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The Development of a Low-Technology Oysterculture Industry in Jamaica

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RESUMEN

El principal problema para el establecimiento de técnicas de acuicultura en países en desarrollo, es la de adaptar la tecnología en tal forma, que le sea posible a comunidades de bajos ingresos que dependen casi solamente de los recursos locales, la de establecer sus propios sistemas de acuicultura. La práctica básica para el cultivo de ostiones ha sido desarrollada por países más desarrollados y emplea una tecnología de alto nivel. Sin embargo, los paises en desarrollo tienen que encontrar técnicas alternantes y materiales más apropiados a su situación. Desde 1977, el Proyecto de Ostricultura (Jamaica) ha estado realizando investigaciones a fin de determinar la factibilidad de una baja tecnología industrial ostrícola en Jamaica.

Este sistema de cultivo evita la utilización de gran capital y los requerimientos tecnológicos de criaderos artificiales al utilizar las larvas fijadas producidas en poblaciones libres del ostion de mangle *Crassostrea rhizophorae*. Estas son recolectadas en superficies artificiales para después permitir su desarrollo a tamaño comercial colgadas por debajo de los niveles de las mareas en balsas flotantes.

Prácticamente todo el material empleado en esta técnica son productos locales, y son fácilmente asequibles a pescadores locales. Los cantos de las neumáticos de automóviles cortados (matrices) a tamaño 8 cm x 8 cm y colgados juntos (ristras) en enrejados de bambú, entre los niveles de mareas, demostraron ser atractivos para la fijación larval. Resultan, al mismo tiempo, más duraderos y más fáciles de obtener que otros materiales probados, como ramas de mangle o nueces de coco. La mayor abundancia de larvas fijadas corresponde a la época de las lluvias; pero la recolecta de larvas fijadas, de hecho, puede llevarse a cabo con éxito alrededor de ocho meses al año.

Cuando la densidad de larvas fijadas en las matrices ha alcanzado niveles aceptables (generalmente después de 2-3 semanas de exposición), las matrices son transportadas a balsas ancladas en aguas más profundas. Estas balsas pueden ser construídas en unas 4 horas, de bambú, empleando tambores usados de 44 galones como flotadores, los que duran más de un año en condiciones normales. Las matrices son nuevamente colgadas con hilos más largos y espaciados con varas de bambú, para mejor circulación del agua. Esta sumersión permanente permite una alimentación continuada y de hecho una tasa de crecimiento más rápida. La fijacion de otros organismos es controlada mediante la exposición de las ristras al sol durante 24 horas, y por lo tanto mata toda la epifauna; los ostiones sobreviven este tratamiento bien.

Las tasas de crecimiento obtenidas hasta el presente, se comparan bien con las obtenidas en otros parajes. Este rápido crecimiento permite dos cosechas al año en operaciones

comerciales. Los resultados obtenidos indican que el costo inicial de instalación de una base de cultivo de ostiones (alrededor de J$500) queda bien retribuída por el valor de la cosecha (J$2,000). Se estima que este sistema relativamente poco costoso, y de baja tecnología para el cultivo de ostiones, es altamente factible en Jamaica. Operaciones comerciales piloto se llevan a cabo en nuestros lugares experimentales, y en otros parajes potenciales se alienta establezcan sus propios campos de cultivo de ostiones.

INTRODUCTION

The mangrove oyster (*Crassostrea rhizophorae*) is widely distributed throughout the Caribbean. It is found cemented intertidally to the roots of the red mangrove tree (*Rhizophora mangle*) in bays and estuaries. Extensive exploitation of the mangrove oyster from the Arawak days of Jamaica, together with the destruction of many mangrove areas in coastal development, has resulted in a decline in the natural oyster populations. Thus the mangrove oyster has become expensive and difficult to obtain.

A likely solution to this problem is cultivation of the mangrove oyster. Cultivation of other oyster species has been achieved in Japan, North America and Europe, with very considerable success, and a variety of elaborate techniques has been developed. However, such cultivation techniques are not feasible in developing countries, such as Jamaica, which lack both the technological and financial resources for such an undertaking. Moreover, the people who are most likely to adopt and benefit by oyster cultivation live in small, frequently isolated, low income rural communities, where exploitation of the ecological productivity of local mangrove systems is already part of their way of life. Consequently, a system of cultivation is necessary which can be adapted to such small coastal communities, using readily available local materials.

In order to arrest the decline in the natural populations as well as to ensure a more stable supply of the oysters at reasonable prices, a number of Caribbean countries have started culturing them under semi-controlled conditions. Cuba, for example, has achieved great success by providing extra mangrove branches on which the oysters may attach and grow to maturity (Nikolic et al. 1976). In Venezuela, culture has been attempted using asbestos tiles as a substrate for the oysters to grow subtidally (Angell, 1974). In Colombia, a method of tray cultivation is showing promising results, while in Panama experiments are being conducted with Cuban assistance based on their method. Thus a significant number of Caribbean countries are developing culture techniques that are appropriate to their local needs and conditions.

The generalized culture techniques adapted by these countries can be divided into two main stages. The first involves collection of young oysters or spat. Artificial surfaces are put out upon which surplus larvae will attach and settle. The growing out stage follows, when the oysters, protected from predators and harsh environmental conditions, are grown to marketable size.

The feasibility of establishing an oyster industry on these lines in Jamaica has been examined by the Oysterculture (Jamaica) Project, involving the cooperation of the International Development Research Centre of Canada (I.D.R.C.), the Government of Jamaica (Ministry of Agriculture) and the University of the West Indies (Zoology Department). This paper describes the techniques that have been developed by the Project since 1977.

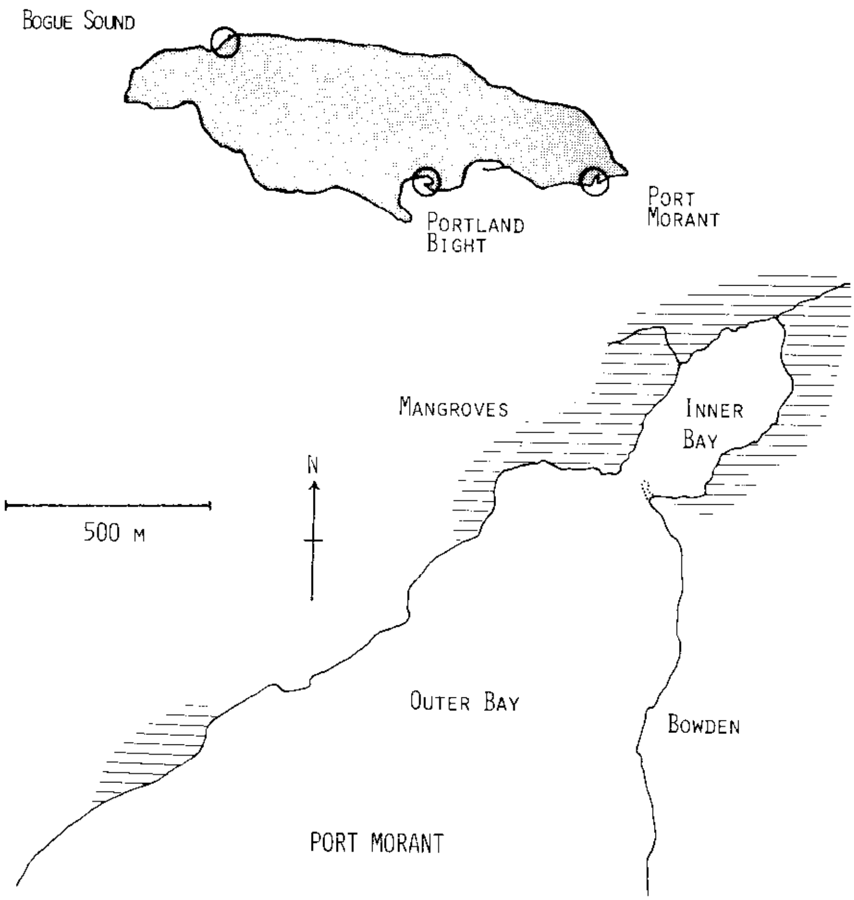


Figure 1. a, Principal mangrove areas in Jamaica; b, Map of Port Morant and its mangrove areas (shaded).

PROJECT AREA

Jamaica is relatively well endowed with mangrove areas, many possessing viable oyster populations. Principal among these are Port Morant at the eastern end of the island, Portland Bight, 30 miles west of Kingston, and Bogue Sound near Montego Bay (Fig. 1a). Port Morant (Lat. 17° 35′, Long 76° 19′) was selected as the main site for development because of the extent of its natural oyster population, its sheltered condition and easy accessibility (Fig. 1b).

Port Morant is approximately a mile wide, and reaches inland for about 2.5 miles. Surrounded by low hills on all sides, it is relatively well sheltered from the stiff onshore breezes that develop in the afternoons. The bay is divided into two distinctive areas by a mud spit. The shallow (1 m depth) inner part is fringed by mangroves extending up to 0.5 mile from the water's edge. A thriving intertidal population of oysters is found in a band extending some 10 m in from the mangrove fringe. The outer part is characterized by deeper water (up to 10 m depth) and a bottom of muddy sand colonized by turtle grass (*Thalassia testudinum*) interspersed with a few coral outcrops.

Tidal fluctuations in the bay are minimal with a daily vertical range of about 24 cm, though fluctuations in wind intensity and direction can modify this considerably. Temperature varies little, but salinity, particularly in the upper meter, can vary between 35 ppt and 10 ppt especially after heavy rains. Currents are light and unpredictable, though silt-laden eddies on the east side of the bay seem to be a regular feature, resulting in the formation of the spit.

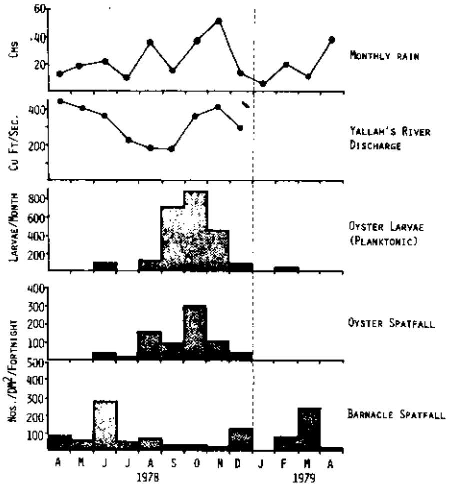
SPAT COLLECTION

A frequent method of obtaining spat in advanced countries is by artificially inducing spawning and fertilization in shellfish hatcheries, where young individuals are reared to an age where they can be set out in open water. This financially and technologically demanding method of obtaining young oysters is clearly unsuitable for most of the Caribbean countries. Another method, much better suited to developing countries, is to utilize the spat from a parent population of wild individuals. *C. rhizophorae* readily lends itself to such a technique. By providing artificial settling surfaces (cultch) in those intertidal areas where the surplus of unsettled larvae accumulates, the oyster farmer is able to collect large numbers of young oysters without any disturbance to the natural parent population.

It is clearly in the interest of an oyster farmer to maximize his utilization of this resource. *C. rhizophorae* has two spawning seasons in Jamaica, each coinciding with periods of increased rainfall (Fig. 2). The first of these occurs in March and is light and somewhat unpredictable, but the second, main, spawning season lasts from August to December. However, the precise timing, duration and intensity of spatfall may vary considerably from year to year (Fig. 3).

The lack of any real long term regularity in spatfall timing means that more precise short term predictions of settlement are essential, not only to maximize the efficiency of spat collection, but also to eliminate spatial competition from barnacles whose settlement periods immediately precede those of oysters (Fig. 2). Thus, cultch have to be made available for settlement at precisely the right times. A particularly useful and cheap method of not only predicting the timing of spatfall, but also establishing the best localities in which to set out cultch, is the use of frosted glass panels hung out in the intertidal zone. Fort-nightly examination of these reveals with some accuracy when the level of barnacle settlement is declining and that of oysters is on the increase. By distributing numbers of these in different parts of the bay the most suitable areas for spat collection have been identified (Fig. 4). Results over 3 years have shown that density is generally higher and lasts longer in the inner part of the bay. A significant exception to this is on the seaward side of the spit (site 4). Settlement here lasts as long as in the inner part of the bay but is particularly high from August to October. It is important to note that the most suitable areas for setting out cultch may not be directly adjacent to the natural population as one might expect, but rather may be more dependent on accumulations of the surplus spat in local currents.

Oyster larvae are conspicuously unselective in their choice of materials and



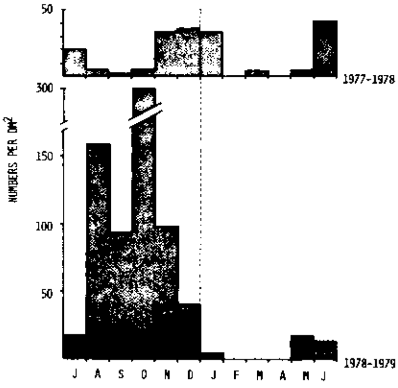


Figure 2. (Left) Numbers of *Crassostrea rhizophorae* planktonic larvae and spat in relation to environmental factors at Port Morant, April 1978 to March 1979.

Figure 3. (Right) Yearly variation in the density of spat settlement.

surfaces for settlement. Thus, in selecting artificial surfaces for settlement, the problem is not so much one of attractiveness to larvae, but rather the durability and convenience of the materials used, and their local availability. Coconut shells, reject plastic bottles, mangrove branches, bamboo and car tires were all tested (Table 1) and found to be attractive to settling spat. Many of them, however, have disadvantages in availability or handling characteristics. Coconut shells are too brittle, for example, while plastic bottles are difficult to obtain, and the oysters fall off easily. Mangrove branches, ostensibly the most suitable because of their similarity to the natural situation, lose their bark, and therefore the attached oysters, after some time. They are also very difficult to transport, and must have some shade in order to attract spat. Old or reject car tires have been identified as being most suitable as cultch. They are very cheap, extremely plentiful throughout Jamaica and all Caribbean countries, and are durable and reusable. Cut sections of side wall are best, though the heavier tread may also be used. The tires are cut into squares of 8 x 8 cm, and drilled in the center. These are then strung together with monofilament plastic line and are separated by 1 cm plastic spacers. Each string contains 10 pieces of tire cultch which is just enough to occupy the intertidal zone. Two weeks' immersion in the sea is necessary before tire pieces become attractive to settling spat.

When barnacle settlement is declining and the numbers of settling spat on the glass panels are increasing, the cultch are hung out in the intertidal zone from racks made of bamboo and mangrove. Both of these materials are readily available in the Port Morant area. The uprights (Fig. 5) are cut from white mangrove (about 8 cm diam.) and driven into the bottom so that approximately 1 m is clear above the

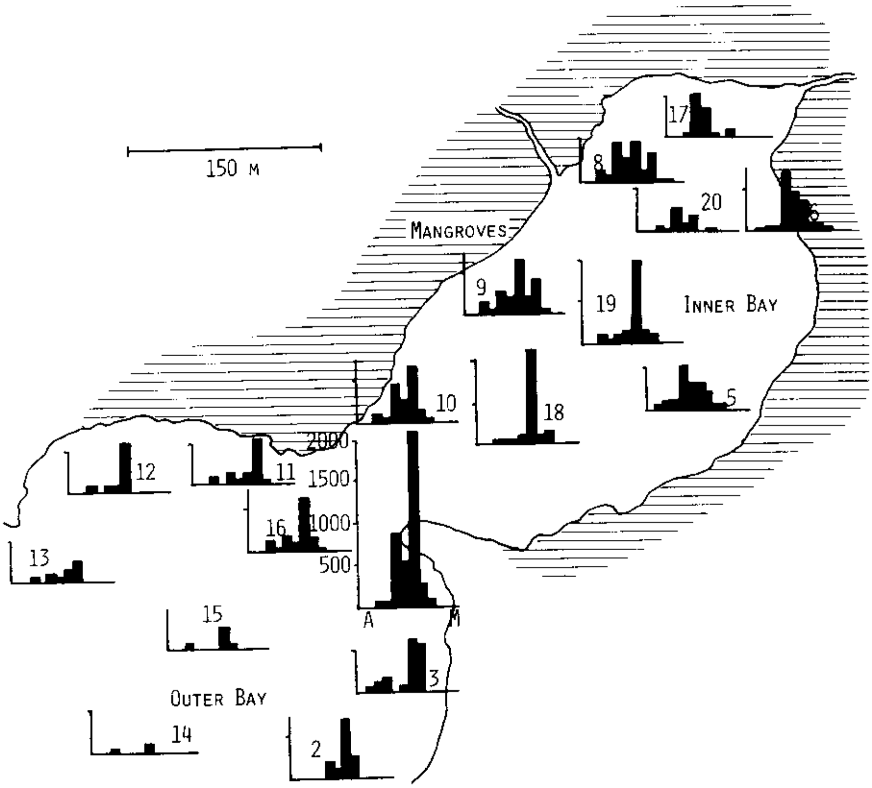


Figure 4. Settlement of spat on frosted glass panels in the inner part of Port Morant from April 1978 to March 1979. Numbers on each "y" axis are density of spat per DM^2.

surface. Each pair of uprights (1.5 m apart from each other) is connected by a horizontal bar constructed of the same material. Bamboos (about 10cm diam.), sun dried to prevent warping, are attached to the mangrove struts, and from these some 160 cultch strings are hung.

The time taken for each cultch to accumulate more than 10 oysters varies according to the intensity of the spatfall, though in the height of the season this can be accomplished in well under 2 weeks. The spatfall season may last 4 months; at least four removals of cultch for growing out are therefore possible, though poorly settled cultch are returned for further spatfall.

Present indications are that spat collecting facilities at Port Morant could be increased considerably without suffering a reduction in the density of settlement. There is, therefore, a very real possibility that if other areas in Jamaica (or elsewhere) have less viable parent populations, Port Morant could act as a very productive source of young oysters. Oysters will survive well for up to 3 days out of water, a feature which, combined with the ease of handling of tire cultch, makes

Table 1. Materials tested for their suitability as cultch and their advantages and disadvantages

Cultch	Advantages	Disadvantages
Coconut shells	Cheap Easily available Durable	Often have to be broken to remove oysters, therefore not re-usable Too brittle
Plastic bottles (Rejects)	Good substrate for spat collection Very durable & reusable Spat good for tray culture	Unpredictable supply Spat fall off easily when handled
Mangrove branches	Cheap Readily available Good intertidal settlement	Spat usually greatly clustered at the nodes, needs shade Outer bark sheds easily with age, larger oysters, and wave action Not re-usable and difficult to transport
Bamboo	Has natural curvature which minimizes silt	Oysters very difficult to remove Difficult to split and bore, to work with generally Not re-usable
Isognomon alatus shells	Numerous Excellent for collecting spat to be used in tray culture, can be easily broken up into spat-bearing pieces	Too brittle to work with in large quantities Not re-usable Difficult to bore
Tires	Cheap and plentiful Very durable and reusable Oysters easily removed without damaging Easy to work with and transport	Heavy

transportation of oyster-laden cultch relatively simple. The transfer of young oysters to other "growing out" areas in the island could well have the beneficial effect of eventually increasing spatfall in those localities by providing artificial parent populations.

GROWING OUT

Although characteristically an intertidal animal, *C. rhizophorae* thrives well in subtidal conditions (Siung, 1976). However, some Caribbean countries have

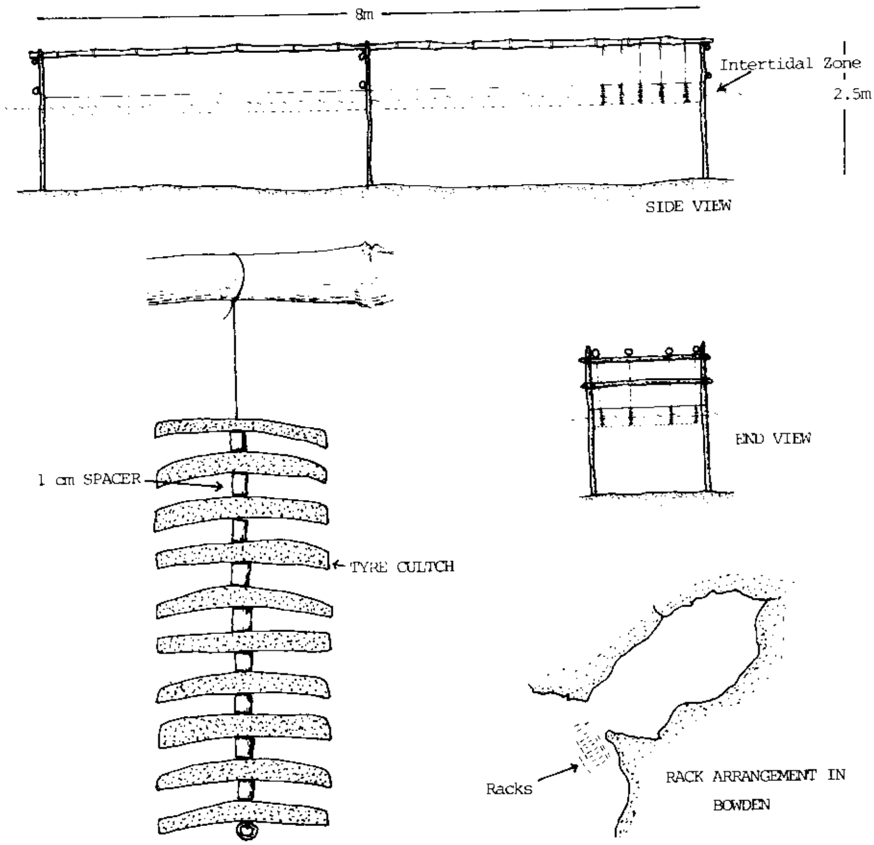
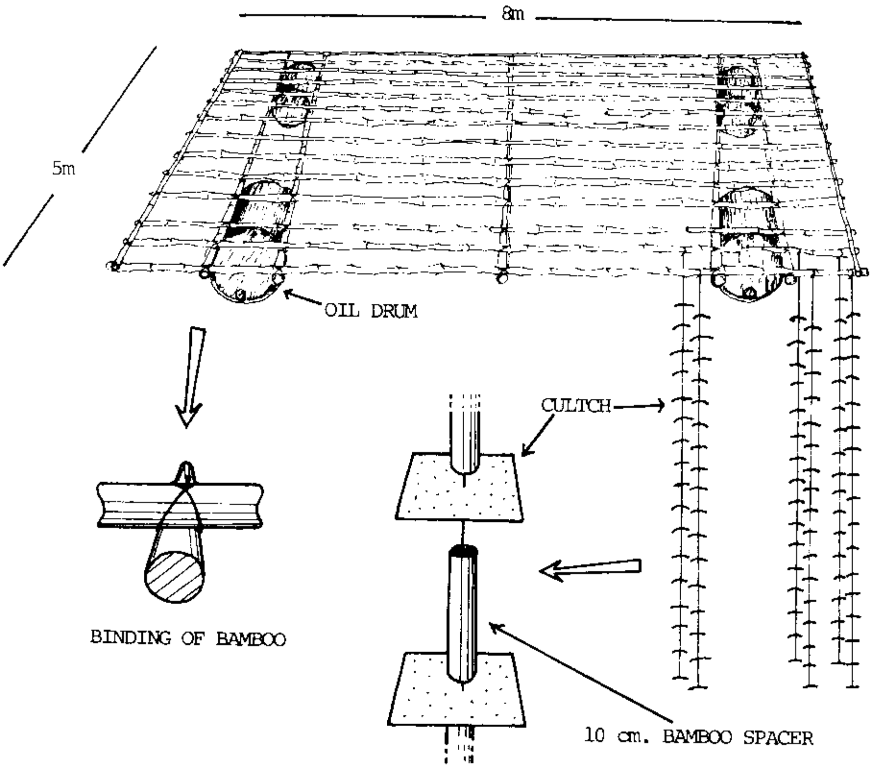


Figure 5. Rack construction and arrangement at Bowden.

concentrated their efforts in cultivating oysters intertidally. The narrow tidal range of Jamaican waters (24 cm) precludes this, so our main efforts have been devoted towards subtidal cultivation. Moreover, by subtidal cultivation the full water column can be utilized, and the permanent submersion permits virtually twice as much feeding time as in the intertidal position.

The removal of cultch from spat collecting areas to a very large extent depends upon the most suitable density for growing out combined with the rate of settlement on the cultch. A certain amount of mortality must be accounted for in the growing out phase (at Port Morant it is approximately 10 % over a 2-month period). However, if the density is too high, growth is generally inhibited and meat content likely to be lower (Mason, 1976). About five oysters per cultch has been found to be a satisfactory final density, producing well-formed oysters of some 70 mm in shell length after 6 months. Thus the preferred initial density is approximately 10 oysters per cultch.



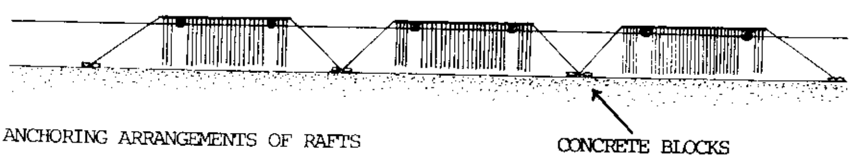


Figure 6. Raft construction and arrangement.

The oyster-laden cultch are restrung on long monofilament plastic 110-lb test line. They are also respaced with 10 cm bamboo rods to permit better water circulation. These are tied to bamboo rafts at intervals of 30 cm. The length of these lines depends on the depth of water the raft is anchored in, but about 0.5 m clearance is left between the lowest cultch and the bottom to minimize siltation, snagging and incursions by predators.

Fouling and predation are frequently a problem in growing oysters. In Port Morant two fouling organisms are noteworthy. In the upper, sunlit cultch, the green alga *Enteromorpha* sp. is particularly common. A more serious fouling agent, however, is the colonial ascidian *Hypergon* sp. which grows throughout the water column. This ascidian, which grows over the surface of the oyster shells, can rapidly smother large numbers of oysters. Other, solitary ascidians are less of a problem unless they occur in large numbers. The simplest and most effective method of removing these fouling organisms is to haul the cultch strings on to the raft and leave them exposed to the sun for 1 day. The oysters survive this treatment well while most sponges, algae and ascidians die. Active predation is less of a problem, but the presence of oyster drills (*Murex* sp.), the black conch (*Melongena melongena*), and crabs could perhaps cause future problems.

Construction of the cultivation rafts is achieved using materials which are readily and cheaply available in rural Jamaica. The rafts are of the Japanese "cantilever" type, which have a life span of well over a year and may survive severe weather conditions. Flotation for these rafts is provided by four 44-gallon oil drums which have been scraped clean of rust and painted with yellow chromate primer, an antirust paint. A grid of bamboos (sun dried to prevent warping) is constructed (Fig. 6) using 15 cm iron nails and 12-14 gauge wire to bind the joints. The weight of this grid holds the drums wedged in place while permitting their occasional rotation to prevent excess fouling. Two men can build the whole structure in 4 h. One raft holds 3,000 cultch, which is equivalent to the contents of three racks.

The rafts are anchored with nylon rope to concrete blocks each weighing about 80 lb. Rafts can either be anchored in lines, each raft sharing a pair of linked anchors, or can be connected into chains of four rafts, the end rafts being anchored. The latter method prevents the twisting and turning of individually anchored rafts, but renders them susceptible to damage from each other in strong winds.

Figure 7 shows the growth rates of oysters cultivated under these conditions at Port Morant. At present the current average size of "wild" oysters collected and sold by local oystermen is between 40-50 mm in shell length. One of the main aims of the project has been to improve on this size, and to produce oysters of between 70-80 mm in shell length, a size more generally marketed in other parts of the world. With the growth rates so far achieved this takes approximately 6 months. Comparison with the growth rates of cultivated *C. rhizophorae* achieved elsewhere in the tropics (Fig. 7) shows that the oysters at Port Morant perform fairly well.

Growth rates tend to vary at different depths. Fastest growth is achieved in the nutrient rich upper layers of the water column, and the slowest growth in the deeper layers probably due to siltation and reduced water movement. However, in a later paper, it is intended to show that differences in density of oysters on the cultch are more critical than the effects of depth and cultch arrangement.

Data on survival and growth rates of oysters in our cultures provide the basis for an estimation of the potential of a cultivation raft. The 3,000 cultch on one raft hold about 30,000 oysters at the onset of growing out. The 10 % bimonthly mortality will reduce this to some 20,000 oysters at the end of a 6-month growing season. Current prices for relatively poor quality wild oysters are about J$1.50 per dozen. At this price each raft can hold about J$2,500 worth of oysters.

This estimation of potential returns from a cultivation raft is based on cultch

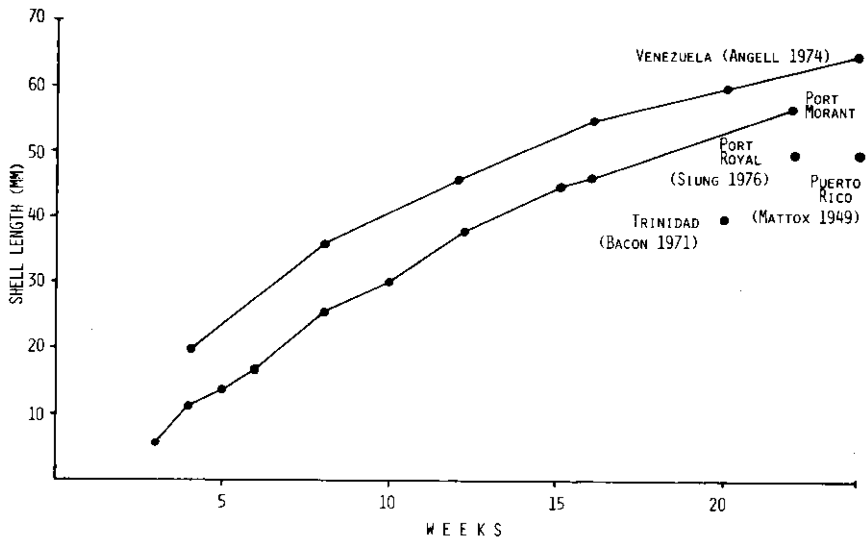


Figure 7. Growth of *Crassostrea rhizophorae* in Jamaica and other Caribbean countries.

strings spaced 30 cm apart on the raft and each cultch yielding not less than five oysters. Since it may be possible to increase the density of oysters on the cultch slightly and to reduce the spacing of cultch strings, the eventual harvest may be increased considerably. The likelihood of two harvests being obtained in a year may mean that the annual yield from a raft could reach about six times the figure quoted here. This, together with the fact that an oyster farmer could easily manage at least four rafts, makes oyster farming by this method a potentially highly lucrative trade.

DISCUSSION

The development of appropriate oysterculture techniques for Jamaica has stressed the utilization of local resources in all stages. The communities most likely to benefit from these techniques are relatively small, low income coastal communities, generally within relatively close access to a mangrove system. Such communities already exploit the mangrove ecosystem, obtaining fish, crabs, and wild oysters, as well as wood for construction. With very few exceptions (nails, antirust paint) all the materials are indigenous (Table 2) and are, to some extent, already used for other purposes. Thus the techniques described above tend to broaden the spectrum of local expertise rather than introduce new, possibly unfamiliar methods. Similarly, on the ecological front, disturbance of the mangrove system is minimal as it is the surplus, unsettled, planktonic larvae that attach themselves to the cultch. In some situations, the establishment of artificially cultivated populations in a bay or estuary may well be beneficial by enhancing the spat production of a less viable wild parent population. Moreover, the presence of large numbers of cultivation rafts may attract reef fishes into the area and so improve fishing stocks in inshore waters.

Table 2. Main materials used in oysterculture at Morant Bay

Materials	Source	Purpose
Tires: a) Reject	Goodyear tire factory	Cultch
b) Old	Local garages	Cultch
Mangrove wood	Local	Rack struts
Bamboo (large)	Local	Rack crossbars, rafts
(small)	Local	Spacers (also reject plastic tubing used for this).
Plastic monofilament line	Fisheries cooperatives	Cultch hanging
44 gal. drums	Oil and paint companies	Raft flotation
Nylon rope	Fisheries cooperatives	Raft anchoring
Cement, nails, wire, antirust paint	Local hardware stores	Anchors

To a very large extent the somewhat robust nature of *C. rhizophorae* has contributed significantly to the viability of the methods described. Its willingness to settle on virtually any surface has greatly simplified the task of selection of cultch material. Old car tires are available virtually everywhere in Caribbean countries, and can be reused more or less indefinitely, helping to reduce the costs of restocking cultivation rafts. They are also compact and strong, and the oysters attach themselves firmly, so that transport of oyster-laden cultch is a relatively simple matter. In such a manner successful experiments have been set up around the island, using oysters transported from Port Morant. Transportation is greatly facilitated by the fact that *C. rhizophorae* is an intertidal organism and is therefore well able to withstand exposure and dessication. This feature also contributes to the ease with which subtidal fouling organisms can be killed by dessication, while the oysters remain unharmed.

Although the oyster is characteristically an intertidal species, its ability to thrive subtidally is critical to the success of the farming methods described. Not only is there greatly increased feeding time due to the constant submersion, but the use of the full water column is particularly important economically, permitting a much more efficient use of any given area of water. This is of particular importance to the local artisan for whom the preparation of cultch, rafts and racks represents a significant investment.

Using the techniques described above, oysters can be grown to a marketable size in 6 months. Each raft therefore may be able to produce two crops in a year. At present virtually all the oysters consumed in Jamaica are half-shelled oysters, collected from wild populations, and sold at a size considerably smaller than that recommended by most traders in other parts of the world (Medcof, 1961). The larger cultivated oysters (70-80 mm) represent a considerable improvement on this, and are likely to be rewarded by a good price in the hotel and restaurant trade. A considerable potential market exists in the form of canned or frozen oyster meats. Here the external appearance of the oyster is immaterial, and the time of harvesting is more dependent on the yield obtained in relation to growing time than to absolute size (Nasciemento et al. 1980). This could provide an outlet for those oysters that fail to meet the more stringent demands of the half-shell trade.

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LITERATURE CITED

Angell, C.H.L.
1974. Crecimiento y mortalidad de la ostra de mangle cultivada (*Crassostrea rhizophorae*). Sep. de la Memoria. Soc. Cien. Nat. La Salle. 49: 1-11, Venezuela.

Bacon, P.R.
1971. Studies on the Biology and Cultivation of the Mangrove Oyster in Trinidad with notes on other Shellfish Resources. Tropical Sci. Vol. XII (4): 265-278.

Mattox, N.T.
1949. Studies on the biology of the edible oysters. *Ostrea rhizophorae* (Guilding) in Puerto Rico. Ecol. Monogr. 19 (4): 339-356.

Mason, J.
1976. Mussel Cultivation. In Marine Mussels. Ed. Bayne, B.L., I.B.P. (1976).

Medcof, J.C.
1961. Oyster farming in the Maritimes. Bull. Fish. Res. Board Can. 131: 157 pp.

Nikolic M., A. Bosch, and S. Alfonso.
1976. A system for farming the mangrove oyster *Crassostrea rhizophorae*. Aquaculture 9 (1): 1-18.

Nasciemento, I.A., S.A. Pereira, R.C. Souza.
1980. Determination of the optimum commercial size for the mangrove oyster (*Crassostrea rhizophorae*) in Todos os Santos Bay, Brazil. Aquaculture 20: 1-8.

Siung, A.
1976. Studies of the biology of three species of mangrove "oysters" (*Isognomon alatus* Gmelin, *Crassostrea rhizophorae* Guilding and *Ostrea equestris* Say) in Jamaica. Ph.D. Thesis. Zoology Department, University of the West Indies.