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The Magnuson Fisheries Conservation and Management Act: An Economic Assessment of the First 10 Years

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The Magnuson Fisheries Conservation and Management Act:

An Economic Assessment of the First 10 Years*

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ABSTRACT

The Magnuson Fisheries Conservation and Management Act (MFCMA) was enacted in 1976 and implemented in 1977. In an analysis of data collected by the National Marine Fisheries Service (NMFS) one observes a significant increase in the landings of fish and shellfish and in nominal and real exvessel revenue. The present value of net variable revenues for the 1968-1976 period was estimated at $1.1 billion as compared to $3.8 billion for the 1977-1985 period. The increase in net revenues, however, appears to be declining due to the increase in the number of vessels in the U.S. domestic fleet. The time path for net revenues suggests that the industry is headed toward a new (purely domestic) open access equilibrium where revenue equals cost and the imputed value of the resource is driven to zero (rent dissipation). It is well known that open access results in welfare losses to both consumers and the fishing industry. If these welfare losses are to be avoided, the eight regional management councils and the Department of Commerce must adopt policies which will reduce yield in the short run (thereby allowing stocks to increase) and efficiently harvest optimum yield in the long run. Transferable quotas for single species fisheries and transferable effort quotas (rights) in multispecies fisheries are attractive because they encourage efficient (least cost) harvest and afford flexibility in a world where the stocks of individual species are subject to fluctuation.

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> ...introducing extended jurisdiction by itself will not immediately restore fish stocks off our coasts, nor will it necessarily inject new vigor into our fishing industry. The ability to restrict foreign vessels from fishing off our coasts will be only a stopgap measure if proper management of national boats is lacking. Extended jurisdiction authority is an important first step, but it will be meaningless unless proper fishery management is instituted...

The above opinion was offered by Lee Anderson in the editorial introduction to the volume Economic Impacts of Extended Fisheries Jurisdiction (Ann Arbor Science, 1977, p. v.). The objective of this paper is to make an assessment of the economic performance of the U.S. fishing industry in the ten years since the passage of the Magnuson Fisheries Conservation and Management Act (MFCMA). Has the law increased net benefits for the U.S. fishing industry above what they would have been? Have the stocks of fish and shellfish within the fishery conservation zone (FCZ) recovered from the low levels induced by U.S. and foreign overfishing? Do the management policies currently employed under the MFCMA contribute to effective future management or has "Anderson's Prophecy" come to pass?

In the next section we will briefly review the factors which led to the passage of the MFCMA and the management institutions and procedures which were created or evolved under that act. In the second section the static and dynamic theory of open access is reviewed. This theory provides a useful conceptual framework to evaluate what has happened and what is likely to happen under the MFCMA, as currently in force.

In the third section we assemble data to try to determine what has happened to the U.S. fishing industry since enactment of the MFCMA in 1976. The data suggest (1) that the MFCMA resulted in a significant increase in landings and net revenues for the U.S. fishing industry during the seven-year period 1977-1983, (2) that net revenues, however, are declining and that the industry and resources on which it is based appear headed toward a second (but now purely domestic) open access equilibrium and (3) that current management policies are ineffective in limiting catch to a target yield and in controlling the entry of vessels or the level of fishing effort.

In the final section we offer recommendations for new policies to manage single and multispecies fisheries which have the potential to encourage efficient (least cost) harvest and to maintain stocks of fish and shellfish at levels producing positive net benefits to the industry and society at large.

I. The MFCMA: Background, Enactment and Management Policies

During the 1960's and early 1970's it became evident that the U.S. commercial fishing industry had gone into serious decline in terms of historical landings and the age and efficiency of vessels in the industry. Much of the blame for this state of affairs was placed on the distant water fleets of foreign countries. Large, modern trawlers and factory vessels, often subsidized by foreign governments, were accused of unfair competition and overharvesting the fish and shellfish resources that had traditionally supported the smaller nearshore vessels that comprised the U.S. Fleet. International management organizations (such as the International Commission for the Northwest Atlantic Fisheries--ICNAF) were often viewed as ineffective, and a situation of de facto open access was thought to exist. (Under open access there is no regulation of effort or catch and individual vessels are helpless to effect conservation measures which might lead to increased stocks and ultimately larger yields).

The intense competition for fish and shellfish was not limited to the nearshore waters of the U.S. coast. Several South American countries had unilaterally extended their territorial waters 200 miles seaward from their coastlines in an attempt to restrict access to tuna and anchovy resources. Congressmen from coastal states were under increased pressure in the early 1970's to write and enact legislation which would provide exclusive harvest rights to U.S. vessels over a comparable coastal zone. While the United Nations had convened conferences on the law of the sea (UNCLOS) in 1958, 1960 and 1973, progress was painfully slow and the rate of "enclosure" continued to accelerate on a unilateral (country-by-country) basis.

On April 13th, 1976 President Ford signed into law the Fishery Conservation and Management Act (later amended to the Magnuson Fishery Conservation and Management Act in recognition of the important contributions by former U.S. Senator Warren Magnuson in the drafting and enactment process). As amended, the law (PL 94-265) provides for exclusive federal management of all fishery resources (except migratory species of tuna and whales) within a fishery conservation zone (FCZ) extending from three nautical miles outward to 200 nautical miles from shore. (The FCZ has been modified off the coasts of Texas, Puerto Rico, the gulf side of Florida and in the Gulf of Maine where the boundary line between Canada and the U.S. was recently arbitrated by the World Court).

Eight regional Fishery Management Councils were created and charged with the task of preparing management plans for the species of commercial or recreational importance in their region. After a council develops a fishery management plan (FMP), covering both domestic and possibly foreign fishing, it is submitted to the Secretary of Commerce for approval and implementation. The Secretary of Commerce may develop a preliminary fishery management plan (PMP) which covers only foreign fishing in the FCZ, or, if a council fails to produce a FMP in a timely fashion, the secretary is empowered to produce a FMP covering both domestic and foreign fishing.

Foreign fishing in the U.S. FCZ is permitted if the U.S. domestic fleet is unable or uninterested in harvesting the optimum yield (OY) for a particular species. In cooperation with U.S. Department of State, the Department of Commerce can negotiate with an interested foreign country a Governing International Fishery Agreement (GIFA) for that portion of OY that will not be harvested by U.S. vessels. After approval by the president it is sent to Congress for review. If no objections are raised by congressional members of the affected coastal states, the foreign country may then apply for a permit for each vessel that will be fishing or receiving fish from U.S. vessels in the FCZ (the latter situation would occur under a "joint venture").

Various fees are collected from foreign countries operating in the FCZ. There is an application fee for each foreign vessel fishing or receiving fish in the FCZ. A poundage fee is charged for foreign vessels actually engaged in fishing based on the amount of a surplus species actually caught. A surcharge fee has been charged in the past to capitalize a fund which can be used to compensate a U.S. fisherman who suffers damage to a vessel or gear from foreign vessels operating in the FCZ. Finally, an observer fee is charged to cover the cost of monitoring foreign fishing through U.S. nationals acting as observers onboard foreign vessels.

The regional Management Councils are comprised of members appointed by the Secretary of Commerce and the governors of the coastal states within the region. Appointments are made so that the council has representation from the fishing industry, processors, sportfishing associations and other concerned (and politically influential) groups. Each council has a small staff headed by an executive director. The council can contract for studies of the industry or resources in their region and will also draw on the expertise of a scientific committee in developing a FMP. Two or more councils may work together in developing a plan for a species that migrates or is harvested in more than one region. After development a FMP is subject to public review and comments are taken in writing or at public hearings.

To date, the FMP's have relied on a variety of management policies including annual quotas, quarterly quotas, trip quotas, closed areas, size limits and net mesh size in an effort to restrict catch to an amount less than or equal to optimum yield. Optimum yield is that rate of harvest that "(1) will provide the greatest overall benefit to the United States, with particular reference to food production and recreational opportunities, and (2) is prescribed as such on the basis of maximum sustainable yield from such fishery as modified by any relevant ecological, economic, or social factors". The second clause seems to have guided the deliberations of most councils in determining OY, although the precise influence of the relevant ecological, economic and social factors is difficult to identify, ex-post.

As of January 1st, 1986 there were 25 fisheries being managed under FMP's and 7 being managed under PMP's. Many of earlier FMP's have been amended since initial implementation as a result of unanticipated changes in the resource stock or industry. A detailed assessment of the success or failure of each FMP is beyond the scope of this paper. Instead we will examine what has happened to the industry in terms of aggregate measures such as landings of fish and shellfish, exvessel revenue, number of registered vessels and variable cost. Before examining the data it will be helpful to review the economic theory of open access.

II. Open Access

Prior to passage of the MFCMA it was maintained that the competition between U.S. and foreign flag fishing vessels had reduced offshore stocks of fish and shellfish to levels where the exvessel revenues received by fishermen just covered the costs of fishing. Such a situation is symptomatic of open access--where harvest is essentially unregulated and vessels enter the fishery (or existing vessels increase fishing effort) until net revenue is driven to zero.

The tendency of a common property fishery to evolve toward an open access (zero profit) equilibrium was first discussed by Gordon (1954). Gordon referred to this process as one of "rent dissipation" because the resource was harvested to a level where competitive vessels, only covering the costs of fishing, would be unable to pay for the right of access. If the resource were owned (by a private individual or by a government agency acting on behalf of its citizens), it would charge fishermen some amount for the right to harvest some portion of the resource stock. Under ownership or agency management the resource has value equal to the present value of future expected rents. Under open access, however, the dissipation of rents implies that the resource has been economically overfished to the point where it can earn no rent and is thus worthless.

It can be shown that open access equilibrium is non-optimal. There will be too many vessels chasing too few fish. If harvest could be restricted and stocks increased, it would be possible to compensate (buy out) the vessels who left the fishery and still have money (rent) left over.

The analysis by Gordon was essentially a static or equilibrium analysis. Smith (1968) presented a dynamic model represented as a system of two differential equations. Suppose X represents the biomass of some species at time t, and E the level of fishing effort. The resource is presumed to exhibit net growth without fishing according to the function F(X). The rate of harvest (fishing mortality) is given by the production function H(X,E). Thus, the rate of change in biomass is given by the differential equation

$$\dot{X} = F(X) - H(X,E) \tag{1}$$

The change in effort (perhaps measured by vessels, vessel-days, or net-hours) is presumed to depend on the level of net revenues (profit rate). In particular, if net revenues are positive effort will expand, while if net revenues are negative effort will contract. Suppose the price per pound for a ton of fish at the dock (that is, the exvessel price) is given by p while the cost of effort is given by k. Then, since H(X,E) represents the rate of harvest, pH(X,E) represents exvessel revenue, while kE represents cost. The rate of change in effort might be described by the differential equation

$$\dot{E} = n[pH(X,E) - kE] \tag{2}$$

where $n>0$ is a "stiffness" parameter indicating the response of effort to net revenue. Taken together, equations (1) and (2) comprise a two-dimensional (planer) non-linear dynamical system. If p, k and all other parameters are time-invariant, the system is autonomous and the identification and stability analysis of stationary states might be accomplished by phase plane analysis.

For a general system similar to equations (1) and (2), Smith (1968) noted the possibility of multiple equilibria, some stable and some unstable. Open access extinction was a possibility if it were profitable to expand effort at low stock levels or if vessels did not leave an unprofitable fishery rapidly enough.

Consider the Gordon-Schaefer model (Clark 1976, p. 203 and 1985 p. 16) where

$$\dot{X} = rX(1-X/K) - qXE \tag{3}$$

$$\dot{E} = n(pqXE - kE) \tag{4}$$

The net growth function is thus $F(X) = rX(1-X/K)$ which is the logistic function where r is the intrinsic growth rate and K is the environmental carrying capacity. The production function is $H(X,E) = qXE$ where q is the catchability coefficient. As before, the parameters p, k, and n represent the per unit price for landed fish, the per unit cost of effort and the adjustment parameter.

The isoclines of Gordon-Schaefer model are obtained by setting $\dot{X}=0$ and $\dot{E}=0$, with the latter immediately implying that the stationary (equilibrium) stock under open access is $\bar{X} = k/(pq)$. The isocline associated with $\dot{X}=0$ is given by the line $E=r(1-X/K)/q$ and thus the stationary level of effort under open access is $\bar{E}=r(1-\bar{X}/K)/q$. The isoclines are drawn in the phase-plane diagram in Figure 1.

The equilibrium $(\bar{X},\bar{E})$ is stable (a node or spiral). Limit cycles are precluded by the Bendixon-du Lac test (see Clark 1976, pp. 203-204). Figure 1 shows a spiral convergence to $(\bar{X},\bar{E})$. When $X<\bar{X} = k/(pq)$, net revenues are negative and effort decreases, while when $X>\bar{X} = k/(pq)$ net revenues are positive and effort increases. A possible time path for net revenues is shown in Figure 2. It exhibits a damped oscillation as net revenues are driven to zero as $X \to \bar{X}$, $E \to \bar{E}$, and $t \to \infty$.

In any empirical investigation price, cost and other parameters will be changing. Individual stocks of fish and shellfish often show significant fluctuation presumably due to stochastic environmental conditions. It is unlikely, therefore, that a "real world" fishery would ever exhibit convergence to a stationary point. In a changing, stochastic world open access might be characterized by more or less random fluctuations in net revenue about N=0 (the t-axis in Figure 2), as the resource stock, price or cost is subject to random variation.

Empirically, then, if a fishery has exhibited damped oscillation toward zero net revenues or random fluctuation about zero net revenues, a strong case might be made for de facto open access. Policies which increase expected net revenue (thus fishery rent) would be consistent with a move toward improved fishery management. (Policies which reduce the variance of net revenues would presumably confer benefits to risk averse individuals). What evidence can be assembled on the status of U.S. commercial fisheries both before and after implementation of the MFCMA?

III. The U.S. Commercial Fishing Industry: 1968-1985

An economic assessment of the U.S. fishing industry is made difficult because of the large number of independent vessels employing often vastly different gear to harvest over 100 different species of finfish and shellfish. The NMFS definition of a vessel is any craft five net tons or greater. In 1977 there were 17,545 vessels registered with the U.S. Coast Guard for commercial fishing. The vast majority, 13,235 or 75%, were less than 50 gross registered tons (GRT). The modal and median class (cell) was 10-19 GRT while the average vessel was 43.7 GRT. The largest vessel class was 3,270-3,279 GRT.

These vessels do not fish year round and may change gear and fisheries within a single year. In a 1982 study of 60-100 GRT otter trawlers, Mueller <u>et al.</u> reported an average of 158.6 days absent from port and an average of 98.2 days fishing during the five-year period 1976-1980. Thus, the number of vessels in the industry is a very crude measure of fishing effort. Its only advantage is that NMFS data on vessel numbers exists for the period 1968-1984. We will use the symbol E_t to denote the number of vessels in year t, where t=0 corresponds to 1968 and t=17 corresponds to 1985.

The NMFS also keeps track of total landings of fish, shellfish and exvessel revenue. Given the highly decentralized nature of the U.S. fishing industry and the tax incentive for cash transactions one can safely assume that the reported data for landings and exvessel revenues understate the amount and value of U.S. catch. The extent of the understatement is not known. We will denote the aggregate landings of fish and shellfish (exclusive of mollusk shell weight) by Y_t and exvessel revenue by R_t.

Given estimates of Y_t and R_t one can obtain an average price $p_t=R_t/Y_t$. With Y_t measured in metric tons and R_t in dollars, p_t is interpreted as the price per metric ton ($/m.t.).

An important time series not estimated annually by the NMFS is industry cost. Given the diversity of vessel size, design and gear operation, this is understandable. The NMFS will periodically conduct studies into the costs and returns of various types of vessels operating in the major commercial fisheries. In addition, the aforementioned report by Mueller <u>et al.</u> (1982) describes a financial simulator which has been used to estimate vessel costs based on design and operating characteristics, days absent from port, cost of food, fuel and ice and other variable and fixed cost components.

In 1977 the NMFS reported that the variable cost of operating a 42 GRT trawler in 1974 was \$44,901. Since the trawler is a dominant vessel type, and the "average" vessel in 1974 was 43 GRT, this variable cost figure was used as an initial condition to generate annual vessel cost for other years. Let k_t denote the variable vessel cost in year t. Then the difference equation

$$k_{t+1} = [1 + (CPI_{t+1} - CPI_t)/CPI_t]k_t \qquad (5)$$

where CPI_t denotes the consumer price index (1967=100) was used to generate variable vessel costs for all other years (1968-1973 and 1975 to 1985).

Knowing the number of vessels E_t and the variable cost of the average vessel, k_t, one can estimate variable cost for the industry as $C_t=k_tE_t$. Net revenue, denoted by N_t, can be calculated as $N_t=R_t-C_t$. This is actually net variable revenue, and the vessel owner would need to cover fixed costs and taxes from net variable revenue. Given the wide range of fixed costs and taxes for similar vessels, no attempt was made at estimation. (Economic theory would suggest that the fishing decision in a given year would be based on variable cost considerations, although future investment decisions would require fixed costs to be covered as well.)

Table 1 provides a summary of notation and definition of variables. Table 2 contains data on Y_t, R_t, P_t, E_t, CPI_t, k_t, C_t and N_t for the period 1968-1985. Table 3 contains notes on the sources and methods of calculation for the data in Table 2. Figures 3-7 present graphs of the time paths for Y_t, R_t, E_t, C_t and N_t.

Simple analysis of the data in Table 2 provides the following insights into the performance of the U.S. fishing industry in the nine years before (1968-1976) and after (1977-1985) implementation of the MFCMA.

•Landings of fish and shellfish significantly increased in the post MFCMA period. The mean for landings during the period 1968-1976 was 2.2 million metric tons as compared to 2.8 million metric tons for the period 1977-1985. A simple test for the difference of two means ($H_0:\mu_2-\mu_1=0$, where μ_2 is the unknown mean yield for the ex-post MFCMA period and μ_1 is the unknown mean yield for the ex-ante period) yielded a test statistic of $t^*=7.57$, leading one to reject equal mean landings at the 1% level. The time path for landings is shown in Figure 3. Increased U.S. landings in many fisheries were likely the result of exclusion of foreign vessels. While data is not available for all the major fisheries, on the U.S. east coast foreign landings declined from an annual average of 1226.1×10^6 m.t. for the period 1970-1974 to 107.4×10^6 m.t. in 1982 (NOAA 1983, p. 13). A similar redistribution (from foreign to U.S. flag vessels) undoubtedly occurred in the Pacific Northwest and Alaska.

•Exvessel revenue also increased in the post MFCMA period (see Figure 4). The numbers reported in column three in Table 2 are nominal and thus reflect the increase in landings as well as inflation. Deflation by the consumer price index will, however, reveal that real (deflated) revenues also increased. The average for the 1968-1976 period was $0.80 billion while it was $2.2 billion (nominal) for the 1977-1985 period.

•An indication of expected profitability is reflected in the increase in the number of vessels in the U.S. Fleet. Even during the pre-MFCMA period there was significant entry. This might reflect current profitability (as in equation (2) in the preceding section on open access) or it may reflect an anticipation of future profits under extended jurisdiction. Certainly by 1973 it was suspected that some form of extended jurisdiction would be unilaterally adopted by the U.S. During the nine-year period before implementation, vessel numbers increased by 3,725. In the nine-year period after implementation, the number of vessels increased by approximately 7,455. The time path for the number of vessels is shown in Figure 5.

·Industry cost (estimated as the product of average variable cost per vessel times the number of vessels) is shown in Figure 6. The cost of operating our "average" vessel increased over three-fold from 1968 to 1985 (see Table 2, column seven). This was the result of general inflation and the dramatic increases in the cost of crude oil and distillate products (including diesel) during the Arab oil embargo (1973-1974) and the disruption accompanying the initial stages of the Iran-Iraq War (1980). In the early 1980's interest payments on new vessels approached ten percent of the gross boat share (Mueller, et al. 1982). The increase in industry variable cost in 1984 and 1985 is more influenced by the number of new vessels entering the industry (estimated at 3,900) than by per vessel cost (which only increased eight percent over that two-year period).

·Industry revenues, variable costs and net revenues are shown in Figure 7. There are two interesting aspects about the time path for net revenues. First, net revenues are significantly greater in the post-MFCMA period, particularly during the years 1977-1983. Using a ten percent discount rate the present value of net revenues for the 1968-1976 period was $1.1 billion versus $3.8 for the 1977-1985 period. While other factors may have contributed to the favorable "bottom line" during the latter period, it seems likely that the MFCMA was the major factor.

The second, more disquieting, aspect is the rapid decline in net revenues in 1984 and (estimated for) 1985. Recall zero net revenues or oscillating (positive and negative) net revenues were symptomatic of open access. It would appear that the U.S. fishing industry may be settling down to a second open access equilibrium. Only now the vessels that are economically overfishing the stocks of fish and shellfish are U.S. flag vessels and reducing their collective catch will be politically more difficult. Again, the costs of open access are under-performance costs in the sense that larger yields could be obtained by a smaller fleet fishing a larger stock. This increase in net revenues from a well-managed fishery would more than exceed the difference in opportunity costs of those fishermen and vessels leaving the fishery.

In summary, it would appear that the MFCMA did play an important role in increasing industry net revenues during the 1977-1985 period. However, the long-term effectiveness of the management plans and policies currently in force is suspect. It would appear that a second, purely domestic open access equilibrium is being approached, along with the associated social cost of under-performance. Anderson's prophecy appears to be borne out by the data on vessel numbers and estimates for net revenues.

If the above analysis is an accurate assessment of industry performance under the MFCMA, then it is also an indictment of the management policies embodied in the FMP's and the PMP's. Recall that the objective of the eight regional councils was to encourage harvest of optimum yield (OY). To define optimum yield in a single species fishery, most councils attempted to follow the guidelines in the second clause of the definition; that is, to determine maximum sustainable yield, and then make appropriate modifications based on the relevant "ecological, economic or social factors". While these latter factors introduce elements of imprecision and subjective judgement, they cannot explain the failure of the MFCMA to avoid or reverse the drift toward domestic open access. What went wrong?

There are at least two factors that would contribute to the ineffectiveness of management based on OY. First, the estimates of OY may presume a stock level larger than the current stock and a continuation of harvest rates at OY only fostered a continued decline in the resource stock or, at best, prevented recovery. In other words, yields considerably less than OY might be required to allow stocks to increase before OY could be harvested on a sustainable (yearly) basis.

Second, the dramatic increase in the number of vessels has likely led to an increase in the amount of <u>unreported</u> landings. This is true even if the rate of under-reporting per vessel is unchanged. Reported landings <u>less</u> than OY might be associated with actual landings <u>in excess</u> of OY and ultimately lead to declining stocks.

There are other possible explanations, but if the above two factors were paramount, then steps to improve management under the MFCMA must focus on (1) transitional yields (TY's) which will lead to stock levels capable of supporting optimal yield, and (2) better monitoring and enforcement of catch both in transition (along an approach path) and at optimal yield, once the stock level supporting OY has been reached.

Economists are also interested in policies which promote efficiency; that is, policies which encourage TY's and OY to be harvested at least cost. As it turns out, policies which promote efficiency might also lead to better monitoring of actual catch. We now turn to a discussion of policies to promote and maintain a more efficient industry.

IV. Recommendations for Improving Management Under the MFCMA

Recent theoretical work in bioeconomics is based on a management objective which seeks to maximize the present value of net benefits. Under certain assumptions this objective will be met by finding that stock level which satisfies a "singular solution", and setting transitional yield at zero if current stock is less than the optimum, or harvesting at maximum yield if current stock is greater than the optimum. In other words, it is optimal to approach the optimal stock as rapidly as possible (Clark 1976, pp. 39-41).

The optimal stock within a bioeconomic model will typically depend on price, cost, parameters of the growth and production functions, and the discount rate. The optimal stock may be greater than or less than the stock necessary to sustain maximum sustainable yield (MSY). This will depend on the magnitude of the "marginal stock effect" relative to the discount rate (Clark and Munro 1975). In an empirical study of tuna in the eastern tropical Atlantic, Conrad and Adu-Asamdah (1986) have estimated that the optimal stock exceeds the MSY stock. This is attributable to cost savings afforded by fishing a larger stock.

The operational objective under the MFCMA is to manage coastal fishery resources so they provide an optimal yield (OY) equal to MSY plus or minus some amount to reflect ecological, social or economic considerations. Thus, the objective under the MFCMA is not inconsistent with the optimal stock which might emerge from application of the simple bioeconomic model. The management policies espoused by economists to achieve and maintain fish stocks near the optimal level, however, are different from those usually recommended by biologists and those which have dominated applied management under the MFCMA.

The key to understanding economic policies for fishery management is "user cost" (Conrad 1986, pp. 390-396). User cost reflects an incremental cost imposed in future periods because an additional unit of the resource is harvested today. By reducing the stock an additional unit today, you reduce future stock by that unit and by the biological growth it would have provided.

Bioeconomic policies have attempted to introduce economic incentives which would cause fishermen to behave "as if" they were cognizant of user cost. These incentive-based policies, in a single species fishery, include landings taxes and transferable quotas (Clark 1985 pp. 157-175 and Conrad 1986, pp. 395-397). A landings tax is a tax per unit on the harvested resource (example: $100 per metric ton of yellowtail flounder landed in New Bedford). A transferable quota is a certificate which entitles the owner to harvest a certain amount of the resource per unit time (example: 10 metric tons of yellowtail flounder in 1986). By transferable, economists mean that the owner of the quota may "fish it" or sell it to another fisherman. Within the single-species bioeconomic model it can be shown that landings taxes, transferable quotas, or a mix of both are capable of inducing competitive fishermen to collectively harvest some target amount, either a transitional yield (TY) or optimal yield (OY). In a mixed system the higher the landings tax, the lower the bid-price for a quota in the transferable quota market.

Management by landings taxes or transferable quotas has the advantage of economic efficiency; that is, they encourage harvest by the lower cost fishermen. With a landings tax only fishermen who can cover costs with "after-tax" revenues would be economically viable. With transferable quotas the lower cost fishermen would be able to offer higher bid-prices and thus, in theory, would be able to purchase the quotas required for fishing.

Under the MFCMA, as currently amended, landings taxes are probably precluded (Christy 1976, p. 144). Thus, we will focus on transferable quotas in a single species fishery and transferable effort quotas (rights) in multispecies fisheries (such as the groundfish fishery on Georges Bank where cod, haddock, flounder and other species may be harvested simultaneously by otter trawlers).

Suppose we are concerned with a single species fishery where the stock is below the level associated with optimum yield. Fisheries scientists on the Council's scientific committee must determine a level for transitional yield (TY) which allows for escapement and growth which will increase the stock. There are, of course, many possible levels for TY including a zero yield (i.e. a fishing moratorium) which would allow for the "most rapid" approach to the optimal stock. Suppose a moratorium is viewed as too extreme and some TY is adopted which scientists think will allow for some positive level of growth.

The TY must now be divided up into some number of transferable quotas. For example, if TY=1,000 metric tons of sea scallops, a total of 100 transferable quotas might be created entitling the owner to harvest up to 10 metric tons in 1986. Care must be taken in specifying a quota amount which could be profitably fished by a single vessel during some part of a year.

How are the quotas to be allocated among the potential fishermen? Fisheries economists suggest that they might be sold to the highest bidder at auction or distributed gratis to some set of "deserving" fishermen. Again, the MFCMA as currently amended may preclude sale by auction. It is also likely to be the case that there will be more "would-be" fishermen than quotas. One suggestion is to set up criteria based on a record of historical landings (involvement) in the fishery which would define a set of "legitimate" vessel owners eligible for a lottery. Say there are 200 such eligible vessel owners. After the drawing, 100 of the eligible vessel owners will have received a quota entitling them to harvest up to 10 metric tons of scallops. The 100 eligible vessel owners who do not have a quota would be able to negotiate with quota holders or submit bids to a quota marketing board that would serve as an intermediary between current holders (suppliers) and eligible vessel owners wishing to acquire a quota (demanders).

There are many details which would need to be worked out. Should a limit be placed on the number of quotas which could be owned by a single individual or corporation? Could a quota holder sell a portion of his quota? Should the quotas be annual or for a longer period of time, thereby allowing a longer horizon for planning investments in vessel, gear and electronics? Should the TY's be specified for more than one year in advance, again providing the quota holder with a less risky management environment?

While the answers to the above questions may have significant implications for the price of quotas and the flexibility with which managers have to alter TY's, they should not pose insurmountable problems if the concept of transferable quotas and the lottery-market process is viewed as acceptable. Over time, if initial TY's do allow stocks to recover, then the number of quotas would presumably increase as TY approaches OY.

Transferable quotas may facilitate enforcement and reduce the amount of unreported "overfishing". The U.S. Coast Guard would have a list of those vessels with quotas and any other vessels found on or near the fishing grounds of the species in question would be suspect and subject to search.

Management of multispecies fisheries is a much more complex and difficult problem (May et al. 1979). In multispecies fisheries where a nonselective gear harvests two or more species simultaneously, it is difficult to apply a system of transferable quotas on a species-by-species basis. The New England Regional Council will attest to this difficulty. They tried and abandoned quarterly quotas by species, trip quotas by species, and are currently operating under a minimum mesh size for the New England groundfishery. By studying trip-file data it should be possible to estimate the number of days absent or days fished and the likely total number of metric tons of groundfish (cod, haddock, pollock, flounder and redfish). A transitional yield and associated number of "days-to-be-fished" (DTBF) is specified. The total DTBF is divided into a finite number of "effort quotas". As before, a set of eligible vessels is determined, and a lottery is employed to assign effort quotas specifying the right to fish some number of days. Those vessel owners who did not win in the lottery would be free to negotiate with the holder of an effort quota directly or submit a bid to the administrator of the quota market.

The value of an effort quota (or right) is more speculative than a catch quota in a single species fishery. This is because effort quota entitles the owner to fish some number of days, but there is no guarantee on catch. No quotas would be levied on individual species and the composition of total catch would be likely to change from year to year. If managers had concerns about the abundance of a particular species within a multispecies complex, analysis of particular grounds may indicate areas which, if closed to fishing, would offer some specific protection to the species of concern. As multispecies biomass increases, the number of DTBF could be increased allowing total catch to increase toward the estimate of OY.

Enforcement of a system of transferable effort rights would be more difficult because it would require a monitoring of the number of days that a quota-holding vessel actually had its net in the water. Vessels might be required to submit "trip plans" to a central office indicating headings and expected time steaming to, from, or between grounds and their home port. Coast guard vessels would be informed of trip plans and when encountering vessels would determine location and status (steaming or fishing).

In both the single and multispecies fisheries the presence of "natural fluctuations" in fish stocks will present a conflict between managers who wish to frequently change TY's or DTBF in response to fluctuating stocks and fishermen who want to know their future quotas or DTBF with certainty. Both the regional councils and the fishermen will have to maintain flexibility as managers learn about the recruitment effects of previous TY or DTBF quotas. The trade-off would hopefully be between a more profitable fishery, subject to changing management policies, versus a static, low profit, de facto open access fishery.

V. Conclusions

Let us return to the three questions posed in the introduction to this paper. The first asked whether the MFCMA increased net revenues above what they would have been during the 1977-1985 period. Our conclusion would be "yes", based on our estimates of industry cost and the calculation of a present value for net revenues of $1.1 billion for the 1968-1976 period versus $3.8 billion for the 1977-1985 period.

The second question asked if the stocks of fish and shellfish in the FCZ have increased since passage of the MFCMA. This question cannot be answered definitively ,but it is likely that stocks have not increased appreciably. The U.S. Fleet expanded rapidly and much of the net revenue gains were probably the result of a redistribution of foreign catch to U.S. vessels. The estimated decline in net revenues is symptomatic that, taken as a whole, the U.S. commercial fishing industry is converging to a new, purely domestic, open access equilibrium. Open access results in underperformance costs. There are too many vessels chasing too few fish. The industry and society (the fish-consuming public) would be better off if stocks were allowed to increase and higher yields could be sustained based on larger standing stocks of fish and shellfish.

The third question asked if current management policies adopted under the MFCMA would provide a basis for long-term, positive net benefits. The answer would seem to be "no". While the MFCMA probably precludes landing taxes as a means to "internalize" user cost in the decisions of fishermen, it does not preclude the use of a system of transferable quotas in single species fisheries or effort quotas (rights) in multispecies fisheries subject to nonselective harvest. A transitional yield-lottery program of management is recommended according to the criteria of efficiency (least cost harvest), flexibility in the face of natural fluctuations, and holding the best promise of providing positive net benefits to the industry and fish-consuming public.

TABLE 1: DEFINITION OF VARIABLES IN TABLE 2

t	=	year index t=0 (1968) to t=17 (1985)
Y_t	=	yield of fish and shellfish (10^6 metric tons), exclusive of mollusk shell weight
R_t	=	exvessel revenue (10^9\$) in year t
P_t	=	average price (\$/m.t.) for finfish and shellfish in year t
E_t	=	number of vessels greater than or equal to 5 net tons in year t
CPI_t	=	consumer price index (1967=100) in year t
k_t	=	variable operating cost of a 42 gross registered ton (GRT) trawler (\$/vessel) in year t
C_t	=	total variable cost (10^9\$) for industry in year t
N_t	=	net revenue (10^9\$) for industry in year t

TABLE 2: THE U.S. COMMERCIAL FISHING INDUSTRY 1968-1985

t (Year)	Y_t (10^6m.t.)	R_t (10^9\$)	P_t (\$/m.t.)	E_t (number of vessels)	CPI_t (1967=100)	k_t (\$/vessel)	C_t (10^9\$)	N_t (10^9\$)
1968	1.9	0.5	263	13,150	104.2	31,675	0.4	0.1
1969	1.9	0.5	263	13,187	109.8	33,378	0.4	0.1
1970	2.2	0.6	272	13,591	116.3	35,354	0.5	0.1
1971	2.3	0.7	304	14,008	121.3	36,874	0.5	0.2
1972	2.2	0.7	318	14,507	125.3	38,090	0.6	0.1
1973	2.2	0.9	409	15,367	133.1	40,462	0.6	0.3
1974	2.3	0.9	391	15,891	147.7	44,901	0.7	0.2
1975	2.2	1.0	454	16,211	161.2	49,005	0.8	0.2
1976	2.4	1.3	541	16,875	170.5	51,832	0.9	0.4
1977	2.4	1.5	625	17,545	181.5	55,176	1.0	0.5
1978	2.7	1.9	703	18,100	195.4	59,401	1.1	0.8
1979	2.8	2.2	785	18,400	217.4	66,088	1.2	1.0
1980	2.9	2.2	758	18,900	246.8	75,025	1.4	0.8
1981	2.7	2.4	888	19,500	272.4	82,807	1.6	0.8
1982	2.9	2.4	827	20,400	289.1	87,883	1.8	0.6
1983	2.9	2.4	827	21,100	298.4	90,710	1.9	0.5
1984	2.8	2.3	821	24,000	311.1	94,570	2.3	0.0
1985	2.8	2.3	821	25,000	322.2	97,944	2.4	-0.1
(see note)	(a)	(a)	(b)	(c)	(d)	(e)	(f)	(g)

TABLE 3:

DATA SOURCE, METHOD OF CALCULATION, AND COMMENTS ON DATA IN TABLE 2

(a) Source: Fisheries of the United States (1985), U.S. Department of Commerce, NOAA, NMFS, p. 36 and p. 3.

(b) Calculated: $p_t = R_t / Y_t$.

(c) Source: Fisheries of the United States (1980-1985) and Fishery Statistics of the United States (1968-1977). Comment: The number of vessels reported in 1984 seems suspiciously high. Comment: The number of vessels reported in 1985 is an estimate by the author. No estimate was available from the NMFS during data collection (June, 1986).

(d) Source: The Handbook of Basic Economic Statistics, April 1986, pp. 91-101.

(e) Source: The 1974 estimate of variable cost for a 42 GRT trawler was estimated by the NMFS in "Revenues, Costs and Returns from Vessel Operation in Major U.S. Fisheries" (1977, p. 7) as $44,901. Calculation: Using k_t=$44,901 for $t=6$ (1974). The other values of k_t were obtained from the difference equation $k_{t+1} = [1 + (CPI_{t+1} - CPI_t)/CPI_t] k_t$.

(f) Calculated: $C_t = k_t E_t$

(g) Calculated: $N_t = R_t - C_t$

FIGURE I. A PHASE PLANE DIAGRAM FOR THE SYSTEM

$$\dot{X} = rX(1 - X/K) - qXE,$$
$$\dot{E} = n(pqXE - kE)$$

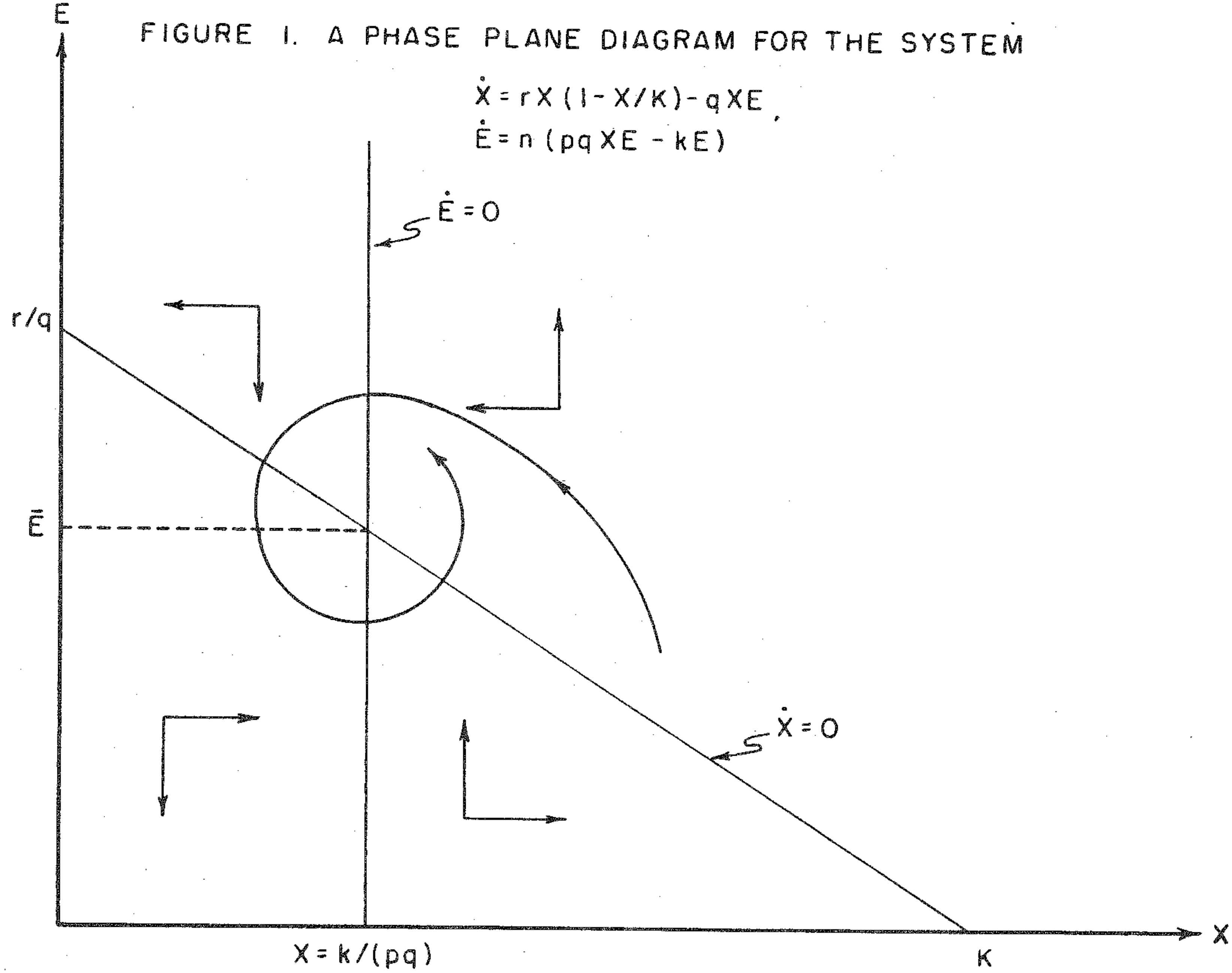


FIGURE 2. THE TIME PATH FOR NET REVENUES FOR SPIRAL CONVERGENCE TO OPEN ACCESS EQUILIBRIUM

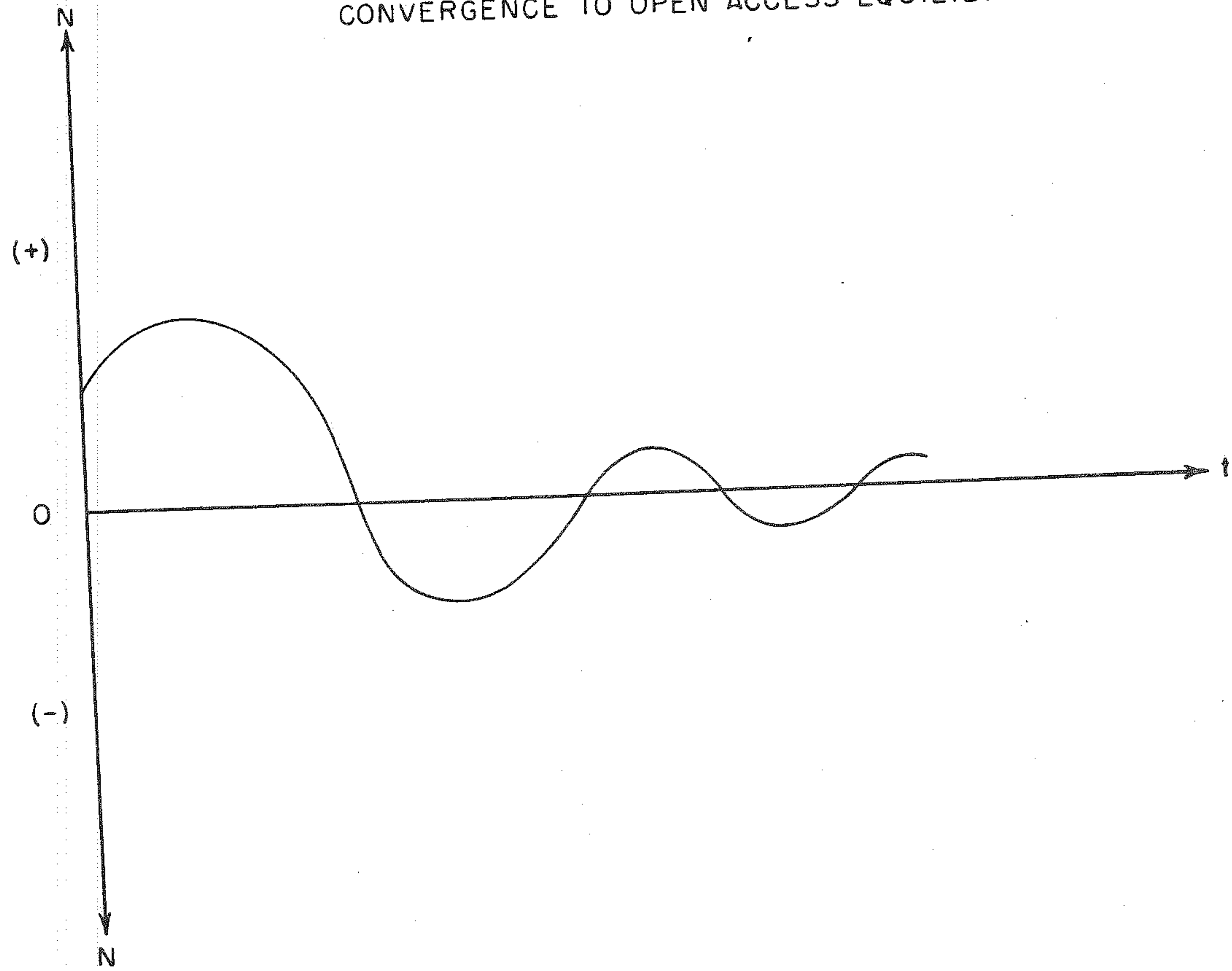


FIGURE 3. LANDINGS OF FISH AND SHELLFISH: 1968-1985

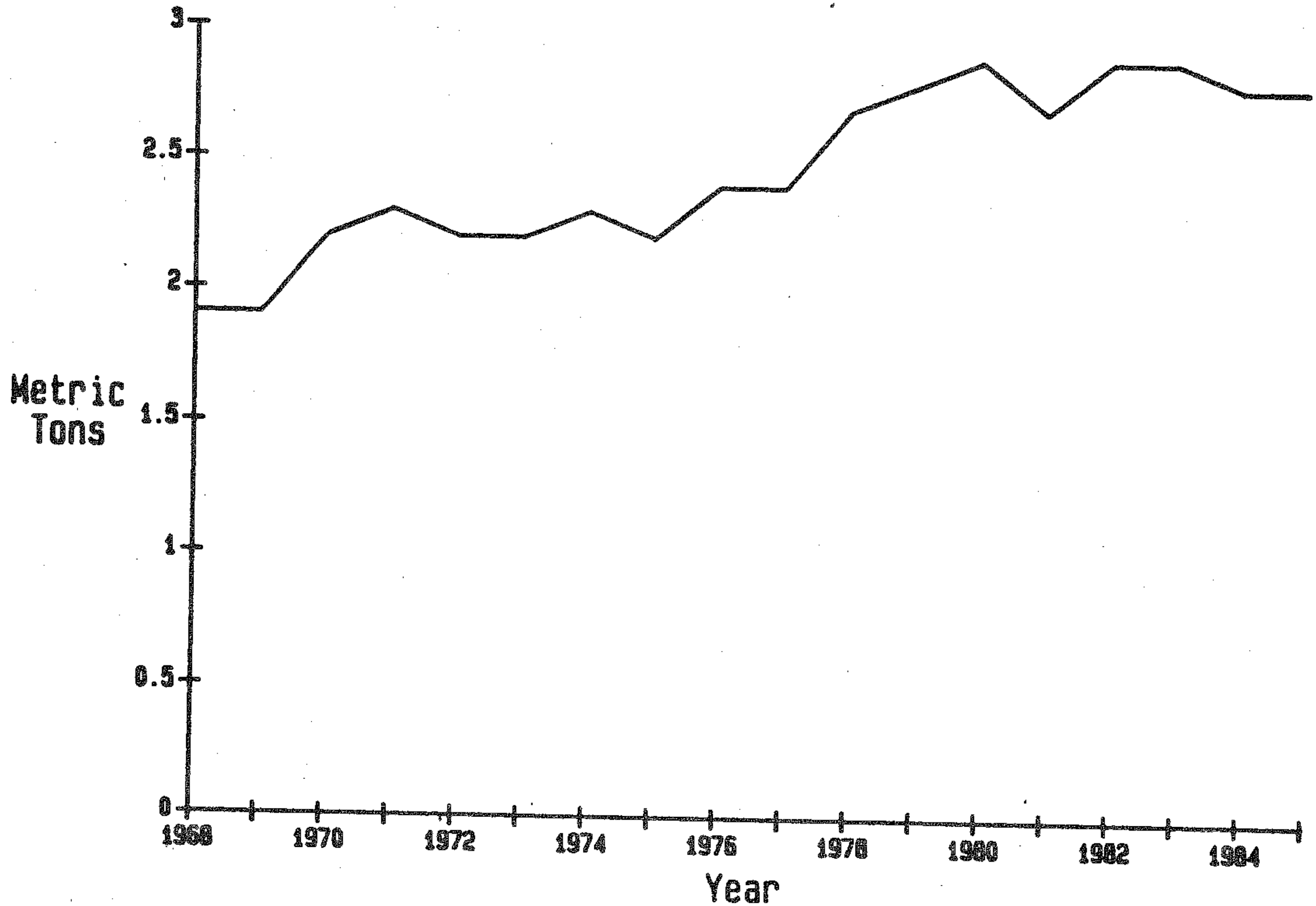


FIGURE 4. EXVESSEL REVENUES: 1968-1985

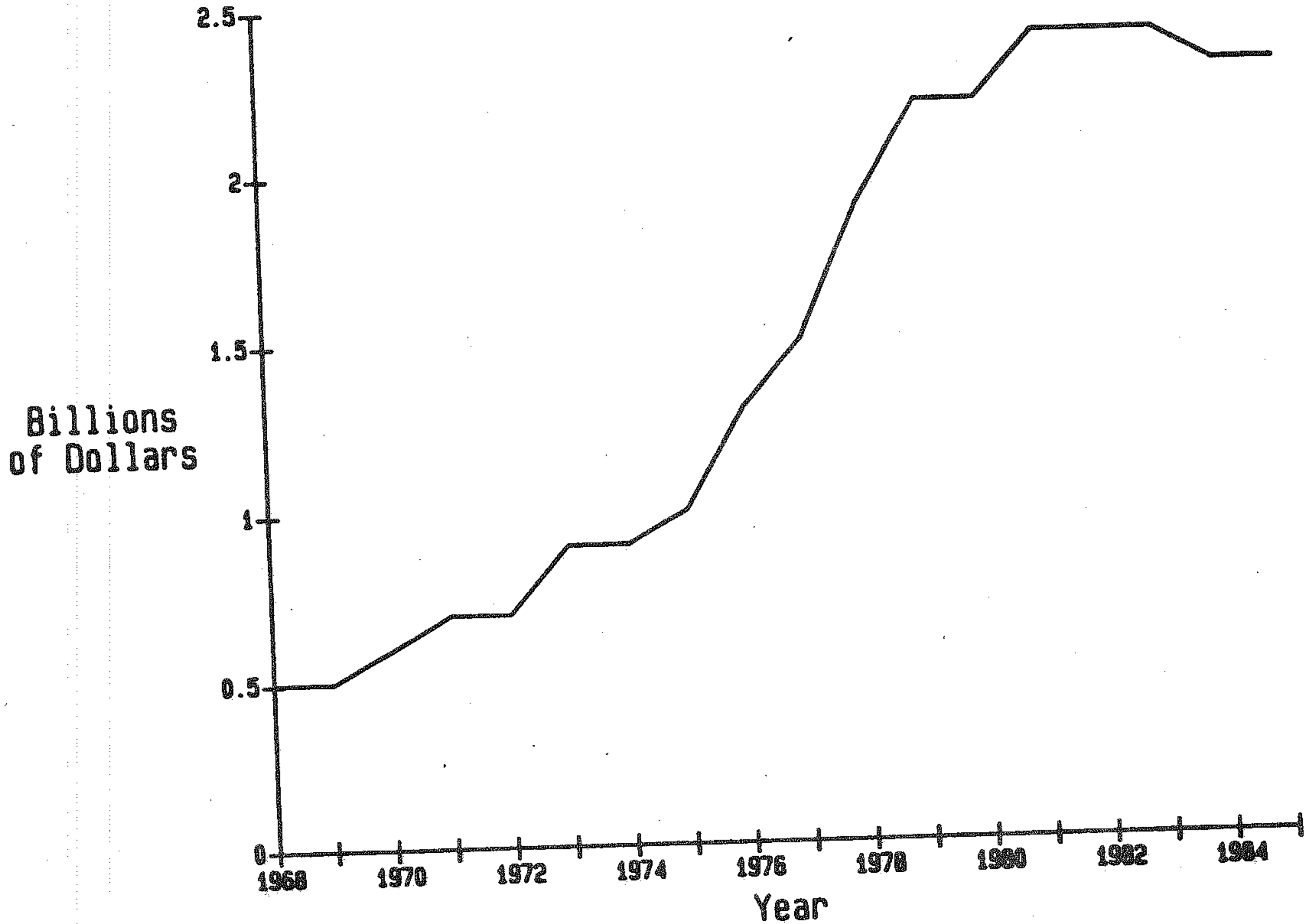


FIGURE 5. NUMBER OF VESSELS: 1968-1985

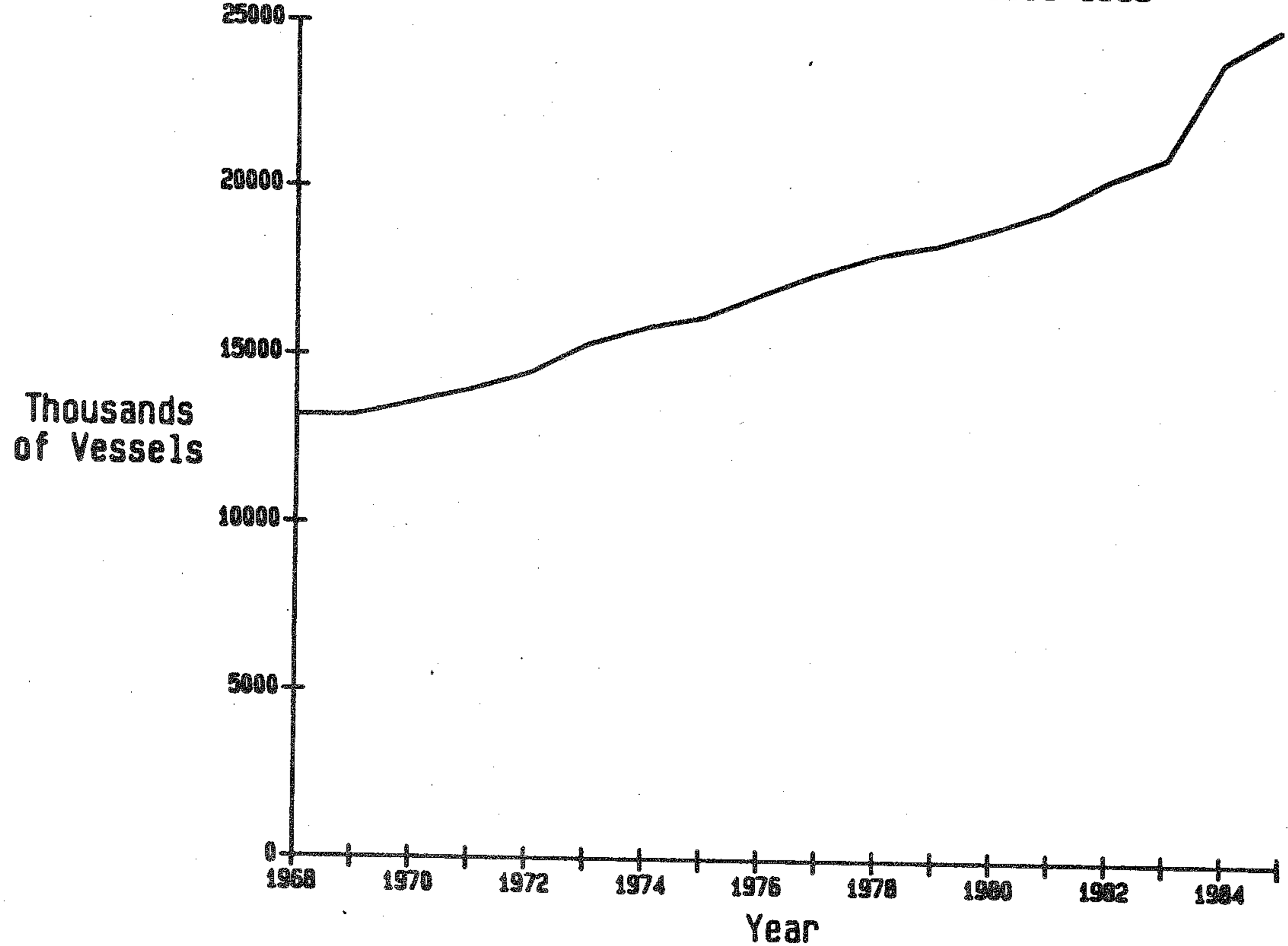


FIGURE 6. VARIABLE COSTS: 1968-1985

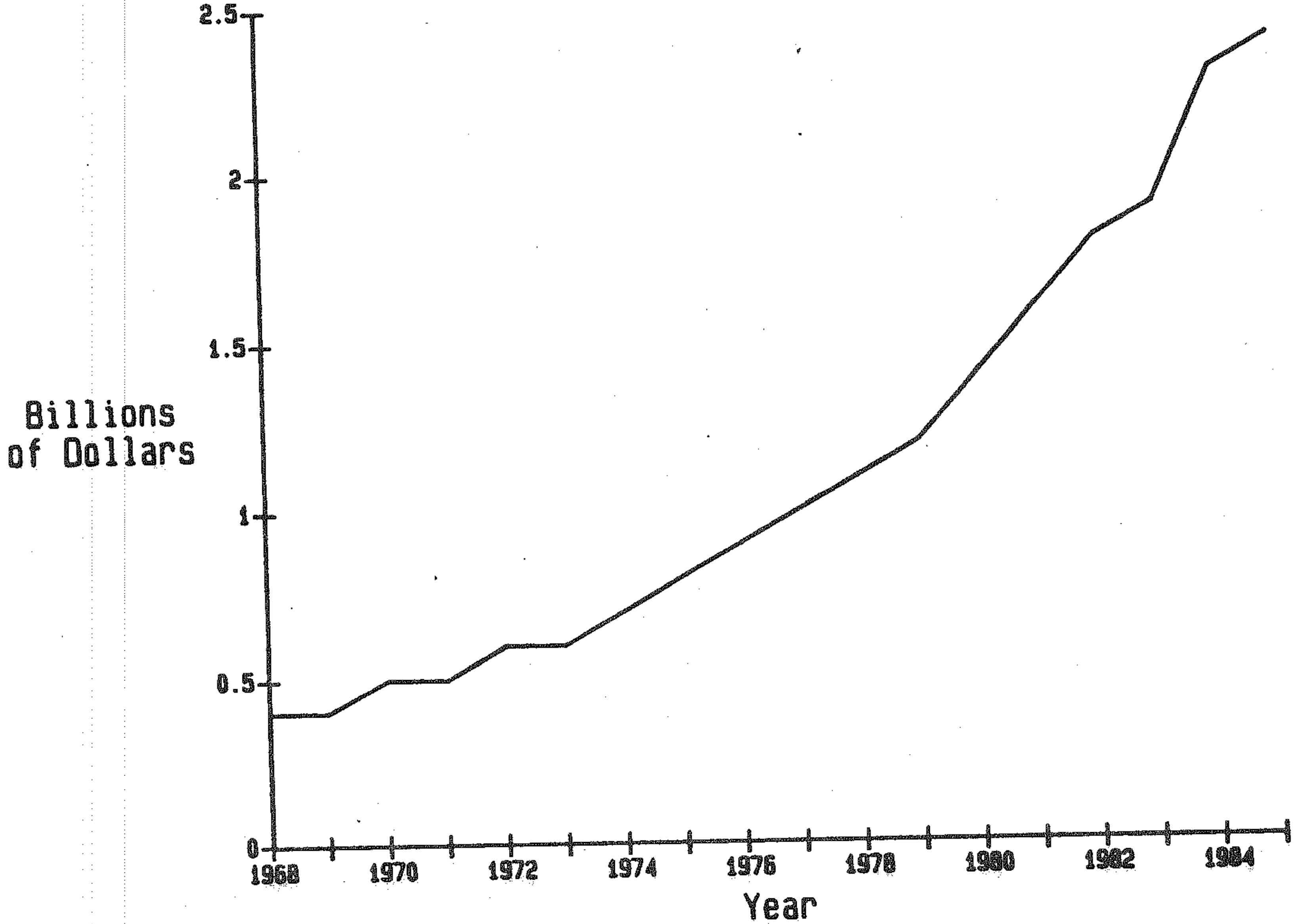
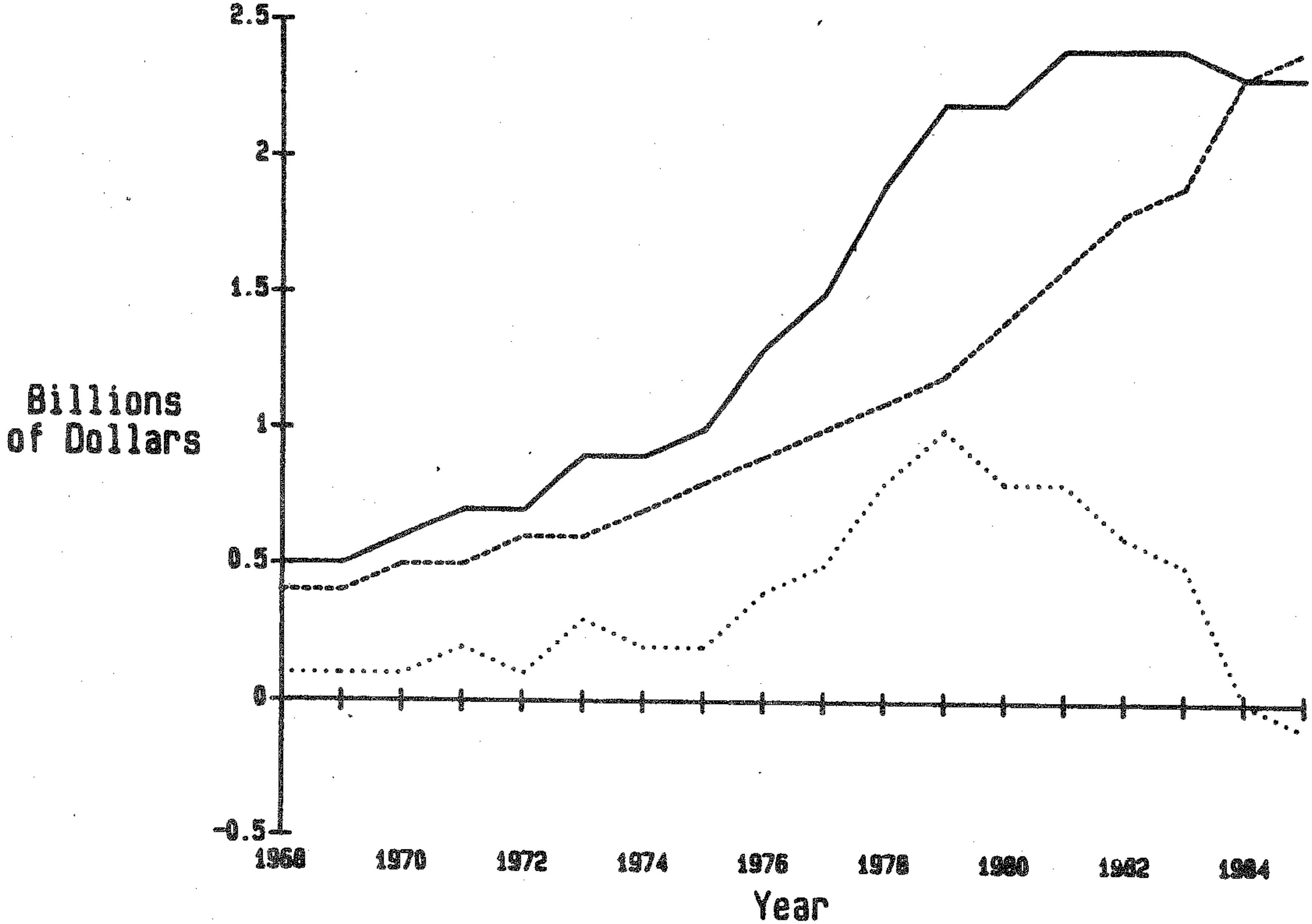


FIGURE 7. REVENUES, VARIABLE COSTS, AND NET RETURNS: 1968-1985



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