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A Limited Information Approach For Determining Capital Stock And Investment In A Fishery

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ABSTRACT

There have been few empirical studies on the level of capitalization and investment in fisheries because the necessary data are often inadequate. Specifically, data on capital stock and investment in a fishery are not routinely collected and compiled or are limited in scope. In this study, a method is provided for estimating the aggregate capital stock and investment in a fishery utilizing the available information. Data on acquisition and list prices and vessel characteristics for a sample of New England vessels are obtained. The data are then used to estimate an hedonic cost function which specifies the acquisition price as a function of vessel characteristics. The resultant equations are subsequently used, with information on vessel characteristics for all New England vessels, to estimate aggregate capital stock and investment. The results indicate that substantial investment occurred in the otter trawl and scallop dredge fisheries, particularly since the Magnuson Fisheries Conservation and Management Act. Moreover, the results demonstrate that the number and change in the number of vessels are inadequate indicators of the level of capital stock and investment in a fleet comprised of vessels with heterogeneous characteristics.

The common property nature of fisheries is recognized as causing excess capitalization and harvesting capacity (Gordon 1954). The theoretical argument is that since fishermen do not have to pay for the utilization of common property fish stocks, new vessels enter a fishery until net revenue is driven to zero. This common-property feature results in more capital and investment than is economically optimum. Public regulation of fishing industries is usually advocated to redress the excess entry, economic inefficiency, and loss of economic rents in a common property fishery (Scott 1979; Sissenwine and Kirkley 1982).

In essence, overcapitalization and excess investment are perceived to be the reasons for many of the major fisheries problems (Hilborn 1983). Economists argue that management of overcapitalization is necessary to realize the benefits of fisheries (Cunningham et al. 1985). Alternatively, gains from fisheries management require control of overcapitalization and excess investment (Charles 1983a, b).

Clark et al. (1979) and Charles (1983a, b) extended the static theory of optimal fisheries investment as developed by Gordon (1954). They also demonstrated the relationships between investment, capital stock, overexploitation, and fisheries management. They concluded that investment should be more conservative to prevent overexploitation.

The economic literature provides substantial justification for the need to solve the problems of overcapitalization and excess investment. Yet, few empirical studies document the level of capitalization and investment.[4] Moreover, there appears to be no attempt by any U.S. agency to routinely collect and compile statistics on either the stock of capital or the level of investment in U.S. fisheries. Overcapitalization and excess investment, though, continue to be suggested as the reasons for many of the economic problems of fisheries.

Since data are often inadequate, many empirical studies on fisheries consider capital stock and investment in terms of the number of vessels. That is, capital stock and investment in a fishery are tyically measured in terms of number of vessels. In the absence of appropriate information, the number of vessels may be the only basis for examining overcapitalization and excess investment. Alternatively, if a fleet has identical-sized vessels, fixed inputs or vessel characteristics, and

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[4]Tettey et al. (1986) provided an exception, but their analysis is restricted to the shrimp fishery and is based on cost data obtained from boat builders.

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gear, the number of vessels may be used to indicate the stock of capital and investment. However, Kendrick (1961) demonstrated that the total number of operating units, such as the number of plants, is an inadequate measure of capital stock. Also, few fleets have identical-sized vessels, characteristics, or gear. As a consequence, the number of vessels does not provide adequate information to indicate the level of capitalization and investment.

This study presents an approach for estimating the aggregate or industry level of capital stock and investment in a fishery comprised of heterogeneous vessels using available information. Data available include acquisition and list prices for some but not all vessels and boat characteristics for all vessels in a fleet. The approach was developed and used to obtain estimates of capital stock in support of the United States and Canadian maritime boundary dispute. It is viewed as an initial step towards examining the problems of excess capitalization by providing estimates of aggregate capital stock and investment.

THE DEFINITION AND MEASUREMENT OF CAPITAL AND INVESTMENT

Capital

The concept of capital has created problems for economists for quite some time. The term has been used in so many different contexts that it is a source of enormous confusion (Hirshleifer 1970). Sloan and Zurcher (1968), in their "Dictionary of Economics", define capital as "One of the major factors of production consisting of property from which an income is derived, expressed in terms of money. Popularly, the term is frequently used interchangeably with capital good. A distinction is sometimes made between money capital, or that part of the capital held in the form of money and bank deposits, and property capital, or that part of the capital held in the form of evidences of ownership such as stocks, bonds, and mortages."

Hirshleifer (1970) presented three meanings of capital: 1) real capital or capital stock, 2) capital value, and 3) liquid capital. Real capital is defined as a collection of capital goods or an aggregate of heterogeneous capital inputs. It is one of the major productive commodities or economic factors of production. Capital value is the net discounted value of expected future income streams associated with a capital good. Liquid capital is the level of current funds available or intended for investment.

In the case of fisheries, real capital or capital stock is the form of capital which should be examined with respect to the problems of overcapitalization and excess harvesting capacity. It is the relevant measure of capital goods used or available for production (National Academy of Sciences 1979). Moreover, capital stock is the concept of capital used to define and measure the services of capital inputs which are required to harvest fish; that is, it is the concept of capital required to define the economic production technology of a fishery. Thus, this study is concerned with the concept of real capital stock.[5]

The measurement of capital stock in a fishery, however, presents several problems. First, capital inputs are usually quite heterogeneous and cannot be easily aggregated without restrictive assumptions about the form of the catch equation or fishermen's behavior. Conceptually, it should be possible to combine all the different types of capital goods by weighting each type by its average compensation (i.e., the rental price). However, information at this level of detail is typically not available. Second, fisheries agencies, particularly in the United States, generally do not collect and compile information necessary to calculate capital stock and investment. Third, in order to compare changes in capital stock over time, the measure of capital stock must be converted to some base period value by deflation.

In empirical economic studies of traditional industries, the common practice is to measure the capital input or stock by converting the purchase or acquisition price or the book values of capital to base period values by the use of a price index (National Academy of Sciences 1979). Varian (1984) noted: "The usual procedure is to measure capital value and then deflate by a price index; in some sense, this should measure the level of capital stock." In this study, the acquisition price is used as the measure of the stock of capital or capital value; the real stock of capital is obtained by dividing the capital value by the producer price index for heavy machinery.

Investment

The definition and measurement of investment is more straightforward than is the definition and

[5]The market value of capital, acquisition price, and cost of capital are used interchangeably in this study.

measurement of capital. In simple terms, investment is the exchange of money for some form of property. Although there are several types of investment (Branson 1972), attention is restricted in this study to an examination of net investment (i_n) which is defined as the difference between the stock of capital in two periods of time (Baumol 1977). This is the same concept of investment examined by Tettey et al. (1986).

Replacement investment is another type of investment. The sum of replacement investment and net investment equals total investment. Replacement investment is measured by multiplying the rate of depreciation times the level of the capital stock. Replacement investment, however, is not estimated in this study since the method and rate of depreciation must be arbitrarily assumed.

METHOD OF ANALYSIS

The Hedonic Approach

While the definition and measurement of real capital stock and investment are conceptually straightforward, limited data and heterogeneous capital inputs complicate the measurement of capital stock and investment. In particular, data are usually only available for a small number of vessels which are often similar in their characteristics; these data are inadequate for calculating actual or observed capital stock and investment in a fishery. However, data are available on the acquisition price and characteristics of vessels which permits estimation of the stock of capital by an hedonic approach. In turn, estimates of capital stock from the hedonic approach can be used to estimate net investment in a fishery.

The hedonic approach hypothesizes that the price of a commodity is influenced by its characteristics (Rosen 1974). The hedonic price or characteristics function in market equilibrium reflects both the distribution of marginal rates of substitution over households and the distribution of marginal rates of transformation over firms. In effect, the hedonic hypothesis states that goods may be valued for their attributes and that implicit or hedonic prices exist as a function of the attributes.

Griliches (1971) estimated hedonic cost functions of U.S. automobiles using advertised or list prices and actual transaction prices. Griliches, however, was concerned with explaining quality differentials. Ladd and Martin (1976) examined prices and demands for input characteristics using a Neoclassical input characteristics model. Triplett (1986) estimated quality adjusted price indexes for computers. Thus, there is a history of deriving prices of commodities as a function of their characteristics.

The hedonic approach offers several attractive properties for estimating capital stock in fishing industries. First, the hedonic method incorporates changes in the quality of capital over time (Triplett 1986). This is because changes in quality should be reflected in vessel acquisition prices. The hedonic approach, thus, permits a quality adjusted measure of capital stock to be obtained. In contrast, vessel count ignores changes in the quality of capital. Second, the hedonic approach allows easy aggregation of the heterogeneous capital inputs frequently observed in a fishing fleet because the heterogeneous capital is measured by value rather than physical measures.

In the hedonic approach, cost (C) or input price may be expressed as a function of the associated characteristics of the commodity or input,

$$C = f(CH_1, CH_2, \ldots, CH_n) \ , \qquad (1)$$

where C is cost, CH_i is the ith characteristic (Braeutigam et al. 1982). The characteristic cost equation can be obtained either from a dual specification or by determining the reduced form equilibrium equation.

The Dual and Reduced Form

The dual specifies cost as a function of input prices and their characteristics. The partial derivative of the dual cost function with respect to input prices yields the demand for the inputs as a function of prices and input characteristics. The reduced form is obtained by solving structural equations, equations which explain the behavior and interrelations of endogeneous variables, of demand and supply for the endogeneous variable, price, in terms of exogeneous variables and disturbance terms.[6]

In this study, the reduced form is directly specified and estimated for two reasons: First, all of the input price data necessary for estimating a dual are not available. Second, estimation of the structural equations is complicated by the need to use a limited dependent variable method of estima-

[6]See Rosen (1974) for additional information on obtaining reduced form equations for hedonic prices.

tion since demand is a discrete choice, and there are individuals or firms which do not purchase a vessel.

Rather than attempt to deal with these difficulties which do not appear to have widely accepted solutions, it is assumed that there are underlying structural equations of demand and supply which permit the derivation of the reduced form equation. Moreover, the direct specification and estimation of the reduced form is the more commonly used approach to estimate the value of a commodity as a function of its characteristics (Bockstael et al. 1986). Last, the use of the reduced form should not create a problem since the hedonic function is a joint envelope in characteristic space of demander's bid schedules and sellers offer schedules, and thus, the observed implicit price locus is a reduced form equilibrium vector reflecting both supply and demand influences. As a result, shifts in both market demand and supply are incorporated into the reduced form equilibrium vector.

The Capital Stock Model

As previously indicated, it is common practice to use the acquisition price as a measure of capital stock. By the hedonic approach, the capital stock or acquisition price of a fishing vessel is postulated to be a function of several vessel characteristics. The following general specification is considered:

$$C = f(LN, CS, YEAR, FI, AGE, DNO, HPWR, GRT), \quad (2)$$

where C is the list or advertised price or the acquisition price of a vessel, LN is length, CS is hull type (1 = steel, 0 = other), FI is fishery or gear type,[7] AGE is age of vessel, DNO is a dummy variable for new and used vessels (DNO = 1 for new and 0 for used), HPWR is engine horsepower, and GRT is gross registered tonnage. The variable year equals the year of the observation. It is included to incorporate technological changes over time, such as the introduction of electronics and stern trawling, and structural changes in the industry such as changes in organization of capital and fish markets and changes in public regulation.

Functional Form

Several functional forms could be specified for Equation (2). Alternatively, generalized Box-Cox (Box and Cox 1962) transformations could be used to determine the functional form. However, the selection of functional form is mostly concerned with obtaining the relationship between the dependent variable and individual independent variables.This study is primarily concerned with estimating the capital stock. Moreover, it may be quite difficult to estimate capital stock from Box-Cox transformations or other functional forms since the conditional expectation is often of a complex form (Smallwood and Blaylock 1986). Also, Dadkhah (1984) noted that predictions based upon some transformations and functional forms result in biased predictions and asymmetric confidence intervals.

Since this study is primarily concerned with estimating capital stock and investment rather than estimating the implicit prices for characteristics, a linear functional form is proposed for Equation (2). The capital stock equation is specified as a second-order polynominal in order to provide an approximation to an unknown, underlying hedonic function. This is equivalent to specifying a generalized quadratic flexible functional form and imposing zero valued restrictions on the cross product coefficients or interaction terms (Lau 1978). Flexible functional forms are widely used in economic studies concerned with determining the underlying economic structure because they impose very little structure on the economic equations of concern (Blackorby et al. 1978).

Postulated Relations

The postulated relations between cost and each of the explanatory variables is as follows: 1) the coefficients for the first order terms of vessel tonnage, length, and engine horsepower should be positive since costs should increase as the size characteristics increase; 2) the coefficient for steel-hulled vessels should be positive since steel vessels are generally more expensive than wood or fiberglass vessels; 3) the dummy variable coef-

[7]Gear type is an integer valued variable set equal to the gear codes used by the Northeast Fisheries Center. This may influence the results similarly to the use of nonbinary dummy variables (Kmenta 1971). The use of this variable implies that the cost difference between gear types is equal to a scalar multiple of the lowest integer valued gear code. Thus, statistical rejection of cost differences due to gear type is actually a rejection of differences not being equal to scalar multiples. However, the large number of gear codes prohibits their separate treatment.

ficient for new vessels should be positive since new vessels tend to cost more because they are newer and usually incorporate more recent technological advances; 4) the second-order coefficients for the size characteristics are expected to be negative since cost is believed to increase at a decreasing rate in response to increases in the size of a vessel.

THE DATA

Data used to estimate the capital stock equation were obtained from three sources: First, information on vessel acquisition price and associated characteristics were obtained for 164 new vessels from the Northeast Regional Office of the National Marine Fisheries Service.[8] Second, data on list prices and vessel characteristics for 946 used vessels were obtained from various trade magazines and vessel brokers. Third, detailed vessel and fishery data were obtained from the U.S. Coast Guard master vessel listing and the Northeast Fisheries Center. Data were obtained for the years 1965 through 1981.

The first two sets of data were used to estimate the capital stock equations. The third data set was used to estimate aggregate capital stock and investment in selected New England fisheries using the estimated capital stock equations; that is, vessel characteristics for all of the vessels in the New England fleet were inserted into the estimated capital stock equations to obtain estimates of capital stocks per vessel in a given year. The estimated capital stock per vessel was summed over all vessels in a year to obtain total or aggregate capital stock. Net investment was then calculated as the annual change in total capital stock.

The use of both the list and acquisition prices, however, presents a problem. The list price reflects the supply price or the price at which a vessel is offered for sale. The acquisition price reflects the price determined by the equilibrium between demand and supply. As a consequence, estimates of capital stock and investment may be in error.

It is not known by how much the acquisition price differs from the list price for used vessels. Thus, the magnitude of the error cannot be calculated. Since the list price is not less than the acquisition price, estimates of capital stock based on Equation (2) are likely upwards biased. Counter to this problem is the argument that by the time a vessel is ready for fishing, required capital modifications or improvements may result in the capital stock being close in value to the list price.

There are no completely satisfactory economic justifications for using both the list and acquisition prices. Two possible justifications are that Griliches (1971) and others used both prices, and capital improvements or modifications may be nearly equal to the difference between the list and acquisition prices. Another possible justification is the accepted use of cost data obtained from boat builders as in Griffin et al. (1978) which may impose similar problems plus the statistical problem of measurement error. In the remainder of this paper, the term "acquisition price" is used although the estimation and calculation of capital stock and investment are based on both price series.

EMPIRICAL RESULTS

Equation (2) was estimated by ordinary-least-squares with the dependent variable, the acquisition price, measured in both nominal and real terms; the real price is the nominal price deflated by the producer price index for heavy machinery. As previously stated, deflation is necessary to estimate the real capital stock. The estimated coefficients and statistical results are presented in Tables 1 and 2.

Equation (2), however, was also estimated using data for several groups of years between 1965 and 1981. The reason for considering different time periods was that prior knowledge of New England fisheries suggested that various changes occurred in the fisheries during the selected time periods.[9] Moreover, economic studies of New England fisheries have often been criticized for assuming stable relationships over time or over different cross sectional units. Failure to incorporate changes in the estimated relationship between cost and vessel characteristics over time may result in biased parameter estimates.

Changes which have possible ramifications for the estimated relationships include 1) depressed resource conditions and the presence of foreign fishing between 1965 and 1971; 2) management by the International Commission for Northwest

[8]Data are confidential and may not be available to other researchers or the general public.

[9]Additional information on possible structural changes in New England fisheries is available in Kirkley et al. (1982), Dewar (1983), Doeringer et al. (1986), and Kirkley (1986).

TABLE 1.—Parameter estimates of hedonic equation for nominal capital stock.

Years	N	Variables[1]												
		Constant	GRT	GRT²	HPWR	HPWR²	LN	LN²	YEAR	DNO	FI	CS	AGE	R^2
1965–71	133	13474.9	616.45	−5.25	−201.68	0.51	−208.99	11.46	−20.0	15692.2	−294.2	2315	−660	0.93
		[2](0.30)	(3.36)	(5.12)	(5.58)	(8.54)	(0.48)	(2.89)	(0.03)	(1.89)	(1.38)	(0.84)	(3.35)	
1972–75	216	−489183.0	−316.47	8.64	52.61	−0.13	6330.40	−59.33	4722.7	20176.7	−290.1	12117	−524	0.91
		(4.72)	(2.23)	(10.49)	(1.03)	(1.74)	(6.10)	(5.21)	(3.40)	(2.00)	(1.10)	(4.95)	(2.56)	
1976–77	164	−1755240.0	1,335.24	0.72	−60.09	0.16	6170.21	−56.79	20668.5	24038.5	968.7	12813	−749	0.85
		(3.58)	(4.30)	(0.61)	(0.65)	(1.65)	(4.24)	(4.04)	(3.17)	(1.82)	(1.96)	(3.07)	(1.83)	
1978–79	189	−3113870.0	673.62	−7.87	−116.75	0.44	1449.86	44.53	38888.1	2232.4	−259.4	13897	−6693	0.84
		(2.88)	(0.72)	(1.90)	(0.60)	(2.06)	(0.50)	(2.02)	(2.81)	(0.91)	(0.19)	(1.82)	(8.15)	
1980	271	−188637.0	261.24	0.99	224.79	−0.05	6059.50	−10.82	—	22818.2	1110.8	3969	−5867	0.89
		(2.22)	(1.52)	(0.56)	(1.65)	(1.33)	(2.09)	(1.49)		(1.93)	(1.87)	(1.44)	(9.25)	
1981	137	−50105.0	−4095.43	14.94	198.19	0.21	8208.01	−2.72	—	10463.9	75.6	34225	−9323	0.78
		(1.25)	(2.28)	(2.09)	(1.60)	(1.65)	(2.06)	(0.05)		(1.87)	(1.39)	(1.74)	(7.20)	
1965–81	1110	−528304.0	713.86	−0.22	−162.83	0.58	4054.12	−30.61	5967.9	45970.8	990.8	55730	−2217	0.82
		(7.04)	(2.05)	(2.15)	(1.57)	(5.25)	(2.47)	(2.28)	(6.20)	(3.59)	(1.42)	(4.60)	(4.08)	

[1]Variables are defined as follows: 1) GRT and GRT² are gross registered tonnage and its value squared; 2) HPWR and HPWR² are engine horsepower and its value squared; 3) LN and LN² are vessel length and its value squared; 4) YEAR is the year of observation; 5) DNO is a dummy variable for new and used vessels (1 = new, 0 = otherwise); 6) FI is a nonbinary dummy variable for gear type; 7) CS is a dummy variable for hull construction (1 = steel, 0 = otherwise); and 8) AGE is the age of the vessel.

[2]Numbers in parentheses are t-statistics.

TABLE 2.—Parameter estimates of hedonic equation for real capital stock, 1967 = 100.

Years	N	Variables[1]												
		Constant	GRT	GRT²	HPWR	HPWR²	LN	LN²	YEAR	DNO	FI	CS	AGE	R^2
1965–71	133	48304.1	724.35	−6.84	−219.74	0.54	−388.90	13.86	−500.2	18111.3	−273.8	2610	−653	0.89
		[2](1.01)	(3.74)	(6.33)	(5.76)	(8.72)	(0.85)	(3.28)	(0.73)	(1.97)	(1.21)	(0.90)	(3.15)	
1972–75	216	−81500.3	−185.96	5.18	32.62	−0.07	4009.60	−36.21	−117.8	13187.6	−213.9	8451	−411	0.90
		(1.17)	(1.96)	(9.37)	(1.05)	(1.61)	(5.75)	(4.73)	(0.13)	(1.94)	(1.21)	(5.15)	(3.00)	
1976–77	164	−782782.0	738.59	0.47	−31.06	0.08	3518.20	−32.20	8924.9	12827.3	559.8	11198	−422	0.83
		(2.88)	(4.28)	(0.71)	(0.60)	(1.18)	(4.35)	(4.13)	(2.46)	(1.98)	(2.04)	(3.11)	(1.95)	
1978–79	189	−1024330.0	331.40	−3.76	−59.41	0.21	897.93	19.14	12618.4	1074.3	−144.4	6882	−3147	0.81
		(2.02)	(0.75)	(1.94)	(0.65)	(2.16)	(0.66)	(1.85)	(1.95)	(0.09)	(0.23)	(2.60)	(8.16)	
1980	271	−78677.5	108.96	0.42	93.75	0.02	2527.30	−4.51	—	9517.2	463.3	1655	−2447	0.89
		(2.22)	(1.52)	(0.57)	(1.45)	(1.33)	(2.09)	(1.49)		(1.94)	(1.87)	(1.44)	(9.25)	
1981	137	−18958.9	−1549.55	5.65	74.99	0.08	3105.60	−1.03	—	3959.1	28.6	12949	−3527	0.78
		(1.25)	(2.28)	(2.09)	(1.60)	(1.65)	(2.06)	(0.05)		(1.87)	(1.39)	(1.74)	(7.20)	

[1]Variables are defined as follows: 1) GRT and GRT² are gross registered tonnage and its value squared; 2) HPWR and HPWR² are engine horsepower and its value squared; 3) LN and LN² are vessel length and its value squared; 4) YEAR is the year of observation; 5) DNO is a dummy variable for new and used vessels (1 = new, 0 = otherwise); 6) FI is a nonbinary dummy variable for gear type; 7) CS is a dummy variable for hull construction (1 = steel, 0 = otherwise); and 8) AGE is the age of the vessel.

[2]Numbers in parentheses are t-statistics.

Atlantic Fisheries and increased fuel prices between 1972 and 1975; 3) the formulation and implementation of the Fisheries Conservation and Management Act in 1976 and 1977; 4) extremely restrictive regulations in 1978 and 1979; and 5) a long dock strike in New Bedford, frozen harbors, and foreign purchases from American fishermen in 1981. In addition, there was substantial entry of new steel-hulled vessels between 1975 and 1977 and 1979 and 1980.

Chow (1960) tests of the equality of regression equations were conducted to further examine the possibility that the statistical relationships between cost and vessel characteristics changed over time. The Chow test is an F-test of the stability of the coefficients (Maddala 1977). The results of these tests are presented in Table 3.

The results of the tests indicate that the estimated relationships between cost and characteristics were not the same for the selected time periods. Alternatively, the hypothesis of the equality of the regression equations for different periods of time could not be accepted at any reasonable level of significance. However, these results only verify that different models should be estimated for different periods of time. They are not conclusive proof of the selection of the years for a particular group of years. A more accurate determination of the years to be included in each group requires considerably more estimation and hypothesis testing which is beyond the intent of this study.

As indicated by the t-statistics in Tables 1 and 2, the age of the vessel, whether or not the vessel is new or used, and the size characteristics appear to be the more statistically significant explanatory variables. These results are consistent with the results of Griffin et al. (1978). The statistically significant negative coefficients for the size characteristics during the years 1972–75 are particularly interesting. These years coincide with the Arab oil embargo when fuel prices increased; expected increases in future operational costs may have deterred new entry. The results also indicate that the value of a vessel declines as it becomes older. The coefficient for hull construction, CS, suggest that steel-hulled vessels are more expensive than are those of other materials such as fiberglass, ferro cement, wood, and aluminum. There does not appear to be a difference in the value of a vessel based on gear type. This may be a result of specification problems with the dummy variable for gear type (see footnote 7).

It is of further interest to examine the elasticities of cost with respect to the vessel characteristics.[10] These are presented in Table 4. As indicated, vessel tonnage, length, and age have the greatest influence on the acquisition price. The elasticity for length is consistent with the manner in which vessels are sold; that is, vessel prices are largely stated in terms of their length.

There are, however, inconsistences in the estimated capital stock equations and elasticities. In

TABLE 3.—Results of tests for the equality of regression equations.

Periods tested	F-statistic[2]	Critical values[1] 0.05	0.01
1965–71 1972–75 1976–77 1978–79 1980–81	39.38	$F_{12,1050} = 1.75$	$F_{12,1050} = 2.18$
1965–71 1972–75	8.45	$F_{12,325} = 1.75$	$F_{12,325} = 2.18$
1965–75 1976–81	20.55	$F_{12,1086} = 1.75$	$F_{12,1086} = 2.18$
1965–75 1976–79	21.33	$F_{12,668} = 1.75$	$F_{12,668} = 2.18$
1976–77 1978–79	3.60	$F_{12,329} = 1.75$	$F_{12,329} = 2.18$
1976–77 1978–81	3.22	$F_{12,737} = 1.75$	$F_{12,737} = 2.18$
1976–79 1980–81	3.35	$F_{12,737} = 1.75$	$F_{12,737} = 2.18$
1980 [3]1981	2.76	$F_{12,384} = 1.75$	$F_{12,384} = 2.18$

[1]F-statistic for denominator degrees of freedom equal to infinity.

[2]Restricted residual sum of squares obtained by pooling data over all time periods and estimating Equation (2). Unrestricted residual sum of squares obtained by estimating Equation (2) for each period being examined and then adding the residual sum of squares for each equation.

[3]Residual sum of squares obtained from estimating Equation (2) without the time variable.

[10] Elasticities indicate the percentage change in cost resulting from a 1% change in the value of a characteristic.

TABLE 4.—Estimated elasticities of cost with respect to vessel characteristics.[1]

Year	Elasticities GRT[2]	HPWR	LN	AGE
1965–71	0.43	0.06	2.88	−0.32
1972–75	0.78	−0.04	−0.08	−0.08
1976–77	1.14	0.09	0.11	−0.11
1978–79	−0.14	0.30	2.38	−0.40
1980	0.16	0.30	1.43	−0.30
1981	−0.64	0.56	2.38	−0.41

[1]Elasticities based on nominal estimates and observed mean values of cost and vessel characteristics.

[2]GRT is gross registered tonnage; HPWR is engine horsepower; LN is length; AGE is age of vessel.

particular, not all of the estimated coefficiencts have the desired or expected sign. For example, the coefficient for tonnage in the 1981 estimate is negative and that for the square of tonnage is positive. In contrast, a positive coefficient for tonnage was expected since vessel cost should increase with vessel tonnage, and the coefficient for tonnage squared was expected to be negative because vessel costs are believed to increase at a decreasing rate.

The incorrect signs could be the result of multicollinearity between vessel characteristics. Auxiliary regressions, though, do not indicate severe multicollinearity. The R^2 values are <0.35. If multicollinearity is a problem, its major effect is on the estimated relationships between cost and individual characteristics, the estimated elasticities, and the previously discussed Chow tests.

Multicollinearity is not thought to be a problem for several reasons. First, Chow tests in the presence of multicollinearity usually result in the acceptance of the null hypothesis of the equality of regression equations or that differences in the estimated coefficients are statistically insignificant (Maddala 1977). Second, multicollinearity does not pose a problem for estimating capital stock and investment; the estimated equations still permit estimation of the conditional mean.[11]

[11] For additional information on the problems of multicollinearity with respect to analysis and prediction, see Kmenta (1971).

The equations for the real or deflated value of capital were used to estimate total capital stock and investment for the New England fleet between 1965 and 1981. The real capital stock equations were applied to vessel data available from the Northeast Fisheries Center, and total capital stock was calculated as the sum of the stock over all vessels. Aggregate net investment was calculated as the difference in total capital stock between consecutive years.

Prior to estimating total capital stock and investment, it was necessary to define vessel type by gear to avoid double counting which might occur since vessels frequently switch port and gear. Three categories of gear types were established: 1) otter trawl, 2) scallop dredge, and 3) all others, which include lobster trawl and pots, herring gear, harpoons, etc. Vessels were assigned a gear type based on a plurality of days at sea. Estimates of capital stock and investment are presented in Table 5.

Several limitations should be considered when evaluating the estimates. First, there is the previously discussed problem that estimates of capital stock may be biased or overestimated. Second, estimates are only for New England vessels or those which are believed to be homeported in New England. Third, the capital stock and investment series pertain to New England and not the United States; that is, estimates should not be interpreted as net changes in the capital stock and investment in U.S. fisheries. Fourth, under-

TABLE 5.—Estimates of real capital stock and investment in New England harvesting sector, 1965–81.[1]

Year	Number of vessels	Capital stock			Investment			Index of investment
		Trawl	Dredge	Other	Trawl	Dredge	Other	
		$ Millions						
1965	594	25.96	16.29	1.98				
1966	619	28.84	14.75	2.82	2.88	−1.54	0.84	100
1967	628	39.37	11.42	1.63	10.53	−3.33	−1.19	276
1968	610	28.65	15.43	1.68	−10.72	4.01	0.05	−301
1969	602	29.22	12.92	1.29	0.57	−2.51	−0.39	−107
1970	607	25.61	8.29	1.37	−3.61	−4.63	0.08	−374
1971	620	23.65	12.80	1.47	−1.96	4.51	0.10	122
1972	655	27.01	7.74	4.70	3.36	−5.06	3.23	70
1973	666	28.42	7.12	5.13	1.42	−0.62	0.43	56
1974	695	21.26	4.19	6.40	−7.17	−2.93	1.27	−405
1975	737	29.04	5.15	8.48	7.78	0.96	2.08	496
1976	783	20.73	7.72	8.16	−8.31	2.57	−0.32	−278
1977	836	28.86	14.19	7.86	8.13	6.47	−0.30	656
1978	881	37.45	12.85	8.65	8.59	−1.34	0.79	369
1979	1,107	45.41	27.30	11.25	7.96	14.45	2.60	1147
1980	1,260	52.26	34.30	11.69	6.85	7.00	0.44	656
1981	1,246	43.35	30.15	11.60	−8.91	−4.15	−.09	−603

[1]Real investment and capital are deflated with producer price index for heavy machinery, 1967 = 100.

tonnage vessels or those which are <5 gross registered tons are excluded since data are unavailable; thus, total capital stock and investment in New England fisheries are underestimated.

Despite these limitations, the results provide information on investment and capital stock in New England fisheries which has not been available. As is characteristic of open-access fisheries, investment in New England fisheries appears to have increased over time. This is quite evident subsequent to the passage of the Magnuson Fisheries Conservation and Management Act of 1976. While possibly true, the observation that investment increased when the act was passed should not be construed to imply that the act was responsible for increased investment. Positive expectations regarding fish stocks or economic conditions could also be responsible for increases in capital stock and investment.

The largest increase in investment occurred in 1979 which coincided with the greatest influx of vessels. It also coincided with increased fish stocks in 1978 and 1979 and high vessel profits of the previous year. In 1979, 226 vessels entered the New England fisheries; 92 vessels were newly constructed.

Disinvestment also occurred, but the reasons are unknown.[12] Disinvestment may be associated with vessel sinkings, foreclosures on vessel mortgages, and exit from the region. Alternatively, if vessel prices reflect the expected net discounted present value of earnings from a fishery, the disinvestment or even changes in investment may be due to changes in economic expectations. Disinvestment occurred between 1968 and 1970, 1974, 1976, and in 1981.

Disinvestment between 1968 and 1970 may reflect expectations of declining future earnings. Disinvestment in 1974 may reflect the effects of high fuel prices. Disinvestment in 1976 and 1981 may be associated with fishermen's expectations of declining fish stocks, the effects of management, and high fuel prices.

The reasons for investment are also unknown. Increasing levels of investment between 1977 and 1980 may be due to economic expectations associated with fisheries management, fish stocks, and future earnings.

The real capital stock increased approximately 6% per year between 1965 and 1981. The largest increase occurred in 1978 and 1979 when there was a substantial increase in the number of new steel-hulled vessels and entry of vessels from the mid-Atlantic region. Capital stock declined in 1981 when some of the mid-Atlantic vessels left New England and the stocks of fish, particularly sea scallops, declined (Northeast Fisheries Center 1985).

The results also indicate why a vessel count should not be used to indicate capital stock or investment. The number of vessels increased between 1969 and 1970 and 1975 and 1976, but investment decreased in 1970 and 1976 (Table 6). Alternatively, the number of vessels increased in each year relative to 1965, but the real capital stock between 1969 and 1976 declined with respect to 1965.

TABLE 6.—Indices of capital stock based on constant dollar value and vessel count.

	Capital stock					
	Constant dollar value			Vessel count		
Year	Trawler[1]	Dredge[1]	Total	Trawler[1]	Dredge[1]	Total
1965	100	100	100	100	100	100
1966	111	91	105	102	94	104
1967	152	70	119	109	77	106
1968	110	95	103	104	106	103
1969	113	79	98	104	106	101
1970	99	51	80	108	74	102
1971	91	79	86	108	83	104
1972	104	48	89	108	74	110
1973	109	44	92	105	79	112
1974	82	26	72	107	49	117
1975	112	32	96	105	66	124
1976	80	47	83	109	202	132
1977	111	87	115	107	202	141
1978	144	79	133	116	189	148
1979	175	168	190	137	313	186
1980	201	211	222	158	440	212
1981	167	185	192	158	413	210

[1]Gear type assigned by plurality of days absent.

The inadequacy of using vessel count is more pronounced when comparing the indices based on gear type. As shown in Table 6, the number of trawl vessels in every year exceeded the number of vessels in 1965 while capital stock was less than that of 1965 for four years. The two scallop dredge indices also indicate dissimilar changes between vessel count and real capital stock. It may, though, be possible than an index based on vessel count and weighted by vessel size would more closely compare to the real capital stock index. The construction of these indices would require considerable additional analysis and determination of the weights necessary for aggregation.

[12]Hirshleifer (1970) provided additional information about disinvestment.

SUMMARY AND CONCLUSIONS

This study developed procedures for estimating the capital stock and net investment using only the information generally available. That is, data on acquisition and list prices for some but not all vessels and characteristics for most vessels in a fleet were used to estimate capital stock and investment in a fishery. An hedonic approach which specified the acquisition price as a function of vessel characteristics was suggested as a possible method for obtaining information necessary for estimating capital stock and net investment. It was argued that the approach was consistent with procedures used by economists to estimate the capital stock and investment in traditional industries.

Estimates were based on 1,110 observations obtained from NMFS and classified advertisements for the period 1965–81. Vessel characteristics pertaining to size and age were shown to be the more significant characteristics for explaining the value of a vessel. The corresponding information was then used to estimate the capital stock and investment in the New England fisheries.

An interesting result was that although investment increased over time, there also was disinvestment in the fisheries. It was suggested that this was possibly the result of vessel sinkings, exit of vessels from the region, foreclosures, and expectations of declining future net returns.

It also was demonstrated that a vessel count should not be used to indicate capital stock or investment. The number of vessels generally increased over time, but the level of capital stock did not coincide with these changes. This suggests that more attention should be given to developing economic measures of capital stock and investment.

A question still in need of attention, however, cannot be answered from this study. That is, given the level of investment, can an optimal utilization and allocation of resources be determined. The answer is clearly no. This requires management authorities to specify the objectives of fisheries management and a detailed bioeconomic model.

There is a need for more research on investment, and in particular, the determination of the optimum rate of investment. This includes research on the social discount rate, reasons for investment, and the marginal productivity of capital. More important, additional research is required to better address the issues of fisheries management, particularly whether or not public expenditures should be allocated to managing fisheries.

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