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The Culture of the Mussel, *Perna perna*, and the Mangrove Oyster, *Crassostrea rhizophorae*, in Venezuela

ENRIQUE F. MANDELLI and AMADO ACUÑA C.

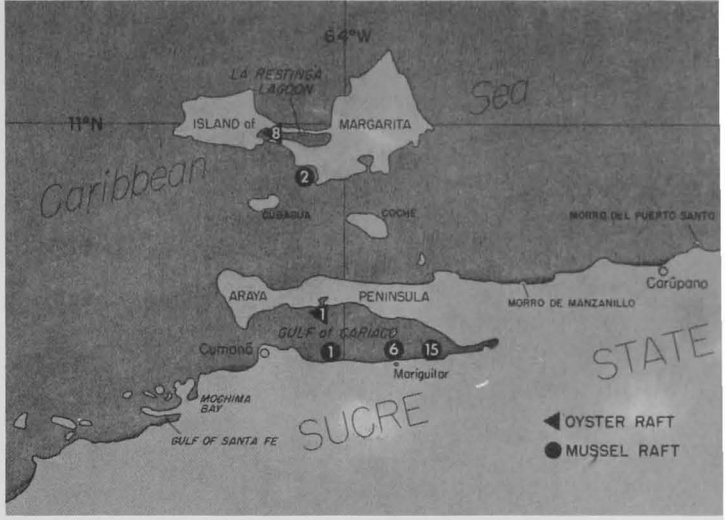

Figure 1.—Location and number of rafts for mariculture operations in eastern Venezuela.

ABSTRACT — The coastal areas of eastern Venezuela offer excellent opportunities for the culturing of mollusks, as suitable unpolluted growing areas with all the ecological requirements are available. Culture of the mangrove oyster, Crassostrea rhizophorae, *and the mussel,* Perna perna, *in Venezuela was started in the early 1960's, using the successful Spanish raft techniques. In spite of initial promising results, oyster and mussel culture in this Caribbean region is now practiced on a small scale. Rapid growth and high yields are the characteristics of these cultures. Projected yields of 200-300 tons/ha/yr for* C. rhizophorae *and 1,000-1,200 tons/ha/yr for* P. perna *were estimated. Studies on* P. perna *growth in relation to environmental parameters are presented and culture guidelines recommended. The future development of the industry is also discussed.*

INTRODUCTION

In the coastal regions of eastern Venezuela the mangrove oyster, *Crassostrea rhizophorae* Guilding, and the mussel, *Perna perna* Linnaeus, are widely distributed in protected mangrove areas and rocky shores, respectively. These mollusk fisheries are relatively small (Food and Agriculture Organization of the United Nations, 1972) and mainly based on the harvesting of natural stocks which in the case of the oysters is done in a wasteful and destructive manner.

The region offers the necessary prerequisites for mariculture of these mollusks. Initial attempts were begun in the early 1960's. Carvajal (1962) and Velez (1968) reported on the experimental culture of *C. rhizophorae*. Andrew (1962), on the other hand, described the encouraging results obtained in the culture of the mussel *P. perna*, as compared to *Mytilus edulis* culture in Spain. However, in spite of initial promising results, after a decade the culture of mollusks in eastern Venezuela represents a small-scale operation of unfulfilled potential.

This paper reviews the current commercial and experimental efforts to further develop the mariculture of *C. rhizophorae* and *P. perna* in eastern Venezuela.

Enrique F. Mandelli is a professor with the Organization of the American States living at Apartado Postal 34, Cumaná, Estado Sucre, Venezuela. Amado Acuña C. is with the Instituto Oceanográfico, Universidad de Oriente, Cumaná, Venezuela. *Their work, reported in this paper, was supported by Grant No. 31.26 S-1-0233 from Consejo Nacional de Investigaciones Científicas y Tecnológicas de Venezuela and Corporación Venezolana de Fomento. The paper was originally presented at the symposium Aquaculture in the Americas held at the Inter-American Scientific Meeting, "Science and Man in the Americas," jointly sponsored by the American Association for the Advancement of Science (AAAS) and Consejo Nacional de Ciencia y Tecnologia (CONACYT), México 18, D.F., México, 20 June to 4 July 1973.*

CULTURE AREAS

Suitable growing areas for mollusks in eastern Venezuela are found within the inshore regions of the southeastern Caribbean Sea. This area is characterized by intense upwelling along the coast and in the Gulf of Cariaco. The northern and southern shores of the gulf are dotted with protected inlets, some of them fringed with dense mangroves (Fig. 1). To the west in the Caribbean Sea there are several potential areas for mariculture, such as Mochima Bay and the Gulf of Santa Fe. To the north, Margarita Island offers excellent ecological conditions for oyster culture. For example, La Restinga Lagoon is a well protected area with many inlets lined with dense mangroves, their roots covered with oysters. Along the northern shores of Sucre State between Manzanillo and Morro del Puerto Santo lie extensive mussel growing areas which provide the seed for current mussel mariculture. Mollusk culture operations are localized now in the Gulf of Cariaco and in La Restinga Lagoon on Margarita Island.

CULTURE TECHNIQUES

The culture of mollusks off the bottom by using Spanish raft techniques has been very successful in Venezuela. Both *C. rhizophorae* and *P. perna* are reared utilizing those techniques, though slightly modified. The suspended or floating culture practice offers several advantages. It can be adapted to shallow waters independently of the type of bottom, and the cultured organisms are protected from benthic predators. Moreover, the water column within the euphotic zone can be conveniently utilized.

Figure 2.—*C. rhizophorae* raft in La Restinga Lagoon, Margarita Island.

The culture of mangrove oysters in La Restinga Lagoon is conducted using wooden rafts of varying sizes from 8 to 12 m^2 (Fig. 2). The abundance of larvae in the lagoon waters insures a constant source of seed. Larvae collectors made of asbestos and cement sheets, 40 × 80 cm, are suspended from rafts below the water surface. The number of larvae collectors varies from 170 for small rafts to 260 for large ones. After setting, the larvae are allowed to grow to about 2.5 cm in length, and only 200-300 are kept on each collector. From this point on, the juvenile oysters are treated at monthly intervals with a lime suspension for 15 min to eliminate space and food competitors. This treatment does not affect the oysters, which reach marketable size in about 6 mo (Fig. 3). The harvested oysters exhibit thin shells as compared with specimens of *C. virginica* of the same size. Rafts in La Restinga Lagoon are now producing between 20 and 30 kg of oysters per collector. Based on these yields, a production of 200-300 metric tons/ha/yr can be projected, considering one crop per year. These figures are from four to five times as great as those reported for Japanese cultures with yields of 58 tons/ha/yr (Ryther and Bardach, 1968).

The culture of mussels as practiced in Venezuela resembles operations in the highly productive Galician bays of northern Spain. As stated previously, the mariculture of *P. perna* is mainly localized in the Gulf of Cariaco near Cumaná. Initial experimental cultures were established in the Caribbean Sea along the rocky shores near Carúpano. However, a combination of adverse factors conspired against the success of the industry in that region. Rafts were damaged by rough seas during the windy season, and heavy crop loses were produced by red tide outbreaks.

The mariculture of *P. perna* in the Gulf of Cariaco involves the following steps: Juvenile mussels, 2.5-3.5 cm in length, are attached to polypropylene, to sisal ropes, or to wooden sticks of guatacaro (*Beureria cumanensis*) with rayon netting being used to hold them in place until natural

Figure 3.—Oyster cultch at harvesting time.

attachment occurs. Of the three systems in use, the one employing guatacaro sticks is the most economical since this wood is impervious to attack by marine boring organisms. The sticks or ropes, ranging from 4.5 to 6.5 m in length, are hung from rafts varying from 7 × 5 m to 26 × 16 m in size (Fig. 4). Smaller rafts holding 200-300 ropes are easier to operate and maintain. When mussels reach a size of about 4-5 cm in length, they are redistributed on additional ropes in order to prevent losses due to detachment and in order to minimize overcrowding, thereby stimulating growth. The harvesting of the mussels takes place after an 8- to 10-mo period. The yields vary according to the length of the ropes from 50 to 80 kg per rope, with a 10 × 10-m raft producing an average of from 10 to 20 metric tons of mussels. A projected yield of from 1,000 to 1,500 tons/ha/yr has been estimated. These projected yields are from three to five times as high as those reported by Spanish operations (Ryther and Bardach, 1968).

ENVIRONMENTAL FACTORS AND MUSSEL CULTURE

During the 1972-73 season a study was carried out on the growth of *P. perna* mussels from an experimental raft in close relation with some environmental parameters. The fluctuating physiocochemical and biochemical properties of the seawater at the site of the culture were tentatively used to formulate general guidelines for mussel culture in the Gulf of Cariaco. The gulf is a nearly isohaline body of water; thus salinity at the experimental site ranged from 36.47 to 36.78 ‰ during the experimental period. The seawater temperature for the same period varied from 24.2° to 28.2°C at the surface and from 21.6° to 27.7°C at the depth of the rope length (6.5 m). Upwelling periods in the gulf were clearly evidenced by the temperature, oxygen, and nutrient distribution data.

In terms of primary organic production the Gulf of Cariaco can be described as an upwelling province (Ryther, 1969). In the studied area, primary organic production ranged from 0.1 to 2.34 g C/m²/day, representing a potential yield of 235 g C/m²/yr for a water column 10 m deep. Two different production seasons were distinguished. From January throughout August, upwelling in the gulf maintained high levels of primary organic production. During the September-December period, however, production levels declined (Fig. 5). Production during both seasons was related to the prevailing winds in the area. The standing crop was dominated by diatoms in the highly productive period and by μ-flagellates the rest of the year, while dinoflagellates predominated in the transition period.

The experimental mussel culture was started in August 1972. The shell length of the seed used had a modal class of 35-38 mm. Juvenile mussels were attached to 300 sisal ropes at a density of about 3,000 per rope. Monthly growth rates were determined by sampling from nine ropes distributed along and across the raft. The procedure consisted of sampling 60 mussels per rope at three different depths with a total sample of 540 specimens collected each month. In Figure 6 are shown the monthly mode of shell growth, body weight gains, and condition index. During the experimental period, rapid growth of the mussels coincided with the end of the 1972 upwelling season, followed by minimum growth from October to December, 1972. The latter period showed low levels of primary organic production. Growth picked up in January 1973 after the onset of the new upwelling season and was maintained at a constant level until harvesting time in April 1973. The pattern of *P. perna* growth was similar to that reported by Carvajal (1969) and Velez and Martinez (1967) working with mussels in their natural habitat.

Regarding the spawning of this species, Carvajal's work offers evidence that the process takes place within the upwelling period. Spawning was apparently triggered by a sharp seawater temperature drop of 3-4°C. During the present study, spawning of the mussels in the experimental raft was not noticed. A commercial operation in the same general area, however, reported *P. perna* spawning in the June-July period (R. Martinez, pers. commun.).

Red tide outbreaks, which regularly occur in the Gulf of Cariaco, are a constant threat to the successful farming of mussels. To cite a specific case, in August 1972 a red tide patch developed in a localized area of the gulf and destroyed the entire mussel crop of six commercial rafts. Apparently there was a concentration of dinoflagellates in the bay followed by a windless period. It was not determined whether mussel mortality occurred due to the toxicity of the phytoplankter or by oxygen depletion when the standing crop decayed. At the site of the experimental culture on the same occasion we found the standing phytoplankton crop dominated by dinoflagellates not reaching red tide density. A similar type of phytoplankton distribution in the Gulf of Cariaco was determined in previous years (E. Reyes, ms. in prep.).

Considering the limitations of the accumulated information, the following recommendations are proposed to minimize adverse environmental conditions: First, the April-May period is a propitious time to start *P. perna* cultures. Three factors support this rationale—good, healthy seed is available, transplant of juvenile mussels will take place during the high productivity season, and the mussels will reach the low productivity period in good physiological condition even if spawning occurs by June or July. Second, mussels should be harvested between March and April of the following year after the onset of the upwelling season.

FUTURE OUTLOOK

It must be understood that current mollusk culture in eastern Venezuela cannot be considered true marine farming. Juvenile mussels are removed from their natural habitat and placed in favorable environments until they reach marketable size. Wild oyster larvae, on the other hand, are allowed to set in man-made cultch materials, and are reared under partially controlled conditions. In both cases man's aim has been to improve natural growing conditions by suppressing overcrowding and encouraging the rapid growth of the mollusks.

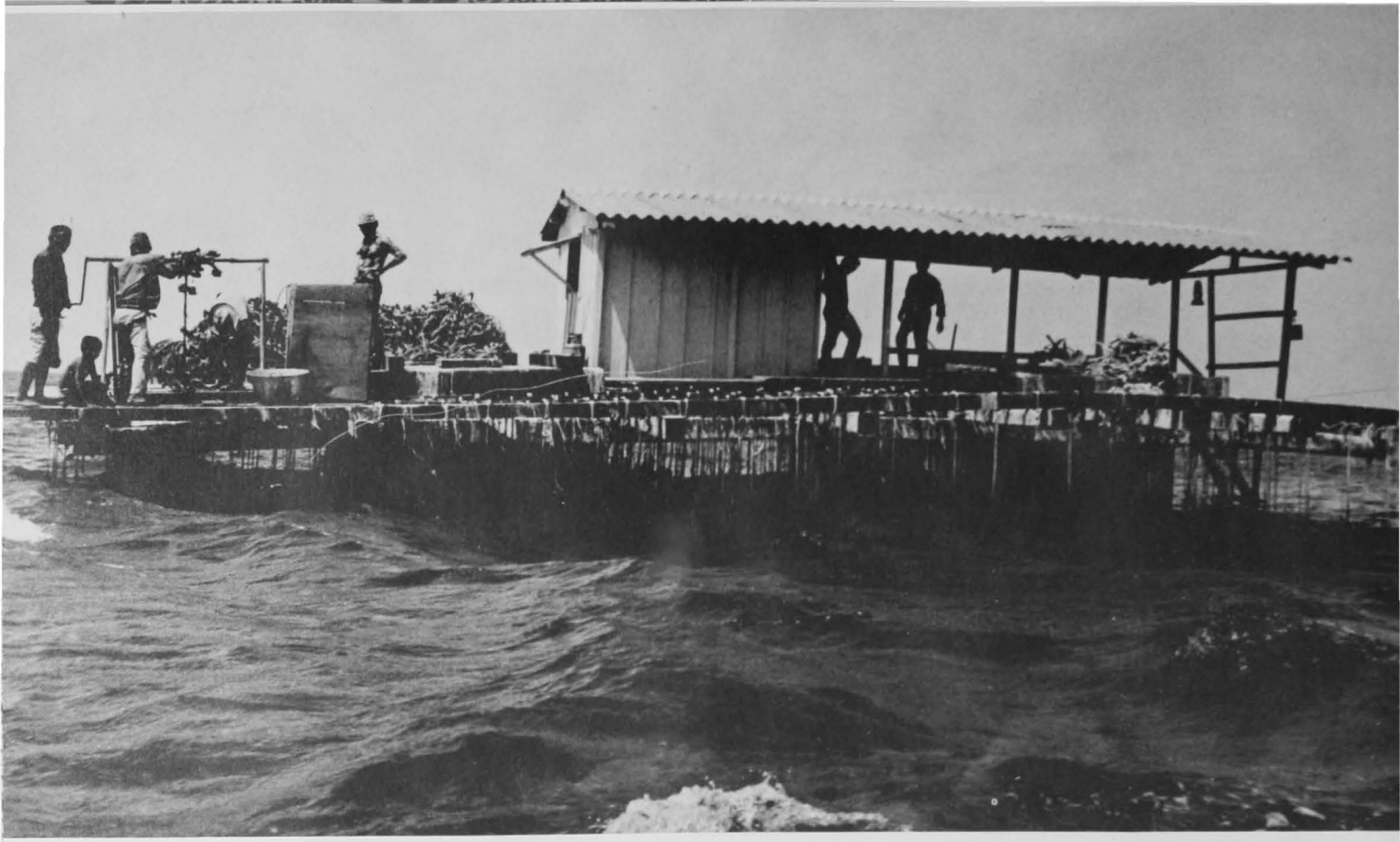

Figure 4.—*P. perna* raft in the Gulf of Cariaco area.

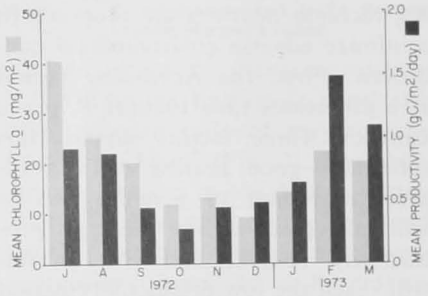

Figure 5.—Phytoplankton biomass and primary organic production at the site of a *P. perna* experimental culture (July 1972 through March 1973).

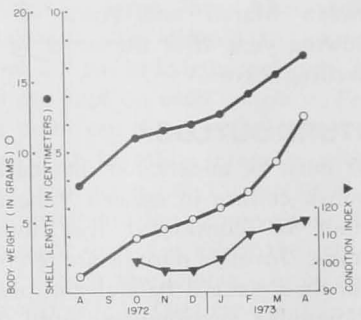

Figure 6.—Monthly modal length, mean body weight and wet weight condition index for cultured *P. perna* mussels (August 1972 through April 1973).

Most of the current commercial operations have a low production capacity and are run by small operators. Mussel production through culture practice reached only 94 metric tons in 1971 and 187 metric tons in 1972. So far this production has been absorbed by internal markets and has yielded reasonable profits. Further expansion of the industry can only be based on a dependable source of seed. In this regard, unregulated exploitation of *P. perna* banks is bound to limit future culture demands. Consequently, hatchery operations or the installation of larvae collecting rafts will be necessary. In either case, higher capital investment and operational costs will possibly curtail development. Cultures of *C. rhizophorae*, apparently freed from seed limitations, present other problems. The rapid growth of this oyster under controlled conditions produces specimens of marketable size but characterized by very thin and brittle shells needing careful handling. Further study is required to solve these and other problems. Thus, research priorities should include improvement of culturing techniques, controlled production of seed and even hybridization (Menzel, 1971). From a commercial standpoint it is uncertain to what extent *C. rhizophorae* and *P. perna* can compete with other, more valuable, species. In the ultimate analysis the expansion of both internal and external markets for these species will be the determining factor in the future development of this industry.

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