Assessment of Mechanical Transplanting as a Means of Rehabilitating Intertidal Oyster Beds

V.G. BURRELL, JR., J.J. MANZI and C.B. O'ROURKE
South Carolina Marine Resources Research Institute
Charleston, S.C. 29412

ABSTRACT

Seasonal transplants of intertidal oysters by mechanical harvester were made on South Carolina oyster beds to determine the effectiveness of this method for the intertidal oyster industry. Oysters were mechanically removed from a dense intertidal oyster bed and replanted on depauperate beds during summer (1986), winter (1986), spring (1987), and summer (1987). Monthly growth and mortality were determined by tagging a group of oysters at the upper and lower intertidal zone at each reception site and comparing this to undisturbed tagged oysters at a control site. The occurrence of disease and the physiological condition were monitored at each site on a monthly basis. A massive oyster kill along the South Carolina coast in the summer, 1986 resulted in loss of the first transplanted population. A new control, harvest and reception (transplant) site was established for subsequent transplantings.

Growth was higher and mortality much lower in the lower intertidal zone than in the upper intertidal zone at both the reception and control sites during the period of study. Mortality was nearly 100% in the upper intertidal transplants during the summer season. Disease and condition index were not greatly different between sites and, therefore, differences in growth and mortality could not directly be attributed to them. Results thus far indicate that the mechanical harvester has potential for rehabilitating oyster grounds that have been overfished or depopulated by a die off. For the seasons tested to date, plantings are successful in the lower intertidal zone, but not for the upper intertidal area. All study sites must be monitored until oysters reach harvest size in order to determine the economic viability of this method to the commercial sector.

INTRODUCTION

The oyster landings in the South Atlantic region have decreased from nearly 20 million pounds in 1908 to less than two million pounds in 1984 (Burrell and Manzi 1985). Although there are several reasons for this decline, low oyster quality and shortage of labor in the harvesting sector are primary factors (Burrell 1982, Cowman 1982, Maggioni and Burrell 1982, and Munden 1982). Both of these problems stem from the fact that greater than 95% of the oysters in the region grow in the intertidal zone (Burrell 1982, Lunz 1950, and Smith 1949). The intertidal oysters grow in clusters because the spawning season is long (May to November) and successive spawn attach to the most available substrate which is usually other oysters. These cluster oysters are elongate, thin shelled, low yielding, and generally unsuitable for the high priced shucked and half shell markets, particularly if the beds are not harvested on a very regular schedule. Intertidal oyster harvest is traditionally a very rigorous and labor intensive process. Oyster harvesters ground their boats on an oyster bed at low tide and pick oysters by hand until a rising tide once more floats the boat and the load is then returned to an offloading site. Weather and time of day of tides often limit working time and production and, therefore, earnings of the harvester. This along with the hard labor involved have greatly reduced the number of recruits to this sector of the oyster industry, and has, in turn, prevented many oyster beds from being harvested on a regular basis. These beds have become even more crowded, further reducing the quality of the oysters present.

The South Carolina Wildlife and Marine Resources Department has obtained a mechanical oyster harvester designed by Clemson University primarily to be used on intertidal beds. Studies have shown that this machine does not cause undesirable long-term impacts on the resource (Manzi *et al.*, 1985). We conducted a study to test the harvesting efficiency of this machine and to develop techniques and protocols that would be used in a long-term program to upgrade intertidal oyster beds and, thereby, help revitalize the industry.

Study Objectives

1. To determine growth and survival of mechanically transplanted intertidal oysters.
2. To determine effect of mechanical transplanting on disease resistance and condition index in intertidal oysters.
3. To determine best season, areas, and best elevation in the intertidal zone to mechanically transplant oysters.

MATERIALS AND METHODS

Transplants using the mechanical harvester were made in summer 1986, and winter, spring and summer 1987 from harvest sites to reception sites in the Folly River, South Carolina system (Figure 1). The oysters were removed from intertidal beds onto barges and washed from the barges by a water cannon at reception sites (Figure 2). The harvest, reception (replant) and a control (undisturbed) site were surveyed prior to transplanting. All oysters at the first sites (summer 1986) died off and new control, harvest and reception sites had to be established. An attempt was made to transplant 250 bushels in an area marked off at the reception site, but when mechanical problems prevented this, the size of reception site was reduced so that the after planting density was approximately that of the control site. Oysters were spread over the intertidal zone so that high and low areas received approximately the same density of oysters. Three to five bushels of oysters were taken from the conveyor belt during each harvest and sampled to determine live/dead ratios, percent damaged and average oyster size. Fifty oysters were returned to the laboratory immediately after planting and monthly thereafter for determination of incidence

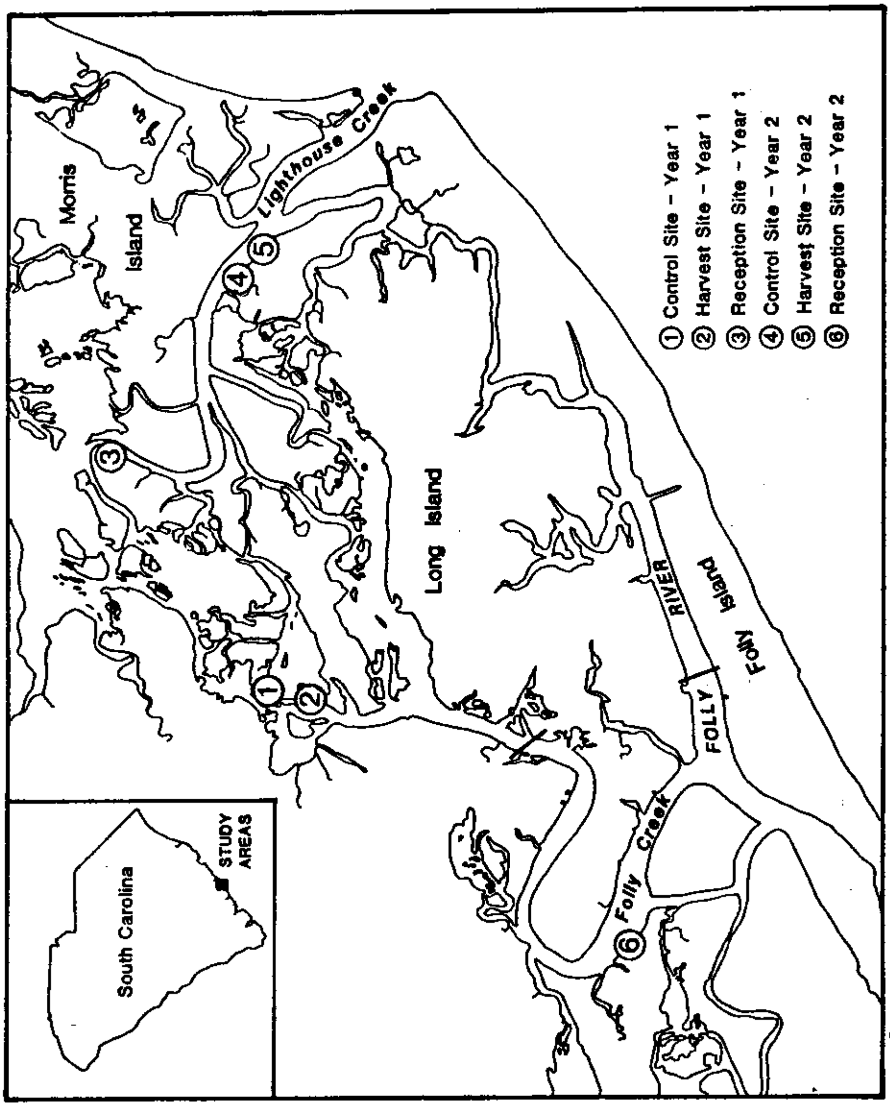

Figure 1

Figure 1. A map of the Folly River, South Carolina system showing the location of control, harvest, and reception sites.

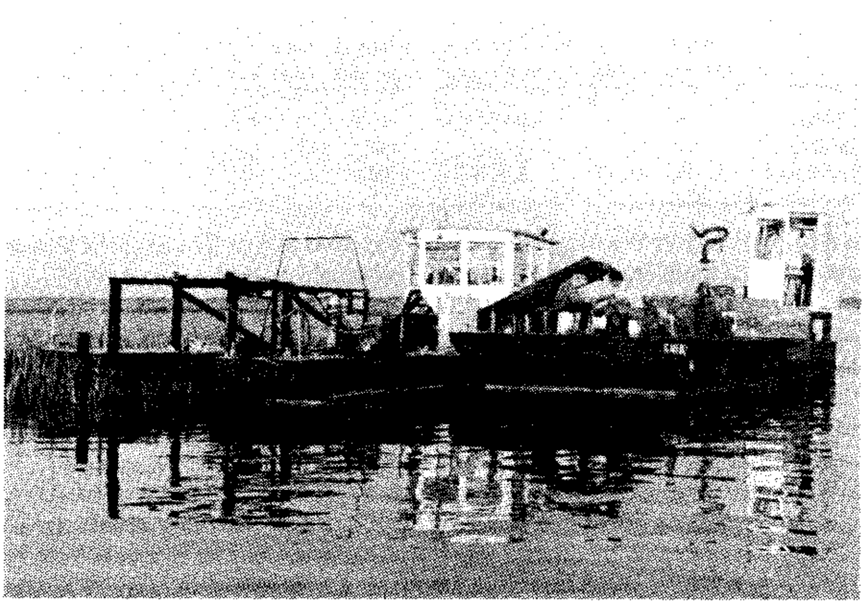

Figure 2. The mechanical intertidal oyster with a partially loaded barge alongside. The water cannon used to wash oysters overboard is mounted just forward of the house on the barge.

of *Perkinsus marinus* (Dermo) and condition index using the techniques of Ray (Quick and Mackin 1971) and Mann and Glomb (1978), respectively.

In order to monitor growth and mortality, 200 oysters were tagged at the control site and 300 tagged during each harvest and placed at the appropriate reception sites. Tagging was accomplished by affixing numbered plastic ovals to each oyster using epoxy adhesive. Tagged oysters were checked monthly for growth and mortality. More oysters had to be marked and placed in the upper intertidal transplant zone to keep pace with mortality in the spring transplant.

RESULTS AND DISCUSSION

Estimates of live oysters per bushel of transplants were low, probably reflecting the general die off experienced in summer and fall 1986; however numbers were adequate for the experimental design (Table 1).Oysters damaged by the harvesting process were high. Loss from this source, however, may be

Table 1. Oysters sampled from each harvest prior to planting.

	No. of bushels sampled	No. of oysters per bushel	x length in mm	Percent live per bushel	Oysters damaged per bushel
Winter	5	372.4	37.4	77	11.0
Spring	3	378.0	38.2	56	13.0
Summer	5	576.2	38.8	70	15.2

reduced by lengthening escalator pick up unit. This will reduce angle of belt and cut down on tumbling of oysters as they are brought on deck.

Survival of transplanted oysters was much greater in the lower intertidal zone than the higher intertidal zone (Table 2). This appears to be related to temperature and time for exposure above water because most deaths occurred as the water temperature increased in late spring and early summer. Control oysters in the upper intertidal zone survived much better than did the upper intertidal transplants indicating that being moved had adversely affected the oysters.

Density at reception sites after transplanting was less than that of the control site, so mortalities could not be directly attributed to crowding (Table 3). The effect of unfavorable orientation after planting could not be assessed from our sampling, however some loss from smothering is expected in relay of oysters. This may account for the slight higher mortalities observed in lower intertidal transplants than in controls.

Percent infection of oysters by *Perkinsus marinus* (Dermo) was initially lower in transplant oysters than controls, but equalized in subsequent sampling (Figure 3). Intensity of infections roughly paralleled that of percent infection in the winter transplants, but in spring transplanted oysters infection remained lower than controls (Figure 4). *Perkinsus marinus* infection and intensity both increased in controls and transplanted oysters with increase in temperature along with increase in mortality in all oysters. Percent infection and intensity was not appreciably higher in transplants than in controls so indications are that if

Perkinsus was a major cause of mortalities; resistance to the effects of this parasite was lowered by transplanting oysters to the high intertidal zone. Condition index of transplants generally was lower than that of the controls, with a drastic decline between June and July in the winter transplants (Figure 5). This again might reflect the trauma of moving oysters and contribute to high mortalities in the upper intertidal zone at REO1. Declining condition index, however, is associated with spawning which is very protracted in intertidal oysters in summer.

Table 2. Mortalities of tagged oysters at control and reception sites. Salinity and temperature were taken one half meter below the surface adjacent to each site.

Location and Date	Monthly Mortality Rate (Percent)	Cumulative Mortality Rate (Percent)	Salinity ‰	Temp°C
Control Site				
C0001. Upper Intertidal Level				
Jan.	1.0	1.0	30.0	10.8
Feb.	2.0	3.0	26.0	9.2
Mar.	0.0	3.0	27.0	15.6
Apr.	1.0	4.0	30.0	21.2
May	1.6	5.6	32.0	27.1
June	7.3	12.9	34.0	28.3
July	5.7	18.6	34.0	29.6
Aug.	4.9	23.5	34.0	30.2
Sept.	3.5	27.0	20.0	26.6
Control Site				
C001, Lower Intertidal Level				
Jan.	0.0	0.0		
Feb.	1.5	1.5		
Mar.	0.5	2.0		
Apr.	0.0	2.0		
May	0.5	2.5		
June	0.5	3.0		
July	3.7	6.7		
Aug.	1.6	8.3		
Sept.	4.3	12.6		
December Reception Site				
REO1, Upper Intertidal Level				
Jan.	2.0	2.0	29.0	11.8
Feb	2.1	4.1	26.0	9.8
Mar.	0.4	4.5	29.0	15.8
Apr.	1.7	6.2	32.0	21.8
May	10.5	16.7	32.0	28.1
June	26.2	42.9	33.0	28.0
July	38.5	81.4	33.0	29.5
Aug.	15.3	96.7	33.0	31.6
Sept.	10.5	107.2*	23.5	28.0

Table 2 (cont'inued).

Location and Date	Monthly Mortality Rate (Percent)	Cumulative Mortality Rate (Percent)	Salinity ‰	Temp°C
December Reception Site				
REO1, Lower Intertidal Level				
Jan.	0.0	0.0		
Feb.	1.1	1.1		
Mar.	1.4	2.5		
Apr.	0.5	3.0		
May	1.0	4.0		
June	3.6	7.6		
July	9.4	17.0		
Aug.	9.0	26.0		
Sept.	3.1	29.1		
April Reception Site				
REO2, Upper Intertidal Level				
May	30.9	30.9	32.0	28.0
June	58.6	89.5	33.0	28.2
July	61.8	151.3*	34.0	30.0
Aug.	33.1		33.0	31.6
Sept.	27.2		23.5	28.0
April Reception Site				
REO2, Lower Intertidal Level				
May	1.3	1.3		
June	3.5	4.8		
July	9.1	13.9		
Aug.	5.8	19.7		
Sept.	9.5	29.5		
July Reception Site				
REO3, Upper Intertidal Level				
Aug.	54.0	54.0	33.0	31.6
Sept.	21.5	75.5	27.0	29.6
July Reception Site				
REO3, Lower Intertidal Level				
Aug.	10.4	10.4		
Sept.	11.9	22.3		

*Cumulative mortality rates exceed 100% when all of the oysters tagged during a particular harvest have died, as well as a percentage of the oysters later tagged to maintain quotas at that site.

Table 3. Density of oysters at each study site before and after planting.

Site	Time	Density per m^2
Control COO1	undisturbed	349.0
December reception site REO1	pre planting	59.3
December reception site REO1	post planting	134.5
April reception site REO2	pre planting	80.3
April reception site REO2	post planting	316.3
July reception site REO3	pre planting	82.3
July reception site REO3	post planting	231.3

Growth was greatest in the lower intertidal zone at all locations and exceeded 1.0 mm per month at the control site and spring reception site (Table 4). Negative growth was observed in several instances in transplanted oysters, and this was attributed to erosion of shell as the oysters recovered from the trauma of being moved. This occurred mostly in the upper intertidal zone. Growth was not as high as recorded in other studies (Burrell *et al.*1981). This was attributed to this study period not being of sufficient duration to allow oysters to recuperate from moving and to resume normal growth. Slow growth in controls was attributed to constraints of clustering which may be alleviated in transplanted oysters.

SUMMARY AND CONCLUSIONS

1. Survival was greatest in lower intertidal control site oysters and lowest in oysters transplanted in the upper intertidal zone.
2. Cause of high mortalities in the upper intertidal transplants could not be directly attributed to the disease (*P. marinus*) because it occurred in equally high incidence and intensity in both control and transplant oyster. It was, however, conjectured to be reduced resistance to disease resulting from stress induced from moving the oysters into the rigorous upper habitat.
3. Growth was greatest in the lower intertidal zone, however the study period was too short to observe if oyster growth improves after a period of recovery from stress due to transplanting.
4. These data indicated that transplants by the mechanical harvester must be made in the lower intertidal zone for acceptable survival and growth and that transplants made in winter and spring survive better than those made in summer.

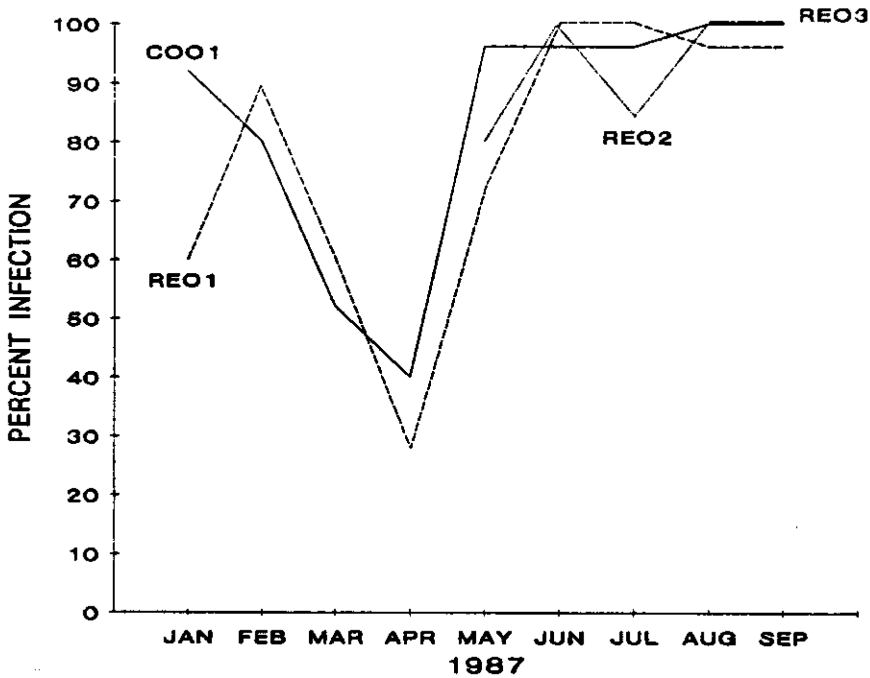

Figure 3. Percent infection of oysters by *Perkinsus marinus* measured monthly during the study period.

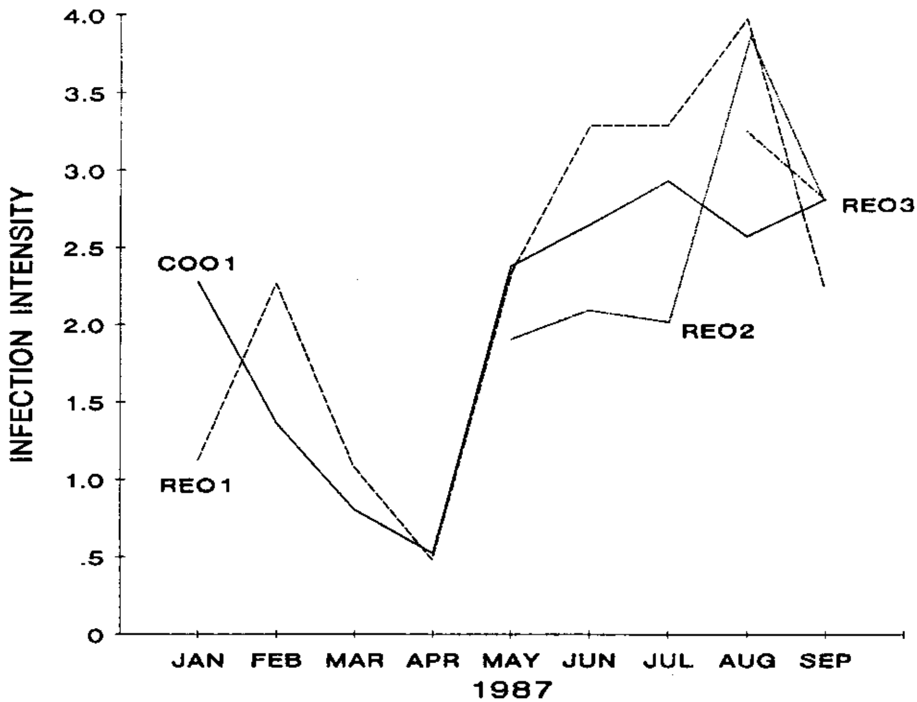

Figure 4. Intensity of *Perkinsus marinus* infection of oysters measured monthly during the study.

Table 4. Monthly growth at control and reception sites during study period.

Station	Period	Mean growth in mm
COO1		
upper intertidal	Dec. – Sept.	0.3
lower intertidal	Dec. – Sept.	1.1
REO1		
upper intertidal	Dec. – Sept.	0.2
lower intertidal	Dec. – Sept.	0.5
REO2		
upper intertidal	Apr. – Sept.	1.0
lower intertidal	Apr. – Sept.	1.9
REO3		
upper intertidal	July – Sept.	–0.2
lower intertidal	July – Sept.	0.5

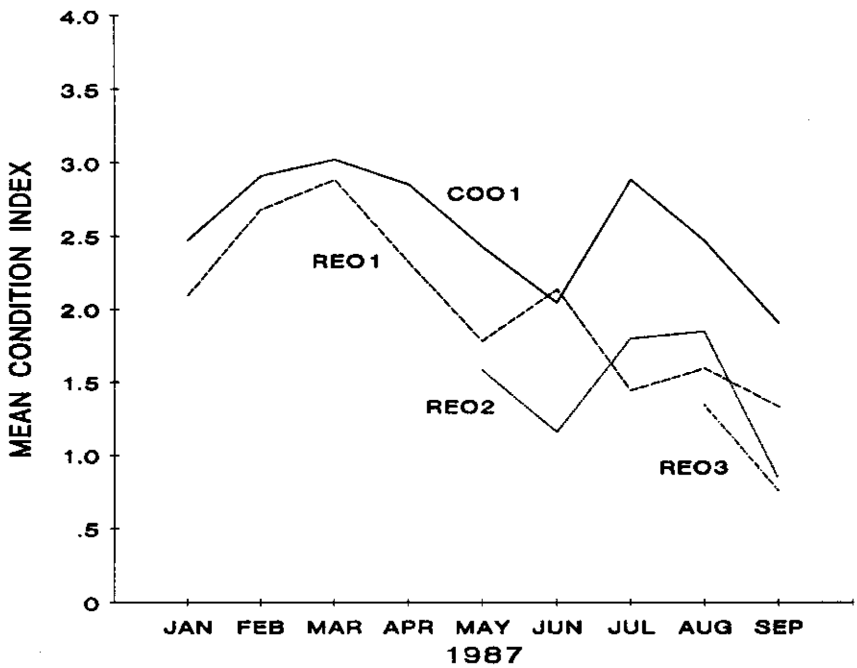

Figure 5. Condition index of oysters from the various sites measured monthly during the study period.

ACKNOWLEDGEMENTS

We are grateful to George Steele, Charles Black, Fred Sanford, and Martin Levisen for field work associated with the project, to Yvonne Bobo and Anil Thakkar for histological work up, to John Ulmer, John Guilds, Elizabeth Hens, and William Oldland for harvester operations. We also thank Louise Hammes for typing the manuscript and Karen Swanson for drafting the figures. Financial support for this project was provided by the Gulf and South Atlantic Fisheries Research and Development Foundation under Contract #GASAFDFI No. 32-11-20725/15955. This is contribution Number 236 of the South Carolina Marine Resources Center.

REFERENCES

Burrell, V.G., Jr. 1982. Overview of the South Atlantic oyster industry. Proceedings of the North American Oyster Workshop. World Mariculture Society Special Publication Number 1: 125-127.

Burrell, V.G., Jr. and J.J. Manzi. 1985. Molluscan fisheries of the South Atlantic region of the United States. National Shellfisheries Association Annual Meeting Abstracts. p. 25.

Burrell, V.G., Jr., J.J. Manzi, and W.Z. Carson. 1981. Growth and mortality of two types of seed oysters from the Wando River, South Carolina. *Journal of Shellfish Research* 1(1): 1-7.

Cowman, C.F., Jr. 1982. A brief analysis of Georgia's oyster industry. Proceedings of the North American Oyster Workshop. World Mariculture Society Special Publication Number 1: 128-131.

Lunz, G.R., Jr. 1950. Production and yield of the oyster canning industry of *South Carolina. American Midland Naturalist* 30(3): 806-808.

Maggioni, G.J. and V.G. Burrell, Jr. 1982. South Carolina oyster industry. Proceedings of the North American Oyster Workshop. World Mariculture Society Special Publication Number 1: 132-137.

Mann, R. and S.I. Glomb. 1978. The effect of temperature on growth and ammonia excretion of the manila clam, *Tapes japonica. Estuarine and Coastal Marine Science* 6: 335-339.

Manzi, J.J., V.G. Burrell, Jr., K.J. Klemanowicz, N.H. Hadley, and J.A. Collier. 1985. Impacts of a mechanical harvester on intertidal oyster communities in South Carolina. Final Report: Coastal Energy Impact Program, Contract Number CEIP-83-06, Governor's Office, Columbia, S.C.

Munden, F.H. 1982. A review of the North Carolina oyster rehabilitation program. Proceedings of the North American Oyster Workshop. World Mariculture Society Special Publication Number 1: 138-151.

Quick, J.A., Jr. and J.G. Mackin. 1971. Oyster parasitism by *Labyrinthomyxa marina* in Florida. Professional Papers Series Number 13. Florida Department of Natural Resources. 55 p.

Smith, R.O. 1949. Summary of oyster farming experiments in S.C. 1939-1940. U.S. Fish and Wildlife Service Special Scientific Report Number 63. 20p.