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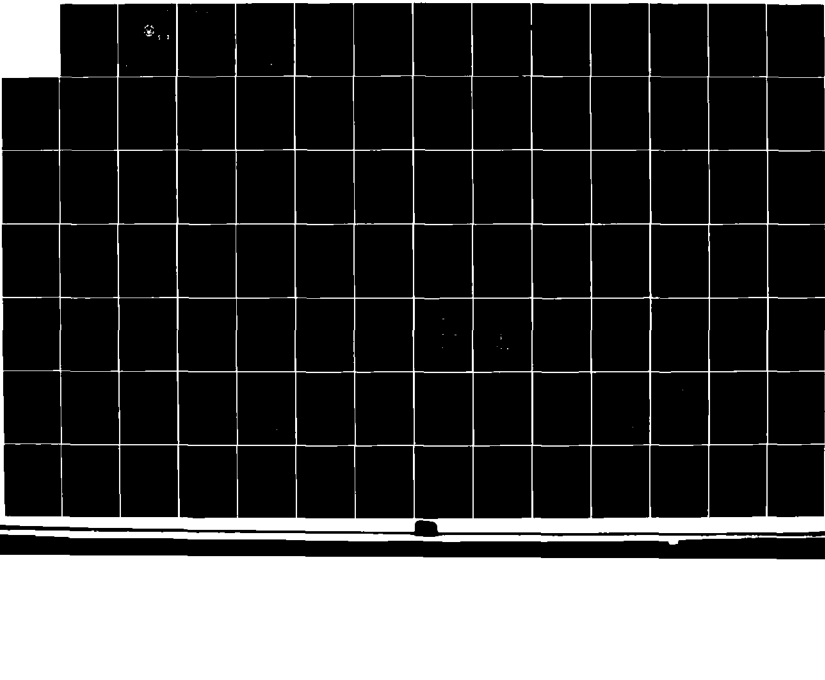

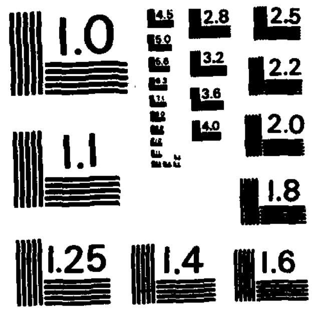

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THESIS

MARKET VALUE ESTIMATION MODELS
FOR MARINE SURFACE VESSELS
WITH THE USE OF MULTIPLE REGRESSION ANALYSIS

by

Thomas D. Johns

December 1982

Thesis Advisors: J. Fremgen
D. Boger

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In order to determine more scientifically the value of property assisted by the Coast Guard in search and rescue incidents, regression analysis was conducted on various characteristics of vessels in order to estimate their fair market values. Data for this research were collected from the U.S. Maritime Administration, the U.S. Coast Guard, and numerous oil and steel companies. Mathematical models were developed

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Market Value Estimation Models for Marine Surface Vessels with the Use of Multiple Regression Analysis

by

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Submitted in partial fulfillment of the requirements for the degree of

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ABSTRACT

In order to determine more scientifically the value of property assisted by the Coast Guard in search and rescue incidents, regression analysis was conducted on various characteristics of vessels in order to estimate their fair market values. Data for this research were collected from the U.S. Maritime Administration, the U.S. Coast Guard, and numerous oil and steel companies. Mathematical models were developed for merchant ships, tugs, fishing vessels, petroleum-carrying ships, and petroleum-carrying barges. Little correlation could be found in the analysis of yachts. To estimate the value of yachts as well as numerous other varieties of boats, it is prudent to utilize a commercially developed data base. Use of the models along with the commercial data base should provide value estimates for approximately 90 percent of the future Coast Guard search and rescue incidents. The search and rescue data base for previous years cannot be corrected because of the precision required in the measurement of vessel attributes and the categorization of characteristics in the Coast Guard assistance reports.

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I. INTRODUCTION

The study of vessel values is an extremely complex topic which transcends the disciplines of economics, accounting, naval engineering, mathematics, and management information systems. The principle of supply and demand coupled with a vessel's attributes are probably the most influential factors determining value. The study is further complicated by the variety of vessels within a particular category. For example, within the category of "cargo ships" are a number of types used for specific purposes such as refrigerated cargo, containerized cargo, bulk cargo, general cargo, etc. Each type of vessel has certain machinery and equipment which is peculiar to its task. Thus, the complexity of the valuation problem rapidly expands as one scrutinizes the elements of supply and demand and subsequently investigates specific categories and types of vessels.

A. IMPORTANCE OF THE "VALUE OF PROPERTY" STATISTIC

The value of property which the Coast Guard (CG) assists annually is one of the major workload measures submitted to the Department of Transportation, Office of Management and Budget, and Congress to help determine as well as justify the budget. In Congress, this measure is extremely visible, being presented twice in authorization hearings as well as appropriation hearings.

Recent years have seen an increased emphasis on reducing the nation's deficit spending. This has led to a scrutiny of all existing federal agencies and their programs to insure that efficient and effective utilization is made of each tax dollar. Due to this scrutiny, it has been noted that the statistic of "value of property assisted" has experienced drastic fluctuations from year to year. On the surface, it is unknown whether these fluctuations are actually due to shifts in the types of assets assisted or whether the valuation process presently in use is in error. In either instance, these fluctuations have raised questions as to the source and validity of this workload measure.

Currently, the value of property assisted is a summation of the estimated value of property involved in each search and rescue (SAR) incident. In marine incidents, the estimate is derived from the vessel's operator, who provides a "best guess" as to the market value of the craft. If the operator is also the owner, he or she may provide the purchase price or the insured value--neither of which necessarily provides an accurate estimate. If the vessel is unoccupied, the senior Coast Guard person on scene normally provides an estimate of the value. In all of the above situations, financial estimates are being made by persons who probably are unfamiliar with current market values of marine assets. Therefore, a study is required to determine if a more accurate method of estimating market values can be derived.

B. MEASURES OF VALUE

One of the initial determinations which must be agreed upon is the specific measure which should be used when quantifying "value." Some common alternative measures may include terms such as book value, net realizable value, current replacement cost, or fair market value.

A possible misconception concerning book value is that the undepreciated cost or book value of an asset is congruent to its fair market value. Book value, using historical cost, is a measure of market conditions at some point in the past rather than at present. Additionally, it must be understood that there exists a variety of depreciation methods, each of which results in a different book value for a particular asset after a given period of time. Any one of these methods may approximate the market value of an asset--depending on the method chosen and the characteristics of the asset. There, however, is no guarantee that any relationship between book value and market value will exist.

Net realizable value indicates the amount realized in the sale of an asset less any cost of preparing the asset for sale or cost required to enter the sale (e.g. brokerage fee) [Ref. 1: p. 9-6]. Depending on whether or not there are any preparation or brokerage costs, the net realizable value may be equivalent to the exit sales price.

The current replacement cost of an asset is the amount that would be paid in order to acquire that item under normal market conditions (i.e. no hoarding, abnormally large inventories, or forced transactions) [Ref. 1: p. 9-6] and is commonly the insured value of an asset. This is not a good measure because the exit sales price and the replacement cost will not be equivalent if a brokerage or dealer fee is involved in the transaction.

The term fair market value or, simply, market value may represent either the exit selling price or the entry purchase price. These two values will be the same only in the circumstance where there is no middleman or other fee involved between the buyer and seller. In this thesis, fair market value is defined as selling price.

For the purposes of this study, "value of property" will be defined as the fair market value (exit selling price). This is the best available approximation of the "value" of property which the Coast Guard saves or assists in its search and rescue efforts, because it measures the financial loss that property owners would incur if Coast Guard assistance were not available.

C. DATA COLLECTION

Intensive investigation led to three main sources of data concerning fair market values. First, the U.S. Maritime

Administration, acting under the 1936 Merchant Marine Act, conducted a valuation of U.S. owned or registered commercial vessels in 1976 [Ref. 2]. This valuation closely approximates the fair market value of those vessels. Second, the Coast Guard collects sales prices when documented vessels change ownership. These figures are available at Coast Guard documentation offices where the transfer of documentation is recorded. Third, various shipbuilders and shipowners possess statistics on lightweight* tonnage, which is highly deterministic of a petroleum-carrying vessel's value.

D. SYNOPSIS OF FUTURE CHAPTERS

Chapter II presents the legal provision under which the Coast Guard operates its search and rescue system, describes the data collection process for that system, and expounds on the use of the "value of property" statistic. Chapter III describes the scope of this study, the methods by which data were collected, and explains the possible errors involved. Chapter IV describes the regression procedure used in analyzing the aforementioned data. Chapter V presents the final mathematical models. Chapter VI offers three alternatives by which to estimate the value of vessels, and Chapter VII presents the author's recommendations for implementing the

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*Lightweight tonnage is also known as light tonnage or light displacement. It is the weight of the ship without any cargo, stores, fuel, passengers, or crew and approximates the amount of scrappable steel.

selected alternative, recommendations for further study, and a brief summary.

II. THE SEARCH AND RESCUE SYSTEM

The U.S. Coast Guard is mandated by law (Title 14, United States Code) to "develop, establish, maintain and operate... rescue facilities for the promotion of safety on, under, and over the high seas and waters subject to the jurisdiction of the United States..." [Ref. 3: sec. 2]. In addition, the Coast Guard "...shall administer laws and promulgate and enforce regulations for the promotion of safety of life and property..." [Ref. 3: sec. 2] and is permitted to "...render aid to persons and protect property at any time and at any place at which Coast Guard facilities and personnel are available..." [Ref. 3: sec. 88]. In order to perform its mission mandated by these laws, the Coast Guard has established various facilities and resources which are strategically located throughout the United States and its territories. In addition, a complex communications network which includes various Department of Defense commands, Federal Aviation Administration facilities, and numerous civilian agencies has been installed. Through this network, the Coast Guard is informed of, responds to, and coordinates search and rescue (SAR) activities of available vehicles and personnel.

A. THE VALUE OF PROPERTY ASSISTED

In order to maintain its facilities and resources, an adequate budget must be established by the Coast Guard for maintenance, personnel support and training, improvement to existing facilities, and new acquisitions. In order to compile and justify such a budget, the supporting statistics must accurately reflect the level of activity and output of the organization. One such statistic utilized in the budget-making process is the value of property assisted (i.e. towed, fires extinguished, dewatered, escorted, etc.) by the Coast Guard on an annual basis. Such property may include various categories of vessels as well as aircraft, land vehicles, shoreside structures (such as piers and warehouses), submersible vehicles, and offshore structures such as drilling rigs [Ref. 4: pp. 1-6-7 to 1-6-8]. In fiscal year 1980, the Coast Guard responded to 73,345 total incidents, 93 percent of which involved property. Of those incidents which did include property, 94 percent involved some type of watercraft [Ref. 5].

The figure of total value of property assisted is used in budget submissions to the Department of Transportation (DOT), the Office of Management and Budget (OMB), and Congress. It constitutes one of approximately seven major workload measures of Coast Guard operating programs. As such, it is utilized as an activity measure for the entire organization rather than exclusively for the SAR program. The measure is visualized as a benefit to the United States by DOT, OMB, and Congress but is most visible in testimony at both Congressional authorization and appropriation hearings. [Ref. 6]

B. THE SEARCH AND RESCUE DATA SYSTEM

The manner in which data are collected for each SAR incident is via the Search and Rescue Data System, which collects information concerning numerous aspects of each case. An example of the nature and type of information collected is the length and primary usage of the distressed unit, the incident location, the type of responding resource, and the value of property which is assisted or lost. [Ref. 4: pp. 1-6-3 to 1-6-17e]

Upon the prosecution of an incident, each responding unit prepares a worksheet entitled the "SAR Incident Summary Report" (See Appendix A). Upon termination or suspension of a case, the information collected is encoded and transferred to the "SAR Assistance Report" [Ref. 4: pp. 1-2-1 to 1-2-2] (See Appendix B). When Coast Guard Auxiliarists are involved, the Auxiliarist completes the equivalent to the aforementioned worksheet entitled the "SAR Incident Auxiliary Report," which contains essentially the same information (See Appendix C). This report is normally forwarded to the operational commander for translation into the SAR Assistance Report [Ref. 4: p. 1-4-1]. Once the SAR Assistance Report is completed, it is forwarded via the chain of command to the Coast Guard district office which exercises administrative control over the originating unit. At this hierarchical level, the report enters the central data base, located in Washington D.C., by means of key to disk or Automated Data Processing (ADP) [Ref. 4: p. 1-5-2].

C. COLLECTION OF PROPERTY VALUES

The "value of property" portion of the SAR Incident Summary Report (i.e. worksheet) is normally ascertained by requesting the operator of the vessel to estimate the value of that property. Many times the operator is also the owner and is equipped with the best available information concerning the asset's value, perhaps the purchase price of the vessel or the amount for which it is insured. Even though this is the best available information, it does not necessarily follow that the estimate is an accurate valuation. In some instances, the operator may not be the owner, in which case the former will provide a "best guess" as to the craft's financial worth and may introduce additional error. In a few incidents, the assisted vessel is unoccupied, in which case the normal procedure is for the senior Coast Guard person on the scene to provide a dollar estimate.

In the above situations, financial valuations are being made by persons who may well be unfamiliar with current market values of marine assets. Such cases result in erroneous estimations being submitted to the SAR data system. For example, in both fiscal year (FY) 1979 and 1980 the Coast Guard assisted exactly 103 towing vessels within the sixty-six to one hundred foot length category. However, the value associated with those vessels in FY79 was $82,122,000, as opposed to $40,728,000 for the following fiscal year [Ref. 7] (See Appendix D). Although it may be possible that these two figures could be accurate for each year, particularly if all tugs assisted in FY80 were older and smaller than those assisted in FY79, such an occurrence is not probable. It is more believable that the value difference is due largely to the estimation technique which is used to collect data. Therefore, an investigation is required to determine if a more scientific approach can be developed to estimate the worth of assets more closely and to determine whether or not the present data base can be corrected.

III. METHOD OF ANALYSIS

A. SCOPE

The complexity of a financial analysis of the many types and varieties of property assisted by the Coast Guard is overwhelming. Therefore, restrictions must be placed so that an analysis may be conducted within a manageable arena. The first restriction is that of analyzing vessels only. As previously stated, 94 percent of all properties assisted in FY80 were marine vehicles. To expand this study beyond these limits would cause a rapid increase in the variety of the assets (e.g. a fishing pier vs. a liquified natural gas terminal). Therefore, the scope of this investigation will encompass only marine surface craft.

The second restriction pertains to cargo aboard the vessels. The value of property which enters the SAR system data base is inclusive of cargo [Ref. 4: p. 1-6-9]. Due to the numerous types of commodities which are shipped via water transportation, both nationally and internationally, and the rapidly changing market prices for such goods, the determination has been made to exclude cargo valuation from this study. Cargo should not be disregarded in the final estimate, however, because it may be significant in value, even to the point that its value exceeds that of the vehicle within which it is carried [Ref. 8]. In addition, fuel has been excluded because of varying tank capacities and fluctuating petroleum prices. The scope of this investigation then is limited to surface vessels with any attached machinery, equipment, electronics gear, and accommodation furnishings but excluding any cargo or fuel.

B. DATA SOURCES

Research into the valuation problem was initiated through attempts to locate data concerning sales or market prices of boats, ships, barges, tugs, etc. A check of six state boating registration agencies indicated that only one (Maryland) collected information as to the sale price of a boat upon transfer of registration and title. However, in order to extract such information from Maryland's computerized data base, reprogramming was required at an associated cost of approximately $3,000. Therefore, this source of information was excluded as a possibility. A computer search was also conducted of the Transportation Research Information Service (TRIS), which was developed by the U.S. Department of Transportation and the National Science Foundation Transportation Research Board. This search resulted in numerous references to the shipbuilding industry and its associated costs but failed to produce information concerning fair market values of either ships or boats.

Inquiries were also made of various maritime associations, shipowners, and marine insurers. Most who replied indicated that no statistics of such a nature were available. However, one of the respondents, Exxon Company, provided additional insight with respect to the economics of petroleum-carrying tank vessels (i.e. including barges). Due to the "oil glut" presently being experienced in the United States, the petroleum transportation system is being underutilized. Thus, an overcapacity has resulted and, in turn, has reduced the market price of petroleum-carrying vessels to the realizable value of their scrap steel. For example, the Motor Vessel EXXON FLORENCE was recently sold in Taiwan for its scrap value of $920,000 [Ref. 9]. The U.S. Maritime Administration had valued the ship at $1,270,000 [Ref. 2] in 1976; this translates into $2,096,678 in 1982 dollars [Ref. 10]. This resulted in a decrease of $1,176,678 or 56 percent of the current-dollar appraised value. This phenomenon holds true for all petroleum-carrying tankers, with the exception of those in the 30,000 to 100,000 deadweight* ton range built after 1970 [Ref. 12].

Further inquiries also led to a ship valuation process managed by the U.S. Maritime Administration. In accordance with Title XII of the Merchant Marine Act of 1936 [Ref. 13: sec. 1289], the Maritime Administration manages the War Risk

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*Deadweight tonnage (summer) is the actual weight of the vessel in long tons (2240 pounds), loaded with cargo, stores, fuel, passengers, and crew to her maximum summer loadline [Ref. 11].

Insurance program for vessels owned or controlled by U.S. citizens [Ref. 14]. In order to execute this responsibility, the Maritime Administration collects several independent appraisals for ships, tugs, and barges, normally for one vessel in each class. These appraisals are then combined with a confidential formula which originated in the U.S. General Accounting Office (GAO). By means of combining the appraisals with the formula, an appraised market value for each vessel in each class is reached. Sister ships are then valued with minor, if any, adjustments on the lead ship. [Ref. 15]

The results of this process were published in the Federal Register in January of 1976 [Ref. 2]. This list was cross-referenced with Merchant Vessels of the United States (CG-408) [Refs. 16 and 17] in order to determine each vessel's characteristics. The characteristics which were chosen to be extracted were gross tonnage*, year built, beam, length overall, hull material, and horsepower. Because of the economics in pricing petroleum-carrying vessels, tankers were not included in the sample. Two criteria which were chosen

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*Gross tonnage is basically "the capacity in cubic feet of the spaces within the vessel's hull, and of the enclosed spaces above the deck available for cargo, stores, passengers, and crew...divided by 100" [Ref. 11]. Gross tonnage is measured according to the law of the nation with which the ship is registered. Variations among countries may occur due to the inclusion or exception of particular spaces. Thus, gross tonnage could be different for a certain vessel depending on its flag.

were that the independent variables (i.e. those characteristics listed above) be available in such places as Lloyd's Register of Ships, Merchant Vessels of the United States, or state boating registration files and that the chosen characteristic closely correlated with value. The first of the criteria was chosen to facilitate estimating a vessel's value in such instances as when an overdue boat remains unlocated, a vessel is lost at sea, or an operator is unsure of a specific characteristic.

It may be argued that the materiel condition of a vessel impacts significantly upon its worth. This is a valid point. However, not only are data on materiel condition not available but such data would also reflect subjective evaluation, which would vary widely among individuals. This topic will be discussed in further detail later in this chapter under the heading of "potential errors."

Another source of data is the Coast Guard vessel documentation system. When a vessel's documentation is transferred, the bill of sale is presented to the Coast Guard Documentation Office where the selling price is recorded along with the new name. This revised information is then forwarded to Coast Guard Headquarters in Washington D.C. for update of the merchant vessel documentation data base. The transfer price, however, is not forwarded and is, therefore, only manually accessible at the local documentation office. A manual examination of documentation records was conducted at the Documentation Branch of the Coast Guard Marine Safety Office in San Francisco, California. Vessels which had changed ownership in the past five years were selected; however, it was found that numerous transfers indicated an extremely low sale price (e.g. $5 or $10). Any such price which appeared not to be a "reasonable" value of the craft was disregarded. Finally, a data sample of 154 non-tank vessel transactions was extracted. In addition to the vessel's new name and documentation number, the year of sale and age at time of sale were recorded. Again, this list required cross referencing with Merchant Vessels of the United States (CG-408) [Refs. 16 and 17]. However, a problem arose in that the 1979 edition is the latest in print. Since almost one half of the recorded transactions had occurred after 1979, the vessels could not be referenced by their new names. The most efficient method of determining the needed characteristics for each craft was to identify it by documentation number in the headquarters' data base. With the assistance of the Merchant Documentation Branch, the recent transfers were successfully extracted and their respective attributes identified.

Another source of information is the BUC Used Boat Price Guide (Volumes I and II) and the BUC New Boat Price Guide. These three volumes contain market prices for most domestic and some foreign boats manufactured from 1905 through 1982. The data for these boats have been compiled over an eighteen year period from information provided by both brokers and dealers [Ref. 18]. There are fifty-five types of boats covered--ranging from trawlers and schooners to jet-ski boats and canoes. In addition to the commonly found cabin cruisers and sailboats, the publication lists such varieties as airboats, kayaks, hovercraft, sport fishing boats, row-boats, houseboats, and various custom-built models. Although boats are listed by manufacturer, the index enables entry via use of the model name and length. Also useful in determining the price are such items as top (e.g. flying bridge or sloop), type of rig (e.g. ketch or yawl), the boat type (e.g. jon or runabout), the hull material, and the type and horsepower of the boat's engine. The price guides also provide for geographic and materiel condition price adjustments. The use of derived tables can result in domestic U.S. price changes of up to 60 percent of the BUC published prices [Ref. 19]. Unfortunately, for copyright protection, the publisher of the above publications has introduced a number of fictitious boats into the output listing [Ref. 20]. Therefore, these books were not utilized as a source of data for model development.

C. SORTING AND ADJUSTMENT OF DATA

After each transaction was recorded and all applicable characteristics of each vessel were referenced, the data were sorted into seven categories: freight barges, tugs, yachts, fishing vessels, sailing vessels, passenger vessels, and merchant cargo ships. The categories of sailing vessels, freight barges, and passenger vessels resulted in only seven, eight, and thirteen transactions respectively. These were considered to be insufficient samples from which to develop mathematical models. No models were attempted for these categories.

After sorting, each transaction price was converted into 1982 current dollars by use of shipbuilding indexes developed by the U.S. Maritime Administration [Ref. 10]. Although the indexes are for shipbuilding costs, they constitute the best and most reasonable index presently available for revising sales prices (See Appendix E). The U.S. Department of Labor, Bureau of Labor Statistics does publish an index for various categories of boatbuilding and shipbuilding [Ref. 21: p. 41]. However, the index for these categories commenced in 1981 and, therefore, could not be used in this study because a majority of the recorded transactions occurred prior to that year.

D. POTENTIAL ERRORS

1. Consideration of Materiel Condition

As previously stated, the vessel's state of repair is not considered herein because of subjective evaluation. This omission will probably introduce error into the developed models, since it is apparent that a vessel whose hull, machinery, electronics, and living spaces were in good repair would realize more dollars on the market than one which had been neglected with respect to maintenance and required repairs or possibly shipyard overhaul. There are no data available to indicate the magnitude of such error.

2. The Use of Shipbuilding Indexes

The index employed in order to update the sale price was developed from the shipbuilding costs of major U.S. shipbuilders such as Todd, Ingalls, American, etc. [Ref. 22]. The potential error introduced here is twofold. First, the costs are derived from large corporations (i.e. large with respect to the shipbuilding industry). Thus, it is possible that they do not accurately reflect the cost associated with small shipyards and boatbuilders. Second, the indexes reflect costs experienced by the companies instead of selling prices or fair market values. Although they are probably closely related, there is no guarantee that the indexes for costs and for sales prices parallel each other and that their ratios of change from year to year are the same. Thus, the use of these indexes may introduce additional errors into the adjusted data.

3. Raw Data from Documentation Files

The raw data extracted from the Coast Guard documentation files in San Francisco, California may provide biases in two respects. First, a geographical adjustment in sales price brought about by the economic factors of supply and demand may be required. Demand will be determined by such variables as the climate, bodies of water, type of fish, affluence of the population, etc., all of which vary according to geographical area. Supply is strictly a function of the number of boats of a particular style, condition, characteristic, and capability. For example, the actual cash value of an offshore sport fisherman would be greater on the Outer Banks of North Carolina than in the Upper Chesapeake Bay region, where it would be of limited or no use. It is further hypothesized that the larger the vessel, the less influence geographical location plays in its value. This occurs because the relative cost of moving the larger vessel from point to point is lower than moving the smaller vessel. To illustrate this hypothesis, a 600-foot general cargo ship might realize the same price regardless of its domestic location whereas the value of a 30-foot yawl would vary drastically according to the above supply and demand criteria.

A second cause of error in the Coast Guard documentation files is the source of the original information. There is no guarantee that the bill of sale which is presented to the documentation clerk accurately reflects the value of the transaction. Instances which may occur include unrecorded cash transfers, assumptions of mortgages, and additional trading of goods. Although the author recorded only "reasonable" amounts as raw data, this criterion is nevertheless subjective and is not an absolute control against false information.

4. Sampling Error

Sampling error may have been introduced to the ship model because sample data were taken exclusively from U.S. owned or registered ships. Since the Coast Guard assists ships from all nations, the selected sample may not truly represent the population. An assessment of the magnitude of this error would require an international collection of data. This error probably approaches zero for smaller vessels because most small vessels assisted are of U.S. ownership.

5. Other Nonsampling Errors

Particular attention was given to preventing such mistakes as transcription errors, keyboard input errors, and erroneous calculations. For example, sales prices were translated into 1982 current dollar figures by employing a single program on the Texas Instruments-59 programmable calculator (TI-59). The calculator program was confirmed in the first iteration of each conversion by manually carrying out the algebraic steps on the keyboard.

Another feature which contributed to a low nonsampling error was the selection of characteristics. All characteristics which were chosen were quantifiable or categorical, leaving room for no opinion or subjective analysis.

For example, the variables--length, gross tonnage, age, horsepower, and beam--were all measurable attributes, while the characteristic of hull material clearly fit into one of the four categories of wood, steel, fiberglass, or ferro-cement. Because of the above precautions and attributes, nonsampling error from these sources is assessed as negligible.

IV. MODEL FORMULATION

A. USE OF THE STATISTICAL ANALYSIS SYSTEM (SAS)

The raw data (adjusted to 1982 dollar value) were entered into the International Business Machine (IBM) System 370, which utilized the 3033 central processing unit (CPU) located at the U.S. Naval Postgraduate School in Monterey, California. The SAS statistical package, developed by the SAS Institute, was used to conduct multiple regression analysis on the data.

B. REGRESSION ANALYSIS OF NONPETROLEUM-CARRYING VESSELS

1. Stepwise Regression

A stepwise regression procedure was initially used on all data pertaining to nonpetroleum-carrying vessels. Stepwise regression is used to determine which variables should be included in a regression model. "Stepwise is most helpful for exploratory analysis..." because it provides insight into relationships between dependent and independent variables [Ref. 23: p. 391]. However, stepwise alone does not necessarily provide the best model or even the model with the highest coefficient of determination (R^2). Because of these shortcomings, the Maximum R^2 improvement technique (MAXR), developed by Mr. James H. Goodnight, was chosen. MAXR "...is considered superior..." [Ref. 23: p. 391] to the basic stepwise procedure. Rather than settling for a single model, it searches for the best one variable model, two variable model, etc. until the number of input variables is reached [Ref. 23: pp. 391-392]. This feature makes the stepwise procedure with the MAXR option an excellent variable selection device. In this manner, those independent variables which possessed the most significance were chosen. The level of significance of 0.85 was chosen in order for any variable to be considered. In addition, transformations of variables were tested such as:

$$Z = (GRTON \times LOA)/AGE,$$

$$M = (BEAM \times HP)/AGE,$$

$$G = LOA \times BEAM, \text{ and}$$

$$H = GRTON/(LOA \times BEAM).$$

The abbreviations contained in the above equations are explained in Table 2 in Chapter V. The motivation underlying the first three variables was that some values would be directly proportional to market value (e.g. gross tonnage, length, beam, and horsepower) while age would be inversely proportional to market value. The last variable is a rough estimate of weight per square foot. The original variables, along with the above transformed variables, brought the total of the independent variables to ten. However, the independent variable of hull material was not tested in the tug and merchant ship categories because all hulls were of steel construction, with the exception of one wood-hulled tug; therefore, in these two categories only nine variables were considered.

In order to prevent multiple collinearity, the transformed variables were not tested simultaneously with the independent variables which were used to formulate those specific transformations (e.g. the variable G was not used with LOA and BEAM).

2. General Linear Model (GLM) Regression

The General Linear Model procedure has the capability of numerous analyses, such as multiple regression, simple regression, analysis of variance (ANOVA), analysis of co-variance, polynomial regression, and multivariate analysis of variance (MANOVA). In addition, the GLM possesses the capability of handling categorical variables. (These will be discussed in the following section.)

The variables previously determined to be acceptable in the stepwise regression were tested in various combinations by using the GLM. Because AGE was in the denominator of some of the transformed variables, an alternative had to be chosen in cases where new vessels (i.e. AGE equals zero) were sold. The values of five-tenths and then one-tenth were substituted for zero with little noticeable difference in output when the values were switched. Single variables or groups of variables were deleted in each iteration. A plot of predicted values overlaid on a plot of actual data was used along with a plot of residual values for each iteration in order to check further for model fit. Any variable, except age, which possessed a negative sign for its regression coefficient was discarded from the model. This is because each variable should be directly proportional to market value and should, therefore, possess a positive slope. The characteristic of age was the only variable for which a negative regression coefficient was accepted, because it should have an inverse relationship to market value.

Residual plots were used to check for violations of regression assumptions such as nonrandom sampling or heteroscedasticity. At first, some plot may appear to violate these assumptions, but the cause is mainly due to a disproportionate number of vessels in a particular spectrum of the population.

3. Categorical Variables

Categorical variables, more commonly known as dummy variables, were used to determine the relationship between hull materials and market value. Categorical variables were used only with fishing vessels and yachts. The collected data included four types of material: wood, steel, fiberglass, and ferrocement. The breakdown of the number of hull types in each vessel class is listed in Table 1.

These hull types were tested individually and in groups with the previously described variables. For example, not only were wood, steel, fiberglass, and ferrocement

TABLE 1

Number of Hull Types in Data Sample

HULL TYPE	FISHING VESSELS		YACHTS	
	Number	Percent	Number	Percent
Steel	4	6.6	1	1.7
Wood	42	68.8	17	28.8
Fiberglass	12	19.7	37	62.7
Ferrocement	3	4.9	4	6.8
TOTAL	61	100.0	59	100.0

tested separately along with BEAM and Z, but various combinations of two hull materials such as fiberglass and ferrocement or combinations of three hull materials such as steel, fiberglass, and ferrocement were tested along with BEAM and Z. These groups were then tested against the null hypothesis that there is no significant difference in the hull material insofar as value is concerned by using the T-test at the 0.85 confidence level. Rejecting the null hypothesis of no significant difference in the hull material would result in a separate regression coefficient for that combination.

C. REGRESSION ANALYSIS FOR PETROLEUM-CARRYING VESSELS

Regression analysis for petroleum-carrying ships was conducted by comparing deadweight tonnage as the independent variable with lightweight tonnage as the dependent variable by means of simple regression. This analysis was performed in order to predict the lightweight tonnage of a given vessel from its deadweight tonnage, which is available in <u>Lloyd's Register of Ships</u>. Subsequently, that lightweight tonnage was multiplied by the current scrap value of steel. Deadweight tonnage was chosen because it is standard throughout the world, whereas gross tonnage, as previously stated, may vary according to law. A similar approach was used with petroleum-carrying barges, employing gross tonnage vice deadweight tonnage as the independent variable. Here, gross tonnage was felt to be a proper variable since barges are normally employed domestically and registered in the United States.

V. FINAL MODELS

The mathematical models contained in this chapter are the final results of the above statistical analysis. Coefficients in the models have been rounded to five significant digits. It should be remembered that these models do not include cargo or fuel but do include items of attached machinery and standard equipment such as electronics, deck machinery, and living accommodations. Therefore, the value of cargo and fuel should be added to these models before a "value of property assisted" is assigned to the SAR Assistance Report. Due to insufficient or uncorrelatable data, no equations were developed for yachts, freight barges, passenger vessels, or sailing vessels. The abbreviations used in the models are explained in Table 2.

A. NONPETROLEUM-CARRYING VESSELS

1. Merchant Ships

Based on 110 observations, the mathematical model derived for merchant ships is dependent upon the values of length overall, beam, effective horsepower, and age (See Appendices F, G, H, and I). Sample data included containerized cargo ships, bulk cargo ships, and general cargo ships. Caution should be taken in the use of this equation outside of the valid range stated below, as the negative intercept

Table 2

Abbreviations for Variables

ABBREVIATION	DESCRIPTION
CURRDOLS	Market Value in 1982 Current Dollars
GRTON	Gross Tonnage (U.S.)
LOA	Length Overall to the nearest tenth of a foot
BEAM	Breadth to the nearest tenth of a foot
HP	Effective Horsepower
AGE	Time from year built to present in years
S	Steel-Hulled Construction
W	Wood-Hulled Construction
C	Ferrocement Construction
F	Fiberglass Construction
DDWT	Deadweight Tonnage
LTWT	Lightweight Tonnage
FRTN	Categorical variable for the 14th CG District only
SVTN	Categorical variable for the 17th CG District only
AA	Categorical variable for Atlantic Area CG Districts only
PA	Categorical variable for Pacific Area CG Districts except for the 14th and 17th
P	Categorical variable which indicates premium on vessels within the 30,000 to 100,000 deadweight ton range and built after 1970

may produce a negative current dollar value for ships beyond the lower limits.

CURRDOLS = -19,002,000 + 45,762(LOA) + 14.062(BEAM x HP/AGE)

R^2 =				.839
F =				278.68

Standard Error of the Regression = 5,269,341.6

Valid Range:	LOA	449.0	to	892.2
	(BEAM x HP/AGE)	1,440	to	4,232,000
	BEAM	54.0	to	105.9
	HP	1,760	to	120,000
	AGE	2	to	66

2. <u>Tugs</u>

Based on a sample of twenty-eight observations, the mathematical model developed for tugs is dependent upon gross tonnage, length, and age as follows (See Appendices J, K, L, and M):

CURRDOLS = 345,150 + 193.22(GRTON x LOA/AGE)

R^2 =				.940
F =				408.73

Standard Error of the Regression = 309,673.4201

Valid Range:	GRTON x LOA/AGE	19.2	to	25,536.0
	GRTON	23	to	989
	LOA	50.0	to	138.3
	AGE	3	to	60

3. Fishing Vessels

Based on a sample of sixty-one observations, the mathematical model developed for fishing vessels is dependent upon beam, gross tonnage, length overall, age, and hull material as follows (See Appendices N, O, P, and Q):

$$CURRDOLS = -97{,}518 + 11{,}333(BEAM) + 40.914 \times (GRTON \times LOA/AGE) + 62{,}932(S)$$

NOTE: IF THE HULL MATERIAL IS STEEL, THEN S=1. OTHERWISE S=0.

R^2 = .700

F = 44.43

Standard Error of the Regression = 22,919.68794

Valid Range:	BEAM	8.0	to	18.0
	GRTON x LOA/AGE	3.22	to	1482.00
	GRTON	6	to	48
	LOA	24.2	to	54.9
	AGE	0	to	68

4. Yachts

Based on a sample of fifty-nine observations, no dependable model could be developed for yachts. The maximum R^2 developed via the stepwise method and produced by acceptable variables was 0.537. This value was obtained by using the independent variables of age, beam, and hull material (See Appendices R and S). One explanation for the low coefficient of multiple determination is that there are numerous varieties of pleasure craft which include custom-built craft. Many of these varieties have unique design features which are not seen on larger vessels. The unique attributes associated with such vessels may contribute significantly to the craft's market value. Therefore, an analysis of value for this category must include measures of attributes other than the six chosen for this study. It should be noted that most of the vessels within the data sample for yachts are also within the scope of the BUC data base. Therefore, BUC International Corporation serves as an alternative method of valuing these assets.

B. PETROLEUM-CARRYING VESSELS

1. Tank Ships

As previously discussed, petroleum-carrying vessels are heavily dependent upon scrap steel rates due to the economics of supply and demand. Ships sold for scrap are normally delivered in Taiwan [Refs. 10 and 24], where scrap rates are significantly higher than in the United States (e.g. $108 vs. $60 per ton). Thus, the higher scrap rate should be used in estimating the ship's value. Current scrap rates in Taiwan are available in such periodicals as Lloyd's Shipping Economics or Seatrade Week.

Since the cost of delivering a tanker to Taiwan is significant, it also must be considered. This cost varies from vessel to vessel depending upon such variables as the type of power plant, the speed of advance, the number of crewmembers, the port of origin, etc. It also assumes that the ship does not terminate its service at a foreign port. However, a rough estimate for a transit from Los Angeles to Taiwan is $400,000 and from New York to Taiwan via the Panama Canal (shortest route) is $550,000 [Ref. 24]. These costs should be adequate estimates for the respective Atlantic Area and Pacific Area Coast Guard Districts with the exception of the Fourteenth District (Hawaii) and the Seventeenth (Alaska). Since a ship transitting to Taiwan from Hawaii would only travel two-thirds of the distance which a ship from the west coast of the United States would travel, the applicable estimate of cost would be $266,667. The distance to Taiwan from Alaskan waters is approximately four-fifths of the distance to the Los Angeles area; therefore, the cost would be approximately $320,000.

Another factor involved is that ships built after 1970 which are within the 30,000 to 100,000 deadweight ton range are in more demand and carry a premium of seven to nine million dollars over their scrap value. [Ref. 24]

A very good correlation exists between a tanker's deadweight tonnage and its scrapable steel or lightweight tonnage. The mathematical model for petroleum-carrying tankers based on a regression of forty-six observations and the foregoing cost and premium considerations is:

CURRDOLS = [5701.2 + 0.12200(DDWT)] x [Taiwan Scrap Steel Rate] + 8,000,000(P) - 550,000(AA) - 400,000(PA) - 266,667(FRTN) - 320,000(SVTN)

NOTE: P = 1 FOR TANKERS BUILT AFTER 1970 WITHIN THE RANGE OF 30,000 TO 100,000 DEADWEIGHT TONS; OTHERWISE P = 0

AA = 1 FOR ALL ATLANTIC AREA CG DISTRICTS; OTHERWISE AA = 0

PA = 1 FOR CG DISTRICTS ELEVEN, TWELVE, AND THIRTEEN; OTHERWISE PA = 0

FRTN = 1 FOR THE FOURTEENTH CG DISTRICT ONLY

SVTN = 1 FOR THE SEVENTEENTH CG DISTRICT ONLY

R^2 = .950

F = 835.51

Standard Error of the Regression = 3216.12

Valid Range: DDWT 25,088 to 553,662

The constant and first term of the equation are derived in Appendices T, U, V, and W. The further terms are non-statistical adjustments based upon location of the vessel and two attributes of the vessel.

2. Tank Barges

Based on a sample of twenty-one observations, the mathematical model for petroleum-carrying tank barges is a function of the vessel's lightweight tonnage--which has been estimated as a function of gross tonnage--and the value of domestic scrap steel. Gross tonnage and domestic scrap steel values were chosen because the majority of barges which the Coast Guard assists are U.S. registered vessels which would not be transported to Taiwan. The value of U.S. scrap steel may be located in such publications as the Wall Street Journal [Ref. 25] or the Washington Post [Ref. 26] which list scrap prices per ton for each business day (See Appendices X, Y, Z, and AA).

CURRDOLS = [188.70 + 0.31715(GRTON)] x [U.S. Scrap Steel Rate]

R^2 = .978

F = 854.95

Standard Error of the Regression = 151.285

Valid Range: GRTON 628 to 11,082

VI. ALTERNATIVES FOR IMPLEMENTING VALUE ESTIMATION

The foregoing mathematical models may be effectively used for estimating values of marine vessels. Since these models do not include such categories as yachts or pleasure craft, the BUC price guides or their computerized equivalent should be used in conjunction with the models to enable all categories of vessels to be valued.

There are three basic alternatives for implementing a value estimation process, each of which employs the above equations along with either the BUC Used Boat Price Guide (Volumes I and II) and the BUC 1982 New Boat Price Guide or the computerized version known as BUCFAX. Since no model could be developed for yachts, the BUC information is an excellent source to be used for value estimation for this category as well as other types of small boats. All alternatives will be briefly presented and then each discussed in detail.

The first alternative is to use the developed mathematical models in conjunction with the BUC price guides at the unit or SAR Mission Coordinator (SMC) level. This is consistent with the present responsibility of determining the property value in a SAR incident (i.e. the unit estimating the value in single unit cases and the SMC estimating the value in multi-unit cases).

The second alternative is to use the mathematical models in conjunction with BUCFAX in the interactive mode. This also would be accomplished by the unit or SMC, as in the first alternative, and would become feasible with the present procurement of the Coast Guard Standard Terminal.

The third alternative is to program the CG Headquarter's computer to carry out the calculations necessary in the developed mathematical models and utilize BUCFAX in the batch processing mode.

Each of the above alternatives have particular advantages and disadvantages in addition to their significant cost differentials.

A. VALUATION PROCESS WITH MODELS AND PRICE GUIDES

This alternative would require the unit responsible for determining the value of a SAR incident to calculate the fair market value of the assisted property. This would necessitate that all three volumes of the BUC price guides be procured for each unit having an operational SAR responsibility. The breakdown of such units is outlined in Appendix BB. In addition, an annual procurement of each year's New Boat Price Guide would be required. Only the cost of initial procurement and distribution is included in the cost figure for this alternative. The initial cost for supplying 521 SAR units is $44,660.50 as calculated in Appendix CC. It should be emphasized that the cost used is a quantity discount price available with prepaid orders only. The price does include shipping. Since the federal government does not prepay and since the largest scheduled quantity discount is for forty-seven units, perhaps negotiations would result in equal or lower prices than those listed. In addition, the shipments may be made directly to the units from BUC instead of the purchase of a bulk quantity requiring redistribution by the Coast Guard. [Ref. 27]

Another consideration is that units which are co-located could use the same price guide, thus reducing the quantity required and the cost.

The calculations of values by means of the mathematical models simply requires a hand-held calculator, which is available at most Coast Guard facilities or can be purchased with appropriated funds at a nominal cost.

The advantage of this alternative is that the person on the scene can readily determine the value of the vessel and make adjustments for materiel condition and geographic area (when the BUC price guides are utilized). Additionally, any obvious discrepancies in operator response to queries may be immediately rectified. The SAR Assistance report may then be completed without the necessity for additional paperwork being forwarded via the chain of command.

The disadvantage of this alternative is that it places added responsibility and burden on already overworked SAR personnel. Another disadvantage is that the BUC price guides do contain some errors due to reporting discrepancies. When discovered and subsequently corrected by the BUC staff, these discrepancies cannot be promulgated until the following edition of the price guide [Ref. 28]. The price guides provide only 20 percent of the information contained in BUCFAX [Ref. 29]. Therefore, the information provided in the price guide is not always the most current or complete.

B. VALUATION PROCESS WITH MODELS AND INTERACTIVE BUCFAX

With the use of the Coast Guard Standard Terminal, all units having access to the terminal could be provided on-line capabilities with BUCFAX. The on-line system provides operator prompts in order to accomplish data entry in the proper format [Ref. 28] by minimially trained personnel. With the use of the Standard Terminal, the mathematical models could be programmed into the Headquarter's computer for calculation so that the responsible unit need only enter the independent variables.

Costs for this alternative depend on several factors which are beyond the scope of this investigation. Two of these factors are the number of terminals used and "which of the many features of BUCFAX are employed." [Ref. 29]

The advantage of this alternative is that it reduces the time involved in calculating the market value from the time required by the first alternative. As a result of its statistical analysis, BUCFAX also has the advantage of providing estimated high, low, and most likely prices for boats not in its data base (e.g. homemade boats). Additionally, the most current information is available, as discussed under the first alternative, so that errors will be further reduced.

The disadvantage of this alternative is similar to the first alternative, in that extra work is placed on operational SAR personnel. However, having the process computerized does somewhat reduce the workload as compared with the first alternative.

C. VALUATION PROCESS WITH MODELS AND BATCH BUCFAX

The third alternative is to program the CG Headquarter's computer to calculate the results using mathematical models in conjunction with using BUCFAX in the batch mode. In this alternative, the computer would read the independent variables for those cases requiring model utilization and subsequently conduct the required operations. For those cases requiring value estimation via BUCFAX, the data would be stored on tape and physically transferred to BUC International Corporation in Fort Lauderdale after the completion of SAR data entries by the Coast Guard for the respective fiscal year. Inasmuch as the only use of the data is the annual budget development and justification, determining the value of property assisted only at the end of the fiscal year is satisfactory. Since sufficient software exists to translate coded information, it should be noted that it is unnecessary for the Coast Guard to use in its SAR Assistance Reports the same abbreviations as BUC Corporation uses for particular vessel attributes [Ref. 28].

Like the on-line environment, the costs associated with batch processing are beyond the scope of this paper. These costs are influenced by such variables as the "quantity and format of descriptors" [Ref. 29] and would be the topic of contract negotiations. However, batch processing in any computerized system usually results in a lower total cost than does interactive processing. The difference in cost could be a strong argument for employing a batch environment.

One advantage of this alternative is that it enables the BUC staff to analyze individually any outliers which may occur in the data set. Another advantage is that the requirement of value estimation is removed from the operational personnel and placed upon administrative personnel.

The disadvantage of this method is that the estimation process is removed in both time and distance from the original incident. Thus, if any question arises as to the veracity of a particular attribute or if further investigation is required, the details may be difficult, if not impossible, to obtain.

In all three alternatives, fuel and cargo values would have to be calculated and submitted at the operational level and added to the vessel's value subsequent to the valuation. The mechanics of this process would vary depending upon the alternative chosen. For example, if the first alternative were chosen, fuel and cargo values would be added to the vessel's value at the unit or SMC level when the SAR Assistance Report is prepared. In the last alternative, these values could be entered into the computer, summed, and then added to the aggregate vessel values after batch processing. A list of the required data to be collected for the foregoing alternatives is presented in Appendix DD.

VII. RECOMMENDATIONS AND SUMMARY

A. RECOMMENDED ALTERNATIVE

The recommended alternative is to employ the mathematical models within the Coast Guard software and use BUCFAX in the batch mode. This is the only alternative which provides for a statistical analysis of any outliers in the boat category. It also has the important advantage of requiring the least amount of effort on operational personnel. With the fore-seen increase of Coast Guard SAR cases, it is the author's view that the SAR Data System should utilize these available computer capabilities to the fullest possible extent.

B. FURTHER STUDY

The use of the mathematical models in conjunction with the BUC data base will provide a valuation method for approximately 90 percent of all prosecuted SAR cases. A study should be conducted of categories of marine assets not covered herein in order to develop value estimation models. Specifically, the categories of oceanographic vessels, drilling rigs and platforms, passenger vessels, oil exploitation vessels, liquified natural gas (LNG) vessels, liquified petroleum gas (LPG) vessels, ferries, and dredges should be investigated.

More research should also be conducted in the category of fishing vessels because of the low R^2 obtained in the foregoing model and because there are many attributes unique to various types of fishing vessels which are not considered herein. For example, different rigs such as clam dredges, longliners, tuna boats, etc. have diverse equipment which could significantly affect the value of the vessel. Such a study should ascertain (1) those variables other than the ones chosen in this study that correlate to market value and (2) if significant differences exist in market values with respect to geographical region to warrant a separate mathematical model for each Coast Guard District. The recommended procedure for this analysis is a collection of data from several Marine Safety Offices in each district by means of a detailed questionnaire. This questionnaire would be completed by a vessel seller prior to transfer of vessel documentation. The proposed content of such a questionnaire is provided in Appendix EE.

C. REVISION OF VESSEL DOCUMENTATION DATA COLLECTION

Presently the Vessel Documentation Offices are collecting sales values, most of which are not the actual transfer price. Since meaningless data are being collected, it is recommended that either the Coast Guard develop guidelines in order to record only actual or "reasonable" sales prices or eliminate the requirement on the Vessel Documentation Offices to collect such data.

D. REVISION OF EQUATIONS

The mathematical models presented in Chapter V should be updated annually by simply applying the index of shipbuilding costs to the dependent variable. In this manner, the value of property assisted will reflect the current dollar value instead of the 1982 dollar value. The process of this thesis (i.e. data collection, data organization, regression analysis, and investigation of economic effects) should be conducted periodically and the results compared with the equations contained in Chapter V in order to verify or revise the mathematical models.

E. SUMMARY

It has been shown that the fair market value of a vessel can be predicted from the vessel's characteristics. Smaller vessels, with their variety of attributes, do not correlate as well as do larger ships. The most reliable predictions are for tugs and petroleum-carrying ships and barges. Because of limited data, no models could be developed for several specialized categories of vessels which are listed in paragraph B. However, the five mathematical models which have been developed along with a commercial data base can be used to estimate approximately 90 percent of all search and rescue incidents. Further investigation should be conducted into the arena of specialized vessels as well as shore facilities which the Coast Guard might assist in order to develop valuation techniques.

In conclusion, a vessel's fair market value can be estimated from various attributes depending upon the type of vessel. Because of the precision required in the measurement of the attributes (e.g. LOA to the nearest tenth of a foot), the SAR data base for past years cannot be studied for errors, since an insufficient number of attributes have been retained and those attributes which have been retained have been categorized (See Appendix D) and, therefore, a certain amount of information has been lost.

With the use of the mathematical models developed herein, with the use of a commercially developed data base, and with the results of further study, the Coast Guard should be able to measure accurately the aggregate value of property which it assists in search and rescue efforts so that an adequate budget may be developed and justified.

APPENDIX A

SAR INCIDENT SUMMARY

SAR INCIDENT SUMMARY

CG	OPFAC (A01)	Unit Case No. (A02)	Multi-Unit Case No. (A03)	Date of Coast Guard Notification (S01) M / D / Y / Time

CASE DATA SECTION

Time from Occurrence (S02)	Initial Severity (S09)	Date/Time of Location (S16)
Means of Notification (S03)	Actual Severity (S10)	Lives Lost (S17) BEFORE / AFTER
Nature of Incident (S04)	Cause of Incident (S11)	Lives Saved (S18)
Distance Offshore (S05)	Owner (S12)	Persons otherwise Assisted (S19)
Latitude (S06)	Usage (S13)	Value of Property Lost (S20) — Value / 1000 i.e. 1500 = 15; 290,000 = 2.90
Longitude (S07)	Propulsion (S14)	Value of Property Assisted (S21)
Method of Locating (S08)	Length (S15)	Value / 1000 i.e. 1500 = 15; 290,000 = 2.90

SORTIE SUMMARY

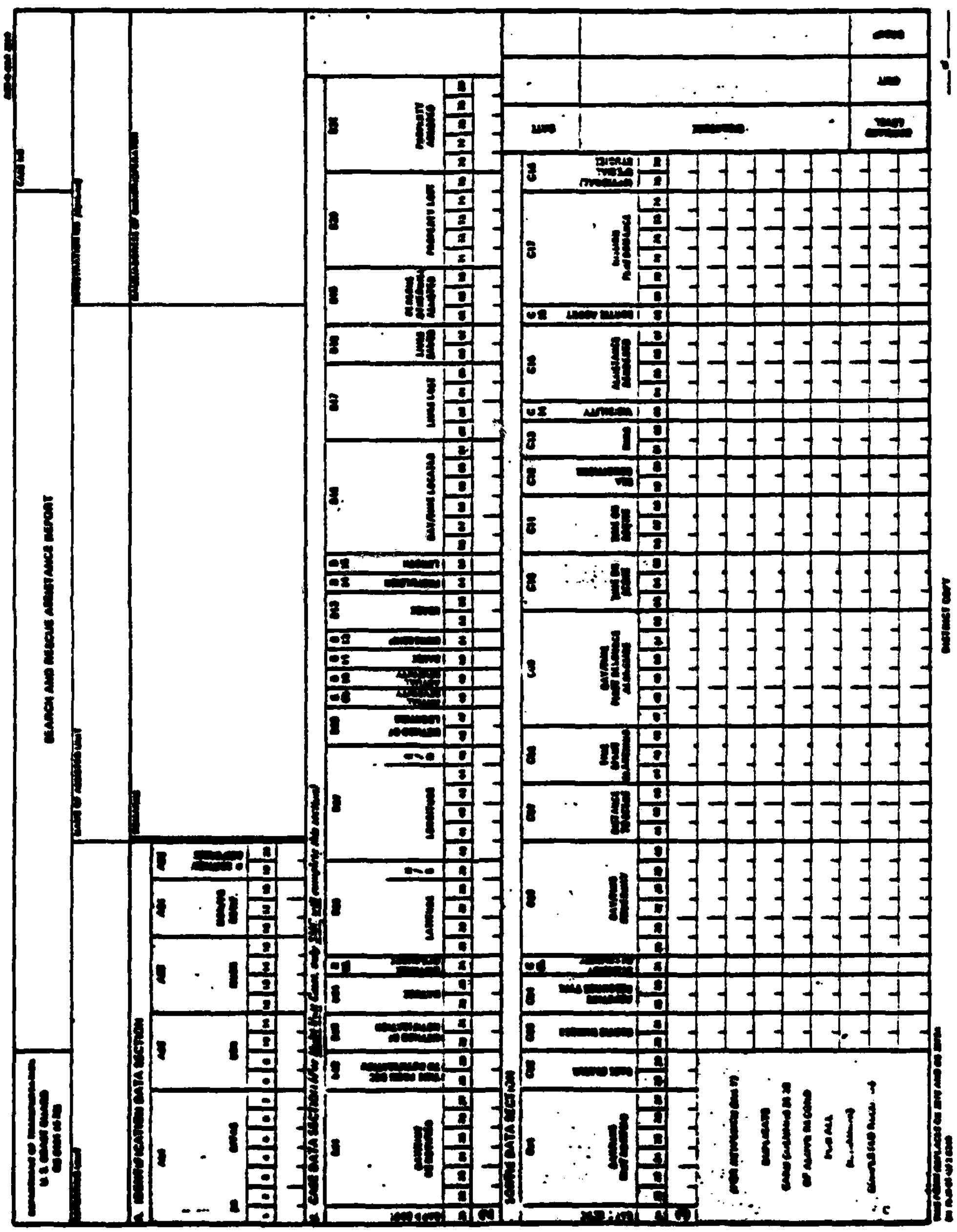
SORTIE	Assisting Resource Type (C 04)	Date / Time Underway (C 06)	Distance To Scene or Search Area (C 07)	Total Time On Search (C 08)	Date / Time Assisting Resource Alongside (C 09)	Total Time On Scene (C 10)	Total Time On Sortie (C 11)	Sea State (Feet) (C 12)	Wind (Knots) (C 13)	Visibility (C 14)	ASSISTANCE RENDERED BY CG (C 15) TCs Personnel	Property
1												
2												
3												
4												
5												
6												
7												

REMARKS

Name of Assisting Unit	Registration No. (optional)	Name/Address of Owner/Operator

APPENDIX B

SAR ASSISTANCE REPORT



APPENDIX C

SAR INCIDENT AUXILIARY REPORT

DEPARTMENT OF TRANSPORTATION
U.S. COAST GUARD
CG-4612 AUX (Rev. [illegible])

SAR INCIDENT AUXILIARY REPORT

AUXILIARY CASE DATA SECTION

(01) Member Number (10)	(14) Members Last Name (29)	[illegible]	Current CME Decal on Assisted Vessel Yes ☐ No ☐
Lives Saved (65-66)	Persons otherwise Assisted (67-68)	Value of Property Assisted/Saved (76-79) Value / 1000 i.e. 0008 = $8,000 0045 = $45,000 0125 = $125,000	

CASE DATA SECTION

Unit Case No (A02)	Longitude (B07)	Length (B15)
Multi-Unit Case No (A03)	Method of Locating (B08)	Date/Time of Location (B16)
Date/Time of Coast Guard Notification (A04) MO DA YR Time	Initial Severity (B09)	Lives Lost (B17) Before After
Time from Occurrence (B02)	Actual Severity (B10)	Lives Saved (B18)
Means of Notification (B03)	Cause of Incident (B11)	Persons otherwise Assisted (B19)
Nature of Incident (B04)	Owner (B12)	Value of Property Lost (B20) Value / 1000 i.e. 1500 = 2 : 250,000 = 250
Distance Offshore (B05)	Usage (B13)	Value of property Assisted (B21)
Latitude (B06)	Propulsion (B14)	Value / 1000 i.e. 1500 = 2 : 250,000 = 250

CG UNIT COPY

SORTIE SUMMARY

Sortie # Assisting Resource Type (C04)	Date Time Underway (C06)	Distance To Scene or Search Area (C07)	Total Time On Search (C08)	Date/Time Assisting Resource Alongside (C09)	Total Time On Scene (C10)	Total Time On Sortie (C11)	Sea State (feet) (C12)	Wind (knots) (C13)	Visibility (C14)	Assistance Rendered by CG (C15) TO Personnel	Property
1											
2											
3											

REMARKS

NAME OF ASSISTED UNIT	REGISTRATION NO. (Optional)	NAME/ADDRESS OF OWNER/OPERATOR

UNIT COPY [illegible]

APPENDIX D

NUMBER OF SAR CASES AND PROPERTY VALUE ASSISTED IN FY79 AND FY80

The following table illustrates the apparent lack of correlation between the number of Coast Guard SAR cases and the total value of property involved in those cases for fiscal years 1979 and 1980. Values are listed in thousands of dollars. An asterisk in the left-hand column indicates statistics which have a high probability of error. For example, there were 232 less passenger vessels assisted in the 16 to 25 foot category in FY79 than FY80; yet, the total value of the 1979 figure is almost fifteen times that of the 1980 figure. There were three tank vessels assisted in FY79 which were less than 16 feet in length; however, there is no value associated with these assets. The same is true for the reported value of vessels greater than 300 feet in the pleasure category.

Two explanations can be provided for these discrepancies. First, the error could be due simply to transcribing or keypunch errors. Second, the vessels may have been reported as having zero value since the SAR Assistance Report requires the boat's value to be rounded to the nearest $1,000. This causes vessels of less than $500 in value to be reported at zero.

VESSEL USAGE AND LENGTH	FISCAL YEAR 1979		FISCAL YEAR 1980	
	Cases	Value	Cases	Value
CARGO				
<16'	7	45	7	46
16-25'	23	359	32	647
26-39'	17	2,607	17	526
40-65'	57	3,298	58	5,014
66-100'	70	63,503	64	19,882
101-200'	85	123,476	87	341,840
201-300'	32	68,085	20	5,902
>300'	111	566,470	72	177,259
PASSENGER				
* <16'	177	11,409	214	578
* 16-25'	801	112,664	1,033	7,511
26-39'	527	229,288	547	13,962
40-65'	268	416,686	273	33,989
66-100'	47	91,541	45	11,871
101-200'	18	12,460	22	13,710
201-300'	2	250	1	900
>300'	5	30,025	2	28,000
TANKER				
* <16'	3	0	0	0
16-25'	6	53	4	1
26-39'	4	83	6	109
40-65'	15	2,002	7	1,245
66-100'	10	51,280	15	62,570
101-200'	7	840	8	2,550
201-300'	9	90,825	10	4,097
>300'	49	522,699	40	450,200

VESSEL USAGE AND LENGTH	FISCAL YEAR 1979		FISCAL YEAR 1980	
	Cases	Value	Cases	Value
FISHING				
<16'	129	8,457	91	192
16-25'	1,647	115,287	1,348	13,876
* 26-39'	2,804	360,982	2,430	64,085
40-65'	2,346	1,252,165	2,403	335,506
* 66-100'	1,340	1,372,502	1,223	227,583
101-200'	93	140,865	86	26,500
201-300'	7	4,060	2	1,050
>300'	1	100	2	700
TOWING				
<16'	6	2	7	22
16-25'	61	829	60	615
* 26-39'	65	101,824	54	830
40-65'	150	81,145	143	66,973
* 66-100'	103	82,122	103	40,728
101-200'	65	233,716	67	166,797
201-300'	7	4,828	5	19,800
>300'	7	49,117	8	69,550
PLEASURE				
<16'	5,675	200,607	5,535	16,134
* 16-25'	31,986	2,992,700	32,500	255,968
26-39'	12,108	2,332,319	11,973	269,527
40-65'	2,635	774,425	2,512	304,191
66-100'	131	19,411	136	22,400
* 101-200'	27	274	38	20,860
201-300'	4	3	6	30
* >300'	4	0	2	30

VESSEL USAGE AND LENGTH	FISCAL YEAR 1979 Cases	FISCAL YEAR 1979 Value	FISCAL YEAR 1980 Cases	FISCAL YEAR 1980 Value
OCEANOGRAPHIC				
<16'	8	29	5	12
16-25'	35	2,278	29	243
26-39'	22	8,471	13	432
40-65'	23	3,467	16	795
66-100'	10	2,095	5	1,210
101-200'	7	2,300	6	8,500
201-300'	0	0	0	0
>300'	0	0	0	0
OTHER				
<16'	163	3,179	83	104
16-25'	376	122,318	249	2,231
26-39'	179	14,618	134	2,723
40-65'	143	13,259	111	56,645
66-100'	45	3,886	37	8,615
101-200'	41	50,800	23	49,313
201-300'	17	9,300	13	60,930
>300'	11	4,800	15	26,550

APPENDIX E

INDEX OF ESTIMATED SHIPBUILDING COSTS IN THE UNITED STATES.

Index values are of 1 January for each year.

YEAR	INDEX	YEAR	INDEX
1939	100	1961	297
1940	101	1962	299
1941	105	1963	303
1942	119	1964	311
1943	127	1965	313
1944	132	1966	318
1945	135	1967	331
1946	131	1968	343
1947	158	1969	359
1948	175	1970	379
1949	189	1971	399
1950	186	1972	418
1951	198	1973	443
1952	212	1974	470
1953	222	1975	558
1954	232	1976	593
1955	238	1977	636
1956	258	1978	677
1957	270	1979	743
1958	285	1980	811
1959	292	1981	892
1960	295	1982	979

APPENDIX F

RAW DATA FOR SHIPS

STATISTICAL ANALYSIS SYSTEM

OBS	LCA	GRTON	BEAM	HP	AGE	HULL	CURRDOLS
1	584.0	15995	75.2	6000	32	S	21214427
2	529.2	10484	75.0	19000	11	S	6438617
3	466.5	9252	68.1	11000	16	S	4127319
4	469.1	9361	68.1	11000	15	S	4292411
5	497.2	17184	71.1	9900	31	S	9938583
6	738.5	26456	100.2	32000	5	S	26934882
7	662.2	17192	78.3	9900	31	S	8477513
8	530.2	12508	76.1	17500	14	S	27974966
9	531.0	11164	75.2	22500	13	S	5175658
10	659.6	18024	78.3	9000	31	S	10376079
11	486.2	10485	74.1	6000	32	S	1873803
12	500.5	11421	71.7	9000	32	S	3986990
13	555.3	13858	75.2	6000	31	S	1865548
14	637.0	17801	82.0	24000	8	S	15526973
15	636.4	16819	76.0	19250	10	S	13042327
16	640.7	21467	90.0	28500	3	S	20306408
17	529.6	13265	76.1	17500	15	S	6438617
18	507.6	11039	75.1	18000	10	S	5365514
19	562.0	11757	90.0	30000	7	S	12794688
20	811.7	32269	100.2	9000	2	S	30996164
21	497.2	10562	71.7	8500	31	S	3661519
22	612.9	16401	78.3	8500	35	S	6999933
23	659.6	18420	78.3	9000	31	S	10381032
24	536.6	9313	82.0	12500	10	S	5844283
25	892.2	41127	105.8	120000	3	S	68496981
26	685.6	23763	95.2	32000	3	S	26560121
27	687.5	24773	95.2	32000	5	S	27132993
28	892.2	41127	105.8	120000	4	S	67795337
29	571.2	11891	69.2	10000	14	S	6237204
30	504.0	7813	68.2	6000	33	S	2220497
31	500.2	10014	71.7	9000	31	S	8465956
32	503.9	7373	68.1	10000	32	S	2839595
33	860.5	40362	105.9	24000	3	S	24763912
34	449.0	8673	63.1	6000	32	S	2624975
35	607.3	14192	75.3	6000	31	S	2790067
36	549.1	9493	82.1	21000	7	S	8535295
37	501.6	11034	71.7	9000	34	S	1758238
38	525.6	8995	76.3	17500	23	S	2699266
39	470.1	9296	69.2	10000	10	S	3706332
40	738.5	26456	100.2	32000	4	S	26934882
41	484.9	9827	70.1	10600	15	S	4482268
42	487.1	10396	70.0	11660	8	S	5433202
43	811.7	32325	100.2	32000	3	S	30996164
44	661.7	13723	72.2	7000	21	S	6083668
45	725.2	21667	105.9	36000	4	S	31598752
46	515.2	10723	76.2	12500	9	S	5398533
47	612.8	16395	78.2	9000	4	S	6999933
48	653.4	14770	92.8	30000	2	S	44702164
49	438.9	6145	63.1	6000	30	S	677880
50	451.9	6451	66.1	8000	30	S	693390
51	474.0	7848	73.1	13750	16	S	3566003
52	471.9	10659	73.1	13750	15	S	4548305
53	471.8	11000	73.1	12500	13	S	4771180
54	473.7	9296	69.2	10000	13	S	3706332
55	449.0	8673	63.1	6000	33	S	2253516
56	543.3	11309	75.1	16500	14	S	5060093
57	543.3	11309	75.1	16500	13	S	5258204
58	473.7	9397	69.2	10000	13	S	3706332
59	584.3	15949	82.1	24000	8	S	9884103
60	497.2	10562	71.7	8500	31	S	3863170
61	725.2	21667	105.9	36000	4	S	31598752
62	627.1	15827	76.3	17500	22	S	10219241
63	674.2	19127	88.8	27300	6	S	16179089
64	674.2	18876	88.8	27300	7	S	14643727
65	531.0	11105	75.2	21600	14	S	5175658
66	468.5	7958	69.6	8500	31	S	908010
67	674.2	18764	88.8	26000	8	S	14645378
68	529.6	9069	76.3	17500	22	S	2699266

STATISTICAL ANALYSIS SYSTEM

OBS	LOA	GRTON	BEAM	HP	AGE	HULL	CURRDOLS
69	594.2	17904	78.2	17500	4	S	16641349
70	653.4	15135	92.8	30000	4	S	44619617
71	515.2	10723	76.2	12500	8	S	5596644
72	562.0	11757	90.0	30000	7	S	12794688
73	497.2	10577	71.7	9000	32	S	1436307
74	811.7	32278	100.2	32000	2	S	30996164
75	497.2	11021	71.1	9000	31	S	1386779
76	497.2	10573	71.1	9000	32	S	1436307
77	497.2	10573	71.1	9000	32	S	1439609
78	473.7	9459	69.2	10000	12	S	3854916
79	473.7	8988	69.2	10000	12	S	4036518
80	530.2	12691	76.1	17500	14	S	5192167
81	610.2	14113	71.7	9000	30	S	3902793
82	468.5	12589	69.6	8500	32	S	4122366
83	685.6	23785	95.2	32000	6	S	31186020
84	584.3	15949	82.1	24000	7	S	9889056
85	529.6	12495	76.3	17500	24	S	2435118
86	549.1	9493	82.1	21000	7	S	8535295
87	607.3	14192	75.3	6000	31	S	2806577
88	504.0	11601	68.2	10000	32	S	8997555
89	497.2	10530	71.7	10000	31	S	1386779
90	571.2	11891	69.2	9000	16	S	6892622
91	738.5	26456	100.2	32000	4	S	26934882
92	635.6	16518	76.1	22000	14	S	10896121
93	529.6	12505	76.3	17500	24	S	2435118
94	629.6	10606	67.0	5000	23	S	3318364
95	529.6	12421	76.1	17500	21	S	2699266
96	738.5	26406	100.2	32000	5	S	25903052
97	653.4	15257	92.8	30000	3	S	44619617
98	584.3	15949	82.1	24000	7	S	9889056
99	468.5	7929	69.6	8500	32	S	908010
100	507.6	11202	75.1	18000	12	S	6504654
101	471.1	11476	71.1	7240	33	S	2360826
102	449.0	8673	63.1	6000	33	S	2253516
103	571.2	11891	69.2	10000	13	S	6240506
104	640.7	21150	90.0	26000	3	S	19893676
105	529.6	8995	76.3	17500	22	S	2699266
106	450.1	9014	72.1	6000	33	S	2253516
107	564.9	10932	78.3	13000	28	S	1657531
108	497.2	11521	71.7	9000	32	S	2666248
109	571.2	11891	69.2	9000	14	S	6240506
110	504.0	6475	54.0	1760	66	S	4424486

APPENDIX G

GENERAL LINEAR MODEL FOR SHIPS

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M   15:02 MONDAY, OCTOBER 18, 1982

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: CURRDOLS

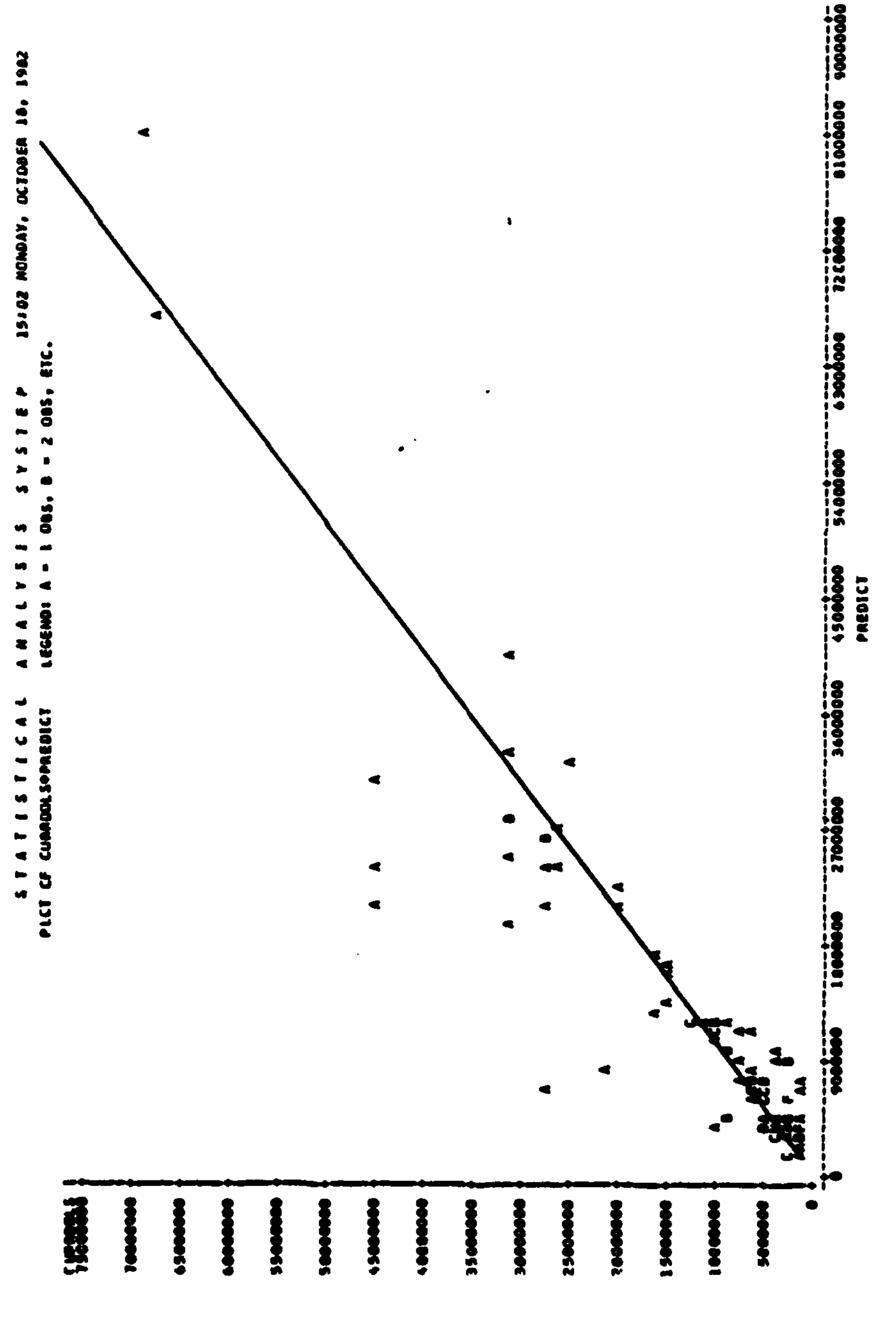
SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	2	1554574840839780345.0	777287424198918? .0	278.60	0.0001	0.838945	47.5424
ERROR	107	2984376951302735.0	27891373376661.1		STD DEV		CURRDOLS MEAN
CORRECTED TOTAL	109	1853012543520110 0.0			5281220.4		11108469.82727273

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE IV SS	F VALUE	PR > F
LOA	1	[illegible]	437.70	0.0001	1	[illegible]	40.98	0.0001
N	1	[illegible]	119.66	0.0001	1	[illegible]	119.66	0.0001

PARAMETER	ESTIMATE	T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	[illegible]	[illegible]	0.0001	[illegible]
LOA	[illegible]	[illegible]	0.0001	[illegible]
N	[illegible]	10.94	0.0001	1.28351256

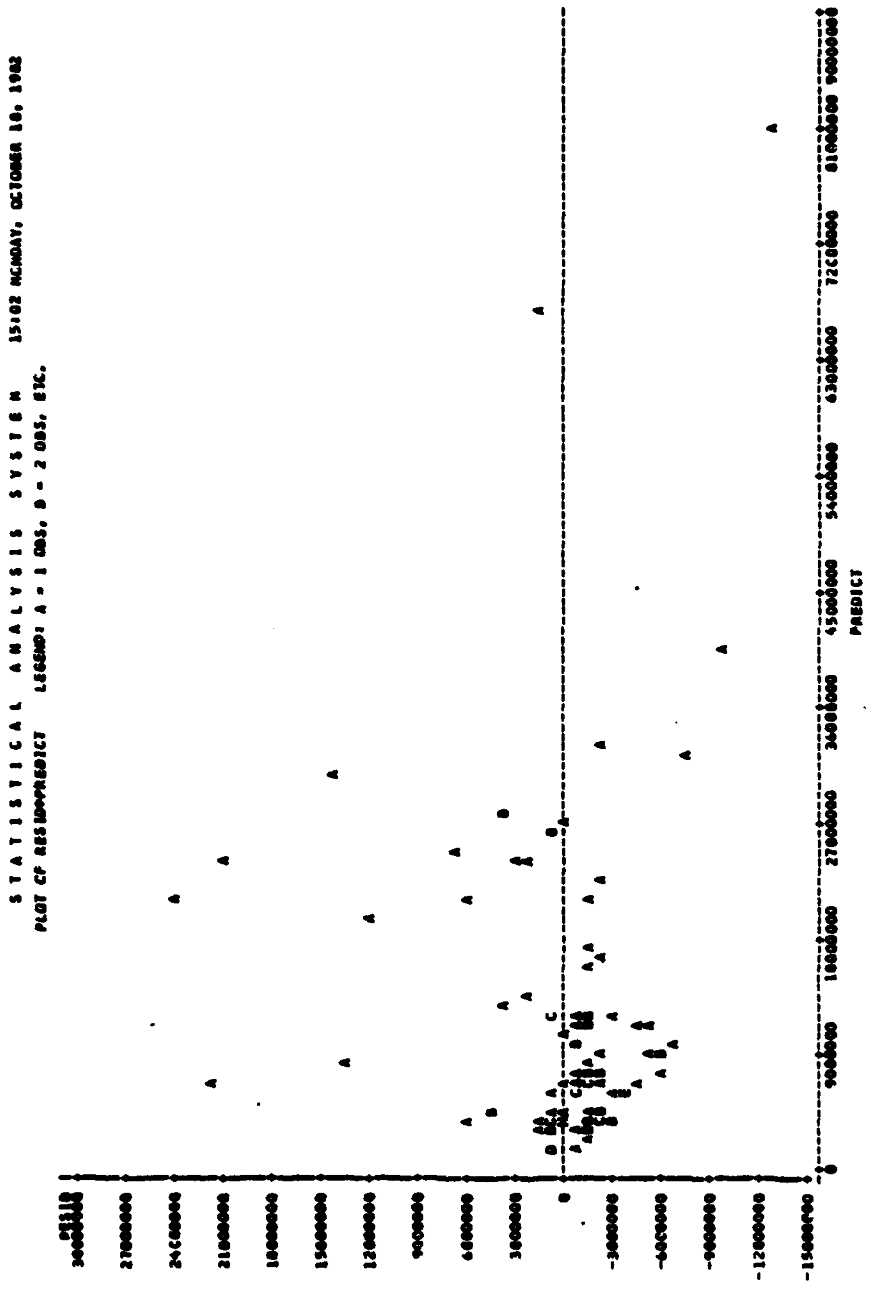
APPENDIX H

REGRESSION PLOT FOR SHIPS



APPENDIX I

RESIDUAL PLOT FOR SHIPS



APPENDIX J

RAW DATA FOR TUGS

STATISTICAL ANALYSIS SYSTEM

OBS	LOA	GRTON	BEAM	HP	AGE	HULL	CURRDOLS
1	52.3	33	14.0	400	11	S	14623
2	138.3	297	33.9	3600	35	S	60358
3	81.1	143	24.0	700	33	S	165056
4	50.0	23	13.8	100	60	W	2635
5	133.0	196	34.5	5000	8	S	1353761
6	78.5	118	20.0	800	31	S	1271214
7	136.1	289	35.0	4320	13	S	1106121
8	89.4	191	28.1	1700	10	S	569570
9	89.4	191	28.1	1530	12	S	503533
10	129.1	920	46.1	11000	5	S	4952782
11	89.4	191	28.1	1530	10	S	495278
12	109.7	195	26.7	2400	11	S	792445
13	89.4	191	28.1	1530	10	S	495278
14	136.1	290	35.0	4320	13	S	1106121
15	94.2	188	25.1	1650	34	S	104008
16	129.1	989	46.1	11000	5	S	4952782
17	78.8	146	24.0	1530	10	S	528297
18	94.7	198	27.1	1800	18	S	445750
19	118.7	198	34.0	4300	3	S	2212243
20	118.7	198	34.0	4300	3	S	2212243
21	94.7	198	27.1	1800	19	S	429241
22	103.3	196	25.5	2460	16	S	693390
23	133.0	196	34.5	5000	8	S	1353760
24	89.4	191	9.5	1700	10	S	569570
25	135.5	497	33.1	3600	33	S	586079
26	89.4	191	28.1	1530	12	S	495278
27	112.1	194	34.0	3000	8	S	1271214
28	83.7	144	23.6	2050	25	S	506835

APPENDIX K

GENERAL LINEAR MODEL FOR TUGS

STATISTICAL ANALYSIS SYSTEM   14:33 MONDAY, OCTOBER 18, 1982

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: CURRBOLS

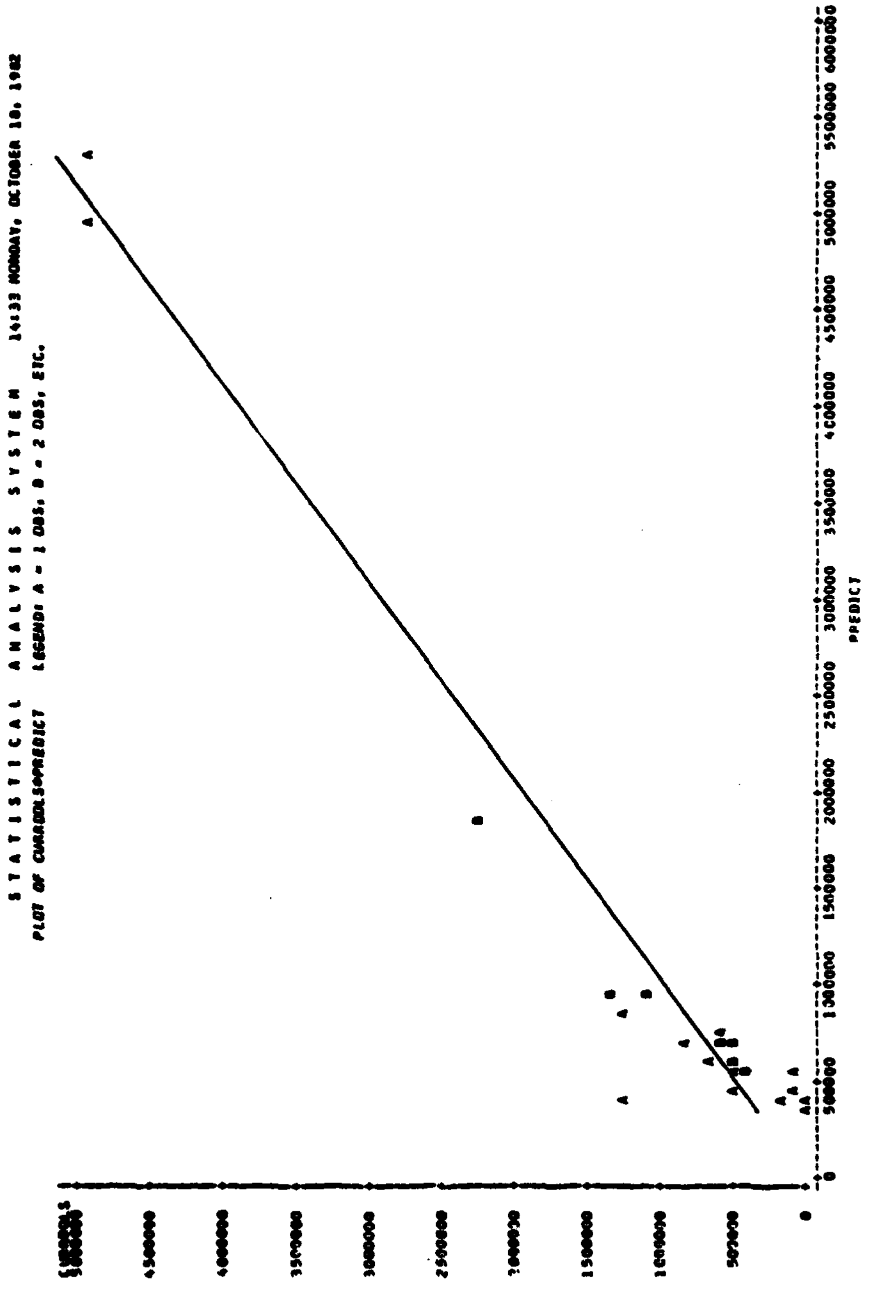
SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	1	39195784581326.3200	39195784581326.3200	408.73	0.0001	0.940192	29.6445
ERROR	26	2493338304460.9296	95897627094.6511		STD DEV		CURRBOLS MEAN
CORRECTED TOTAL	27	41689122885787.2500			309673.4201		1044623.75000000

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE IV SS	F VALUE	PR > F
Z	1	39195784581326.3200	408.73	0.0001	1	39195784581326.3200	408.73	0.0001

PARAMETER	ESTIMATE	T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	345148.[illegible]	5.08	0.0001	67905.[illegible]
Z	193.21654185	20.22	0.0001	9.55714344

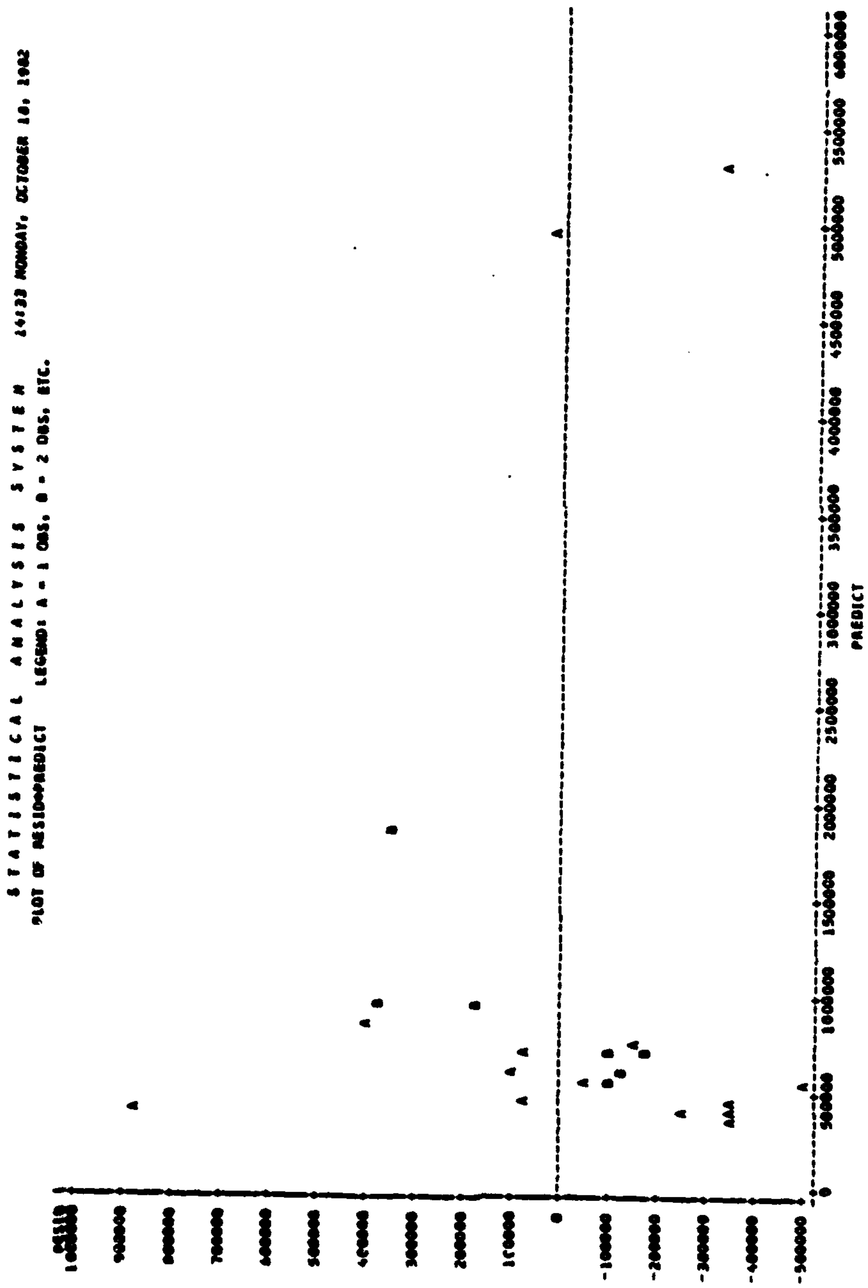
APPENDIX L

REGRESSION PLOT FOR TUGS



APPENDIX M

RESIDUAL PLOT FOR TUGS



APPENDIX N

RAW DATA FOR FISHING VESSELS

STATISTICAL ANALYSIS SYSTEM

OBS	LOA	GRTON	BEAM	HP	AGE	HULL	CURRDOLS
1	24.7	6	8.0	250	0.1	0	49653
2	26.6	7	10.6	280	18.0	0	27438
3	36.7	14	12.9	180	31.0	0	49389
4	27.6	8	10.5	125	38.0	0	21691
5	40.0	12	10.3	60	59.0	0	50000
6	28.5	7	10.4	55	39.0	0	13176
7	31.5	11	11.4	25	7.0	0	17788
8	31.8	9	9.0	76	57.0	0	19764
9	27.4	7	9.8	68	34.0	0	23717
10	41.5	23	13.5	65	30.0	0	98778
11	28.6	8	9.8	37	8.0	0	49167
12	28.0	10	9.3	365	7.0	0	21082
13	34.0	17	11.6	210	5.0	0	43901
14	27.0	6	9.0	195	1.0	0	19945
15	36.5	21	13.1	130	4.0	1	114964
16	53.1	37	18.0	450	18.0	0	94103
17	28.1	8	10.0	225	3.0	0	29647
18	39.3	13	9.7	40	36.0	0	23717
19	42.3	11	11.0	110	61.0	0	2635
20	42.0	14	10.6	225	3.0	0	21691
21	35.0	14	10.9	165	5.0	0	13176
22	28.0	8	10.0	140	60.0	0	3139
23	38.0	22	13.9	225	35.0	0	50097
24	27.8	10	10.5	50	5.0	0	9400
25	36.0	14	11.2	72	40.0	0	66037
26	26.3	8	10.1	36	6.0	0	23090
27	37.5	12	10.7	25	1.0	0	6507
28	49.6	26	12.2	175	63.0	0	1372
29	45.3	45	15.4	225	4.0	1	223323
30	38.3	27	12.0	165	2.0	0	72429
31	38.6	17	11.6	110	56.0	0	25000
32	35.5	7	9.8	165	34.0	0	659
33	35.2	16	11.4	100	2.0	0	26353
34	44.5	24	13.4	330	34.0	0	4562
35	32.3	14	11.6	165	28.0	0	32282
36	29.1	7	8.9	40	44.0	0	3953
37	28.1	7	9.5	40	61.0	0	18799
38	34.5	10	10.3	165	39.0	0	16900
39	40.5	25	12.9	165	3.0	1	93996
40	48.5	35	15.3	120	4.0	0	111400
41	35.4	19	12.6	45	54.0	0	53960
42	34.1	17	11.0	86	6.0	0	36152
43	27.6	6	9.3	100	42.0	0	16268
44	28.7	8	10.6	55	32.0	0	39529
45	38.7	29	13.8	380	55.0	0	120729
46	27.8	7	10.2	40	49.0	0	16463
47	36.0	12	10.2	165	31.0	0	8957
48	29.0	8	10.1	125	64.0	0	4612
49	38.3	13	10.3	200	27.0	0	13584
50	43.5	13	10.4	160	37.0	0	4466
51	54.9	21	10.9	225	68.0	0	18903
52	44.6	48	15.1	250	8.0	1	123145
53	32.9	10	9.8	60	43.0	0	8780
54	34.0	14	9.8	225	38.0	0	7697
55	36.4	17	12.6	165	32.0	0	17788
56	23.7	5	8.4	200	6.0	0	549
57	24.2	7	9.6	140	33.0	0	3694
58	33.8	12	12.0	53	38.0	0	7230
59	28.9	11	10.3	240	8.0	0	45000
60	40.7	17	11.5	110	31.0	0	82546
61	43.5	15	10.4	165	34.0	0	21082

APPENDIX O

GENERAL LINEAR MODEL FOR FISHING VESSELS

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M   16:00 MONDAY, OCTOBER 18, 1982

GENERAL LINEAR MODELS PROCEDURE

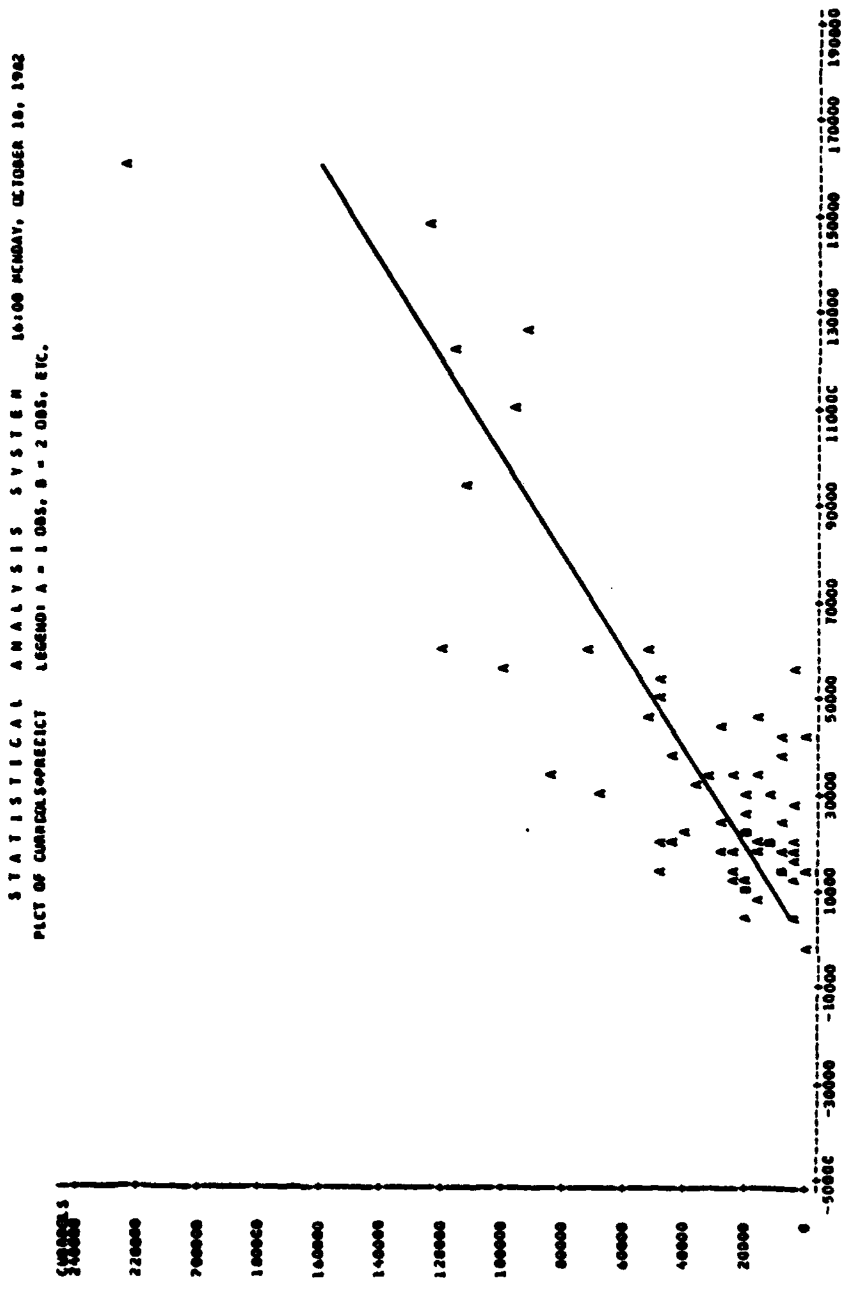
DEPENDENT VARIABLE: CURRDOLS

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	70021375760.0940000	23340458586.6982660	44.43	0.0001	0.700465	62.2525
ERROR	57	29942789430.1674950	525312095.2660964		STD DEV		CURRDOLS MEAN
CORRECTED TOTAL	60	99964165190.2622900			22919.6079400		36817.27868852

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE IV SS	F VALUE	PR > F
Z	1	[illegible]	[illegible]	0.0001	1	[illegible]	8.65	0.0047
BEAM	1	[illegible]	[illegible]	0.0001	1	[illegible]	[illegible]	0.0001
HULL	1	11207468438.4572600	21.33	0.0001	1	11207468438.4572600	21.33	0.0001

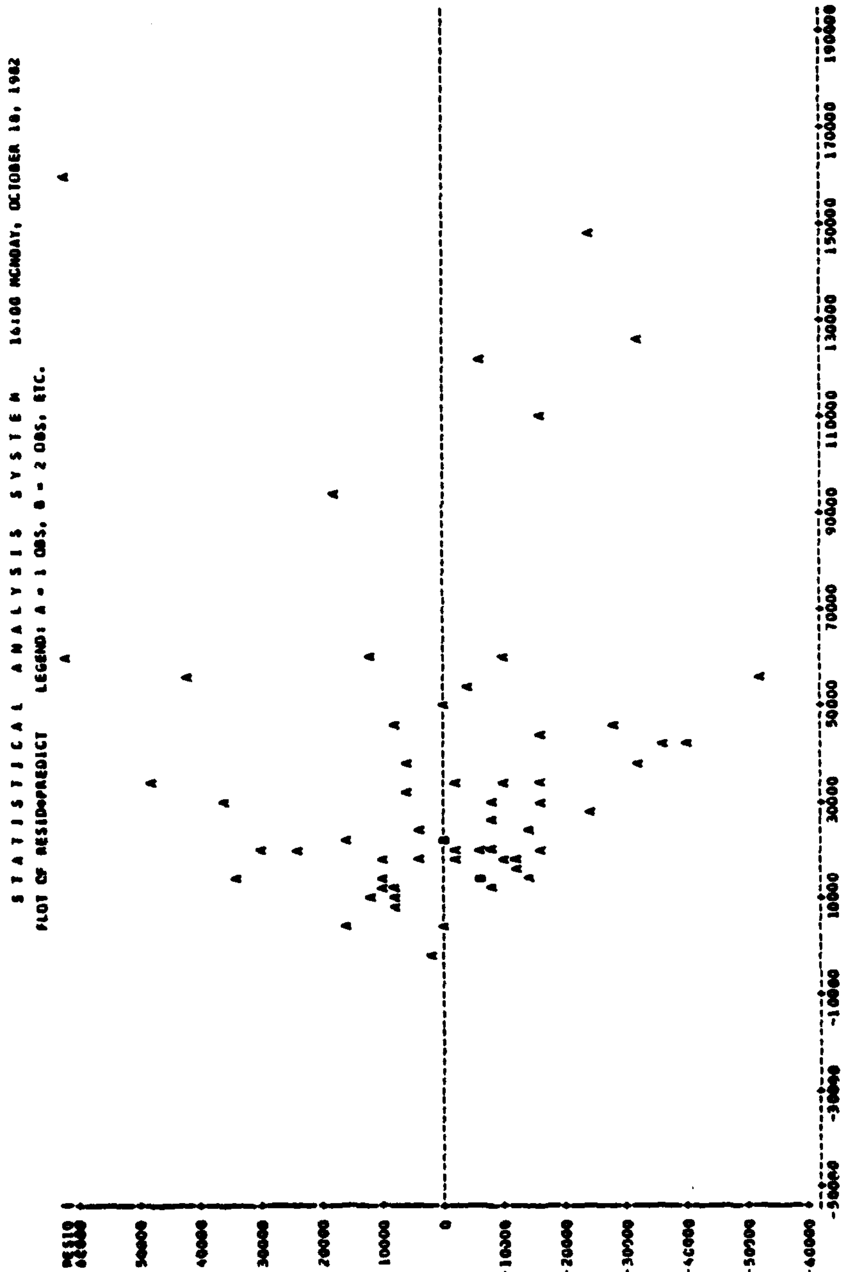
APPENDIX P

REGRESSION PLOT FOR FISHING VESSELS



APPENDIX Q

RESIDUAL PLOT FOR FISHING VESSELS



APPENDIX R

RAW DATA FOR YACHTS

STATISTICAL ANALYSIS SYSTEM

OBS	LOA	GRTON	BEAM	HP	AGE	HULL	CURRDOLS
1	31.9	9	9.4	22	0.1	F	53922
2	43.5	15	12.0	50	42.0	W	26415
3	40.5	18	11.1	150	42.0	W	15153
4	32.9	9	10.6	30	2.0	F	69157
5	36.5	14	11.1	26	2.0	F	62735
6	30.9	10	10.8	560	15.0	F	25035
7	37.0	21	12.5	290	2.0	F	99056
8	32.0	15	11.0	38	5.0	F	39511
9	30.7	12	10.5	20	0.1	F	83286
10	44.7	20	10.9	100	55.0	W	5488
11	34.5	7	10.0	75	8.0	F	39836
12	36.4	14	10.0	32	6.0	F	69412
13	55.0	39	15.8	175	2.0	C	54322
14	36.0	10	11.1	25	2.0	F	64572
15	29.9	6	10.0	28	5.0	F	32325
16	33.5	14	11.7	40	2.0	F	66750
17	47.4	31	13.3	36	4.0	C	42164
18	30.0	8	9.1	30	8.0	F	25350
19	36.7	12	11.5	60	2.0	F	77727
20	29.6	13	11.5	500	1.0	F	74644
21	37.6	14	10.9	40	16.0	F	41936
22	31.5	9	11.0	40	1.0	F	72470
23	30.2	7	10.0	35	41.0	W	13072
24	47.0	34	15.0	516	1.0	F	100644
25	35.0	21	11.7	300	31.0	S	3380
26	29.0	9	9.0	15	4.0	W	40490
27	29.2	8	10.0	50	27.0	W	1713
28	36.0	10	11.1	50	3.0	F	62772
29	31.3	8	9.2	50	8.0	F	31386
30	36.7	18	10.8	25	0.1	F	12597
31	48.6	25	15.5	120	3.0	W	181602
32	32.0	8	11.0	28	1.0	F	18234
33	39.1	19	12.4	115	30.0	W	48488
34	32.9	11	10.0	30	7.0	F	39836
35	32.2	7	10.0	36	23.0	W	23059
36	50.0	40	14.0	85	3.0	F	123820
37	37.0	21	11.5	40	0.1	F	90380
38	50.4	25	11.5	400	51.0	W	8942
39	47.0	28	14.5	180	9.0	W	120025
40	36.3	23	12.9	185	9.0	W	19764
41	33.6	12	12.0	38	11.0	W	61084
42	48.8	23	13.8	55	6.0	C	30179
43	31.5	13	10.0	16	0.1	F	71597
44	25.6	7	9.1	9	17.0	F	25596
45	42.0	22	12.1	450	21.0	W	65186
46	30.0	7	10.1	15	2.0	F	53115
47	39.0	21	11.3	50	6.0	F	71340
48	42.6	19	14.6	50	7.0	C	54951
49	30.6	17	11.5	440	2.0	F	48890
50	40.0	14	12.5	255	3.0	F	36152
51	34.6	9	11.0	46	1.0	F	79747
52	34.0	10	10.0	10	4.0	F	24747
53	28.2	7	9.1	30	3.0	F	36559
54	26.6	7	9.1	37	7.0	F	34258
55	32.0	13	10.1	25	3.0	F	33019
56	44.4	22	11.0	40	0.1	F	29335
57	60.4	48	14.9	464	0.1	W	40000
58	47.0	19	13.3	65	3.0	W	136202
59	40.4	18	10.5	220	51.0	W	46096

APPENDIX S

STEPWISE REGRESSION FOR YACHTS

STATISTICAL ANALYSIS SYSTEM

MAXIMUM R-SQUARE IMPROVEMENT FOR DEPENDENT VARIABLE CURRDOLS

STEP 1 VARIABLE BEAM ENTERED R SQUARE = 0.24356208 C(P) = 33.23368936

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	1	16858779249.24085800	16858779249.240858	18.35	0.0001
ERROR	57	52358807552.55575700	918575571.097469		
TOTAL	58	69217586801.79661000			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-61734.56101033				
BEAM	9973.00505970	2327.93271235	16858779249.240857	18.35	0.0001

THE ABOVE MODEL IS THE BEST 1 VARIABLE MODEL FOUND.

STEP 2 VARIABLE AGE ENTERED R SQUARE = 0.39894626 C(P) = 17.10910940

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	2	27614097324.30817700	13807048662.154088	18.58	0.0001
ERROR	56	41603489477.48843700	742919454.955151		
TOTAL	58	69217586801.79661000			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-41259.62663720				
AGE	-946.45514964	248.74781521	10755318075.067319	14.48	0.0004
BEAM	9049.42057296	2107.57752567	13696706797.378676	18.44	0.0001

THE ABOVE MODEL IS THE BEST 2 VARIABLE MODEL FOUND.

STEP 3 VARIABLE W ENTERED R SQUARE = 0.43140277 C(P) = 15.32326340

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	3	29860658516.12692700	9953552838.7089750	13.91	0.0001
ERROR	55	39356928285.66968800	715580514.2849034		
TOTAL	58	69217586801.79661000			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-26742.57757067				
AGE	-1341.82056304	330.73853828	11778169139.061847	16.46	0.0002
BEAM	7663.36633665	2211.41430395	8593250083.902639	12.01	0.0010
W	18834.54462101	10629.60386202	2246561191.818749	3.14	0.0820

STEP 3 AGE REPLACED BY F R SQUARE = 0.46832815 C(P) = 11.01615144

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	3	32416544454.43767100	10805514818.145890	16.15	0.0001
ERROR	55	36801042347.35894300	669109860.861072		
TOTAL	58	69217586801.79661000			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-183108.47747688				
BEAM	15903.73392174	2337.50031347	30973642182.350437	46.29	0.0001
W	43678.03673897	13905.85931965	6601277440.793615	9.87	0.0027
F	65775.07363666	14211.02893280	14334055077.372591	21.42	0.0001

THE ABOVE MODEL IS THE BEST 3 VARIABLE MODEL FOUND.

STATISTICAL ANALYSIS SYSTEM

MAXIMUM R-SQUARE IMPROVEMENT FOR DEPENDENT VARIABLE CURRDOLS

STEP 4 VARIABLE AGE ENTERED R SQUARE = 0.53705157 C(P) = 5.00000000

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	4	37173413784.07333000	9293353446.0183320	15.66	0.0001
ERROR	54	32044173017.72328400	593410611.4393200		
TOTAL	58	69217586801.79661000			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-129687.93247040				
AGE	-918.53750480	324.42471887	4756869329.635659	8.02	0.0065
BEAM	12707.55112127	2473.88919366	15657360538.919674	26.39	0.0001
W	51155.21621202	13359.27641677	8701002340.438782	14.66	0.0003
F	50605.53975667	14415.68207558	7312755267.946404	12.32	0.0009

THE ABOVE MODEL IS THE BEST 4 VARIABLE MODEL FOUND.

APPENDIX T

RAW DATA FOR TANK SHIPS

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M

OBS	DDWT	LTWT	SOURCE
1	150000	26941	CHEVRON
2	255350	33520	CHEVRON
3	70192	14877	CHEVRON
4	78872	12880	CHEVRON
5	33866	9507	CHEVRON
6	48210	13865	CHEVRON
7	39990	10597	UNION
8	70459	14631	UNION
9	266428	34993	UNION
10	35337	10041	CITIES SVC
11	28000	8200	EXXON
12	165000	24000	EXXON
13	41000	12500	EXXON
14	43971	15285	GETTY
15	68474	14999	GETTY
16	223765	30000	GETTY
17	135235	20000	GETTY
18	155099	16000	GETTY
19	130700	22500	GETTY
20	125000	17600	GULF
21	227000	36000	GULF
22	228499	34834	STD OF INDIANA
23	150000	25774	STD OF INDIANA
24	78061	14105	STD OF INDIANA
25	188099	28992	SHELL
26	398143	58840	SHELL
27	553662	77300	SCALLOP
28	71153	14910	SCALLOP
29	30990	7260	SCALLOP
30	32230	7700	SCALLOP
31	278220	39268	SCALLOP
32	318000	40634	SCALLOP
33	117151	18390	SCALLOP
34	53444	13100	SCALLOP
35	68562	21071	SCALLOP
36	28808	7832	GETTY
37	25088	5783	GETTY
38	25184	5783	GETTY
39	60406	21557	HESS
40	59400	20487	HESS
41	271857	35908	CONOCO
42	136138	22172	CONOCO
43	272426	38950	CONOCO
44	61370	12115	CONOCO
45	61928	11891	CONOCO
46	64652	13747	CONOCO

APPENDIX U

GENERAL LINEAR MODEL FOR TANK SHIPS

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M   15:46 MONDAY, OCTOBER 18, 1982

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: LTWT

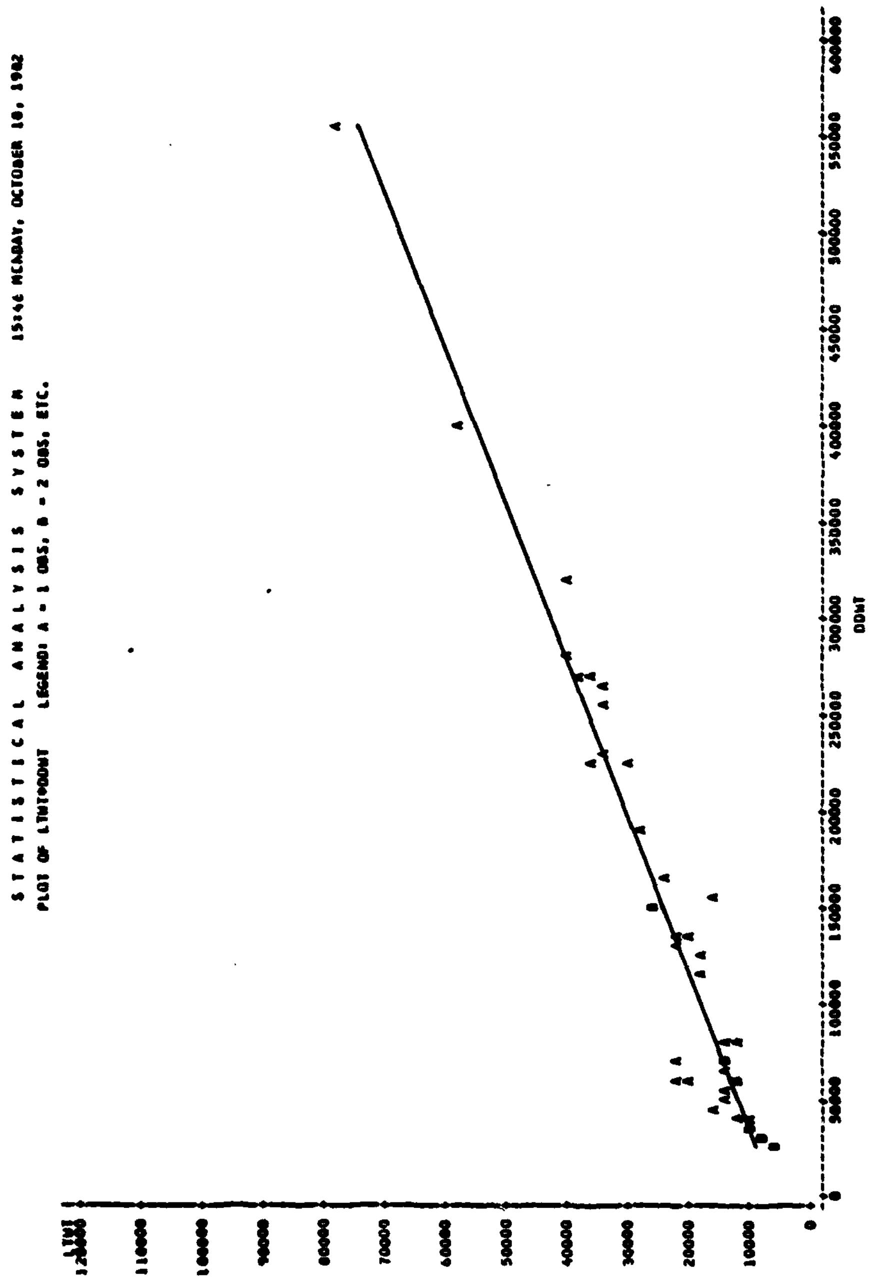
SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	1	8642048652.06994300	8642048652.06994300	835.51	0.0001	0.949972	14.8336
ERROR	44	455110267.25614450	10343415.16491238		STD DEV		LTWT MEAN
CORRECTED TOTAL	45	9097158919.32608700			3216.11802720		21681.28260870

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE IV SS	F VALUE	PR > F
DDWT	1	8642048652.06994300	835.51	0.0001	1	8642048652.06994300	835.51	0.0001

PARAMETER	ESTIMATE	T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	5701.22443051	7.83	0.0001	728.34913863
DDWT	0.12196694	28.91	0.0001	0.00422058

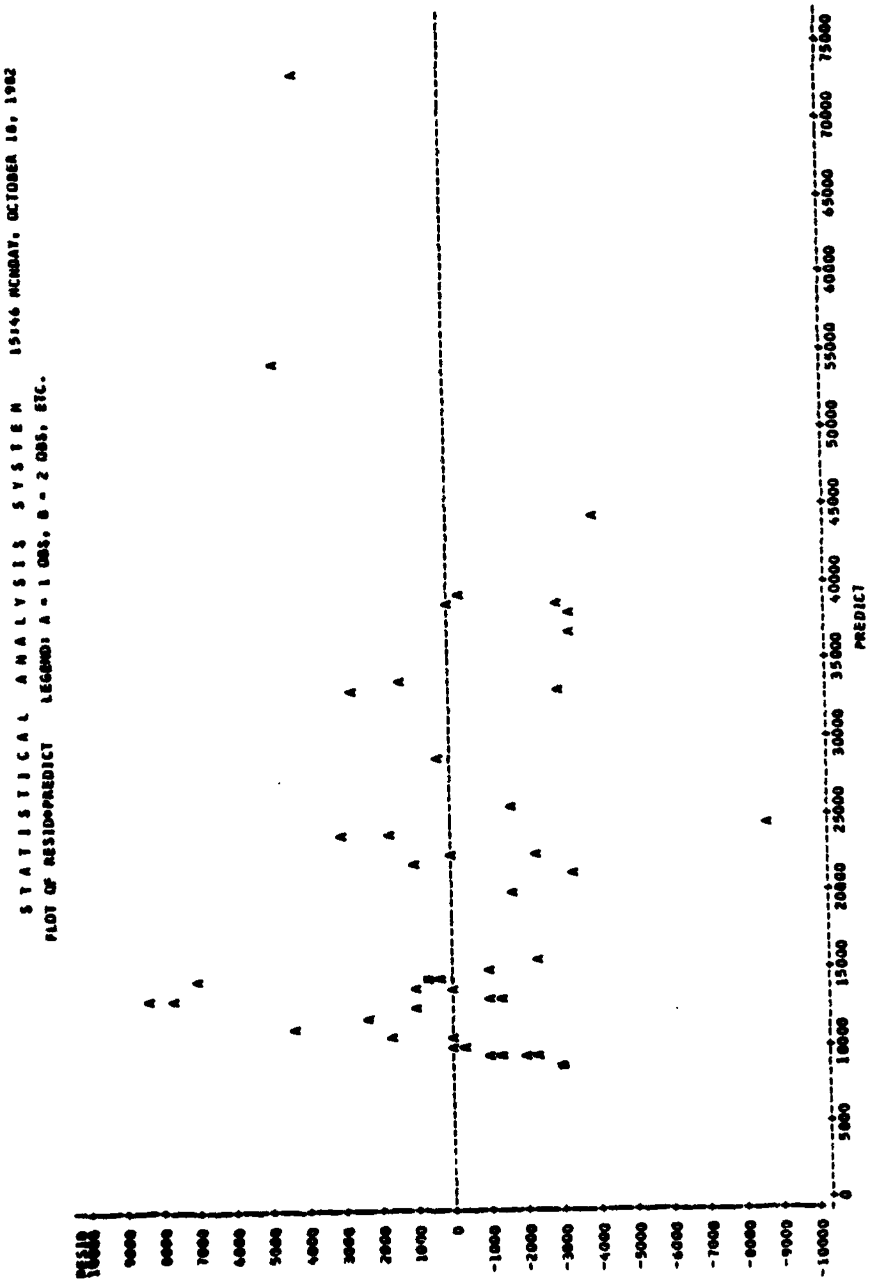
APPENDIX V

REGRESSION PLOT FOR TANK SHIPS



APPENDIX W

<u>RESIDUAL PLOT FOR TANK SHIPS</u>



APPENDIX X

RAW DATA FOR TANK BARGES

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M

OBS	LTWT	GRTON
1	2850	7847
2	3050	9844
3	1680	3549
4	360	907
5	1230	2680
6	3755	11082
7	485	1495
8	790	1570
9	535	851
10	1205	3146
11	605	1156
12	320	628
13	1560	4272
14	1040	2596
15	666	1713
16	556	1626
17	615	1675
18	748	1624
19	800	1922
20	1625	5248
21	2815	8123

APPENDIX Y

GENERAL LINEAR MODEL FOR TANK BARGES

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M   15:34 MONDAY, OCTOBER 18, 1982

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: LTWT

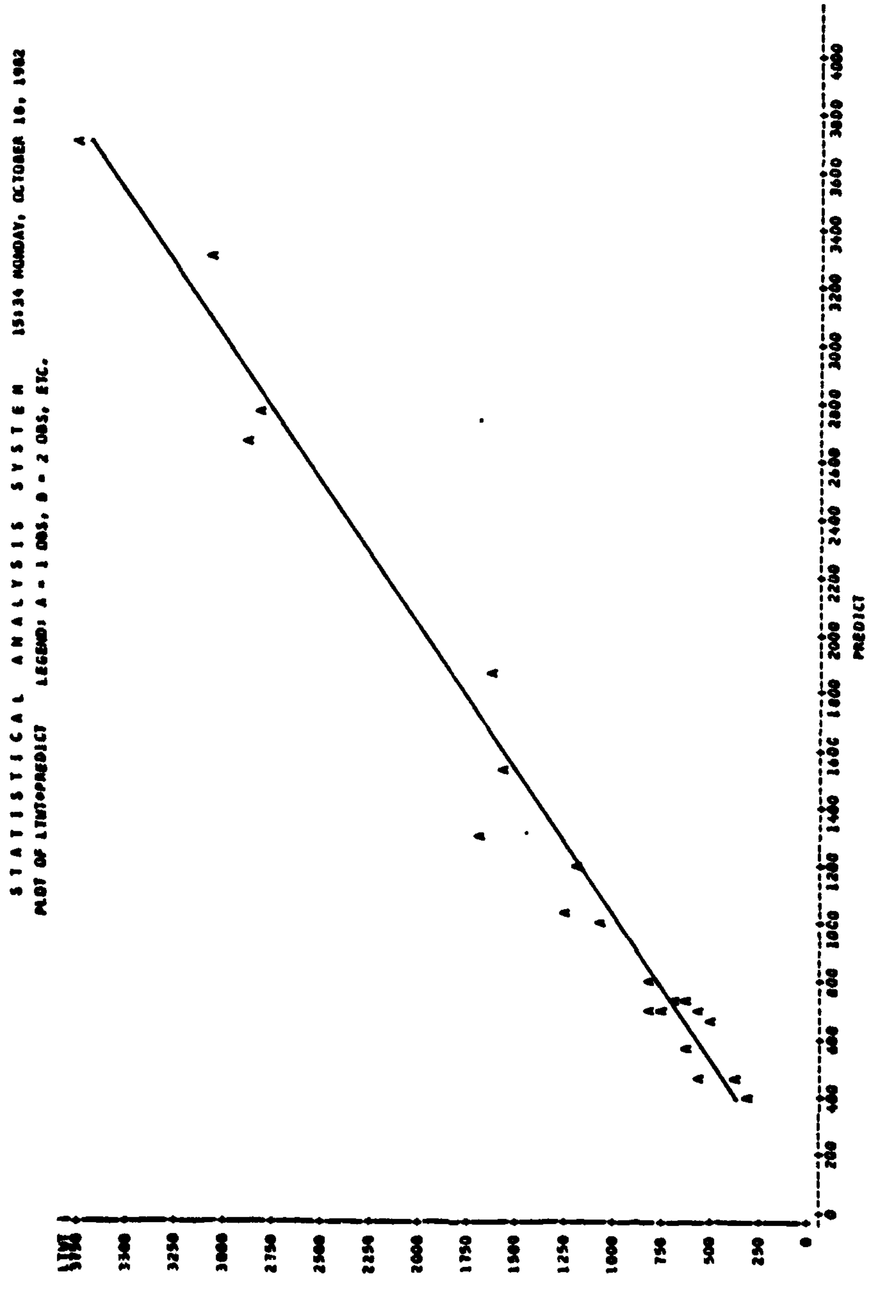
SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	1	19567533.54241217	19567533.54241217	854.95	0.0001	0.978260	11.6416
ERROR	19	434857.69568307	22887.24714121		STD DEV		LTWT MEAN
CORRECTED TOTAL	20	20002391.23809524			151.28531700		1299.52380952

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE IV SS	F VALUE	PR > F
GRTON	1	19567533.54241217	854.95	0.0001	1	19567533.54241217	854.95	0.0001

PARAMETER	ESTIMATE	T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	18[illegible]	3.75	0.0014	50.[illegible]
GRTON	0.31714383	29.24	0.0001	0.01084445

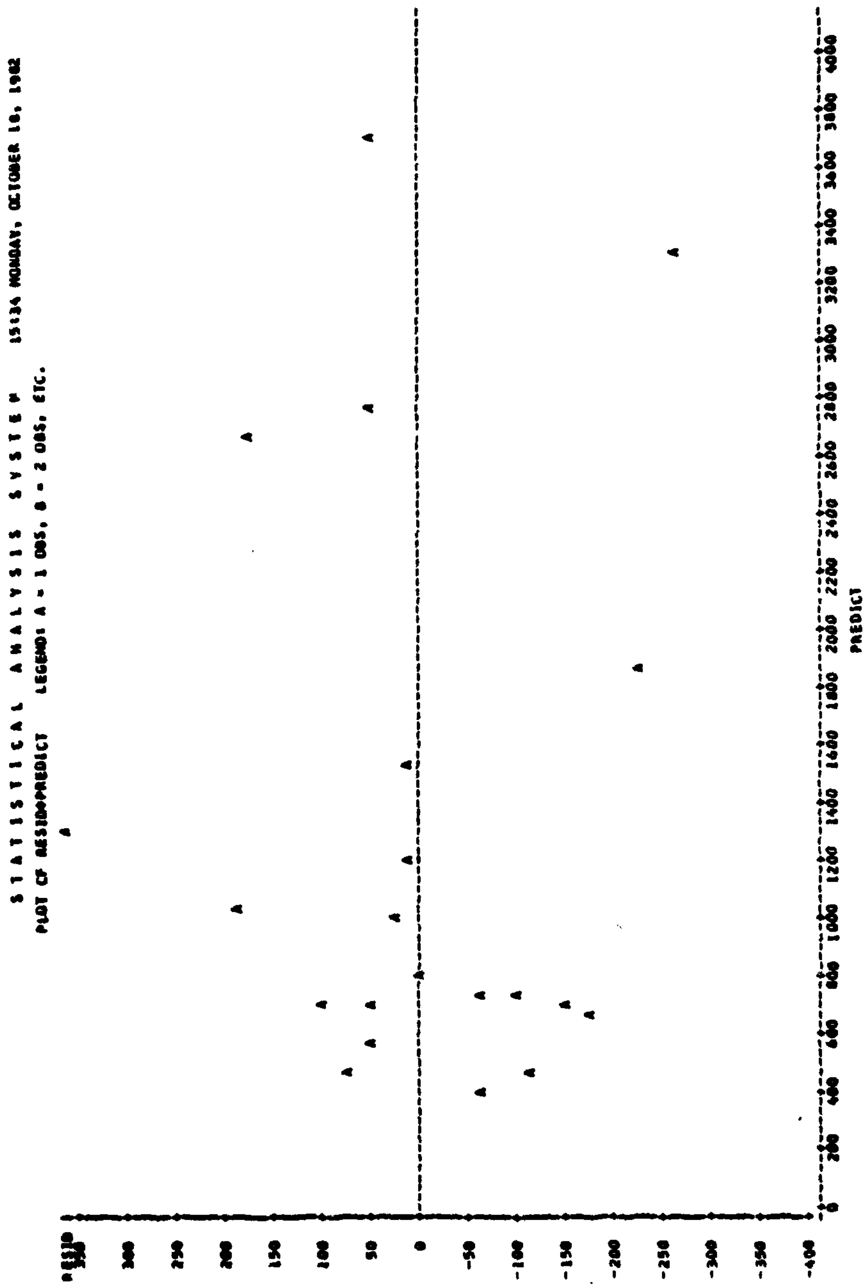
APPENDIX Z

REGRESSION PLOT FOR TANK BARGES



APPENDIX AA

RESIDUAL PLOT FOR TANK BARGES



APPENDIX BB

DISTRIBUTION LIST FOR BUC PRICE GUIDES

Cutters (except light vessels and MESSENGER)	231
Surface Effect Ships (SES)	2
Headquarters (G-OSR/3)	1
District Operations Centers	12
Sections	3
Training Center Governor's Island (SAR School)	1
Coast Guard Institute	1
Air Stations (Large)	12
Air Stations (Small)	13
Stations	158
Groups	47
Boating Safety Detachments	15
Aids to Navigation Facilities	11
Radio/Communications Stations	9
Selected Bases:	5
Saint Louis	
Gloucester City	
San Juan	
Terminal Island	
Honolulu	
TOTAL	521

APPENDIX CC

COST CALCULATIONS FOR BUC PRICE GUIDES

BUC QUANTITY DISCOUNT COSTS

QUANTITY	USED BOAT PRICE GUIDE (VOLUMES I & II)	NEW BOAT PRICE GUIDE
1	$85.00	$16.00
2-23	$83.50	$14.50
24-47	$79.50	$12.50
47+	$77.00	$12.50

Cost per unit supplied when purchases of greater than forty-seven are made is $77.00 + $12.50 = $89.50.

The number of units to be supplied is 521 (from Appendix BB). Therefore, total cost is $89.50 x 521 = $44,660.50.

It should be noted that the above costs are applicable only to prepaid orders.

APPENDIX DD

DATA TO BE COLLECTED

FOR MERCHANT SHIPS:

Length Overall

Beam

Horsepower

Age

FOR TUGS:

Gross Tonnage

Length Overall

Age

FOR FISHING VESSELS:

Beam

Gross Tonnage

Length Overall

Age

FOR TANKERS:

Deadweight Tonnage

Age

Location

FOR TANK BARGES:

Gross Tonnage

AD-A126 457 MARKET VALUE ESTIMATION MODELS FOR MARINE SURFACE VESSELS WITH THE USE OF MULTIPLE REGRESSION ANALYSIS (U) NAVAL POSTGRADUATE SCHOOL MONTEREY CA T D JOHNS 2/2

UNCLASSIFIED DEC 82 F/G 6/7 NL

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DATE
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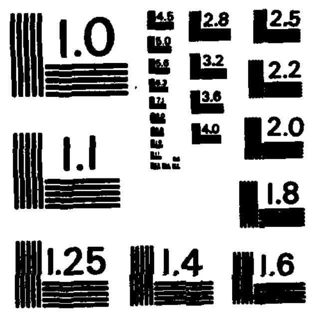

MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

FOR BOATS (if using price guides):

Name	Engine Manufacturer
Model	Top or Rig
Year Built	Boat Type
Manufacturer	Hull Material
Engine Horsepower	Hull Type
Engine Type	Beam
Number of Engines	Weight
Length Overall (in feet and inches)	

FOR BOATS (if using interactive or batch processing):

*Length Overall	Number of Engines
*Manufacturer	Horsepower
*Model Year	Engine Manufacturer
*Boat Type	Top or Rig
Engine Type	Engine Model Number

*Designates minimal information required

APPENDIX EE

ITEMS FOR INCLUSION IN DATA GATHERING OF FISHING VESSELS

PRIMARY CATCH

Clam	Swordfish
Lobster	Tuna
Menhadden	Whale
Oyster	Clam
Shrimp	Snapper
Snapper	Cod
Other ______________	

TYPE OF GEAR

Clam Dredge	Tongs
Purse Seine	Pots
Trawl	Longlines

TYPE OF RIG

Eastern	Stern Trawler
Western	Side Trawler
Other ______________	

CHARACTERISTICS

Length	Horsepower
Deadweight Tonnage	Draft
Gross Tonnage	Beam
Net Tonnage	Age
Hull Material	

ELECTRONICS

Radar
Fathometer
VHF-FM
Other ______________

HF
LORAN C
LORAN A

MISCELLANEOUS EQUIPMENT

Auxiliary Boats ____________________________
Rafts ____________________________________
Winches ___________________________________
Capstans __________________________________
Anchors ___________________________________
Refrigeration _____________________________

PROPULSION

Number of Engines __________________________
Horsepower (total) _________________________
Number of screws ___________________________
Fuel Capacity ______________________________
Other _____________________________________

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