Publication No. NCRI-W-91-007

Revitalizing A Northern Gulf Coast Oyster Fishery: Determination Of The Cost Versus Benefits From Relaying Oysters

Prepared by

David D. Burrage
Benedict C. Posadas
C. David Veal

May 1991

Prepared for

NCRI
National Coastal Resources Research & Development Institute

NCRI Publication No. W-91-007

REVITALIZING A NORTHERN GULF COAST OYSTER FISHERY: DETERMINATION OF THE COST VERSUS BENEFITS FROM RELAYING OYSTERS

by

David D. Burrage
Benedict C. Posadas
C. David Veal

Mississippi State University
Mississippi Cooperative Extension Service
Coastal Research and Extension Center
Sea Grant Advisory Service
Biloxi, Mississippi

May 1991

This project was funded by the National Coastal Resources Research and Development Institute, Newport, Oregon, under Contracts No. 2-5618-28 and F137.88S-5618-28-2.

Additional support was provided by the NOAA/National Sea Grant College Program, U.S. Department of Commerce, under Grant No. NA 16RGO155-01, the Mississippi-Alabama Sea Grant Consortium, and Mississippi Cooperative Extension Service/Mississippi State University. The U.S. Government and the Mississippi-Alabama Sea Grant Consortium are authorized to produce and distribute reprints for governmental purposes notwithstanding any copyright notation that may appear within.

ABSTRACT

The northern Gulf Coast oyster industry has experienced severe declines in production over the past two decades. Loss of oyster grounds to siltation, extreme salinity fluctuations, and sanitary closures have reduced landings. Relaying oysters from restricted to approved waters may aid this fishery. Calculating the cost and benefit of relaying will allow an assessment of such efforts. Economic and technical data on dredging, planting and harvesting for a pilot relay program were collected.

Over 5,300 barrels (one barrel = three Mississippi sacks = four U.S. bushels = 0.17 cubic meter) of oyster seed and shells were relayed from May to August, 1989. Dredging cost was $33,492 or $6.24 per barrel planted. Contracted planting boats added $8,123 or $1.51 per barrel planted. The cost of monitoring was $4,003 or $0.75 per barrel planted. The total direct cost of relaying was $45,618 or $8.50 per barrel planted.

During the 1989-91 seasons, total oyster harvest was 5,669 sacks representing over 35 percent recovery rate. At an average ex-vessel price of $24 per sack, the landing value of total oyster harvest was $136,056. Harvesting cost was $28,229 or $4.98 per sack harvested.

After considering the time value of money, inflation and risk, the total direct net benefits were over $50,000 suggesting a direct benefit-cost ratio of 1.78:1.00. In addition, juvenile oysters remained in the relay site.

Relaying and harvesting also created additional economic activities in other sectors. By using multiplier analysis, the expansion in output, income, and employment resulting from the relaying and harvesting activities was measured. Under these circumstances, the discounted final benefit-cost ratio was 3.1:1.0 or final net benefits of about $136,000.

CONTENTS

Contents (cont'd)

FIGURES

TABLES

Contents (cont'd) Page

I. INTRODUCTION

The Mississippi oyster industry, and in fact much of the upper Gulf of Mexico oyster industry, are plagued by severe environmental problems, ranging from the lack of (or too much) fresh water to pollution. The increase in coastal populations along the Gulf of Mexico has placed pressure on the estuaries from sewage disposal, industrial activities, increased runoff from urban areas, and agricultural and livestock activities (M. Broutman and D. Leonard) [5].

Under the National Shellfish Sanitation Program guidelines [5], waters are classified for harvest based on the presence of pollution sources and levels of fecal coliform in surface waters. Oyster harvests for direct marketing are allowed in approved waters. Conditionally approved waters do not meet the criteria for approved waters at all times, but may be harvested when the criteria are met. In restricted waters, oysters may be harvested if subjected to a suitable purification process. Harvests of oysters are not allowed at any time from prohibited waters.

The annual landings of oysters harvested from the state water bottoms have declined tremendously. Current production is about 100,000 pounds of meats per year which is one tenth of the average over the past several decades. Efforts are underway to alleviate the effects of many of these problems on a local and regional level. Louisiana, Mississippi, and the U.S. Army Corps of Engineers are pursuing a freshwater diversion project, which hopefully would substantially increase oyster production in the Mississippi and Louisiana coastal areas in the future.

In the meantime, substantial oyster resources exist in the nearshore areas of Alabama, Mississippi, and Louisiana, but harvesting of these resources is prohibited due to pollution. In Jackson County, Mississippi, a large public reef immediately adjacent to Ingalls Shipyard contains several hundred thousand barrels of oysters, yet fishermen do not have access to them. As a result, people who depend upon the oyster industry for their livelihood are unemployed much of the time.

It is possible to move oysters from restricted public reefs to more pristine waters for depuration. These oysters could then be harvested later when the oyster season opens. The opening of these oyster resources for depuration provides additional economic activities in the adjacent coastal areas. The increase in oyster landings due to relaying would create more output, income and employment for the oyster harvesting, seafood processing, wholesaling, and retailing sectors.

Before this process could be undertaken on a large scale by either the public or the private sector, several questions, particularly about economics, must be answered. Specifically, is the relaying of oysters from polluted waters to waters open for oyster harvesting economically viable? Since other alternatives for depurating oysters also exist, it is important to have the full economic picture before embarking on a large-scale publicly or privately financed oyster relaying project. In evaluating the economics of oyster relaying, a pilot relaying project was undertaken to determine capital and operating costs, and oyster growth, survival, and harvests.

The general goal of this pilot project is to evaluate the benefits and costs of relaying oysters from closed oyster reefs to clean oyster fishing grounds. The project aims to identify the production characteristics and practices of participating oystermen, to determine the level of effort, amount of time and capital resources, and type of equipment employed in the relaying process, and to determine the accompanying costs incurred and benefits received by the different participating economic units. The results of this pilot project will be used as a basis of comparing the economic desirability of the oyster relaying technique to other methods such as depuration or cultch planting.

II. METHODS

A. Sources Of Data

The primary sources of data were oyster fishermen who participated in relaying and crew members of the dredge boat. This pilot program was started on May 15, 1989 and the results were monitored until the closing of the 1989-90 and 1990-91 oyster seasons. The technical data on fishing boats, engines and equipment were collected through interviews with boat owners at the start of the project. Both technical and economic data on dredging, planting and monitoring were compiled on a daily basis. Harvest and effort data on the 1989-90 and 1990-91 oyster seasons were collected from the oyster tags issued by the Mississippi Department of Wildlife, Fisheries and Parks/Bureau of Marine Resources (BMR), as well as on-site observation.

1. Contract Boats

Before the program was started, the purpose of the study was presented to the participating oystermen. The operators of the contract boats were also made aware of the monitoring forms and interview schedules used. Information on planting equipment was collected through personal interviews with participating oystermen. Interview schedules recorded preliminary information on contract and harvest boats (Appendices A and B). A monitoring form was used to record pertinent information on daily planting activities of contract boats (Appendix C). The oystermen's activities during planting time were monitored daily for 24 planting days. These data were used to estimate contract planting costs.

2. Harvest Boats

Oysters harvested by resident and out-of-state fishermen from Mississippi waters either recreationally or commercially were tagged in designated check-in stations along the Gulf Coast (Mississippi Department of Wildlife, Fisheries and Parks) [20]. An oyster trip ticket was issued by the BMR to each fishing boat reporting at the check-in station.

The information specified on each tag includes date, time in and out, harvester's name, license number, boat number, registration number, gear type (tong or dredge), harvest type (recreational or commercial), harvest area, sacks per area, total sacks, shell tax, tag sequence, check-in location, inspector, number of fishermen and destination of catch. Harvest data collected from oyster tags issued to fishermen in Bang's Lake Reef were used in determining harvesting costs.

A sample of the fishermen who harvested oysters from the relay site was interviewed during harvest time. Information on fuel and oil consumption (gal), repair and maintenance ($) and landing price ($/sack, Appendix D) was collected during these interviews. These data were used to estimate harvesting costs.

3. Dredge Boat

The data about the participation of the dredge boat in this program were retrieved from its files. An interview schedule was used to gather preliminary information regarding the dredge boat (Appendix E). The boat captain and the Business Manager's Office of the BMR provided data on purchase cost ($), current value ($), major repair and maintenance ($), remaining useful life (yr) and age of the dredge boat (yr). Seven monitoring forms were used to record the daily dredging operations of the boat (Appendix F). These data were used in estimating dredging costs.

4. Oyster Resources

Both the oyster grounds and oysters were sampled before planting and at intervals before, during and after harvest. Samples were taken to determine mean and variance of oyster size and proportion of live to dead oysters. The data collected were temperature (^{o}C), salinity (ppt), number of boxes, number of live oysters, sample composition (spat, seed, juvenile, adult) and size per class (mm). These data were used to estimate recovery rates, size and composition of the remaining oyster population after the closing of the season.

5. Program Management

The principal investigator maintained information on contract boat wage rate ($/hr), daily contract boat time (man-hr/day), area planted (acre), project supervision (man-mo), secretarial staff (man-mo) and travel, services and supplies ($). While these costs were unique to the pilot program, similar management expenses would apply both to the public and private sectors if a full scale relay program was undertaken.

B. Analytical Framework

1. Technical Description

The technical description of the dredging activities included characteristics of the dredge boat, dredging effort and inputs used. Dredging effort was measured by the number of dredging days, dredging trips, and boat operating time. Variable dredging inputs measured were man-hours, fuel and oil.

The size of contract boats was measured in terms of the total length of the boat. Contract planting effort was measured by the number of planting days, planting trips, and boat operating time. Nominal operating time consisted of running, loading, planting, and miscellaneous time. The effective operating time, however, excluded miscellaneous time. Miscellaneous activities include repair of engines, delays due to storms and other unforeseen events. The primary variable contract planting inputs were man-hours added by owners and crew members, fuel and oil.

The technical aspects of oyster harvesting included boat size, engine horsepower, gear type, oyster harvest, harvesting effort, and variable inputs used. Harvesting effort was measured by harvesting time, harvesting trips and man-days.

The size of oysters, proportion of live to dead oysters, water temperature and salinity, size of each group of oyster seed, and population growth rates were measured on a monthly basis during the first year of the project and periodically thereafter. The biological monitoring assessment was undertaken by oyster biologists from the Gulf Coast Research Laboratory (GCRL).

2. Cost Analysis

Cost analysis determines the various costs incurred by different participating sectors in all stages of oyster relaying. The activities included in relaying were dredging oyster seed or shells in Pascagoula River, transporting and planting oyster materials in Bang's Lake, biological monitoring of oysters, and harvesting and transporting mature oysters to the tagging station. Specifically, total direct cost of relaying includes cost of dredging, planting, harvesting, and monitoring ($/season, $/bbl, $/trip).

Dredging costs refer to all costs incurred by the dredge boat and support craft from dredging area (Pascagoula River) to relay area (Bang's Lake) and cost of project management ($/season, $/bbl, $/trip). Variable dredging cost consists of repair and maintenance of dredge boat, regular and overtime salaries of crew members, fuel, oil and hydraulic fluid, food supplies and launching fees. Fixed dredging cost includes depreciation and project management.

Contract planting costs refer to total private costs incurred by participating oystermen in moving the oysters from the dredge boat to the planting area and the cost of hiring contract boats paid by the program ($/season, $/boat, $/bbl). Contract planting variable expenses are repair and maintenance of boats, engines and gear, gloves and boots, and fuel and oil. Contract planting fixed costs are depreciation for boats, engines and gear, licenses, insurance, dockage and interest on borrowed capital.

Harvesting costs refer to total private costs incurred by oystermen to and from the harvesting area and to and from the BMR tagging station ($/season, $/bbl). Variable harvesting costs include repair, maintenance, gloves, boots, fuel and oil, and launching fee. Fixed harvesting costs are depreciation and licenses. Since data on harvest boats were not monitored on a daily basis, estimates of harvesting costs were based on interviews with captains of sample boats. The equation used in estimating harvesting cost is as follows:

$$HC = (VC \times FE) + (AD \times FE) + (LC / HD) \times FE,$$

where

HC = total harvesting cost ($/season),
VC = average variable harvesting cost ($/trip),
FE = total fishing effort (trips/season),
AD = average depreciation ($/trip),
LC = oyster fishing license ($/season), and
HD = harvest period (days/season).

Monitoring costs refer to the cost of assessing the biological characteristics of oyster resources to ensure compliance with existing oyster fishing regulations and management practices ($/season, $/bbl). The major monitoring cost items incurred were personnel time, supplies and equipment.

3. Benefit-Cost Analysis

Total direct benefits derived from oyster relaying and harvesting refer to the landing value of oysters harvested during the first and second years after relaying ($/season). Total direct net benefit refers to the difference between total direct benefit and total direct cost ($/season). Landing values were estimated from total oyster harvest (sacks/season) and average ex-vessel price ($/sack). The data on oyster harvests were taken from BMR reports and from estimates of unreported fishing trips. The estimates on unreported oyster harvests from the relay site were partially confirmed by confidential information provided by oyster fishermen. The ex-vessel price of oysters was determined from interviews with fishermen and seafood processors.

The benefit-cost ratio is obtained when the present value of the benefit stream is divided by the present value of the cost stream (P. Gittinger) [9]. The benefit-cost ratio measures the economic desirability of relaying oysters. The formal selection criterion is to accept if the benefit-cost ratio is equal to or greater than one when the cost and benefit streams are discounted at a suitable discount rate [9]. Otherwise, it is not economically wise to pursue this method of oyster fishing under the present economic, biological and environmental circumstances facing the Jackson County oyster industry.

The direct benefit-cost ratio was estimated from direct benefits derived from reported and unreported landings and direct costs during the first and second oyster seasons after relaying. The final benefit-cost ratio integrates the net secondary and tertiary benefits arising from relaying and harvesting during the 2-year period to the direct benefits and costs during the same period. The secondary benefits are the indirect income accruing to other economic sectors arising from relaying and harvesting activities. The tertiary benefits are the induced income resulting from the interaction of the household sector with the rest of the economy as a result of relaying and harvesting.

Sensitivity analysis measures the effects of changes in ex-vessel price, fuel cost, recovery rate, seed cost and contract wages on the benefit-cost ratio. This method evaluates the stability of relaying vis-a-vis the risks and uncertainties brought about by fluctuations in critical economic and technical factors. By using switching values, critical values of factors that will make the project economically unacceptable are determined [9].

4. Economic Impact Analysis

The revitalization of the ailing oyster industry would boost the state's regional economy. This pilot relaying project may give rise to secondary benefits through a multiplier effect especially with economies having excess capacity [9]. The economic impact of oyster relaying was measured by the value of output, income, and employment generated by the various economic sectors affected.

Total output effects consist of direct, indirect, and induced effects ($/season). Direct output effects include the initial expenditures on dredging, planting, monitoring and harvesting. Indirect output effects refer to the additional spending by business firms as a result of receiving the money injected into the economy by the initial purchases of supplies by different participating units. Induced output effects are the added expenditures of other business establishments that are recipients of spending by employees of the business enterprises initially affected by the injection of income.

The output multiplier for each sector is the total value of production in all economic sectors that is necessary in order to satisfy a dollar's worth of final demand for its output (R. Miller and P. Blair) [15]. Two types of sectoral multipliers were used in measuring output effects. The Type I multiplier covers the direct and indirect effects. Besides direct and indirect effects, the Type II multiplier measures induced effects. The basic difference between the two types of multipliers is the treatment of the household sector (K. Lee) [13].

Estimates made by Kenneth Roberts [29] showed that for the entire U.S. economy, a dollar's worth of oysters landed brings in $6.50-$7.00 final value at the retailer's level. In the South Atlantic and Gulf of Mexico region, the Type I output multipliers are as follows: harvesting 2.03, processing 2.17, wholesaling 1.52, retailing 1.43, restaurant 1.54 (Centaur Associates, Inc.) [7].

Total income effects consist of direct, indirect and induced personal income ($/season) generated in various inter-related economic sectors (R. Nelson and W. Hardy) [21]. Direct personal income refers to regular and contract wages and salaries of dredging and planting crew, management and monitoring staff, and net income of captain and crew of harvest boats. The net income of harvest crew is the difference between landing value and harvesting cost. Indirect income is that income related to the purchases of supplies by fishermen and crew members as businesses purchase goods and services from other suppliers. Induced income is that income related to purchases of goods and services resulting from the personal income generated by those economic units affected by relaying and harvesting.

Besides output and income effects, oyster relaying brings about additional employment opportunities (man-hours/season) in the region. Direct employment effect was measured by the number of man-hours spent by the dredging, planting and harvesting crew, and management and monitoring staff. Indirect employment effect is that employment created by the purchases of supplies by fishermen and crew as businesses buy goods and services from other suppliers. Induced employment effect is that employment created by purchases resulting from personal income generated in economic sectors affected.

III. TECHNICAL DESCRIPTION OF RELAYING

The location of the Jackson County oyster relaying program is shown in Figure 1. The oysters were planted in the southern end of the lake covering about 10 acres. The selection of Bang's Lake was done with the local oystermen, the BMR and oyster biologists from the GCRL. The decision criteria for the selection of the relay area were water quality considerations, bottom substrate, and ease of monitoring. The site is accessible only by water through one ingress and egress point. A baseline study of the area was conducted before planting to assess existing oyster populations in the relay site. The area was marked and signs were posted in agreement with regulations of the U.S. Food and Drug Administration.

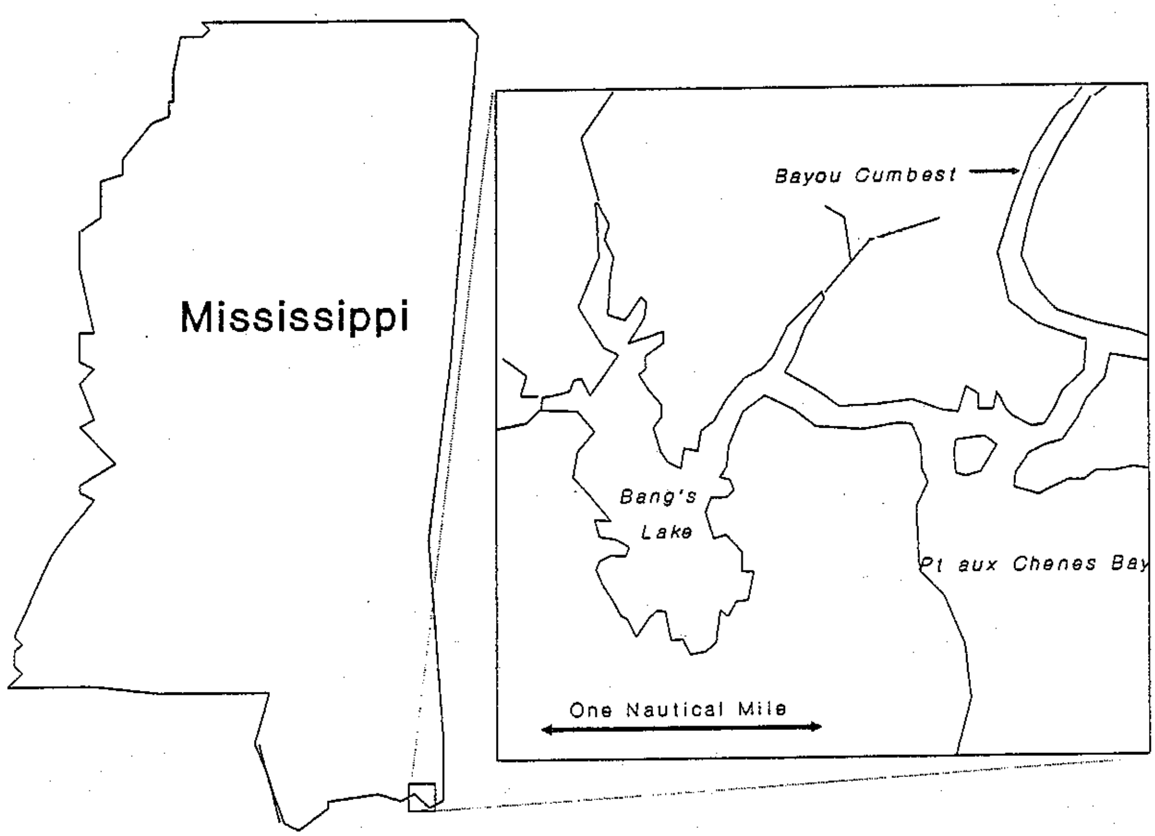

Figure 1. Location of Relay Site

The economic viability of relaying oysters largely depends on the environmental conditions prevailing in the relay area. Table 1 shows the environmental requirements of the American oyster in the Gulf of Mexico as summarized in Stanley and Sellers [30]. The optimum water temperatures for growth, reproduction and survival range from 68 ^{o}F to 86 ^{o}F. Mature oysters usually occur at salinity levels between 10 ppt to 30 ppt. The most suitable habitats are shallow bays and mud flats. Tidal flows of 156-260 cm per second are needed for optimum growth in Mississippi. Serious deviations from these environmental requirements might lead to excessive mortalities and slow growth. Several causes of high mortality of oysters along the Gulf of Mexico were identified such as pollution, excessive freshwater flow, high water temperature, diseases, parasites, and predators.

Table 1. Environmental Characteristics and Decision Criteria

Criteria	Value
Water temperature	68 - 86 ^{o}F
Salinity	10 - 30 ppt
Substrate	Shallow bays and mud flats
Current	156 - 260 cm/sec
Oxygen consumption	39 ml/kg/hr
Sedimentation	Lesser sedimentation reduces mortality
Ph	6.75 - 8.75 (growth)

Data from J. Stanley and M. Sellers (1986) [30].

The pilot relaying program was divided into three components: dredging, planting and harvesting (Figure 2). The dredging component was undertaken by BMR personnel using the dredge boat R/V Conservationist. Oysters were dredged from three different sites along the restricted waters of the Pascagoula River. A reef adjacent to the West Pascagoula Causeway was dredged 11 times. Ten dredging trips were conducted in the Middle Pascagoula River. Three dredging operations were conducted along the West Pascagoula River. These dredge areas are located approximately 12 nautical miles west of the relay site. The dredging component ended when the oysters were transported to the relay site.

The planting component began when the oysters were shoveled to the contract boats for transplanting to selected sections of Bang's Lake. These oysters settled at the bottom of the lake, grew to mature sizes, and cleansed themselves. The oyster planting was closely supervised by personnel of the BMR and Sea Grant Advisory Service (hereinafter SGAS). Growth and survival rates were monitored by the GCRL biologists. Interestingly, there was negligible mortality associated with the relay technique even though conducted during the hottest time of the year.

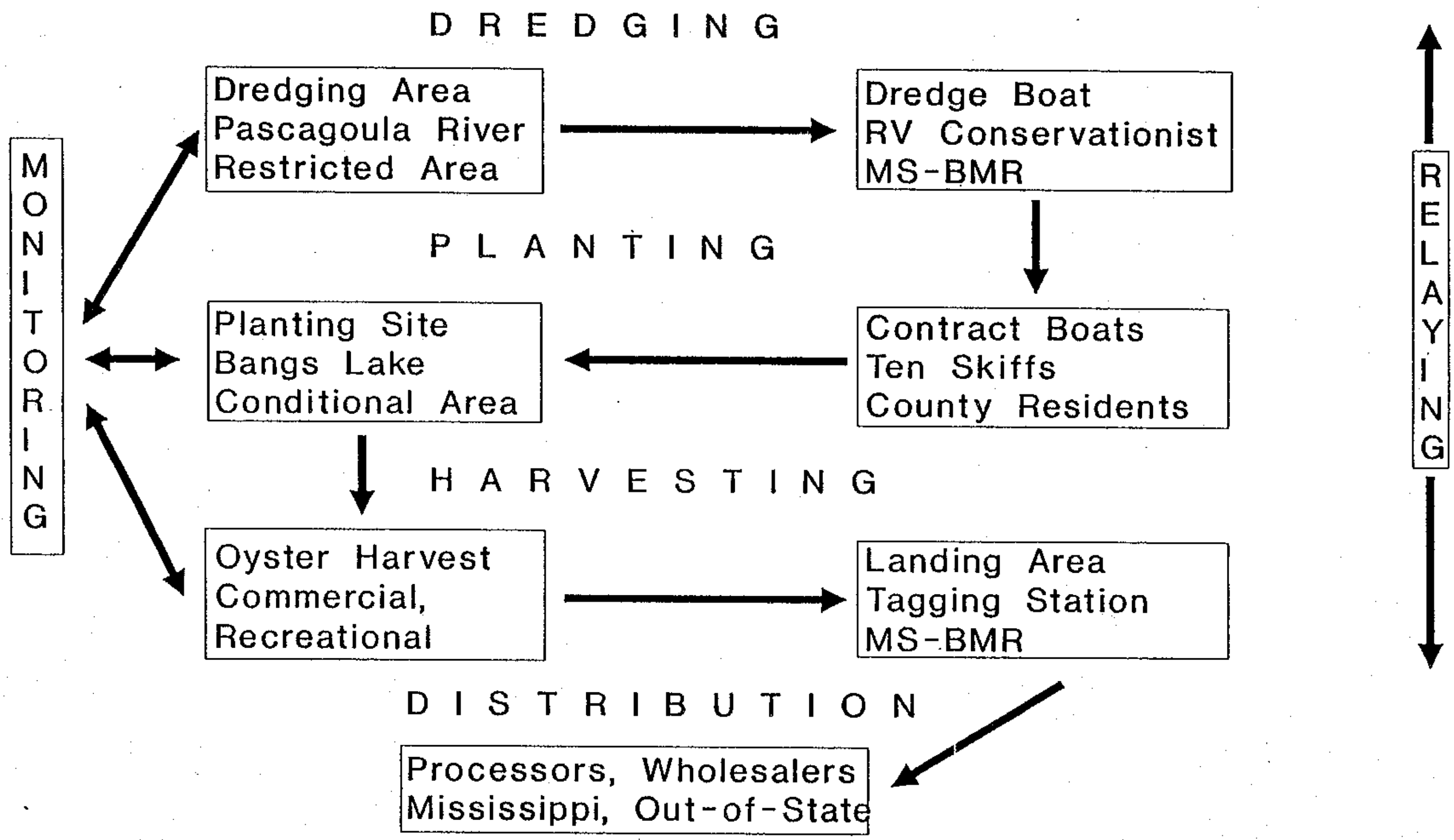

Figure 2. Relaying Flow Chart

The final component of the relaying program was harvesting. This component began when the lake was declared by the BMR as open waters. Mature oysters were harvested by licensed oyster fishermen and tagged by BMR inspectors at designated stations.

A. Dredging Component

The dredge boat used in the relaying program was the 65-ft R/V Conservationist which was provided and operated by the BMR. The dredge boat was equipped with two 115-pound, 16-tooth dredges. It was acquired in 1974 for $80,000 but a similar boat will cost $120,000 now. The boat underwent major repairs every other year. The cost of this major repair was estimated at $15,000. It is expected that the boat will be useful for 7.5 more years. The current value of the boat was estimated at $100,000.

Besides the dredge boat, two other boats were used to ferry crew and program staff members and to survey the oyster grounds. The first support craft was a 14-foot fiberglass boat with a 70-horsepower engine. The other support craft was 18 feet long and had a 150-horsepower engine. The first support craft was used every dredging day while the other boat was employed during the first month. The principal investigator used a 13-foot boat powered by a 10-horsepower engine.

Dredging started on May 15 and continued through August 3, 1989. The R/V Conservationist made 24 dredging trips in 48 days. Each trip was completed in two days beginning at high tide. Table 2 shows the total operating time of the dredge boat during the 12-week relaying period.

Upon arrival at the relay site, the size of oyster load was measured in two different ways. The total method was based on a fixed formula suitable for the shape of the oyster load as specified by the Mississippi Commission on Wildlife and Conservation [18]. The skiff method measured the amount of oysters loaded in each contract boat per planting trip. The oyster load per skiff was determined by counting the number of barrels loaded in each boat during the first three planting days. During relay operations in the Gulf of Mexico, the amount of material is typically reported in barrels. The difference between the two estimates of oyster loads was about 1 percent.

Table 2. Dredge Boat Operating Time, (hours)

Item	Total	Percent	Per barrel*	Per trip
Running	166.47	35.96%	0.0310	6.94
Dock-dredge site	48.72	10.52%	0.0091	2.03
Dredge-anchor area	10.50	2.27%	0.0020	0.44
Anchor-relay site	58.42	12.62%	0.0109	2.43
Relay-dock area	48.83	10.55%	0.0091	2.03
Dredging	210.33	45.44%	0.0392	8.76
Unloading	69.63	15.04%	0.0130	2.90
Miscellaneous	16.45	3.55%	0.0031	0.69
Total	462.88	100.00%	0.0863	19.29

* (One barrel = four U.S. bushels = three Mississippi sacks = 0.17 cubic meter).

The total quantity of oyster seed or shells transplanted was 5,363 barrels (16,089 sacks, 21,452 U.S. bushels, or 912 cubic meters) consisting of at least 2,400 barrels of oyster seed. The rest of the relayed material was empty oyster shells which later became cultch materials for new oyster spat. The size of oyster loads carried by the dredge boat ranged from 168-323 barrels per trip (Figure 3).

The man-hours spent by regular and volunteer crew members in dredging are shown in Table 3. The dredge boat was manned by four regular crew including the captain. The regular crew members were helped in their dredging operations by 3-4 inmates from the Jackson County Adult Detention Center. Each regular crew member (state employee) renders 171 hours of work every month. Overtime work beyond this limit had been rendered under contract with the program. The volunteer crew of inmates provided free labor to the program. The inmates were compensated in the form of sentence reduction by one day per day of work with the program.

Table 3. Variable Dredging Inputs

Item	Total	Per barrel*	Per trip
Labor input (man-hr):			
Regular crew	2,052.00	0.3826	85.50
Contract crew	1,078.38	0.2011	44.93
Volunteer crew	1,316.50	0.2455	54.85
Total	4,446.88	0.8292	185.29
Fuel and oil (gal):			
Diesel fuel	2,168.80	0.4044	90.37
Gasoline	131.97	0.0246	5.50
Engine oil	11.86	0.0022	0.49
Hydraulic fluid	70.00	0.0131	2.92

* (One barrel = four U.S. bushels = three Mississippi sacks = 0.17 cubic meter).

B. Planting Component

The planting of oysters was undertaken by the captains and crew of 10 contract boats in 24 days from May 16 to August 3, 1989.

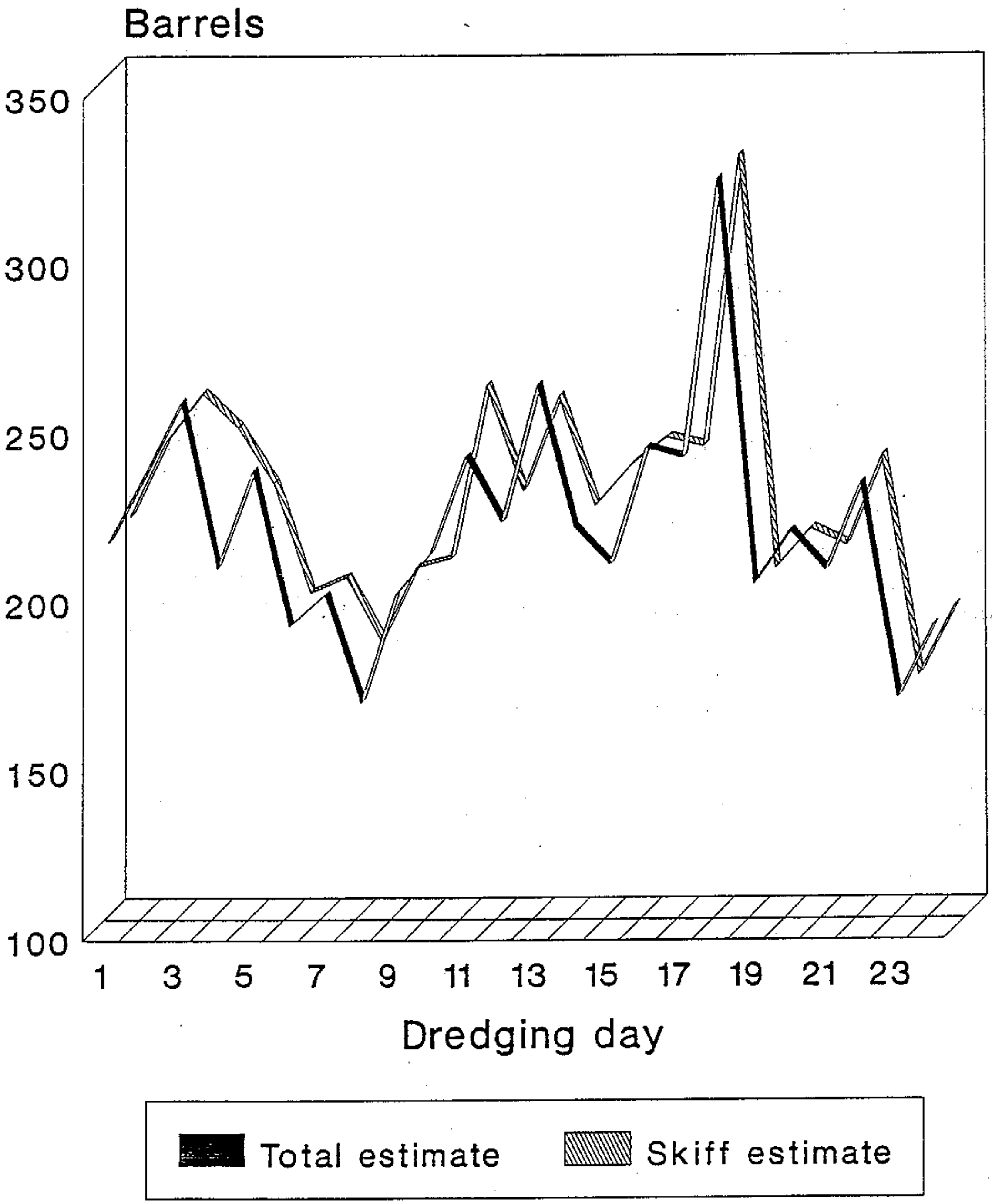

Figure 3. Oysters Dredged

The individual participation of contract boats in planting oysters ranged from 3-24 days with four boats participating at least 20 days. The limited participation of the remaining six boat owners was due either to other economic activities or delayed entry into the program. Most of these skiffs were made of wooden materials except for two fiberglass boats. Table 4 lists the average technical characteristics of contract planting boats.

Table 4. Average Technical Characteristics of Contract Boats

Item	Per boat
Number of crew	1.70
Fishing boat:	
Length (ft)	17.50
Age (yr)	1.65
Lifetime (yr)	7.30
Market value ($)	1,050.00
Engine:	
Horsepower	32.00
Age (yr)	2.85
Lifetime (yr)	6.30
Market value ($)	1,664.60

Table 5 shows planting effort exerted by the fishermen during the relaying period. The contract boats planted all the oyster seed or shells under different conditions ranging from breezy and sunny days to adverse weather conditions with strong winds, big waves, and poor visibility. An average of 224 barrels of oyster materials were planted by the contract oystermen every planting day. An average contract boat planted more than five barrels per planting trip or about 43 barrels per planting day.

Table 5. Oysters Planted, Contract Planting and Fishing Effort

Item	All boats	Per boat
Planting effort:		
Number of man-days	117.00	11.70
Number of trips	965.00	96.50
Trips/man-day	40.21	7.92
Fishing days/year:	1,820.00	182.00
Oysters planted:		
Number of barrels*	5,362.99	536.30
Barrels/day	223.79	42.85
Barrels/trip	54.58	5.46

* (One barrel = four U.S. bushels = three Mississippi sacks = 0.17 cubic meter).

Each planting day started with the owners of the contract boats assembling at the Point of Pine which is the launching area most proximate to the relay site. The principal investigator conducted routine matters with the fishermen at the same site. The contract boats departed simultaneously for the relay site, covering the 3.5 mile distance within 13-22 minutes depending on the size of boat, engine, and weather conditions.

The loading of oysters to the skiffs took 3-8 minutes per boat. Loading was done simultaneously on both sides of the dredge boat. Two persons, either crew or program staff, loaded the oysters to the waiting skiffs on each side. The load of oysters in each skiff ranged from 3.5 barrels for the smallest boat to 10 barrels for the largest boat. The skiffs navigated the distance between the dredge boat and the sections of the relay area selected each planting day in 2-4 minutes per trip. Running time depended on the distance, weather conditions and size of oyster load. Planting oysters took some time, especially if the boat was operated by one crew member. Planting time varied from 6-20 minutes per trip depending on the number of crew, oyster load and weather conditions.

Table 6 shows the operating time of all contract boats. One-third of total boat-hours consisted of running time from the dock to relay site and from dredge boat to planting site. Loading of oysters to skiffs time added 13 percent, while planting contributed 27 percent. The remaining time was spent on repairs of engines, delays in arrival of dredge boat, and delays due to bad weather conditions.

Table 6. Operating Time of Contract Boats, (hours)

Item	All boats	Percent	Per boat	Per barrel*
Nominal time				
Running	180.78	33.54%	18.08	0.0337
Dock-boat-dock	63.70	11.82%	6.37	0.0119
Boat-site-boat	117.08	21.72%	11.71	0.0218
Loading	68.48	12.70%	6.85	0.0128
Planting	145.97	27.08%	14.60	0.0272
Miscellaneous	143.78	26.68%	14.38	0.0268
Total	539.00	100.00%	53.90	0.1005
Effective time	395.22	73.32%	39.52	0.0737

* (One barrel = four U.S. bushels = three Mississippi sacks = 0.17 cubic meter).

Table 7 shows labor services and fuel consumed by contract planting boats. Each contract boat was usually manned by two crew members. One operated the boat while the other planted and sometimes helped in loading the oysters. In three cases, however, the owners handled their boats by themselves. The crew of the contract boats devoted 822 man-hours in planting with each boat working 4-5 hours per day.

Table 7. Variable Contract Planting Inputs

Item	All boats	Per boat	Per barrel*
Labor (man-hr):			
Boat owner	539.00	53.90	0.1005
Crew member	283.01	28.30	0.0527
Total	822.01	82.20	0.1533
Fuel (gal)	520.00	52.00	0.0970
Oil (gal)	10.62	1.06	0.0020
Oil-fuel ratio	0.02		

* (One barrel = four U.S. bushels = three Mississippi sacks = 0.17 cubic meter).

The amount of fuel consumed by contract boats was strongly affected by the number of planting trips. Simple linear regression results showed that 89 percent of the variation in fuel consumption was directly related to the number of planting trips. The estimated regression equation between fuel consumption of contract planting boats and number of planting trips is as follows:

$$F = 4.1629 + \underset{(8.2044)}{0.4957}\,T \pm 14.2394,$$

$R^2 = 0.8937$,
DW = 1.9797,
F-ratio = 67.3132,

where

F = fuel consumption (gallon/boat/season),
T = planting effort (trip/boat/season),
R^2 = coefficient of determination,
DW = Durbin-Watson statistic.

C. Harvesting Component

The harvesting of oysters from the relay site was monitored during the two seasons following the relaying period. During the 1989-90 season, Bang's Lake was opened four times (December 23-31, January 17-20, March 7-15 and April 21-30) for a total of 32 days. The temporary closure of the lake was usually done after heavy rains. BMR biologists then analyzed three water samples which normally took 10-14 days. During the 1990-91 season, the lake was opened three times (November 15-December 3, 1990, December 14-20, 1990 and March 30-April 7, 1991) for a total of 35 days.

The Pascagoula BMR station issued oyster tags from 7:00 A.M. until 4:00 P.M. every harvest day. Fishermen were required to check in before proceeding to the lake and check out before disposing of their harvest. In the Gulf of Mexico, oyster harvests are monitored in terms of sacks (one barrel = three Mississippi sacks = four U.S. barrels = 0.17 cubic meter). Each sack must be tagged. Fishermen employed hand tongs in harvesting oysters. Hand tongs normally have useful life of 10 years. The relaying area had been designated as open only to tongs. Each boat was usually equipped with one set of tongs. Usually, two fishermen operated an oyster fishing boat while a few were manned by either one, three or four person(s). One fisherman operated the tongs while the other culled the oysters. Each boat spent 30-40 minutes to harvest and cull one sack of oysters.

Table 8 shows oyster harvest, fishing trips and man-days. Total harvest and fishing effort consisted of reported and unreported components. Reported harvest was 5,305 sacks or 79 sacks per day, representing a total recovery rate of about 33 percent. Commercial fishermen from Mississippi and Alabama reported harvesting 63 and 26 percent, respectively. About 11 percent was harvested by resident recreational fishermen. Mississippi does not allow nonresident recreational harvest. All fishing boats reported making 1,679 trips to Bang's Lake. Resident commercial and recreational fishing boats reported 983 and 367 trips, respectively. Nonresident commercial fishing craft accounted for 329 fishing trips. The reported harvest of commercial fishing boats averaged 3.62 sacks per trip (Mississippi 3.41 sacks per trip and Alabama 4.25 sacks per trip) was lower than the catch limit of six sacks per trip. Recreational harvest by resident fishermen averaged 1.52 sacks per trip as compared to the limit of three sacks per week.

Table 8. Harvest, Fishing Trips and Man-days of All Commercial and Recreational Boats

Item	1989-90	1990-91	Total
Catch (sacks)*:			
Reported**	2,341	2,964	5,305
Unreported	364	0	364
Total	2,705	2,964	5,669
Per trip	3.10	3.20	3.16
Per person	1.73	1.84	1.79
Trips:			
Reported**	754	925	1,679
Unreported	117	0	117
Total	871	925	1,796
Man-days:	1,571	1,607	3,178
Fishermen-boat ratio:	1.80	1.74	1.76

* (One barrel = four U.S. bushels = three Mississippi sacks = 0.17 cubic meter).
** Data from Mississippi Bureau of Marine Resources (1990) [14] and (1991) [15].

The reported fishing effort and harvests, however, need further validation. The magnitude of nonreporting of fishing effort was too considerable to be neglected. This behavior among some fishermen was measured to depict an accurate picture of the benefits and costs of relaying oysters. The authors did not exert any effort to identify these fishermen or to ascertain their motives. Every harvest opening day, the number of trailers parked at the dock was compared with the number of boats actually fishing in the lake. It was observed via on-site monitoring that the correlation between the number of trailers parked at the dock and boats out in the lake harvesting was very close to unity.

In January 1990, the number of trailers parked at the dock exceeded the number of trips reported to the BMR by 16 percent among resident fishermen and 28 percent among nonresident fishermen. The overall proportion of nonreporting of fishing trips declined in March, 1990. The shift in nonreporting of fishing trips during the later part of the first season was largely due to the presence of BMR boats patrolling the relay area and conservation officers checking all incoming fishing boats.

The estimated quantity of oysters not reported to BMR was 364 sacks or 6.42 percent of total harvests. This estimate was based on the number of unreported fishing trips and average catch during those days when nonreporting was observed. Confidential information provided by oyster fishermen confirmed that some fishermen did not report their trips to the relaying area.

D. Monitoring Component

Figures 4 and 5 show the mortality rates and size distribution of oysters found in one-half U.S. standard bushel dredge samples taken from the Pascagoula River Reef and Bang's Lake. Observed mortality rates remained low, not exceeding 3 percent, as compared to the mortality rate of 20 percent not uncommon during summer. Fouling organisms and predators from the Pascagoula River Reef were negligible. Moderate concentrations of mussels and barnacles were present. Salinities throughout the period were optimum for oyster growth and culture except in October, 1989.

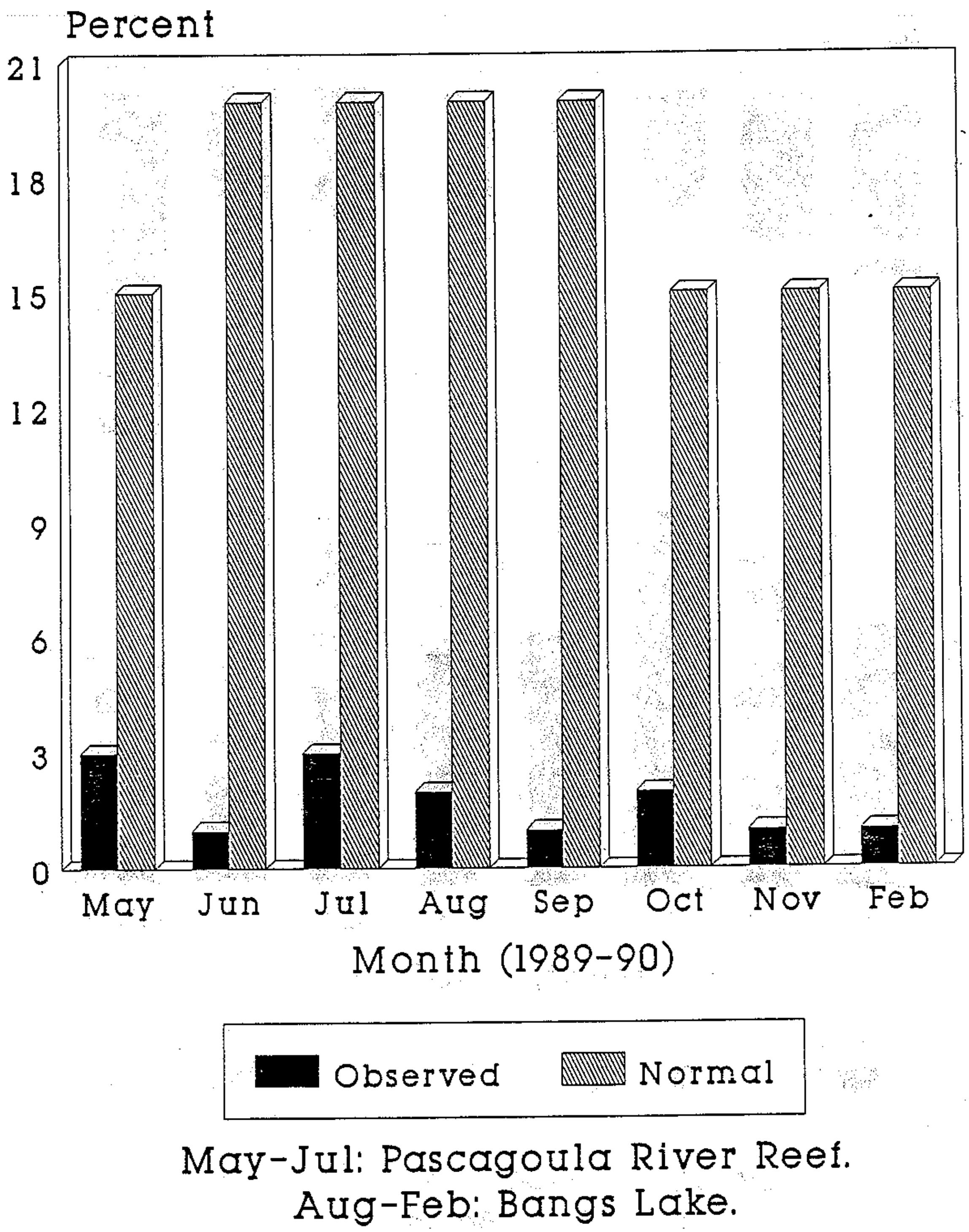

Figure 4. Mortality Rates

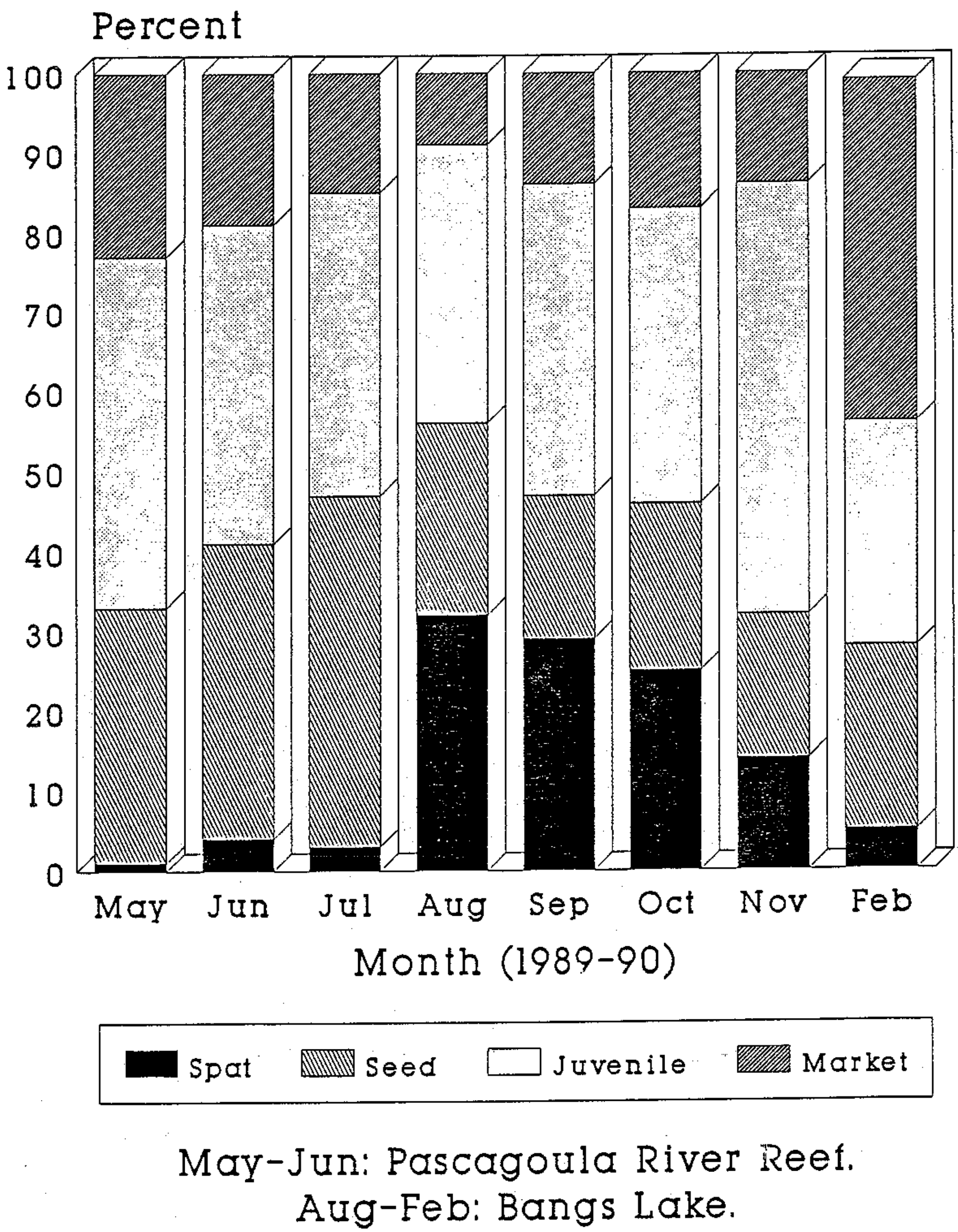

Figure 5. Size Distribution

The composition of oyster materials planted and the remaining oyster population in the relay site are as follows:

As of August 3, 1989 (completion of relaying):
Seeds planted = 7,240 sacks*
plus: Shells planted = 8,849 sacks
equals: Total material = 16,089 sacks

As of April 30, 1990 (end of first season):
Reported harvest = 2,341 sacks
plus: Unreported harvest = 364 sacks
equals: Oyster harvest = 2,705 sacks

As of April 7, 1991 (end of second season):
Reported harvest = 5,305 sacks
plus: Unreported harvest = 364 sacks
equals: Total harvest = 5,669 sacks.

* (One barrel = four U.S. bushels = three Mississippi sacks = 0.17 cubic meter).

The biological assessment in February, 1990 showed that over 40 percent of the remaining population were mature oysters. Over half of the total oyster population remaining at the relay site were juveniles. About 5 percent of the remaining oyster population were spat which will mature in about 2 years. The landings during the 1990-91 season confirmed the biological assessments of oyster resources relayed in Bang's Lake.

The heavy fishing pressure applied to the oyster resources relayed in the lake during the last two seasons might have resulted in the harvest of most of the mature oysters. However, the economic benefits received from the pilot relaying program could range over a longer period of time since the materials relayed consisted of seed, juvenile, market-size, spat, and empty shells. Future harvests may be expected from juvenile oysters inhabiting the relaying area.

IV. DIRECT COSTS OF RELAYING

A. Total Direct Costs

Table 9 shows the direct costs incurred by participating units in the pilot program and by fishermen during the succeeding two harvest seasons. The total costs of relaying and harvesting were $73,847, $13.77 per barrel planted or $13.03 per sack harvested. The total contribution of the BMR to the pilot program was $20,404, $3.81 per barrel planted or $3.60 per sack harvested. The program allocated a total of $23,701, $4.42 per barrel planted or $4.18 per sack harvested. Mississippi oyster fishermen incurred $23,158, $4.32 per barrel planted or $4.08 per sack harvested. Alabama oyster fishermen spent $6,585, $1.23 per barrel planted or $1.16 per sack harvested.

Table 9. Distribution of Expenditures Incurred by Participating Units, ($)

Item	1989-90	1990-91	Total	Percent	Per barrel*
Dredging cost:					
BMR	20,404	0	20,404	27.63%	3.8046
Program	13,088	0	13,088	17.72%	2.4404
Sub-total	33,492	0	33,492	45.35%	6.2450
Planting cost:					
Program	6,610	0	6,610	8.95%	1.2325
MS boats	1,513	0	1,513	2.05%	0.2820
Sub-total	8,123	0	8,123	11.00%	1.5146
Monitoring cost:					
Program	4,003	0	4,003	5.42%	0.7464
Sub-total	4,003	0	4,003	5.42%	0.7464
Harvesting cost:					
MS boats	8,210	13,434	21,644	29.31%	4.0358
AL boats	5,203	1,382	6,585	8.92%	1.2279
Sub-total	13,413	14,816	28,229	38.23%	5.2637
Total cost:					
BMR	20,404	0	20,404	27.63%	3.8046
Program	23,701	0	23,701	32.09%	4.4193
MS boats	9,723	13,434	23,157	31.36%	4.3178
AL boats	5,203	1,382	6,585	8.92%	1.2279
Total	59,031	14,816	73,847	100.00%	13.7696

* (One barrel = four U.S. bushels = three Mississippi sacks = 0.17 cubic meter).

The total cost of dredging, amounting to $33,492, was financed by the BMR and the program. The BMR contributed $20,404 for the operation of the dredge boat; the program spent $13,088 for the payment of contract wages, food and launching fees.

The total cost of contract planting, $8,123, was funded by the program and contract planters. The program paid $6,610 for the contract wages of the planters and launching fees. The participating Mississippi oyster fishermen incurred $1,513 for the operation of their skiffs during planting.

Oyster fishermen spent $13,413 to operate their fishing boats at the relay site during the 1989-90 oyster season. In the 1990-91 oyster season, total harvesting cost was $14,816. In addition, the program spent $4,003 for the assessment of the biological characteristics of the oyster grounds and oyster resources.

B. Dredging Costs

Table 10 shows the cost of dredging oysters from Pascagoula River and transporting them to Bang's Lake. Total dredging cost was $33,492, $6.24 per barrel planted or $5.91 per sack harvested. Total variable dredging cost was $28,826, $5.37 per barrel planted or $5.09 per sack harvested. Total fixed dredging cost was $4,666, $0.87 per barrel planted or $0.82 per sack harvested. The total cost of dredging averaged about $1,400 per trip.

Table 10. Dredging Costs, ($)

Item	Total	Percent	Per barrel*	Per trip
Variable costs:				
Labor	23,275.38	69.50%	4.33	969.81
Regular crew	15,010.38	44.82%	2.79	625.43
Contract crew	8,265.00	24.68%	1.54	344.38
Fuel and oil	2,242.95	6.70%	0.42	93.46
Repair and maintenance	1,045.56	3.12%	0.19	43.57
Food supplies	2,238.16	6.68%	0.42	93.26
Launching fees	24.00	0.07%	0.00	1.00
Sub-total	28,826.05	86.07%	5.37	1,201.09
Fixed costs:				
Depreciation	2,105.37	6.29%	0.39	87.72
Administration	2,560.54	7.65%	0.48	106.69
Sub-total	4,665.91	13.93%	0.87	194.41
Total	33,491.96	100.00%	6.24	1,395.50

* (One barrel = four U.S. bushels = three Mississippi sacks = 0.17 cubic meter).

Regular salaries were paid by the BMR while contractual payments were paid out of the program budget. Volunteer workers from the Adult Detention Center were not financially remunerated for services rendered. Total labor cost was $23,275, $4.33 per barrel planted or $4.11 per sack harvested.

The vessel refueled three times during the relaying period. Expenses on repair and maintenance were incurred to restore the dredge boat to its running condition before it was used for relaying. The costs of fuel and repair were paid by the BMR. The total cost of fuel, oil and hydraulic fluid was $2,243; $0.42 per barrel planted or $0.40 per sack harvested. The total allocation on repair and maintenance was $1,046; $0.19 per barrel planted or $0.18 per sack harvested.

Food was purchased for both the regular and volunteer crew members. The program funded expenditures on food and launching fees of small craft used by the supervisor. Total expenses on food supplies were $2,238; $0.42 per barrel planted or $0.39 per sack harvested.

Depreciation was computed by using the straight-line method. The cost of major repairs needed to restore the vessel to good running condition was deducted from replacement cost to get the current market value. The depreciation expense charged to the program was prorated based on the number of hours the vessel was used in the program and the estimated annual operating time. Total depreciation expense was $2,105; $0.39 per barrel planted or $0.37 per sack harvested.

Forty-seven percent of the administrative costs were allocated to the principal investigator, secretarial staff, benefits, services, and travel. The balance was appropriated to data analysis and report preparation which were considered as part of the study but not directly related to relaying. Total management cost directly attributable to relaying was $2,560; $0.48 per barrel planted or $0.45 per sack harvested.

C. Planting Costs

Table 11 shows the cost of contract planting incurred by boat owners and the cost of hiring contract boats incurred by the program. Total contract planting cost was $8,123; $1.51 per barrel planted or $1.43 per sack harvested. Total variable planting cost was $7,552; $1.41 per barrel planted or $1.33 per sack harvested. Total fixed planting cost was $571; $0.11 per barrel planted or $0.10 per sack harvested.

The program spent $6,468; $1.20 per barrel planted or $1.14 per sack harvested for services rendered by captains and crew of contract boats. The program allocated $142 for the launching fees of all contract boats. The $660 fuel cost was paid by contract planters. Some joint-cost items incurred by owners of contract boats were allocated between planting oysters and other fishing and shrimping activities. Repair, maintenance, gloves and boots were prorated based on the number of planting days and the number of fishing days during the planting period.

The depreciation of contract boats and engines was computed by using the straight-line method with the current market value, remaining life and zero salvage value of boats, engines, and equipment. The owners of three fishing boats have outstanding balances for equipment loans at an annual interest rate of 13.5 percent. One of the two fiberglass boats was covered by insurance. Three contract planters paid for docking facilities. All fixed cost items were prorated based on the number of planting days and number of fishing days each year.

Table 11. Contract Planting Costs, ($)				
Item	All boats	Percent	Per boat	Per barrel*
Variable costs:				
Contract crew	6,468.00	79.63%	646.80	1.20
Fuel and oil	659.78	8.12%	65.98	0.12
Repair and maintenance	245.00	3.02%	24.50	0.05
Gloves and boots	36.93	0.45%	3.69	0.01
Launching fees	142.00	1.75%	14.20	0.03
Sub-total	7,551.71	92.97%	755.17	1.41
Fixed costs:				
Depreciation	507.19	6.24%	50.72	0.09
Interest	18.62	0.23%	1.86	0.00
Insurance	1.00	0.01%	0.10	0.00
Dockage	44.08	0.54%	4.41	0.01
Licenses	0.00	0.00%	0.00	0.00
Sub-total	570.89	7.03%	57.09	0.11
Total	8,122.60	100.00%	812.26	1.51

* (One barrel = four U.S. bushels = three Mississippi sacks = 0.17 cubic meter).

D. Harvesting Costs

Table 12 shows the cost of harvesting oysters from the relay site. Total harvesting cost during the two seasons was $28,229; $5.26 per barrel planted or $4.98 per sack harvested. Total variable harvesting cost was $16,796; $3.13 per barrel planted or $2.96 per sack harvested. Total fixed harvesting cost was $11,433; $2.13 per barrel planted or $2.02 per sack harvested.

Table 12. Harvesting Costs, ($)					
Item	1989-90	1990-91	Total	Percent	Per sack*
Variable cost:					
Fuel and oil	3,037	4,228	7,265	25.74%	1.28
Launching fees	871	925	1,796	6.36%	0.32
Repair and maintenance	2,093	2,222	4,315	15.29%	0.76
Land transport	1,547	1,730	3,277	11.61%	0.58
Miscellaneous	69	74	143	0.51%	0.03
Sub-total	7,617	9,179	16,796	59.50%	2.96
Fixed cost:					
Depreciation	3,965	4,211	8,176	28.96%	1.44
License	1,831	1,426	3,257	11.54%	0.57
Sub-total	5,796	5,637	11,433	40.50%	2.02
Total	13,413	14,816	28,229	100.00%	4.98

* (One barrel = four U.S. bushels = three Mississippi sacks = 0.17 cubic meter).

The average harvesting costs of resident and nonresident commercial fishermen were $5.29 and $4.18 per sack harvested, respectively. The difference in average harvesting costs could be attributed to variations in average catch per unit effort and differences in license fees. Mississippi commercial fishing boats harvested fewer sacks of oysters than Alabama commercial fishing boats. In 1989-90, Mississippi boats harvested 2.93 sacks per trip while Alabama boats harvested 4.08 sacks per trip. Resident and nonresident fishing boats reported harvesting 3.72 and 4.84 sacks per trip during the 1990-91 season, respectively. Resident fishermen paid $50 per boat for oyster tonging licenses and $10 per boat for recreational fishing licenses. Nonresident fishermen paid $100 per boat for oyster tonging licenses.

The costs of fuel and oil consumed by fishing boats and land transport during the two seasons were based on interviews with some of the fishermen at the relay and launching areas during harvest time. Total fuel cost was $7,265 or $1.28 per sack harvested. Land transport was $3,277 or $0.58 per sack harvested. The cost of launching fishing boats at the nearest dock remained at $1.00 per boat during the period. The costs of repair, maintenance, and depreciation were estimated using the data provided by contract planting boats. Repair and maintenance was $4,315 or $0.76 per sack harvested. Depreciation expense was $8,176 or $1.44 per sack harvested.

V. ECONOMIC BENEFITS FROM RELAYING

A. Output Effects

This pilot project was a joint endeavor among oyster fishermen, state and county officials, and program staff to determine the costs and benefits of relaying as a means to revitalize the ailing oyster industry. Mississippi and nearby states benefit directly and indirectly from oyster relaying in the form of additional output, employment, and income in the oyster industry and other sectors of the economy. The economic benefits from this pilot program include direct benefits, indirect and induced income effects from relaying, harvesting, processing, and distribution of oysters harvested from the relay site.

Table 13 shows the output effects of relaying and harvesting. Output effects are determined by expenditures and the fisheries output multiplier. The Types I and II fisheries output multipliers were 1.5599 and 2.4659 [13], respectively. The total undiscounted output effects of relaying and harvesting were $182,098. The indirect and induced effects were $41,345 and $66,906, respectively.

Table 13. Computation of Output Effects, ($)

Item	Undiscounted Values 1989-90	1990-91	Total	Discounted Values 1989-90	1990-91	Total
Direct effects:						
Dredging	33,492	0	33,492	29,904	0	29,904
Planting	8,123	0	8,123	7,252	0	7,252
Monitoring	4,003	0	4,003	3,574	0	3,574
Harvesting	13,413	14,816	28,229	11,976	11,811	23,787
Total	59,031	14,816	73,847	52,706	11,811	64,517
Indirect effects:						
Dredging	18,751	0	18,751	16,742	0	16,742
Planting	4,548	0	4,548	4,060	0	4,060
Monitoring	2,241	0	2,241	2,001	0	2,001
Harvesting	7,510	8,295	15,805	6,705	6,613	13,318
Total	33,050	8,295	41,345	29,509	6,613	36,122
Induced effects:						
Dredging	30,344	0	30,344	27,093	0	27,093
Planting	7,359	0	7,359	6,571	0	6,571
Monitoring	3,627	0	3,627	3,238	0	3,238
Harvesting	12,153	13,423	25,576	10,851	10,701	21,551
Total	53,483	13,423	66,906	47,752	10,701	58,453
Total effects:						
Dredging	82,588	0	82,588	73,739	0	73,739
Planting	20,029	0	20,029	17,883	0	17,883
Monitoring	9,871	0	9,871	8,813	0	8,813
Harvesting	33,076	36,534	69,610	29,532	29,124	58,657
Total	145,564	36,534	182,098	129,968	29,124	159,092
Output multipliers:						
Type I	1.5599	1.5599	1.5599			
Type II	2.4659	2.4659	2.4659			
Discount rate:				12.00%	12.00%	
Discount factor:				0.8929	0.7972	

The total discounted output effects were $159,092: direct effect $64,517; indirect effect $36,122, and induced effect $58,453. The discounted values are lower than the undiscounted values due to the discount factor which expressed future into present values. Arbitrarily, the discount rate used was 12 percent considering the amount of risks involved in oyster relaying, the interest rate charged to equipment loans made by oyster fishermen, and inflation.

B. Employment Effects

The increase in employment could be seen in the number of man-hours devoted to the project by oyster fishermen, crew, and staff members. These fishermen purchased equipment needed in oyster fishing from business establishments which in turn bought supplies from other business firms. The expansion in business activity would require more man-hours in these establishments. The primary effects on employment, however, were felt by the oystermen who for years had been closely dependent on the economic well-being of the oyster industry.

The total increase in employment resulting from relaying and harvesting is equal to the man-hours multiplied by fisheries employment multiplier. The Types I and II fisheries employment multipliers were 1.25423 and 1.57263 [13], respectively. Table 14 shows the employment effects of oyster relaying and harvesting. The total employment created by all sectors affected was 16,058 man-hours. Oyster relaying produced employment of 10,211 man-hours in the oyster industry. The employment created in secondary and tertiary sectors were 2,596 and 3,251 man-hours, respectively.

C. Income Effects

The total income effects of relaying and harvesting are the incomes received by oyster fishermen and employees of secondary and tertiary business firms affected. The total income effects are equal to the total direct incomes of oyster fishermen and crew members multiplied by the fisheries income multiplier. The Types I and II fisheries income multipliers are 1.35528 and 1.70531 [13], respectively.

Table 15 shows the income effects of oyster relaying and harvesting. The undiscounted income generated by relaying and harvesting was $242,065. The program generated an additional $50,431 in secondary sectors and $49,686 in tertiary sectors. As with output effects, the discounted values were lower than the undiscounted values considering the time value of money and inflation. The discounted income effects consisted of direct effect - $121,351, indirect effect - $43,114, and induced effect - $42,477, for a total of $206,942.

D. Benefit-Cost Ratios

Table 16 summarizes the benefits and costs of the pilot relaying project. Total benefits consist of direct and indirect benefits. Direct benefits are equal to the ex-vessel value of the total oyster harvest shown in Table 8. Indirect benefits include indirect and induced income effects resulting from both relaying and harvesting, as shown in Table 15. Direct costs are the costs incurred in relaying and harvesting oysters, as summarized in Table 9.

Net direct benefits are equal to total direct benefits less direct costs, while final net benefits are total final benefits minus direct costs.

Table 14. Computation of Employment Effects, (man-hours)

Item	1989-90	1990-91	Total
Direct effects:			
Dredging	3,275	0	3,275
Planting	822	0	822
Monitoring	30	0	30
Harvesting	3,004	3,080	6,084
Total	7,131	3,080	10,211
Indirect effects:			
Dredging	833	0	833
Planting	209	0	209
Monitoring	8	0	8
Harvesting	764	783	1,547
Total	1,813	783	2,596
Induced effects:			
Dredging	1,043	0	1,043
Planting	262	0	262
Monitoring	10	0	10
Harvesting	957	981	1,937
Total	2,271	981	3,251
Total effects:			
Dredging	5,150	0	5,150
Planting	1,293	0	1,293
Monitoring	47	0	47
Harvesting	4,725	4,843	9,568
Total	11,215	4,843	16,058
Employment multipliers:			
Type I	1.2542	1.2542	1.2542
Type II	1.5726	1.5726	1.5726

Table 15. Computation of Income Effects, ($)

Item	Undiscounted Values 1989-90	1990-91	Total	Discounted Values 1989-90	1990-91	Total
Direct effects:						
Dredging	25,366	0	25,366	22,648	0	22,648
Planting	4,955	0	4,955	4,424	0	4,424
Monitoring	3,800	0	3,800	3,393	0	3,393
Harvesting	51,507	56,320	107,827	45,988	44,898	90,886
Total	85,628	56,320	141,948	76,453	44,898	121,351
Indirect effects:						
Dredging	9,012	0	9,012	8,046	0	8,046
Planting	1,760	0	1,760	1,572	0	1,572
Monitoring	1,350	0	1,350	1,205	0	1,205
Harvesting	18,299	20,009	38,309	16,339	15,951	32,290
Total	30,422	20,009	50,431	27,162	15,951	43,114
Induced effects:						
Dredging	8,879	0	8,879	7,928	0	7,928
Planting	1,734	0	1,734	1,549	0	1,549
Monitoring	1,330	0	1,330	1,188	0	1,188
Harvesting	18,029	19,714	37,743	16,097	15,716	31,813
Total	29,972	19,714	49,686	26,761	15,716	42,477
Total effects:						
Dredging	43,257	0	43,257	38,622	0	38,622
Planting	8,450	0	8,450	7,544	0	7,544
Monitoring	6,480	0	6,480	5,786	0	5,786
Harvesting	87,835	96,044	183,878	78,424	76,565	154,989
Total	146,022	96,044	242,065	130,376	76,565	206,942
Income multipliers:						
Type I	1.3553	1.3553	1.3553			
Type II	1.7053	1.7053	1.7053			
Discount rate:				12.00%	12.00%	
Discount factor:				0.8929	0.7972	

Table 16. Computation of Benefit-Cost Ratios

Item	Undiscounted Values 1989-90	1990-91	Total	Discounted Values 1989-90	1990-91	Total
Direct benefits ($):						
Reported harvest	56,184	71,136	127,320	50,164	56,709	106,873
Unreported harvest	8,736	0	8,736	7,800	0	7,800
Sub-total	64,920	71,136	136,056	57,964	56,709	114,673
Indirect benefits ($):						
Indirect income	30,422	20,009	50,431	27,162	15,951	43,114
Induced income	29,972	19,714	49,686	26,761	15,716	42,477
Sub-total	60,394	39,723	100,117	53,923	31,667	85,590
Total	125,314	110,859	236,173	111,888	88,376	200,264
Direct costs ($):						
Dredging	33,492	0	33,492	29,904	0	29,904
Planting	8,123	0	8,123	7,252	0	7,252
Monitoring	4,003	0	4,003	3,574	0	3,574
Harvesting	13,413	14,816	28,229	11,976	11,811	23,787
Total	59,031	14,816	73,847	52,706	11,811	64,517
Net benefits ($):						
Direct	5,889	56,320	62,209	5,258	44,898	50,156
Final	66,283	96,044	162,327	59,181	76,565	135,747
Benefit-cost ratios:						
Direct	1.10	4.80	1.84	1.10	4.80	1.78
Final	2.12	7.48	3.20	2.12	7.48	3.10
Discount rate:				12.00%	12.00%	
Discount factor:				0.8929	0.7972	

The results were favorable despite the low recovery rate during the first year. The program showed positive undiscounted net direct benefits of about $6,000, and over $56,000 during the first and second year, respectively. The undiscounted net final benefits from relaying for 2 years were over $162,000, involving net direct benefit of over $62,000 and indirect and induced benefits of over $100,000.

With undiscounted values, the direct benefit-cost ratio during the first year was 1.1:1.0. The undiscounted B-C ratio increased to 4.8:1.0 during the second year because no dredging, planting, and monitoring costs were incurred. The undiscounted direct benefit-cost ratio after 2 years from relaying was 1.84:1.0, which implies that a dollar invested in oyster relaying would generate total direct benefits amounting to $1.84 after 2 years.

After considering the indirect and induced income effects of relaying, the undiscounted final benefit-cost ratio was 2.12:1.0 in 1989-90. The absence of dredging, planting and monitoring activities in 1990-91 considerably increased the undiscounted B-C ratio to 7.48:1.0. After 2 years, the undiscounted final benefit-cost ratio was 3.20:1.0.

Considering the time-value of money and inflation, it was necessary to discount future values to the present. Using an annual discount rate of 12 percent, the discount factors were 0.8929 and 0.7972 for the first and second years, respectively. Consequently, the discounted direct and final benefit-cost ratios were 1.78:1.0 and 3.10:1.0, respectively. The effects of different discount rates on the B-C ratios are discussed in the next section.

The remaining juvenile population in the relay site may provide a future stream of net economic benefits. Projections beyond two oyster seasons succeeding the relaying program, however, were considered irrelevant since no reliable basis for estimation is available.

The total income and employment effects might be over-estimated since there were no market transactions involved in home-consumed harvest. Some of the oysters harvested from the lake went to home consumption or were given away to friends (Figures 6 and 7). Nevertheless, home-consumed harvest could not possibly influence the ex-vessel price of oysters since it was a small proportion of the entire Mississippi oyster landings. For the purpose of this report, home-consumed landings were valued at current ex-vessel price.

VI. CRITICAL ECONOMIC FACTORS IN RELAYING

The oyster fishery in the Northern Gulf of Mexico is characterized by wide variations in landings and ex-vessel prices from year to year. In Mississippi, landings have ranged from a high of four million pounds of meats to current levels of 100,000 pounds in the last decade. The annual ex-vessel price in Mississippi varies greatly. Because of this volatility, it is prudent to perform a sensitivity analysis in order to ascertain how the economic aspects of oyster relaying varies according to these fluctuations.

A. Recovery Rate

Figure 8 shows the sensitivity of the discounted benefit-cost ratios of the relaying project to fluctuations in recovery rate. The recovery rate after two years from relaying was over 35 percent. With the average price and cost structure of oyster relaying, the critical recovery rate is about 20 percent. If actual recovery rate is lower than the critical level, a higher ex-vessel price or lower direct costs are required to make the project viable. At the critical rate, total direct costs incurred by all participating units would be equal to total direct benefits accruing from the project.

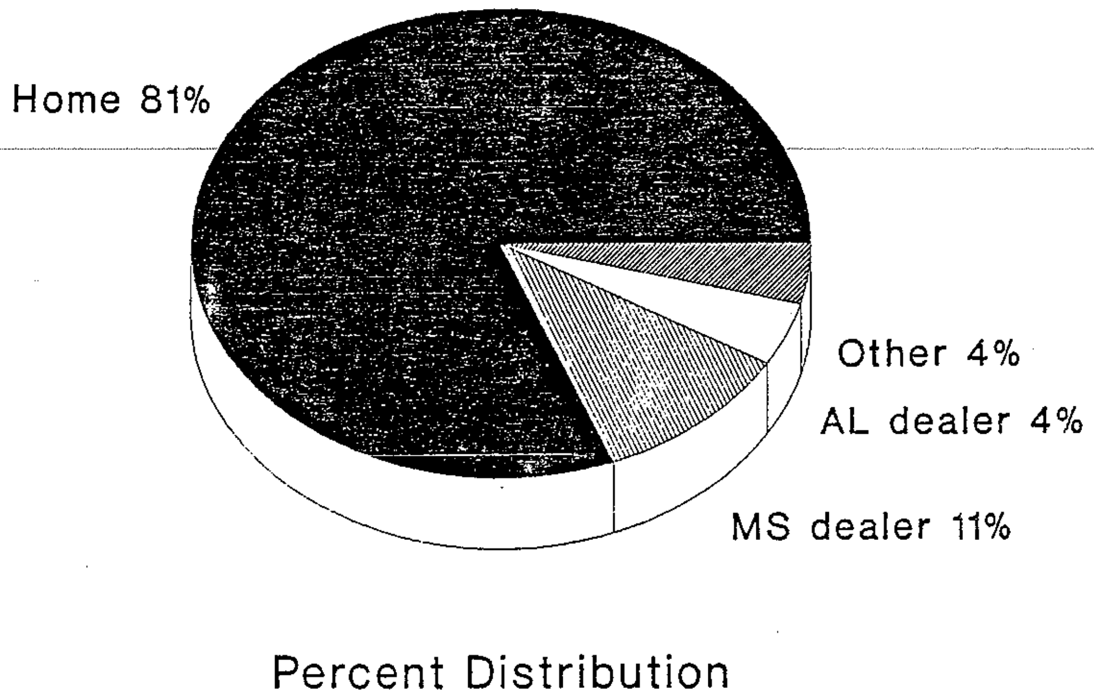

Figure 6. Harvest Disposal by Mississippi Fishing Boats

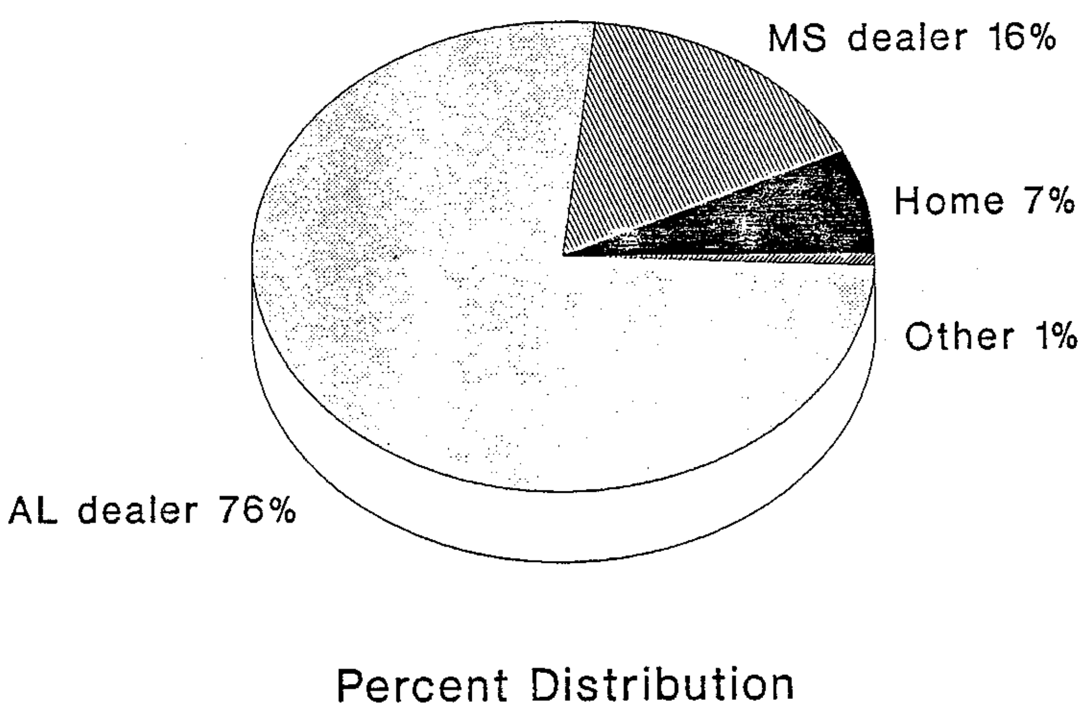

Figure 7. Harvest Disposal by Alabama Fishing Boats

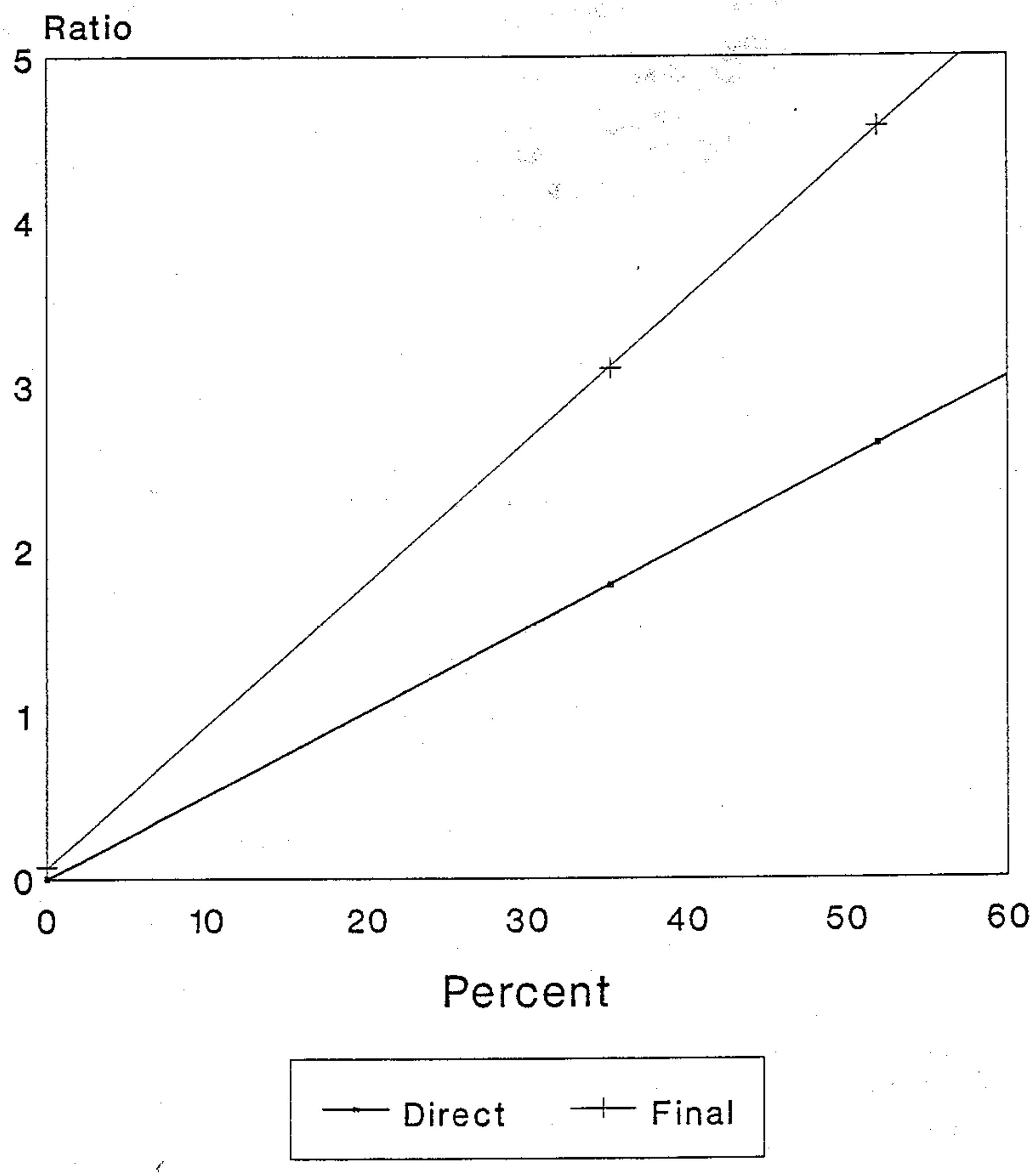

Figure 8. B-C Ratios and Recovery Rate

B. Ex-vessel Price

Figure 9 shows the responsiveness of the discounted benefit-cost ratios of the pilot relaying program to changes in ex-vessel price. During the past 10 years, the ex-vessel price ranged from $18 to $30 per sack. The decline in oyster harvest during the past few years caused the upward pressure on landing prices. With the current recovery rate and cost structure, the critical ex-vessel price of relaying is about $14 per sack. At an ex-vessel price of less than $14 per sack, a higher recovery rate or lower direct costs are necessary to make this project viable.

C. Seed Cost

The sensitivity of the discounted benefit-cost ratios to variations in oyster seed cost is shown in Figure 10. The seed cost consisted of dredging and planting costs. In fact, the project is still profitable as long as seed cost is less than $6.00 per sack of oysters relayed, *ceteris paribus*. A higher ex-vessel price or higher recovery rate is needed if seed cost exceeds the critical value.

D. Wage Rates

Figure 11 shows the viability of the project at various changes of wage rates, average price structure, and current recovery rate. About two-thirds of all direct costs consisted of regular and contract wages and salaries of crew and staff members working on the relaying project. The critical limit for increases in wages and salaries at the current harvest and price levels is about 130 percent. When wages and salaries are more than doubled, a higher ex-vessel price or higher recovery rate is needed to keep the project viable.

E. Fuel Costs

The effects of the changes in the costs of diesel fuel, gasoline, engine oil, and hydraulic fluid on oyster relaying is shown in Figure 12. The viability of the project was tested at various fuel costs, current recovery rate, and the average ex-vessel price of $24 per sack. The weak responses of the benefit-cost ratios to changes in fuel costs indicate that the viability of the project was not strongly influenced by fuels costs since fuel cost comprised a minor portion of total direct costs.

F. Discount Rate

Figure 13 shows the effects of different discount rates on oyster relaying. The benefit-cost ratios were estimated at various discount rates, current recovery rate, and the average ex-vessel price of $24 per sack. The viability of the project was not strongly influenced by the discount rate as shown by the flat B-C ratio lines.

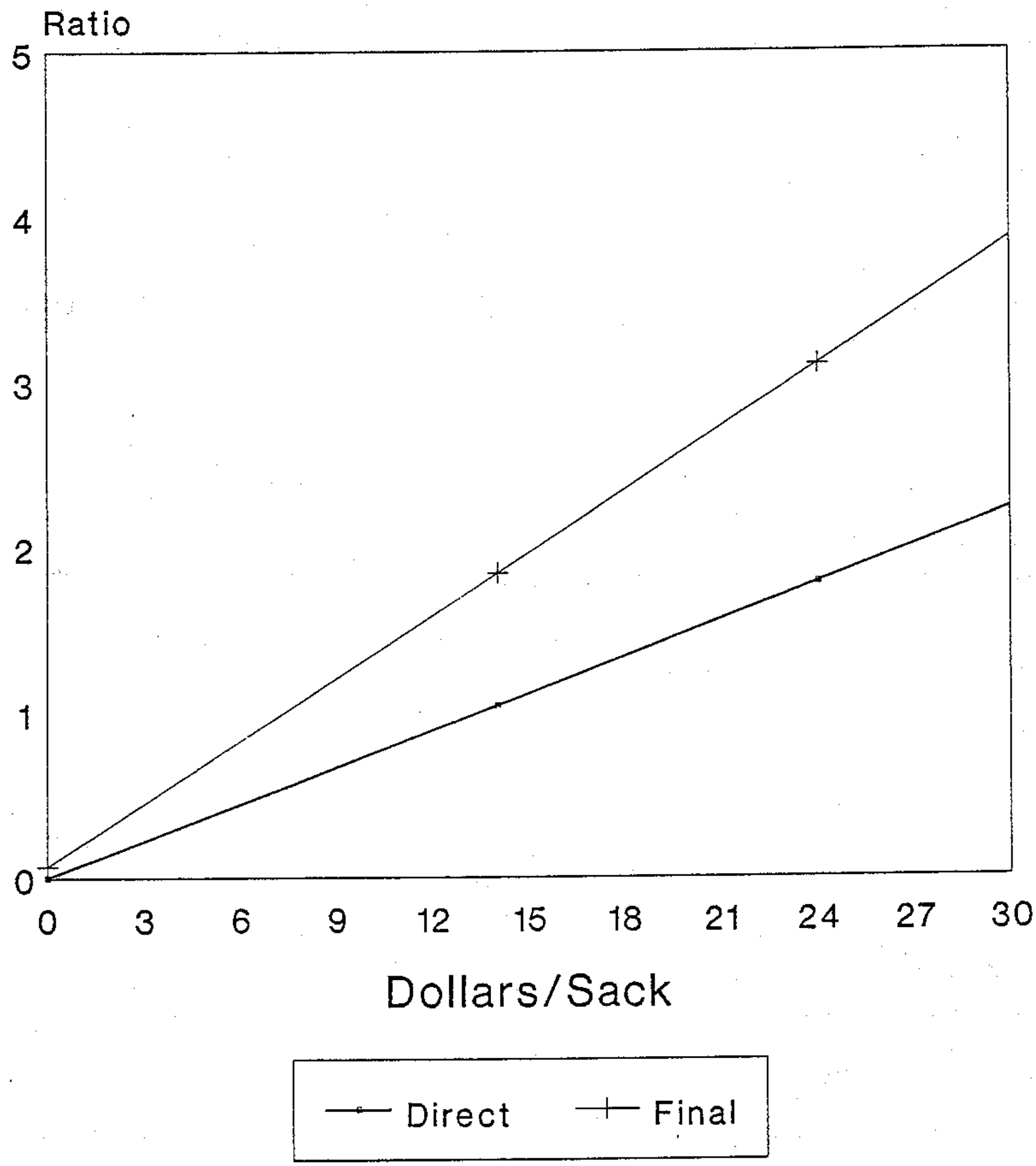

Figure 9. B-C Ratios and Ex-Vessel Price

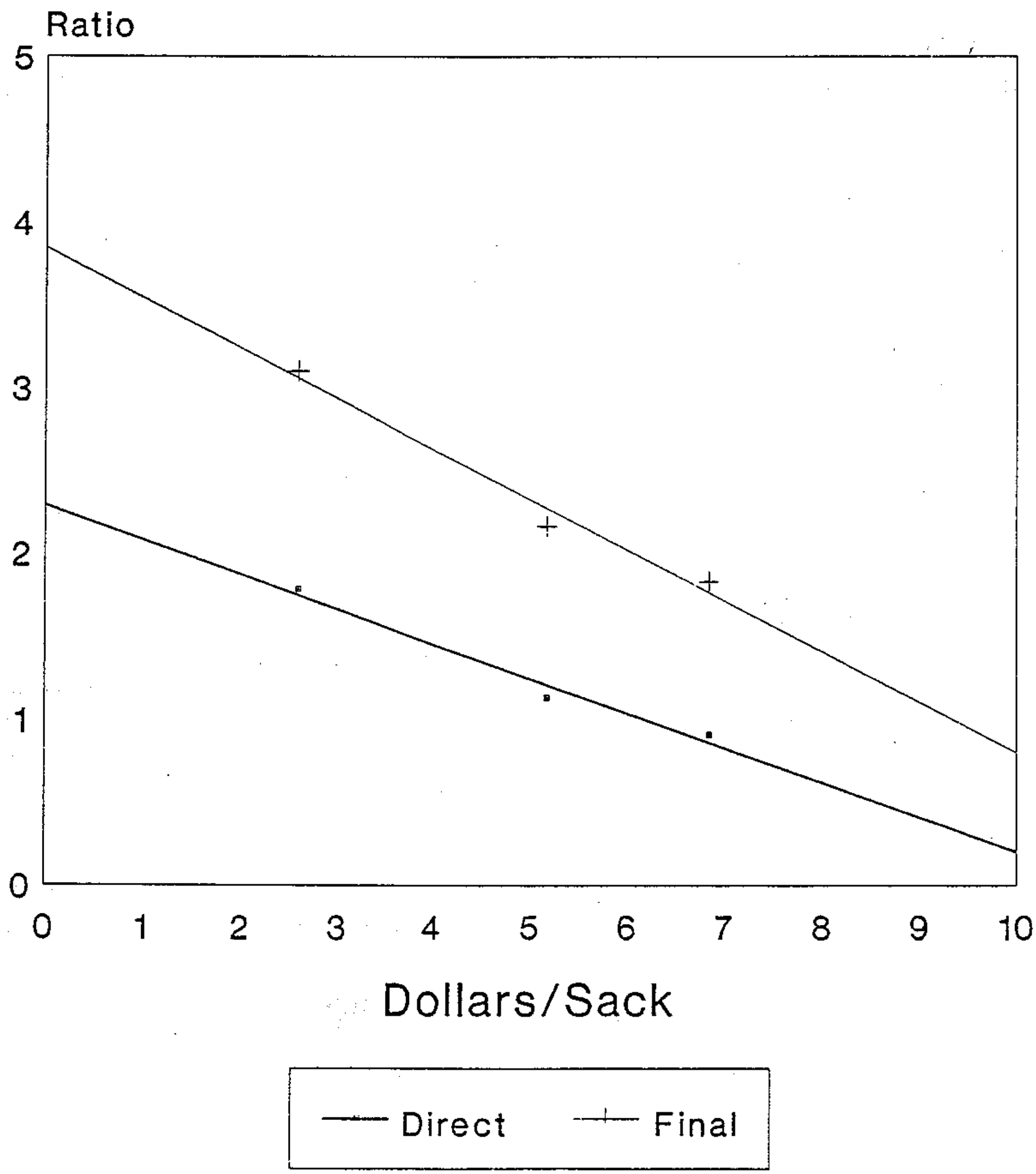

Figure 10. B-C Ratios and Seed Cost

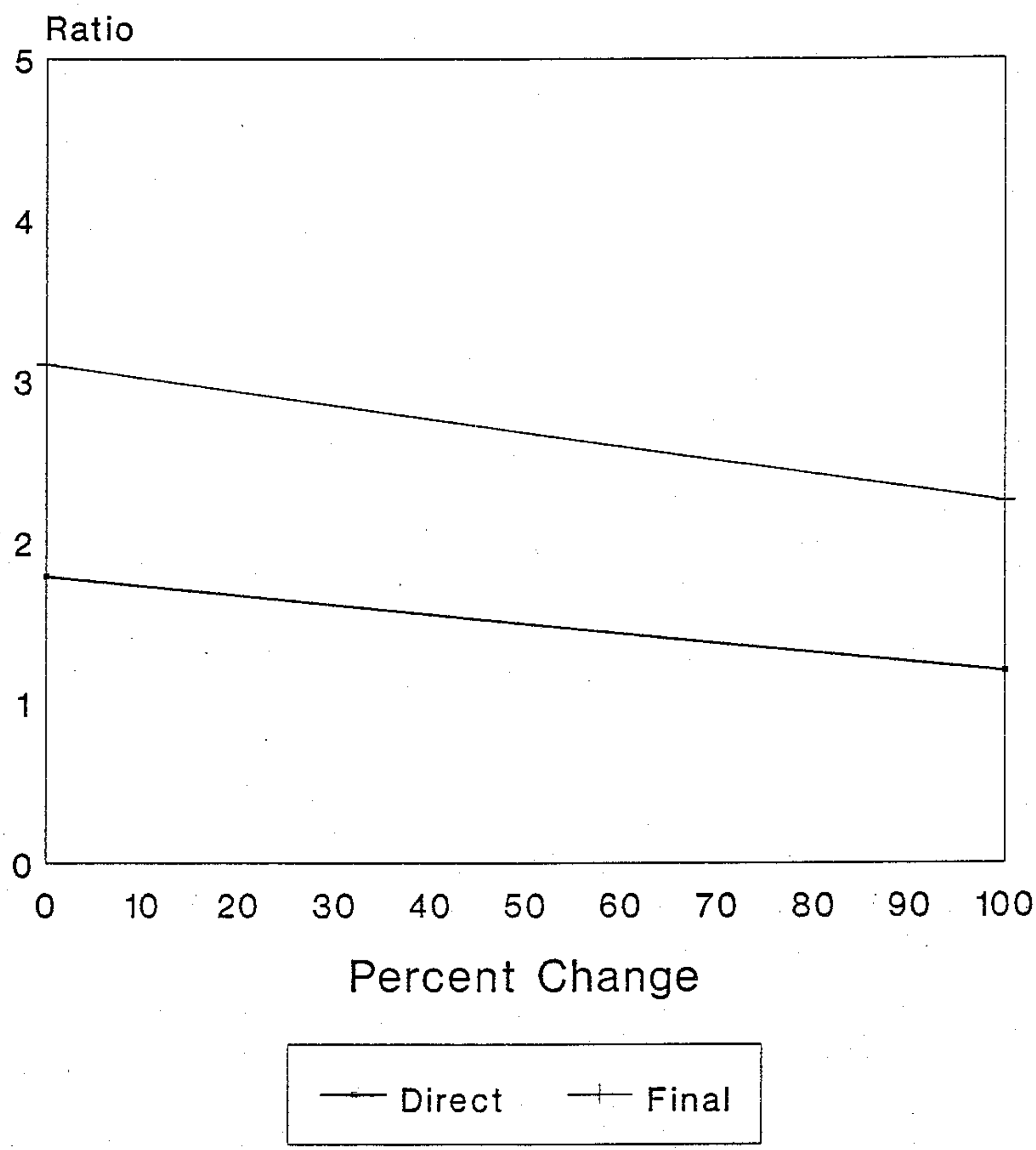

Figure 11. B-C Ratios and Wage Rate

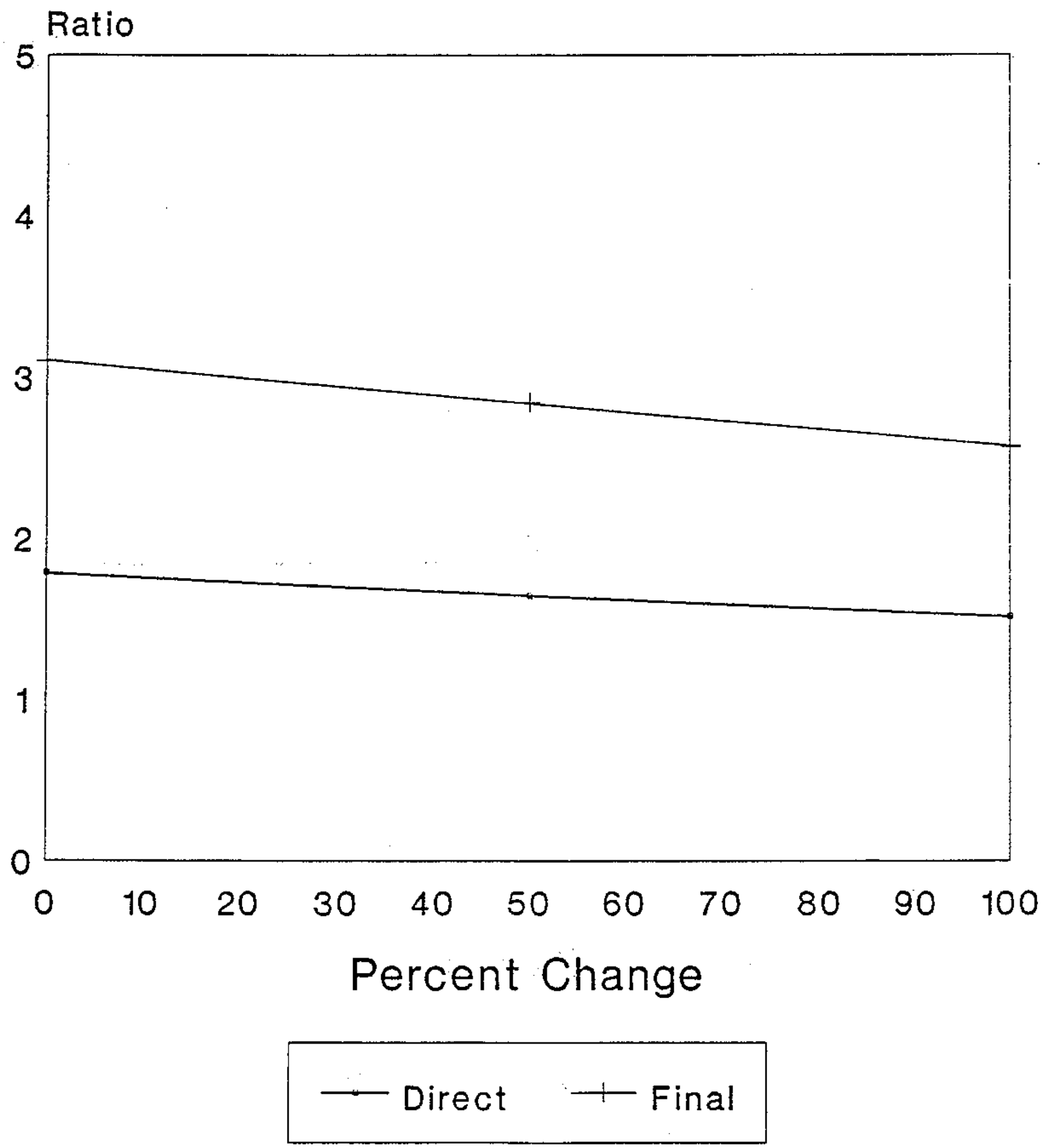

Figure 12. B-C Ratios and Fuel Cost

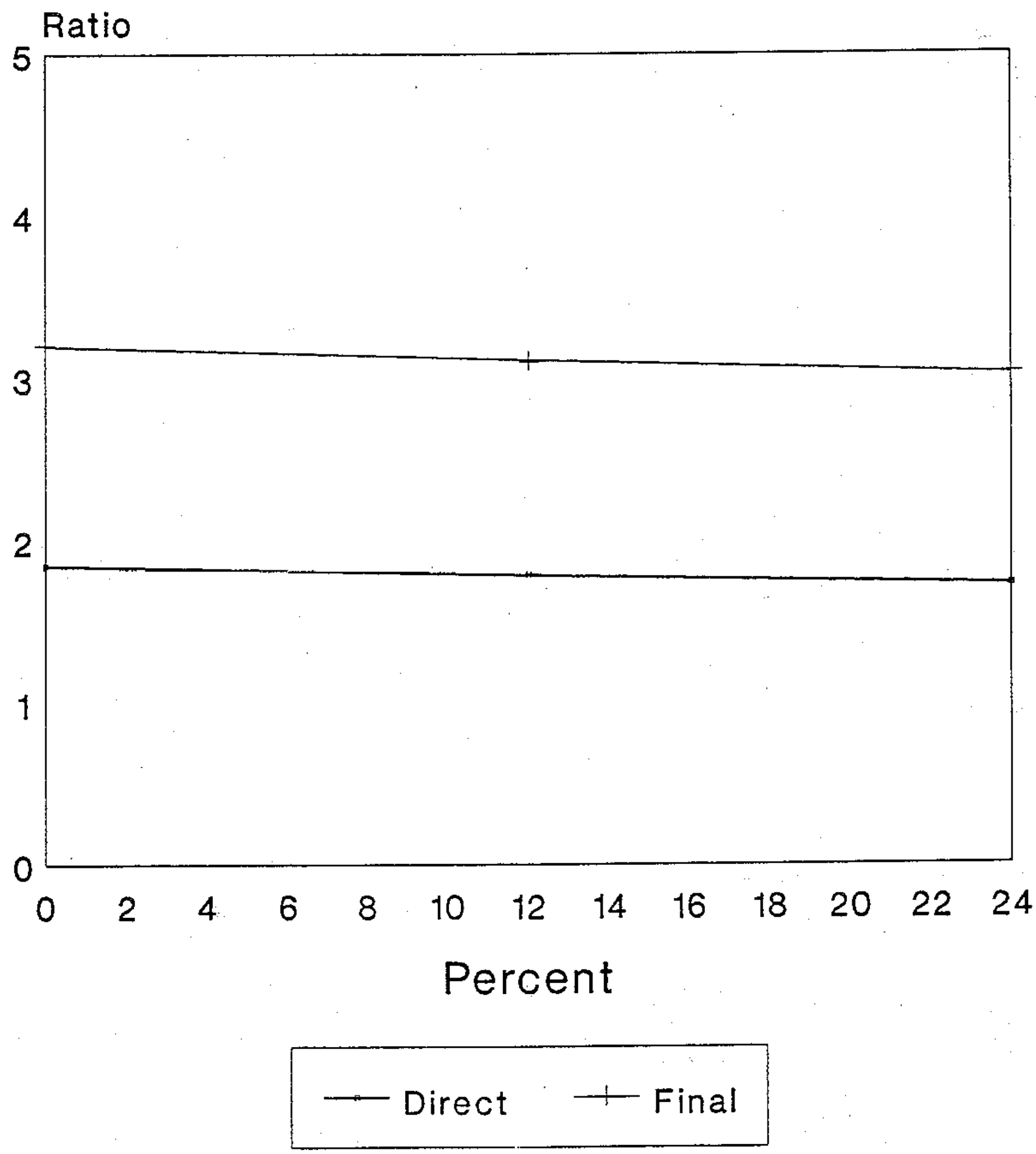

Figure 13. B-C Ratios and Discount Rate

VII. DISTRIBUTIONAL ISSUES IN RELAYING

There are distributional issues concerning how benefits were shared in relation to the cost of relaying and harvesting. The BMR incurred total expenditures of $20,404 for the project. The state of Mississippi stands to benefit from oyster relaying in the form of shell retention taxes and oyster licenses. Shell retention taxes consist of $0.50 per sack of oysters harvested from Mississippi waters. The expected shell tax collections generated from the reported harvest of 5,305 sacks amounted to $2,652.50.

Oyster fishermen also buy commercial and recreational fishing licenses before they can harvest oysters, and the opening of the relay site induced oyster fishing in the area. This incentive to fish enabled the state to collect $3,257 from oyster fishing licenses sold to fishermen who harvested oysters in Bang's Lake. Bang's Lake was opened more often than any other public oyster reefs in the state. The availability of oysters in the lake should lead to more fishing licenses sold by the state.

The state and local governments would realize a sizable amount of sales taxes every time oysters changed hands, e.g., retailers to households, restaurants to customers. Sales taxes are expected from the sale of processed oyster products at the processor, wholesaler, retailer and restaurant levels. Income taxes are also due from personal income generated by oyster harvesting, processing, and distribution. This report, however, did not include any information on the effects of the program on tax collection.

A major drawback in state-funded relaying would occur when the expected tax collections are not achieved as a result of unreported harvests and fishing trips. Further, massive leakages from the state economy would occur if nonresident fishermen harvested most of the relayed oysters and sold them to out-of-state processors/wholesalers. As a result, secondary and tertiary benefits associated with relaying would not be fully realized by the state economy. Value added in processing and distribution of oyster products is also foregone under these circumstances.

VIII. CONCLUSION

The primary goal of this pilot relaying project was to determine the benefits and costs of relaying oysters from restricted to approved waters. Despite the presence of a considerable amount of oysters in polluted waters in the state, the oyster industry had been suffering from an acute decline in oyster landings during the past few years. As a means to remedy this rapidly declining harvest of oysters, relaying has been considered as a viable alternative. Before any definite proposal on relaying can be formulated on a state-wide or federal basis, certain economic issues need to be resolved to shed light on the economic potentials of relaying.

From the point-of-view of oyster fishermen as seen from the ratio between harvesting costs and landing value, any oyster available for harvest, either within relaying grounds or not, brought more benefits than costs. But this type of oyster fishery could not be sustained on a long-term basis given the present circumstances facing the oyster industry.

From the societal point-of-view, the benefits generated from relaying came in different forms and levels. At the relaying stage, direct and indirect benefits were generated in the form of additional income for fishermen and more sales for businesses affected. Higher household spending arising from relaying oysters generated more economic activities for the state. During the harvest season, oyster fishermen purchased goods and services needed for the fishery. These purchases further enhanced the economy of the coastal areas of the state. The income earned by fishermen was spent on household goods and services. These purchases in turn generated further economic activities in other sectors.

On a macro-level, society stands to benefit more than what it cost the different participating units to relay oysters. The issue of distribution, however, arose when the sharing of the costs vis-a-vis benefits from relaying was considered. Leakage from the state economy arose from the harvesting by a considerable number of out-of-state fishermen in the relay site. Furthermore, the benefits which the state expected to receive in the form of licenses and shell taxes were not achieved when some fishermen failed to report their fishing trips to the relay area.

As an investment alternative, however, oyster relaying could be viable. Further evaluation of the enterprise budgets for private oyster relaying is necessary. This method of purifying oysters from polluted or restricted waters proved to be sensitive to fluctuations in ex-vessel price, harvest levels, and seed cost.

Acknowledgments

The authors wish to thank the Jackson County Port Authority, Mississippi Department of Wildlife, Fisheries and Parks/Bureau of Marine Resources, the Gulf Coast Research Laboratory and the Jackson County Adult Detention Center for their direct involvement in this study. Special thanks are also due to the oyster fishermen of Jackson County for their assistance during the planning and implementation phases of the project and to Dr. Ken Roberts and Dr. Dan Williams who provided the insights on the application of multiplier analysis to oyster harvesting. Mrs. Cynthia Nix devoted many painstaking hours to developing this document outlining the methodologies and results associated with this undertaking. Any errors of omission or commission are the sole responsibility of the authors.

References

[1] Bahr, L., and W. Lanier. The ecology of intertidal oyster reefs of the South Atlantic coast: a community profile. Washington, D. C.: U.S. Fish and Wildlife Service; 1981. 105 p.

[2] Banoub, S., N. J. Blake, and G. E. Rodrick. An approach to a cost-analysis of shellfish depuration. Florida: University of South Florida; undated. 34 p.

[3] Berrigan, M. E. Biological and economical assessment of an oyster resource development project in Apalachicola Bay, Florida. Journal of Shellfish Research. 9(1): 149-158; 1990 June.

[4] Broutman, M., and D. Leonard. National estuarine inventory: classified shellfish growing waters by estuary. Maryland: National Oceanic and Atmospheric Administration; 1986. 11 p.

[5] Broutman, M., and D. Leonard. National estuarine inventory: The quality of shellfish growing waters in the Gulf of Mexico. Maryland: National Oceanic and Atmospheric Administration; 1988. 44 p.

[6] Cannette, J. On-bottom relaying in Mississippi in The Mississippi oyster industry: past, present and future, D. Burrage, ed. Mississippi: Mississippi State University; 1988. 57.

[7] Centaur Associates, Inc. Economic impact of the commercial fishing industry in the Gulf of Mexico and south Atlantic regions. Washington, DC: Gulf and South Atlantic Fisheries Development Foundation, Inc.; 1984. 202 p.

[8] Dressel, D., D. Whitaker, and Teh-Wei, Hu. The U.S. oyster industry: an economic profile for policy and regulatory analysis. Washington, DC: National Marine Fisheries Service; 1983. 46 p.

[9] Gittinger, P. Economic analysis of agricultural projects. Maryland: John Hopkins University Press; 1982. 505 p.

[10] Gordon, S. Oyster resource enhancement in The Mississippi oyster industry: past, present and future, D. Burrage, ed. Mississippi: Mississippi State University; 1988. 40.

[11] Gulf States Marine Fisheries Commission. The oyster fishery of the Gulf of Mexico United States: a regional management plan. Mississippi; 1991. 174 p.

[12] Herrington, T. Classification and trends of shellfish growing waters in Mississippi in The Mississippi oyster industry: past, present and future, D. Burrage, ed. Mississippi: Mississippi State University; 1988. 17-19.

[13] Lee, K. A study of the Mississippi input-output model. Mississippi: Mississippi Research and Development Center; 1986. 35 p.

[14] Marelli, D. C., and W. S. Arnold. Estimates of losses associated with field depuration (relaying) of *Mercenaria* spp. in the Indian River Lagoon, Florida. Journal of Shellfish Research. 9(2): 315-321; 1990 December.

[15] Miller, R., and P. Blair. Input-output analysis: foundations and extensions. New Jersey: Prentice-Hall, Inc.; 1985. 464 p.

[16] Mississippi Bureau of Marine Resources. Data on oyster harvest, fishing trips and fishing man-days, Bang's Lake, 1989-90 season. Mississippi; 1990. 2 p.

[17] Mississippi Bureau of Marine Resources. Data on oyster harvest, fishing trips and fishing man-days, Bang's Lake, 1990-91 season. Mississippi; 1991. 2 p.

[18] Mississippi Commission on Wildlife Conservation. Ordinance No. 8001: an ordinance to establish official standards of measure. Mississippi; 1985. 1 p.

[19] Mississippi Commission on Wildlife Conservation. Mississippi wildlife and marine resources strategic plan for 1988-1992. Mississippi; 1988. 109 p.

[20] Mississippi Department of Wildlife, Fisheries and Parks. Guide to saltwater fishing regulations. Mississippi; 1988. 14 p.

[21] Nelson, R., and W. Hardy. The economic and environmental structure of Alabama's coastal region, Part I: economic structure. Mississippi: Mississippi-AlabamaSea Grant Consortium; 1980. 126 p.

[22] Nissan, E., and D. Williams. 1980. The economic structure of Mississippi's coastal region. Mississippi: Mississippi-Alabama Sea Grant Consortium; 1980. 18 p.

[23] Nissan, E., D. Williams, T. Green, W. Hardy, and R. Nelson. 1978. An economic input-output analysis for Mississippi-Alabama coastal counties. Mississippi: Mississippi-Alabama Sea Grant Consortium; 1980. 18 p.

[24] Perkins, G. B. Economics of the oyster fishery in Mississippi. Mississippi: Mississippi State University; undated. 15 p.

[25] Posadas, B., M. Walrod, and C. D. Veal. Economic impact of oyster harvesting and processing in Alabama, Louisiana and Mississippi. Mississippi: Mississippi State University; 1990. 39 p.

[26] Prochaska, F., and W. Keithley. Economic and financial analysis of production, costs and revenues in the harvesting sector of the Florida oyster industry. Florida: Florida Sea Grant College; 1986. 16 p.

[27] Quast, W., M. Johns, D. Pitts, Jr., G. Matlock, and J. Clark. Texas oyster fishery management plan. Texas: Parks and Wildlife Department; 1988. 178 p.

[28] Richards, G. Relaying and depuration in The Mississippi oyster industry: past, present and future, D. Burrage, ed. Mississippi: Mississippi State University; 1988. 41.

[29] Roberts, K. Economic profile of the U. S. oyster industry in The Mississippi oyster industry: past, present and future, D. Burrage, ed. Mississippi: Mississippi State University; 1988. 4-7.

[30] Stanley, J., and M. Sellers. Species profile: life histories and environmental requirements of coastal fishes and invertebrates (Gulf of Mexico) - American oyster. U.S. Fish and Wildlife Service and U. S. Army Corps of Engineers; 1986. 26 p.

[31] Shang, Y. C. Aquaculture economic analysis: an introduction. Louisiana: The World Aquaculture Society; 1990. 211 p.

[32] Supan, J. Case study of off-bottom relaying in Mississippi in The Mississippi oyster industry: past, present and future, D. Burrage, ed. Mississippi: Mississippi State University; 1988. 53-56.

[33] Williams, Jr., D. C., D. J. Etzold, and E. Nissan. Oyster depuration facility: economic assessment. Mississippi: Mississippi-Alabama Sea Grant Consortium; 1980. 28 p.

APPENDIX A. CONTRACT BOAT INTERVIEW SCHEDULE

Date interviewed ____________ Interviewed by________________
Edited by ___________________ Tabulated by ________________

I. ECONOMIC INFORMATION

1. Are you the owner of the boat you are using in oyster fishing?
2. What is the registration number of your boat?
3. How many partners will accompany you in planting oysters?
4. How much did you spend for the repair this planting season?
5. How much did you spend for gloves, boots this planting season?
6. How much did you spend for licenses and dockage this year?
7. How much is the outstanding balance of your equipment loan?
8. What is the interest rate on the equipment loan?

II. TECHNICAL INFORMATION

1. What is the total length of your boat?
2. How many years have you been using your boat?
3. What is the estimated lifetime of your boat?
4. What is the current value of your boat?
5. How many horsepower is your engine?
6. How many years have you been using your engine?
7. What is the estimated lifetime of your engine?
8. What is the current value of your engine?
9. How far is your planting site from the dock?
10. How far is your planting site from the market?
11. How many days do you use your boat every week?
12. How many months of the year do you use your boat?

APPENDIX B. HARVEST BOAT INTERVIEW SCHEDULE

Date interviewed ____________ Interviewed by______________

Edited by ________________ Tabulated by ______________

I. TECHNICAL INFORMATION

1. Do you harvest oysters in Bang's Lake this season?
2. What kind of boat do you use in harvesting oysters?
3. What is the total length of your boat?
4. How many years have you been using your boat?
5. What is the estimated lifetime of your boat?
6. What is the brand name of your engine?
7. How many horsepower is your engine?
8. How many years have you been using your engine?
9. What is the estimated lifetime of your engine?
10. How many gallons of fuel does your engine burn each harvest trip?
11. What type of harvesting gear do you use this season?
12. How many years have you been using this gear?
13. What is the estimated lifetime of this gear?
14. What is the length and width of your culling box?
15. How far is the harvest site from the dock?
16. How far is the harvest site from the oyster market?
17. How many days do you use your boat every week?
18. How many months do you use your boat every year?

II. ECONOMIC INFORMATION

1. What is the current market value of your boat, engine and harvesting gear?
2. How much did you spend for the repair since the opening of the harvest season?
3. How much did you spend for the purchase of gloves and boots since the beginning of the harvest season?
4. How much did you spend for oyster license, insurance, and dockage fees?
5. If applicable, how much is the outstanding balance of any loan you have made for your boat and engine?
6. If applicable, what is the interest rate charged by your lender for the loan?

APPENDIX C. CONTRACT BOAT MONITORING FORM

Date monitored ____________ Monitored by ________________
Edited by ____________________ Tabulated by ________________

Item	1	2	3	4	5	6	7	8	Total
Number of trip									
Number of crew									
Running time (min) Dock-boat Boat-site									
Planting time (min) Boat-skiff Skiff-site									
Oysters planted (bbl)									
Fuel consumed (gal)									
Oil consumed (pint)									
Fuel price ($/gal)									
Oil price ($/gal)									
Boat repair ($)									
Engine repair ($)									

APPENDIX D. HARVEST BOAT MONITORING FORM

BACKGROUND INFORMATION

Date monitored: ____________ Monitored by: ____________________
Edited by: ____________________ Tabulated by: ____________________

TECHNICAL INFORMATION

Item	Amount
Type of harvest (C or R)	
Oysters harvested (sack)	
Time started	
Time completed	
Number of crew	
Fuel consumed (gal)	
Oil consumed (pint)	

ECONOMIC INFORMATION

Item	Amount
Landing price ($/sack)	
Fuel price ($/gal)	
Oil price ($/pint)	
Boat repair ($)	
Engine repair ($)	
Gear repair ($)	

APPENDIX E. DREDGE BOAT INTERVIEW SCHEDULE

Date interviewed______________ Interviewed by________________
Edited by ___________________ Tabulated by _________________

1. What are the positions of the crew members of the dredge boat?
2. How much are they paid per hour?
3. How much was spent on repair this planting season?
4. How much was spent on equipment this planting season?
5. How much was spent on insurance and dockage this year?
6. How many hours was the dredge boat operated during this planting season?
7. How many hours was the dredge boat operated during the entire year?

APPENDIX F. DREDGE BOAT MONITORING FORMS

Monitored by ________________
Edited by ________________
Tabulated by ________________

SOURCE AND QUANTITY OF OYSTERS DREDGED

Date	Area dredged	Barrels dredged

RUNNING TIME

Date	Dock-dredge	Dredge-anchor	Anchor-relay	Relay-dock

DREDGING AND UNLOADING TIME

Date	Dredging time	Unloading time

FUEL AND OIL CONSUMPTION

Date	Fuel consumed	Oil consumed

MAN-HOURS

Date	Regular crew	Volunteer crew

FOOD SUPPLIES AND OTHER EXPENSES

Date	Description	Total cost ($)

REPAIRS AND MAINTENANCE

Date	Labor services	Parts and materials