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economic considerations for management of the fishery

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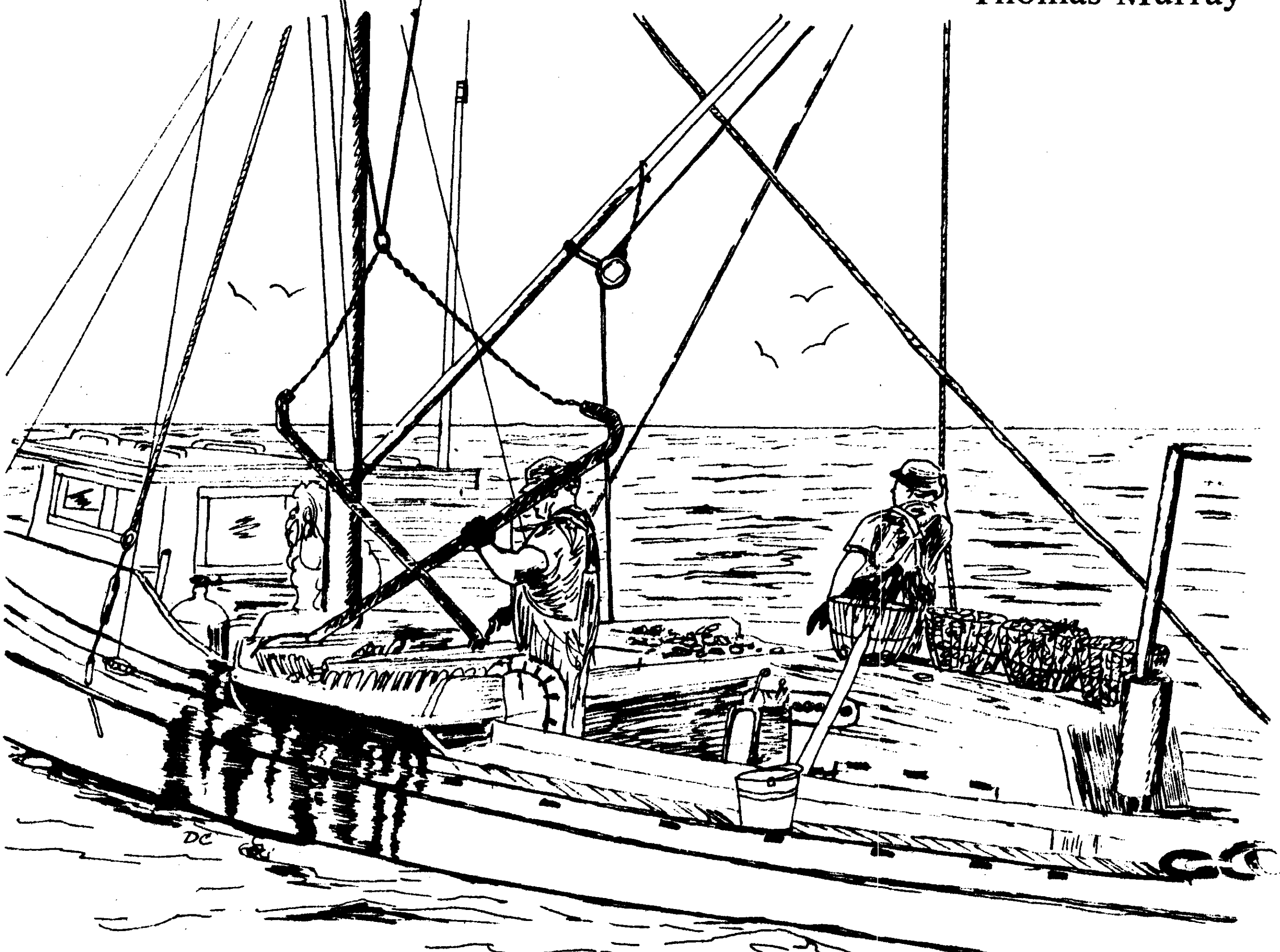

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PRICE FLEXIBILITY ANALYSIS

OF VIRGINIA HARD CLAMS

Economic Considerations for

Management of the Fishery

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ABSTRACT

Price flexibility coefficients estimated for ex-vessel prices of Virginia hard clams indicate a very small (4.292×10^{-6} to 6.994×10^{-6}%) decrease in price would occur given a 1% increase in the quantity supplied by Virginia harvesters. Data used were monthly landings of Virginia, New York, New Jersey, Rhode Island, Maryland and North Carolina over the period 1960-1979. Fifty-eight percent of the ex-vessel price changes are not explained by the supply response model used, suggesting other market and consumer demand factors play a large role in determining ex-vessel price. This conclusion is reached considering the historical range of production in Virginia.

Possible legislative changes to aid the fishery are: (1) Allowing the use of efficient harvesting technologies on private leased bottom, (2) Consider seasonal use of efficient harvesting technologies to take advantage of seasonal peaks in ex-vessel prices, (3) Institute a new statistical reporting system that reports the catch/day of each harvester and the proportion of each market grade caught, (4) Establishment of subaqueous bottom areas specifically for the field culture of hard clams, and (5) Set and enforce a minimum legal cull size.

GENERAL INTRODUCTION

The hard clam, *Mercenaria mercenaria* (Linne, 1758), Family Veneridae (Frissel, 1936; Turner, 1953; Wells, 1957a), is a euryhaline bivalve found along the eastern and Gulf coasts of North America ranging from the Gulf of St. Lawrence to the Yucatan Pennisula (Carriker 1961; Wass, 1972; Abbott, 1954; Miller et al., 1975). It has been and continues to be the focus of an important commercial fishery along the Atlantic coast (Belding, 1912, 1931; Tiller et al., 1952; Andrews, 1970; McHugh, 1972, 1977; Miller et al., 1975). Hard clams are consumed in a wide variety of ways, with the larger clams (>80 mm) being used in chowder and the more succulent littlenecks (<60 mm) ("nicks") and cherrystones (61-80 mm) ("cherries") being eaten either steamed or raw on the half shell.

The production along the Atlantic coast, Virginia in particular, is characterized by considerable production fluctuations. Peak production for the U.S. fishery came in 1950 with total landings of almost 21 million pounds of meats and a nominal[1] ex-vessel value of 8.9 million dollars (Lyles, 1966). Virginia production peaked in 1965 at about 2.5 million pounds of meats and a nominal ex-vessel value of 1.4 million dollars (Lyles, 1966; Ritchie, 1976). The high level of production in Virginia followed the decline of the Virginia oyster fishery caused by the pathogen MSX (*Minchinia nelsoni*) (Andrews and Wood, 1967; Andrews, 1979), as harvesters turned to clams when

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[1]Nominal dollars are those not adjusted for inflation.

production from private oyster ground decreased. Low periods of production for the total U.S. fishery occurred in 1979 (12.1 million pounds of meats and 14.2 million nominal dollars) and in 1978 for the Virginia fishery (0.5 million pound of meats and 0.46 million nominal dollars) (National Marine Fisheries Service, 1980). Virginia's share of total U.S. landings dropped to 3.5% in 1978 after reaching a peak of 16.5% in 1965 (National Marine Fisheries Service, 1980). Decreases in Virginia production are thought to have occurred from declining fishing effort and not from decreases in stock availability.

The hard clam fishery in Virginia is concentrated on the seaside of the Eastern Shore and in the rivers of the lower Chesapeake Bay (Tiller et al., 1952; Andrews, 1970; Castagna and Haven, 1972). The mouths of the rivers of the lower Bay (James and York Rivers) and the large expanse of sheltered bays on the Eastern Shore provide large areas with salinities greater than 15 $^{o}/oo$ (Chanley, 1958; Andrews; 1970; Castagna and Chanley, 1973) and less than 35 $^{o}/oo$ (Belding, 1931; Davis and Calabrese, 1964) that are essential for growth and survival of larvae. Water temperatures in both areas provide the rise above 15°C in the summer required to stimulate spawning but remain below 33°C, the maximum temperature for effective larval development (Loosanoff et al., 1951).

Commercial harvesting methods in Virginia have traditionally been labor-intensive, preventing overexploitation of the resource in the absence of a comprehensive management plan. Most commercial harvesting takes place on public clam grounds. As such, clams are a common property natural resource, and the industries that harvest such resources are traditionally inefficient (Christy, 1964).

Hand rakes, hand tongs, clam picks (Fig. 1), and patent tongs (Fig. 2) are some of the labor intensive methods used (Tiller et al., 1952; Dumont and Sundstrom, 1961). In the lower Chesapeake Bay harvesting is primarily accomplished by patent tongs because clams are found in deeper water (3-7 m). Typically, a patent tong boat is a one man operation with the waterman controlling the throttle and patent tong from one location. Occasionally two individuals will outfit a single boat with two patent tong units. This does increase the catch/boat/day but the catch/man is about equal to boats with one man working. The harvest on the western shore of the Bay continues throughout the year, concentrating on the six high density areas delineated by Haven et al. (1973). Intense harvesting takes place during the summer (May 1-August 15) in the lower James River. This area is closed to fishing during the remainder of the year because of high bacterial levels. Fishing is permitted only during the summer because higher water temperatures cause clams to circulate water faster through their bodies than during the winter, allowing them to be cleansed when placed in clean water for 15 days. Average landings are between 1500 to 3000 clams/boat/day. Many watermen participate only in the James River summer fishery, engaging in some other fishery, such as oysters, during the rest of the year.

Figure 1. Clam rakes and picks used to manually harvest hard clams in Virginia.

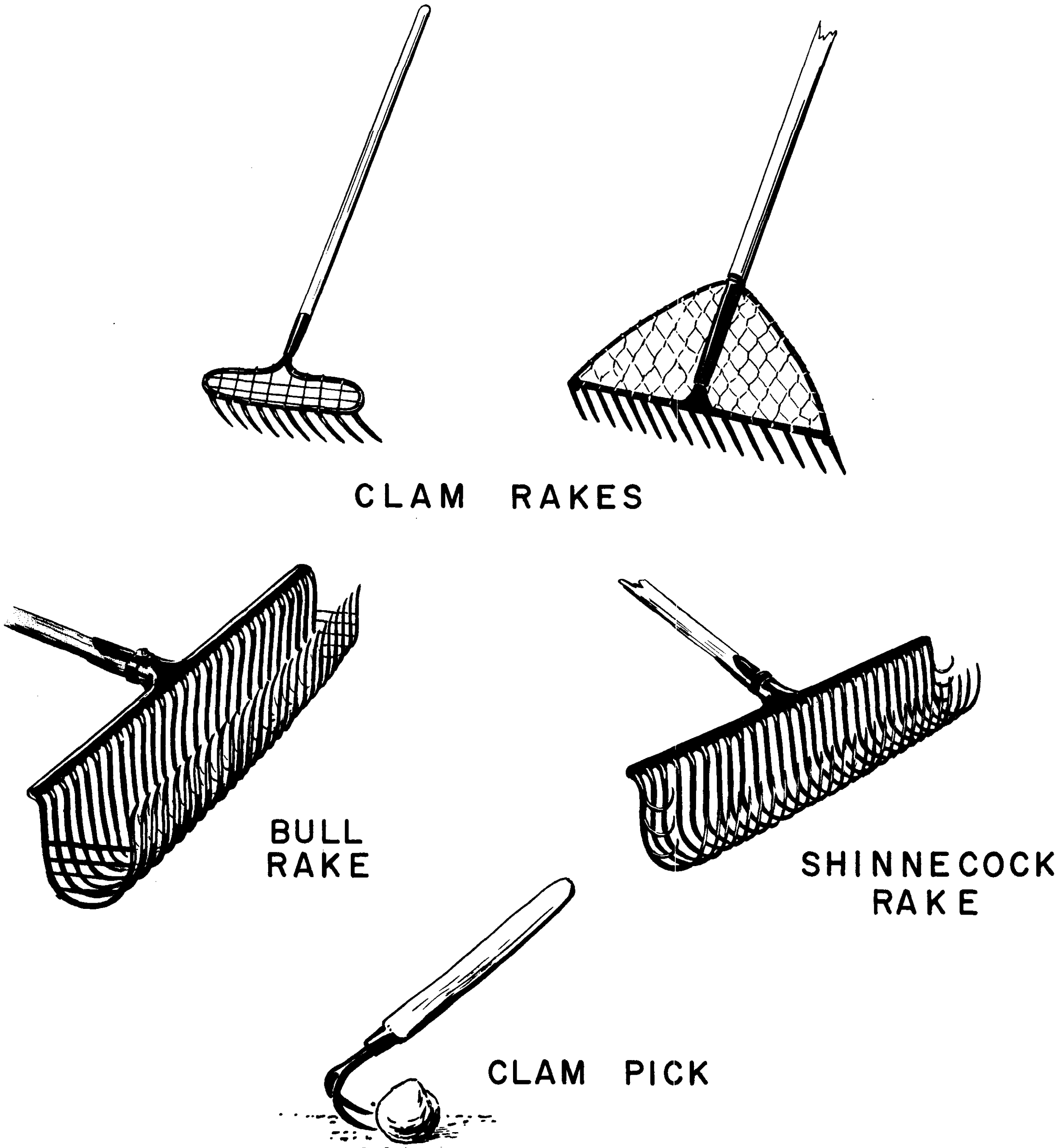


Figure 1. Clam rakes and picks used to manually harvest clams in Virginia. (Illustrations from Dumont and Sundstrom, 1961).

Figure 2. Patent tong gear used to harvest clams.

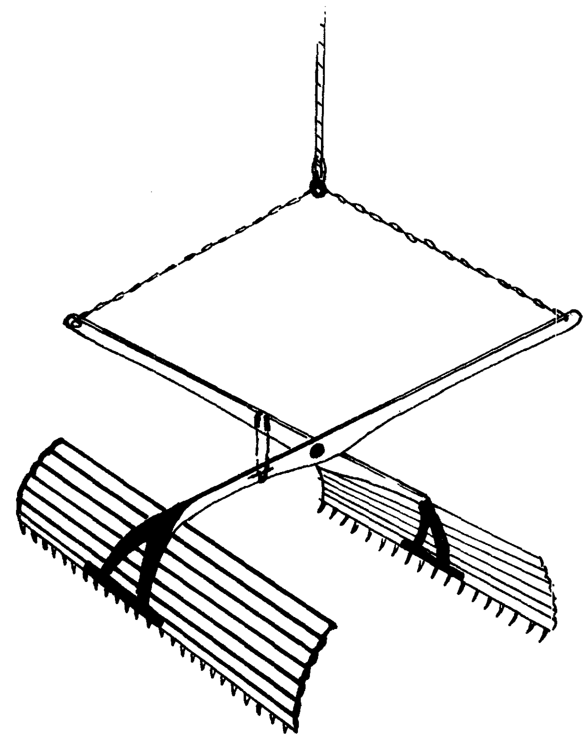
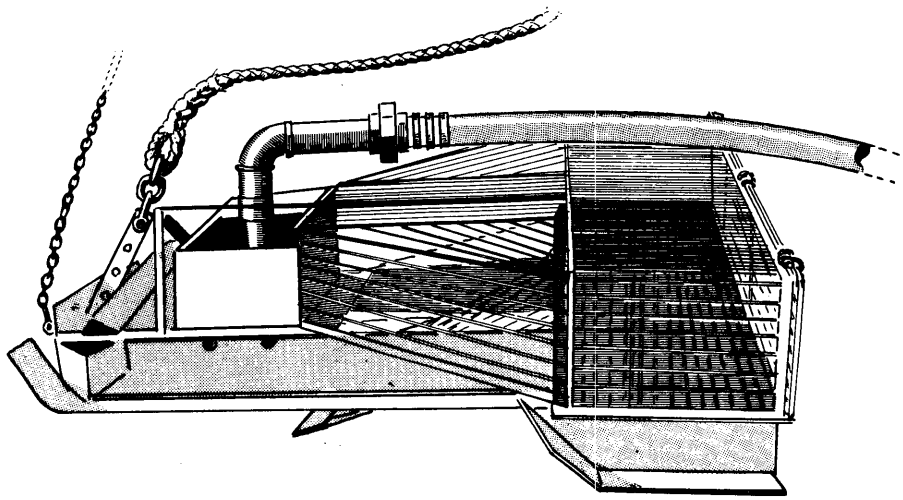
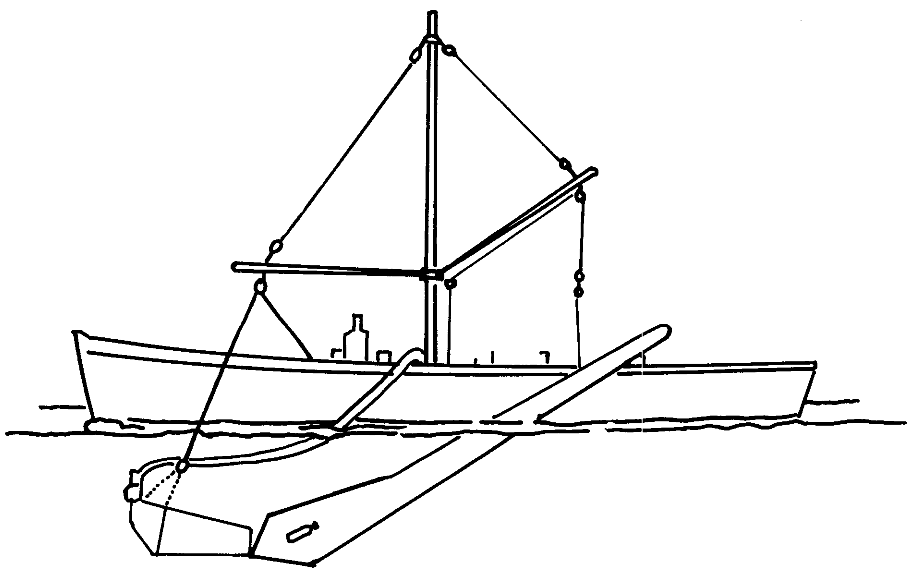


Figure 2. Patent tong gear used to harvest clams.

Figure 3. Hydraulic escalator harvester.



HYDRAULIC DREDGE — HARD CLAMS



HYDRAULIC ESCALATOR DREDGE

Figure 3. Hydraulic escalator harvester.
(Illustrations from Dumont and Sundstrom, 1961)

The large intertidal areas of the seaside of the Eastern Shore facilitate a much different mode of harvesting clams than in the deeper rivers of the lower Bay. Signing clams with clam picks, hand rakes or with barefeet are the common ways of harvesting. This allows recreational clam harvesting to develop to a much greater extent than is present in the lower Bay.

Experimental use of the hydraulic escalator harvester (Fig. 3) developed by MacPhail (1961) was permitted in Virginia on an experimental basis by the Virginia Marine Resources Commission (VMRC) in 1980. Its efficiency has been estimated to be from eight (Austin and Haven, 1981) to 60 (MacPhail, 1961) times that of conventional patent tong gear. The hydraulic escalator harvester is used in many of the Atlantic coast states under strict management schemes. The relative efficiency of the hydraulic escalator harvester and its potential effect on available resources and bottom communities has been the source of many studies (Glude and Landers, 1953; Godwin, 1968; Anderson et al., 1978; Austin and Haven, 1981; Oceanographic Institute of Washington, 1981. The Virginia General Assembly passed a statute in 1981 outlawing the use of the hydraulic escalator harvester for harvesting hard clams (Virginia Code §§ 28.1-128.01) after individual harvesters argued the hydraulic escalator would depress prices, cause high unemployment and damage clam beds. In a recent court decision (May 1982), the Circuit Court of Hampton ruled the holders of the permits could continue to use their hydraulic harvesters on private leased grounds.

Early research by Kellogg (1903) and Belding (1912) dealt with growth and embryology of the larvae. Loosanoff (1937a, 1937b, 1959) and Loosanoff et al. (1951) pioneered early work on sexual development and spawning habits which would later set the stage for an intensive mariculture effort. Haskin (1949, 1952), Carriker (1952, 1956, 1961), Chestnut (1952), Turner (1953), Gustafson (1954), Turner and George (1955), Haven and Andrews (1957), Chanley (1959), and many others investigated growth and development of young M. mercenaria. Kerswill (1941) documented environmental factors limiting growth and distribution of M. mercenaria, as did Wells (1957b), Pratt (1953), and Pratt and Campbell (1956).

Studies of growth rates of M. mercenaria by Kellogg (1903), Gustafson (1954), Ansell (1964), Menzel (1964), Loesch and Haven (1973a), Cunliffe and Kennish (1974), Kennish and Olsson (1975), Eldridge et al. (1979), and Kennish and Loveland (1980) described growth by change in volume, length and shell size. Haven and Andrews (1957), Woodburn (1961), Menzel (1964), and Ansell (1968) studied growth of a hybrid produced by crossing the northern quahaug, M. mercenaria, with southern quahaug, Mercenaria campechiensis. Heppell (1961) and Ansell (1964, 1968) described the growth of M. mercenaria in British waters.

Loosanoff's (1937a, 1937b) success in spawning and breeding experiments developed into a long series of research papers dealing with the mariculture of M. mercenaria. The results are well documented in the literature (Wells, 1924, 1927; Loosanoff and Davis, 1950; Loosanoff et al., 1951; Loosanoff, 1954, 1959; Davis and Calabrese, 1964; Menzel, 1964; Menzel and Sims, 1964; Castagna et al., 1970; Keck et al.,; Kennedy et al., 1974; Kraeuter and Castagna, 1977, 1980; Meyers, 1981; and others). McHugh et al. (1982) has produced an excellent bibliography on all aspects of hard clam mariculture and ecology, so it will not be documented here.

Juvenile (8-10 mm) clams produced naturally or by culture operations have proven very susceptible to predation by a large number of free-living invertebrates (Andrews, 1970). Subsequent research was focused on determining these predators and their feeding rates. MacKenzie (1977, 1979) described in detail the predators of hard clams. Readers are urged to consult his works for a complete discussion.

The national hard clam fishery was studied by Ritchie (1976). His study examined the industry in each state, making recommendations for the improvement of the entire U.S. industry. Summaries for each state were not included in Ritchie's 1976 publication. Summaries for South Carolina (Bearden, 1976), Rhode Island (Bockstael, 1976), Delaware (Cole, 1976), Maine (Dow, 1976), Massachusetts (Marine Research Inc., 1976), New York (McHugh and MacMillian, 1976), Florida (Menzel, 1976) Maryland (Rinaldo and Scott, 1976; Strand, 1976a), North Carolina (Street, 1976), and New Jersey (Sugihara, 1976) detailed the status and potential of the fishery in each state. Noticeable for its absence was Virginia. The summaries were only reviews of the industry and did not entail any new research.

Studies of _M. mercenaria_ and its fishery in Virginia are limited aside from the extensive mariculture efforts. Haven and Loesch (1972), Haven et al. (1973), Loesch and Haven (1973a, 1973b), Haven and Kendall (1974, 1975), Loesch (1977), Haven and Morales-Alamo (1980), and Fritz (1982) studied abundance, growth, and size-age relationships in the lower Chesapeake Bay. Loesch (1974) devised a sampling plan for estimating _M. mercenaria_ abundance using a hydraulic escalator harvester which was later used by Rhodes et al. (1977) to estimate the standing crop of _M. mercenaria_ in the Santee River estuary, South Carolina. Larsen (1979) investigated heavy metal concentrations in hard clams in Hampton Roads, Virginia. Austin and Haven (1981) monitored experimental use of a hydraulic escalator harvester on Hampton Bar. Strand (1976b) conducted a limited price analysis of the hard clam fishery of the Eastern Shore.

In the fall of 1980, as the use of the hydraulic escalator dredge for harvesting clams was being considered a bill before the General Assembly of Virginia, questions arose regarding socioeconomic and environmental effects of the hydraulic escalator dredge. The biological concerns were cited as the main point of contention, but the real fear amongst harvesters was the effect of anticipated increases in supply on the ex-vessel price of hard clams received by the individual watermen.

The objective of this study then is to determine impacts of anticipated increases in supply on the ex-vessel price received by watermen by means of analysis of price flexibility.

Price flexibility is widely used in agricultural economics to determine relative impacts of production fluctuations on prices (Tomek and Robinson, 1972). Similar analysis on seafood products has also been common. Cato (1976) described flexibilities for Florida mullet and found them to be flexible in price over an extended time period of production. Conrad (1980) analyzed wholesale prices of hard clams over a 40-week period at the Fulton Market, New York, and concluded hard clam wholesale prices at the market were inflexible for clams with respect to the quantity sold, without being able to identify the major determinant of the wholesale price. There has been no such analysis of Virginia seafood products, although Strand (1976b) did conduct a limited price anlysis of the hard clam fishery on the Eastern Shore of Virginia. He concluded that both landings and real ex-vessel prices were declining.

METHODS

Own price flexibility is the ratio of a percentage change in price of the subject product associated with a one unit change in the quantity of the product sold (Houck, 1966). The general equation used to define the price flexibility coefficient is:

$$F_i = \frac{\%\Delta P}{\%\Delta Q}$$

where $\%\Delta P = P_1 - P_2 / P_1 + P_2$

$\%\Delta Q = Q_1 - Q_2 / Q_1 + Q_2$

P_1=price of clam meats in nominal dollars/pound at Q_1

P_2=price of clam meats in nominal dollars/pound at Q_2

Q_1=quantity in pounds of meats at P_1

Q_2=quantity in pounds of meats at P_2 (Tomek and Robinson, 1972).

Price flexibilities may range from zero to $-\infty$, the negative sign resulting from a normal price-quantity relationship[2]. Absolute values from zero to one indicate a relatively inflexible price while absolute values greater than one indicate a relatively flexible price.

Using the price flexibility equation of $F_i = \%\Delta P / \%\Delta Q$, Tomek and Robinson, 1972), an aggregate flexibility can be estimated for

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[2]Price and quantity are usually negatively related, i.e., higher quantities bring lower prices given constant demand.

Virginia hard clams using linear regression analyses. Monthly landings and ex-vessel prices over the period 1960-1979 were used to determine the slope of the least-squares line fitting the individual flexibility points. The slope (B) is equal to the percentage change in ex-vessel price resulting from a one percent change in quantity landed. Monthly landings and ex-vessel values for each of the major Atlantic coast hard clam producing states were obtained from published statistics (Bureau of Commercial Fisheries, 1960-1969a-f; National Marine Fisheries Service, 1970-1979a-f). Ex-vessel values were left in nominal dollars on the premise that watermen look at the prices they receive in current terms. Hypothetical seasonal changes in price flexibility were tested by dividing the year into a summer (May-September) and winter (October-April) season.

A multiple regression analysis was used to determine regression coefficients and aggregate price flexibilities. The dependent variable in each regression model was a price index equal to the monthly nominal price per pound of clam meats divided by the average nominal price per pound in 1972. The base year of 1972 was chosen because it represents a year of nearly average prices and quantities landed in Virgnia over the period 1960-1979. This index was used instead of "constant" dollars (those adjusted for inflation) because of potential anomalies in consumer price indices for the periods of study. Consumer price indices are determined by measuring the rates of price increase of a selection of goods, which usually does not include seafood products. The use of a price index alleviates this problem. The price per pound of clam meats is derived by dividing the total landings in pounds by the total nominal value. The unit of price per pound of meats is a valid unit for price flexibility analysis. Price flexibility deals with percentage changes in value given a percentage change in quantity, not in absolute amounts. Price per pound of meats reflects the true ex-vessel value because the basic data compiled are based on graded landings and ex-vessel prices for the respective grades of clams (Personal communication, Paul Anninos, Virginia Marine Resources Commission, 26 February 1982). Graded landings are totalled into respective bushel (bu.) sizes (approximate bushel sizes: 250 chowders=1 bu., 400 cherrystones=1 bu., 500 littlenecks=1 bu.) and each bushel is multiplied by eight to give the total number of pounds of meats. Similarly the total value is the summation of each grade at its respective price. The total value reflects prices received for all grades landed and in effect is a weighted total. The ratios of the two (total value/total pounds), yields a price per pound based on relative valuation and quantity of the graded clams landed. Graded landings information is not published in Virginia.

Three independent variables were used in the regression program for determination of flexibilities: (1) Monthly landings of Virginia clams in pounds of meats, (2) Monthly landings in pounds of meats from the Northeast region (total of New York, New Jersey, and Rhode Island), and (3) Monthly landings from the Mid-Atlantic region (total of Maryland and North Carolina). These regional landings were used as variables because it was hypothesized that these are the suppliers that Virginia competes against for respective market areas. Together these states account for 80-90% of the hard clams produced nationally.

The regression program employed was from the Statistical Package for the Social Sciences (SPSS with graphics option for Prime 400/500, Version M, Release 8.1, 15 June 1981) (Nie et al., 1975; Hull and Nie, 1981). A test for significance at the 1% level was used to test the null hypothesis $H_0{:}B=0$ (Sokal and Rohlf, 1969). Additional tests of significance for the individual regression coefficients at the 1% level were performed to establish whether specific B values were non-zero. The two tests of significance were run for the entire year in addition to the winter and summer periods.

RESULTS

Regression statistics for the overall F test for the entire year indicate that total hard clam production from Virginia, the Northeast and Mid-Atlantic regions had a statistically significant impact at the 1% level on the price received in Virginia (Table 1). However, R^2 values of 0.27, 0.08, and 0.07, respectively, explain only 7 to 27% of the variation in Virginia price per pound. The cumulative effect of production from all major Atlantic coast states explains only 42% of the variation in Virginia prices during the entire year, suggesting other market factors, such as consumer demand, play a major role in determining ex-vessel prices.

Acceptance of the alternative hypothesis $H_1:B \neq 0$ (rejection of the null hypothesis $H_0:B=0$) indicates that one or more of the partial regression coefficients have an absolute value greater than zero. Further tests of significance for the partial regression coefficients at the 1% level are needed to establish whether specific B values are non-zero. All partial regression coefficients (-5.851×10^{-6}, 4.498×10^{-6}, 7.861×10^{-6}) are statistically significant at the 1% level (Table 2).

The results of seasonal regression analyses are shown in Tables 3-6. Total production from Virginia, the Northeast and Mid-Atlantic regions had a statistically significant impact on the prices received in Virginia during the winter months (Table 3) and summer months (Table 5). The overall F values is significant at the 1% level for

Table 1. Regression statistics describing the effects of Virginia, Northeast, and Mid-Atlantic clam landings on the ex-vessel price of Virginia clam meats during January through December, 1960-1979.

Dependent Variable: Virginia price index based on 1972 price.

Independent Variables:	R^2	Slope (B)	$F_{.01, (3,236)}$	Overall F
1. Virginia clam landings	0.27	-5.851×10^{-6}	3.87	60.83*
2. Mid-Atlantic clam landings	0.07	4.498×10^{-6}		
3. Northeast clam landings	0.08	7.861×10^{-6}		
	0.42			

* Significant at the 1% level

Table 2. F tests of significance for partial regression coefficients during January through December, 1960-1979.

Dependent Variable: Virginia price index based on 1972 price.

Independent Variables:	Slope (B)	F	$F_{.01, (3,236)}$
1. Virginia clam landings	-5.851×10^{-6}	114.67*	3.87
2. Mid-Atlantic clam landings	4.498×10^{-6}	30.91*	
3. Northeast clam landings	7.861×10^{-6}	36.92*	

* Significant at the 1% level

Table 3. Regression statistics describing the effects of Virginia, Northeast, and Mid-Atlantic clam landings on the ex-vessel price of Virginia clam meats during October through April, 1960-1979.

Dependent Variable: Virginia price index based on 1972 price.

Independent Variables:	R^2	Slope (B)	$F_{.01,\ (3,136)}$	Overall F
1. Virginia clam landings	0.37	-6.994×10^{-6}	3.95	34.10*
2. Mid-Atlantic clam landings	0.05	3.527×10^{-6}		
3. Northeast clam landings	0.01	5.841×10^{-6}		
	0.43			

* Significant at the 1% level

Table 4. F tests of significance for partial regression coefficients during October through April, 1960-1979.

Dependent Variable: Virginia price index based on 1972 price.

Independent Variables:	Slope (B)	F	$F_{.01, (3,136)}$
1. Virginia clam landings	-6.994×10^{-6}	88.26*	3.95
2. Mid-Atlantic clam landings	3.527×10^{-6}	11.71*	
3. Northeast clam landings	5.841×10^{-7}	2.31	

* Significant at the 1% level

Table 5. Regression statistics describing the effects of Virginia, Northeast, and Mid-Atlantic clam landings on the ex-vessel price of Virginia clam meats during May through September, 1960-1979.

Dependent Variable: Virginia price index based on 1972 price.

Independent Variables:	R^2	Slope (B)	$F_{.01, (3,136)}$	Overall F
1. Virginia clam landings	0.33	-4.292×10^{-6}	3.99	37.12*
2. Mid-Atlantic clam landings	0.04	7.800×10^{-6}		
3. Northeast clam landings	0.17	5.761×10^{-7}		
	0.54			

* Significant at the 1% level

Table 6. F tests of significance for partial regression coefficients during May through September, 1960-1979.

Dependent Variable: Virginia price index based on 1972 price.

Independent Variables:	Slope (B)	F	$F_{.01,\ (3,136)}$
1. Virginia clam landings	-4.292×10^{-6}	67.94*	3.99
2. Mid-Atlantic clam landings	7.800×10^{-6}	36.08*	
3. Northeast clam landings	5.761×10^{-6}	7.32*	

* Significant at the 1% level

both seasons, allowing rejection of the null hypothesis H_0:B=0. Total R^2 values of 0.43 for the winter season and 0.54 for the summer months only explain 43 to 54% of the variation in prices received in Virginia during the winter and summer months, respectively.

Acceptance of the alternative hypothesis H_1:B≠0 indicates that one or more of the partial regression coefficients have an absolute value greater than zero. Further tests of significance for the partial regression coefficients at the 1% level are shown in Table 4 (winter) and Table 6 (summer). For the winter months, Virginia and Mid-Atlantic clam landings have a B value that is statistically significant. Regression analysis for the summer months indicate all three regions have a B value which is statistically significant at the 1% level. Virginia is the only area which has a negative B for the winter, summer, and entire year.

DISCUSSION

Results of the regression analysis indicate that 58% ($1-R^2$) of Virginia clam price fluctuations are not explained by landings of major Atlantic coast states. Fifty-eight percent of the winter price fluctuations and 45% of the summer price fluctuations are not explained by this model. This is in part because the regression equation purposely included only supply parameters. The addition of parameters which would reflect changes in consumer demand (demand shifters), such as wholesale and retail prices, would have increased the R^2 considerably. Consumer demand shifts to take advantage of changes in the price of substitutes and declining retail prices, and these correlate closely with ex-vessel prices. The model was concerned only with effects of changes in the quantities supplied.

The R^2 values for Virginia clam landings for the entire year, winter, and summer months (0.27, 0.37, and 0.33, respectively) move in the direction anticipated for the seasonal analysis. Virginia's landings are a greater determinant of the ex-vessel price in the winter because of frozen northernly bays and rivers, primarily Great South Bay of New York, which supplies the major portion of the clams on the market in the Northeastern U.S. The inability of New York fishermen to harvest clams during the winter enables Virginia watermen to control the market to a greater extent than they do in the summer. Consequently, Virginia clam buyers raise their ex-vessel price paid to watermen during the winter by about one cent per clam (Personal communication, William F. Hunt, Hunt Clam and Oyster Co., 12 Feb.

1982; Personal co munication, Roy E. Davis, Roy E. Davis Seafood Co., 12 Feb. 1982). The Mid-Atlantic region, particularly North Carolina, has only begun to boost production during the last three years, but this recent boost is offset by previous years of minimal production in this analysis.

During the summer, the influence of Virginia landings on the ex-vessel price received by watermen is diminished. This is primarily due to a surge in production from the Northeast. The increase in the R^2 value from the winter to the summer for the Northeast region reflects this increase in landings. New York, Rhode Island, and New Jersey have become substantial producers during the summer months, reducing Virginia's influence on the market. Again, Mid-Atlantic production increases in the last three years are offset by previous years of minimal production in this analysis. Virginia contributed 22% of the winter production and 18.6% of the summer production during peak landings in 1964. Production has dropped to 3.3% of the total summer production and 5.2% of the total winter production in 1978. This drop in production is thought to occur from shifts in fishing effort, not a decline in stock availability.

Over the entire year, the influence Virginia exerts on its ex-vessel price is offset by winter production increases in other regions and traditional drops in ex-vessel prices during the summer. Dramatic increases in production during the summer from states hindered by frozen bays and rivers during the winter (New York, Rhode Island, New Jersey) cause a loss of Virginia market influence.

Virginia's production during the same time period shows a much smaller increase than the Northeast region. A plot of mean monthly clam landings during 1960-1979 for the four major producing states that Virginia competes against depicts this (Fig. 4). The rapid increase in New York landings as the weather warms coincides with only a small rise in Virginia production. Coupled with Virginia's gradual decline in the percentage of total U.S. landings (from 16.5% in 1965 to 3.5% in 1978), it is obvious that Virginia has lost any market influence it may once have had.

The flexibilities calculated from the regression analysis show the Virginia price per pound of clam meats to be inflexible when considered over the current range of production. Statistically significant values of B in both the yearly and seasonal analysis show Virginia price to be inflexible with respect to the landings of the other states. Flexibilities for the yearly and seasonal analysis show a negligible (from 4.492×10^{-6} to 6.994×10^{-6}%) drop in price associated with a 1% increase in landings. It is evident that, based on the best data available and given current market conditions and consumer demand, there is little effect of increased Virginia landings on the ex-vessel prices received by watermen. This conclusion is reached considering the range of production studied (a minimum of 400,000 pounds and a maximum of 2.5 million pounds).

Rationale to support this conclusion comes from Virginia clam dealers, as representative dealers indicate they could market four to five times the number of littleneck clams (<60 mm in length) than they

Figure 4. Mean monthly clam landings from Virginia, Rhode Island, New York, and North Carolina over the period 1960-1979. (Source: Bureau of Commercial Fisheries, 1960-1969a-f; NMFS, 1970-1979a-f).

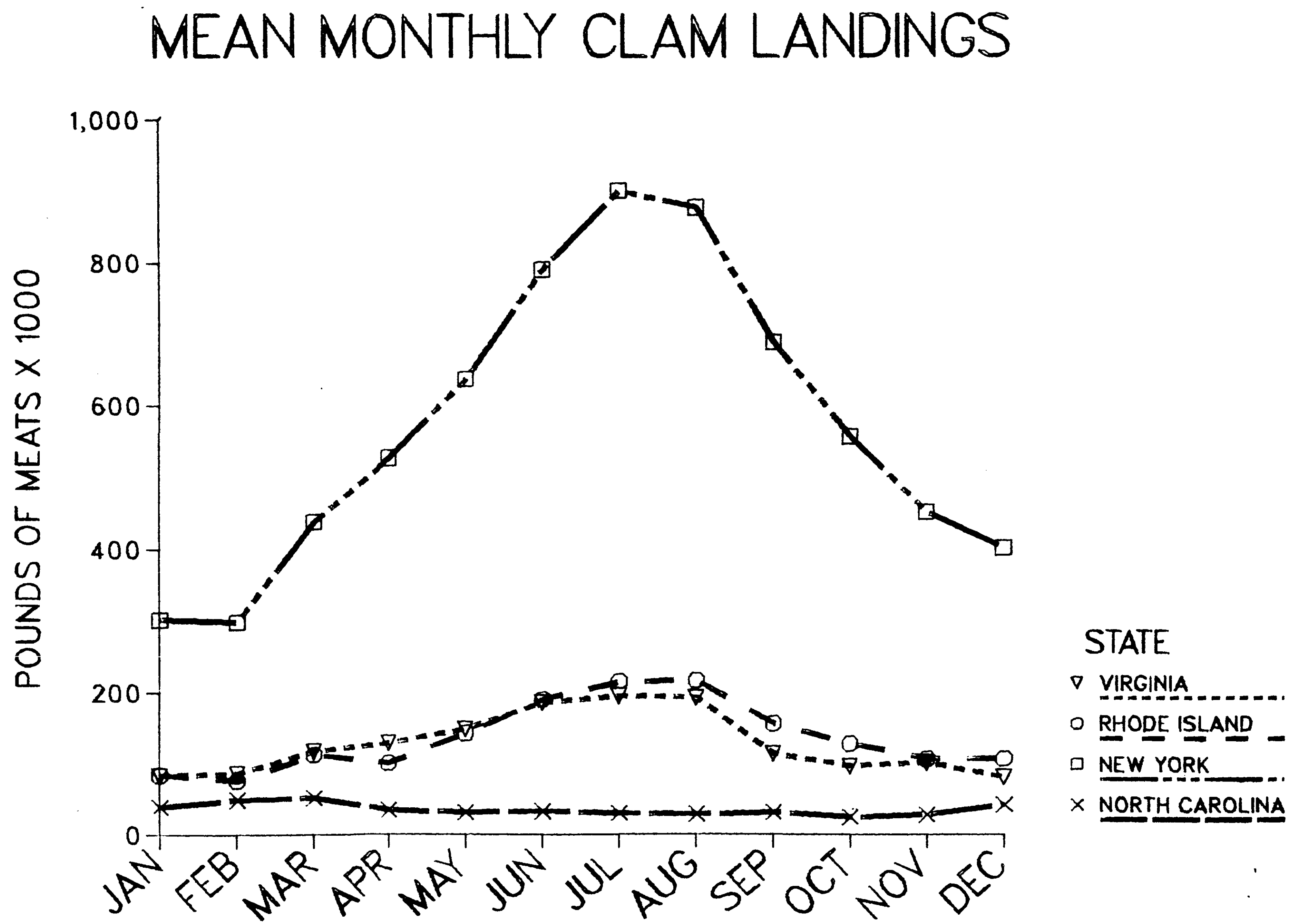
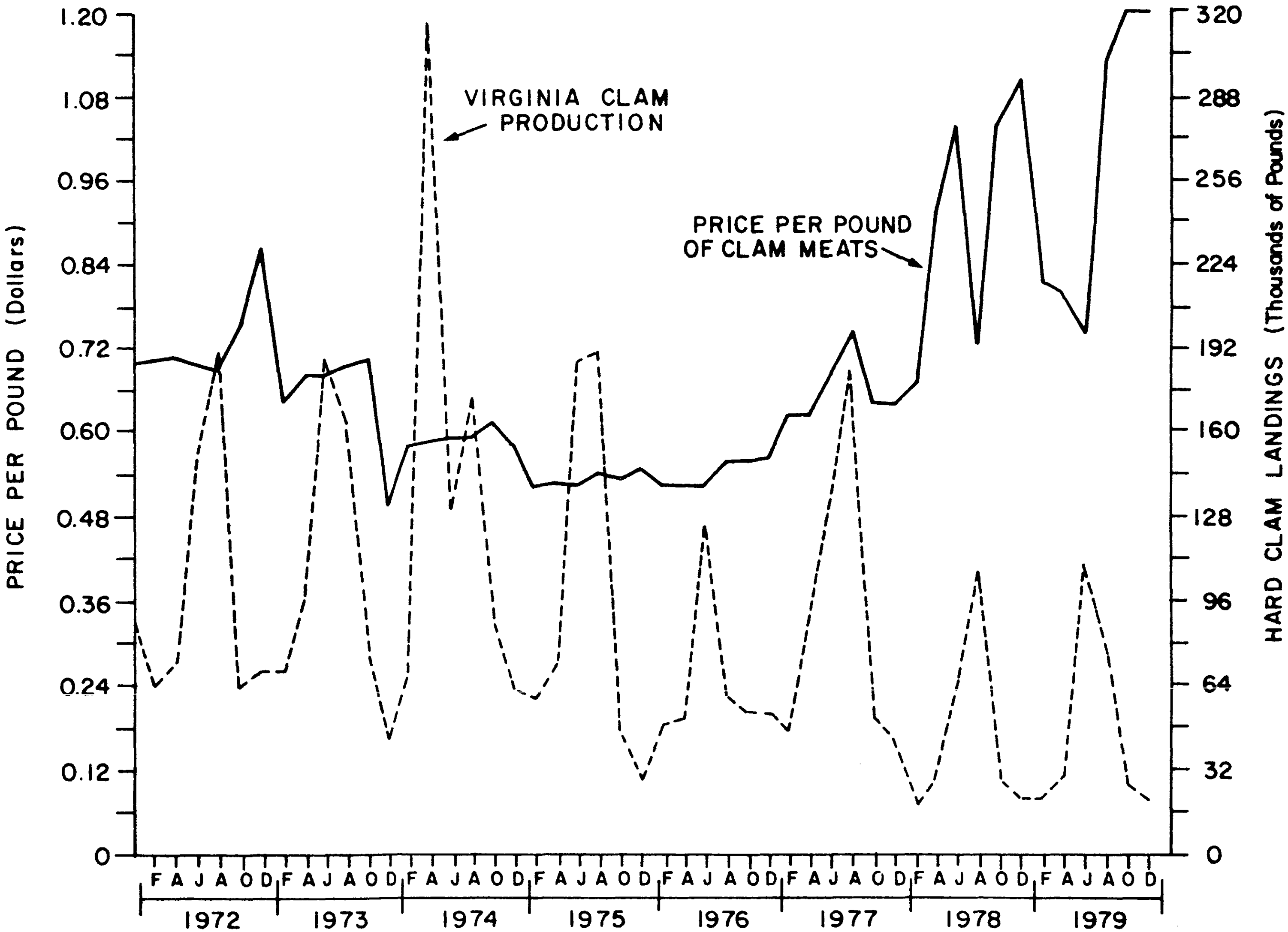

MEAN MONTHLY CLAM LANDINGS
POUNDS OF MEATS X 1000
1,000
800
600
400
200
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
STATE
VIRGINIA
RHODE ISLAND
NEW YORK
NORTH CAROLINA

FIGURE 4

Figure 5. Virginia clam production and real ex-vessel price by months over the period 1972-1979.



PRICE PER POUND (Dollars)
1.20
1.08
0.96
0.84
0.72
0.60
0.48
0.36
0.24
0.12
0
VIRGINIA CLAM PRODUCTION
PRICE PER POUND OF CLAM MEATS
HARD CLAM LANDINGS (Thousands of Pounds)
320
288
256
224
192
160
128
96
64
32
0
F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D
1972
1973
1974
1975
1976
1977
1978
1979

presently do. Demand for the smaller clams is consistently inelastic (Bell, 1978), but supply constraints, such as extended periods of bad weather, limit the markets that dealers are able to enter and furnish with a consistent supply. Reportedly, premium prices are paid to dealers (by retailers) for a constancy of supply. This inflexibility of price is reflected in a comparison of monthly hard clam production and real ex-vessel price during the last eight years (Fig. 5). In general, price was not responsive to quantities landed during years 1972 to 1979. Apparent price response to changes in quantity evident during the summer of 1978 and 1979 is not explained by this model.

The unavailability of grade information for commercial hard clam landings makes further price analysis difficult. Although wholesale price information on the various grades of hard clams is available throught the Fishery Market News Reports from the National Marine Fisheries Service, local Virginia processors indicate very little relation between the prices paid to watermen and those prevailing at the Fulton Market. Ex-vessel pricing in Virginia tends to be seasonal, changing about two to three times a year, not being tied to the Fulton Market price. Therefore overall downward trends and significant fluctuations in Virginia clam landings may be one of the factors limiting income generated by the Virginia hard clam industry. Management strategies aimed at higher production and based on ex-vessel price flexibilities should bring higher total revenues to industry as increases in quantities landed should offset any resulting decreases in price per unit.

Further research should focus on the effects of demand parameters on prices received in Virginia which could help to synthesize a predictive price equation for Virginia hard clams.

OVERALL CONCLUSIONS

The hard clam fishery of Virginia has existed in a state of flux, alternating between periods of prosperity and scarcity. Fluctuations in landings are thought to be primarily produced by changes in fishing effort rather than stock availability. Those who participate in the fishery full-time appear to generate quite substantial revenues, in the range of 25,000 to 40,000 dollars a year, although rising costs of operation, especially fuel, have eroded profits in recent years. Hard clam harvesting in Virginia is still labor intensive and changes to improve the efficiency of harvest will be advocated in the future. The use of efficient, economical harvesting methods on leased ground could be legislated to allow leaseholders more control on the seasonality and level of harvest. A management regime would have to be instituted should these methods be introduced by legislative action.

Economically, the fishery in Virginia has not reached the equilibrium point in the market where increases in domestic production will effect the ex-vessel price nationally or regionally. Current demand far outpaces available supply and until Virginia can meet this high demand with a domestic supply, ex-vessel prices will remain high and stable for the smaller (nick and cherrystone) clams. At present the only way of increasing supply from Virginia waters is by increasing fishing effort. The introduction of efficient harvesting technologies may allow Virginia to once again exert a more pronounced influence on the national and regional price.

The present mode of commercial statistics collection does not provide adequate information to permit accurate determination of stock size or catch per unit effort. A new system must be initiated to allow acquisition of catch and effort data so that management practices can be implemented should stock size or catch per unit effort decrease substantially. This system should include: (1) A report of the landings in graded clam sizes, (2) Triennial abundance surveys to monitor abundance in areas where commercial catch and effort data cannot be acquired, (3) Legislative action to compel dealers to record daily each individual transaction, thus providing a rough measure of catch per unit effort, and (4) Research pertaining to the hard clam focused on determining vital population parameters of naturally occurring stocks, including rates of natural mortality and recruitment which are presently unreported in the literature. Research conducted toward this goal would not only supplement the existing knowledge of hard clam biology but would assist in the development of a management strategy for the fishery.

One measure that could be taken immediately to aid the fishery would be to institute a minimum culling law, setting the minimum legal size for harvesting clams. No such law exists at this time. Dealers are often faced with large quantities of very small littleneck clams (called "buttons" by dealers) which are difficult to market. Several states on the eastern seaboard have minimum culling laws which, if stirctly enforced, would assure a good supply of spawners to provide recruitment of new stocks (McHugh, 1981). This suggestion was voiced by several of the dealers contacted during this study.

Development of mariculture operations of hard clams have nearly perfected spawning and rearing of larvae (Castagna et al., 1970; Castagna and Kraeuter, 1977, 1981; Kraeuter and Castagna, 1977, 1980). Grow-out experiments to raise the juveniles to market size have also proven successful. The private sector has shown some initiative in setting up such operations, but on the whole there is apprehension about entering into such a venture. Future efforts by VIMS may result in the availability of seed clams to private individuals which can be field cultured to adults. However, present statutory provisions inhibit the use of subaqueous bottom for grow-out of seed clams. Once reaching market size, field-cultured clams are presently harvested manually. Enactment of statutes reducing impediments to culture of hard clams and allowing more efficient and economical means of harvesting would expedite the contribution of mariculture to market availability. These efficient harvesting methods could also be applied to private ground.

Prioritizing, the following measures are suggested:

1. Legislative action to allow the use of efficient harvesting methods on leased ground. This would eliminate one of the present drawbacks to large scale mariculture efforts.

2. Consider seasonal use of efficient harvesting technologies to take advantage of seasonal peaks in ex-vessel prices. This could start to maximize economic benefits to all sectors of the fishery.

3. Initiate a new statistical reporting system that reports at least catch per boat per day, breaking down the catch into the three grades of clams.

4. Legislative action to establish areas specifically for the culture of hard clams. This would allow these areas to not conflict with other uses of coastal areas.

5. Institute a minimum legal cull size to regulate the harvest of small clams. This is the current practice in several states.

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