be directly attributed to the marketing efforts of two large companies, Assael International and Golay Buchel Inc.

Figure 22. In recent years, black cultured pearls have appeared in the salons of some of the finest jewelers in the world. This necklace of white and black cultured pearls (9–13 mm) with emerald clasp and the accompanying earrings (11 and 16 mm) were created in 1985 by Harry Winston, Inc. Courtesy of Harry Winston, Inc.; photo © Harold & Erica Van Pelt.

Salvador Assael has been credited with having "almost single-handedly popularized the natural color Tahitian black pearl" (Federman, 1987). In the 1960s, he worked with Jean-Claude Brouillet, owner of the S. Marutea Atoll, to develop a viable black-pearl culturing operation. Eventually, they produced as many as 22,000 cultured pearls per harvest. Backed by this production, in the early 1970s Assael began to promote cultured black pearls directly to the jewelry industry, bypassing the traditional Japanese distribution system. Not only did he and Brouillet promote their pearls to tourists throughout French Polynesia, but they also wrote articles, placed advertisements in magazines around the world, and convinced major companies such as Harry Winston and Van Cleef

Figure 23. This 12–15 mm Polynesian black and gray cultured pearl necklace with emerald and diamond clasp sold for $649,000 in October 1988, at the time the highest price ever paid at auction for a Polynesian cultured black pearl necklace. Courtesy of Sotheby's & Co.

and Arpels to include black cultured pearls in their inventories of fine jewels (figure 22). Today, Assael continues to be a major force in the marketing of black cultured pearls, along with other distributors such as Golay Buchel, who plays the prominent role in the important Japanese market (A. Goetz, pers. comm., 1989).

Another key factor in raising the public's awareness of black pearls has been the jewelry auctions held by Christie's and Sotheby's. In 1969, a three-row strand of 141 black pearls sold for $168,000. Ever since, single pearls or pearl necklaces have been a routine item in the "magnificent jewelry" auctions. In October 1988, a double strand of black and gray cultured pearls sold at Sotheby's New York for $649,000 (figure 23). The three-strand necklace in figure 1 sold for $880,000 at Christie's October 24, 1989, auction in New York.

Pearls are marketed in Tahiti through different jewelry stores, some owned by the pearl producers themselves. For example, the Tahiti Pearl Center and Museum in Papeete is owned by Robert Wan, currently the largest producer of black cultured pearls. The museum not only sells pearl jewelry, but also educates through videos, photos, and displays. Most hotels display pearls and pearl jewelry, thus exposing travelers to the gem.

CARE OF PEARLS

Pearls are products of living organisms and thus react strongly to acids and chemicals, including those in perfumes, soaps, and hairsprays. Because soaps and dishwashing detergents that contain bleaching agents may discolor pearls, it is particularly important that rings containing black pearls be removed before immersion of the hands in these solutions. To avoid dehydration and cracking due to dryness, some members of the trade recommend rubbing pearls with a dab of a natural oil placed on a soft cloth; this will also enhance the pearl's beauty and luster. Historically, sandalwood oil has been preferred for this purpose (C. Rosenthal, pers. comm., 1989).

Because pearls are not very hard – only 3.5 on the Mohs scale – they can be scratched fairly easily. In manufacturing, it is recommended that the jeweler not place the pearls in a design where they will rub against other gems or metal or will be in a position of tension with a metal, such as in a prong setting. In storing pearls, it is best to keep them separate from other jewelry and wipe them with a soft cloth after wear.

CONCLUSION

Polynesian cultured black pearls have been called the "rainbow gem of the 20th century" (Salomon and Roudnitska, 1986). Indeed, the development of the black-pearl culturing industry in the 1960s has now made the worldwide distribution of natural-color cultured black pearls feasible. Without this technology, black pearls would have remained the oddity they were for the first 70 years of this century. Technology has also given the major gemological and pearl-research laboratories the tools by which to separate natural-color black pearls from most of their treated counterparts.

Today, cultured black pearls are seen in fine jewelry stores everywhere. Given the level of government support and the broad scope of the pearl-culturing industry in French Polynesia, it appears that there will continue to be a steady supply of these attractive gems in the future.

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