Ethnobiology

Lisa L. Price · Nemer E. Narchi *Editors*

Coastal Heritage and Cultural Resilience

Springer

Ethnobiology

Ethnobiology is the study of the dynamic relationship between plants, animals, people, and the environment. Academic and applied interests include ethnobotany, ethnozoology, linguistics, paleoethnobotany, zooarchaeology, ethnoecology, and many others. The field lies at a dynamic intersection between the social and biological sciences. The major contribution from the biological sciences has come from economic botany, which has a rich historical and scientific tradition. Indeed, the objectives of the colonial enterprise were as much about the quest for "green gold" –herbal medicines, spices, novel cultivars, and others—as it was for precious metals and sources of labor. The view that ethnobiology concerns mostly the discovery of new and useful biota extended into the 20th century. The social sciences have contributed to the field in both descriptive studies but also within quantitative approaches in cognitive anthropology that have led to general principles within ethnobiological classification. Ethnobiological research in recent years has focused increasingly on problem solving and hypothesis testing by means of qualitative and especially quantitative methods. It seeks to understand how culturally relevant biotas are cognitively categorized, ranked, named, and assigned meaning. It investigates the complex strategies employed by traditional societies to manage plant and animal taxa, communities, and landscapes. It explores the degree to which local ecological knowledge promotes or undermines resource conservation, and contributes to the solution of global challenges, such as community health, nutrition, and cultural heritage. It investigates the economic value and environmental sustainability to local communities of non-timber forest products, as well as the strategies through which individual ecological knowledge and practices encourage resilience to change—modernization, climate change, and many others. Most importantly, contemporary ethnobiological research is grounded in respect for all cultures, embracing the principles of prior informed consent, benefit sharing, and general mindfulness.

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Chapter 5
A History of Nacre and Pearls in the Gulf of California

Mario Monteforte and Micheline Cariño-Olvera

Introduction

This chapter examines pearling in the Gulf of California, whose role in the world history of fishing, trading, and cultivation of nacre and pearl began 482 years ago. The narrative of this chapter touches on two key species: the mother-of-pearl, *Pinctada mazatlanica* (Hanley 1856) or *madreperla*, and the winged pearl oyster, *Pteria sterna* (Gould 1851) or *concha nácar*. Both are bivalve mollusks of the family Pteriidae, which comprises about 300 species, subspecies, and varieties assigned to 8 genera, *Pteria* and *Pinctada* included. There are 28–33 species and sub-levels known for *Pteria* and 21–23 correspondingly for *Pinctada* (World Register of Marine Species). Within these two genera are included what may be called "true pearl oysters", but only 10 in total of them have had measurable influence on the environmental history of coastal areas and islands across the wide tropical-temperate marine belt where these species are distributed In the case at hand, we have derived our data from a number of articles on the subject, most of them from our authorship.

This line of research has been part of our academic interests for the past 30 years. Thus, the purpose of offering a new look at this subject is to strengthen the argument that pearling heritage has played a role in the development of mariculture farms and the conversion-diversification of fisherfolk communities in the region.

Throughout this chapter, we present an analysis of the historical profile of the Gulf of California and argue that the area was formed through a dynamic relationship linking societies and pearl oysters over time. We have arranged our argument in

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a chronological way, emphasizing actors and key events and focusing on the series of coincidences that led from one episode to another, from the arrival of Hernán Cortés to La Paz Bay until the application of mariculture technologies and their integration into modern coastal development schemes. In this analysis, we carry out a critical review of the processes that have had far-reaching effects on the configuration of societies in the Gulf of California. These processes, rooted, for the most part in pearling, have social and environmental implications, both regionally and globally. For example, they still exert significant effects on regional politics, as well as on the global advancement of science and technology. These processes are also tied in complex ways to market and climatic uncertainties of a global nature. In sum, our conclusion is that mariculture in the form of social microenterprise is revealed as the best alternative to achieve a sustainable state and could create a significant *longue durée* impact if adequate strategies for integrated coastal management are applied.

This chapter is built principally upon the bibliographical background of a number of previous publications of our authorship exploring two professional avenues—oceanology and history—and a shared dream. The reader will find here abundant citations to works that provide more detailed information. The rationale for adding one more version to this body of work is to ratify a perspective on the use of natural marine resources to which we have dedicated our lives in the Gulf of California. In September 1985, when we decided to plant roots in this region, its history showed us that nacre and pearls had deeply influenced the profile of nature and societies in every period from Paleo-Indian occupation up to the present. Lessons learned from reconstructing a world history of nacre and pearl industries led us to understand the wide potential that this region had for the wellbeing of coastal communities. However, it was also evident that we would have to deal with a vulnerable and overexploited resource. Thus, our research portrays the environmental history of pearling in Baja California Sur under a broad and diverse scope of events (i.e. systematic construction of key episodes over time), focusing on multifactorial issues related to target species (socioeconomic, cultural, political, psychological, and group dynamics; scientific and technological state of the art; and more). Our objective is to offer a small-scale mariculture-based conversion/diversification model paralleling successful cases occurring in coasts and islands of the Indo-Pacific roughly at the same time, not only with pearl oysters but also with edible species. We show that in order for pearling to promote prosperity through cultivation and replenishment of pearl oysters and cultured pearl production, sectoral planning must take into account specific social groups (e.g., fisherfolk and local entrepreneurs), while also being sensible and overtly critical toward the particular trend of coastal development and environmental issues prevailing in the Gulf of California.

In the next sections, we construct a succinct analysis that endorses such an approach under the lens of environmental history. To do so, we first contextualize pearling and nacre industries in a global context, offering a general review of the bioecological data on farmed and cultured pearls. Second, we offer a historical reconstruction of the human use of pearls in Baja California Sur, from Paleo-Indian times until the exhaustion of wilds stocks (circa 1940). Finally, we make use of archival research (Bruner 1991; Polletta et al. 2011) to describe the many maricul-

tural attempts to recover the productivity of pearling assets, emphasizing the need to apply a coherent farming-based activity to an integrative scenario of sustainable use, with La Paz as a pilot application.

Pearl Oysters, Nacre, and Pearls: Thematic Framework

Historical Background

As said before, about ten species of true pearl oysters are considered as milestones in spatial and temporal episodes of the world history of fisheries, commerce, and cultivation of nacre and pearls. Based on several indicators (e.g., distribution, abundance, size, nacre quality, incidence of natural pearls, and quality), we have identified 11 pearling regions with historical significance (Cariño and Monteforte 2005). We have also registered and classified the fishery periods and regions based on their date of first operation, resource lifespan, and onset of pearl oyster farms and cultured pearls development . By a spatiotemporal approach, the ethnobiological role of nacre and pearls was analyzed in each region, taking into account the environmental, economic, cultural, social, political, and managerial aspects of pearling. We discovered that the exploitation of nacre and pearls over the vast Indo-Pacific seascape (broadly from eastern Africa, the south Arabian and Red seas, to Tuamotu, Kiribati, Micronesia, and Japan) ended by the early 1930s. The considerable size of the aforementioned pearling metaregion can be explained only through the lens of colonial capitalism. The material and subjective value of nacre and pearls has always been significant, regardless of species size. In strengthening the processes of accumulation, capitalism expanded at the expense of sumptuary commodities and became a remarkably strong force that enabled the opening of an incipient pearl fishery. Larger shells and pearls obviously have been preferred at all times, yet for hundreds of years every shell was useful for the enormous button manufacturing and nacre inlay industries. This changed when plastic imitations displaced natural nacre and pearls within the global market (circa 1948–1950).[1] In order to envision the intensity of extraction of pearling goods (and gold, silver, luxury wood, precious minerals, etc.), consider the adornments in many Roman Catholic temples (in Latin America, Spain, Portugal, Italy), in palatial collections (e.g., Topkapi, Tower of London) and other monarchical treasures, and in personal collections of magnates and countless women, “even Mrs. Smith next door” (George 2008).

[1] English chemist, Cameron Douglas-Castle registered a patent in the United Statesin 1906 (US809909) claiming the manufacture of “artificial mother-of-pearl” out of shell and mica powder. The know-how took several years (and enhancements) to reach commercial level while the declination of natural stocks was unstoppable. By browsing the internet databases (e.g., journals, magazines, open-access libraries, and special-interest channels such as the Gemological Institute of America and Pearl Guide), it seems that artificial marine nacre acquired presence in the market since the early 1950. Nevertheless, it is difficult to set a precise date because the industry also exploited some large naiads inhabiting continental rivers and lakes, mainly the Mississippi region (U.S.).

The transition from pearl oyster fisheries to farms and cultured pearls has followed different paths in different regions over time. However, the gradual drainage of natural stocks by intensive fisheries remains a common feature in all cases (Cariño and Monteforte 2005). By the mid-nineteenth century, businessmen had been eagerly urging scientists to find a way to cultivate oysters. So did pioneers such as William Saville-Kent, Gastón Vives, and Cyril Crossland, respectively, in the Thursday/Albany Islands, Australia; La Paz Bay, Mexico; and Dongonab Bay, Sudan.

Among these researchers, only Vives (with *Pinctada mazatlanica*) and Crossland (with *P. erythreaensis*) practiced extensive culture,[2] making nacre shells their most important product. Nonetheless, the added value of natural pearls was always appreciated. Vives managed a large operation at La Paz Bay from 1902 to 1914, the Compañía Criadora de Concha y Perla de Baja California (Conch and Pearl Nursery Company of Baja California, CCCP), whose annual harvests were around ten million cultured adults of *P. mazatlanica* (Cariño and Monteforte 1999). Vives himself commercialized in Europe the beautiful natural pearls that appeared in amazing numbers, thanks to the high density of oysters on his farm.

Crossland's farm at Dongonab Bay remained in operation for l8 years (1905–1923), after which the Sudanese government seized the facilities and its oysters (Crossland 1931). It was smaller than Vives's (about four million *P. erythreaensis* a year) and also focused on nacre shells and the eventual bonus of natural pearls. However, Crossland also produced Mabé (half-dome, or blister, pearls) in profitable amounts and quite likely assayed surgery for round pearls as well.

William Saville-Kent is considered the original inventor of the so-called Mise-Nishikawa surgical procedure to inoculate oysters with round pearls. He did so on the giant mother-of-pearl, *P. maxima*, by 1892–1893 on his farm at Thursday/Albany Islands, as validated by Denis George's posthumous paper (George 2008). However, some do not question the Japanese origin and even relate their own versions of the story (e.g., Taylor and Strack 2008; Nagai 2013). In any case, Saville-Kent was not collecting spat; instead, wild adults were extracted, placed into cages or baskets suspended in off-shore systems,[3] and then utilized to produce Mabé and free nucleated pearls. It was a small operation that lasted from 1890 to 1891 until his death in 1909 (George 1968). As a scientist, he was eager to share his expertise with anyone who asked (George 1968, 2008), including Tokichi Nishikawa and Tatsuhei

[2] The Internet provides plenty of information and details about methods and techniques to cultivate shell-bearing mollusks and induce production of every kind on them, particularly pearl oysters, naiads, queen conch and abalone. Sources include manuals, pictures, slides, videos, formal publications, documents from the United Nations Food and Agriculture Organization, vendors of surgery instruments and anesthetic compounds, specialist and not-so-specialist web pages and interest groups, and so on.

[3] This modality is called "capture-based extensive culture" or "enclosure modality." It is still used by many modern commercial farms of *P. maxima* in southeast Asia and northwestern Australia (the Broome-Exmouth area), usually under draconian rules (e.g., expensive fines for violating restrictions on minimum and maximum size, sites, quota, seasons, management, equipment, and so on), especially in Australia. The modality also applies to carnivorous fish ranching (tuna, skipjack), shrimp husbandry in ponds, naiad farming, and other examples. To a certain extent, the traditional management of ornamental marine species may be assigned to this modality.

Mise (Taylor and Strack 2008; Nagai 2013). The former was a young biologist recently arrived in Australia to work on Japanese fishery licenses for *P. maxima*. The latter was a stepson of a midlevel Japanese fishery official who undoubtedly knew about Saville-Kent working locally with the target species.

Those pioneer experiences established the core of scientific and technological research in pearl culture and thus became the cornerstone of commercial pearl farms. Pioneers such as Denis George in Australia and later in Mexico[4]; Kasim Alagarswami and team (A. Chellam, S. Dharmaraj, A.C. Victor, and others) in India; and William Reed, André Intes, Martin Coeroli, and Philippe Cabral in French Polynesia pursued the endeavor and played major roles in the initial stages of what would ultimately develop into a multimillion dollar industry.

At this point, Kokichi Mikimoto's merit would be his entrepreneurial approach to (indirect) teachings by Saville-Kent, which contends with different interpretations (Nagai 2013). Nevertheless, the milestone post-World War II report by A.R. Cahn, a U.S./Allies commissioner in Tokyo (Cahn 1949),[5] may introduce further support for D. George's statements:

- Mikimoto commenced his farming operation on *P. martensi* circa 1890, very likely with the enclosure modality used by Saville-Kent in Australia (Nagai 2013). He produced Mabé pearls with an adaptation of the millenary Buda pearl method learned in China. Could it be that he heard about Saville-Kent and sent Nishikawa to inquire what was happening in Australia? It does not sound illogical since the young biologist was Mikimoto's son-in-law.
- Based on Cahn (1949) (e.g., historical arguments, dates and contents of patents, drawings, and descriptions of methods and techniques), Mikimoto seemingly started to employ extensive culture circa 1920. This assumption concurs with Nagai (2013), although the paper provides scarce details about culture modalities. Therefore, we believe Mikimoto could have had a key opportunity to listen/see the pictures of Leon Diguet's publications about Gastón Vives and the CCCP (Diguet 1899, 1911, 1919) between 1920 and 1925, when he began promoting his cultured pearls in Paris, the world center of the natural pearl business at that moment (Cariño 1996a, 1998; Cariño and Monteforte 2005). How did he learn about Diguet or the CCCP? Perhaps the French greeted him with a tour of the Muséum National d'Histoire Naturelle, and someone tried to impress the visitor or a superior. It is conceivable that some of the French professors would have preferred not to divulge any information since they were aware of Mikimoto's role and what he needed.

[4] Professor Denis George (+ 2007) assisted in the development of a pearl farm (*P. mazatlanica)* at La Paz Bay from 1970 to 1972. It was the first successful project since the CCCP, but personal rivalries with government actors resulted in decommission and closure just a few days before the farmers had planned to harvest the first generation. The farm had more than 10,000 animals, each with at least a Mabé pearl. Professor George himself told us the pearls were beautiful (personal communication, May 1994). The fate of this material is unknown.

[5] Cahn (1949) is a meticulous disclosure of the long-secret Japanese "pearl files" on *P. martensi* and the naiad *Hyriposis schlegeli* (endemic to Lake Biwa, Japan, and almost extinct today). This report is regarded as one of the most influential factors in the subsequent spread of pearl oyster farms based on larger species.

- Vives published technical details of the CCCP until 1918, when he was engaged in (unsuccessful) negotiations with the postrevolutionary Mexican government to reinstall his work, which had been destroyed in 1914 (Cariño 1998). In 1908 a group of Japanese (sent by Mikimoto?) once wanted to visit the farm already renowned by then, but Vives did not allow them (see interviews with Vives's relatives in Cariño 1991). Several years later, Mikimoto traveled to Paris. Since the Muséum library was already famous by then, he may have asked to include it in the tour.
- In the faraway Red Sea, Cyril Crossland was doing extensive culture with *P. erythreaensis* (1905–1923), probably independently or based on Diguet's papers. He published his work until 1931 (Crossland 1931), and there is no mention of Japanese visitors or communications with them. It is plausible that Crossland learned his implanting techniques (Mabé) from the work of naturalists such as Carl Linnaeus (in *Margaritifera margaritifera*, a large European naiad) and Louis Boutan (in Polynesian pearl oyster, *P. margaritifera* and European abalone, *Haliotis tuberculata*), both of which may have been inspired by the sight of Chinese Buda pearls brought by Marco Polo.

Cahn's report became a seminal reference for researchers and entrepreneurs. Hence, the possibilities of harvesting large species broadened the scientific and technological perspectives on pearl culture while impacting the pearl market preferences of the day. From the late 1950s to the early 1990s, the number of non-*P. martensi* farms (and specialized technicians) rapidly grew until thousands were located throughout Indo-Pacific coasts (Southgate et al. 2008; Tisdell and Poirine 2008; Monteforte and Cariño 2013). In 1986, the vogue reached Latin America, with La Paz Bay as its first stop. We will explain later why this date is considered important not only in chronological terms. After 30 years of experimenting and hence accumulating a robust body of knowledge and expertise, seven non-American pearl oysters (six species of *Pinctada* and one of *Pteria*, *Pt. penguin*, the latter still at an experimental scale) were the key species of a multimillion dollar market relying exclusively on extensive culture and cultured pearls. This market flourished from the late 1950s on and generated a large body of knowledge and practical expertise (Gervis 1991; Gervis and Sims 1992; Tisdell and Poirine 2008). For example, post-World War II Japanese scientists had founded the National Pearl Research Laboratory, and in its Bulletin (22 volumes, 1956–1978) a large number and wide variety of studies about *P. martensi* were published, including those related to biotechnology, genetics, quality improvements to nacre and pearls, and other innovations.[6] The existence of these previous lessons represented an advantage for the initiation of studies on Latin American species.

[6] M.H. Gervis compiled a bibliographic list containing 1227 references to a large variety of studies on pearls oysters done to that date (Gervis 1991). Except for a few cases, it does not break down the list of publications in the 22 volumes of the Bulletin. It should be noted that before 1990 the complete collection was available for consult only in situ and only in a very small number of non-Japanese institutional libraries: University of California San Diego, Library of Congress, Washington, DC (incomplete), and Muséum National d'Histoire Naturelle, Paris.

Aims and Scope

The Gulf of California supplied a large share of the world nacre/pearl fishery during the 400 years that followed Hernán Cortés'[7] arrival to La Paz Bay (May 3, 1535). From 1937 to 1939, the effects of overexploitation rendered the pearling industry unprofitable. The Gulf of California was one of the world's last discovered pearling regions and the last to reach overexploitation (Cariño and Monteforte 2005, 2009). Although pearling grounds at the Gulf of Panama were discovered virtually at the same time (see Spalding and Mellado, this volume), pearling there ended earlier, circa 1920 (Cipriani et al. 2008). A key factor differentiating the lifespan of pearling in Baja California Sur and Panama was CCCP's massive contribution to stock replenishment.

We are now able to sketch a standard pattern of development and evolution of the pearling industry throughout the world. Pearling begins as an aboriginal low-scale, low-technology activity, then is massively exploited by sumptuary capitalism and transformed from a rustic to a highly mechanized fishery so efficient as to overstress natural stocks to the brink of extinction. Finally, the introduction of mariculture and pearl technologies leads to conservation/management policies. Such a pattern, combined with the sociocultural and environmental histories of the Gulf of California, allows us to explain how a natural resource was transformed from food and simple ornament, initially harvested in the wild by native people, into a global commodity farmed at commercial scales.

Nacre and Pearls Through Time in the Gulf of California

Nutrition and Ornaments for Indigenous Societies

The Baja California Peninsula extends more than 1200 km, from about 23°N to 32°N, with an average width of 140 km. It is bordered by the Gulf of California on the east and the Pacific Ocean on the west. In addition to aridity, rugged terrain, and wide climatic and oceanographic variations, the peninsula has historically been disconnected (in a broad sense) from the continent. Under these conditions, its quasi-insularity has had a great impact on the evolution of diverse regional societies, particularly the development and evolution of Baja California Sur's native societies: the Guaycuras, Pericúes, and Cochimíes (del Barco 1973). In their arduous process of adaptation, these groups developed multiple strategies to exploit scarce natural resources distributed throughout their territory. The regional population before the Spaniards' arrival varied from 40,000 to 50,000 (Aschmann 1959; Bendimez 1987). These groups were nomadic hunter-gatherers limited to a harsh livelihood due to the

[7] The "Mar de Cortés" (also Cortes, Cortéz, Cortez), also known as the Sea of Cortez, should not exist. It is a looting schema and geographically incorrect; also, each user writes it differently whether in English, Spanish, or French (see Monteforte 2008; Monteforte and Cariño 2009).

inherent constraints of their territories. Subsistence and social reproduction was possible because they had achieved deep knowledge of the environment. They practiced sustainable ways of living, e.g., obtaining different food in different seasons and areas at coastal zones and inland and never threatening the balance of ecosystems (Cariño 1996b). Seaweed and marine fauna (sea cucumbers, mollusks, crustaceans, fish, turtles, mammals, and other edibles) constituted a more nutritious contribution than foodstuffs of terrestrial origin because these species thrived in the bays and coastal lagoons of the Pacific and the Gulf and were easy for primitive, yet skilled, free divers to catch. Freshly captured mollusks were heated over embers to open the shells. Shellfish were eaten fresh or salt/sun dried to preserve for later consumption. These peoples used the shell of pearl oysters as tools and ornaments and were familiar with natural pearls. Malacological analyses of *concheros* (ancient shell deposits coinciding with human settlements in Baja California) have shown that size-driven selection of shells was a general norm regardless of species. People limited collection to mature adults, thus assuring that the resource would be renewed (Castellanos and Cruz 1995). It is common to find that these shell mounds contain a lesser amount of pearl oyster shells (generally medium-sized), and most of these broken. This observation suggests that these peoples used the larger and better preserved shells for ornamental and/or religious purposes. In addition, nacre and/or pearls also seem to be part of the offerings on the few burial sites found so far. Evidence has been placed under custody of the National Museum of Anthropology.

The Colonization Period (Sixteenth and Seventeenth Centuries)

When Christopher Columbus inadvertently discovered "Las Indias" in 1492, he found groups of Caribbean-Antilles natives whose clothing was adorned with nacre and pearls of *P. imbricata* and *Pt. colymbus*. Bartolomew Columbus, his brother, exploited the natives' diving skills to become the first pearl entrepreneur of the New World. In contrast, pearl exploitation in the Gulf of California had to wait for a series of coincidences (Monteforte and Cariño 2012). In 1534, an individual named Fortún Ximénez, pilot of *La Concepción*, conducted a mutiny against his captain and ran the ship aground somewhere along the southern coast of the Baja California Peninsula. Some mutineers survived and reported back to Hernán Cortés about "indianos" (Pericúes) wearing long hair braided with "beautiful pearls and large startlingly bright nacre shells adorning their bodies" (size selection of shells, that is). No doubt they also commented on how unfriendly the encounter had been because the natives had rebelled and killed some of the mutineer crew when they tried to force them to dive for pearl oysters or seize their adornments. Cortés immediately assembled an expedition, arriving in La Paz Bay on May 3, 1535. (He named it Santa Cruz Bay; Sebastián Vizcaíno renamed it in 1596.) The newly founded colony lasted only a few months. Cortés confirmed the wealth of pearl oyster beds but also reported that the land was dry and difficult to live in; it offered poor food and no other supplementary goods worthy of consideration. He finally realized that pearl oysters fishery was extremely difficult because it relied on aboriginal people, who were skilled but unmanageable.

For the next 170 years, there were several unsuccessful Spanish attempts to settle a colony and exploit the *placeres perleros*[8] of the Gulf of California—an effort to develop self-sustaining explorations and map the Baja California Peninsula coast without burdening the royal treasury. The viceroyalty granted licenses for exploiting pearl oyster fisheries. In order to receive such a license, grantees had to supply navigation charts and knowledge and find a proper port-refuge for the Nao of Manila.[9] These settlers would pay a *quinto de perlas*, a 20% tax on the value of pearls found. It is very likely that grantees intentionally undercounted their pearl production in order to evade taxation. Among well-known licensee fleets, some that stand out are Sebastián Vizcaíno's (licensed in 1596 and 1602), Tomás de Cardona's (1611), and Pedro Porter y Casanate's (1640) (del Río 1985).

These successive exploration and colonization efforts, along with those dedicated to the pearl oyster fishery, did not help much in broadening information about the Peninsula and its surroundings—nor the rest of the continental coast—but definitively consolidated the Gulf of California as one of the most important pearling regions in the world. By 1685, King Carlos II ordered Admiral Isidoro Atondo y Antillón to launch another expedition. In his final report, Atondo y Antillón stressed the critical impoverishment of *placeres perleros* as a result of intensive fishery over the past decades. In parallel, this expedition awakened the interest of the Jesuit missionary Francisco Kino, for the aridity of the land and the "pure state" of the indigenous people matched the Jesuit image of a natural paradise (Bayle 1933).

Secular Establishment (Eighteenth Century)

During the missionary era (1697–1740), Jesuit friars settled missions close to the principal pearl oyster grounds and, to the great dissatisfaction of soldiers, enforced fishing prohibitions (del Río 1984). While the Jesuits' goal was to prevent sinful (lustful) behavior and the abuse and corruption of the natives, the prohibitions indirectly increased the resilience of shell beds, giving them a respite after more than 160 years of constant extraction. Then, in 1740, Manuel de Ocio, a soldier serving at the San Ignacio Mission, challenged the priests' authority when he received news that thousands hundreds of oysters had been cast ashore by the tide. After collecting those on the beach, he abandoned his service to the Jesuits and set out to exploit the Gulf of California central coasts so intensively that in an 8-year span the beds faced complete depletion, so de Ocio changed his interests and moved inland toward the gold and silver mines in Sierra de San Antonio (about 100 km south of La Paz),

[8] The term *placer* relates to mining sites, i.e., profitable deposits of gold, silver, precious stones, or other valuable minerals. A *placer perlero* (pearly pleasure) is a site with an abundance of large, healthy pearl oysters and good incidence of natural pearls.

[9] The "Galeón de Manila" or "Nao de China" or "Nao de Manila" was the generic name for big commercial sail-ships that travelled the transpacific route back and forth twice a year … between the Philippines and the major Mexican ports over the Pacific coast (Cabo San Lucas, South Baja California, Banderas and San Blas bays in Nayarit, and Acapulco, Guerrero). The Naos had different names (Santísima Trinidad, Nuestra Señora de Covadonga, etc.)

where he invested his pearling-derived earnings. Then he founded (1748) the first colonial establishment of the Californias, the Real de Santa Ana, leading to the establishment of the first regional economic structure. In the winter, de Ocio focused on terrestrial mining, and in the summer he turned his attention to the sea. He practiced cattle raising and commerce year-round. Since aboriginal people had been decimated by that time, de Ocio imported cheap labor from elsewhere (Yaqui Indians from Sonora; Indians and slaves from Costa Grande, Acapulco, and inland zones of what now is the state of Guerrero; and European immigrants), finally achieving the goal of colonization (del Río 1984).

The Bourbon Dynasty and First Management Policies (1770–1830)

As a consequence of political struggles involving the Jesuits, King Carlos III endorsed Marquis José de Gálvez as Visitador Real (royal supervisor) to the north of New Spain. The new Visitador was commissioned to apply Bourbonic reforms, and evicting the Jesuits from the Peninsula was among his instructions. Gálvez promptly perceived nacre and pearls as highly valuable resources and promoted their commercial exploitation. He designed an Asian-Mexican company that would export nacre and pearls to Asia; unfortunately, the natural stock had already been depleted by the previous actions of de Ocio and other entrepreneurs (Cariño 1998).

A few months after the beginning the independence movement, the Courts of Cádiz published an ordinance (April 1811) to promote the development of the Californias on the basis of prosperity from fisheries and other marine resources. The document declared pearling to be a free activity, accessible to all of His Majesty's subjects throughout the Indies. The document also released the contracts made between *armadores* (owners of fishing fleets) and divers (AHPLM 1811). These decrees became legitimate when Emperor Iturbide eliminated the *quinto real* tax. Alas for the young independent Mexican government, the peninsular region became a burden, as it was always necessary to send support to cope with its chronic economic penury and to ensure mechanisms that could guarantee a growing population and infrastructure development. In search of solutions, the central government created the Junta de Fomento de Las Californias (Las Californias Development Commission), a special bureau to plan for rebuilding the economy and governance of these provinces. The result was a package of seven documents. The sixth document was a proposal seeking to secure trade agreements with Asia to exchange pearls, fine fish, and leather handcrafts (BNM 1828). Although the Junta de Fomento took a different approach than Marquis de Gálvez, it also placed the pearl/oyster industry at a central role as a source of regional wealth and, thus, one of the region's most valuable assets.

Since the sixteenth century, *placeres perleros* displayed constant cycles of abundance and exhaustion that resulted in extensive periods of rest and recovery (approximately 50 years). The former can be seen in the historical literature from the colonial era and until the mid-twentieth century—when pearl oyster fisheries had completely

ceased in the Gulf of California; the holistic role of nacre and pearls is constantly, but intermittently, present in the history of this region (Monteforte and Cariño 2012). In the early days of the twentieth century, pearl oysters saw a new phase of abundance so that the mirage of pearling utopia became reality when nacre shells became the principal target of fisheries in 1830. Joint incomes from *armadas perleras,*[10] mining at Sierra de San Antonio, and commerce derived from both helped to build the first regional Marine Customs office in the region of La Paz (Southworth 1989). The city and port of La Paz became the most important pearling business center in Mexico and a world supplier of high-quality nacre and natural pearls.

Nacre Shells, the Hub of La Paz Socioeconomic Development (1830–1879)

The first decades of the nineteenth century saw new commercial channels when Gulf of California nacre became appreciated and demanded in the world market. Previously, natural pearls were considered the only valued good in the pearl industry, and shells were treated as refuse to be discarded at the beach. In 1830, Cyprian Combier, a French marine merchant, used discarded piles of shells to ballast his ship and sold them in Europe (Diguet 1899). From then until 1938, shells constituted the main focus of fisheries and the main export. The new commodity revitalized the regional economy, reconfigured the socioeconomic structure, and promoted the establishment of new human settlements, mainly around La Paz. Between 1838 and 1868, about a hundred *armadas perleras* requested new pearling licenses (Cariño 1998; Valadéz 1963). The fleets traveled along the southwestern Gulf of California from Cabo Pulmo to Mulegé Bay, including the Gulf's islands up to the Tiburón Basin. Native divers were able to free-dive as deep as 5–6 fathoms and remain on the bottom for up to 2 min collecting pearl oysters, repeating such immersions for a daily average of 40 times. Divers and their families were fed by their employers. These meals were considered an advance payment to their salaries. The diet was basically corn and dry meat, equivalent to one *real* per person per day (estimate US$0.0017). Pearling divers were supposed to pay back their food debt to the *armador* once the pearling season was over. They were allowed to freely sell pearls, but the *armador* had the first option to buy them, usually at a low price so that divers barely paid their debts (if at all) and owners kept the entire product. Eventually the pearls were sold at a high profit (Esteva 1977).

[10] An *armada* was a fleet formed by a steam vessel—a brig, frigate, or sloop—and a number of small canoes. Some *armadores* even had pilot boats to move bulky air-compressor machines and diving gear such as scaphander helmets, canvas suits, lead plummets, long rubber hoses, and cables, plus the *cabo de vida* (pump-man) and crew. Generally, the *armador* was not proprietary of the fleet but an employee of richer businessmen. Problems among *armadores* and divers were frequent because the latter lived eternally in debt. In addition, paying the divers in advance for a diving season was customary, but often a number of them furtively escaped with the money and did no work. This was a pursued crime, along with the concealment of harvested pearls; this robbery was the logical consequence of low salaries and hard working conditions.

Pearling activities boosted the regional economy and fostered its development throughout the nineteenth century. In the meantime, pearling became a detrimental activity for the region, as it depended on highly vulnerable and already overexploited mollusk stocks, causing a marked decline of natural beds. Aware of this decline and its impact, José María Esteva, a government delegate, applied and enforced regulations to manage pearl oyster fisheries in the Gulf of California in 1857. Although the regulations were limited to a reduction in the fishery quota (basically, the number of oysters collected), it was one of the first preservation decrees issued in modern history (Cariño and Monteforte 2005). Several laws followed Esteva's decree in other pearling regions of the world, such as the Gulf of Mannar, India, the northern banks of Australia, and the Tuamotu atolls. A later decree (1874) divided the Gulf of California into four coastal sections and established rest periods for pearl fisheries of every 2 years. An 1878 reform increased the rest period to 4 years. *Armadores* rarely obeyed those restrictions and continued exploiting the pearl banks relentlessly, taking advantage of difficulties in applying the law because it depended on surveying the ever-expanding and unpopulated marine and coastal area. Surprisingly, pearling remained a profitable enterprise for a number of decades. *Placeres* began to show signs of exhaustion; thus the *armadas* became less profitable. Against this backdrop, the introduction of compressed-air diving gear was fundamental in reviving pearl companies in the Gulf of California.

Industrial Fishery Under the Porfirio Díaz Government (1875–1912)

The arrival of mechanized diving in the Gulf of California (in 1874) reconfigured pearling fisheries by implementing concessionary policies over vast marine areas until 1912 (Cariño and Monteforte 1999). Porfirio Díaz's presidential administration fostered economic growth by attracting foreign capital. To do so, the administration implemented new legislation that favored foreign investment and colonization. Within this new framework, natural resource exploitation concessions in Baja California were granted to foreigners and Mexicans alike. Partnerships between Mexican nationals and foreign investors were common. The whole Peninsula was fragmented into mining and pearling concessions. The granting of marine areas and their pearl grounds was a flagrant violation of the 1874 regulation that had declared these to be common access resources. Government offices received constant complaints from *armadores* who refused to cede fishing rights in areas where large pearling companies had obtained exclusivity.

That same year, the pearling industry changed dramatically with the introduction of mechanized diving gear. Productive advances from the new technique attracted large managers and raised a new working organization in the *armadas perleras*. Scaphander divers could reach natural beds in deep bottoms, while *chapuz* (traditional free-dive) divers, soon to be displaced by the former, did so in shallow coastal areas. The licenses followed similar guidelines to those previously issued. These

new licenses were valid for a starting period of 16 years, later to be shortened to 10 years. The tax paid to Marine Customs was MEX$8 per ton of oysters during the first 2 years of a contract, increasing to MEX$10 afterward. The fourth clause of the contract stated rights and obligations for concessionaires to cultivate pearl oysters. However, not a single contract was canceled for breaking the law. All licenses issued to foreign concessionaires had equal considerations to those issued to Mexicans. A particular point is that the granting of a license obliged grantees to give employment and training preference to Mexican workers. The fifth clause exempted *armadas* from paying import taxes on some articles and goods needed in their operations. In exchange, *armadas* were to aid the government in dealing with smugglers. Pearling companies were forbidden to sell, give, or mortgage their license without federal authorization; these actions would render the license null. Extracting juvenile oysters and damaging marine grounds were other causes of license forfeiture.

The federal government had two main goals for this strategy: conserving resources and earning money through taxes. It also counted on positive effects for the regional economy and social wellbeing. Pearling companies were supposed to give to the Secretaría de Fomento three silver pesos per ton of fished oysters to continue fostering regional infrastructure development. Yet, from a total of 26 contracts signed over 22 years, only 10 were put in operation, and only half of the operating companies, aside from the CCCP, had significant earnings. These companies were González & Ruffo Asociados (GRA), Compañía Perlífera del Golfo de California (CPGC), Compañía Perlífera de San José (CPSJ), and Compañía Perlífera de Baja California (CPBC) (Cariño 1998).

CPGC, owned by Adolfo Schirabe and Edmundo Vives, Gastón Vives's brother, worked for 10 years. Their concession comprised a portion of the eastern peninsular coast between 24°N and 29°N. CPBC was established in 1885 in San Francisco, California, with a capital investment of US$100,000 as a co-venture of a U.S. citizen, Herman Levison (55%), and Mexicans Juan Hidalgo (30%) and Maximiliano Valdovinos (15%). The concession for this company covered the entire west coast of the Gulf of California—from Cabo San Lucas to the outlet of the Colorado River, and from Acapulco, Guerrero, all the way to the Guatemalan border. The Cerralvo, Espíritu Santo, and San José Island complexes were not part of the lease because they had been granted a year earlier to GRA. CPBC had great regional importance due to its working capital and number of employees (400–500). It owned five steam vessels and numerous ships and canoes that served as much for fishing as for building a regional communication network.

Under Porfirio Díaz's regime and his policy of exclusive territorial concessions, the federal government favored the participation of rich entrepreneurs who imposed their conditions on smaller *armadas*. Their aim was to eliminate the access of *armadores* and local divers to marine resources. As a consequence, in 1893 several companies joined together to create the Compañía Perlífera de Baja California Sucesores. This new company was short lived because that same year it sold its rights to the British company Mangara Exploration Limited Co., better known as La Mangara (AGN 1899), thus giving this company almost absolute control of the Mexican pearl resources and fisheries in general.

La Mangara never reached its goals of establishing sites to develop pearl oyster farms and cultivating at least 10,000 specimens a year, as indicated in the contract. On the contrary, the company used devastating fishery methods such as dynamite, dredges, and trawlers, along with a quadrille of mechanized divers. Nonetheless, the government, instead of revoking La Mangara's concession, extended it for 16 more years starting from 1916 (AGN 1905). Besides the burden of dreadful working conditions, La Mangara was accused of many irregularities, while British owners complained that Marine Customs employees failed to investigate "crimes" that harmed their interests. Despite the lack of social justice and unfair agenda of exploitation carried out by La Mangara under Díaz's regime, it is important to underline that the policies of economic development prevailing then gave origin to the only pearling company that engaged in conservation of pearl oysters and positioned Gastón Vives as Mayor of La Paz City.

First World Mariculture Experience by Gastón Vives (1903–1914)

Gastón Vives is the first mariculturist of America and the first scientist in the world to achieve massive quantities of cultivated pearl oyster—*P. mazatlanica* (*madreperla*). In 1903, after several years of research, he founded the Compañía Criadora de Concha y Perla de Baja California, S.A. (CCCP), the first pearl emporium of the world first pearl emporium of the world and largest operation known to present even with modern technologies at hand. It is relevant to highlight the fascinating innovations developed by Vives's farm, although the crucial role of Gastón Vives and the CCCP has been thoroughly described elsewhere (e.g., Cariño 1998; Cariño and Monteforte 1995, 1999, 2009; Monteforte and Cariño 2012). Hence, for the purpose of this chapter we will highlight three main points: (1) CCCP employed 16–18% of the active population of La Paz and created supplementary services; (2) Vives established the traditional three-stage extensive culture of commercial bivalve mollusks (spat collection, nursery culture, and late culture), and (3) the CCCP cultivation system at Isla Espíritu Santo is considered the largest mariculture-based replenishment source ever known.

After 9 years, the CCCP multiplied its capital and became the world's most important exporter of high-quality nacre shell and natural pearls. Unfortunately, it was targeted by looters and rioters in 1914 during the Mexican Revolution. In spite of demonstrating the results of this looting campaign before the judiciary and arguing how much the region would benefit from his company's activities, Vives was not able to reestablish the company. Without the reproductive fitness of millions of farmed *P. mazatlanica*, the renewed intensive fisheries in the Gulf of California exhausted the resource in just two decades. The fate of Mexican pearling wealth had been sealed.

Liberation of the Pearl Oyster Fishery and Exhaustion of the Resource (1912–1939)

Although the destruction of the CCCP was a consequence of the Mexican Revolution, it was not caused by the movement itself but rather by vengeance of a bitter enemy of Vives, who, having received the grade of colonel, saw the perfect opportunity to put an end to Vives and his work once and for all. However, the greatest expression of the revolutionary movement in regards to the Gulf of California was against La Mangara. Since 1910, fishermen and *armadores* of La Paz led an epistolary war and a series of public protests against the company's power and abuses. Some of La Mangara's workers joined in and accused the company of submitting them to near slavery conditions (Cariño 1998). La Mangara retaliated against its workers, escalating the situation until June 1911, when an enormous protest against La Mangara took place. Demonstrators petitioned President Francisco I. Madero to cancel La Mangara's licenses. In response to the popular clamor, President Madero's first signed ordinance (May 28, 1912) was the definitive cancelation of La Mangara and its licenses. Therefore, the conflict was directed against La Mangara and not the CCCP, despite Vives's connection to Porfiro Díaz, because even La Mangara's plaintiffs recognized how much pearl oyster cultivation had benefited, in terms of resilience, the natural pearl beds they sought to exploit. The La Mangara concession was supposed to expire in 1932, and the owners demanded reimbursement of MEX$300,000 (they had invested MEX$150,000 initially). The fishing infrastructure and all equipment were given to the federal government and were auctioned off for a meager MEX$70,000 (AHPLM 1912).

With the liberation of fishing, the people of Baja California Sur hoped for a period of prosperity because every diver and *armador* sought the resources that the British company had previously monopolized. The productivity of the *placeres perleros* survived only 22–23 years, yet this was enough to revitalize the regional economy. Conditions for approval of fishery permits remained relatively the same as those during the Díaz concessionary regime; the only requirement now was to request a legal license from Port authorities and respect regulations. Wages paid to crew members and divers of *armadas* also were the same or even less than those previously paid by the big pearl companies. However, workers were at last able to offer their services to any *armador*. Therefore, working conditions, at least in this regard, were better than before. In addition, beginning in 1913, the benefits generated by exploitation of pearl oysters were invested in the town instead of being repatriated by foreign companies, contributing therefore to increased local wealth and infrastructure. In such a way, the revitalization of pearl oyster fisheries again had an important multiplier effect in the regional economy (AHPLM 1913).

Up to this time, the history of pearl oysters in the Gulf of California had been characterized by phases of collapse and recovery, revealing the underlying mechanism of a resilient cycle that worked as follows: (1) a period of natural overabundance, (2) marked declines in capture volumes, (3) suspension of pearling efforts, and, finally, (4) resurgence of shell beds after a stressor-free period.

Between 1884 and 1914, in spite of increased pearling efforts, the signs of *placeres* exhaustion were delayed. This is attributable to the fact that it was shells—not natural pearls—that were the focus of exploitation. Therefore, the extractive intensity was reduced, allowing *armadas* to capitalize their activity. However, the CCCP and its decisive influence in replenishing *P. mazatlanica* natural stocks along the southwestern coast and islands of the Gulf of California also played a key role in delaying overexploitation. In the late 1920s, after the dismantling of CCCP and the liberation of fisheries, the consequences of overexploitation became obvious. To halt this process and prevent, once again, disastrous economic consequences to the region, Andreu Almazán suggested a 3–4 year ban on pearling (AHSRE 1930). *Armadores* refused, arguing that free fisheries were one of the achievements of the Mexican Revolution. Thus, the victories of *the people* could not be suppressed, leading to increased overexploitation. By 1937–1938, divers could harvest barely 200–300 pearl oysters in a journey. In contrast, 20 years earlier, divers could collect more than 1000 pearl oysters in a single day.

Vives died in 1939. That same year, a strong degradation of the *placeres* did not help pearl oysters overcome mass mortality. Divers discovered numerous dead pearl oysters lying on the bottom of the Gulf of California, their valves opened. Folk stories attributed this phenomenon to Japanese sabotage. Allegedly, Japanese pearl entrepreneurs managed to poison the waters in order to eliminate competition from the Gulf of California. A more plausible explanation for mass mortality could be oceanographic oscillations in salinity, temperature, oxygen, pH, and nutrients. These oscillations, atypical in nature, may have been a consequence of the construction of upriver dams (Hoover in 1936, Imperial and Parker in 1938). These dams on the Colorado River reduced the fresh water and terrigenous material input into the system. Agriculture spills (pesticides, fertilizers), El Niño/La Niña events, red tide, starvation, and/or opportunistic infestations (parasites, fungi, bacteria, etc.) may have contributed to increased oyster mortality. These alterations undoubtedly impacted other species. However, because of their importance to economic prosperity and regional identity, it was the decline of pearl oysters that was most frequently reported. Finally, in 1940, the federal government declared a permanent ban on pearling (DOF 1940; Estrada 1977). The ban was specific to *P. mazatlanica,* although it included *Pt. sterna* to a certain extent.[11] Nevertheless, this measure was ineffective at eliciting recovery. Clandestine and tolerated fisheries did not cease until all actors were faced with the disappearance of nacre and pearl mines. It was necessary to wait out several decades of accumulated and successive failures to demonstrate that the model carried out by Gastón Vives could be emulated only by working as he did—engaging in research on the environment, biology, and ecology of targeted species and integrating technological mastery with perspectives on sustainability and social integration.

[11] The decree of 1940 established mother-of-pearl (*Pinctada mazatlanica*) as a species "in danger of extinction." Its status was changed in 1994 to "under special protection." None of these decrees underlined *Pt. sterna* but its commercial fishery is rather illegal. However, both species are extracted somewhat clandestinely on a small scale for shell artcrafts and immediate consumption in snack stalls, particularly *Pt. sterna*, which is called "callo de árbol." On occasion, they are part of the fisherfolk's lunch during fishing journeys or become souvenirs for irresponsible tourists.

The Winding Pathway to Redeem the Pearling Potential in the Gulf of California

First Scientific and Commercial Attempts (1939–1988)

Between 1939 and 1988, the growing value and success of pearl farms in other regions of the world triggered about 20 known pilot farms around La Paz Bay aimed at reviving pearling. However, the CCCP remained the most feasible model to ensure sustained and sustainable production of pearl oysters. Table 5.1 presents a compilation of these projects. A series of variables was constantly present in pilot farms, which may explain their failure and successive abandonment:

- Lack of knowledge about the bioecology of native species and their physiological response under culture management and pearl induction methods
- Application of inadequate methods and techniques (imported and/or adapted) unsuitable for the native species and local environment
- Lack of attention to development of culture techniques that would foster repopulation (The focus was on producing cultured pearls using wild individuals.)
- Other obstacles: changing national or local government actors and policies, financial shortfalls, logistical complexity, rivalry among actors and groups, etc.

Few of these projects performed assays of extensive culture, and even fewer had positive results. Among the 20 projects, only one assembled hatchery and larval culture tests yielding promising results (Table 5.1). The remaining projects prioritized pearl production using the meager wild population, an unaffordable supply if taking into account the steep learning curve of untrained technicians and impatient entrepreneurs. Japanese experts who handled the species for the first time were involved in two major fiascos that resulted in the extraction and subsequent killing of thousands of oysters at La Paz Bay and its surroundings (Table 5.1). This accumulation of failures provoked immediate rejection of any proposal involving pearl farms as an axis for regional development. On the contrary, the buoyancy of white shrimp and edible oysters took over and, along with the efforts and funding for scientific and technological research, monopolized the investment flow for mariculture development.

We faced a somewhat related experience in 1986 at the Centro de Investigaciones Biológicas de La Paz (CIB) when presenting yet another pearl oyster proposal before the General Director, Dr. Daniel Lluch-Belda. Nearly 2 years of independent experiments on pearl oyster cultivation finally rendered reliable proof of applicability. Professor Lluch, perhaps worn down by our insistence and probably swayed a bit by a handful of juvenile oysters grown on the experimental farm, decided to endorse the project. The first pilot was placed in the sea in April 1988 with a meager MEX$30,000 budget granted by the Mexican National Council of Science and Technology (CONACYT). The Pearl Oysters Research Group (GOP) was formed, and students were incorporated into the team (although none under official hire). Thirteen successfully concluded projects were sponsored over the next 15 years by national and international agencies. CONACYT granted us research funding on two

Table 5.1 Projects related to pearl oyster management (culture or other) and pearl production in the Gulf of California, 1939–2016

Actors	Date, location	Actions	Observations
Y. Matsuii, Mexico-Japan agreement	1939, La Paz Bay and Loreto Bay	Prospecting for natural beds; pearl culture assays on wild individuals	Very scarce natural populations. Large mortality postsurgery. Project abandoned
Secretaría de Pesca (Mexico)	1961–1962, La Paz Bay	Assays of spat collection and extensive culture	Results not satisfactory. Project cancelled after changes in government actors
A. Martínez (CRIP, Secretaría de Pesca, Mexico)	1962, La Paz Bay, Loreto Bay, and nearby islands	Prospecting and transplants	Populations in alarming state of exhaustion. Barely acceptable results on transplanting. Project abandoned
Denis George (Australia), agreement with the Secretaría de Pesca	1969, La Paz Bay	Spat collection and culture (Mabé and round pearls in wild individuals)	Great mortality and rejection postsurgery. Promising results on extensive culture
M. Díaz-Garcés and A. Gallo (Mexico); trained by D. George in 1969	1970–1971, La Paz Bay	Extensive culture and Mabé implants	Good results, but the commercial initiative did not progress because of political rivalries. Project abandoned with a large economic loss
Shoei Shirai and K. Sano (Japan), Agreement with the Secretaría de Pesca (Mexico)	1979, La Paz Bay	Prospecting for natural beds and sites; attempt to install a pearl farm; assays of pearl culture in wild individuals	Deceiving results concerning abundance of pearl oysters. Great mortality and rejection postsurgery. Project abandoned
Delegación de Acuacultura de Baja California Sur (Mexico)	1976–1978, La Paz Bay	Assays of extensive culture	Acceptable results. Project abandoned because of budget shortfall and administrative shifts
Yamamoto and K. Sano (Japan), "confidential" agreement with private group in La Paz	1979–1980, La Paz Bay	Pearl culture in wild individuals	Scandalous failure. Ransack of natural beds. Expensive installations were abandoned and later pillaged
Jaime Singh (CRIP-BCS, Secretaría de Pesca, Mexico)	1981–1982, La Paz Bay	Assays of extensive culture; pearl culture in wild individuals	Good results overall. High mortality postsurgery. No pearls

(continued)

Table 5.1 (continued)

Actors	Date, location	Actions	Observations
Manuel Mazón (CRIP-BCS, Mexico)	1987, laboratory in CRIP, La Paz	Hatchery studies in *P. mazatlanica*	Gonad conditioning and larval growth and survival were acceptable. No fixation. Project abandoned
Fernando Bückle, CICESE, Ensenada (Mexico)	1988, Los Ángeles Bay, northwest Gulf of California	Extensive culture studies on *Pt. sterna*; some assays for round pearl induction	Excellent results in extensive culture only. Project interrupted and abandoned because of budget shortfall, administrative constraints, and vandalism
Grupo Ostras Perleras (GOP/CIBNOR)	1988–2002, La Paz Bay	Research on science and technology applied to extensive culture and pearl production in *P. mazatlanica* and *Pt. sterna*	First harvest of high-quality Mabé pearls in April 1992. Certified technology in 1998
ITESM (Perlas del Mar de Cortéz)	1995–2017, Bacochibampo Bay, Guaymas	Apply standard extensive culture on *Pt. sterna*; employ local manpower and interact with students	Single farm producing round pearls on *Pt. sterna*
Ingeniería y Síntesis (assisted by GOP/CIBNOR)	2002–2004, La Paz Bay	Pilot microentrepreneurship; extensive culture of *P. mazatlanica* and Mabé	Harvest of 1500 high-quality Mabé. The project did not continue because of the entrepreneur's personal reasons
UABCS (Perlas del Cortéz)	2001–2017, La Paz Bay	Extensive culture of *Pt. sterna*	Smaller than the farm at Guaymas. Harvest is only Mabé so far
Fisherfolk cooperatives assisted by M. Monteforte	2009–2015, La Paz Bay	Polyspecific extensive culture; special devices tested	Excellent results. Project abandoned due to issues of group dynamics

occasions after that. Our research findings have been published in scientific and academic media, notably Monteforte[12] (2005, 2013) and are available online.

The research program comprised a series of sequential studies (Table 5.2) on fundamental components of extensive culture and management, with La Paz as a model scenario. Four objectives were pursued: (1) to become familiar with oceanographic parameters and their variations, along with general characteristics of the study area—currents, geomorphology, and geolocation of propitious sites; (2) to characterize spatial, biological, ecological, and bioenergetic profiles of wild popula-

[12] Contains a compilation of the certified package of extensive culture and pearl production of *P. mazatlanica* and *Pt. sterna*.

Table 5.2 Principal study subjects on the extensive culture of pearl oysters performed by the Grupo Ostras Perleras (GOP) in La Paz Bay, 1987–1997

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Resource prospecting	M, C	M, C	M, C	M, C	M, C	M, C	M, C	M, C	M, C		
Oceanography				M, C			M, C				
Evaluation of sites		M	M, C			C		M, C			
Ecology of spat collection			M, C					M, C	M, C		
Chronological distribution			M, C	M, C	M, C	M, C	M, C	M, C			
Vertical distribution			M, C	M, C	M, C	M, C	M, C	M, C			
Tests for substrates			M, C		M, C	M, C		M, C			
Tests for collectors		M	M		M	M		C	C		
Nursery culture											
General assays		M	C	C							
Sites				M	M, C	M, C					
Depth			M	M	M, C				M, C		
Density					M	M	M, C	M, C			
Duration					M	M	C	C			
Artifacts			M, C	M, C	M, C						
Ecology					M, C	M, C	M, C	M, C		M, C	M, C
Late culture											
General assays				M	C						
Sites					M	M, C	M, C				
Depth				M	M	M, C					
Artifacts				M, C	M, C	M, C	M, C				
Ecology						M, C	M, C	M, C	M, C	M, C	M, C

M = *P. mazatlanica*, C = *Pt. sterna*

tions and how individuals would respond to extensive culture management and pearling manipulation, (3) to evaluate a number of strategies to ensure availability of healthy adult pearl oysters and maintain a productive source, e.g., ad hoc location of farms and sites to install repopulation cells; and (4) to promote a network of social microentrepreneurships as an alternative livelihood for vulnerable groups, based on social services, socioeconomic prosperity, and sustainable management.

Toward Modern Science and Technology (Twenty-First Century)

Some colleagues in the pearling guild may consider the Pearls'94 International Congress and Exposition (Honolulu, Hawaii, May 1994) as a milestone in pearl oyster farming and cultured pearls in Latin America. The paramount contribution of this event—besides bringing together renowned scientists, farmers, jewelers, and pearl world VIPs (mostly non-Japanese)—was the exposition area, where huge displays of culture material added further information to 5 days of top-notch conferences and vibrant interactions (Fassler 1994). Monteforte and Cariño presented nine papers on behalf of the GOP. These papers touched on different aspects leading to a successful pearling culture in La Paz Bay from 1988 to 1993. These aspects included clear-cut proficiency as to how native pearl oysters should be managed in extensive culture conditions, as well as preliminary results on cultured Mabé and round pearls. Coincidentally, some Mexicans from the Instituto Tecnológico y Estudios Superiores de Monterrey (ITESM, Guaymas campus) and the Universidad Autónoma de Baja California Sur (UABCS, La Paz) also attended the event and learned a lot. Later, each group installed its own farm, Perlas del Cortez and Perlas del Mar del Cortez, at Guaymas, Sonora, and La Paz, respectively. The former was launched in 1995–1996, while the latter required several attempts before formally starting operations around 2001. Remarkably, both companies display the same orthographic issue (Cortés …es, éz, ez), and their location/name is often mistaken or misinterpreted in real-estate and tourist promotions (Monteforte and Cariño 2009). Both farms work on extensive culture of *Pt. sterna* and produce Mabé jewelry, with the slight difference that the one in Guaymas achieved commercial production of beautiful round pearls by 1999 (Douglas MacLaurin, personal communication), while the other has continued with Mabé production and has diversified its production toward nacre-based cosmetic and dermatological products.

Aside from the GOP and the two Mexican companies mentioned above, a quick review of other commercial and/or scientific initiatives in Latin America following Pearls'94 shows that most were one-time unsystemized projects of short duration. The GOP continued its research program at La Paz Bay, introducing improvements and innovations and producing a substantial number of publications and dissertations. By 1999–2000, nearly 75% of the post-CCCP literature about *P. mazatlanica* and *Pt. sterna* had been published by GOP students and alumni in collaboration with us (Monteforte 2005, 2013). In the meantime, the farm at Guaymas acquired notoriety thanks to strict quality control on oysters (*Pt. sterna*) and pearl production,

as well as effective marketing strategies. The front office of ITESM, a private university, had detected the value of this technology, so it gave the entrepreneurs—and continues to do so—full support. In fact, the ventures at La Paz received similar attention from their sponsor institution, the UABCS and its campus facilities at Port Pichilingue, but the level of production, marketing strategies, and image design have not been as successful as those of their private counterpart.

GOP received attention from private national and foreign investors, who, for the most part, preferred enclosures as a pearl-producing modality. These proposals were rejected by the researchers in charge. In addition, CIB's administrative system was not equipped to deal with the few investors, let alone the foreign ones, that were interested in true farming (only three Mexicans and a United States group).

In the mid-1990s, neoliberal policies were fully adopted in some research centers that had the means to transfer technology, such as the CIB (Rodríguez-Araujo 1990; López-Zárate 2008). The Mexican government decided to establish rules on academia–entrepreneur associations. Until that time, these associations had been based on somewhat marginal agreements with knowledge-holders, principally those able to generate technologies with potential for investment. Special departments were established in several institutions, whose mission was to identify those technologies, seek a means of controlling them (institutional propriety, patents), and attract private entrepreneurs, whether national or foreign. The Mexican government's regime for science and technology funding also experienced marked reforms. For example, financial channels were centralized, and associations with third-party partners were required to supply matching cash, operating costs, payments for expert services, and a share of future benefits. Similarly, the creation of the National System of Researchers in 1984 opened a supplementary source of income to elected members, based primarily on the number of publications per year (especially in foreign journals) and number of advised students (preferably at the post-graduate level). Such associations with wealthy private partners became an add-on that was economically rewarded.

In 1994, CIB adopted the name of Centro de Investigaciones Biológicas del Noroeste (CIBNOR), and its appointing office, the Dirección de Gestión Tecnológica, willingly adopted the neoliberal model proposed by the national science bureau. Since the social perspective at the basis of the GOP model had remained a constant objective, we opposed what we considered privatization of public knowledge and expertise in detriment of coastal fisherfolk cooperatives. In response, in 1995 we founded an independent corporation named Perlamar de La Paz, whose purpose was to mount a permanent fundraising campaign in order to carry out outreach programs to support and transfer techniques, knowledge, and capacities to fishing cooperatives and to manage communitarian farms along the lines of the one implemented in French Polynesia since the late 1960s by the Group d'Intérêt Économique (Cariño and Monteforte 2005; Tisdell and Poirine 2008).

Perlamar was a dissident initiative; it challenged the radical conservationism imposed by environmental policies and exposed the lack of interest in community development, thus raising a topic that annoyed authorities, who advised us to cease. Perlamar was closed in 1997 before ever having effectively commenced. The GOP was dismantled, and some of its graduate students moved into academic employment

elsewhere in Mexico or at CIBNOR, being absorbed by the establishment. A positive consequence was that, finally, studies devoted to pearl oysters were now considered a CIBNOR priority. However, this was not without significant modifications, i.e., biotechnological research was now aimed at publishing results in peer-reviewed journals and, due to wealth-generating value, graduate dissertations were crafted in a sort of fast-track mode. Some outside experiments to improve and perfect key details of extensive culture and pearl production were still carried out by us (see Monteforte 2005, 2013). These experiments relied on polyspecific-integrated modalities based on other edible native bivalves and marine ornamental species (Monteforte and Cariño 2011; Monteforte et al. 2017a; Ivanova et al. 2017) and development of abalone pearl culture (Monteforte and Bervera 2010). It is worth mentioning that there is a gender-oriented abalone pearl microentrepreneurship underway on Natividad Island (Monteforte et al. 2017b). Especially as regards *P. mazatlanica* and *Pt. sterna*, the mastery of main components and walk-through strategies for management/production scenarios had been largely defined by 1996 (Monteforte 2005, 2013).

An external prospection on the premise above may clearly highlight a neoliberal approach to science and technology policies (Rodríguez-Araujo 1990; López-Zárate 2008). As time went on, rural and coastal communities gradually found more obstacles, principally of financial nature, that hindered their access to productive alternatives. The most direct consequence of this trend, was the diminishing of funds for community-based productive projects and the strengthening of requirements for concurrent investment. Fewer academicians were willing to commit to developing outreach programs, which are severely underrated in institutional establishment. Additionally, outreach programs involve endless bureaucratic processes. These programs also place researchers in the middle of academic marginalization, conflictive intergroup dynamics, vandalism, complex governances, and more.

While progress with special studies on *P. mazatlanica* and *Pt. sterna* continued after 1986, substantial advances also accumulated relating to similar species (see Southgate and Lucas 2008). Soon the Internet and software tools provided new methods of science dissemination, access, and information sharing. In parallel, the Pearl Myth (Monteforte and Cariño 2012) acquired a sense of technical feasibility, thereby attracting a good number of entrepreneurs, even though nacre and pearls have turned into simple objects of trade in a modern, ruthlessly competitive and saturated sumptuary market (Tisdell and Poirine 2008; Monteforte and Cariño 2013). In fact, the mid-1990s pearling economic peak has decreased quite rapidly as a consequence of excessive supply, low prices, Chinese pearls, and the global crisis in general (Tisdell and Poirine 2008; Monteforte and Cariño 2013). The creation rate of new farms has dropped sharply; nonetheless, new farms are still occasionally seen, although with less frequency and generally of short duration. For example, as recently as 2010–2013, ventures of extensive mariculture and cultured pearls on *P. imbricata* and *Pt. colymbus* were implemented in the Gulf of Cariaco, Venezuela, and Cozumel Island, Mexico. Interest is also seen in Acapulco and Huatulco, both on the Pacific coast of Mexico. Panama, Costa Rica, Ecuador, and especially Peru have not underestimated their pearling potential, and some studies—still scarce and discontinuous—have been carried out. Furthermore, British Columbia, California, New

Zealand, Mexico, and Chile show substantial advancement in abalone pearl culture, and this appeal is attracting abalone farmers from Spain, France, and South Africa. In addition to achievements on cultured pearls, farmed species now include several pearl-producing mollusks like queen conch (*Strombus gigas*), lion paw scallop (*Nodipecten subnudosus*), red thorny oyster (*Spondylus princeps*), giant turban (*Megastraea undosa*), and the nacred top-shell (*Trochus niloticus*), among others.

Embedded in these developments are two events that induced a particular change in the prospect of sustainable pearl farming. First, the Guaymas pearl company had been lobbying for a proposal to regulate pearl oyster farms and cultured pearls in Mexico and to declare them exclusive reserves for cultivation purposes, among other measures aiming at conservation and protection, correct management of oysters, and care of pearl quality standards. The promoters managed to gather support within the Mexican pearling guild and among other interested actors (e.g., entrepreneurs, government, and pro-conservation civil associations) so that the proposal achieved its goal in 2013 (DOF 2013). The decree states that farmers must collaborate with government offices (SAGARPA/CONAPESCA, PROFEPA, SEMARNAT)[13] in periodic surveys and must provide reports of their farming activities, along with a thorough description of their harvests. It also precludes fisheries and import-export of rootstock and underlines strict measures related to the transport and/or exchange of native larvae, juveniles, or adults in Mexico, even between neighboring farms. However, the decree fell short of establishing the patrimonial strategic value of proprietary methods and techniques. This topic was neglected in various workshops held to develop the document, assuming that professional ethics would prevail.[14]

Second, beginning in the early twenty-first century, a conservationist upsurge in Mexican environmental policies and social sectors, in parallel with enforcement of fisheries regulations, created a gap between fisher cooperatives and the areas and/or species that previously provided a fishing livelihood (e.g., Natural Protected Areas,

[13] SAGARPA: Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación. CONAPESCA: Comisión Nacional de Pesca y Acuacultura. PROFEPA: Procuraduría Federal de Protección al Ambiente. SEMARNAT: Secretaría del Medio Ambiente y Recursos Naturales.

[14] The gap in these patrimonial rights was exploited by Chilean academics and entrepreneurs in 2004–2005. They were assisted by a Mexican specialist in an unsuccessful trial of hatchery and/or extensive culture and production of pearls in *Pt. sterna.* This species' latitudinal range usually extends north and south its normal distribution in the Panamic province due to temporary effects of El Niño/La Niña phenomena and/or anomalies of climate change. A subsequent, yet indirect, consequence of this gap was the swift introduction of abalone broodstock and foreign experts in Chile during the early 1970s—*Haliotis rufescens* (from Baja California) and *H. discus* (from Japan). In the former case, the expert also was Mexican. The outcome was the development of abalone farming in Chile on an industrial scale within a few years. Therefore, the coincidence of interests in cultured pearls and again Mexican assistance—now in abalone pearls—led to a logical expectation of profitability and the crafting of a tailor-made patent issued in 2015, which was restricted to Chilean jurisdiction in order to control knowledge related to a prosperous Chilean industry. Behind this patent lies two factors: (1) the inefficiency of patenting agencies in situations that are on the cutting edge of cloning and (2) plagiarism of deliberately uncited state-of-the-art sources, regardless of the high visibility of top-positioned sources in popular Internet browsers and academic databases (Monteforte and Bervera 2010; Monteforte et al. 2017b).

Marine Reserves and Parks, Biosphere Reserves, and special labels for some of the species that make up the small-scale or artisanal fishery). In theory, these policies included maricultural activities, although eligibility criteria have been inadequately addressed, giving preference to high-impact projects as a means to attract investment at all cost (Monteforte 2008).

As a combined effect, fisherfolk became marginal actors in the middle of fast-changing scenarios aimed at propelling megaproject expansion over coastal zones (Gámez and Ángeles 2010), sacrificing, as a trade-off for development, coastal small-scale fisheries. Either way, fisherfolk are required to submit to the one-sided guidelines of diverse programs of rational fisheries. Accordingly, conservationism (e.g., protection/vigilance against clandestine fishing or mistreatment of sites, cleaning and maintenance, control of biological invasions, environmental education, etc.) is applied to charismatic ecosystems, such as areas under legal status. Temporary agreements (subventions and temporary employment) are often used by megaproject developers to convince fishers to stop their activities, while private, small-scale ecotourism entrepreneurship is allowed. Sometimes, targeted groups may engage in activities related to replenishment of and caring for culture stock (e.g., endangered and/or key commercial species), wherein government and/or academic institutions supply laboratory-reared seed and husbandry training.

Mariculture-Based Social Microentrepreneurships: Potential and Challenges

GOP/Perlamar laid down a principle of community-based microentrepreneurship and untiringly pursued the integration of fisherfolk cooperatives, beginning with La Paz. After GOP was dismantled, we continued with that endeavor in a personal way. We did so before action by any of the currently involved entities, i.e., federal/state bureaus in charge of productive social development, civil associations, local entrepreneurs, and international foundations.

Commitment from involved parties was limited, despite the alleged social focus of these entities. In addition, the cost of mariculture projects in Mexico, even small-scale projects, exceeds the budgets of most social governmental programs, which are more commonly directed toward temporary social programs that serve to boost the image of officials. Any mariculture process needs time to reach equilibrium and a further period to become profitable. This is especially true in the case of large, slow-growing species, such as local pearl oysters and cultured pearls (Monteforte 2005, 2013). Naturally, fisherfolk need financial backing to sustain mariculture until the first harvest. A workable plan should consist of a system of rotating teams in accordance with the different stages of cultivation, considering that the traditionally inefficient trade-off between fishing and conservationism could be used more productively.

The initial assumption of Indo-Pacific-style community-based socioeconomic prosperity—based on pearl farming—had to be adapted to the modern market. It must be realized that economic prosperity based solely on pearl production is no

longer realistic, even in the short term (Southgate et al. 2008; Tisdell and Poirine 2008; Monteforte and Cariño 2013). For the past two decades, many small pearl farmers have gone bankrupt and been forced to close their businesses. A small number of these farmers still manage to barely survive. With this in mind, a broader diversification of pearl farms was conceived. This new concept was aimed at tackling polyspecific cultivation by incorporating edible bivalves and ornamental marine species. Prototype systems, intentionally rustic, were successfully tested in real conditions. The project was submitted in response to various requests for proposals, mainly from CONACYT. However, there were few opportunities to integrate rural/coastal people because they were required to offer matching funds and to cover expenses that were beyond their economic capabilities. Furthermore, regular funding from federal agencies such as SAGARPA and its bureau, CONAPESCA, is seldom available, and their budget is insufficient for projects of such a scale. However, on two instances we managed to obtain small amounts of funding to purchase at least some of the much-needed equipment and materials. At the same time, we promoted our plan in meetings and workshops with fisherfolk cooperatives in order to identify and evaluate conditions overall. We acknowledged that fisherfolk almost always were ready to participate, but in many cases few, if any, printed reports had resulted. These projects generated few effective results, while funds seldom were sufficient to achieve the announced objectives. This, in the long run, has caused great mistrust on the part of these groups toward promoters (government, academics, civil associations, and other special interest groups) and supposedly sustainable projects (Awortwi 2012; Bennett and Dearden 2014).

In 2011, CONACYT issued a call for technology-based projects that were reasonably designed for rural communities. We submitted our new model, and it was funded with MEX$3 million. Two fisherfolk cooperatives partnered with the project on the assumption that they would work well together. Although the rules established that, as in all federally funded projects, beneficiaries had to raise matching funds and afford operating costs, we decided to undertake the venture since several local actors (e.g., state and municipal governments, entrepreneurs, and NGOs) had made a commitment (some written, others with a handshake) to contribute funds. The required amount was no more than a government official might spend on a shopping travel to US or Europe. However, unfortunately, as frequently happens, local actors did not honor their commitment. As a result, CONACYT canceled the project. Nonetheless, we were able to utilize a small part of the budget to launch the project, thanks to the fact that it complemented the previously acquired equipment and material. Unfortunately, old feuds between the senior presidents of the two cooperatives unleashed conflicts that hampered the development of our work. Finally, the project was abandoned and left afloat in the sea. The installations were vandalized, and the project ended with simple, throwing overboard a few thousand survivors of the approximately 40,000 bivalves—about nine species in total—including nearly 15,000 young adults of Pt. sterna that were contained in the installations when top advances had been (attained, accomplished, achieved) in those generations.

Bringing together these two cooperatives was a mistake, as psychological factors and group dynamics were not detected until it was too late. As Perkins

et al. (2002) put it: "Psychological factors point to what motivates individuals to participate in particular settings and behaviors, how to maintain that participation, and how those motivations and behaviors interact with various setting and organizational characteristics to promote effective social capital." In addition, administrative issues related to aquaculture licenses were a roadblock, as licenses are given to a single cooperative and cover only its territory, even if two projects are contiguous, exactly the same, and directed by the same expert. This policy creates the need for two costly licenses and two copies of a bulky file differentiated only by the name of the project's beneficiary and the shape or location of the working area. Arguments about optimization of labor, material, and financial resources were ignored.

Other variables also impacted the system; for example, the cultivation site is part of the Balandra-Merito Natural Protected Area, and some of the targeted species are under some level of protection (e.g., *P. mazatlanica*, *Pt. sterna*,[15] the lion paw scallop [*N. subnudosus*], and various fish and invertebrates identified as ornamental). However, the site's aquaculture permits had been issued before the formal declaration of the natural protected area. In fact, our research in CIBNOR has been carried out in that location since 1988, including parallel studies by other colleagues and students (e.g., recruitment of cryptic fish and invertebrates, cultivation tests with hatchery-reared edible oysters and scallops, and others, along some oceanographic research). Ultimately, these issues should have been a minor problem; we always stressed that repopulation would be carried out and that natural populations would not be touched. The farm itself was seen as a source of larval dispersal, like the CCCP. Nonetheless, this experience showed the laxity of bureaucratic officials and a clear manipulation of federal resources.

Discussion and Conclusions

Pearl oysters are particular assets in the environmental history of the Gulf of California across social, cultural, and political processes over time. The material and subjective value of nacre and pearls has gone beyond their role in the precarious economies of indigenous people, leading to the justification for intense fisheries in search of luxury goods. The processes involved in this particular environmental history are sociohistorical, multifactorial, and multicomponent. In specific moments, pearl production implied a true breakthrough in scientific and technological development around the cultivation of oysters and production of pearls. In many senses, the history of pearling has been analogous for all pearling regions, although fundamental differences stand out in geographical context (anthropological ecology, cultural frameworks, policies, marketing frameworks, configuration of actors, etc.). In addition, methods and techniques used in the extensive culture of pearl oysters—including pearl induction—are essentially standard, although each farmer may develop generally minor adaptations or innovations.

[15] The decree on pearl oyster farming (DOF 2013) did not change the status of "special protection" for *P. mazatlanica* established in 1994, and, in fact, explicitly extended protection to *Pt. sterna*.

We have presented the global evolution of nacre and pearl fisheries toward commercial farms as a holistic process that transformed the hazards of overexploitation of natural beds by equally overexploited divers into a more social and highly profitable activity based on small-scale mariculture farms, stock replenishment, and skilled, well-paid technicians. As a matter of fact, the modern pearl world is one excellent example of equitable gender roles in sustainable community-based models, wherein women are often incorporated equally with men in the entrepreneurial and cooperative structures that control pearl farms and marketing channels (Cariño and Monteforte 2005; Monteforte and Cariño 2013; Tisdell and Poirine 2008). Therefore, the chronological narrative analyzed in this chapter should lead us to place the pearling history of the Gulf of California in a global context, where key dates and events have given shape to 482 years (1535–2017) of coincidences that include a band of mutineers, the CCCP, a Director's signature, and Pearls'94, among other events revisited in this chapter. Upon closer examination, the history of fisheries in this region ineluctably reveals the strong link between periodic cycles of resilience and resurgence of the Pearl Myth, finally transitioning to a technological enterprise in the late 1980s.

Key to this chapter are the roles of *P. mazatlanica* and *Pt. sterna* as native assets. A set of cumulative episodes demonstrates why the presence of these species is considered a natural vocation, as much for their influence during the era of colonization and fisheries as for the approach to farms and cultured pearls.

Throughout this chapter, the changes that occurred in environmental and sociocultural systems were analyzed from many points of view, not just chronologically. We also take into account behavioral and psychological profiles of human actors, set against the backdrop of fluctuating profitability of pearl fisheries. The trend of pearl oyster mariculture and cultured pearls that took place in La Paz Bay and the succeeding transmission to other commercial ventures and/or studies in Mexico and Latin America may have taken a different direction if the CCCP had not been forced to cease operations or if the policies related to science and technology had allowed more coherent strategies, rather than limiting access by marginal communities such as fisherfolk cooperatives. At the structural basis of the peninsular history of small-scale fisheries in general there has been a gradual, yet clear, shift from nacre and pearls in the Gulf of California to highly prized edible species in the Pacific (e.g., lobster, red crab, abalone, sea urchin, sea cucumber, giant snail, lion paw and Catarina scallops, and a variety of sport-fishing fish). In fact, fisherfolk cooperatives inhabiting the Pacific coast of the Peninsula have several advantages that allow them to be more prosperous than others on other Mexican coasts (Alcalá 2011; Tovar-Lee et al. 2015).

It may be uncommon in the academic literature to find authors that write about themselves and practice extensive self-citation. We cannot help it. Destiny placed us in this history book, and this topic has been engrained in our livelihoods for the past 30 years. Perhaps our professional development may be counted as a form of regional asset insofar as it has led to systematic research and technological developments that provided valuable information to modern commercial ventures and/or efforts that eventually became profitable, specifically in pearl microentrepreneurship. Even if these ventures are more in line with private interests than with regional development, at least they can be considered to be environmentally sustainable.

Thus, this chapter recognizes that environmental history—from a global to regional view—has to be understood as a significant constituent of community behavior and human interactions in general. What should be valued here is the strong *historic nativeness* of community capital (environmental, geographical, socioeconomic, political, cultural/group, knowledge/psychological) (e.g., Barbier 2007; Emery and Flora 2006; Glowacki-Dudka et al. 2013; Matarrita-Cascante and Brennan 2012; Perkins et al. 2002).

This chapter has examined circumstances that shaped this case study in real-time conditions and discussed their effect on the evolution of fisheries and the culture of nacre and pearls in the Gulf of California. We explained what construct was followed, and why this construct was chosen, to draw interpretive conclusions that would ultimately serve to envision opportunities to activate community capital from technology-based social microentrepreneurships.

An unanswered question remains: how to balance the criteria used to measure the relative level of prosperity through the lens of capacity-building actions. This implies the consideration of productive projects, such as mariculture, within concepts of conservation and sustainability that must address the need for coherent strategies designed to integrate vulnerable communities into the rigorous dynamic of coastal development models. It is recognized that coastal fisherfolk compete among themselves for scarce ecosystem services and resources. Competition is far more disadvantageous when fishers face more powerful actors. Privatization of a valuable common resource such as the coastal-marine interface by real-estate enterprises, luxury resorts, commercial and sport fisheries, over-conservation, and industrial mariculture has been associated with unequal policies and high socioeconomic, environmental, and cultural costs in exploited regions, such as the Gulf of California. In addition, despite the fact that the twenty-first century offers the latest scientific and technological upgrades, the principal stakeholders have demonstrated their incapability (or unwillingness) to conceive ideal project designs (Wallerstein 1998). This situation is reflected in the present state of stagnation and deterioration that characterizes Mexican mariculture, as well as other activities related to coastal management, including considerable evidence of the exhaustion of numerous species by unplanned and excessive fisheries. In mariculture, conservation-oriented approaches to the management of ecosystem services and the application of sustainable technology to alternative frameworks for regional coastal development rarely align with the interests of decision-makers, stakeholders, or science and technology entities, including those in the private and governmental sectors. It is not surprising that the generation of knowledge in the fields of sustainable management and landscape and natural resource conservation—as well as the proactive promotion of sustainable technology—has been cornered into models and requirements whose implementation is under the control of powerful groups, often influenced by external demands.

Therefore, "Mar de Cortés" applies not only to the geographical Gulf of California (Monteforte and Cariño 2009; Gámez and Ángeles 2010), but also to the general trend in selected coastlines around Mexico (e.g., Vallarta, Cancún, Ixtapa-Zihuatanejo, Huatulco, and many others). In this model, society obtains few positive outputs; benefits accrue to a few privileged sectors, while less privileged sectors of society receive few, if any, benefits. Among the deleterious consequences currently seen in many

coastal areas are the private monopolization of territory and the consequent concentration of wealth; the deterioration of environmental services and quality of life; and the irregular pattern of institutional, local, state, and national development plans that rarely converge to meet real local needs. Some sectors have raised clamor against pushing up the pressure on environmental and global factors in detriment of well-being. It is remarkable, for example, to see the creation and expansion of nongovernmental organizations dedicated to community development, conservation, and sustainable planning and the increase, in number and extent, of natural protected areas.

In 2005, a World Heritage designation was awarded by UNESCO to the islands in the Gulf of California. In 2006, SEMARNAT published the *Programa de Ordenamiento Ecológico Marino para el Golfo de California* (Cariño and Monteforte 2008), wherein low-impact mariculture was identified as the best option for coastal zones that have not yet been irrevocably affected by deleterious development plans. However, the implementation of congruent and functional strategies, such as sustainable mariculture, needs participation of many responsible actors. This participation, in its simplest form, should go beyond the interests that exist in coastal areas themselves and should address the inertia of the complex policy system. There is no choice but to succeed in establishing a proactive criteria that would allow for an integrative and conservationist social vision, leading to a general improvement in the quality of life for the communities inhabiting this space.

The previous framework has not changed much since 1986 when we started to work in La Paz Bay. The establishment of a community-based pearl-farming organization in French Polynesia had demonstrated since the 1970s the enormous benefits of applying science and technology to enhance the natural vocations by increasing socioeconomic wellbeing and environmental conservation from a productive perspective. However, at the turn of the new millennium, we may expect unavoidable changes in the Pearl World, resulting not only from technological advances but also from the expansion of pearl farms in developing countries. The future version of the world Pearl Myth will face the modern harmful development models of coastal and mariculture management as well as the demands of a growing society in need of survival alternatives that, most of the time, do not fit the definition of sustainable management.

In that sense, and agreeing with principles of sustainability (notably those related to food security, self sustainability, and a solidarity economy (Toledo and Ortiz-Espejel 2014), it is evident that the extensive culture of pearl oysters and pearls has complementary links with edible mollusks and ornamental marine species. In either case, the activity represents the best alternative to achieve the resilience of many commercial species that have seen their numbers diminished in the wild or have nearly disappeared. Therefore, the idea of social-based mariculture (small-scale farms or social microentrepreneurships, gender-oriented or not) should debunk the traditional Pearl Myth of boundless short-term wealth, which is no longer realistic. This complementary input from polyculture modalities does not pretend to be a millionaire business; on the contrary, it is directed at supplying reliable and viable technologies to target groups and a means to acquire valuable skills through a process of conversion/diversification and training, as well as increased awareness of conservation and care for the environment.

It is important to not forget that the glamor of nacre and pearls always will be grounded in sumptuary markets; hence, the products represent a significant add-on to the financial outline of polyculture modalities. At the bottom line, the activity should generate decent income for fisherfolk and their families. Only then will we be able to understand how to conceptually and pragmatically approach resilience in one of the most significant natural resources in the history of the Gulf of California. Hopefully, this time, the shine of pearls will not feed greed. Instead, it should feed deep sustainability.

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Ethnobiology

Lisa L. Price · Nemer E. Narchi *Editors*

Coastal Heritage and Cultural Resilience

This book explores the knowledge, work and life of Pacific coastal populations from the Pacific Northwest to Panama. Center stage in this volume is the knowledge people acquire on coastal and marine ecosystems. Material and aesthetic benefits from interacting with the environment contribute to the ongoing building of coastal cultures. The contributors are particularly interested in how local knowledge — either recently generated or transmitted along generations — interfaces with science, conservation, policy and artistic expression. Their observations exhibit a wide array of outcomes ranging from resource and human exploitation to the magnification of cultural resilience and coastal heritage. The interdisciplinary nature of ethnobiology allows the chapter authors to have a broad range of freedom when examining their subject matter. They build a multifaceted understanding of coastal heritage through the different lenses offered by the humanities, social sciences, oceanography, fisheries and conservation science and, not surprisingly, the arts. Coastal Heritage and Cultural Resilience establishes an intimate bond between coastal communities and the audience in a time when resilience of coastal life needs to be celebrated and fortified.

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Reviewer Comment Form
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It will greatly assist us if you give us your opinion of the article as a potential chapter for the volume on Coastal Heritage and Cultural Resilience by choosing one of the recommendations under "Overall Evaluation".
Detailed comments with suggestions for improvement are most helpful to both editors and authors. We thank you again for taking the time to perform this important service.

Title: A History of Nacre and Pearls in the Gulf of California
Chapter Number: 4

Review Sheet: General Judgement
==========

1. Is the paper acceptable for publication

- [x] Publish with minor revisions
- [ ] Recommend minor revisions and reassess.
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- [ ] Reject as not suitable for this book
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- [ ] I cannot adequately assess the content because the English is unclear.

2. Significance of research question.

- [ ] excellent
- [x] good
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3. Originality of the research.

- [x] excellent
- [ ] good
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- [ ] poor

4. Accuracy of data presented and validity of data interpretation.

- [x] excellent
- [ ] good
- [ ] fair
- [ ] poor

5. Organization of manuscript.

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- [ ] good
- [ ] fair
- [ ] poor

6. Clarity of writing

- [ ] excellent
- [x] good
- [ ] fair
- [ ] poor

7. Effective and appropriate use of tables and illustrations.

- [x] excellent
- [ ] good
- [ ] fair
- [ ] poor

Coastal Heritage and Cultural Resilience

II. Comments for authors and editors.

I have read Chapter 4 "A History of Nacre and Pearls in the Gulf of California". The manuscript uses the human-pearl relationship as a canvas in which to unfold an intricate history, ubiquitous to pearl producing societies, in which social, political and economic forces give positive feedback to a cycle that swings between overexploitation and recovery. The manuscript's language has greatly improved since my last appraisal. Along those lines, it has also become evident that the author(s) have not left unanswered my comments and recommendations. However, I am convinced that the last part of the manuscript "Mariculture-Based Social Microentrepreneurships: Potential and Challenges" remains disconnected from the rest of the piece, as it deals with great political phenomena, yet leaves aside the ethnobiological aspects of community-based microentrepreneurship.

It is, perhaps, not the time to ask for more data on community acceptance and assimilation of GOP/Perlamar projects. Nonetheless, I strongly recommend that the author(s) pursue a second article dealing with how the community perceives, gets involved, and finally appropriates such an exogenous project. Moreover, if these projects are yet to be pitched to these and other fisherfolks and ther families, the author(s) should explore the possibilities of adopting postcapitalist frameworks such as those proposed by David Barkin and Mara Rosas (2006) in order to offer much more than a technological package. That is, a completely new set of economic and community values that would allow for alternative and fairer modes of accumulation.

In addition to the aforementioned, there are some edits that need to be taken care of, especially those concerning the footnotes. I am listing these suggestions below:

1. I'm not sure what the "+" refers to in "+2007" in footnote 4.
2. The Steinbeck 1951 citation in footnote 7 does not appear in the reference list.
3. I'm not sure what you mean by "It is a looting schema" in footnote 7. Please clarify.
4. Naïve readers will be unaware of what the Nao of Manila is. Please clarify with a footnote.
5. p. 12 I'm not sure what you mean by "they escaped for not paying what armadores or proprietors had advanced them." Please rephrase.
6. I'm confused by the sentence in footnote 13 that reads "This species' latitudinal range usually extends toward that coastal hemisphere (as well as the northern one) due to temporary effects of el Niño/la Niña phenomena and/or anomalies of climate change." The highlighted phrase isn't clear to me.
7. Please clarify whether footnote 13 refers to a project in Chile or Mexico.
8. Please go through the reference section and restructure accordingly to Springer's citation style and requirements

I leave below the references that I have used to strengthen my argument. I hope these are understood as a recommendation and never as an imposition.

Barkin, D., & Rosas, M. (2006). ¿ Es posible un modelo alterno de acumulación?. Una propuesta para la Nueva Ruralidad. Polis. Revista Latinoamericana, (13).

Coastal Heritage and Cultural Resilience

Reviewer Comment Form
Reviewer 1

Please provide your comments in the text boxes at the bottom of the form. Note that one is for comments to be shared with the author, and the other for editors' eyes only.
It will greatly assist us if you give us your opinion of the article as a potential chapter for the volume on Coastal Heritage and Cultural Resilience by choosing one of the recommendations under "Overall Evaluation".
Detailed comments with suggestions for improvement are most helpful to both editors and authors. We thank you again for taking the time to perform this important service.

Title: A History of Nacre and Pearls in the Gulf of California
Chapter Number: 4

Review Sheet: General Judgement
==========

1. Is the paper acceptable for publication

- ☐ **Publish with minor revisions**
- ☐ Recommend minor revisions and reassess.
- ☐ Recommend major revisions and reassess.
- ☐ Reject as not suitable for this book
- ☐ Reject as not publishable on grounds of poor scholarship.
- ☐ I cannot adequately assess the content because the English is unclear.

2. Significance of research question.

- ☐ excellent
- ☐ **good**
- ☐ fair
- ☐ poor

3. Originality of the research.

- ☐ **excellent**
- ☐ good
- ☐ fair
- ☐ poor

4. Accuracy of data presented and validity of data interpretation.

- ☐ excellent
- ☐ **good**
- ☐ fair
- ☐ poor

5. Organization of manuscript.

- ☐ **excellent**
- ☐ good
- ☐ fair
- ☐ poor

6. Clarity of writing

- ☐ excellent
- ☐ **good**
- ☐ fair
- ☐ poor

7. Effective and appropriate use of tables and illustrations.

- ☐ excellent
- ☐ **good**
- ☐ fair
- ☐ poor

II. Comments for authors and editors.

This chapter presents a new and extensive exploration of the history of the pear in the Gulf of California. The authors present the environmental history of pearling and the context of the oyster exploitation in the light of the interface of the socio-economic, socio-cultural and the political dynamics across time. The manuscript is both highly detailed as well as expansive. This review covers the manuscript with already English language corrections and thus it is in very good shape to move forward in the editorial process.

Minor corrections for your attention:

- (Hanley 1856) cited in text is not in the reference list
- (Gould 1851) cited in text is not in the reference list
- Is (Nakai 2013) as cited in text actually Nagai as in the reference on the reference list?
- In Strinbeck 1951 citation in footnote 7 does not appear the reference list. I am also not sure what you mean by “It is a looting schema” in foot note 7.
- (Ortiz-Espejel 2014) not in the reference list.