1977

A benefit-cost analysis of the Virginia oyster subsidies : an historical appraisal and proposals for the future

Samuel H. Baker
Department of Economics, William & Mary

Frederick Holladay deBrosche Harris
Department of Economics, William & Mary

Carlisle E. Moody
Department of Economics, William & Mary

A BENEFIT-COST ANALYSIS OF THE VIRGINIA OYSTER SUBSIDIES: AN HISTORICAL APPRAISAL AND PROPOSALS FOR THE FUTURE

A report

to the

Marine Resources Commission

Commonwealth of Virginia

Samuel H. Baker III

Frederick H. deB. Harris

Carlisle E. Moody

Department of Economics
College of William and Mary

December 23, 1977

Williamsburg, Virginia

This project was funded through the Virginia Marine Advisory Service with funds from the Office of Sea Grants, National Oceanic and Atmospheric Administration, U. S. Department of Commerce and the Virginia Institute of Marine Science.

CONTENTS

CHAPTER 1

INTRODUCTION

As a leading producer of seafood in the United States, the Commonwealth of Virginia has long maintained an interest in the vitality of its private seafood industry. The present study focuses on the state's oyster industry which is distinguished for its long record of producing one-third of the entire national catch, but which, recently has suffered a variety of natural and economic setbacks. Herein, we wish to examine the economic value of the subsidy programs enacted to meet these recent threats to the very existence of the Virginia oyster industry.

DESCRIPTION OF PROGRAMS - OYSTER REPLETION

Environmental catastrophes in the form of MSX disease in 1960 and Tropical Storm Agnes in 1972 have induced a substantive assist to oystermen from the public sector. Thus, the Commonwealth's Oyster Repletion Program (ORP) is an on-going disaster-relief program designed to channel federal and state funds for cultch and reseeding to damaged public and private seedbeds. The rationale for public investment in this area is three-fold: (1) ORP reflects the option demand by the people of Virginia (especially seafood lovers and those making their living in seafood) for disaster-relief institutions able to respond quickly in the event of an environmental emergency, (2) ORP represents an in-kind transfer to watermen of insurance against catastrophic losses, frequently unobtainable in private insurance markets, or (3) a redistributive subsidy to assist in meeting the frequently prohibitive cost of such insurance (e.g., flood insurance) to entrepreneurs in a sometimes only subsistence-level occupation.

One primary objective of this study has been to estimate the benefit/cost ratio for ORP at the current level of appropriation. In addition, while the Marine Resources Commission already contracts out these seedbed repletion services, we sought to examine the standard cost-effectiveness question: given the well-justified need for a program of size "X", what is the cheapest was to do it; by contract or in-house? Since these two forms of provision are <u>not</u> mutually exclusive and may be, at least in part, complementary, a thorough answer to the cost-effectiveness question necessitated marginal analysis (as to the appropriate size ("X") of the contract repletion program) and, thus, returned us to estimating demand and measuring benefits as required by the primary objective.

DESCRIPTION OF PROGRAMS - PUBLIC ROCKS REPLENISHMENT PROGRAM

Unfortunately, however, not only events of nature have caused "catastrophe" in oystering. Oyster seedbeds constitute a classic example of an exhaustible, but replenishable, <u>common</u> property resource. Economic theory predicts that such a resource will be "exploited to exhaustion", as each fishing competitor attempts to reap his maximum yield before exhaustion. No entrepreneur has the incentive to invest in replenishment activity (even if that simply requires less harvesting for n time periods or perhaps just slightly less harvesting in every time period), because no entrepreneur has the property right to exclude others from reaping the gains of his replenishment. Even <u>with</u> such rights well-specified and carefully assigned to private leasors, the cost of detecting violations may itself be prohibitive, and thus the race to exhaustion again ensues.[1]

This classic case of a common property rights externality (see Agnello and Donnelly 1975a, 1975b, 1976) was recognized as early as 1884 by the Baylor survey and subsequently internalized by legislation about 1890 identifying all the "best" oyster seedbeds as henceforth in the public domain. The rationale for public intervention here was well established as the cultch in most deep-water seedbeds was well below its optimal height.[2] While implementing one now-accepted correction for such a "market failure" by mandating the regulation (licensing, leasing) of oyster seedbeds, the turn of the century legislation went further and implied an obligation by the Commonwealth to sustain yield from the seedbeds withough regard to future catastrophic losses (from floods, disease, etc.) or the subsequent cost increases. This legislation constitutes, then, the original charter to the Virginia Marine Resources Commission (VMRC) which oversees (in addition to ORP) an on-going seedbed maintenance program, the Public Oyster Replenishment Program (PORR).[3]

While the in-kind subsidy to oystermen has been small (varying in recent years between 6% and its current 1-2% of dockside value), we sought to focus particular attention on this public investment decision as to continuous public oyster rock replenishment. But without site-specific data, it has not been possible to separate the benefits of on-going replenishment (PORR) from repletion efforts (ORP) since throughout the time-period of this study (1967-1976), disaster-relief <u>was</u> taking place. Furthermore, not only were the benefits and costs of ORP continuously present during 1967-1976, but also, the variation in total subsidy appropriations for the oyster industry has been dominated over the past ten years by variation in the ORP expenditures on disaster-relief.

Had this not been the case, the benefit-cost ratios across the ten years could have generated rate of return information reflecting alternative levels of appropriation for replenishment alone. Instead, this study yields primarily conclusions as to the economic value of the disaster relief, repletion program so pervasive in recent years. Extensive advice in the interpretation of these hybrid benefit-cost results is therefore provided in conjunction with proposed extensions of the present model and our current recommendations.

CHAPTER 2

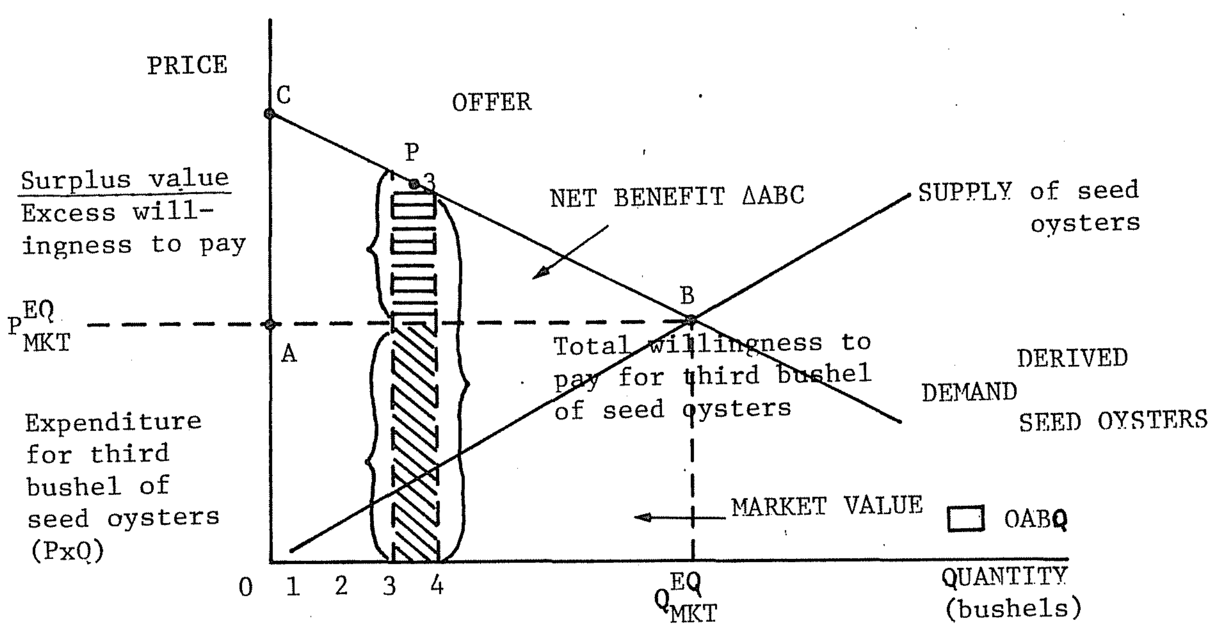
AGGREGATE BENEFIT METHODOLOGY

THE MARSHALLIAN MEASURE OF BENEFITS

Net benefits from the in-kind transfers conveyed to watermen by ORP and PORR consist of two major components: the value to planters of the seed oysters above their market price and the net income accruing to license/leaseholders of replenished seedbeds. The former concept of surplus value reflects total "willingness to pay" and is derived ultimately, of course, from the final market value of mature oysters. Net benefits to planters are, then, the maximum price they would be willing to offer for a bushel of seed (say, $PRICE_3^{OFFER}$, for the third bushel) minus the going market price (P_{MKT}^{EQ}), summed over all bushels exchanged (see ΔABC in Figure 1).

Figure 1

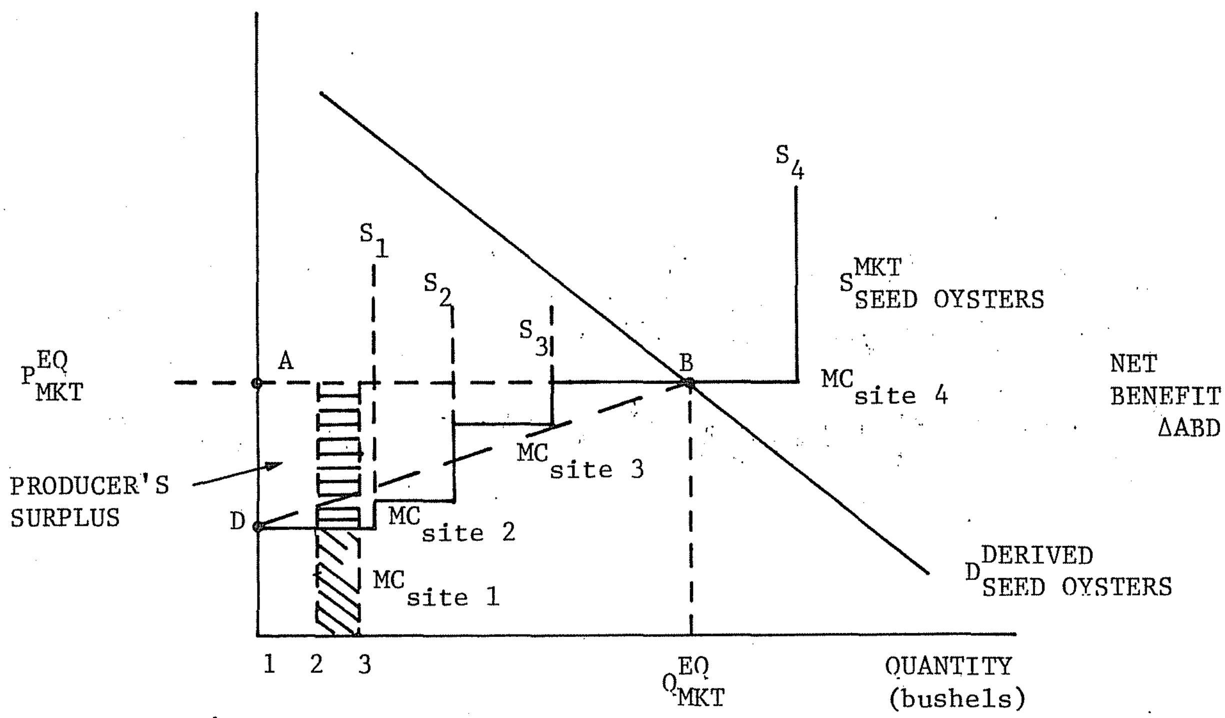
SEED OYSTER MARKET



Likewise, capturing the second component of net benefits easily identifying the net income of seabed leasors--that is, the difference between market value received, P^{Q}_{MKT}, and the outlays (say, MC_1, for the second bushel on site 1). Again summing over all bushels exchanged, ABD (in Figure 2) measures the surplus value to seed producers or, by Marshall's definition, the "producer's surplus."[4]

Figure 2

SEED OYSTER MARKET



Using monthly data, aggregated over seven counties and eight water areas, we calculated both net benefit triangles by estimating the following simultaneous equations model of the seed oyster market:

(2.1) $Q_t^D = q^d(P_t^{SE}, P_t^{SH}, D_i, \text{MONTH DUMMY}_i)$

(2.2) $Q_t^S = q^s(P_t^{SE}, E_t^C, R_t, P_t^{CR}, P_t^{CL}, P_t^{SCL}, D_i, \text{MONTH DUMMY}_i, A_t)$

where the "t" subscript denotes a month between January 1966 and May 1976 and where [5]

Q_t^D = quantity of seed oysters demanded

Q_t^S = quantity of seed oysters supplied

P_t^{SE} = the price of seed oysters

P_t^{SH} = the price of shuck ("mature") oysters

D_i = dummy variables indicating natural or man-made disasters with adverse publicity effects that decrease the demand for oysters

MONTH DUMMY_1 = dummy variables for each of the eight months oysters are in season

E_t^C = an index of alternative employment opportunities

R_t = the cost of capital

P_t^{CR} = crab price index

P_t^{CL} = clam price index

P_t^{SCL} = surf clam price index

A_t = a biological measure of seed oyster availability

SPECIFICATION AND IMPLICATIONS - THE DEMAND EQUATION

Fishery firms (whether owner-managed or manager-controlled, single or multiple employee) are at any moment pursuing both profit-maximizing and cost minimizing objectives. Given an optimal profit-maximizing decision as to output (here, catch size) harvesters of, say, market oysters will proceed to make cost minimizing factor/input choices[6]. They do so, quite intuitively, by equating the marginal contribution to the catch of another dollar spent on any inputs, be that tongers, vessel equipment, or seed oysters. That is, if $75 spend hiring the last crewman increased output/catch by only 60 bushels/week while an additional $75 spent renting patent tongs would increase catch by 100/bushels/week, then the oyster entreprenuer would be well advised to lay off the crewman and rent the tongs. Indeed, we can expect and predict this behavior. Now by an axiom of economics so universally verifiable that it is proclaimed as a "law"--the law of diminishing returns--we note that each remaining tonger is, perhaps, less crowded and appears more productive and therefore that an additional set of patent tongs (perhaps as inventory for quick replacement) is of lower marginal product than the previous fully-employed sets.

With some discontinuities, this equilibration process will continue until the higher marginal contribution (to the output/catch) of the now more scarce labor per dollar (its marginal physical product per dollar is approximately equal to the decreased marginal product of the now more extensive capital equipment (MPP_{CE}) per dollar:

(2.3) $MPP_{EQ}/P_{EQ} = MPP_{TONGER}/P_{TONGER}$ ($\equiv MPP_{LABOR}$/Wage Rate).

We can then say that the marginal cost (actually the inverse of marginal product per dollar, MPP_i/P_i, that is, the additional price or cost of one more unit of input, P_i per unit MPP_i) of all inputs is equal and total costs of the previously-given optimal fishery harvest are at a minimum. That is,

$$(2.4)\ \text{COST MIN} \Longrightarrow (MC^{OUTPUT}_{BY\ EQUIP} = MC^{OUTPUT}_{BY\ TONGERS} = MC^{OUTPUT}_{BY\ SEED}).$$

Now, if the final product market for mature oysters is competitive, then we can expect each harvester to offer additional shuck oysters until his MC of output is just equal to the going market price, P^{SH}_{MKT}. Since, as we have just seen, output can be increased at identical cost by adding either more equipment, more tongers, or more seed oysters, we can analyze any of the intermediate product/input markets <u>in isolation</u>. That is, an additional twelve bushels of shuck (for each of which the harvester receives P^{SH}_{MKT}, say in 1977, \$1.25) may be supplied at a MC of \$15 by simply employing another tonger for a day, so in this market structure

$$(2.5)\ P^{SH}_{MKT} = [MC_{\substack{SHUCK\\OUTPUT}}\ (\equiv \frac{P_{TONGER}}{MPP_{TONGER}} = \frac{P_{EQ}}{MPP_{EQ}} = \frac{P_{SEED}}{MPP_{SEED}})].$$

Thus, if one wants to know what price planters would offer for seed, the answer can be obtained by simply rearranging equation 2.5--or, more generally, the maximum offer prices/demand curve for different quantities of seed may be derived from the maximum offer prices/demand for shuck:

$$(2.6)\quad P_{SEED} = P^{SH}_{MKT} \times MPP_{SEED}$$

The demand for seed oysters is a function of the price of shuck and any variables influencing the marginal product of seed in the production of shuck, or more generally, any variables influencing the production function of shuck oysters.

In specifying the structural demand equation to be estimated, 2.1, we identified this all-encompassing shuck price series as the primary determinant of seed oyster demand.[7] The final product price replaces in equation 2.6 all the usual determinants of fishery demand (like income, seafood price indices, market size, etc.), but in precisely tracking the shuck market equilibrium, it encompasses all the information about final product demand better than any more extensive group of independent variable possibly could. That is the unique nature of the intermediate product/market studied here. In addition, we include in equation 2.1 monthly dummy variables to reflect fish population dynamics and other time-related vagaries of the oystering business like weather, salinity, temperature, etc.[8] It would be preferable to have direct observations on fishery stocks ("availability") and the other catch parameters, but in the absence of that information, monthly dummies will capture any seasonal patterns.[9] Finally, we insert disaster dummies into the specification of equation 2.1 to represent major structural changes (in the relevant aquatic ecosystems) which might adversely affect the production or the price of shuck seed/oysters and, thus, the MPP_{SEED} (in equation 2.6).

While the a priori relationships between the month dummies and seed quantity demanded are better known to those marine biologists studying the shuck oyster production function en vivo, we can predict an unambiguous negative sign for the adverse publicity about environmental contamination precipitated by the extensive flooding following Tropical Storm Agnes.[10] In addition, of course, because of massive salinity changes, flooding and ecological disasters in general adversely affect both the seed and shuck production functions and, thus, both seed quantitiy supplied and (through MPP_{SEED} in equations 2.3 to 2.6) seed quantity demanded.[11] This latter implication, one should note, reinforces the adverse publicity effects captured by the disaster variable in equation 2.1 (the demand equation). Finally, b equation 2.6, we expect the sign on P^{SH}_{MKT} to be positive and, by "the iron law of demand," that on P_{SEED} to be negative.[12]

SPECIFICATION AND IMPLICATIONS - THE SUPPLY EQUATION

In specifying a structural equation for fishery supply, one is overwhelmed not by the paucity but by the profusion of possible supply shifters. In theory, the cost of producing seed oysters is a function of (1) factor/input prices (here, the interest rate on marine equipment, the wage rate paid to tongers and the price of cultch material--usually shells), (2) the biological fertility of fragile aquatic ecosystems and (3) the price of alternative seafood products which oystermen might easily supply.[13] As above, the price of inputs appears in the seed supply function because seed oyster firms will cost-minimize by equating the marginal contribution per dollar of capital equipment (i.e., CE), tongers, and cultch material to the seed harvest:

$$(2.7)\ 1/MC^{SEED}_{OUTPUT} \equiv [MPP^{SEED}_{CE}/R \equiv MPP^{SEED}_{TONGER}/W = MPP^{SEED}_{SHELLS}/P_{SHELLS}]$$

where R and W are the relevant interest rate and wage rate. With again a competitive market structure, this time in the factor market, no particular supplier can withhold enough seed to permanently influence the terms of exchange so the schedule of minimum asking prices (i.e., the supply curve for seed) is the cost-minimizing MC schedule. Thus,

$$(2.8)\ P^{SEED}_{ASKING} = MC(\equiv g(Q_{SEED})) \equiv R/MPP_{CE} = W/MPP_{L} = P_{SHELL}/MPP_{S})$$

or, by the inverse function rule,

$$(2.9)\ Q_{SEED} = g^{-1}(P_{SEED}) = h(MPP_{CE}/R,\ MPP_{L}/W,\ MPP_{S}/P_{S}).$$[14]

Capital costs to oystermen "R" are widely dispersed because collateral seldom extends beyond the vessel to be purchased and because small-scale watermen are notorious for keeping almost no record of their week-to-week operations. Thus, the default risks avoided by creditors can not be properly estimated from actual data. Bankers do not revel at this kind of uncertainty, and thus, watermen either establish very solid, long-term reputations in a community or they are quoted prohibitive capital costs. In order to reflect this phenomena, we pursued a monthly interest rate series with a "lender of last resort," the Federal Land Bank Association, but found that despite (perhaps because of) the informational deficiencies, local banks handled the great majority of loans to watermen.[15] Thus we have adopted various Virginia interest rate series beginning with the AA bond rate.

The local wage rate paid crewmen in oystering "W" is not directly observable. In fact, the Virginia Employment Commission (VEC) disaggregates their published data no further than all fish species which are, unfortunately, also lumped with forestry and agriculture. Nevertheless, it is possible to take observations on the most significant determinants of "W" and allow these proxies to stand in for the theoretically indicated variable. Beyond "agriculture, forestry, and [other] fishing," the predominant alternative employment opportunity for oystermen throughout the sample area is home construction, usually in the unskilled, non-union jobs.[16] After calculating county specific weights based upon the VMRC's 1974 and 1976 employment counts of "casual oystermen on boats and shore plus crewmen on vessels" (see Table 1), we constructed two weighted average wage/employment indices for these mobile oystermen (one for construction, as defined by the VEC and the other for agriculture, forestry, and fishing).[17]

Table 1

SAMPLE AREA: SELECTED OBSERVATIONS[18]

County/City of Residence	Weights: Percentage of Mobile Oystermen	Construction Earnings/Wk Jan-June'76	Manufacturing Earnings/Wk Jan-June'76	Agriculture, Forestry, and Fishing Earnings/Wk Jan-June'76
Gloucester	31%	$131	$101	$280
Accomac	26.75%	144	121	142
York	11.85%	188	283	124
Mathews	10.35%	128	148	105
Northampton	6%	166	114	239
Isle of Wight	6%	197	217	79
Newport News	6%	213	226	139

Sources: Marine Resource Commission, "1976 Data Run", and Employment Summary Sheets, 1974-1976; Virginia Employment Commission, "Covered Employment and Wages."

In order to ultimately justify this aggregation across the sample area, we must of course show that the six county (and one city) series on wages/employment are highly correlated. Equilibrium employment in fishing and thus job choice is established in large part by the relative wages in each area (the ratio of oystering to construction wages, for example). To the extent that employment opportunities are comparable across the sample area (see footnote 16), the relevant relative wage rates may differ a great deal (as Table 1 and 2 demonstrate), but it is only when the relative wages change in opposite directions that an aggregated, weighted average wage rate in construction or manufacturing or oystering will be inappropriate. We did examine the simple correlation coefficients between all pairs of county-county and county-city indices, as well as those correlations between each individual series and our aggregated Virginia index and found them to be positive.[19]

Table 2

VEC REPORTING AREAS: SELECTED OBSERVATIONS

Reporting Area	Materials Handler (Manufacturing Laborer) Hourly Earnings (1976)
Exmore	$3.03
Suffolk	3.61
Warsaw	2.64

Source: Virginia Employment Commission, Manpower Research Division, "1976 Wage Rates and Fringe Benefits for Selected Occupations Paid by Virginia Manufacturers."

With job or skill distributions not controlled, however, the aggregated wage indices take on an ambiguous meaning.[20] We can not be sure what is implied, for example, by a rise in the aggregate construction wage. Does it signify that demand for construction labor at all job/skill levels has increased, or does it mean that the skill distribution has shifted upward such that there are now more engineers, but fewer laborers? In the former case, alternative employment opportunities for oystermen (in general, and for casuals and crewmen, in particular) have expanded and wage costs in oystering will rise, while in the latter case precisely the opposite effect on wage costs is implied. Thus, without an unambiguous implication as to unskilled wage rates and, through crewmen labor costs, as to seed quantity supplied, the construction and other wage indices are expendable.[21]

We opt therefore for the alternative employment opportunity index, which weights, for example, construction engineers and construction laborers equally.[22] For example, in mid-1967, when

Accomac County construction wages fell from $87 at the start of the year to $78/week, we would not expect less substitution toward construction by watermen, but more, because (in this case) job availability was enhanced by an influx of low-paying construction openings (from 188 total in January up to 250 in June). And it is job availability that induces substitution by watermen.[23] Thus, when the construction employment index increases by one, we can infer unambiguously that one labor slot opened at the base of the construction crew's hierarchical pyramid or, because of the pyramid's multipliers, that more laborers will be hired to fill out the crew of the one carpenter, foreman, contractor or engineer.

A final potential problem with even these alternative employment indices remains, howver, and that involves the argument that it is not the presence of a weighted average job at a higher relative wage that induces a crewman to quit (and substitute out of oystering), but instead, the presence of a single marginal job opportunity at higher wages. That is, our average employment indices assume a job choice equilibrium in each county--an equilibrium which is then disturbed by an attractive job opening anywhere in the entire sample area. Fortunately, the presence of few licensed oystermen in the legal jurisdictions immediately surrounding the James River's prolific seedbeds verifies just that kind of mobility (from Isle of Wight, Surry and James City Counties to the oystering construction and manufacturing jobs in Hampton and Newport News) presupposed by this aggregated model. Thus, as is clear from equation 2.9, we predict that an increase in the interest rate, the price of shell, or any of the alternative employment indices will raise capital, shell, or labor costs and, by increasing the marginal cost of production, will reduce the equilibrium seed quantity supplied.

Again, examining equation 2.9, we clearly must include in the supply specificiation both the month and disaster dummies as they reflect important determinants of the marginal product (MPP) of labor, shell, and capital in the production of seed. As before, popular dynamics and many other seasonal parameters of catch should be captured by the Agnes variable plus the eight dummies identifying those continuous months during which oysters may be legally landed. Our expectation is that at a later date, a biological "availability" measure of spatfall counts on shell strings would supplement these crude, dichotomous attempts to capture all the critical seasonal determinants of a seed oyster production function.

Finally, we must include those seafood products toward which seed entrepreneurs might easily substitute their vessels and equipment. Typically, this cyclical pattern of effort in various fisheries can be well predicted by the price indices of seafood for which the oystermen's boat, gear, and knowledge is complementary--in particular, clams and crabs.[24] One can easily perceive the theoretical implication that leads to this result by noting an analogy to our previous discussion about the demand for seed oysters. Here, too, the offer price by clam or crab buyboats for an input--in this case, the oyster entrepreneur's knowledge and equipment--is derived from the demand for and thus price of clams or crabs. Hence, P_{INPUT} is again the value of the marginal product:

$$(2.10)\quad (P^{OFFER}_{\substack{OYSTERMAN'S\\ASSETS}} = ROR_{CE}) = P^{CLAMS}_{MKT} \times MPP^{CLAMS}_{\substack{OYSTERMAN'S\\ASSESTS}}$$

(compare equation 2.6). Now, since seed quantity supplied is a function of marginal costs and since, with a rise in the price of clams, the realizable rate of return (or opportunity cost) on oyster capital will increase, we expect the seed quantity exchanged to fall. Thus, Q_{SEED} and all the seafood price indices of supply substitutes (i.e., hard clams, crabs, and surf clams) should be inversely related.

But why in the specification of the supply equation (i.e., 2.2) have we specified separate price indices (for, say, two products as similar as hard clams and surf clams), rather than employing an aggregated "supply substitute" price index? In general, why is it necessary to use disaggregated price series for supply and demand shifters, not extensively aggregated price indices? With an equilibrium allocation of time to the four species in question (crabs, clams, surf clams, and oysters), an oyster entrepreneur does not wait around for a change in the price of weighted average clams to alter his labor choice. If the price of hard clams rises relative to the alternative species, he shifts effort and equipment to harvesting hard clams, independent of whether or not the price of surf clams falls just enough to offset any rise in an appropriately weighted claim price index.

Table 3 consolidates all the foregoing information as to the implied signs of each variable in our simultaneous demand and supply model.

Table 3

IMPLICATIONS

Demand Variables	Expected Sign
P_{SEED}	–
P_{SHUCK}	+
D_1^d(DISDUMMY)	–
MONTHDUMMIES	?
Supply Variables	
P_{SEED}	+
R (INTERESTRATE)	–
P_{SHELL}	–
P^{CR}(CRABPRICEINDEX)	–
P^{CL} (CRABPRICEINDEX)	–
P^{SCL} (SURFPRICEINDEX)	–
E^C (CONSTRUCEMPL)	–
D_1^S (DISDUMMY)	?

ESTIMATION AND INTERPRETATION OF RESULTS

The specifications detailed in the previous two sections yield an estimated time-series model:[25]

$$(2.11)\quad Q_t^d Seed = \alpha^d - B_1^d P_{SEED_t} + B_2^d P_{SHUCK_t} \pm B^d_{3,4,5,6,7,8,9,10} MONTHDUMMIES_t - B_{11}^d DISASTERDUMMY_t + u_t$$

$$(2.12)\quad Q_t^s SEED = \alpha^s + B_1^s\, P_{SEED_t} - B_2^s R_t - B_3^s P_t SHELL - B_4^s CLPI_t$$
$$- B_5^s SCLPI_t - B_6^s CRPI_t - B_7^s CONSTRUCEMPL_t$$
$$\pm B^s MONTHDUMMIES_{8,9,10,11,12,\,t\,13,14,15} - B_{16}^s DISASTERDUMMY_t$$
$$+ v_t$$

$$(2.13)\quad Q_t^d SEED = Q_t^s SEED.$$

However, because of the simultaneity of equation 2.11 and 2.12, the P_t^{SEED} term in the demand equation feeds back on the dependent variable in the supply equation, $Q_t^s SEED$, and thus, in equilibrium is (by 2.13) correlated with the error term on $Q_t^d SEED$--namely, u_t. Since this phenonmenon violates the ordinary least squares (OLS) assumption of non-stochastic explanatory variables, the OLS estimators of the slope coefficients (the Bs), as well as the t tests for significance, are biased and inconsistent. Moreover, even the direction of bias on each estimated slope coefficient on P_{SEED} (i.e., B_1) is generally not predictable, and since the slope is critical to the estimation of a seed oyster demand curve (and thus to our benefit measure), this deficiency of OLS must be remedied.

As the failure-proof prescription, to predict Q_{SEED}^{EQ} or P_{SEED}^{EQ} by estimating with OLS the reduced-form coefficients, will not yield a benefit measure, we proceed to estimate both structural equations 2.11 and 2.12 with two-stage least squares (2SLS). The 2SLS method employes all predetermined variables as instruments in the first-stage, reduced-form specification of the model:

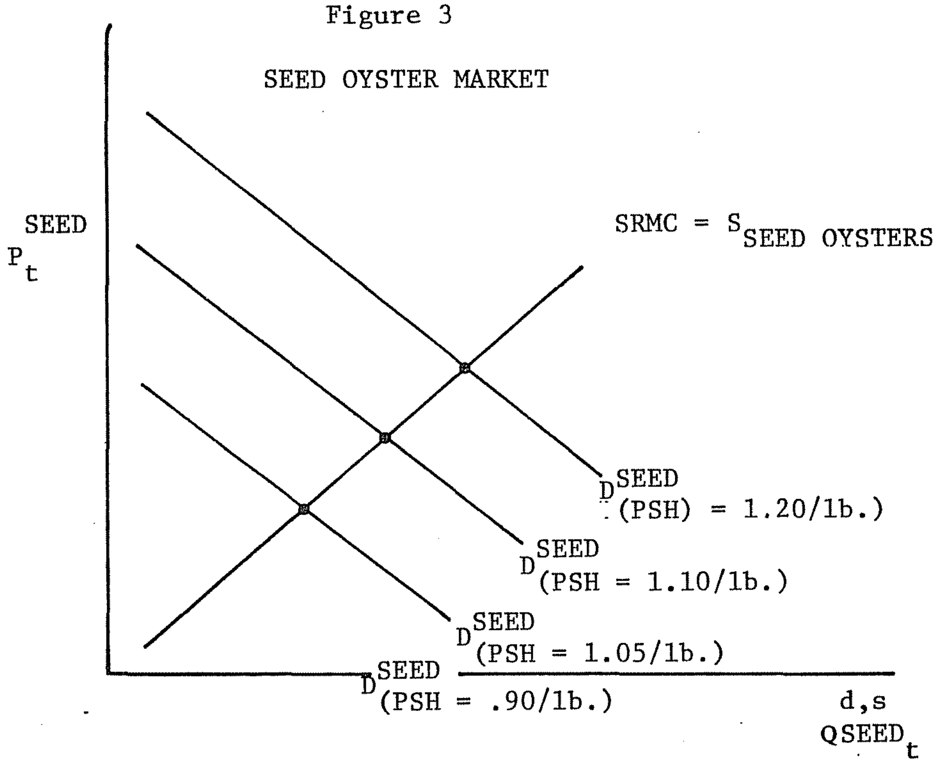
$$(2.14)\ P_t^{SEED} = \alpha^{1st} + B_1^{1st}P_{SHUCK} + B^{1st}_{2,3,4,5,6,7,8,9}MONTHDUMMIES + B_{10}^{1st}DISASTERDUMMY_t + B_{11}^{1st}R_t + B_{12}^{1st}CLPI_t + B_{13}^{1st}SCLPI_t + B_{14}^{1st}CRPI_t + B_{15}^{1st}CONSTRUCEMPL_t + z_t$$

The predicted values of P_t^{SEED} from this reduced-form regression are then used as an instrument in the two structural (demand and supply) specifications containing only relevant explanatory variables (i.e., equations 2.11 and 2.12).

By the order condition that the number of predetermined variables excluded be equal to or exceed the number of endodgenous variables included minus one, we find both structural equations identified with the supply curve exactly identified.[26] Since all the month and disaster dummies reflect determinants of seed (as well as shuck) production costs and therefore influence seed quantity supplied, none of them can assist in identifying the supply function. While all these factors are predetermined and thus may be employed as instruments, the identification of the structural supply equation 2.2 is totally dependent upon the shuck price series. That is, P_t^{SHUCK} is the only exclusively-demand shifter--the only variable in the two-equation system which shifts the demand curve but not the supply--and as such, only it can unambiguously trace out or "identify" the supply curve (see Figure 3). This dependency on only one variable to screen out all the accessory influences and identify a clean price-supply relation assures a particularly precarious estimation but the variable in question is all-important for input markets, and we expected a significance would be attached thereto and generate meaningful estimates.[27] Indeed, the second stage regression results confirm all hypothisized signs (save that on $DISDUMMY^s_t$ and SCPI) with only scattered instances of simply marginal statistical significance. Otherwise, the structural equations 2.15 and 2.16 emerge with t-scores justifying widespread confidence in the plausible estimates (see Table 4).[28]

Figure 3

SEED OYSTER MARKET



One should note immediately that equations 2.15 and 2.16 are demand and supply <u>functions</u> and not the curves of interest for our benefit calculus. Thus, the intercept terms of a downward-sloping demand curve and an upward-sloping supply curve are <u>not</u> 28T lbs. and 142T lbs., respectively; otherwise, the two would never meet.[29] In

TABLE 4

DEMAND

(2.15) $$Q^{d}SEED_t = 28802.6 - 53142.9\ P^{SEED}_t + 20725.7\ P^{SHUCK}_t$$
(lbs.) (3.09)*** (2.39)***

$$+ \hat{B}^{MONTHDUMMIES_t}_{3,4,5,6,7,8,9,10}$$
(all > 3.2 save Jan. and Dec.)***

$$- 24034.1\ DISASTERDUMMY^{d}_t$$
(2.65)***

d.o.f. = 75 R^2 = .64
D.W. = 1.99 F = 12.79

SUPPLY

(2.16) $$Q^{s}SEED_t = 142126.5 + 215295.4\ P^{SEED}_t - 21.3\ R_t$$
(1.29)* (0.21)

$$- 217.5\ CLPI_t + 182.4\ SCPI_t - 3488.6\ CRPI_t$$
(1.75)*** (1.68)*** (2.09)***

$$- 549.4\ CONSTRUCEMPL_t \pm MONTHDUMMIES_t$$
(1.35)* (all < 1.0 save March and Nov. - both positive and strongly significant)

$$+ 27582.0\ DISASTERDUMMY^{s}_t$$
(1.13)

d.o.f. = 69 R^2 = .67
D.W. = 2.14 F = 10.17

general, after adjusting for autocorrelation with the Hildreth-Lu procedure (rho = 0.12), the demand estimation was very attractive.[30] Indeed, we have had little apprehension about proceeding to a calculation of the seed demand curve and its Marshallian consumer's surplus triangle.[31]

Unfortunately, the case is quite different with respect to Marshallian producers' surplus and the supply function in general. Given the paucity of identifying variables in the demand specification, the 90 percent statistical significance on a positive P_{SEED} term was a pleasant surprise.[32] The cost of capital, R_t, may be significant because our choice of an easily accessible AAA bond rate altogether fails to reflect the risk class of loans to watermen. While such measurement error is a possibility, we believe otherwise. Instead, we suspect capital asset (i.e., boat) replacement is a sufficiently infrequent event that capital costs simply do not influence the short-run supply of decisions of seed oyster entrepreneurs.[33]

The positive sign on the surf clam price index indicates that, contrary to our a priori implications, this alternative seafood product is a complement to, not a substitute for, seed oyster effort. This result makes some sense in light of the recent emergence of the Eastern Shore's surf clam fishery, since one can plausibly argue that the new catch probably attracted additional fishermen (from within and without) who in their off-season and down-time, tried their hand at oystering.[34]

Finally, let us comment on the construction employment index and the present methodology with respect to disaster dummies. $CONSTRUCEMPL_t$ enters as a clearly insignificant determinant of seed quantity supplied, probably because of the high collinearity between CONSTRUCEMPL and the price of alternative seafood products. That is, simple correlation between crab prices and oyster employment (documented above for Gloucester County) is just one side of a multi-faceted job-choice equilibrium. For a mobile laborer, all data bearing on alternative employment opportunities are input into the same decision calculus, so one ex post market observation (say, a rise in the price of crabs) is as likely a conveyor of that initial, exogenous shock as any other (e.g., a fall in construction as well as oystering employment). Technically, multicollinearity causes the standard errors of both collinear variables to "explode," thereby eroding t-scores and diminishing the chances of each for statistical significance.[35]

Although the disaster dummy in the demand function performed its role of reflecting adverse publicity effects as expected, our investigation of supply-related disaster phenomenon has been eye-opening. The <u>positive</u> sign on $DISDUMMY_t^S$ suggests that one might pursue a distinction between the biological impacts of an ecological disaster (which we hypothesized to be adverse) and the massive in-kind subsidies proffered by public sector disaster relief. The latter phenomenon (here, the importation of seed oysters and shell to replete public and private beds damaged by the post-Agnes floods) may be adequately reflected by a structural change dummy (separating the sample into pre-Agnes and post-Agnes time periods). Such an argument accounts for the positive sign on our qualitative disaster variable, which is of this structural change variety.

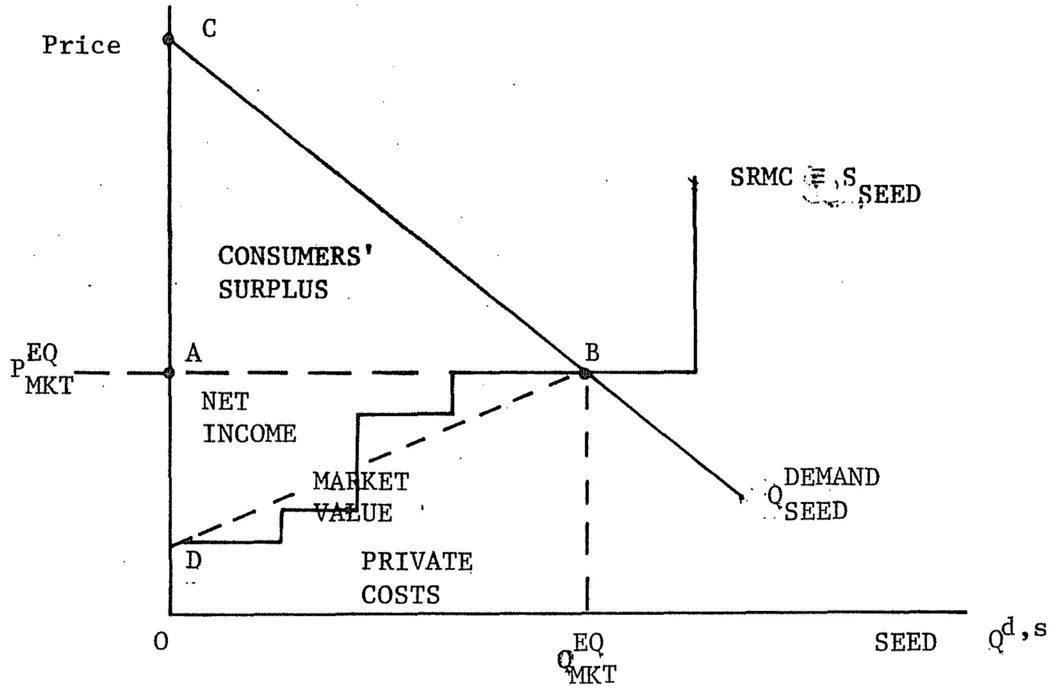
The biological phenomenon, on the other hand, would be perhaps better reflected by a single life-cycle dummy or a continously decomposing dummy. The same is true for the continously declining shock of adverse publicity effects following an ecological disaster, despite the predictable behavior of a structural-change disaster dummy in our demand function.[36] While we have, in general, much less confidence in the structural supply parameters (than in those of equation 2.15), the supply R^2 of 0.67 is higher than that for the demand equation, and the postivie P_{SEED} term in 2.16 is marginally significant. Thus, we proceed to calculation of net consumer and producer benefits from the Virginia seed oyster subsidies.

AGGREGATE BENEFIT ESTIMATES

Recalling the graphical measure of net consumers' and producers' benefit or "surplus" illustrated in Figure 1 (a fascimile of which is reproduced below), note that the tetrahedron $OCBQ^{EQ}_{MKT}$ is easily calculated by integrating under the now-known demand curve from zero to Q^{EQ}_{MKT}, the remaining triangle ABC is, indeed, an estimate of the value of seed oysters above what planters pay at the going market price, P^{EQ}_{MKT}. Similarly, if one integrates under the now-known supply curve from zero to Q^{EQ}_{MKT} and nets these costs OBQ^{EQ}_{MKT} of market value $OABQ^{EQ}_{MKT}$, then the remaining triangle ABD is a reflection of net income (or quasi-rent) accruing to seedbed leaseholders.

Figure 4

SEED OYSTER MARKET



But we do not know the demand and supply curves as yet, for we have estimated the demand and supply functions. To reduce the estimated equation 2.15 to demand curve which shifts with the exogenous parameters of 2.15, we need to construct the two-dimensional (price-quantity) intercept "a" for the representative month when market oysters are at their representative price.[37] Thus, we obtain

(2.17) $a_t = \alpha + \Sigma(M_{it} \times \hat{B}_i)$ where M_{it} is the monthly mean of exogenous variable i in year t

which for equation 2.15 begins

$$a_t = \alpha^d + (M^t_{PSH} \times \hat{B}^d_2) + (M^t_{MONTHDUMMY\ 1} \times \hat{B}^d_3) + \ldots$$

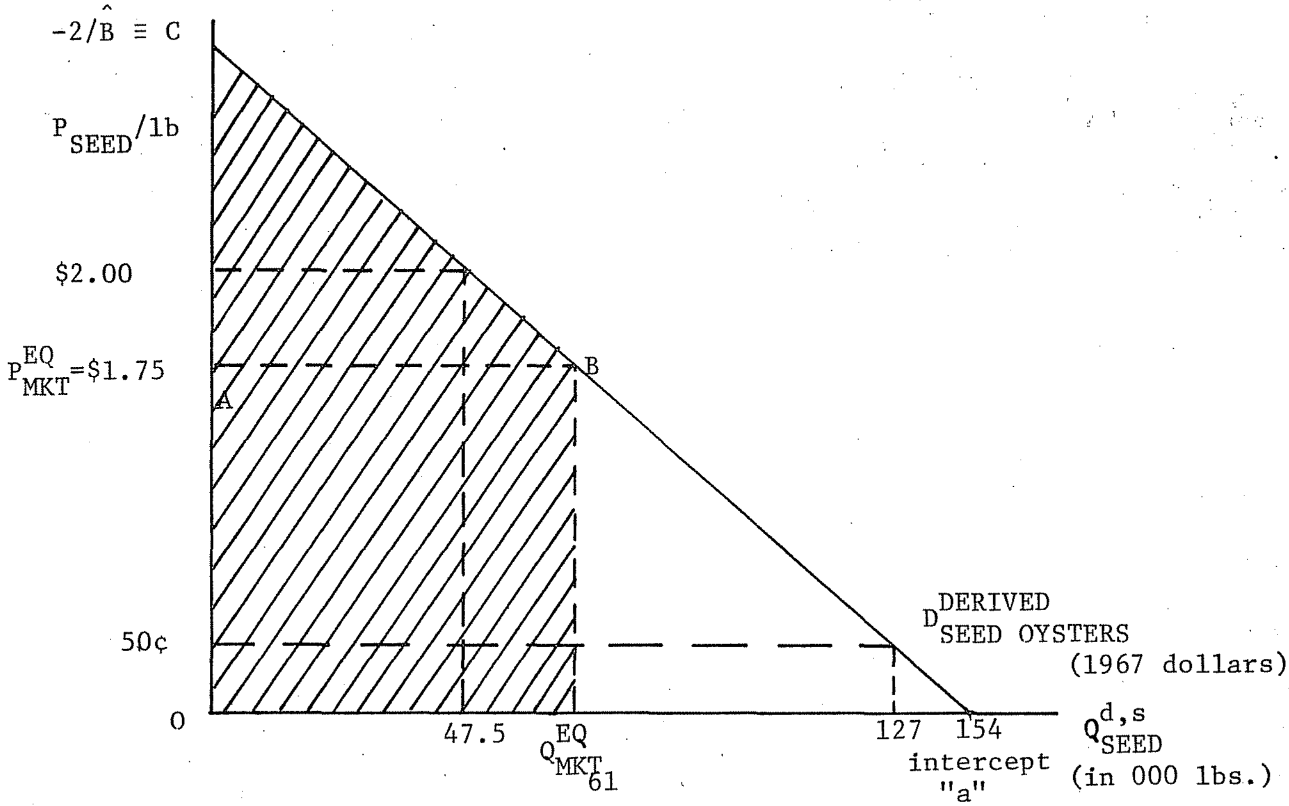
An illustrative reduction from 2.15 to the representative monthly demand curve for seed oysters in FY 1976 yields an equation for the line

(2.18) Q^d_{SEED} = 153,799 lbs. - 53,143 P_{SEED}

(in lbs) (in deflated 1967 \$)

Figure 5

SEED OYSTERS DEMAND/MONTH (1976)



Now $OCBQ^{EQ}_{MKT}$, that tetrahedron measuring gross "consumer" benefits or <u>total</u> willingness to pay, is obtainable by integrating under the demand curve 2.18 from 0 to Q^{EQ}_{MKT}.[38] That is, if $Q^{SEED} = a + B\ P^{SEED}$, the $P^{SEED} = -a/B$, and thus in general

$$\text{Gross "Consumer" Benefits} \equiv \int_0^{Q^{EQ}} P^{SEED}\, dQ$$

$$= \int_0^{Q^{EQ}} (-\ a/\hat{B} + Q^{SEED}/\hat{B})\, dQ$$

$$= \int_0^{Q^{EQ}} -a/\hat{B}\ dQ + 1/\hat{B} \int_0^{Q^{EQ}} Q^{SEED} dQ$$

$$= -a/\hat{B}[Q^{SEED}]_0^{Q^{EQ}} + 1/\hat{B}[Q^2_{SEED}/2]_0^{Q^{EQ}}$$

$$(2.19)\ \text{Gross "Consumer" Benefits} \equiv -a/\hat{B}\ Q^{EQ} + 1/2\hat{B}\ Q^2_{EQ}.$$

With this derivation (2.19) plus the estimated parameters of the seed oyster demand function (2.18), it is now possible to calculate the gross consumer benfits attributable to the seed oyster subsidies for any given month from January 1966 to May 1976.[39] Table 5 shows these gross benefits aggregated to fiscal years.

Table 5

GROSS CONSUMERS' BENEFITS (DEFLATED, 1967 DOLLARS)

FY 1967	$1,434,248
FY 1968	1,467,856
FY 1969	1,211,752
FY 1970	1,084,800
FY 1971	1,319,336
FY 1972	1,263,728
FY 1973	1,049,664
FY 1974	1,119,736
FY 1975	928,856
FY 1976	1,553,000

To obtain net "consumer" benefits or excess willingness to pay, we simply reduce Table 5 by the market value of seed oysters $OABQ^{EQ}_{MKT}$ for each time period. The remaining triangle ABC measures the "consumer" surplus associated with Virginia seed oysters and, thus, with the VMRC's replenishment and repletion program (see Table 6).

Table 6

CONSUMER SURPLUS (NET CONSUMER BENEFITS)

FY 1967	$530,675
FY 1968	528,396
FY 1969	405,296
FY 1970	377,137
FY 1971	510,935
FY 1972	522,617
FY 1973	201,239
FY 1974	-65,917
FY 1975	238,883
FY 1976	555,700

Finally, a re-estimation of the supply function (2.16) excising all insignificant exogenous variables, [40]

$$\text{(2.16b)} \quad \overset{s}{\underset{t}{Q}}SEED = 111958.7 + \underset{(2.37)^{***}}{176216.7}\, P_t^{SEED}$$

$$-/+ \; MONTHDUMMIES_t - 3047.3\, CRPI_t$$

(all <1.5 save March and Nov. - both positive and strongly significant) (2.27)***

$$- \underset{(2.25)^{***}}{220.1\, CLPI_t} + \underset{(1.59)^{**}}{151.1\, SCLPI_t}$$

$$- \underset{(3.30)^{***}}{359.6\, CONSTEMPL_t},$$

d.o.f. = 73 $\quad R^2 = 0.66$

D.W. = 2.08 $\quad F = 11.44$

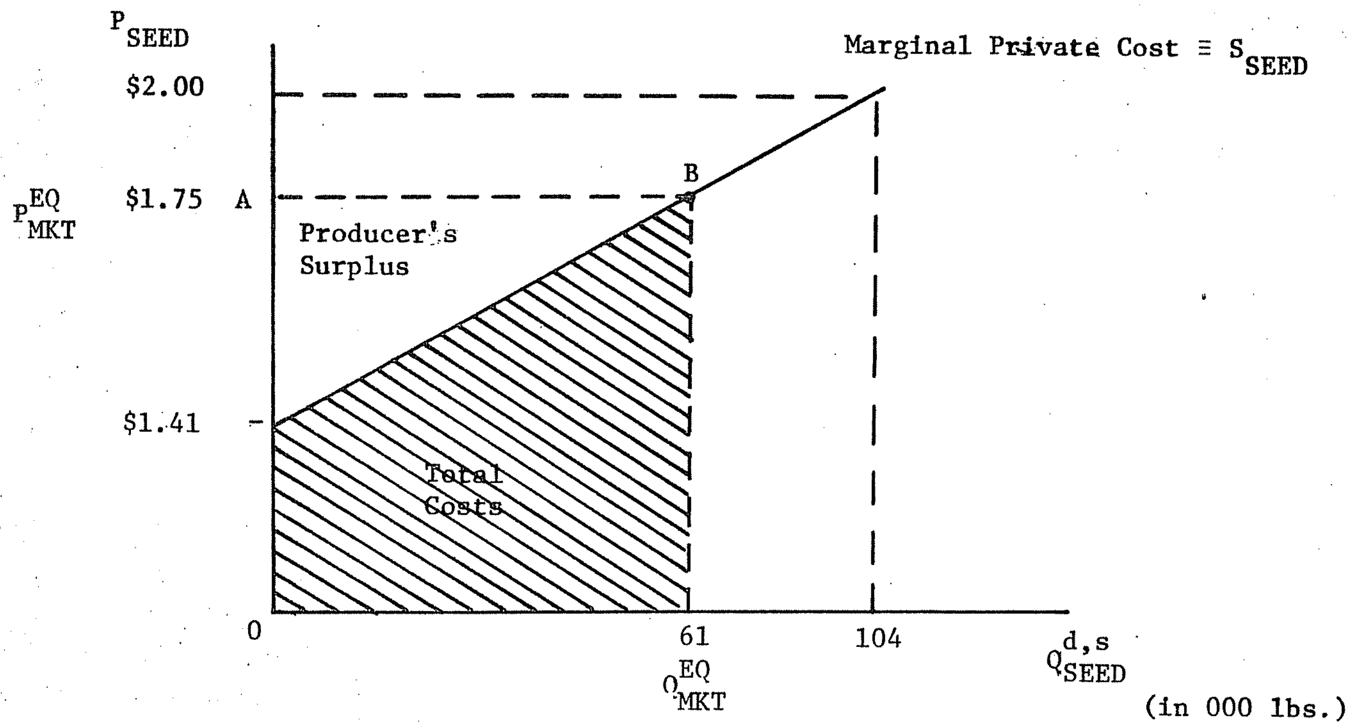
yields an equation for the linear supply curve of seed oysters in a representative month in FY 1975 of

$$\text{(2.20)} \quad \overset{s}{\underset{t}{Q}}SEED = -248{,}039.6 \text{ lbs.} + 176{,}216.6\, P_t^{SEED}$$

(in deflated, 1967 \$)

Figure 6

SEED OYSTER SUPPLY/MONTH (1975)



Again, we can integrate under the supply curve (2.20), which by a fully analogous argument yields producer (i.e., cultivator/harvester) costs as shown in Table 7. Net income or Marshallian producer's surplus is, in aggregate, then

Table 7

ESTIMATED PRIVATE (Producer) COSTS[41]

FY 1967	$1,000,272
FY 1968	924,656
FY 1969	780,024
FY 1970	537,096
FY 1971	758,488
FY 1972	776,384
FY 1973	764,848
FY 1974	966,848
FY 1975	636,280
FY 1976	840,824

Table 8

PRODUCERS' SURPLUS (Net Producer Benefits or Net Income)

FY 1967	$-96,699
FY 1968	14,802
FY 1969	26,427
FY 1970	170,567
FY 1971	49,913
FY 1972	-35,276
FY 1973	83,583
FY 1974	218,807
FY 1975	53,696
FY 1976	156,471

simply total market value, $OABQ^{EQ}_{MKT}$, minus total costs OBQ^{EQ}_{MKT}. Table 8 presents these results for annual data. Summing net "consumer" and producer benefits as in Figure 7, we obtain a measure of the total benefits OCB to seed and shuck oystermen of the Virginia seed/oyster/subsidy programs (see Table 9).

Figure 7

SUBSIDIZED SEED OYSTER MARKET
(per month, 1976)

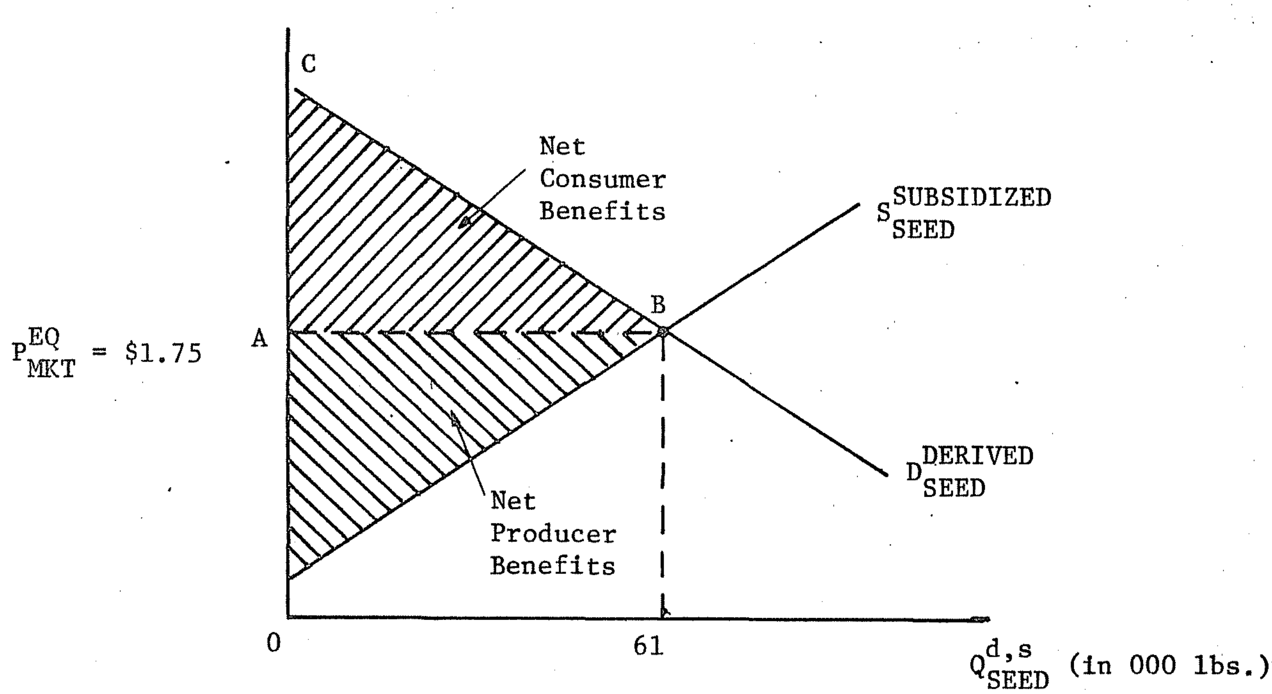


Table 9

AGGREGATED NET BENEFITS[42]

FY 1967	433,976
FY 1968	543,198
FY 1969	431,723
FY 1970	547,704
FY 1971	560,848
FY 1972	487,341
FY 1973	284,822
FY 1974	152,890
FY 1975	292,579
FY 1976	712,171

CHAPTER THREE

BENEFIT-COST ANALYSIS

AGGREGATE COST METHODOLOGY

Since any single generation of seed oysters requires little or no maintenance expenditures, the time stream of costs incurred when deciding to replenish a particular seedbed is very short (approximately one year) and discontinuous from planting to harvest.[43] To analyze this time stream of outlays correctly requires a discounting of the appropriately isolated harvesting expenses. Thus, "costs" in economic analysis refer not to the outlays themselves, but to the opportunities foregone when expenses are incurred. Timing is all-important. A dollar contracted to be paid out a year from today necessitates that one begin foregoing less than one dollar in alternative consumption/investment opportunities. That is, I need not save (and therefore sacrifice the spending power of) a dollar today to make a dollar outlay one year from now. Instead, 91¢ saved/invested at 10 percent interest will generate one full dollar by a year from now when the outlay is due. Thus, if a discount rate of 10 percent were found to be appropriate, the present cost of a dollar in harvesting expenses to be incurred a year from now is not $1.00, but 91¢.

Unfortunately, it has not been possible to examine carefully the planting versus harvesting costs and to perform an appropriate discounting of the latter.[44] This deficiency is ameliorated, however, by two considerations: first, the acceptance of nominal line-item harvesting costs versus discounted expenditures is of less consequence with as short a time-stream as is relevant here; and, second, public harvesting (which only occurs during repletion transplanting of seed) represents a small part of the oyster subsidy programs. On both scores, then, this overstatement of costs is relatively minor.

A possibly more serious bias results from the fact that following a disaster, the VMRC does plant cultch material on private as well as public oyster grounds, but the replenishment tax data on which our benefit estimates are based reflect public and private havesting on public seedbeds only. Since site-specific expenditure data employing the private versus public-bed distinction also is not readily available, we have been forced to include in our program cost calculations some VMRC expenditures the benefits of which our model does not capture. In that sense, the cost figures do unquestionably reflect an overestimate of the first choice benefit-cost measures.

To preserve some congruency with these benefit estimates generated by tax data on all public seedbeds, we aggregate repletion and replenishment costs statewide as exhibited in Table 10A. Total VMRC administrative costs are also depicted, as the on-going replenishment and disaster-relief repletion institutions are inseparably intertwined. Nevertheless, we are inclined to argue that these administrative expenditures and other possible imputations (like the law enforcement costs of patrolling the oyster beds) are non-marginal overhead. Since we expect neither administrative nor law enforcement personnel or equipment would be cut back if the oyster subsidies were even substantially reduced, these costs are (from the perspective of replenishment and repletion budgeting) non-avoidable and should not therefore be attributed to the oyster

Table 10A

TOTAL DEFLATED COSTS OF REPLENISHMENT (1967 Dollars)[45]

Fiscal Year	Operating	Shells[46]	VMRC Administrative
1967	417,404	305,004	62,432
1968	520,250	481,605	64,953
1969	340,830	200,905	67,700
1970	272,932	244,445	72,975
1971	361,045	344,693	79,500
1972	322,705	163,364	75,699
1973	412,811	322,705	69,083
1974	333,129	370,594	77,655
1975	253,771	473,253	63.523
1976	425,522	105,949	63,000

subsidy program.[47] The Engineering Office of the VMRC Law Enforcement Division seems to present something of an exception in its role of continuously surveying and charting the oyster beds.[48]

BENEFIT-COST RATIOS, NET BENEFITS AND INTERNAL RATES OF RETURN

As we see it, the call for a benefit-cost analysis of oyster subsidies has arisen for the following reason. Prior to the mid-1970's, a crude proxy for benefits--namely, the market value of the seed harvest--seemed to provide a thorough-going rationale for the Virginia oyster subsidies in that market value always far exceeded program costs. Since 1973, however, that Market Value/Total Public Cost ratio has been close to and, at times, less than one. That is, program expenditures ODEQ in fiscal year 1975 actually exceeded the market value of the entire harvest of seed oysters OABQ (see Table 10B and Figure 8).

Figure 8

FY1975 SEED OYSTER MARKET AND SUBSIDY PROGRAMS

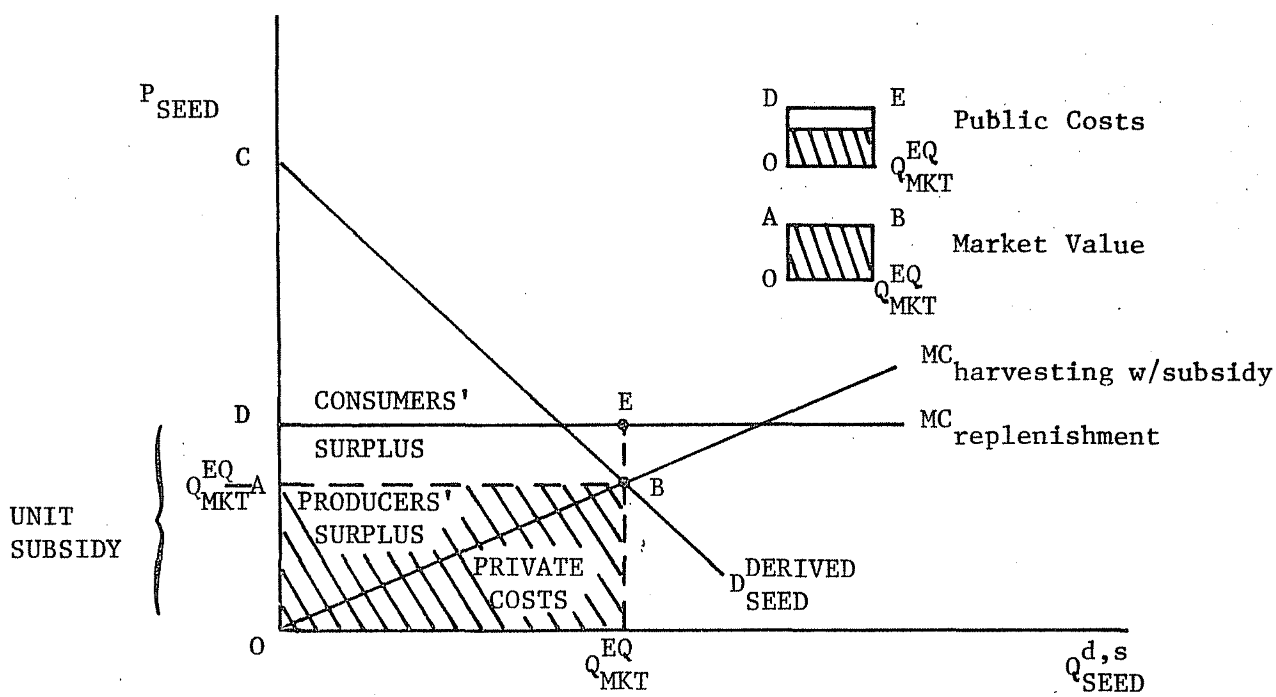


Table 10B

MARKET VALUE/STATE COST RATIOS

Fiscal Year	Estimated Market Value	State Costs	Ratio
1967	901,763	720,963	1.25
1968	951,671	1,014,879	0.94
1969	842,743	620,287	1.36
1970	772,061	564,438	1.37
1971	907,023	791,838	1.15
1972	862,652	565,785	1.52
1973	1,069,866	934,324	1.14
1974	1,741,723	1,033,328	1.68
1975	1,183,999	1,247,573	0.94
1976	1,791,144	954,521	1.88

Table 10C

MARKET VALUE/STATE COSTS RATIOS
(Deflated 1967 Dollars)

Fiscal Year	Estimated Market Value	State Costs	Ratio	Once-Lagged Ratio
1967	903,570	722,408	1.25	
1968	939,458	1,001,855	0.94	1.30
1969	806,453	541,735	1.36	0.80
1970	707,664	517,377	1.37	1.31
1971	808,398	705,738	1.15	1.15
1972	741.110	486,069	1.52	1.05
1973	848,427	740,939	1.14	1.74
1974	1,185,652	703,723	1.68	1.56
1975	689,976	727,024	0.94	0.98
1976	997,296	531,471	1.88	1.37

That result is somewhat attenuated by recognizing the biological fact that state subsidy costs this year impact primarily upon seed output next year (due to the single-year lifecycle from spat set to seed oyster harvest). A one-year lagging of the state expenditures in Table 10C demonstrates this point as the 50% increase in real (price deflated) subsidies from FY 1972 to FY 1973 generates a substantial increase in estimated market value in FY 1974. But market value/public cost ratios are subject to criticism on more fundamental grounds. In the economist's sense employed here, neither "welfare gains" (i.e., net benefits) nor net costs include any measure of the market value of the seed oysters OABQ, because it is argued there was an even exchange. The planter/buyers gave up spending power on alternative goods and services in an amount just equal to the going market value of the seed received. Thus, only the net income realized by tonger/harvesters from that exchange (i.e., MKT VALUE OABQ - COSTS OBQ = NET INCOME OAB) is counted as a "welfare gain" to producers.

Quite appropriately, therefore, a potentially more enlightening question has now been asked--namely, "Does the welfare gain to shuck oystermen and seed oystermen from a viable seed oyster market justify the massive repletion and replenishment subsidies?" This question necessitated a more sophisticated analysis than could be accomplished with simply a market value measure of benefits because the "welfare gain" in question is an attempt to capture (1) the excess willingness to pay (above equilibrium price) of planters as well as (2) the net income of tonger/harvesters. Indeed, such measures of consumer's and producer's surplus required the estimation of demand and supply curves (as described in Chapter 2), so we can now ask "Does the consumers" surplus triangle ABC (see Figure 9) plus the producer's surplus triangle OAB delineate sufficient benefits to justify the subsidy ODEQ?

For this to be so, an appropriately defined benefit-cost ratio must be greater than one. Accordingly, the aggregate net benefit (OAB + ABC) to state cost (ODEQ) ratios are exhibited in Table 11.[49] Alternative reflections of this same information also appear in Table 11 as internal rates of return, which we define in the present context as follows:

SUBSIDIZED PRIVATE ROR ≡ [NET INCOME (OAB)/PRIVATE COSTS (OBQ)]-1.0

PUBLIC (STATE) ROR ≡ [NET INCOME + CONSUMERS' SURPLUS/PUBLIC COSTS (ODEQ)]-1.0

From the legitimately narrow perspective of a state budget allocator, these benefit-cost results indicating (for the most recent year) an excess of total economic value over cost of 34 percent are valid and final as they stand.

Table 11

BENEFIT-COST RATIOS AND INTERNAL RATES OF RETURN

Fiscal Year	B/C Ratio	Public (State) ROR	Private ROR
1967	0.60	-40%	-177%
1968	0.54	-46%	87%
1969	0.80	-20%	-73%
1970	1.06	6%	-254%
1971	0.80	-20%	-47%
1972	1.03	3%	-136%
1973	0.38	-62%	-13%
1974	0.22	-78%	181%
1975	0.40	-60%	-32%
1976	1.34	34%	149%

But recent federal subsidies to expand the post-Agnes disaster relief have been quite substantial, amounting to better than a third of a million dollars in only five years. While the opportunity cost to the state in terms of alternative federal funding foregone may indeed be zero, these federal funds allocated to oyster do, nevertheless, reflect real resources not available elsewhere, and thus their cost should not be totally ignored.[50] Accordingly, a full-cost analysis of the net benefit from oyster repletion and replenishment is provided in Table 12.

Table 12

BENEFIT-COST RATIOS (Federal Funds Included)[51]

Fiscal Year	State Cost	Federal Cost[52]	B/C Ratio
1967	722,408	65,130	0.55
1968	1,001,855	26,549	0.53
1969	541,735	43,669	0.74
1970	517,377	45,830	0.97
1971	705,738	44,563	0.43
1972	486,069	42,955	0.48
1973	740,939	59,477	0.26
1974	703,723	65,214	0.17
1975	727,024	60,606	0.28
1976	531,471	10,440	1.31

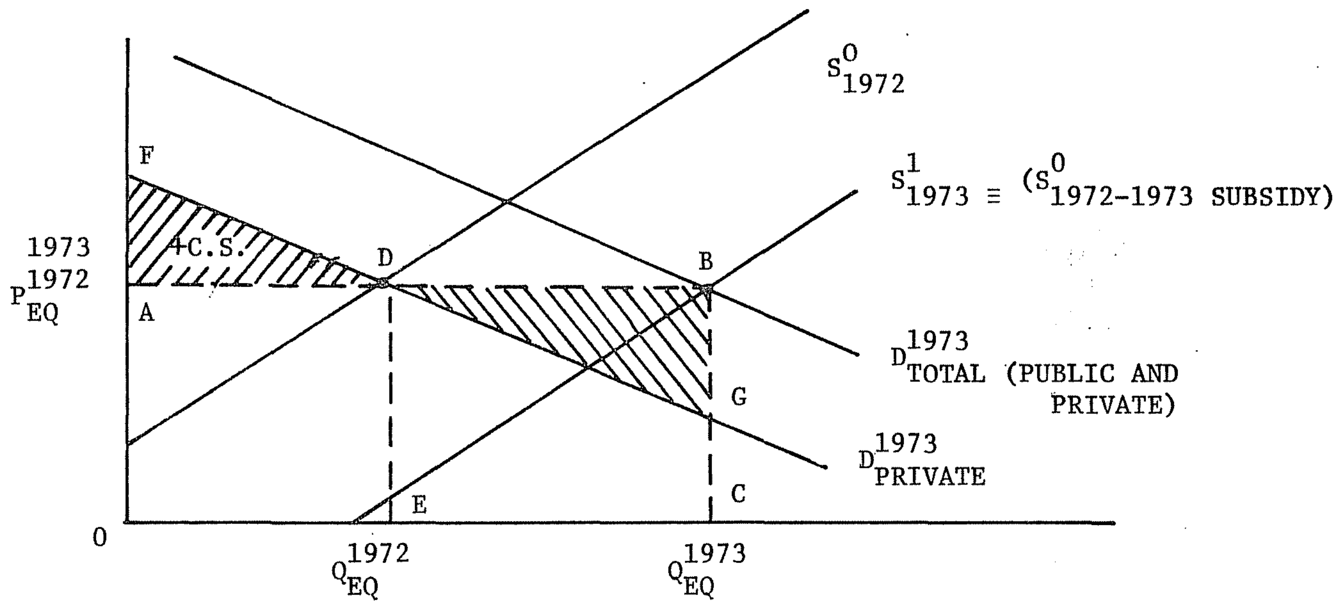
ON INTERPRETING BENEFIT/COST RATIOS

Benefit-cost ratios provide an easy-to-understand encapsulation of the economic value of a public program, relative to its nominal resource costs. Such evaluative information can thus provide the decisive input into public policy decisions as to program retention and development. Immediate qualifications must, however, be delivered in order to ensure a valid interpretation of the results presented in Tables 11 and 12. One must, that is, thoroughly understand the limits of cost-benefit data and take appropriate care in their application.

Initially, let it be noted that no particular year (recent or distant) can be adequately representative of the subsidy program as a whole. Unique circumstances do occasionally dominate any market (subsidized or otherwise) and annual snapshots of "reality" may therefore obscure the fundamental balance of demand and supply forces in a morass of transitory detail. Thus, for example, despite the most recent B/C ratio demonstrating a 34 percent excess of benefits over costs, in 1973 the market value of seed oysters ABCO (in Figure 9) actually outstripped the total private willingness to pay FGCO by $65,519. This 1973 anomaly of a negative consumer surplus resulted from the MRC's extensive intervention on both sides of the seed market in response to the devastation by Tropical Storm Agnes. Seed supply costs had decreased (re: the shift downwards of the supply curve from S_0 to S_1) following a massive public investment in seed and cultch replenishment begun the previous season. In addition, with the backing of special state and federal appropriations, the VMRC entered the market in 1973 to acquire seed for the continuance of this massive disaster-relief operation (re: shift of demand out from $D^{1973}_{PRIVATE}$ to D^{1973}_{TOTAL}).

Figure 9

1973 SEED MARKET



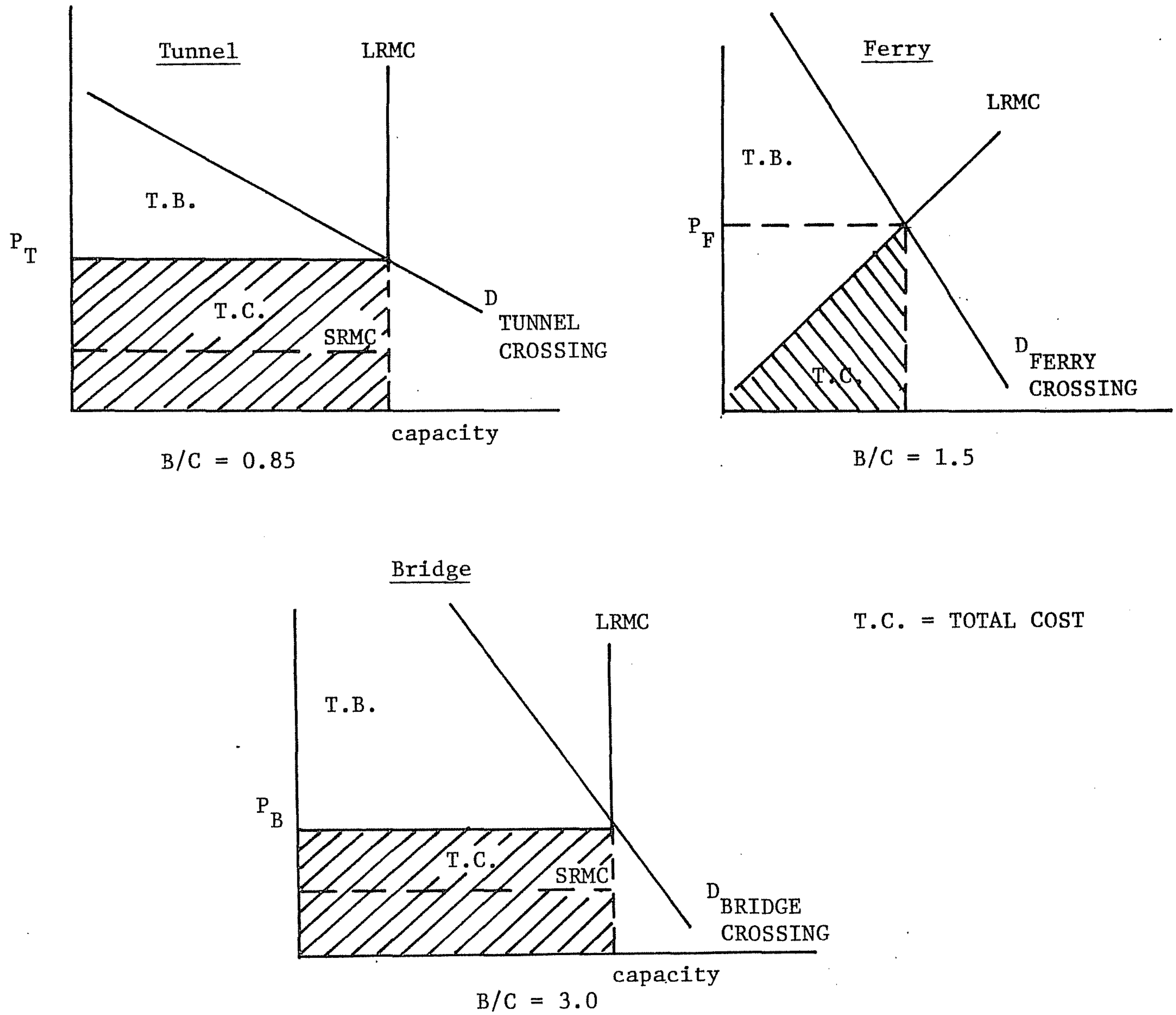
The net effect of the VMRC action appears to have been that seed price remained almost unchanged from 1972, but the quasntity exchanged practically doubled. Graphically, the market value rectangle ADEO expanded substantially to the right (re: ABCO) as both demand and supply shifted in that direction. However, as the benefits captured by our present model reflect only <u>private</u> willingness to pay (i.e., the area under $D_{PRIVATE5}$, note that under expanded D_{TOTAL} (PUBLIC AND PRIVATE)), the seed consumers' gross benefits OFGC <u>could</u> theoretically be less than the total market value of seed purchased by both private planters and the VMRC (i.e., OABC).[53] In this case, it was![54,55]

While the net income of those receiving benefits on the supply side (i.e., the seed harvesters/marketers) was sufficient to offset this negative consumer surplus and leave a positive total "net benefit" for 1973 in the amount of $17,666, the lesson of 1973 should not be missed. A cursory evaluation of the benefit-cost ratios in 1972-73-74 would have misled a short-sighted investigator to conclude that the oyster subsidies in Virginia ought to be abolished. A per se indictment of public sector costs greater than benefits (and thus a negative rate of return) especially for 1973 is impregnable to criticism on narrow grounds. But to apply that one-time B/C result to longer-term public policy choices and conslude that the oyster subsidies should be abolished would have been to miss the point. In 1973, it was not that oyster subsidies had outlived their usefulness. Quite the opposite; the 1972-74 oyster subsidies were probably decisive in the rebuilding of a recently viable industry just devastated by the second natural disaster in twelve years.[56] The 1.34 B/C ratio or the most recent year studied (FY 1976) is evidence that a longer-term, investment perspective on the massive 1973 subsidies was justified.

ALTERNATIVE INVESTMENT OPPORTUNITY COSTS AND MARGINAL ANALYSIS

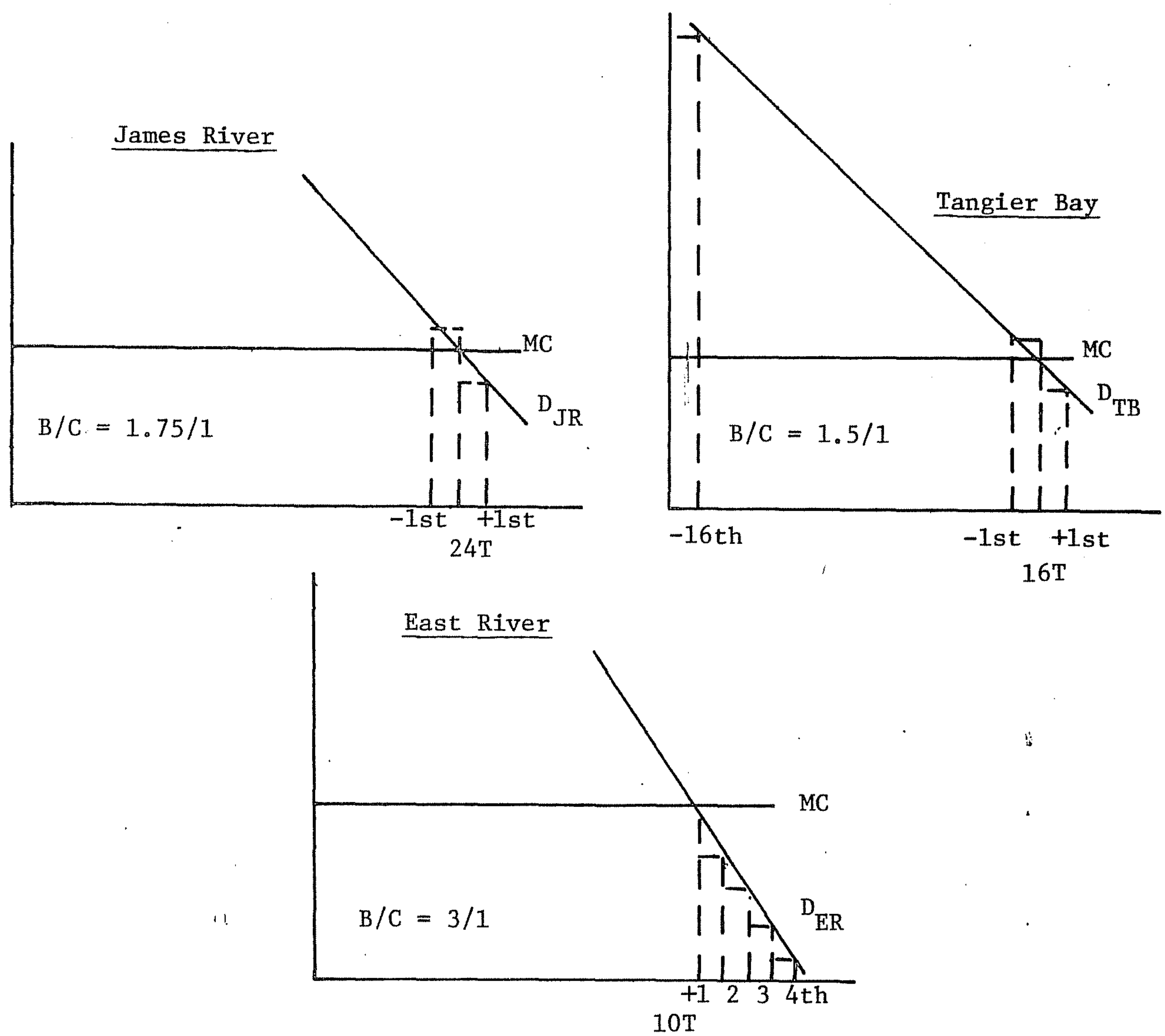
The benefit-cost ratio of 1.34 for FY 1976-77 is indicative of an internal rate of return of 34 percent, but even this spectacular one-year return on "investment" is as meaningless in a vacuum, in isolation, as was the anomalous negative return of 1972. Beyond the single-year criticism delivered in the last section, additional dollars ought to be invested in the oyster programs only if the Commonwealth's alternative "investment" opportunities offer lesser rates of return.

Figure 10



But the allocative use of total benefit/total cost ratios implicit above is strictly applicable not to incremental funding decisions among complementary programs, but rather to discrete (i.e., non-continuous) and mutually exclusive public investment projects. Thus, if the appropriate legislative oversight and appropriations subcommittees were considering a new tunnel, ferry, or bridge across the lower James River (as depicted in Figure 10), then we might validly rank the "no-frills" version of the three projects on the basis of their benefit cost ratios and recommend funding the bridge.[58]

Figure 11



However, if the investment choices are not mutually exclusive, as is more typically the case, then the total benefit/total cost ratios will usually not indicate where additional dollars ought to be spent or additional budgets rescinded.[59] Suppose, that is, the VMRC was considering future cultch replenishment on three sites, Tangier Bay, the East River, and the lower James River, and the site-specific benefit-cost appraisals yielded results such as those in Figure 11.[60]

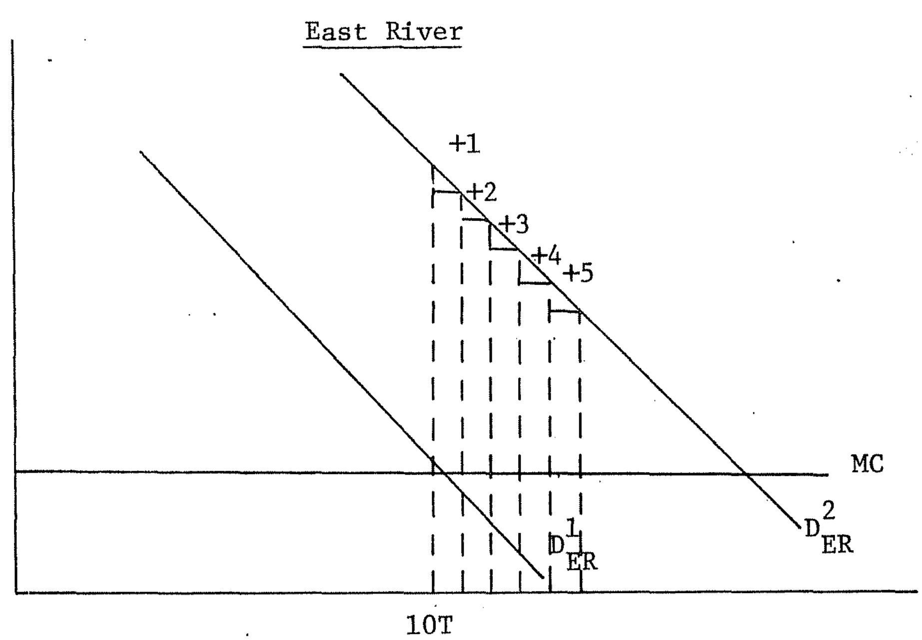
The emergent policy implication would not be that an additional $4,000 ought to be allocated to the East River (even though its B/C ratio is clearly highest). Similarly, efficient budget-cutting of, say, $16,000 would not be accomplished by ending the Tangier Bay subsidies, even though Tangier Bay does have the lowest B/C ratio of 1.5 to 1.

Instead, in each case marginal analysis of incremental budget changes would be preferable to discrete project-wide budget changes. For example, the fourth thousand dollars in additional funding for the East River program does not generate as much benefit (as measured by the height of the standardized unit rectangle under D_{ER} labelled 4th) as does an additonal thousand dollars expended on either Tangier Bay or the James River. Also, the last thousand dollars of $16T rescinded from Tangier Bay entails a loss of benefits (as measured by the height of the rectangle under D_{TB} labelled 16th) much greater than that foregone when a first thousand dollars is rescinded from either the East River or the lower James (labelled 1st).

Thus, a welfare maximizing (benefit maximizing/loss minimizing) criterion will lead to the <u>equalization of marginal benefits across all three programs</u>. If, for example, the demand at one of the sites increased, say, because each unit of East River seed was now more productive (in the generation of shuck oysters), then the relevant marginal comparisons would indicate additional dollars, when available, ought to be allocated to the East River as the marinal benefits (measured by the height of the rectangles in Figure 12 labelled +1, +2, etc.) are greater there than the marginal benefits of an additional thousand dollars spent at either of the other sites.[61]

Thus, the raw B/C results reported in Table 11 can be only suggestive of the financial well-being of the oyster subsidy programs at any point in time. Nevertheless, in the absence of the site-specific data necessary for <u>marginal</u> analysis, the current B/C ratio (and the implied rate of return) can provide a guide to allocative planning both within the VMRC and the legislature.

Figure 12



CHAPTER 4

RECOMMENDATIONS

DISASTER-RELIEF INSTITUTIONS

Less than twenty years ago, the Virginia portion of the Chesapeake Bay watershed regularly yielded 25 to 35 percent of the entire national supply of shuck oysters. But historical overfishing and recent ecological disasters have depleted this fishery to the point that today the Virginia catch represents only about 10 percent of the national market.[62]

For decades, the Virginia Marine Resources Commission has been charged with the responsibility of controlling this overfishing and more recently has expanded its disaster-relief programs in response to the onslaught of MSX disease organism in 1960 and Tropical Storm Agnes in 1972. The foregoing benefit-cost analysis has been an attempt to document the net economic value of these recent VMRC efforts to substantially expand the small post-disaster seed oyster harvests. Of necessity, therefore, our conclusions and recommendations focus primarily upon the oyster repletion program, not upon the on-going replenishment program.

The cost of in-kind subsidies (of seed and cultch) as funded by the Commonwealth's repletion and replenishment programs has never been in doubt, but prior to the present analysis the other side of the ledger was! Thus arose a persistently unanswered question--namely, "What is the benefit attributable to subsidized culch?" Is it simply the market value of the culch material itself? Clearly not, for then benefits and costs could never diverge. Is it the market value of the seed harvested from public seedbeds? Yes, in part, but we have shown that this measure is an underestimate since the full economic value of a seed harvest ought to also capture whatever excess willingness to pay (above the going, market price) is exhibited by seed buyers.

In order to delineate this "surplus value" accruing to the planter-buyers of the subsidized seed, it was necessary to estimate the demand function for seed oysters. Not surprisingly, the most significant determinant of seed demand was found to be the going price of mature, shuck oysters. Indeed, the most current benefit-cost appraisal of these repletion and replenishment programs reveals seed benefits 34 percent in excess of costs in large part because the real, deflated price of shuck oysters rose in 1976 more than a dollar per bushel above its 1970s average. And as shuck prices rose, seed prices rose, thereby increasing the net income of seed producer/harvesters. Weighting these "producer surpluses" and the previous "consumer (planter/buyer) surpluses" equally, we have aggregated the two to obtain a full reflection of the economic value of the seed harvest in any recent year. These results have been consolidated from Tables 6, 8, 10 and 11 and are presented below in Summary Table 13.[63]

Perhaps the most striking impression created by Table 13 is the truly catastrophic nature of the recent ecological disasters in late-1960 and mid-1972. Our evidence suggests that MSX disease was

Table 13

SUMMARY STATISTICS

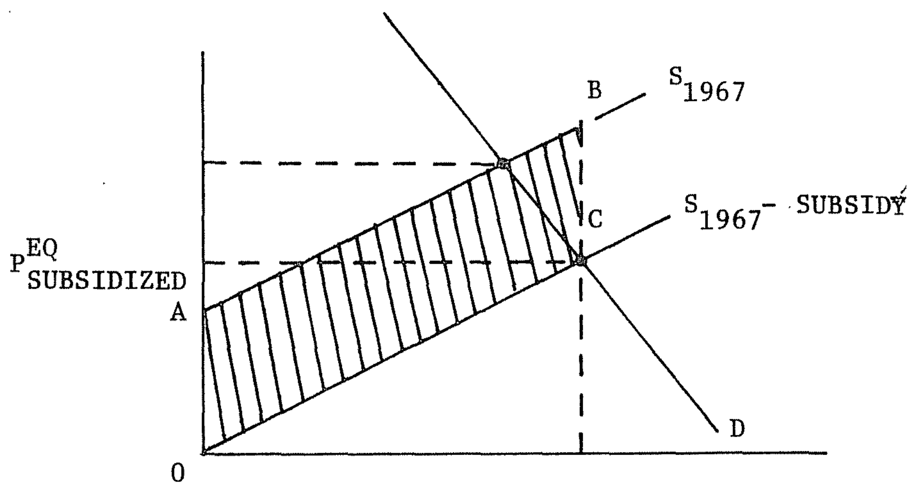
Fiscal Year	Consumer Surplus	Net Income	Total Net Benefits	State Costs	Federal Costs	Benefit/State Cost Ratio	Public (State) ROR	Private ROR
1967	530,675	-96,699	433,976	722,408	65,130	0.601	-39.9%	-177%
1968	528,396	14,802	543,198	1,001,855	26,549	0.542	-45.8%	- 87%
1969	405,296	26,427	431,723	541,735	43,669	0.797	-20.3%	- 73%
1970	377,137	170,567	547,704	517,377	45,830	1.059	5.9%	254%
1971	510,935	49,913	560,848	705,738	44,563	0.795	-20.5%	- 47%
1972	522,617	-35,276	487,341	486,069	42,955	1.003	0.3%	-136%
1973	201,239	83,583	284,822	740,939	59,477	0.384	-61.6%	- 13%
1974	-65,917	218,807	152,890	703,723	65,214	0.217	-78.3%	181%
1975	238,883	53,696	292,579	727,024	60,606	0.402	-59.8%	- 32%
1976	555,700	156,471	712,171	531,471	10,440	1.340	34.0%	149%

All figures are price deflated (1967) dollars.

the more persistent in its impact upon the Chesapeake Bay oyster industry. Even as late as 1967 (at the start of our sample period), estimated producer surplus was still negative; indeed, seed harvesters in that year suffered net losses approaching $100,000. Indeed, when one includes the cost of the public sector's in-kind subsidy OABC (see Figure 13), the seed oyster market did not move again into the black for almost ten full years, until FY 1970.

Figure 13

SEED OYSTER



Recovery from the freshwater deluge following Tropical Storm Agnes has been much faster; notice that estimated net income of seed producers did nosedive in 1972, but rebounded almost immediately (with sizeable gains in both 1973 and 1974). The timely commitment of additional state and federal funds for reseeding damaged beds appears responsible. (Indeed, the deflated budget figures document a 30 percent increase in state (28%) and federal (38%) oyster subsidies between 1972 and 1973.)

While the publicly provided cultch and imported seed did reduce private cost sufficiently that the net income of harvester/producers was again positive by 1974, Agnes was no trivial incident in the Chesapeake Bay ecosystem. Instead it has taken almost four years for the seed oyster market to again display a net benefit/total cost ratio greater than one. However, in the most recent year studied, FY 1976, the public investment in seed oysters was returning a more than respectable 34 percent in net benefits to harvesters/planters (and ultimately retail consumers). Thus FY 1976 would seem to have been a turning point in the actuarial fortunes and accomplishments of Virginia's oyster programs.[64]

EQUIPMENT REGULATIONS

Of course, other causes contributing to the decline in Virginia's oyster market share abound. The tax records of the VMRC document, for example, the steady decline in the labor force of the Virginia oyster industry. Further, the increasing upward asymmetry of the oystermen's age distribution suggests that net losses are not occuring randomly in all age groups. Instead, the industry is failing to attract new entrants in their teens and twenties. Can these trends really be any wonder when numerous employment opportunities in manufacturing are appearing where there were almost none before (say, in food processing, and now industrial construction, on the Eastern Shore)?

The nominal net income accruing to seedbed harvesters (and probably to shuck oystermen as well) is not only lower on average than that available in these alternative employments, but also it is significantly more variable. While there is a certain differential independence characterizing those who make their living at sea, can anyone really suppose that oystermen are so much less risk-averse than the rest of us that even the exceptional instability of their recent earnings stream (see the private ROR column of Table 13) will not impact upon their future employment decisions? Perhaps the most feasible way to make oystering more attractive and to ensure therefore the long-run viability of the oyster industry is to no longer prohibit the wide-spread adoption of more efficient equipment. Not only might the industry then realize some of the productivity gains which twentieth century innovation has allowed elsewhere, but also patent tonging and, in some places, dredging equipment would permit a single oysterman (or group of oystermen) to diversify, spread their present efforts across a greater number of seedbeds and thereby perhaps reduce the enormous variability of their income stream.

Clearly, this institutional change would necessitate careful and vigorous action by the Virginia Marine Resources Commission to protect against overfishing. However, it would appear that the various marine advisory services of the Virginia Institute of Marine Science are well-equipped to assist the VMRC in making optimal catch determinations of just this sort and that the VMRC possesses the necessary enforcement capability in its law enforcement division. We do, therefore, propose that such a regulatory change be given serious consideraton, although clearly further research (most notably by environmental biologists) is necessary.[65]

We make this proposal in full awareness of the status quo inertia which such an alteration in the rights attched to an oyster grounds lease must overcome. After all, the present rights structure has been firmly in place for many decades. But it is precisely this long-term regulatory prohibition of new innovations in oystering which has contributed to the present difficulty. For, if an industry is forced to sacrifice those cost-cutting innovations which occur from time to time, it may ultimately find its product prohibitively expensive relative to near and distant substitutes alike. Then, not only output, but employment within that industry declines.

And recall that the oyster industry has, at times, been managed in the interest of maximizing employment. Whether primary plus ancillary employment maximization was the appropriate resource management objective in those periods is not in question. What we do ask now is whether the Commonwealth ought to continue its traditional prohibition of mechanized oystering, when future employment opportunities in tonging appear so unattractive to prospective entrants. At one time these regulations served to both protect against overfishing and to maximize employment; now, however, the former rationale has been rendered less necessary, while the latter is false.

Again, net income in non-mechanized oystering is both more variable and less profitable on average than the ever more numerous alternative employment opportunities now open to children of watermen. Thus, despite the fact that the resource might continue be managed for maximum job slots, the negative influence of, say, patent tong prohibitions upon labor supply will continue to contribute to an actual decline in the waterman workforce.[66]

Further, with the costs of detecting privateers, interlopers and gluttonous overfishers having been reduced in recent years with aircraft, electronics, and an automated data system, it no longer seems necessary to artifically constrain the harvesting productivity above a seedbed by requiring manual rather than mechanized equipment.

PUBLIC OYSTER GROUND LEASES

Another major group of VMRC regulations directs attention to the question of present overfishing. In particular, the leasing of public oyster grounds reflects a long-term attempt to specify, assign, and enforce individual property rights and thereby avoid the usual externalities or "market failures" associated with a common property resource. The disucssion which follows is based upon F. H. DeB. Harris, "Pareto Optimality, Market Structure and Common Property Resources."[67,68]

In the pre-regulatory (i.e. pre-leasing) era, there were costs being imposed on all parties without their consent, in this case not because of the usual incomplete specification, assignment, or enforcement of property rights. The situation was worse! Indeed, there was a total absence of assignment due to the prohibitively high transaction costs associated with policing and enforcing any assignment of private seedbed rights. Thus the effective rights assignment (as with any such common-property resource) was by default and each individual competitor perceived that the appropriability of benefits from investing in replenishment was severly attenuated. As such, each oysterman consistently misallocated resources towards harvesting within the current period in pursuit of a maximum share of seedbed output before exhaustion.[69]

As demonstrated by Anthony Scott ("The Fishery: The Objectives of Sole Ownership...," Journal of Political Economy, April 1955) some years ago, however, a resource monopolist with sufficient appropriability over time and space would have an incentive to internalize the externality resulting from the underproduction of replenishment activity. As such, his harvest/replenish production decision would come to be based on a comparison of the marginal contribution to net revenue of an additional unit of harvesting to its discounted marginal cost (i.e., the "marginal user cost"). By equating the marginal net revenue and user cost, the resource monopolist would maximize the present value of not just the fishery's existent resources, but of his entire package of rights (among which is included, of course, the right to appropriate the full return from replenishment).

This self-corrective mechanism has been the predictable result of the Commonwealth's historical attempts to assist watermen in reducing the transaction costs associated with specifying, obtaining, and enforcing their rights to particular seedbeds. Thus, for a minimum fee the VMRC's Engineering Division became an inexpensive arbiter of border disputes, while the Enforcement Division subsidized that policing of the seedbeds necessary to detect lease violations and bring the perpetrators to justice. Again, the predictable result of assigning effective rights to these small-scale resource monopolists has been the virtual termination of overfishing. In that sense, the public sector initiatives launched with the Baylor Survey have come to fruition. Nevertheless, certain particulars of the present leasing institutions lead to correctable inefficiencies.

One distinctive characteristic of competitive markets which serves consumers and, in the long-run, producers particularly well is the frequent recontracting made possible by freedom of entry. When buyers can take their business elsewhere on relatively short notice, sellers have a more or less continuous incentive to engage in cost-minimizing production and investment decisions. Moreover, if a given resource-holder finds he generates less surplus than another entrepreneur might, the former owner-manager has a practically irresistible temptation to replace himself with the more efficient manager, while perhaps retaining an ownership interest. And competitive markets reveal this information about the transfer earnings of all factors of production in a particularly obtrusive manner.

A variant of these continuous incentives encouraging the efficient allocation of land, labor, capital and entrepreneurial skill can be introduced, we believe, into the leasing of oyster seedbeds without jeopardizing the externality-reducing mechanism offered by assigning seedbed rights to short-term resource monopolists. According to the production function studies by Dexter Haven and Ivar Strand of VIMS, the life-cycle and thus the investment cycle of an oyster seedbed is relatively short with few returns carrying much beyond two years.[70]

Indeed, the speed of the post-Agnes recovery confirms that with the appropriate replenishment effort, the turn-around of yield statistics can be very quick indeed! Thus, not only the economic but also the biological information suggests that one might induce efficient replenishment by seedbed monopolists with a much shorter leasing agreement than now exists.[71]

We propose, therefore, that the periodic releasing be more frequent and that individual lease allocations be open to competitive bidding. To allay fears of too precipitous exit and to preserve some semblance of the familial division of those leases in the same hands for decades, the VMRC might both (1) control the maximum number of leases to single and corporate entities and (2) set aside certain additional grounds as initially exempt from the competitive lease institutions. While more frequent recontracting may erode the surplus appropriated by owners of the currently most productive seedbeds, this institutional change would do more than perhaps any other to insure the long-term viability of the oyster industry because it would stimulate efficient production and investment on the currently less productive seedbeds. Coupled with a repeal of some current prohibitions against mechanized equipment, more frequent competitive leasing of oyster seedbeds might well induce those productivity gains the Virginia oyster industry has sorely missed for some time.

BIBLIOGRAPHY

Agnello and Donnelly, "The Interaction of Economic, Biology and Legislative Forces in the Middle Atlantic Oyster Fishery", Fisheries Bulletin, 1975.

________________, "Prices and Property Rights in Fisheries", SEJ, October 1975.

Baker, Garrett, and Strand, "Publicity Effect of Pollution-Related to Kepone", Sea Grant Proposal, VIMS, 1977.

Charbonneau, Joseph J. and Richard Marasco, "A positive Spatial Equilibrium Model of Oyster Markets: A Simultaneous Equation Approach", Agricultural Experiment Station, Univ. of Maryland, May 1975.

Harris, Fred, "A Competitive Model of Oyster Seedbed Leasing", manuscript, Williamsburg, Virginia, June 1977.

________________, "On Estimating the Benefits of an In-Kind Subsidy Program: Repletion and Replenishment in the Virginia Seed Oyster Industry", presented at Virginia Economics Association Meetings, Richmond, March 30, 1978.

________________, "Pareto Optimality, Market Structure and Common-Property Inputs", Manuscript, Williamsburg, Virginia, November 1976.

Haven and Kendall, "Oyster Spatfall on Shellstrings in Virginia Rivers", Marine Resorce Information Bulletins, VIMS, 1975 and 1976 annual summary.

________________, Marine Resource Information Bulletin, VIMS July 29, 1974.

________________, "Virginia Landings", NOAA-National Marine Fisheries Service, Summary issue 1970.

Scott, Anthony, "The Fishery" The objectives of Sole Ownership..." Journal of Poltical Economy, April 1965.

FOOTNOTES

[1]Differential detection or monitoring costs appear to be a good way to distinguish the deep-water, essentially common-property seedbeds from tidal-flat seedbeds, the riparian right claims to which are enforceable at less than prohibitive cost.

[2]The probability of a successful set per free-swimming spat is a function of cultch height off the bottom, since larval-stage oysters (spats) die if the habitat in which they are forever cemented is invaded by shifting sand or mud. For a more extensive discussion, see VIMS, "Marine Resources Information Bulletin, July 29, 1974.

[3]PORR replaces the shell taken out in the process of transplanting seed oysters in order to keep the cultch pile of constant height.

[4]"Seed producers" here refers to those engaged in harvesting operations whether by tongs, patent tongs, or dredge.

[5]Rather than 126, there are "only" 85 observations in this 10-1/2 year time series as oysters are taken in only the first five and the last three months of each year.

[6]In most fisheries, catch is constrained by legal limits. This artificial barrier to continuous marginal decision-making by the owner-entrepreneurs appears to be somewhat less effective in oystering.

[7]The documentation of data sources from which all variables in 2.1 and 2.2 were constructed appears in Appendix A.

[8]As the offer prices being estimated are those of the planters-harvesters for seed, we refer here to the production function of <u>mature</u> (shuck) oysters from seed, labor, capital equipment, etc. Seasonal phenomena affecting the production of <u>seed</u> oysters are reflected by the supply function's month dummies (see equation 2.2).

[9]We have great expectations, for example, as to the eventual applicability in such a model of periodic "spatfall on shell string" surveys by the Virginia Institute of Marine Science. At this juncture, however, that series is quite short and the data collection process is still evolving as VIMS (in collaboration with the VMRC) attempts to improve the reliability of spatfall counts as a measure of seed oyster setting and, thus, of "bioavailability". See Haven and Kendall, 1974, 1975, and 1976.

[10]Normally, of course, one would explore the relevant theory and derive the implications of all explanatory variables included in one's specifications, but as the biological seasonality of the

oyster is quite technical and has no direct bearing on our benefit calculations, we leave that task to others more qualified in these matters.

[11]In the physicist's sense, of course, all catastrophes, because they are, themselves, irreversible, are "natural". Nevertheless, one can be somewhat less deterministic about manmade events that precipitate long-term damage so mammoth they are immediately denoted "catastrophes". The Kepone catastrophe along the James River system presents a case in point. We think that disaster and the foregone benefits it destroyed can be evaluated by a variant of the present model.

[12]In reality, the demand for Virginia seed oysters is also influenced by the scope of the VMRC's transplanting efforts on the public grounds. However, as the benefit of that in-kind subsidy is reflected by market value in the shuck oyster market, we ignored both the cost and the benefits of said program in this seed oyster study.

[13]Of course, changes in seed quantity supplied can also be induced by changes in the going price of seed oysters (that is, by demand shifts, and, thus, movements along--not shifts of--a given supply curve), so we include P_{SEED} in equation 2.2.

[14]Other inputs may be extensively employed like lime for predator control but the principal remains the same--input prices must appear in equation 2.2.

[15]In the entire eastern half of Virginia, the Federal Land Bank held less than half a dozen watermen loans in June 1977.

[16]The only major exception is Northampton County where the recent emergence of manufacturing plants has introduced openings in unionized factory jobs.

[17]"Mobile oystermen" was defined so as to exclude those boat owners and shore licensors making more than half of their income in oystering (thus, non-"casuals"), because we wished to distinguish the marginal labor decisions explored here from the marginal entrepreneurial decisions as to which fishery to work in a given month. The latter are discussed below.
We ignored the 1975 employment data because Gloucester County plummeted from its roughly 30 percent trend down to 3 percent of "crewman and casuals," while Mathews and Northampton Counties doubled to 21 percent and 14 percent from respective trends of 10 percent and 6 percent. The lack of a stable geographic distribution of oyster employment is worrisome, but the usual criticism that these place of residence data should be replaced with the more relevant (but costly) place of work data (say, by water area) will not serve to improve stability, but will worsen

it.
Watermen, especially in eastern Gloucester County, are incredibly mobile in following, indeed anticipating, movements in a fishery. But few would claim that close to 150 fishermen and their families actually moved in 1974-75 and returned to the marshes in 1975-76. Instead, this aberrant 1975 licensing data reflects a very fundamental phenomenon in economic science--after a year in which the real price of crabs rose over 50 percent, the Gloucestermen simply failed to renew their oyster licenses in anticipation of another big year for crabs (see footnote 24).

[18]Our selection criterion in choosing these six counties and Newport News was legal jurisdictions, contiguous with water areas where seed oysters were taken in 1976, having more than 5 percent of the mobile oystermen in 1974-76.

[19]See the Alternative Wage/Employment Opportunity Index for Virginia Seed Oyster Industry in Appendix B.

[20]The skill distribution is seldom stable for long periods of time, especially in construction where the peculiar requirements of each site may dominate. It is highly probably that much of the variability in the construction wage series reflects job or skill distribution changes. Otherwise, such wage differentials as are exhibited in Table 1 simply could not exist between contiguous counties (for example, between York and Gloucester).

[21]In addition, of course, wage data do not convey the underemployment impact of cyclical phenomena, especially in the construction industry. Wage income data would be preferable. Finally, union rigidities in firings/layoffs and (to a lesser extent) the irregular and secondary worker phenomena will always conceal some of the changing employment opportunities that might be reflected by a truly equilibrium wage.

[22]In constrast, of course, an additional engineer's wages influence the aggregated, average wage index more than do an additional laborer's.

[23]This case is, however, exemplary of the great caution with which such wage data must be handled. In mid-1968, just the opposite scenario began--wages rose so less substitution not more might be expected, but this time there really was an aggregate demand increase in construction. Job openings as well as average wages rose and more watermen substituted towards the alternative employment opportunity, not less.

[24]Why clams and crabs? For a start, patent clam and patent oyster tongs are essentially the same. Note that we include a post-1969 surf clam price series as well as a full-length hard clam price series. Also, medium-sized buyboats substitute easily to

crabbing operations as demonstrated by the great numbers making that transition in what is the summer off-season for oysters. The MRC has suggested that a finfish price series would likely be important here since the primary supply substitute, clams, is not evenly distributed across the geographic area in which oysters are landed. However, we remain uncertain as to which finfish to include (we know, for example, that oystermen sometimes crew on menhaden vessels in their May to December season) and note that crab potting presents the <u>most</u> universal substitute production opportunity. Indeed, we ran across a massive example of that substitution from crabs to oysters and back again (by 69 non-"casual" Gloustermen in 1974-76) as the once-lagged real (inflation-adjusted) crab price index fell from 1.0 to 0.78 and rose again to 1.18.

[25]Of course the regression coefficients (i.e., the Bs) are themselves signed. We have simply indicated the implied signs in Equs. 2.11 and 2.12 with each coefficient appearing technically as its absolute value (e.g. B_1^d in Equ. 2.11 is actually B_1^d).

[26]As is clear above, in the case of exact or over-identification, the 2SLS and instrumental variable estimation methods are identical.

[27]Our discussion above has so myopically focused on supply only because the demand curve (equation 2.11) is identified by all manner of exclusively-supply shifters--R_t, $CRPI_t$, $SCPI_t$, A_t, etc. Of course, the generation of meaningful demand estimates is no less critical to our purpose.

[28]T-scores for use in tests of statistical significance are in parentheses. Three asterisks at 95% and one at 90%.

[29]For the derivation of demand and supply curves from these results, see the section below entitled "Aggregate Benefit Estimates."

[30]The R^2 of .64 (measuring the "explanatory power" of the regression with a ratio of explained to total variation in the dependent variable) is a trifle low for non-individual data, but well within the range of published regression results on the final product, shuck oyster market. See Joseph J. Charbonneau and Richard Marasco, "A Positive Spatial Equilibrium Model of Oyster Markets: A Simultaneous Equations Approach," Agricultural Experiments Station, Univ. of Maryland, May, 1975.

[31]The one substantive exception has been a gnawing concern that the demand function should "work" in log form and that ignoring this presupposition may result in misspecification error. The troublesome implication as to functional specification is all to easy to derive (in a variety of ways) from the definition of the offer price of an input as the value of the marginal product (i.e., $P_{MKT}^{FINAL} \times MPP_{INPUT}$). There can be no question, however,

in this case, the log specification of 2.15 results in absolute nonsense, from the inexplicable positive signs of P_{SEED} to the insignificance of everything other than dummy variables. A perusal of the residuals from equation 2.15, however, turned up no evidence of either heteroskedasticity or misspecification error.

[32]One-tailed hypothesis tests of B_1^s (on P_{SEED} are not quite as automatic as the iron law of demand allows hypothesis tests of B_1^d to be, but we have chosen to report on a one-tailed null (i.e., $B_1^s = 0$) and alternative (i.e., $B_1^s > 0$).

[33]Alternatively, one might argue that watermen replace boats and equipment primarily through disaster-relief programs and that these subsidized funds cause capital costs to vary over time independently of interest rates.

[34]See the 1970 summary issue of "Virginia Landings," NOAA-National Marine Fisheries Service, for an announcement of the surf clam's descent from Maryland waters.

[35]Without incorporating additional information (perhaps as to how one might better distinguish the two variables in questions by avoiding particular kinds of measurement errors), the only remedy for multicollinearity is to identify whichever of the collinear regressors better reflects the variability of interests, and leave the other out.

[36]Sam Baker has explored various ways one might measure this all-important rate of decomposition, but as yet his methods have not been implemented.

[37]No similar adjustment of the seed <u>price</u> coefficient is necessary because the multiple regression model generates "partials." That is, it holds all other variables provisionally constant and thus nets out all accessory influences while estimating the systematic relationship between price and quantity in isolation, for example.

[38]Recall that "consumer" benefits refers here in the case of an input, to producers of the final product, market oysters.

[39]As is perhaps obvious, alternative specifications of the demand curve 2.18 as other than linear imply alternative formulas for gross "consumer" benefits (compare 2.19). However, in the present case, alternative specifications of demand were found to be inferior to the linear form.

[40]Again, three asterisks refer to statistical significance at the 99% confidence level, two asterisks--the 95%--and one asterisk--the

90%.
Note that the t-score on our all-important variable, P_{SEED}, has been substantially improved from 1.29 to 2.37; much random variation has been removed as the diminished standard error indicates.

[41]All figures shown are in deflated (1967) dollars.

[42]Figures shown are in real, deflated (1967) dollars.

[43]Predator control by continuous applications of lime does take place in other oyster fisheries, but not in the Chesapeake region.

[44]Shell planting costs are separated in the VMRC budget, but harvesting for transplanting is lumped with the line-item "Other Contractual Services."
Alternatively, one can argue that the cost in 1975 goes toward harvesting the seed from which one calculates benefits in 1975, but also toward the planting of a 1976 seed crop. So the more sensible approach might be to discount not costs but benefits--in particular, the future benefits associated with next year's seed crop. But all these discounting methods require data on public planting versus harvesting, and that expenditure data are not available from the line-item budgets with which we have worked.

[45]We reaggregated monthly Department of Commerce data to obtain the following fiscal year wholesale price index used as the implicit deflator throughout this study:

1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
.998	1.013	1.145	1.091	1.122	1.164	1.261	1.469	1.716	1.796

[46]"Shells" cost includes all seedbed-related culth costs--e.g., for the turning of beds, as well as for the delivered materials itself.

[47]The issue at hand is clearly a matter of degree. Strictly, the above argument as to the non-marginality of essentially overhead expenses holds true only at or near the present level of appropriations. If the oyster subsidy programs were really radically reduced then some of these administrative and law enforcement expences would surely become relevant. There are, however, non-marginal and therefore our perspective "irrelevant" costs if only incremental budget changes are under consideration.

[48]We have been unable to ascertain the budget of the Engineering Office, although descriptions of the duties of its small professional staff suggest that perhaps only a portion of its costs ought to be imputed to the repletion and replenishment programs themselves. Indeed, decreasing the cultch programs by

releasing more of the Baylor grounds to private leaseholders might actually increase the workload of the Engineering Office, not decrease it.

[49]This particular benefit-cost ratio implicitly assumes that in the absence of public sector intervention (that is, in the absence of the oyster subsidies), soon no private output would be forthcoming. For the implications of an alternative assumption, see Technical Appendix A and Fred Harris' "On Estimating the Benefits of an In-Kind Subsidy Program: Replenishment and Repletion in the Virginia Seed Oyster Industry," manuscript, Williamsburg, Va., presented at the Virginia Economics Association Meetings, Richmond, March 30, 1978.

[50]In this era of general revenue-sharing, state legislators may soon find the opportunity costs of such allocations non-zero, as the choices among federally-supported highway, hospital and seedbed funding are increasingly being returned to the states.

[51]All figures are again expressed in real, deflated 1967 dollars.

[52]Not aggregated to a precise fiscal year timing of outlays.

[53]This result can be seen most easilty by noting that the hatched area DBG (the excess of market value AB over partial willingness to pay ADG) is greater than the remaining willingness to pay ADF. Thus, market value exceeds total willingness to pay!

[54]While the VMRC purchases some seed on a regular basis, it was the unusually large, federally-funded buying that caused the anomalies of 1973. The much more frequent practice of simply transplanting public grounds seed from one spot to another fails to alter these aggregate, market demand and supply curves "at all."

[55]A more easily comprehendible anomaly appears in the results for 1967 and 1972 when harvesters' net income is negative. In that case, producer losses (versus "producer surpluses") were probably due to the lingering effects of MSX disease, although we do not have any historical time series reflecting the mid or early sixties and can not, therefore, confirm such a pattern of declining losses and increasing market viability. Nevertheless, the well-documented magnitude of this previous disaster suggests that is could well have been 1968 before seed cultivators/harvestors again crawled into the black. Again following Agnes, the net income of seed producers was negative (see Table 8 for the year 1972 as well as the negative private rate of return for 1972 in Table 10), prior to the 30% increase in subsidies.

[56]The B/C ratios in Table 11, as well as production indices (in the

VMRC's annual reports and the National Marine Fisheries bulletin "Virginia Landings") indicate that the industry had recovered from MSX and was viable in 1968-1972.

[57]Recall that all B/C ratios and component series are in deflated, 1976 dollars.

[58]Notice that in a world of scarce resources, tradeoffs must frequently be made and therefore a benefit-cost ratio greater than 1.0 does not, by itself, indicate that a program should be funded. We may, that is, forego a positive rate of return (on the tunnel, say) in order to maximize the return on our investment of state funds (with the bridge).

[59]Among non-mutually exclusive projects, the only exception occurs when allocative choice involves programs which entail discrete lumpy investements--say a vessel acquisition, a building construction and a microwave tower installation. In that case, if the respective benefit-cost ratios were 2.3, 1.7 and 1.3, then one must rank entire projects since, in fact, one-third of a vessel or tower has no functional meaning.

[60]Notice that we are assuming constant costs across the various seedbeds.

[61]In order to account for the differential transportation costs of shells delivered to Tangier Bay vs. the lower James, we would simply replace the site-specific allocative criterion above (i.e., equate the marginal benefits) with the more general proposition--equate the ratio of marginal benefits to marginal costs ($MB_{TB}/MB_{JR} = MC_{TB}/MC_{JR}$). Rearranging, we could then claim that the marginal benefit of a dollar's expenditure in Tangier Bay was equal to the MB of a dollar's expenditure in the lower James (i.e., $MB_{TB}/MC_{TB} = MB_{JR}/MC_{JR}$).

[62]To date we have been unable to verify a claim that 65 percent of the catch attributed to Maryland is actually imported from Virginia. Obviously, a transfer of that magnitude would significantly improve Virginia's catch statistics and might substantially offset the precipitous fall of recent decades.

[63]For further details, amplification of the major findings and additional qualifications, see the separate tables and surrounding text.

[64]Other less commensurable benefits of the oyster subsidies have been posed at times as rationales for the programs. We have not doubt that the gradual assimilation of a subsistence-level socio-economic subculture into the more prosperous, wider society has been enhanced by the subsidies. Nevertheless, it has been beyond the scope of the present study to try to specify and

valuate these secondary benefits in any precise manner. Further, there was a time when the VMRC's regulatory policies met a sometimes-stated, sometimes-implicit objective of maximizing the employment opportunities within the oyster harvesting, processing and retailing industry as a whole. While these secondary benefits may have been substantial (with two or three jobs generally credited beyond the raw production sector), such arguments provide no additional rationale for oyster appropriations. Indeed, almost all potential state investments have these same "multiplier effects" on both expenditures and jobs.

[65] For example, we remain unable to resolve the apparent inconsistency between two frequently encountered statements about the more radical of these regulation repeal proposals--namely, (1) "dredging destroys the natural bottom" and (2) "one of the best ways to renew a currently unproductive bed is to turn over the seedbed with a dredge."

[66] The maximum employment objective itself may soon be questioned in light of the imminence of an automated shucking device.

[67] The presently unpublished note has been submitted to the American Economic Review.

[68] The framework of the analysis is that of a replenishable resource with significant public good characteristics, say an ocean fishery. Two additional restrictions appear useful to the simple manipulation of the analysis: first that the replenishment activity be of a continuous variety. While threshold replenishment systems seem to be more prevalent in nature, the model is always determinate and of more general applicability in its present continuous form (e.g., the skill training of some workers is a continuous replenishment activity with significant public good characteristics). And second, for the purposes of the present analysis, further simplifications can be obtained by assuming that the only input necessary for the production of replenishment is a reduction of harvesting (more generally, a reduction of production). The crucial elements of the model can be identified then as the intertemporal nature of the production decision and the attenuation of the rights structure associated with the replenishment activity. As such, the externality in question consists of current over-production leading to a reduction in the net present value of each firm in the industry.

[69] Clearly, the finality of this intertemporal perspective suggests extremely powerful forces operating towards coalition or cooperation. However, the voluntary private bargaining implication suggested by any such potentially Pareto relevant, mutual gains from trade is here shortcircuited. We have encountered an externality the transaction costs of which are

such that it can not be optimally abated by any rights reassignment short of monopoly creation.

[70]Depending on the optimal cultch pile height in various bottom environments, the start-up (or "fixed") costs of establishing a productive seedbed could be large enough to extend the investment cycle beyond the first two years, but not plausibly far beyond. Further VIMS research could, of course, establish otherwise. At the moment, however, oyster market decision-making appears to be in marked contrast to, say, timber management where the payoff from a resource monopolist's optimal replenishment is many decades hence.

[71]For further amplification, see F. H. deB. Harris, "A Competitive Model of Oyster Seedbed Leasing," unpublished manuscript proposed for delivery at the Richmond Meetings of the Virginia Economics Association, Spring 1978.

[72]In the economist sense employed here, "welfare gains" do not include the market value of the seed oysters OABQ as a net benefit (or the private cost OBQ) because indeed there was an even exchange; the planter buyers gave up spending power on alternative goods and services in an amount just equal to the going market value of the seed received. Only the net income realized by producers from that exchange (i.e., OABQ-COSTS of OBQ = NET INCOME OAB) is counted as welfare gain. In addition, of course, total "welfare gain" includes the net benefit to consumers.

[73]For further development of this conclusion, see Fred Harris, "On Estimating the Benefits of an In-Kind Subsidy Program: Repletion and Replenishment in the Virginia Seed Oyster Industry," manuscript, Williamsburg, Va., presented at the Virginia Economics Association Meetings, Richmond, March 30, 1978.

APPENDIX A: DATA

All figures are listed in price-deflated (1967) dollars. To obtain nominal, raw data multiply by the fiscal year price deflator employed in this study (see footnote 46).

Month No.		Production Seed	Production Shuck	Value Seed	Value Shuck	WPI
Jan 1	1966	31031	51397	32619	172589	998
2		15113	59368	15380	214327	986
3		225391	60869	212954	230651	993
4		227183	44331	249140	132349	993
5		78274	33733	111015	114108	994
6		207765	53509	240510	194437	1001
7		158345	59019	116965	163061	998
8		50910	34572	51641	96205	998
9		23845	32786	24206	88966	1001
10		20190	13762	20091	38914	999
11		42973	9900	59349	35114	996
12		216453	3262	244050	11395	992
13		97839	20045	146758	8639	997
14		114768	48436	130950	167405	1001
15		151910	37742	163469	121547	1001
16		69927	32856	78569	104435	1008
17		24120	29799	26340	93696	1011
18		36952	34057	51843	112720	1019
19		60730	30246	97838	99958	1021
20		224121	23409	274565	60942	1021
21		66461	26451	115884	67450	1024
22		162548	48711	237222	154120	1029
23		104350	48462	134729	149722	1033
24		20858	38740	27013	128124	1036
25		10858	25600	13843	72804	1043
26		24792	18882	32171	51412	1048
27		39339	19380	58150	54767	1054
28		142680	15159	178492	38393	1055
29		81684	12643	124833	31764	1063
30		34900	47782	58156	144171	1074
31		82524	41343	110088	121932	1081
32		25617	36214	26168	109997	1086
33		11708	20004	10344	59391	1093
34		22467	21797	23812	67248	1097
35		150652	21016	172704	68740	1099
36		83421	4009	151030	11010	1100
37		77681	22	155362	60	1100
38		136962	66860	205280	195277	1109
39		74552	57060	106760	185292	1109
40		31174	54634	42554	179075	1110
41		16589	20876	20043	80682	1118
42		11423	35171	12594	118494	1128
43		28774	30249	34492	90770	1130
44		207330	9555	245976	34130	1133
45		83077	6596	140699	22131	1138

Month No.	Production Seed	Production Shuck	Value Seed	Value Shuck	WPI
46	82655	66912	155990	258429	1146
47	78788	51536	134186	192774	1145
48	33157	57646	51640	204064	1154
49	26609	38901	27261	119014	1163
50	28222	27114	38738	88455	1173
51	48159	16441	71451	62592	1174
52	170062	580	118250	1966	1175
53	64624	1111	143594	3754	1182
54	62787	27586	123509	137481	1200
55	64854	32896	121831	138914	1207
56	39906	32873	94691	142168	1229
57	45661	30574	82270	140132	1245
58	29399	17544	52132	68640	1269
59	81019	11786	117712	56044	1298
60	58134	4297	110225	16662	1305
61	58376	352	146057	1638	1332
62	76267	57699	154176	216062	1387
63	76083	96089	138255	378666	1392
64	34016	67883	63012	245368	1418
65	42566	78155	78202	288598	1466
66	31501	40783	59256	155416	1495
67	47226	23175	104057	103134	1514
68	11888	9024	299257	38640	1527
69	101278	1696	289437	7614	1550
70	63209	95888	133292	407323	1702
71	42928	89439	67465	427171	1719
72	40701	61653	71242	353822	1715
73	45735	60299	78458	300443	1718
74	9109	53935	14140	214119	1713
75	23917	37147	41488	157418	1704
76	94823	5376	170012	19319	1721
77	59048	1	113880	0.001	1732
78	121832	89017	205131	483415	1789
79	85977	76739	150070	432384	1782
80	25716	79539	39764	452205	1787
81	2153	73549	2560	413543	1793
82	37333	50801	68738	325902	1793
83	42072	27564	81686	169697	1796
84	121933	1	231204	0.001	1813
May 76 85	109396	1	218144	0.001	1818

MONTHDUMMIES

Year Month	'67	'68	'69	'70	'71	'72	'73	'74	'75	'76	Feb	Mar	Apr	May	Oct	Nov	Dec
1.66	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.66	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
3.66	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
4.66	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
5.66	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
10.66	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
11.66	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
12.66	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
1.67	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.67	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
3.67	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
4.67	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
5.67	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
10.67	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
11.67	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
12.67	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
1.68	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.68	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
3.68	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
4.68	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
5.68	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
10.68	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
11.68	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
12.68	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
1.69	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.69	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
3.69	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
4.69	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
5.69	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0
10.69	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0
11.69	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0
12.69	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
1.7	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
2.7	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0
3.7	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0
4.7	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
5.7	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0
10.7	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0
11.7	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0
12.7	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
1.71	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
2.71	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
3.71	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0

MONTHDUMMIES

Year Month	'67	'68	'69	'70	'71	'72	'73	'74	'75	'76	Feb	Mar	Apr	May	Oct	Nov	Dec
4.71	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0
5.71	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0
10.71	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
11.71	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0
12.71	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
1.72	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
2.72	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
3.72	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
4.72	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
5.72	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0
10.72	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0
11.72	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
12.72	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
1.73	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
2.73	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
3.73	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
4.73	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0
5.73	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0
10.73	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0
11.73	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0
12.73	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
1.74	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
2.74	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
3.74	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
4.74	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0
5.74	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0
10.74	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0
11.74	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
12.74	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
1.75	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
2.75	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
3.75	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
4.75	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
5.75	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0
10.75	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0
11.75	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
12.75	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
1.76	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
2.76	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
3.76	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
4.76	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
5.76	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0

Year Month	Seafood Price Index	Crab Price Index	Clam Price Index	Surf Clam Price Index
1.66	100.2	4.437	450.9	0
2.66	88.88	5.839	634.9	0
3.66	66.33	6.734	526.7	0
4.66	24.69	6.491	513.6	0
5.66	18.3	6.79	508	0
10.66	17.91	4.733	608.4	0
11.66	15.82	4.602	631.3	0
12.66	63.93	4.231	638.3	0
1.67	73.24	4.237	604.4	0
2.67	83.61	5.561	597.6	0
3.67	56.14	7.66	606.4	0
4.67	24.7	5.229	602.8	0
5.67	17.31	4.902	558.7	0
10.67	23.31	6.112	528.5	0
11.67	18.48	6.556	585.4	0
12.67	93.3	5.455	579.4	0
1.68	91.37	6.465	551.9	0
2.68	108.4	8.233	566.2	0
3.68	72.72	15.67	559.3	0
4.68	20.46	13.81	492.7	0
5.68	23.7	12.17	497.1	0
10.68	14.96	8.862	601.6	0
11.68	23.58	8.861	608.9	0
12.68	99.75	8.295	596.5	0
1.69	119.8	16.23	617.4	0
2.69	116	15.97	590.6	0
3.69	80.17	22.29	599.6	112
4.69	20.39	15.07	543.1	106.2
5.69	17.85	23.01	527.8	105.4
10.69	16.29	4.96	588.5	0
11.69	36.92	4.614	581.9	0
12.69	87.72	4.618	589.3	0
1.7	99.66	4.571	640.4	0
2.7	94.54	4.539	650.9	0
3.7	72.59	4.55	572.3	100.1
4.7	19.17	4.502	572.7	111.8
5.7	12.19	4.62	570.9	118.2
10.7	16.54	5.109	622.2	117.2
11.7	19.33	7.148	604.1	117.2
12.7	87.09	6.272	584.7	134.2
1.71	110.2	10.58	619	143.1
2.71	97.98	8.222	621.5	141.8
3.71	66.73	12.31	653.1	93.81

Year Month	Seafood Price Index	Crab Price Index	Clam Price Index	Surf Clam Price Index
4.71	29.25	4.929	656.7	88.26
5.71	21.4	7.596	703.9	87.87
10.71	14.32	5.136	608.2	89.88
11.71	13.27	5.88	710	95.2
12.71	67.99	5.29	695	94.45
1.72	71.28	6.983	695.6	96.3
2.72	82.14	9.677	719.5	95.48
3.72	77.61	9.094	691.7	80.92
4.72	38.78	6.734	720	89.36
5.72	24.09	5.944	703.9	93.06
10.72	10.61	7.119	752.5	90.83
11.72	13.37	7.97	786.2	90.31
12.72	35.54	6.699	752.6	91.13
1.73	63.24	11.44	714.1	87.55
2.73	70.92	13.89	687.2	85.89
3.73	58.57	14.95	717.3	83.2
4.73	39.76	13.86	710.3	87.36
5.73	29.23	12.06	701.2	84.08
10.73	21.5	5.967	675.6	80.03
11.73	20.33	6.097	676	81.18
12.73	23.05	7.17	665.7	77.57
1.74	58.29	8.133	620.1	81.17
2.74	59.47	9.264	533.8	84.28
3.74	50.3	9.579	616.9	75.3
4.74	36.81	7.737	613	69.42
5.74	23.49	7.412	604.5	81.29
10.74	21.01	5.609	576.4	76.6
11.74	18.02	5.88	561.4	74.3
12.74	31.48	5.767	546.9	78.55
1.75	62.68	8.306	539.6	83.28
2.75	54.91	10.97	532.5	85.09
3.75	50.46	13.54	552.9	98.63
4.75	37.78	12.27	545.9	102.1
5.75	25	11.39	545.9	128.5
10.75	31.07	6.891	525.1	161.3
11.75	43.77	8.642	530.7	231.1
12.75	57.56	8.774	530.2	231.2
1.76	90.55	12.72	526.7	256.9
2.76	116.4	13.5	530.3	297
3.76	69.49	14.42	522.5	327.6
4.76	47.48	12.52	526.6	324.4
5.76	41	15	529.4	354.6

APPENDIX B

Alternative Employment Opportunity Index for Virginia Seed Oyster Industry

Month.Year	
1.66	263.1
2.66	259.1
3.66	284.8
4.66	300.5
5.66	332
10.66	289.6
11.66	298.2
12.66	286.6
1.67	249.7
2.67	249.1
3.67	259.2
4.67	281.7
5.67	290.9
10.67	299.4
11.67	286.5
12.67	264.1
1.68	305.8
2.68	322.8
3.68	339.4
4.68	288.6
5.68	302.9
10.68	324.4
11.68	313.6
12.68	310.6
1.69	332.5
2.69	338.2
3.69	336.7
4.69	355
5.69	355.4
10.69	336.7
11.69	327.4
12.69	317.5
1.7	289.6
2.7	300.1
3.7	311.2
4.7	334.6
5.7	353.2
10.7	354.4
11.7	358.2
12.7	356.2
1.71	326.6
2.71	323.9
3.71	340
4.71	341
5.71	361.2
10.71	363.3
11.71	373.9
12.71	359.3
1.72	376.9
2.72	387.1
3.72	398.9
4.72	416.7
5.72	426.7
10.72	456.7
11.72	454.3
12.72	452.4
1.73	401.4
2.73	410.7
3.73	420.9
4.73	451.7
5.73	474.4
10.73	507.2
11.73	496.4
12.73	483.9
1.74	463.4
2.74	462.1
3.74	475.9
4.74	469.8
5.74	483.4
10.74	466.3
11.74	464.6
12.74	437.4
1.75	394.8
2.75	384.7
3.75	381
4.75	408.9
5.75	408.5
10.75	404.2
11.75	393.1
12.75	392.2
1.76	365.6
2.76	368.1
3.76	372.8
4.76	396.8
5.76	417.1

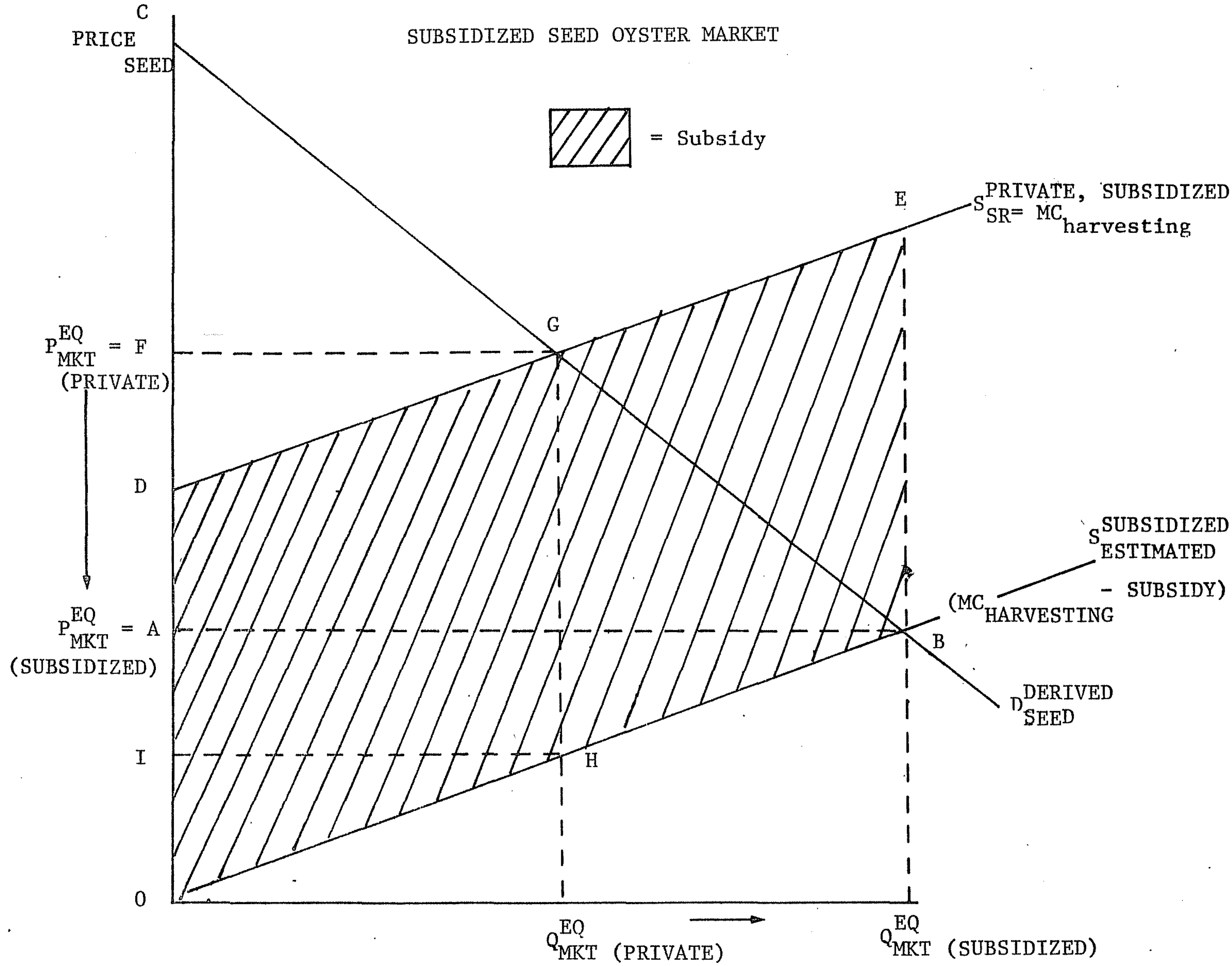
TECHNICAL APPENDIX A

In the foregoing benefit-cost analysis, we have assumed that in the absence of subsidized culch the private seed oyster industry would quickly go under. An alternative assumption as to the self-sufficiency of the private industry might lead to the following restatement of our motivating question:

> Does the enlarged consumers surplus triangle ABC (see Figure 14) plus the enlarged producers surplus triangle OAB delineate a sufficient increase in net benefits to justify that subsidy ODEB responsible for the reduction in price and increase in output?

Figure 14

SUBSIDIZED SEED OYSTER MARKET



For this to be so, an appropriate benefit-cost ratio, defined as the change in aggregate net benefits [(ABC-FGC) + (OAB-DGF)] to public cost (ODEB), must be greater than one:[72]

ALTERNATIVE BENEFIT/STATE COST RATIO ≡ [(ABC-FGC) + (OAB-DGF)]/ODEB

We include in the numerator only the increase in net benefits to tongers and planters because to do otherwise (to attribute the entire net income OAB, plus the entire consumer surplus ABC, to the subsidy programs) would imply that in the absence of public intervention, no private output would be forthcoming. But of course, that is not the case (as depicted by the positive and substantial private market output, $^{MKT}QEQ_{PRIVATE}$ in Figure 15). Thus, we might have calculated (ABGF = ABHI)/ODEB for each fiscal year and reported alternative reflections of that same information as public and private rates of return.

The calculations entailed by adopting this more sophisticated benefit measure (the tetrahedron ABGF + ABHI, that is, FGBHI) are not different in kind from those explained in great detail in Chapter 2, but they are considerably more complicated. Before integrating under the demand function ($Q = \hat{a}^D + \hat{B}^D P_{seed}$) from, say, $P_{PRIVATE}$ to $P_{SUBSIDIZED}$, it was necessary to establish what the equilibrium private-market price would have been in the absence of the subsidies.

Assuming a unit subsidy, we simply subtracted the appropriate subsidy from the estimated supply function (see Figure 14) to obtain the free-market, unsubsidized supply,

$Q^{PRIVATE} = (a^s + \text{UNIT SUBSIDY}) + B^s P_{SEED}$.

Then setting private supply equal to estimated demand,

$[a^s + \text{UNIT SUBSIDY}) + B^s P_{SEED}] = [a^D + B\ P_{SEED}]$

it was possible to solve for the private market-clearing price. Various integrations involving this and the subsidized price (for example,

$$\text{NET CONSUMER BENEFIT, ABGF} = \int_{P_{SUBSIDIZED}}^{P_{PRIVATE}} (a^D + B^D\ P_{SEED})\ dP = (\hat{a}^D x \Delta P) + \hat{B}/2(P_{PRI}^2 - P_{SUB}^2)$$

where $\Delta \equiv (P_{PRI} - P_{SUB})$, brought us eventually to the area of FGBHI, the net benefit measure of interest. Calculations for the most recent years 1974-76 confirmed our suspicion that these benefit meausures would be smaller than those reported in the text (see Tables 12 and 13).[73]

We have chosen to report the larger benefit-cost ratios primarily because we believe that the public subsidies have been critical to the survival of the seed oyster industry in recent decades. That is, the devastations precipitated by both MSX and Agnes were, arguably, of sufficient scope that the industry might have never recovered without public subsidies. Only a thorough-going simulation analysis can confirm this presupposition, but it will remain our operative assumption until proven otherwise.