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Solutions to the 'Tragedy of the Commons': Sea Urchin Management in St. Lucia, West Indies

Allan H. Smith, M.Sc. (McGill)
Caribbean Natural Resources Institute
Clarke Street, Vieux Fort
St. Lucia, West Indies

and

*Fikret Berkes, Ph.D. (McGill)
Professor
Institute of Urban and Environmental Studies
Brock University
St. Catharines, Ontario L2S 3A1
Canada

Please address all correspondence on the manuscript to Berkes

INTRODUCTION

According to the "tragedy of the commons" model of Hardin (1968), commonly owned scarce natural resources are destined to be overexploited, as allegedly in the case of the medieval English grazing commons. The model has been useful in drawing attention to the fact that completely free and open access to a resource invites non-sustainable use. More generally, the "tragedy of the commons" model has focussed attention on difficulties inherent in the management of all common property resources --- fisheries, grazing lands, forests and water. Common property is defined here as a class of resources in which (1) the control of access (or exclusion) is difficult, and (2) each user has the potential of subtracting from the welfare of all other users (Berkes et al., 1989).

The original and subsequent formulations of the "tragedy of the commons" (Hardin, 1968; Hardin & Baden, 1977) have been criticized for allowing for only two options in solving the commons problem. The first type of solution is the privatization of the resource. This is relatively easy to do with terrestrial resources such as farm lands; for marine resources, assigning quantitative harvest rights (individual transferable quotas) serves the same purpose (Dewees, 1989). A second possible solution is government control of the resource and the regulation of the users by government agencies to assure sustainable use. Marine resource management in much of the world has opted for the second solution, and employs the necessary government research,

management and enforcement infrastructures.

There is, however, a third possible solution to the commons problem, as has been suggested by an increasingly large number of workers: community-based management or communal property (res communes) systems (National Research Council, 1986; McCay & Acheson, 1987). Further, it has been argued that community-based systems of resource use, some of them traditional, already exist in many rural areas of the world and that their potential role in resource management has generally been underestimated (Berkes, 1989; Johannes, 1989).

Do any of these three potential solutions actually result in the long-term sustainability of a given resource, as compared to its unrestricted use under open-access (res nullius) conditions? Even though there is a very large body of literature on the management of various types of common property resources, such as fisheries, forestry and grazing lands, there are few cases in which the "tragedy of the commons" and its solutions have been investigated systematically by the use of biological data. In the field of fisheries, the only case we know of in which this question has been asked and actually tested with field data is the Maine lobster fishery.

The Maine study compared two types of lobster fishing areas. In fishing areas in which lobstermen defended their territory along its entire boundary ("perimeter-defended territories"), the catch per unit effort was significantly higher, and the average size of lobsters was greater, than in areas where the lobster

territories of adjacent communities ("nucleated territories") graded into one another with no defense of the territory along its boundary (Wilson, 1977; Acheson, 1988).

It should be noted that in Maine, territories are enforced by communities ("harbor gangs") of lobstermen, and not by government agencies, which do not even recognize the existence of the territories. There are of course other kinds of government regulations that apply to lobster fishing, and hence the resource is under both communal (res communes) and government (res publica) management. The comparison of the two kinds of lobster fishing areas is relevant to the question of testing the "tragedy of the commons" because the data show that restriction of access results in better management compared with the case in which access is relatively easier for fishermen of adjacent areas. Nevertheless, even "nucleated territories" by no means represent a res nullius situation.

In the present study, data on sea urchin population density at three separate geographical sites were used to compare the outcome of restricted access, as opposed to open access, in maintaining productive stocks of the resource. At two of the sites, access is restricted by two different kinds of management regimes. The first is government control of the waters of a nature reserve and the second is communal control of a bay. This study thus goes one step further than the Maine lobster case in comparing the outcomes of two potential solutions to the commons dilemma.

THE SEA URCHIN RESOURCE

Exploitation

Eastern Caribbean fisheries are by law open-access, whereby anyone who chooses to fish can do so (Goodwin et al., 1985). There are a few exceptions involving community-based access restrictions in the Caribbean region, such as the communal fishtrap (potfishing) territories in Jamaica (Berkes, 1987), and local informal rules for inshore fishing in Dominica (Wylie, 1989). In general, eastern Caribbean governments have encouraged new entrants into the fishery and the deployment of greater fishing effort through the use of larger boats and new technology with the objective of achieving self-sufficiency in fish production. There are season and area restrictions and size limits for a number of species, but such indirect effort controls are not intended to substitute for the control of the total number of entrants into a fishery.

St. Lucia (Fig.1) shares with its neighbours an open-access policy to marine resource development, and an over-fished nearshore area (Goodwin et al., 1985). However, compared to many other eastern Caribbean islands, the nearshore fish stocks of St. Lucia and a number of non-fish marine resources used as human food are probably not as badly depleted. Management strategies for important species such as turtles, conch and lobster have included combinations of closed season, minimum size and weight

limitations and protection of gravid (egg-bearing) females. In response to declining wild stocks of seamoss, various species of the red algal genus Gracilaria that are in great demand for the preparation of drinks, a programme of commercial mariculture development has augmented the natural supply of the resource (Smith et al., 1984; Smith, 1989).

The white-spined sea urchin is harvested in many Eastern Caribbean islands, where the gonads of both sexes are a delicacy. It is known as sea egg in English, chadon in St. Lucian creole and oursin blanc in French. The species is most abundant in shallow water, and harvesting in St Lucia is done by free-diving, either by swimming from shore of from dugout canoes. Methods of preparation vary among the islands. In St. Lucia carefully opened tests are filled with the gonads of a number of animals and cooked over a fire and sold for EC$ 5.00 (US $ 1.85) each. Gonad size varies with season and approximately 5 to 10 urchins are needed to fill a test of 100mm diameter.

The St. Lucia sea urchin resource seems to have been used sustainably until recent years. In the past sea urchins were collected by family groups, and harvesting took place mainly during school vacation months. Parents and children shared the work of diving, collecting, cleaning and cooking the sea eggs. At least in the south of the island, the major harvesting area, traditionally most harvesting took place over a two-month period, allowing the resource to grow back over a ten-month period.

In more recent years, sea egg collecting has become a commercial venture rather than a family-based subsistence activity. Since prices were relatively high and demand exceeded supply, sea urchin collecting attracted many young and underemployed people looking for a part-time income, and year-round harvesting became common. Considering that three to four sea eggs sold for the equivalent of one day's wages for a banana worker (EC $15 to 20 or US $5.55 to 7.40), the potential incomes were attractive. In islands such as Barbados and Martinique in which sea eggs had been depleted earlier, the prices were even higher, as much as six to nine times higher in Martinique as compared with St. Lucia.

Sea egg populations in St. Lucia were severely affected by hurricanes in 1979 and 1980. Their recovery by 1983 was followed by uncontrolled harvesting and severe depletion of stocks in many areas by late 1986 (A.H. Smith, unpublished). The Government of St. Lucia responded by imposing a total ban on harvesting in December 1987 for the protection of remaining stocks..

Biology of a Vulnerable Species: Tripneustes ventricosus

The white-spined sea urchin is a shallow-water species. It occurs most commonly on rocky bottoms or loose broken rock supporting heavy growth of algae, and in sea grass (Thalassia testudinum and Syringodium filiforme) beds (Lewis, 1958; McPherson, 1965; Cameron, 1986). Although some individuals occur

in waters as deep as 25m in St. Lucia, the bulk of the population is found in waters of less than 6m, clearly within free diving depths. This species is therefore vulnerable to over-harvesting but appears capable of rapid recovery if protected (Goodwin et al., 1985).

Reproduction in L. ventricosus was found to be seasonal in Barbados, with the peak of spawning occurring in July and early-August (Lewis, 1958). However, there may be is some reproduction year-round in many populations as shown for example by McPherson (1965). Hence, a certain fraction of the population would contain mature gonads at any given time of the year. The larvae spend a relatively long time in the plankton, four weeks or more (Lewis, 1958; Cameron, 1986). Gonads begin to ripen about half way through the first year of life, and the sea urchin reproduces at one year or age, at a size of 5-8cm diameter (Lewis, 1958).

The Barbados government had instituted a closed season for L. ventricosus from May to September, beginning in the 1950's. Yet harvesting pressure was so heavy that by November, the year-old group would be fished out in many localities where the populations would consist only of juveniles which had settled during the summer (Lewis, 1958). All fishing was eventually banned (1987) in Barbados, in an attempt to rehabilitate L. ventricosus populations.

Since sea egg collectors look for gonads, year-round collecting, as was the case in St. Lucia before the ban, not only removes the ripe individuals from the population but also results in the destruction of many young individuals with non-ripe

gonads. Further, as the population is gradually depleted, collectors turn to progressively smaller sea urchins, many of them likely to be immature.

METHODS OF STUDY

Populations of L. Ventricosus were studied at three locations in St. Lucia: within the Maria Islands Nature Reserve, Laborie Bay and Anse La Raye (Fig. 1). These have been important commercial harvesting sites. The commercial harvest at the Maria Islands was greatly reduced after the establishment of the Nature Reserve and virtually ceased by 1987. The other two sites were not under any legal protection or restriction until the nation-wide ban on the harvest of sea urchins in December 1987.

Urchin densities were estimated each month at the three sites using belt transects, which have been employed successfully with other urchin species (e.g. Vadas et al., 1982). The belt width was 2.0m but this was reduced to 1.0m when visibility was low due to rough water conditions. Belt length varied from 140 to 280m, with counts summed every 10m. The minimum diameter of animals in the counts was between 5 and 10mm.

Information on the harvesting and marketing of sea eggs was obtained from informal discussions with harvesters.

RESULTS

Maria Islands Nature Reserve was established in 1982, but the marine boundaries were not finalized until 1988. The sea urchin population is located approximately 600m offshore, and thus not readily accessible to swimmers. Sea egg collecting continued after 1982 by relatively few people. However, the harvests were large because collectors used boats, supplying a market in Martinique through a local dealer. This trade largely ceased after May 1987. Population density at Maria Islands varied with time. Lowest densities were seen from June to August, 1987, and in October, 1988, being less than 0.2 urchins.m^{-2}. Highest densities were noted in November, 1987, and July and December 1988, with densities above 6.0 urchins.m^{-2} (Fig. 2).

Aupicon was a heavily used sea egg collecting area after T. ventricosus populations recovered in 1983, following the destruction caused by hurrican Allen of 1980. Sea egg collecting in Aupicon was completely free and open, and no formal or informal controls of any sort were in force. During the period of study, harvesting continued throughout the year. By early 1987, the population density at Aupicon (Fig.2) had been reduced to less than 0.1 urchins.m^{-2} and remained below that level throughout 1987 and 1988 because of continued illegal harvesting despite the ban. There were no marked seasonal increases in abundance and thus recruitment appears to have been minimal in both years.

Laborie, a community of about 800 people, was unusual in that it retained the traditional school vacation summer harvest of the sea egg. As practiced at least for the past 60-70 years, a

communal harvest took place for about one month preceding the start of school. At other times of the year, sea egg collecting was not allowed, either for local residents or for outsiders. The community was able to enforce this informal "closed season" fairly well in the small bay on which Laborie is located.

Informants did not consider the practice at Laborie to be "conscious management" of the resource: "it was just done that way". Since sea urchin collecting and processing is labour-intensive, it made sense that the open season coincided with the last month of availability of the school children.

Urchin population density at Laborie remained above 3.0 urchins.m^{-2} in the first half of 1988, decreasing to less than 1.0 urchins.m^{-2} in October and November, followed by a peak above 5 urchins.m^{-2} in January 1989.

DISCUSSION

There was an evident increase in harvesting of the Maria Island population in 1986, in response to access to the Martinique market provided by a local intermediary. As a result of the concern in the local press early in 1987, this export ceased and there was, therefore, negligible harvesting in the 1987 season. Following the moratorium imposed by the government at the end of 1987, and with increasing awareness of the restrictions that applied within the boundary of the Maria Islands Nature Reserve, there was no harvesting in 1988. The increase in population density at the end of each year indicates recruitment of juveniles to the population.

Ongoing harvesting of the Laborie population continued through 1987, under community control. In 1988, the first year of the closure, population density was similar to that at Maria Island, indicating successful recruitment in 1987 and 1988. Ongoing harvesting under community control, therefore, permitted the annual increase in population density necessary for sustainable exploitation.

The uncontrolled year-round harvest at Aupicon resulted in a very different sitatuion. Population density was reduced to a very low level and annual recruitment was minimal. This low population density can be attributed to the harvesting regime rather than to the suitability of the habitat. Reports of harvesters, and the vast amount of test remains from harvests in earlier years, both confirm the past importance of this area as a harvesting site. Further, while variation in currents could result in between-year variation in recruitment, this is unlikely to have been the cause in the present case given the evidence of strong recruitment at the nearby Maria Islands population.

Common property resources such as fisheries, grazing lands, forests and water often have to be shared among a number of interdependent users. This leads, on the one hand, to a divergence between individual and collective rationality; there is always a tendency towards a " tragedy of the commons". But, on the other hand, interdependance of users is a condition that is likely to select for systems of cooperation that would lead to the sustainable utilization of the resource in the long-term (Gadgil, 1987). If effective local institutions and management systems based on the cooperation of users exist, or if remnants

of such systems can be rehabilitated, this would greatly simplify the task of resource management. Both the World Conservation Strategy (1980) and the World Commission on Environment and Development (1987) make the argument that resource conservation stands a better chance of success if it benefits local communities and if users are involved in the management of resources.

In the present study, the Aupicon case is an example of the conditions leading to the "tragedy of the commons". The individual users know that harvesting too many or taking undersized sea eggs will be against all users' best interests in the long run, but each user has no other option but to take all he can because what he leaves behind may be taken by someone else the next day. There is neither sufficient community pressure nor sufficient enforcement of government regulations to conserve the populations. The data clearly show resource depletion and continuing low levels of the sea urchin population.

In the Laborie case, the biophysical environment is not unlike Aupicon, and the users are much the same kind of people. But the outcome is very different because the rules of the game are different. Whereas Aupicon was characterized by an absence of property rights over the resource, there are property rights in Laborie Bay. The community controls the area and the resource, and is able to enforce its own informal rules. Such community-based management helps counter individualistic tendencies at the expense of collective benefits. An individual harvester can afford to show restraint because everyone else does: and if he does not, he may encounter social disapproval of his actions.

When the traditional harvesting time comes, the resource is plentiful, equitably shared, and there is little point in harvesting undersized urchins, which will in turn provide a good crop for the following year.

In the Maria Islands case, population density data show that conservation efforts have been successful, and that the "tragedy of the commons" has been avoided. The data indicate similar population densities in the two success cases even though there are no government officers to enforce the boundaries of the reserve. The planning of the park had involved a considerable effort to obtain local participation in decision-making, so the park boundaries are generally backed up with local social approval and are informally protected by fishermen and other resource users. The individual users may not themselves be in full support of a marine reserve which is out of bounds for harvesting. But if they cannot harvest it themselves, they would like to make sure that others do not, either.

The Laborie and Maria Islands cases provide examples of sustainable resource use under communal property and state property regimes, respectively. The third possible solution to the "tragedy of the commons", which is the privatisation of the resource, is not represented in this study. Consider, for example, the leasing of Laborie Bay or some other productive resource area to an individual or corporation, conferring to it full and exclusive rights of resource harvest. Such an arrangement would be an example of the privatization solution. Another example would be the leasing of oyster beds, as done in many countries. St. Lucia's Fisheries Act of 1984 does not have

provisions for leasing exclusive harvest rights of wild populations, but its Article 21 provides for the leasing of aquaculture grounds.

The results of this study support the suggestion that, under certain conditions, community-based management or communal property (res communes) systems provide a solution to the commons problem. This is not to say that community-based management is always effective. There are many cases in which communal property systems have broken down under conditions of population growth, commercialisation and technology change (Berkes, 1989), or for reasons related to the inability of the community to maintain appropriate institutions (Ostrom, in press). But by the same token, the other two possible solutions, privatisation of the resource and government controls, do not always work either.

Several case studies, many of them from Third World countries, indicate that centralizing resource management decision-making, replacing existing local-level controls with government controls, and nationalizing resources are often unsuccessful (Berkes, 1989). Third World governments, often pressed for funds, are rarely able to provide for the necessary research, management and enforcement for the conservation of a given resource. In the present study, resource conservation by government regulation in the Maria Islands Nature Reserve was successful, in the absence of effective government enforcement infrastructure, only because significant segment of local public opinion favoured conservation.

Many conservationists and resource managers are abandoning the assumption that commonly owned resources are destined to be overexploited. Many resources, by nature, require collective action for their use because of the interdependency of the users. Many such rural resources throughout the world continue to be held communally and used sustainably (McCay & Acheson, 1987; National Research Council, 1986). The policy implications of these findings is that community-based systems and co-management with complementary government and local responsibility, as in the case of Marie Islands, may be more promising for sustainability than previously recognised.

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SUMMARY

Possible solutions to the commons problem have rarely been investigated systematically by the use of biological data on the status and sustainability of the resource. The edible sea urchin (Tripneustes ventricosus) resource of St. Lucia, West Indies, on which we have carried out such a study, is highly prized but

vulnerable to exploitation because of its shallow water distribution. In the southeast of St. Lucia the resource was depleted in the study area in which access was free and open. It remained sustainable in the other two areas in which there were access controls. In one case, the area was under government control as a marine reserve, a measure that enjoyed local support; in the other, there was a locally practiced "closed season" and community-based management of access into a bay. The results indicated that both government controls and informal, community-level controls can lead to successful resource management outcomes. These findings challenge the conventional wisdom that commonly owned resources are destined to be overexploited.

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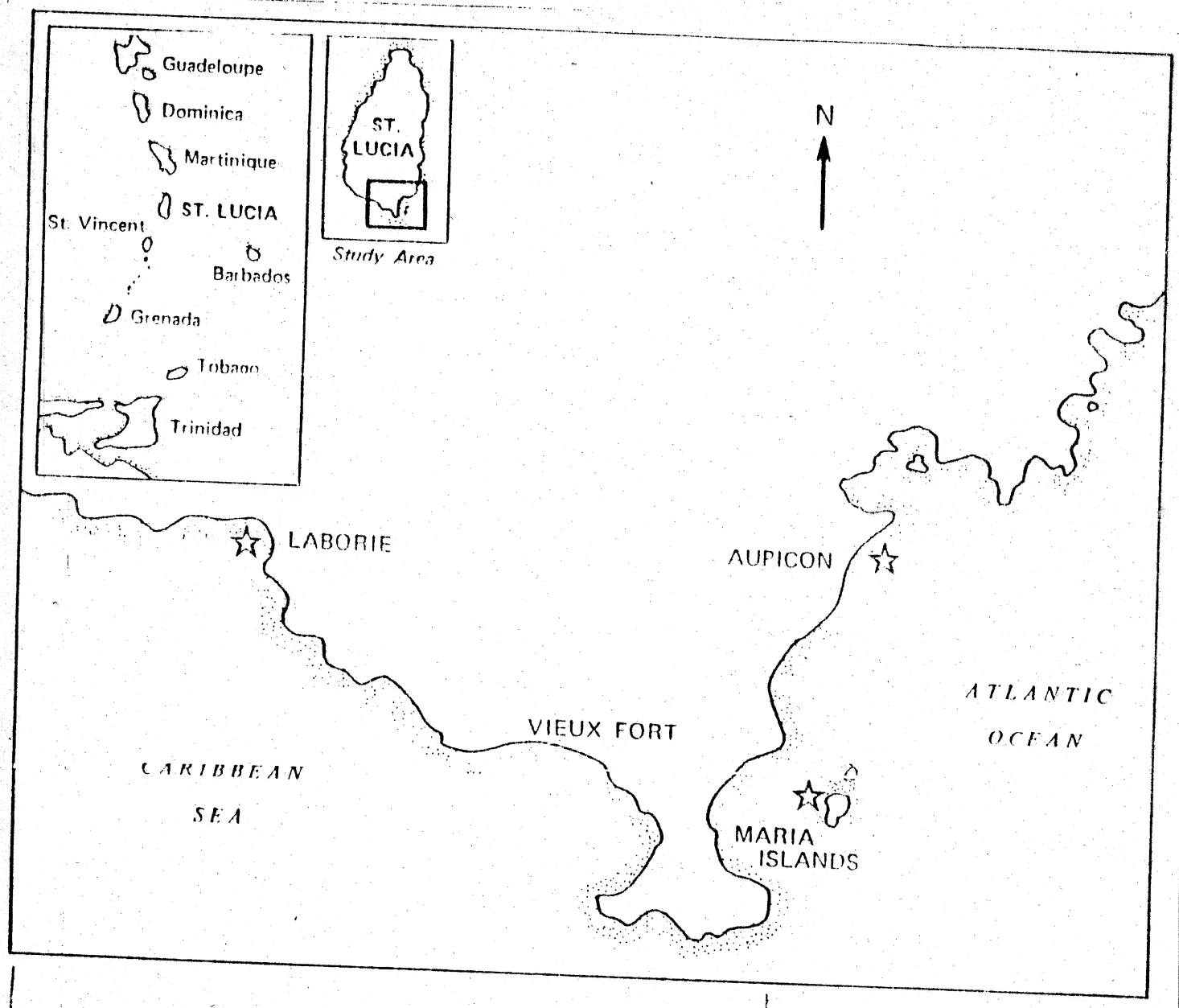

Fig. 1 Location of study sites.

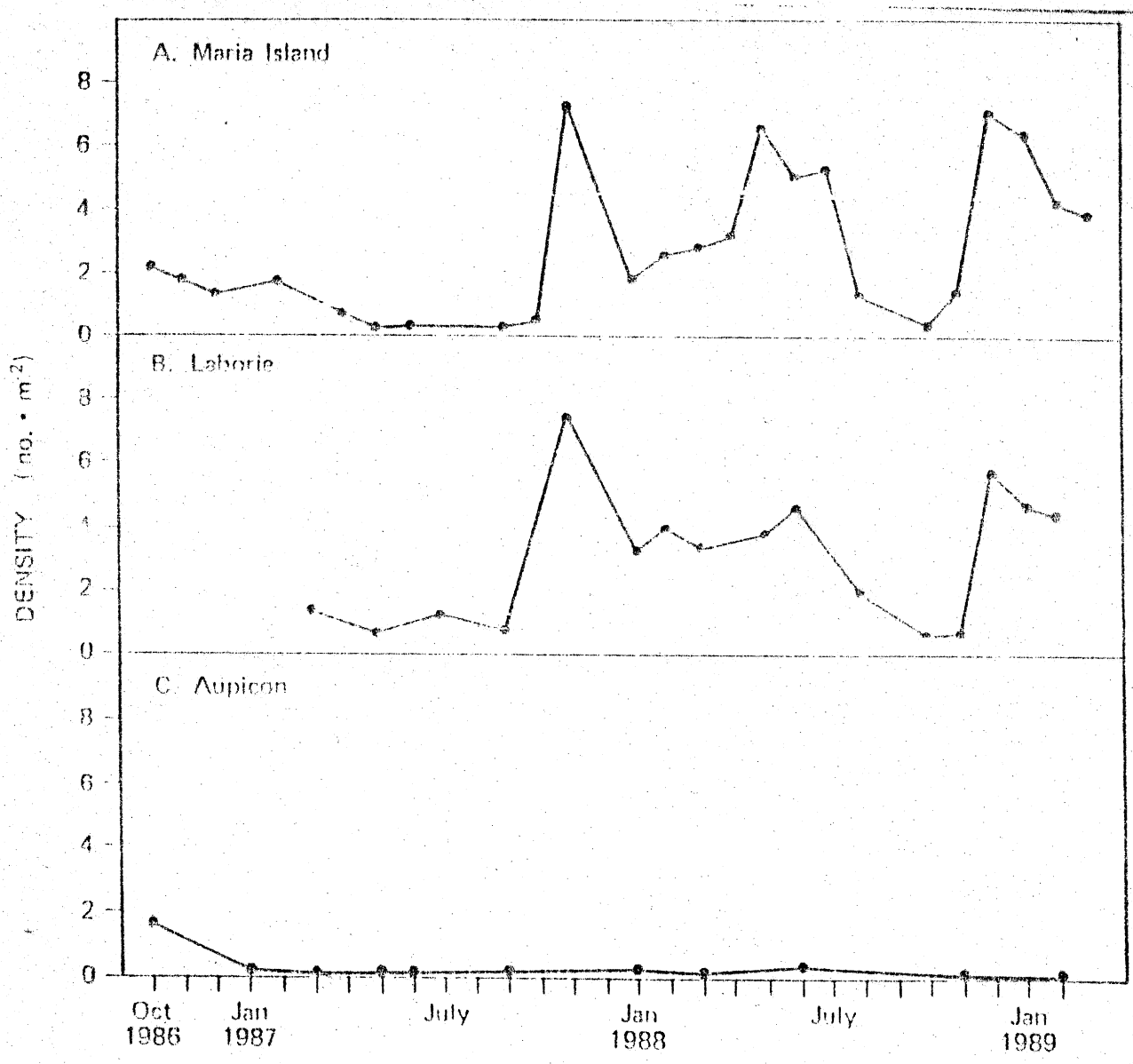

Fig. 2 Mean sea urchin density ($no.m^{-2}$) by month at three sites in St. Lucia. (A) Maria Islands, (B) Laborie and (C) Aupicon